E.ON Climate & Renewables

Analysis of Marine Environmental Monitoring Plan Data from the Robin Rigg Offshore Wind Farm, Scotland (Operational Year 1)

Executive Summary & Non-Technical Report

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Authors	Richard Walls (Team Leader), Dr. Sarah Canning, Dr. Gillian Lye, Laura Givens, Dr. Claudia Garrett & Dr Jane Lancaster.	10/03/2012
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Revision History

Issue	Date	Changes
A	10/11/2011	First issue
B	16/03/2012	Second issue
C	31/08/2012	Third issue
D	17/01/2013	Final issue

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Robin Rigg Offshore Wind Farm is E.ON Climate and Renewables' (E.ON) third offshore wind farm and the first commercial offshore wind farm in Scottish waters. The site is comprised of 60 three megawatt Vestas turbines and an offshore sub-station and is situated within the central part of the Solway Firth, immediately to the north of the English/Scottish boundary which roughly bisects the firth. The centre of the turbine layout lies some 11 km from the Dumfries and Galloway coastline within Scotland and 13.5 km from the Cumbrian coastline in England.

Prior to the construction of the wind farm, a Marine Environment Monitoring Programme (MEMP) was developed in conjunction with the Robin Rigg Management Group (RRMG), covering the pre-, during and post construction stages of development in accordance with consent from Scottish Ministers under Section 36 of the Electricity Act 1989.

The remit of the MEMP was to record any changes to the physical and ecological environment that may be caused by the construction and operation of the wind farm, complying with condition 6.4 of Section Consent 36 conditions. The programme concentrated on areas where there was uncertainty on the effects of the offshore wind farm and where those effects may cause potential impacts on the marine ecology. This included benthos, fish, birds and marine mammals.

The purpose of this report is to assess data collected as part of the MEMP prior to the construction of the Robin Rigg Wind Farm (defined as baseline/pre-construction, 2001 - 2007) with that collected during its construction (December 2007 – February 2010) and during operational year one (March 2010 – February 2011). These data will form a basis from which to assess any impacts from the operational phase of Robin Rigg for E.ON, the RRMG and Scottish Government (Marine Scotland). A summary of reports completed to date can be found in Table 1 below. Reports examining operational years two, three, four and five will follow.

Table 1: Summary of reports completed examining ecological data collected as part of the MEMP for the Robin Rigg Offshore Wind Farm.

Report Number	Report Title	Version
035_R_NPC_EON_1	Analysis of MEMP ecological data: pre-construction & construction phases. Technical report.	Final
035_R_NPC_EON_2	Analysis of MEMP ecological data: pre-construction & construction phases. Non-technical report.	Final
1022189	Analysis of Marine Environmental Monitoring Plan Data from the Robin Rigg Offshore Wind Farm, Scotland (Operational Year 1) –Executive Summary and Non-technical report.	Final
1022038	Analysis of Marine Environmental Monitoring Plan Data from the Robin Rigg Offshore Wind Farm, Scotland (Operational Year 1) – Technical Report	Final

- ***Benthic Ecology***

Predictions made in the environmental statement relating to the potential impacts of the construction and operation of the Robin Rigg Wind Farm were supported by the data collected. There is no evidence, to date, that the construction and operation of the Robin Rigg Wind Farm has had any significant or permanent impact upon the benthic fauna in the immediate or surrounding area.

The predominant biotope in the area, *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand (SS.SSa.IFiSa.NcirBat), is characteristic of naturally high energy environments, and has been the predominant biotope since the baseline survey. Over the construction years there appears to have

been spatial shift in biotopes, with *Abra prismatica, Bathyporeia elegans* and polychaetes in circalittoral fine sand (SS.SSa.CFiSa.ApriBatPo) biotope found however returning to SS.SSa.IFiSa.NcirBat during the operational year.

- ***Non-migratory Fish***

Predictions made in the environmental statement relating to the potential impacts of the construction and operation of the Robin Rigg Wind Farm were supported by the data collected. There is no evidence, to date, that the construction and operation of the Robin Rigg Wind Farm has had any significant or permanent impact upon the fish and epibenthic communities in the immediate or surrounding area.

Fish and, to an extent, epibenthic abundances, did vary across the construction periods, with the largest abundance caught during the baseline survey. This, however, is thought to be due to the shifting of channels so that the trawls are no longer in the channel but on top of the sand bank where there is naturally less fish and epibenthos. The fish and epibenthic community assemblage, however, did not show any considerable change throughout the construction periods compared to the baseline.

- ***Electro-sensitive Fish***

The majority of electro-sensitive fish (thornback rays and dogfish) were not found in the vicinity of the cable route, but on the Scottish side of the Solway Firth to the north of the wind farm site. As so few elasmobranch species were found around the cable route, it is possible to conclude that the area is not of critical importance to the thornback ray and dogfish populations in the Solway Firth. Any potential effects as a result of EMF from the electrified cable are likely to be of minimal significance to their populations as a whole.

Temporal changes in community structure and biodiversity point to the need for continued monitoring with regards to the electro-sensitive fish. It is also recommended that additional grab sites are added to the north-west and south-west of the wind farm.

- ***Birds***

As predicted by the environmental statement, little indication of a significant effect on the abundance of common scoter and red-throated diver was found between the three phases of the development. An increase in cormorant and large gull species abundance was observed in operational year one.

- ***Marine mammals***

As predicted by the environmental statement, no evidence of a decline in harbour porpoise or grey seal abundance was found between the three development phases.

Possible avoidance of wind farm area during the construction period by harbour porpoise was suggested by the density maps. This will be investigated further at the next stage of the analysis.

1. INTRODUCTION

Robin Rigg Offshore Wind Farm is E.ON's third offshore wind farm and the first commercial offshore wind farm in Scottish waters. The site is comprised of 60 three megawatt Vestas turbines and an offshore sub-station; the turbines began full commercial operation/generation in April 2010.

In accordance with the consent from Scottish Ministers under Section 36 of the Electricity Act 1989, a Marine Environment Monitoring Programme (MEMP) was developed to record any changes to the local physical and ecological environment as a result of the construction of the wind farm.

This report represents an update to the analysis performed on data collected before and during construction as part of the MEMP to include data collected during the first year of operation (April 2010-March 2011).

These data will form a basis from which to assess any impacts from the operational phase of Robin Rigg for E.ON, the Robin Rigg Management Group (RRMG) and Scottish Government.

1.1. Site Description

The Robin Rigg Offshore Wind Farm (Figure 1.1, 1.2 and 1.3) is situated within the central part of the Solway Firth, immediately to the north of the English/Scottish boundary which roughly bisects the firth. The centre of the turbine layout lies some 11 km from the Dumfries and Galloway coastline within Scotland and 13.5 km from the Cumbrian coastline in England. The nearest towns are Dalbeattie in Scotland, 21 km to the north-northwest and Maryport in England, 14 km to the southeast.

All turbines are connected using subsea cables via an offshore sub-station. These cables come ashore near Seaton, Cumbria and continue for approximately 2 km inland to an onshore substation.

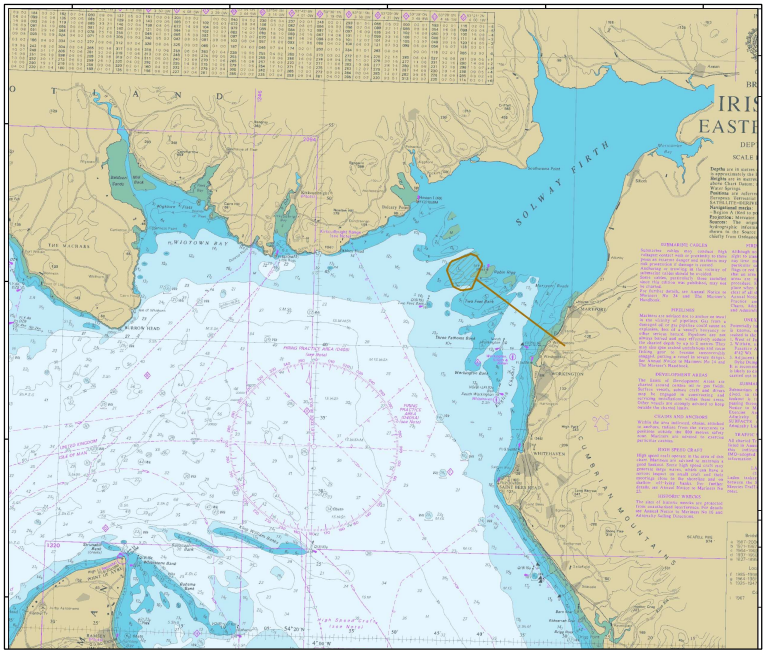

Figure 1.1: Map of Solway Firth showing the location of the Robin Rigg Offshore Wind Farm.

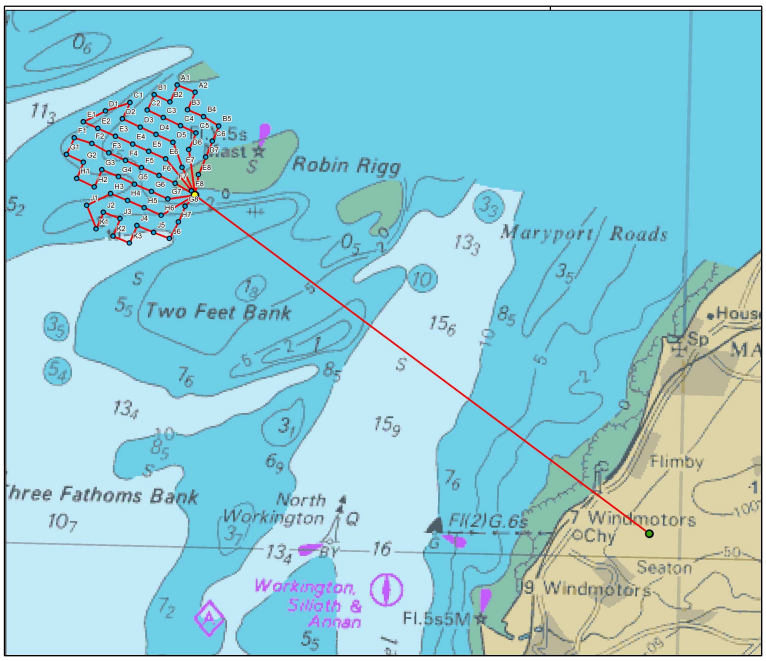

Figure 1.2: Schematic of Robin Rigg Offshore Wind Farm showing turbine locations (blue dots), inter-array cabling and grid connection to shore (red lines).

Figure 1.3: Photograph of Robin Rigg Offshore Wind Farm.

2. ECOLOGICAL MONITORING AT ROBIN RIGG

An Environmental Statement was prepared for the Scottish Executive Energy Division under Section 36 of the Electricity Act (Scotland) 1989; a Private Bill for the Scottish Parliament; the Scottish Executive - Transport Division under Section 34 of the Coastal Protection Act 1949 and the Scottish Executive – Rural Affairs Department under the Food and Environment Protection Act 1985; and in accordance with the statutory procedures set out in The Environmental Assessment (Scotland) Regulations 1988 and the Environmental Impact Assessment (Scotland) Regulations 1999, in support of an application for an offshore wind farm at Robin Rigg in the Solway Firth.

Prior to the construction of the Robin Rigg Wind Farm, a MEMP was developed in conjunction with the RRMG, covering the pre-, during and post construction stages of development in accordance with consent from Scottish Ministers under Section 36 of the Electricity Act 1989.

The remit of the MEMP was to record any changes to the physical and ecological environment that may be caused by the construction and operation of the wind farm, complying with condition 6.4 of Section Consent 36 conditions. The programme concentrated on areas where there was uncertainty on the effects of the wind farm and where those effects may cause potential impacts on the marine ecology. This included benthos, fish, birds and marine mammals. Intertidal surveys were also required and conducted; however the results of these surveys are not included in this report as the data has already been presented in a separate report.

Below is a summary of the data available for analysis. All data collected during construction of the Robin Rigg Wind Farm was undertaken as part of the requirements for the MEMP.

2.1. Benthic Surveys

- Marenco Ltd was commissioned in 2001 by Solway Offshore LTD and Offshore Energy Resources to assess the likely impacts of the development on benthic flora and fauna as part of the EIA process.
- Amec E & I UK Ltd (formerly Entec UK Ltd) has been contracted by NPC since July 2007 to undertake post EIA ecology benthic monitoring.

EIA baseline surveys

- Day grab samples were collected from a total of 100 stations, within and adjacent to the perimeter of the proposed wind farm development area during October 2001 and February 2002 by Marenco Ltd.
- Samples were also collected at five additional sites to the north and northwest of the main development area during February 2002 by Solenvo Marine Environmental Consultants.
- These additional surveys were undertaken in order to provide information on possible food sources for common scoters, which were found to be feeding in these areas.
- As the location of the cable route had not been finalised at this stage, no surveys of this area were undertaken.

MEMP monitoring

- Bi-annual benthic surveys were conducted throughout the pre-construction and construction phases on both the cable route and wind farm site (generally in the spring and autumn).
- Post construction: annual surveys for two years.

- Samples were collected from six stations within the site and three from outside the development area. All sampling stations surveyed correspond with ones sampled during the EIA baseline survey.
- For the cable route, sampling was conducted at eight stations along the cable route.

Table 2.1: Summary of when benthic surveys were conducted. WFS = wind farm site; CR = cable route; Light blue = baseline/EIA; Orange = pre-construction; Purple = construction; Green = operation.

Benthic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2001										Benthic	Benthic	Benthic
2002		Benthic	Benthic									
2003												
2004												
2005			Intertidal									
2006												
2007							Benthic (WFS)				Benthic (CR)	
2008			Benthic (WFS); Intertidal		Benthic (CR)						Benthic (WFS & CR)	
2009			Intertidal			Benthic (WFS & CR)			Intertidal			
2010			Intertidal		Benthic (WFS & CR)				Intertidal			Intertidal
2011	Inter-tidal	Intertidal	Intertidal	Benthic (WFS & CR)					Intertidal			

2.2. Fish Surveys

- Baseline data for the EIA was collected by Solenvo Marine Environmental Consultants.
- Amec E & I UK Ltd (formerly Entec UK Ltd) has been contracted by NPC since July 2007 to undertake post EIA ecology fish monitoring of both non-migratory and electro-sensitive fish species (excluding migratory fish).

EIA baseline surveys

- Monthly trawls of 31 sampling stations in and around the area of the proposed wind farm were conducted from November 2001 to April 2002 by Solenvo Marine Environmental Consultants.
- As the location of the cable route had not been finalised at this stage, no surveys of this area were undertaken.

MEMP monitoring

- In accordance with FEPA requirements, fish surveys for non-migratory species were not undertaken during pre-construction.
- During the construction phase (December 2007 - February 2010), non-migratory fish surveys were originally performed monthly for the first three months, after which survey frequency reduced to quarterly.
- Non-migratory fish post construction – quarterly surveys during first operational year, biannual surveys for a further two (assuming no significant change in numbers of distribution observed during construction phase).
- Non-migratory fish surveys were performed at the same 31 sampling stations surveyed during the EIA process. This was dropped to 28 in latter stages of construction periods due to turbine presence.
- As no electro-sensitive fish survey of the cable route was undertaken during the EIA process, they were performed biannually during the first year of pre-construction, reducing to annually after February 2009.

- Electro-sensitive fish post construction – quarterly for 1 year assuming benthic community recovered.

Table 2.2: Summary of when fish surveys were conducted. NM = non-migratory fish; ES = electro-sensitive fish; WFS = wind farm site; CR = cable route; Light blue = baseline/EIA; Orange = pre-construction; Purple = construction; Green = operation.

Benthic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2001										NM Fish	NM Fish	NM Fish
2002		NM Fish	NM Fish	NM Fish	NM Fish	NM Fish	NM Fish	NM Fish	NM Fish			
2003												
2004												
2005												
2006												
2007								ES Fish			ES Fish	
2008		NM Fish	Fish (ES & NM)	NM Fish		ES Fish	NM Fish		ES Fish		NM Fish	
2009		Fish (ES & NM)				NM Fish		NM Fish				NM Fish
2010		NM Fish		Fish (ES & NM)			Fish (ES & NM)			Fish (ES & NM)		
2011			Fish (ES & NM)									

2.3. Bird Surveys

Ecology Consulting completed the assessment of potential impacts of the development on birds from 2001 onwards as part of the EIA process and continued to conduct boat-based surveys required under the MEMP.

EIA baseline surveys

- Boat-based surveys consisting of ten transects were conducted on a monthly basis between May 2001 and April 2002 (with exception of May and October 2001 when only one survey was completed).
- Each transect was about 18 km in length with 2 km intervals between.

MEMP monitoring

- Monthly boat-based surveys were conducted in April/May 2003 and bi-monthly surveys between January and September 2004 with an addition survey performed in July 2007, just prior to construction commencing.
- Construction phase surveys began in January 2008 and continued on a bi-monthly basis until the end of the phase in February 2010. Surveys were completed in all months of the construction phase except November 2009.
- Post construction – one survey per month for five years with review after three to establish if further surveys still required.

Table 2.3: Summary of when bird and marine mammal boat surveys were conducted. MM = marine mammals; B = birds; Light blue = baseline/EIA; Orange = pre-construction; Purple = construction; Green = operation.

Benthic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2001					Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds
2002	Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds	Birds
2003				Birds	Birds							
2004	Birds	B & MM	B & MM		B & MM		B & MM	B & MM	B & MM	MM	MM	MM
2005	MM											
2006												
2007							B & MM					
2008	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM
2009	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM		B & MM
2010	Birds	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM
2011	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM	B & MM		

2.4. Marine Mammal Surveys

- Information collected for the EIA on marine mammals took the form of a desk-based literature review with no additional surveys performed.
- Peter Ulrich has been involved with the mammal surveys required under the MEMP since 2004, both independently and in conjunction with the Centre for Marine and Coastal Studies Ltd.

EIA baseline surveys

- No surveys for marine mammals were conducted as part of the EIA process.

MEMP monitoring

- Boat-based surveys were conducted on a monthly basis between February 2004 and January 2005 with an additional survey performed in July 2007, just prior to construction commencing.
- Construction phase surveys began in January 2008 and continued on a bi-monthly basis until the end of the phase in February 2010.
- Surveys were completed in all months of the construction phase except November 2009.
- Under the Disturbance Licence conditions (Scottish Government, DEROG 068A/2007), a marine mammal observer was required to observe for marine mammals at least 30 minutes prior to the commencement of piling activities. In addition to this, an acoustic deterrent device was deployed for the same period.
- Post construction – one survey per month for two years.

3. ECOLOGICAL ANALYSIS RATIONALE

The analytical methodology has been determined by the data available to Natural Power Consultants (NPC), collected in both the extended baseline / pre-construction period and as part of the MEMP during construction and operation.

The approach to the ecological analysis has been developed after reviewing the requirements of the MEMP, FEPA licensing requirements and the recent CEFAS document, "Strategic review of offshore wind farm monitoring data associated with FEPA licence conditions"[1]. As part of this process consultation with Marine Scotland and SNH identified key questions or concerns for specific focus.

Data analysis was specifically tailored to the predictions made in the EIA and addresses the licence monitoring conditions. The analysis is focused on key areas highlighted by the RRMG and where data was available and appropriate, to address uncertainties as outlined in the aims of the MEMP.

Specific key questions have been identified by E.ON (with NPC) and the RRMG for the data analysis. These relate to:

- Disturbance/displacement of specific species;
- Changes in patterns of abundance and distribution with distance from the wind farm; and
- Identifying any predicted impacts/sensitivities from the EIA process.

Analysis of the Bird and Marine Mammal data has been undertaken by the NPC Ecology & Hydrology Department. This has only been possible where these data, the survey program, the survey methods and the rigour and consistency of the data collected by 3rd party consultants allowed for the analysis to be undertaken.

Amec E & I UK Ltd (formerly Entec UK Ltd) was contracted by NPC to conduct the analysis of the benthic and non-migratory fish data collected by them through the pre-construction, construction and operational phase and by Solenvo Marine Environmental Consultant during the baseline.

3.1. Birds and marine mammals

The stages of ecological analysis followed (by NPC) for birds and marine mammals are identified below. Seven bird species (common scoter, diver species, Manx shearwater, gannet, cormorant, kittiwake and guillemot) and two marine mammal species (harbour porpoise and grey seal) were initially targeted for analysis (see Report No 035_R_NPC_EON_2). For the second phase of analysis, diver species was singled down to red-throated diver and large gulls (including greater black-backed and herring gull), razorbill and all auks species were also examined.

To ensure a robust approach was undertaken, the following steps were followed:

i) All data available from the sub-consultants since 2001 has been collated by NPC, to ensure a complete dataset is available to E.ON and the RRMG. Data spreadsheets were converted to a standardised format and combined. Survey routes and observations were then visualised using ArcGIS. Throughout these two procedures data were checked visually and any concerns were referred back to the 3rd party surveyors (Ecology Consulting) and errors were either corrected or removed if no information was available as to where mistakes had been made or errors existed.

ii) Raw data were plotted in ArcGIS with circles of differing sizes representing the number of individuals constituting each observation. Colour was used to distinguish between animals observed during the different construction periods.

[1] Walker, R. & Judd, Adrian. 2010. Strategic Review of offshore wind farm monitoring data associated with FEPA licence conditions. CEFAS, SMRU Ltd, FERA on behalf of DEFRA & MMO.

iii) Boat survey transects were segmented by distance (600 m for birds; 1000 m for mammals) to produce replicate sampling blocks of equal effort. The number of observations was calculated for each block. The depth and sediment type for each sample block was also extracted using GIS. Depth was adjusted for tidal state using tidal measurements recorded at Workington[2].

iv) Birds: Simple Generalised Linear Models (GLM) accounting for month and effort were applied to data to investigate changes in numbers of observations among the three phases and allow comparison with previous analysis.

For birds recorded on the sea, a detection function was applied to the data to take into account imperfect detection of animals by surveyors. For each construction phase, General Additive Models (GAMs) were then fitted, incorporating the calculated detection function and a variety of covariate combinations (depth, sediment type, month, distance to coast, xy position). The final models included month and x,y position. These GAMs were then used to predict distribution across the whole survey area producing density surfaces and abundance estimates for the entire survey and turbine area.

For each prediction grid cell, the difference in value between the three phases of the development was calculated (difference plots). Parametric bootstrap methodology was used to calculate standard errors around overall predictions for the turbine and survey areas and for each individual grid cell in order to assess statistical significance of any changes observed.

v) Marine mammals: A simple Generalised Additive Model (GAM) accounting for month, effort and sea state was applied to the data to investigate changes in numbers of observations of grey seals and harbour porpoise among the three phases.

The same procedure as for the birds was then applied to the harbour porpoise data to produce abundance estimates for the three different development phases and to create prediction grids. There was insufficient data to repeat this for grey seals.

3.2. Benthos and non-migratory fish

The following procedure was applied to benthos, non-migratory fish and electro-sensitive fish, to ensure robust analysis:

i) Differences in community structure between sampling periods for benthic communities, fish assemblages, epifaunal assemblages and fish/epifaunal combined were assessed using multivariate techniques based on the Bray-Curtis Similarity Index, implemented in Primer6.

ii) Analyses of similarity (ANOSIM) were used to investigate changes in community structure at sampling stations within the wind farm area among different sampling periods. In order to investigate whether changes observed were attributable to construction, or simply a product of natural variation, an additional two-way crossed ANOSIM analysis was carried out using areas outside of the wind farm as a control.

iii) PERMANOVA+ is a recent (2008) add-on package to the main PRIMER v6 programme, which extends the resemblance-based methods of PRIMER and allows the analysis of more complex sampling structures, experimental designs and models. This test is stronger than ANOVA as it can take into account the discrepancies in the survey design.

iv) For benthic data, biodiversity indices were also calculated and compared among sampling periods using Kruskal-Wallis tests. In addition, a combination of cluster analysis, MDS plots, similarity

[2] Data supplied by the British Oceanographic Data Centre as part of the function of the National Tidal & Sea Level Facility, hosted by the Proudman Oceanographic Laboratory and funded by the Environment Agency and the Natural Environment Research Council

percentage (SIMPER) analysis and particle size analysis (PSA) were used to carry out biotope classification allowing the detection of changes among years.

4. KEY FINDINGS - BENTHIC ECOLOGY

- **Predictions made in the environmental statement relating to the potential impact of wind farm construction at the Robin Rigg site were supported by the data collected**.
- Significant changes observed in biodiversity and community structure cannot be linked to construction phase activity alone (baseline vs. construction) and are most probably a result of natural variability in this dynamic environment or are due to other pressures not considered within the scope of these works.
- There is no evidence that the construction phase of the Robin Rigg Wind Farm has had any effect on the demersal fauna and benthos in the immediate or surrounding area.
- It is worth noting that overall there is very little change in biotopes and diversity throughout the years.
- Temporal changes in community structure and biodiversity are key to understanding inputs. The focus of monitoring programmes to be implemented for offshore wind farm installations to better enable the power to detect change is important.
- Furthermore, it is recommended that an additional control site, outside of and to the northwest of, the Robin Rigg wind farm be incorporated into the sampling programme.

A summary of environmental statement predictions and analysis conclusions can be found in Table 4.1 below.

Table 4.1: Summary of predictions made in the environmental statement (ES) relating to benthic communities and main conclusions from present analysis.

Ecological Group	Predictions from ES	Main conclusions from construction analysis	Main conclusions from operation year 1 analysis
Benthic	• The only biotope present within the wind farm site was SS.SSa.IFiSA.NcirBat, characterised by *Nephytis cirrosa* and *Bathyporeia* species in infralittoral sand. • Habitat loss for the above species as a result of the Robin Rigg Wind Farm was predicted to be 0.4%. • No significant long-term impacts on benthos were predicted.	• The benthic environment at the Robin Rigg wind farm site is dynamic such that changes in community structure and diversity over time are expected at any given sampling location. • Species diversity and community structure varied significantly among years. • Community structure did not vary between the control, cable-route and site areas. • No evidence that changes in species diversity and/or community structure are attributable to construction of the Robin Rigg Wind Farm.	• Predominant biotype remained same since baseline period. • No significant change in benthic community types during survey periods. • Op yr 1 confirmed only change in benthic community occurred between baseline (EIA) and pre-construction period. • Species diversity low during all periods – as expected for Solway Firth.

5. KEY FINDINGS - NON MIGRATORY & ELECTRO-SENSITIVE FISH

Non-migratory fish:

- Fish and demersal assemblages did vary over time, but the dominant fauna in baseline surveys were still dominant throughout 2010.
- A non-significant dip occurred in the numbers of fish and invertebrates captured during the construction years, however numbers have increased again during the first year of operation. It should be noted the high number of invertebrates found during the operational phase was due to a large number of brittle stars found to the north west of the site (near Heston Island) on one survey during the summer of 2010. It should be noted that brittle stars have always been found in relatively high numbers at these sites.
- This same pattern can be seen in the numbers of brown shrimp caught throughout the survey area.

Electro-sensitive fish:

- It is likely that electro-sensitive and/or magneto-sensitive species found in the vicinity of the Robin Rigg Offshore Wind Farm will be able to detect some of the iE-field and B-field emissions associated with its AC cables.
- The majority of thornback rays and dogfish were not found in the vicinity of the cable route, but on the Scottish side of the Firth, to the north of the wind farm site.
- As so few elasmobranch species were found around the cable route during the baseline and pre-construction phase it is possible to conclude that this area is not of critical importance to the thornback ray and dogfish populations in the Solway Firth.
- Any potential effects as a result of EMF from the electrified cable are likely to be of minimal significance to their populations as a whole.
- Analysis of the pre-construction, construction and operational phase electro-sensitive fish trawling data revealed that there had been an apparent increase in the number of electro-sensitive species found in the cable route trawls during the first year of operation. This pattern was however mirrored across the Solway in the results obtained from the non-migratory fish survey. This therefore indicates that the increase in elasmobranches at the cable route was as a result of a general population increase across the Solway as a whole.

A summary of environmental statement predictions and analysis conclusions relating to non-migratory and electro-sensitive fish can be found in Table 5.1 below.

Table 5.1: Summary of predictions made in the environmental statement (ES) relating to non-migratory and electro-sensitive fish and the main conclusions from present analysis.

Ecological Group	Predictions from ES	Main conclusions from construction analysis	Main conclusions from operational year 1 analysis
Non-migratory Fish	• Negligible impacts on commercially important flatfish (plaice/sole). • Short-term displacement of demersal species (e.g. whiting). • Impacts on migratory and non-migratory fish expected to be low.	• Most abundant species sampled were dab, plaice and whiting. • Significant change in community structure of fish and epifauna among years. • Community structure did not vary between the control, cable-route and site areas. • Evidence for a general decrease in species	• Number of fish decreased during construction period but increased to almost pre-construction values in Op yr 1. • Similar trend for invertebrates. • Very little change in community structure of both fish and epifauna within wind farm area. • No evidence of change in fish structure along cable route but no change for

		richness of both fish and epifaunal species through time, potentially due to re-positioning of channels. • No evidence that observed changes in species richness and/or community structure is attributable to construction of the Robin Rigg Wind Farm.	epifauna. • Some evidence of difference in diversity between study periods for both wind farm area (pre-cons vs. Op yr 1) and cable route (Op yr 1 vs. pre-cons/construction).
Electro-sensitive fish	• No significant impacts on electro-sensitive fish are expected • Focal electro-sensitive fish found in proximity to the Robin Rigg Wind Farm were thornback ray, lesser spotted dogfish and Blond ray. These were observed in small numbers.	• Electro-sensitive species found within the vicinity of the Robin Rigg Wind Farm will be able to detect EMF from cabling. • During baseline/pre-construction the majority of electro-sensitive fish species were found on Scottish Solway coast, away from the cable route suggesting this area is not as important for these species. • Potential effects of EMF from the electrified cable on electro-/magneto-sensitive fish are likely to remain negligible/minimal significance.	• So few electro-sensitive species were found in the pre-construction, construction phase and post construction surveys along the cable route it is not possible to undertake statistical analysis on the results. The 3 elasmobranch species found in the vicinity of the Robin Rigg Wind Farm were the thornback ray (*Raja clavata),* lesser spotted dogfish (*Scyliorhinus canicula*), and Blond ray (*Raja brachyura*). • Although greater numbers of electro-sensitive species were found on the cable route during the operational phase monitoring, this pattern was reflected across the entire Solway. • Therefore it was concluded that this slight increase in numbers was due to a population increase rather than any attraction affects of the cable itself.

6. KEY FINDINGS - BIRDS

- A single monitoring technique alone was used in relation to ornithological monitoring (boat-based surveys), with the analysis for these boat-based surveys focused primarily on seabirds / offshore water birds. These data do not allow any conclusions for migrating waders, waterfowl or passerines, as this technique and this dataset does not account well for these species.
- The way the data were collected for birds in flight (no snap shots, few distance bands) restricts reliable collision analysis to birds recorded within 100 m of the vessel. This reduces the sample size to such an extent that any results at this stage would be unreliable. It is suggested that the question of collision impacts is readdressed at a later stage of the monitoring (i.e. after year two completed) when more data are available. Preliminary analysis of available data on flight heights suggests that the majority of birds observed are flying below rotor height.

A summary of the main predictions from the environmental statement relating to birds and conclusions from the present analysis can be found in Table 6.1 below.

Table 6.1: Summary of predictions made in the environmental statement (ES) and main conclusions from present analysis.

Ecological Group: Birds	Predictions from ES	Main conclusions from construction analysis	Main conclusions from operational year 1 analysis
Common scoter	• 70660 individuals recorded, 11.69 per unit sample effort. • Some displacement expected (up to 800 m from wind farm area). • For impacts to influence the national population common scoter would need to be displaced from an area greater than 3 km. • Collision impacts were predicted to be low (3.4 birds per annum).	• 87910 individuals recorded, 7.05 per unit sample effort. • Some evidence for a decrease in birds across the whole survey area but potentially due to other environmental factors e.g. benthic prey. • Density maps support a shift in focus of core areas for common scoter along the northern coastline in inshore areas. • Evidence suggests that Robin Rigg Wind Farm has not affected common scoter distribution in the Solway from this baseline information to construction.	• 19547 individuals recorded, 6.39 per unit sample effort. • No indication of an impact from the development on numbers observed on the sea within study area (pre vs. post). • Some evidence for a decrease in number of flying birds (pre vs. post) but more data required to confirm.
Red-throated diver	• 550 individual red-throated divers recorded, 0.09 per unit sample effort. All divers: 1046/0.17. • Some displacement expected (up to 800 m from wind farm area). • For impacts to influence the national population	• 562 individual red-throated divers recorded, 0.05 per unit sample effort. All divers: 2182/0.17. • Across the survey area, more divers (all species) were observed in flight during the construction phase than pre-	• 506 individual red-throated divers recorded, 0.17 per unit sample effort. All divers: 794/0.26. • No overall decrease in numbers (pre vs. post) but some evidence of a decrease in numbers within the wind farm

Ecological Group: Birds	Predictions from ES	Main conclusions from construction analysis	Main conclusions from operational year 1 analysis
	red-throated diver would need to be displaced from an area greater than 5km. • Collision impacts for red-throated diver were predicted to be low (3.3 birds per annum).	construction. • Evidence for a shift away from the wind farm area during construction.	site. • Distribution maps highlight the importance of shallow coastal waters for this species. • Wind farm area was not used much prior to construction resulting in any impacts being small.
Manx shearwater	• 1566 individuals recorded, 0.26 per unit sample effort. • ES survey work only recorded Manx shearwater in the Spring-Summer months (breeding season) with peak counts between April and August.	• 1672 individuals recorded, 0.13 per unit sample effort. • Distribution in the Solway is similar between baseline/pre-construction and during construction periods. • Observed patterns of Manx shearwater are skewed by the detection of significant aggregations in the baseline/ pre-construction and construction period. Count anomalies of 100, 1000, birds recorded against a background of lower counts (1-5 birds) across the survey area. • Therefore some limited evidence for displacement during the construction period but difficult to be definitive due to inconsistent records.	• 160 individuals recorded, 0.05 per unit sample effort. • Simple GLM found no difference in numbers on the water (pre vs. post) but a reduction in numbers in flight. • Insufficient data to conduct full pre/post analysis.
Gannet	• 476 individuals recorded, 0.08 per unit sample effort. • Predominantly recorded during the Spring-Summer (breeding season) with peak counts between April and October. • Observations evenly distributed across the survey area.	• 845 individuals recorded, 0.07 per unit sample effort. • Evidence for a decrease of gannet in flight during the construction phase (19% decrease in raw observations). • Evidence for a decrease of gannet on sea during the construction phase (24% decrease in raw observations).	• 132 individuals recorded, 0.04 per unit sample effort. • Simple GLM found decrease in numbers on the sea (pre vs. post) but not for birds in flight. • Improved analytical techniques suggest decline with wind farm site during construction.

Ecological Group: Birds	Predictions from ES	Main conclusions from construction analysis	Main conclusions from operational year 1 analysis
		• Clear spatial evidence from the small scale and large scale for displacement effects of gannet is hard to determine statistically from these data.	• Raw data for operation year 1 suggest a displacement rate of 50% but more data required to complete the analysis.
Cormorant	• 454 individuals recorded, 0.08 per unit sample effort. • Highest numbers of cormorants recorded during the Spring-Summer with a focus in distribution in the north-west of the Solway close to the Scottish coast off Balcary Point. • The Solway cormorant population was identified as medium sensitivity in the ES but with no significant impacts predicted.	• 3266 individuals recorded, 0.26 per unit sample effort. • Raw count data for cormorant clearly indicates a shift in peak numbers associated with the presence of Robin Rigg Wind Farm, in the centre of the Solway. • Cormorant observations increased approximately three-fold both in flight and on the sea in proximity to Robin Rigg Wind Farm. • Density maps clearly show a shift in peak cormorant observations in and around Robin Rigg Wind Farm; this is supported by E.On construction and operation staff.	• 1225 individuals recorded, 0.40 per unit sample effort. • Simple GLM found increase in numbers in flight pre vs. construction. • Also found increase in pre vs. post for both birds on the water and in flight. • Possible shift in distribution from northern to southern side of the Solway Firth but more data required to confirm. No evidence that this shift is related to development. • Increased number of cormorants within wind farm area during operation year 1 although not as pronounced as for construction phase.
Kittiwake	• 922 individuals recorded, 0.15 per unit sample effort. • Highest numbers recorded in spring and summer (breeding season).	• 1794 individuals recorded, 0.14 per unit sample effort. • Basic analysis of numbers observed both in flight and on the sea would indicate a decrease in kittiwake numbers during the construction phase across the whole study area. • However this is difficult to link to the Robin Rigg Wind Farm from the more complex analysis (including environmental variables), specific and clear evidence for	• 286 individuals recorded, 0.09 per unit sample effort. • Evidence of a decrease in numbers during construction and some evidence of an increase during operation, more data required to confirm. • No clear evidence for changes in distribution relative to the wind farm area but again, more data required to confirm.

Ecological Group: Birds	Predictions from ES	Main conclusions from construction analysis	Main conclusions from operational year 1 analysis
		displacement both in flight and on the sea is hard to identify.	
All gulls combined	• 5076 individual large gulls recorded, 0.84 per unit sample effort. Herring gull: 1294/0.21; Great black-backed gull: 207/0.03.	• 17503 individual large gulls recorded, 1.40 per unit sample effort. Herring gull: 1837/0.15; Great black-backed gull: 587/0.05.	• 3949 individual large gulls recorded, 1.29 per unit sample effort. Herring gull: 255/0.08; Great black-backed gull: 224/0.07. • Simple GLM found increase in numbers pre vs. post both on the sea and in flight. • Analysis of single species suggested this was primarily due to increase in greater black-backed gulls. • Density surface model suggests no difference in gull presence pre vs. post of the entire study area.
Guillemot	• 4157 individuals recorded, 0.69 per unit sample effort. • The focus of guillemot numbers was observed in the relatively deeper waters of the outer Solway, in the south-west of the study area. • Numbers were highest in spring-summer but with an increase in numbers also observed in the autumn, with low numbers in August.	• 5840 individuals recorded, 0.47 per unit sample effort. • Evidence for a decrease in guillemot numbers in flight (5% decreases in raw observations). • Evidence for a decrease on the sea during construction (32% decreases in raw observations) supported further when other environmental variables are taken into account. • The data support partial displacement of guillemot away from the wind farm area during construction.	• 1736 individuals recorded, 0.57 per unit sample effort. • Decrease in numbers pre vs. construction. • Increase in numbers construction vs. operation. • Some evidence guillemots may be avoiding wind farm area but more data required to confirm.
Razorbill	• 2199 individuals recorded, 0.36 per unit sample effort. • Less abundant than guillemot. • Distribution more even than that for guillemot.	• 2956 individuals recorded, 0.24 per unit sample effort.	• 608 individuals recorded, 0.20 per unit sample effort. • Decrease in numbers pre vs. construction. • Increase in numbers construction vs. operation. • No evidence of

Ecological Group: Birds	Predictions from ES	Main conclusions from construction analysis	Main conclusions from operational year 1 analysis
			avoiding wind farm site post construction.
All auks combined	• 6095 individuals recorded, 1.01 per unit sample effort.	• 10721 individuals recorded, 0.86 per unit sample effort.	• 3106 individuals recorded, 1.02 per unit sample effort. • Density estimates suggest displacement rate of 30%. • Decrease in numbers pre vs. construction. • Increase in numbers construction vs. operation.

Figure 6.1: Cormorants on handrail of Robin Rigg turbines.

7. KEY FINDINGS - MARINE MAMMALS

- Only one year of pre-construction data was available for marine mammals, as no data was collected as part of the EIA process.
- Analysis of the boat-based survey data suggests that the construction of the Robin Rigg Wind Farm has had no significant overall effect on the abundance and distribution of harbour porpoise and grey seals within the Solway Firth, upholding the prediction of the ES that any impacts would be short-term.
- Since analysis of the fish data for the Solway Firth upheld the predictions that there would be no significant impacts on fish populations as a result of the development, prey sources are still available to marine mammals in this area.

A summary of environmental statement predictions and analysis conclusions relating to marine mammals can be found in Table 7.1 below.

Table 7.1: Summary of predictions made in the environmental statement (ES) and main conclusions from present analysis.

Species	Predictions from ES	Main conclusions from construction analysis	Main conclusions from operational year 1 analysis
Harbour porpoise	• No data collected for the ES. 99 individuals recorded during baseline monitoring, 0.06 individuals per unit effort. • Short-term avoidance of local area of construction works expected. • Mitigation should be used to avoid startle/alarm responses in response to the onset of piling activities. • Impact on small cetacean species expected to be low.	• 249 individuals recorded during construction, 0.05 individuals per unit effort. • Harbour porpoise observations across the study area decreased between the pre- and during construction periods, but this could not be directly attributed to construction activities. • Numbers of harbour porpoises observed increased significantly with days since the last piling and/or construction activity suggesting short-term displacement associated with these activities. • Evidence would indicate, as has been documented at other offshore wind farm sites during construction, that noise effects cause displacement effects to marine mammals such as harbour porpoise at Robin Rigg. These datasets do not support detailed analysis of this	• 68 individuals recorded during operation year 1, 0.05 individuals per unit effort. • Simple GAM found no change in numbers of either grey seal or harbour porpoise between the different development phases.

		type.	
Grey seal	• No data collected for the ES. 20 individuals recorded during baseline monitoring, 0.01 individuals per unit effort. • Short-term changes in behaviour of seals close to the site at the start of construction. • Low risk of physiological risks to seals due to piling. • Seals expected to habituate to construction activities. • Impact on seals considered to be moderate.	• 41 individuals recorded during construction, 0.01 individuals per unit effort. • The low numbers of grey seal observations greatly reduces the likelihood of detecting any response to construction activities. • Grey seal observations across the study area decreased between the pre- and during construction periods, but this could not be attributed to construction activities. • No evidence was found for impacts of piling on grey seal but this is likely to be due to the very low number of grey seals observed during the construction period (57 observations when hauled out individuals are excluded).	• 19 individuals recorded during construction, 0.01 individuals per unit effort. • Simple GAM found no change in numbers between the different development phases. • Insufficient data to do complete analysis.