Inch Cape Offshore Wind Farm

New Energy for Scotland

Offshore Environmental Statement:
VOLUME 2C
Appendix 10B: Data Gap Analysis and Data Review

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SEAENERGY RENEWABLES LIMITED

INCH CAPE AND NEART NA GAOITHE OFFSHORE WIND FARMS

DATA GAP ANALYSIS AND DATA REVIEW

Report Reference. P1476_A_RN2597_Rev2

Issued 19 May 2011

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DOCUMENT RELEASE FORM

Title:	INCH CAPE AND NEART NA GAOITHE OFFSHORE WIND FARMS DATA GAP ANALYSIS AND DATA REVIEW
Client:	SEAENERGY RENEWABLES LIMITED
Report Reference:	P1476_A_RN2597_REV2
Date of Issue:	19 May 2011

		Hard Copy	***Digital***
Distribution:	SEAENERGY RENEWABLES LIMITED	No: n/a	PDF
	Intertek METOC	No: n/a	PDF
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Rev No	***Date***	***Reason***	***Author***	***Checker***	***Authoriser***
Rev 0	07.04.2011	Original	ELH	PAT	DW
Rev 1	15.04.2011	Initial comments from client	ELH	PAT	DW
Rev 2	20.05.2011	Final comments from clients	ELH	PAT	DW

COPY NUMBER: (applies to hard copies only)

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SUMMARY

SeaEnergy Renewables Limited (SERL) has commissioned Metoc Limited (Intertek METOC) to undertake assessments of metocean and coastal processes relating to Scottish Territorial Waters (STW), Forth and Tay offshore wind farm (OWF) developments at Inch Cape (for SERL) and Neart na Gaoithe (for Mainstream Ltd).

The study requires the delivery of a calibrated and validated coastal hydrodynamic (HD) and spectral wave (SW) model, and the delivery of a coastal processes assessment using the models and available information.

An adequate quantity of suitable data, of sufficient quality, is essential to deliver models with high confidence. An extensive search and review of the available data relating to the hydrodynamics, metocean environment and coastal processes that could be used for the project has been carried out.

A range of data and information, such as bathymetry data, water levels, flow velocities, wave climate, meteorological data, river flows, geophysical and geotechnical data has been reviewed to form a bank of data for model construction, calibration and validation and metocean, coastal processes and scour assessments.

Due to the lack of high resolution information available locally for deeper offshore sites, the offshore wind developers, SERL and Mainstream, have undertaken extensive field studies in 2010 and additional surveys are planned for 2011. Data from these surveys are to provide inputs to the physical processes modelling for technical design and the environmental impact assessment. A metocean survey was conducted covering both the Inch Cape and Neart na Gaoithe OWF sites. A range of surveys including hydrographic, geophysical, geotechnical and benthic data collection have been carried out at Neart na Gaoithe. To date there has also been a hydrographic and geophysical survey completed at Inch Cape OWF.

A wide range of other data sources has also been reviewed and collated.

A combination of multi-beam bathymetric data (obtained during the surveys), and third party data from the UK Hydrographic Office (UKHO), SeaZone and C-MAP, will provide sufficient water depth information to create an accurate sea-bed bathymetry dataset for the model. The high-density, multi-beam hydrographic survey data cover Inch Cape and Neart na Gaoithe OWFs development sites with areas of approximately 150 km^2 and 100 km^2 respectively. This meets the current best practice requirements that model bathymetry should not be under-resolved in the area of interest around the development sites and cable

route options. Admiralty charts will be used as a visual check on the model generated bathymetry, and where general bathymetric information outwith the sites is required.

There is also sufficient tidal level, tidal current velocity, wave parameter and freshwater information available to provide data for the model boundaries. All of the data selected for model construction have successfully undergone quality checks.

There are sufficient data available for the calibration and validation of the Forth and Tay Modelling System (FTMS) HD and SW models. Data selection for the use of model calibration and validation is based on the geographic locations and quality of the data, with a high quantity of data in both Inch Cape and Neart na Gaoithe OWFs, and a good coverage over the whole model domain. Each dataset selected for model calibration and validation is also available at the required temporal resolution.

There are adequate particle size distribution (PSD) and suspended sediment concentration (SSC) data available for the Neart na Gaoithe OWF to progress with the coastal processes element of the study for this site. However, there are no SSC data for the Inch Cape OWF (none were commissioned within the FTOWDG metocean contract), which may create difficulties in the coastal processes assessment where bottom sediments differ significantly from those at Neart na Gaoithe. The geotechnical and benthic surveys have not yet been completed for Inch Cape OWF, but these are planned for summer 2011.

There is also an adequate amount of extant data to provide supporting sediment regime information for the OWFs and the wider area, including all the relevant coastal sediment cells.

Information on the type of structure and development envelope (density of development, build-out plan, layout) has yet to be obtained from the developers. However, this is an iterative process and this information will become available before it is required for the impact assessments and subsequent to the baseline study.

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FIGURES

GLOSSARY

ADCP	Acoustic Doppler and Current Profiler
AWAC	Acoustic wave and current meter
BGS	British Geological Survey
BODC	British Oceanographic Data Centre
CEFAS	Centre for environmental, fisheries and aquaculture sciences
CEH	Centre for Ecology and Hydrology
C_{dis}	White capping dissipation coefficient
δ_{dis}	White capping dissipation coefficient
EIA	Environmental Impact Assessment
FTMS	Forth and Tay Modelling System
FTOWDG	Forth and Tay Offshore Wind Developers' Group
Metocean	Meteorological and oceanographic
OWF	Offshore wind farm
POL	Proudman Oceanographic Laboratory
psd	Particle size distribution
ScW	Scottish Water
SEPA	Scottish Environment Protection Agency
SERL	Sea Energy Renewables Ltd
SNH	Scottish Natural Heritage
STW	Scottish Territorial Waters
TSS	Total suspended sediment
UKHO	United Kingdom Hydrographic Office
UKMO	United Kingdom Meteorological Office

1 INTRODUCTION

SeaEnergy Renewables Limited (SERL) has commissioned Intertek METOC Limited to undertake assessments of meteorological / oceanographic (metocean) and coastal processes relating to Scottish Territorial Waters (STW), Forth and Tay Offshore Wind Farm (OWF) developments at Inch Cape and Neart na Gaoithe. SERL are developing the Inch Cape OWF, whereas the Neart na Gaoithe is being developed by Mainstream Renewables Power Ltd (Mainstream).

These developments will potentially affect both the metocean and coastal processes regimes in and around the development areas. Effects may range from short to long term; the assessment will consider timescales up to 25 years. The OWF developers require an understanding of the magnitude and significance of these effects, with a view to implementing, where necessary, appropriate mitigation measures in order to minimise impacts.

The study requires the delivery of a calibrated and validated coastal hydrodynamic (HD) and spectral wave (SW) model, and the delivery of a coastal processes assessment using the models and available information. The proposed assessments will provide the developers and other stakeholders with the regional and site-specific characterisation of the metocean and sedimentological environment. This will allow the baseline environmental conditions to be determined, against which the effects of each individual development, and the in-combination and cumulative effects of all developments can be assessed. The study results will provide input into the Technical/Design Report and the required Environmental Impact Assessment (EIA) for each development.

An adequate quantity of suitable data, of sufficient quality, is essential to deliver models with high confidence. Following an initial data review by HR Wallingford (HR Wallingford, 2010), Intertek METOC has undertaken an extensive search and review of the available data relating to the hydrodynamics, metocean and coastal processes that could be used for the project. A review of the available data and their quality at the start of the project are very important in identifying any necessary surveys at an early stage. The data collation process has been undertaken for the most relevant and useful data.

1.1 SCOPE OF REPORT

The objectives of the data review are:

- Interpretation and review of the data collected as part of the STW campaign.
- Collation of the other extant data sets relevant to the assessment.
- A review of the gap analysis and subsequent advice on any additional survey requirements
- Advice to clients on potential for modeling the two sites with existing data.

A range of data and information, such as bathymetry data, water levels, current velocities, wave climate, meteorological data, river flows, and geophysical and geotechnical data has been reviewed to form a bank of data for model

construction, calibration and validation and metocean and coastal processes assessments.

The sources of data reviewed are:

- **Bathymetry Data** – These include: multi-beam bathymetry data collated during the site specific (hydrographic) surveys; bathymetry data extracted from the C-MAP dataset; SeaZone data provided by Mainstream; and the UK Hydrographic Office (UKHO) bathymetry provided by SERL.
- **Offshore Model Boundary Conditions** – These include data derived from Intertek METOC's English Channel and North Sea Model and the UK Meteorological Office (UKMO) UK Waters 12km Wave model.
- **Wave Climate** – Time series from the Forth and Tay Metocean Survey campaign. Time series data from the Centre for Environment, Fisheries, and Aquaculture Science (CEFAS) WaveNet wavebuoy. UKMO wave statistics and times series. Wave roses and distribution tables presented in the HR Wallingford Report, Preliminary engineering design criteria.
- **Wind** – These include data collated from the meteorological buoy (metbuoy) deployed during the Forth and Tay metocean survey campaign. UKMO wave statistics and times series. Wave roses and distribution tables presented in HR Wallingford Report, Preliminary engineering design criteria.
- **Velocities** – These include Acoustic Doppler and Current Profiler (ADCP) data from the Forth and Tay Metocean Survey campaign, British Oceanographic Data Centre (BODC) current mooring data, current data from Scottish Water (ScW) historical surveys and tidal diamond information available from UKHO Admiralty Charts.
- **Water Levels** – These include ADCP data from the Forth and Tay Metocean Survey campaign, Proudman Oceanographic Laboratory's (POL) Tide Gauge Network data and ScW historical survey data.
- **River Flows** – These include statistical information published by Centre for Ecology and Hydrology (CEH) on river flows for major rivers entering into the study area.
- **Seabed Sediments, Sedimentary Environment and Sedimentary Structures -** These include particle size distribution data (PSD) from site specific surveys and British Geological Survey (BGS) sediment maps. These also include sediment features maps, and sediment thickness maps.Sediment transport regime information has been collated from site specific geophysical surveys, Admiralty Charts, Coastal Cell Reports available from Scottish Natural Heritage (SNH) and Council Shoreline Management Plans.
- **Suspended Sediment Concentrations** – These include optical backscatter data collected from the acoustic wave and current meter (AWAC) deployed at Neart na Gaoithe and modelled suspended sediment concentration published by "Scotland's Marine Atlas". Water quality samples taken at the AWAC site are available and SEPA also hold some spot samples data of SSC from riverine inputs.
- **Scour** – These include information on foundation structure type and size and development envelope details available from the developers.

2 DATA REVIEW

2.1 SOURCES OF DATA

Due to the lack of high resolution information available locally for deeper offshore sites, the developers have undertaken extensive field studies during 2010, and additional surveys in 2011 are planned. Data from these surveys are to provide inputs to the physical processes modelling for technical design and the EIA. A metocean survey was conducted covering both the Inch Cape and Neart na Gaoithe OWF sites. A range of surveys including hydrographic, geophysical, geotechnical and benthic have been carried out at Neart na Gaoithe. To date there has also been a hydrographic and geophysical survey completed at Inch Cape OWF.

To date five major survey programmes have been completed, as following:

- Partrac (2010) – A tidal current velocity and metocean survey was conducted providing real-time tidal currents and levels, and wind and wave data suitable for construction and calibration of HD and SW model. There was also total suspended sediment (TSS) and PSD data collated from the AWAC and water samples taken down through the water column. *Shared survey – data may be disclosed to both SERL and Mainstream.*
- EMU (2010) - Hydrographic and geophysical surveys of Neart na Gaoithe OWF and associated cable route options were conducted providing data on seabed sediments, seabed features and potential mobility for the coastal processes assessment. *Mainstream-commissioned survey – data may not be disclosed to SERL (Inch Cape)*
- EMU (2010) – A benthic survey was conducted providing PSD data from grab samples suitable for informing the coastal processes assessment. *Mainstream-commissioned survey – data may not be disclosed to SERL (Inch Cape)*
- Gardline (2010) - A geotechnical survey was conducted providing PSD data suitable for input to the coastal processes assessment. *Mainstream-commissioned survey – data may not be disclosed to SERL (Inch Cape)*
- IX Survey (2010) - A hydrographic and geophysical surveys of Inch Cape OWF were conducted providing data on seabed sediments, seabed features and potential mobility for input to the coastal processes assessment. *Mainstream-commissioned survey – data may not be disclosed to SERL (Inch Cape)*

The geotechnical and benthic surveys planned for the Inch Cape OWF will provide further information to corroborate the assessment, which will be based on the data currently available. This survey campaign is planned for the spring of 2011. This will be a SERL-commissioned survey, and the data will not be available to Mainstream for the Neart na Gaoithe site.

A wide range of other data sources has also been reviewed and collated. These data are not owned by either SERL or Mainstream, and will be available for use at either site. These include:

- Intertek METOC – English Channel and North Sea 1350m HD model

- ScW– Data provided includes real-time water level and tidal velocity data.
- C-MAP – Data provided includes depth soundings within the entire model domain
- UKMO – Modelled wind and wave data, presented as 2-way or 3-way joint frequency tables, statistics or times series.
- CEH – Data provided includes statistical hydrological data of all watercourses surveyed by CEH.
- CEFAS – Data provided includes real-time wave parameter and meteorological data.
- BODC – Data provided includes real-time historical current meter data.
- Admiralty – Data provided includes tidal diamonds and Admiralty Charts of OWF sites and wider model domain. Admiralty Charts also provide information on sea bottom features.
- BGS – Data provided includes 1:250,000 digitized seabed sediments maps.
- SEPA – Data provided includes long-term tidal level data from their tide gauge network and SSC data from river water quality spot samples.
- SNH – Data provided includes information on coastal geology, geomorphology and littoral processes along the Scottish coast presented in a series of coastal cell reports. County councils – Data provided includes sediment transport pathways, patterns and rates presented in a series of coastal cell reports and Shoreline Management Plans.
- Marine Scotland – Data provide includes modelled suspended sediment concentrations within Scottish Territorial Waters.

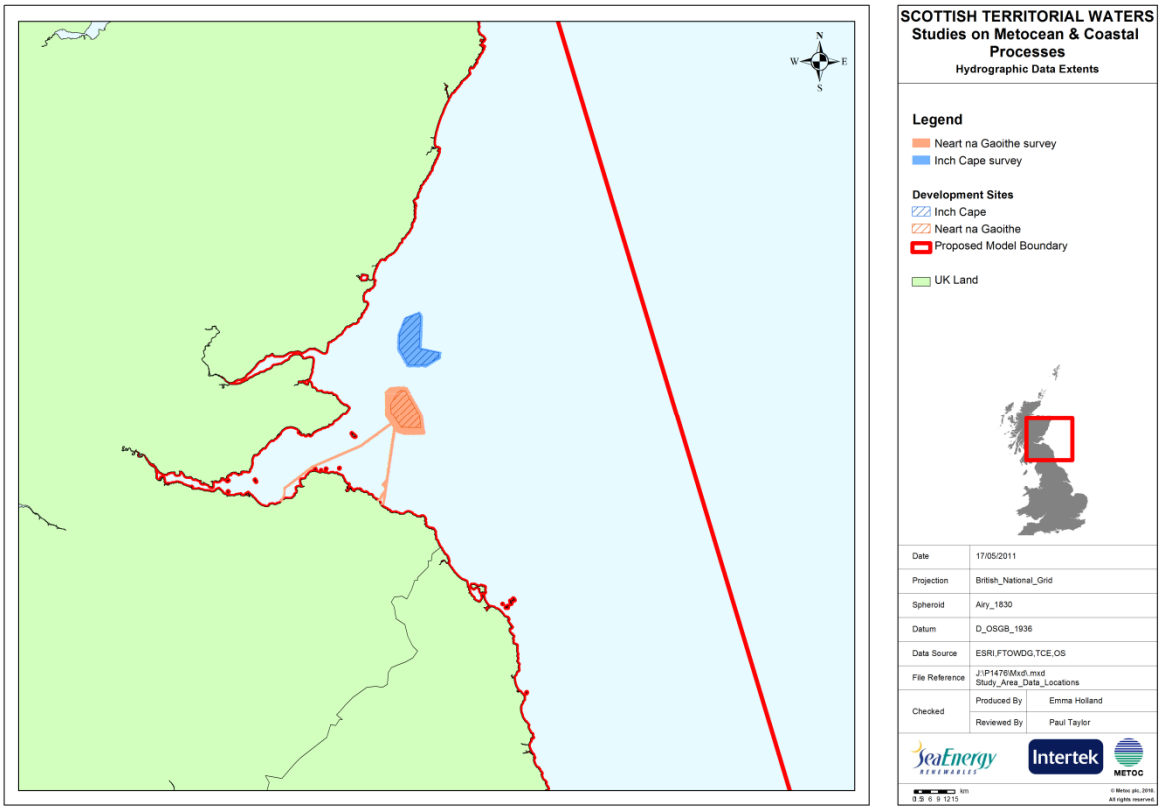
2.2 DATA FOR MODEL CONSTRUCTION

2.2.1 Bathymetry

Multi-beam Site Surveyed Data

The multi-beam bathymetric data obtained from site surveys at Inch Cape OWF and Neart na Gaoithe OWF have a 2m resolution. This resolution was required to interpret the features of the seabed. The horizontal datum of the data is UTM30 and the vertical datum is corrected to LAT. Bathymetry data that cover the entire development sites of the OWFs have now been collated and a suitable density of soundings will have to be assessed iteratively during the model build. Figure 2-1 shows the extents of the survey at both OWFs.

Figure 2-1: Extents of completed multi-beam bathymetric surveys

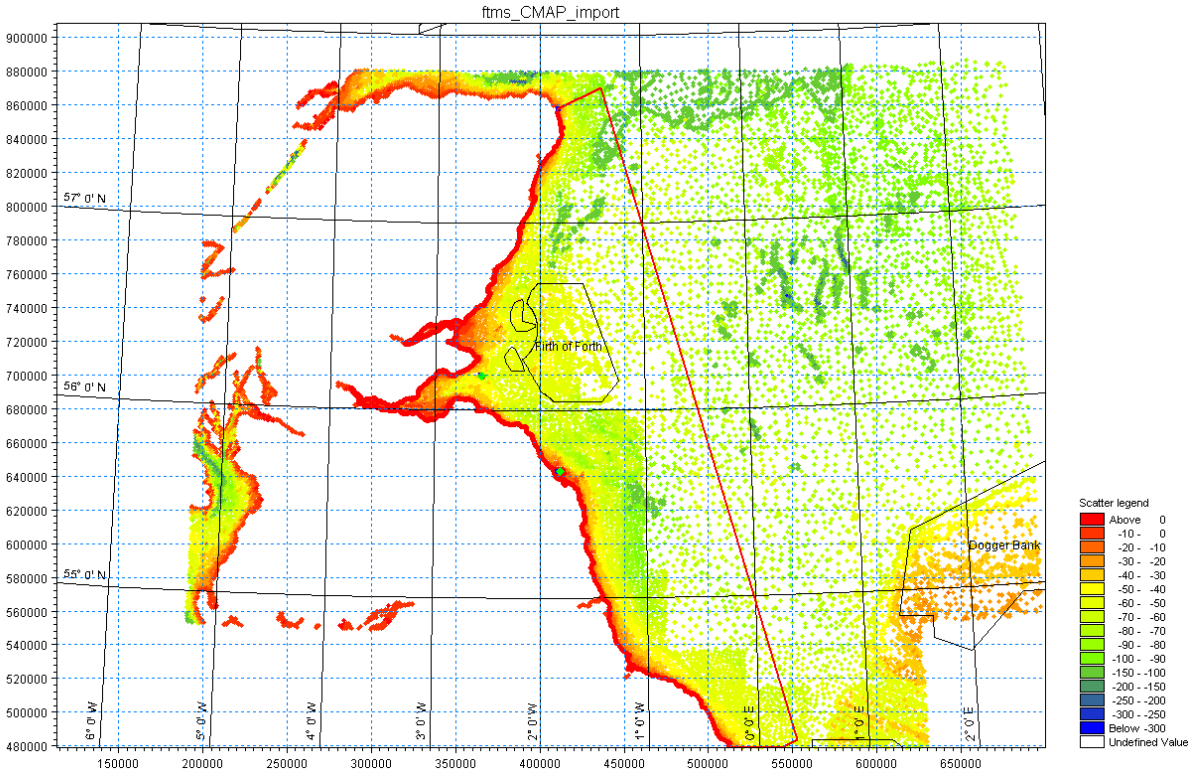


C-MAP data

The bathymetry data has been obtained through the MIKE C-MAP dataset which Intertek METOC possesses as part of our MIKE modelling software license. These bathymetry data are specifically available for the MIKE coastal models of the UK. Due to the specific terms of the license, Intertek METOC is not permitted to pass the raw MIKE C-MAP data to third parties (such as SERL and Mainstream). However, we will be able to provide the full model bathymetry files since these are a derived product.

The C-MAP dataset is derived from digitized contours and sounding data taken from the appropriate Admiralty charts. Datasets are provided in XYZ format (easting, northing and bed level to Chart Datum). Figure 2-2 shows the coverage and density of the dataset for the entire model area. Also shown are the outlines of the exclusive lease areas for the Neart na Gaoithe and Inch Cape wind farms together with the Firth of Forth Round 3 zone.

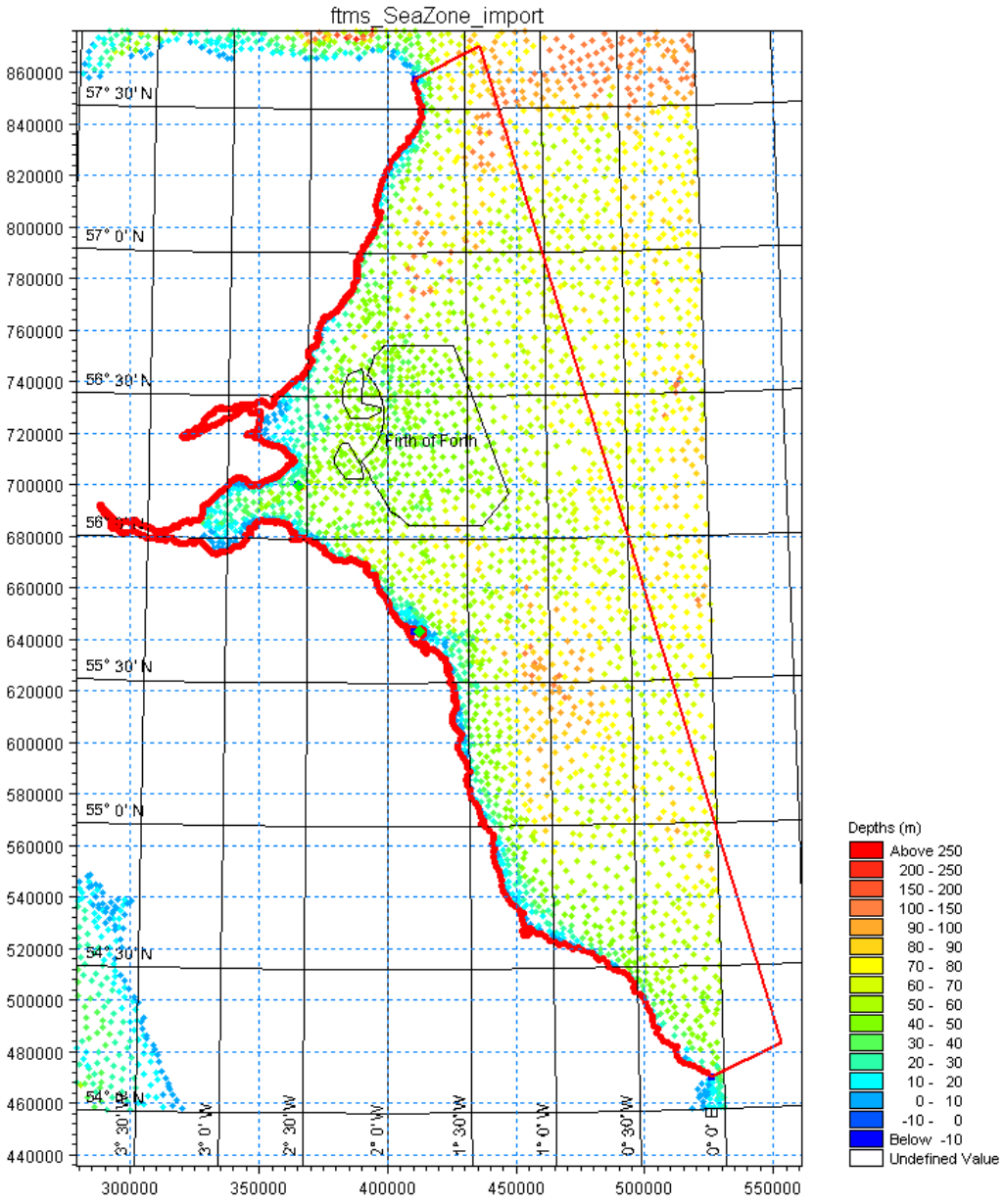
Figure 2-2: CMAP data coverage



SeaZone Data

SeaZone supply accurate bathymetric data, soundings and contours that have been digitized from fair sheets (which contain the original survey data and are typically more highly resolved than the derived charts) and are quality controlled at the UK hydrographic office (UKHO). For this study, SeaZone data has been collated for the majority of the model domain. Datasets are provided in XYZ format, the horizontal datum is WGS84 and the vertical datum is local Chart Datum. Figure 2-3 shows the coverage and density of the SeaZone data available within the model domain. From this figure it is evident that there isn't complete coverage of the model domain. There are some gaps in the dataset for the model domain that has been selected at the southeast corner, as well as upstream in the Forth and Tay estuaries.

Figure 2-3: SeaZone Data Coverage



2.2.2 Offshore HD Model Boundary Conditions

Offshore (seaward) boundary conditions for the proposed FTMS HD model can be defined in the form of either water levels or fluxes, which can be extracted from our existing English Channel and North Sea model. This model was constructed by Intertek METOC in 2007 to provide a regional model to drive a number of inshore models to assess water quality at Bathing Waters under the revised Bathing Waters Directive (2006/7/EC). The English Channel and North Sea model has a grid resolution of 1350m, and was calibrated and validated against tidal elevations, current speeds, current directions, surveyed drogue tracks, dye traces and co-tidal and co-phase contours. The model was fully calibrated and validated, and the inshore models produced were accepted by the EA as fit for the purpose of assessing water quality. Details of the North Sea and English Channel model specification are presented in below:

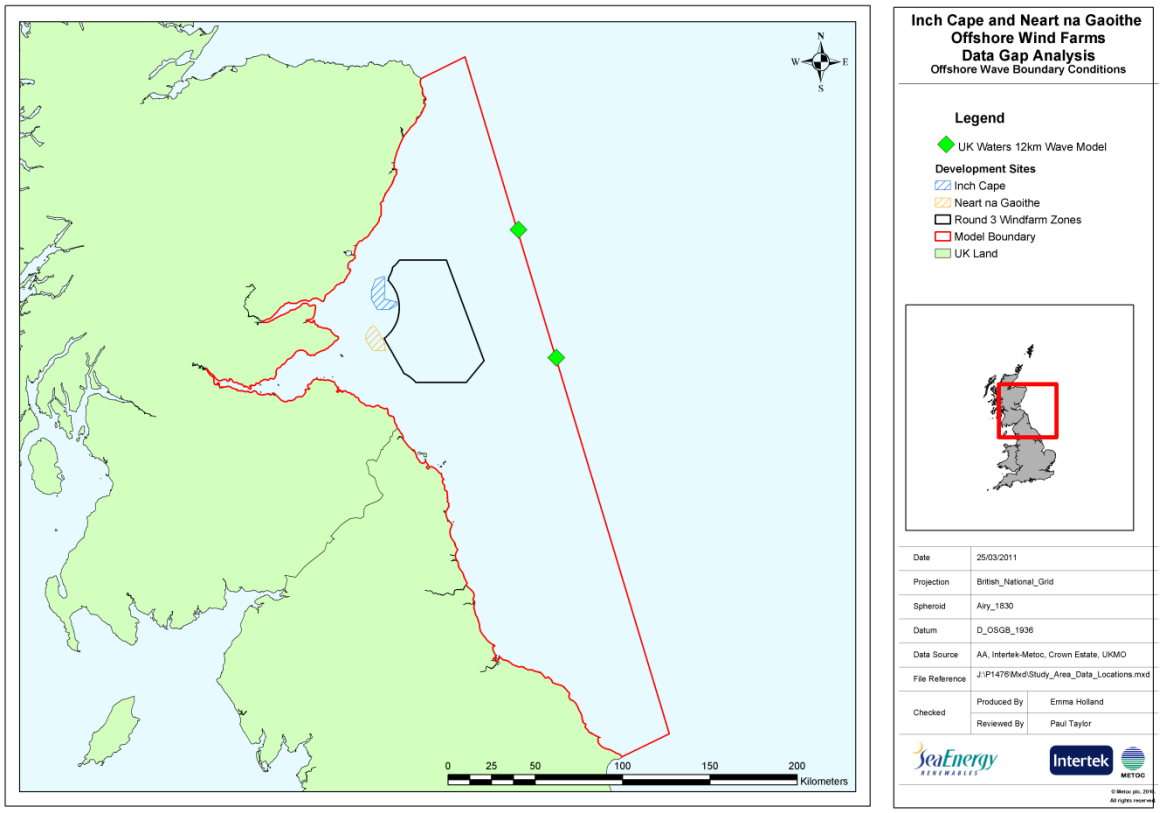
Origin	47.59°N, 2.53°W
Rotation angle	324.4°T
Grid Cell Size	1350 m x 1350 m
Area	900 x 745 cells
TimeStep	75s
Maximum Courant Number	4.5
Bed Roughness	$45m^{1/3}s^{-1}$
Boundary Time Step	900s
Boundary Data Type Tidal	Elevations
Vertical Datum	Mean Sea Level

2.2.3 Offshore SW Model Boundary Conditions

Offshore boundary conditions for the proposed FTMS SW model can be defined in the form of significant wave height, peak period, mean wave direction and spreading which can be obtained from the UKMO's UK Water Wave Model. This model was constructed by UKMO in 2000 to provide higher resolution information on wind parameters for sea and swell. The UKMO UK Waters model has a grid resolution of 12 km, and is validated daily using real time wave data from the available networks of in situ, wave buoys with telemetry links. It is widely accepted in academia and industry as fit for generating representative wave data at 3 hourly intervals across the north-east European Continental Shelf.

Two locations within the UKMO UK waters model have been selected to provide boundary information to the FTMS spectral wave model. One is located north-east and the other is located south-east of the Round 3 Wind Farm Zone, Firth of Forth, see Figure 2-4.

Figure 2-4: Locations of selected UK Waters Wave Model grid points



2.2.4 River Flows

Flow statistics (mean, 95%ile, 10%ile) were obtained from the CEH for the rivers listed in a review of existing data for design options (HR Wallingford, 2010). These rivers were deemed to have some significance on the hydrodynamic regime close to the area of interest. In addition to those identified by HR Wallingford, we believe that the North and South Esk rivers may also have a localised influence. There are also a number of other rivers that drain into the model domain. The rivers and their associated flow statistics are presented in Table 2-1. These are large rivers in the model domain, and/or rivers close to the STW OWF areas, and will be included in the model as inputs, for completeness. However, it is considered that these freshwater sources will not have a noticeable influence on the hydrodynamics at the proposed offshore windfarm sites.

Table 2-1: River Flow Statistics

No.	Station no.	River	River Catchment area (km^2)	Mean flow (m^3/s)	95% ile (m^3/s)	10% ile (m^3/s)
1	11001	Don	1273	20.64	5.36	40.3
2	12002	Dee	1844	46.93	8.48	96.2
3	13007	North Esk	732	19.1	3.17	39.3
4	13008	South Esk	488	12.27	2.17	25.6
5	15006	Tay	4581.1	168.17	42.81	333.4
	15013	Almond [Firth of Tay]	174.8	5.25	0.73	11.5
	16004	Earn	782.2	28.81	3.72	64.9
				combined as one source = 202.23	47.26	409.8
6	14001	Eden	307.4	3.94	0.24	8.1
	14005	Motray Water	60	0.55	0.09	1.2
				combined as one source = 4.49	0.33	9.3
7	17002	Leven [Firth of Forth]	424	6.45	1.12	13.6
8	18011	Forth	1036	46.96	5.48	115
	18013	Black Devon	56.2	0.94	0.16	2.1
	18002	Devon	181	4.54	1.02	9.5
	18005	Allan Water	210	6.83	0.93	15.6
	18014	Bannock Burn	23.7	0.86	0.2	1.9
				combined as one source = 60.13	8.91	157.7
9	19001	Almond [Firth of Forth]	369	5.99	0.96	13.7
10	19007	Esk	330	4.17	0.96	8.8
11	20001	Tyne [East Lothian]	307	2.81	0.57	5.6
	20006	Biel Water	51.8	0.56	0.15	1
				combined as one source = 3.37	0.72	6.6
12	21009	Tweed	4390	80.88	14.1	169.5
	21022	Whiteadder Water	503	6.58	1.11	13.1
				combined as one source = 87.46	15.21	182.6
13	23001	Tyne [NE England]	2175.6	45.42	6.17	102.3
	23007	Derwent	242.1	2.52	0.81	4.9
				combined as one source = 47.94	6.98	107.2
14	24009	Wear	1008.3	14.56	3.06	32.3
15	25009	Tees	1264	19.04	2.93	44.3
	25005	Leven [NE England]	196.3	1.88	0.25	4.2
				combined as one source = 20.92	3.18	48.5

2.2.5 Data Appraisal

A combination of multi-beam bathymetric data, SeaZone data and C-MAP data will provide sufficient soundings to create an accurate bathymetry for the model. The high-density, multi-beam hydrographic survey data cover Inch Cape and Neart na Gaoithe OWFs development sites with areas of approximately 150 km^2 and 100 km^2 respectively. This meets the current best practice requirements that model bathymetry should not be under-resolved in the area of interest around the development sites and cable route options (Lambkin and Harris, 2009). Admiralty charts will be used as a visual check on the model generated bathymetry.

There is also sufficient tidal level, tidal velocity, wave parameter and freshwater information available to provide data for the model boundaries. All of the data selected for model construction have gone through quality checks.

2.3 Data For Model Calibration and Validation

2.3.1 HD Model

The HD model will be calibrated and validated against water elevations and velocities. Calibration will be undertaken by adjusting key modelling parameters such as the Manning number for bed friction, wind drag coefficient for surface friction and eddy viscosity for shear stress within water mass of turbulent flow. The model will be calibrated against one set of data (e.g. spring tide), and validated against an independent set (e.g. neap tide data). This section provides reviews of available water elevation data and velocity data and quality appraisal of these data.

2.3.1.1 Water Elevations

A range of sources of tidal elevation data have been collated. They are:

- ADCP pressure data collated during site specific metocean survey
- Water level data collected in historical surveys (permission is presently being sought from Scottish Water for use of their datasets).
- Twenty-six Admiralty ports at which tidal levels can be predicted.
- Two long-term tide gauges maintained by Proudman Oceanographic Laboratory (POL) as part of the UK tide gauge network.
- Five long-term tide gauges maintained by the Scottish Environment Protection Agency (SEPA) as part of the SEPA tide gauge network.
- Historic current mooring data available from the BODC may also have recorded some tidal level data.

A summary of the available tidal elevation data available from tide gauges are given in Table 2-2, and their locations are shown in Figure 2-5. The Admiralty ports are listed in Table 2-3.

Table 2-2: Summary of Tidal Gauge Data

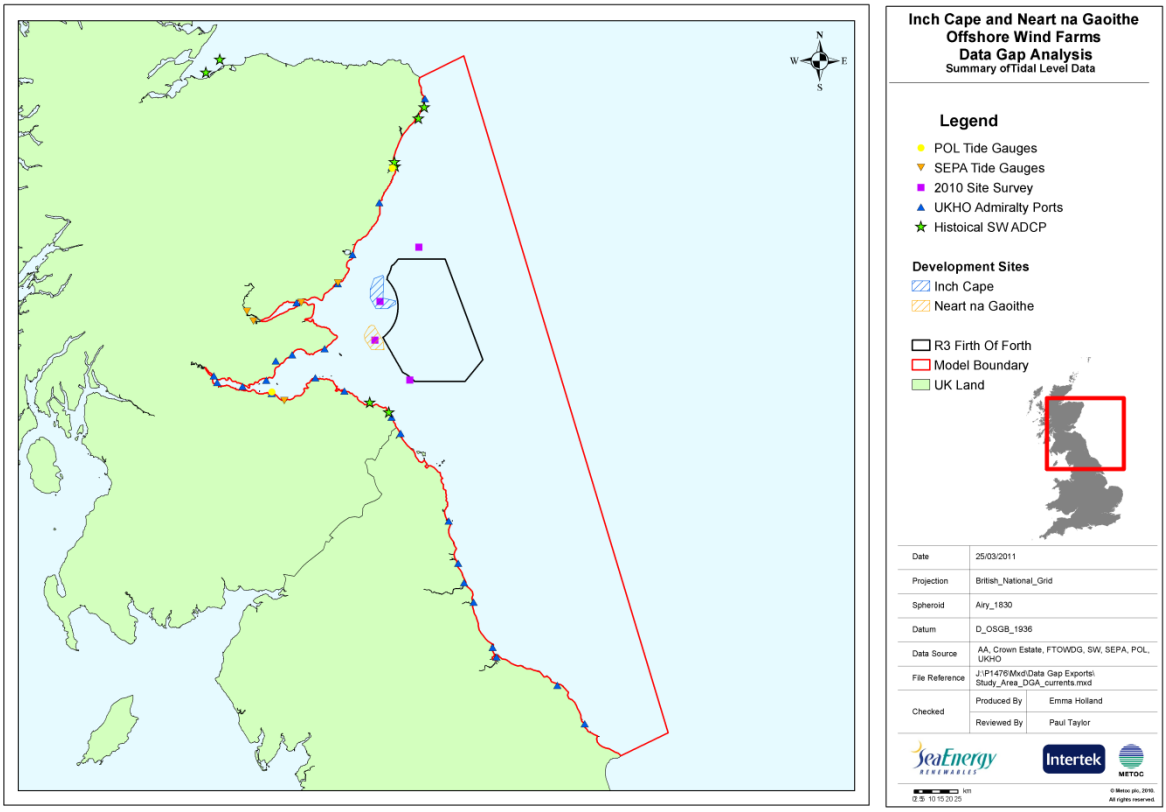
ID	Site	Easting	Northing	Start Date	End Date	Source	Interval
ADCP 1	Forth Array	405204	684910	08/12/2009	12/07/2010	FTOWDG	15 min
ADCP 2	Neart na Gaoithe	385304	707754	10/12/2009	26/06/2010	FTOWDG	15 min
ADCP 3	Inch Cape	388270	729731	10/12/2009	26/06/2010	FTOWDG	15 min
ADCP 4	North Offshore	410427	760813	10/12/2009	25/06/2010	FTOWDG	15 min
Torness ADCP	Torness	382432	672216	04/08/2009	09/09/2009	Scottish Water	15 min
Eyemouth ADCP	Eyemouth	393231.7	666667.1	04/08/2009	15/09/2009	Scottish Water	15 min
Aberdeen ADCP	Aberdeen	396931.4	807085.6	15/07/2009	24/08/2009	Scottish Water	15 min
Aberdeen North ADCP	Aberdeen	396494.9	809583.2	15/07/2009	24/08/2009	Scottish Water	15 min
Cruden Bay ADCP	Cruden Bay	410193	834435	12/02/2009	01/04/2009	Scottish Water	15 min
Peterhead ADCP	Peterhead	413492.8	840824.4	15/007/2009	19/09/2009	Scottish Water	15 min
Aberdeen	Aberdeen	395240	805904	1980	Present	POL	15min
Leith	Leith	326379	678056	1989	Present	POL	15min
Musselburgh	Musselburgh	333542.7	673039.6	TBC	Present	SEPA	15min
Newport-on-Tay	Newport-on-Tay	343226.7	729136.5	TBC	Present	SEPA	15min
Bridge on Earn	Bridge on Earn	315893.9	718452.5	TBC	Present	SEPA	15min
Perth	Perth	312073.1	724119.2	TBC	Present	SEPA	15min
Arbroath	Arbroath	364277.3	740243.4	TBC	Present	SEPA	15min

FTOWDG = Forth and Tay Offshore Wind Developers' Group

Table 2-3: Summary of Admiralty Ports at which tidal levels can be predicted

Admiralty Port	Easting	Northing	Port
SCARBOROUGH	505236	488745	Secondary
RIVER TEES ENTRANCE	454862	526812	Standard
RIVER TYNE (NORTH SHIELDS)	436230	569279	Standard
BLYTH	432951	580381	Secondary
DUNBAR	367780	678676	Secondary
LEITH	326175	677333	Standard
ROSYTH	309618	681359	Standard
GRANGEMOUTH	295120	683543	Secondary
METHIL	337935	699409	Secondary
ABERDEEN	394959	806551	Standard
WHITBY	489612	510672	Secondary
HARTLEPOOL	452646	532349	Secondary
SUNDERLAND	441661	558199	Secondary
AMBLE	427487	604454	Secondary
BERWICK	400000	654444	Secondary
EYEMOUTH	394785	663721	Secondary
FIDRA	351235	686252	Secondary
KINCARDINE	293136	687303	Secondary
BURNTISLAND	323189	684806	Secondary
KIRKCALDY	328564	695845	Secondary
ANSTRUTHER EASTER	356592	702889	Secondary
DUNDEE	340420	729056	Secondary
ARBROATH	364141	739919	Secondary
MONTROSE	372447	756552	Secondary
STONEHAVEN	387841	786160	Secondary
PETERHEAD	413983	845531	Secondary

Figure 2-5: Locations of Tidal Level Data



2.3.1.2 Tidal Velocities

A range of sources of tidal velocity data have been collated. They are:

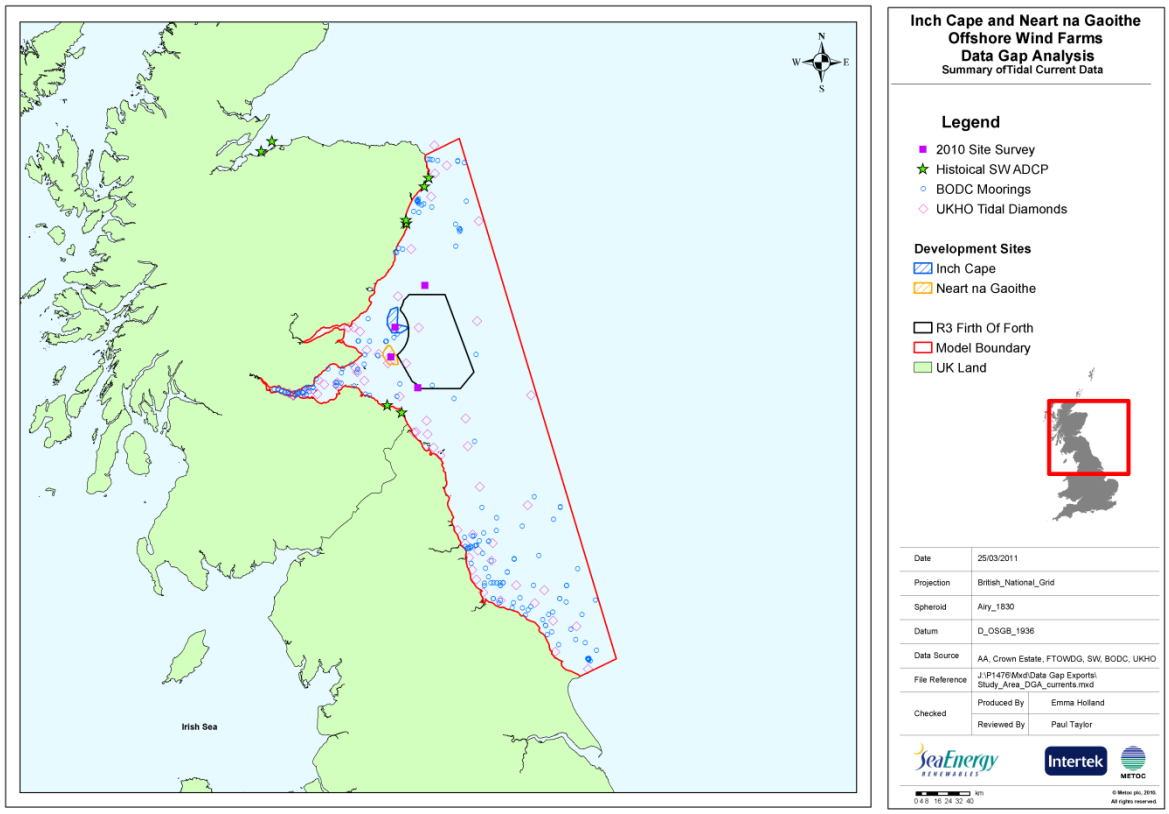
- ADCP current data collated during site specific metocean survey
- Current data collected in historical surveys
- Historic BODC current mooring data
- Current data over a spring tidal cycle and a neap tidal cycle is available from UKHO Admiralty tidal diamonds

A summary of the key available current data are given in Table 2-4 and the locations of all available data are shown in Figure 2-6. Within the model domain there are 496 BODC moorings and 96 Admiralty tidal diamonds. Not all of these data will be used for model calibration, as some datasets will be considered unsuitable for this purpose due to the quality or quantity of the data available. Therefore, rather than listing them in their entirety in the Data Gap Analysis and Data Review Report, those that are selected for calibration will be presented in the model calibration report.

Table 2-4: Summary of Key Current Data

ID	Site	Easting	Northing	Start Date	End Date	Source	Interval
ADCP 1	Forth Array	405204	684910	08/12/2009	12/07/2010	FTOWDG	15 min
ADCP 2	Neart na Gaoithe	385304	707754	10/12/2009	26/06/2010	FTOWDG	15 min
ADCP 3	Inch Cape	388270	729731	10/12/2009	26/06/2010	FTOWDG	15 min
ADCP 4	North Offshore	410427	760813	10/12/2009	25/06/2010	FTOWDG	15 min
Torness ADCP	Torness	382432	672216	04/08/2009	09/09/2009	Scottish Water	15 min
Eyemouth ADCP	Eyemouth	393231.7	666667.1	04/08/2009	15/09/2009	Scottish Water	15 min
Aberdeen ADCP	Aberdeen	396931.4	807085.6	15/07/2009	24/08/2009	Scottish Water	15 min
Aberdeen North ADCP	Aberdeen	396494.9	809583.2	15/07/2009	24/08/2009	Scottish Water	15 min
Cruden Bay ADCP	Cruden Bay	410193	834435	12/02/2009	01/04/2009	Scottish Water	15 min
Peterhead ADCP	Peterhead	413492.8	840824.4	15/007/2009	19/09/2009	Scottish Water	15 min

Figure 2-6: Locations of Current Data



2.3.2 SW Model

The spectral model will be calibrated and validated against wave height, wave period, and wave direction. The calibration of the model will be undertaken by adjusting key modelling parameters that affect factors such as bed friction and wave breaking. This section provides a review of available wave data and quality appraisal of these data.

2.3.2.1 Wave Parameters

A range of sources of wave parameter data have been collated. They are:

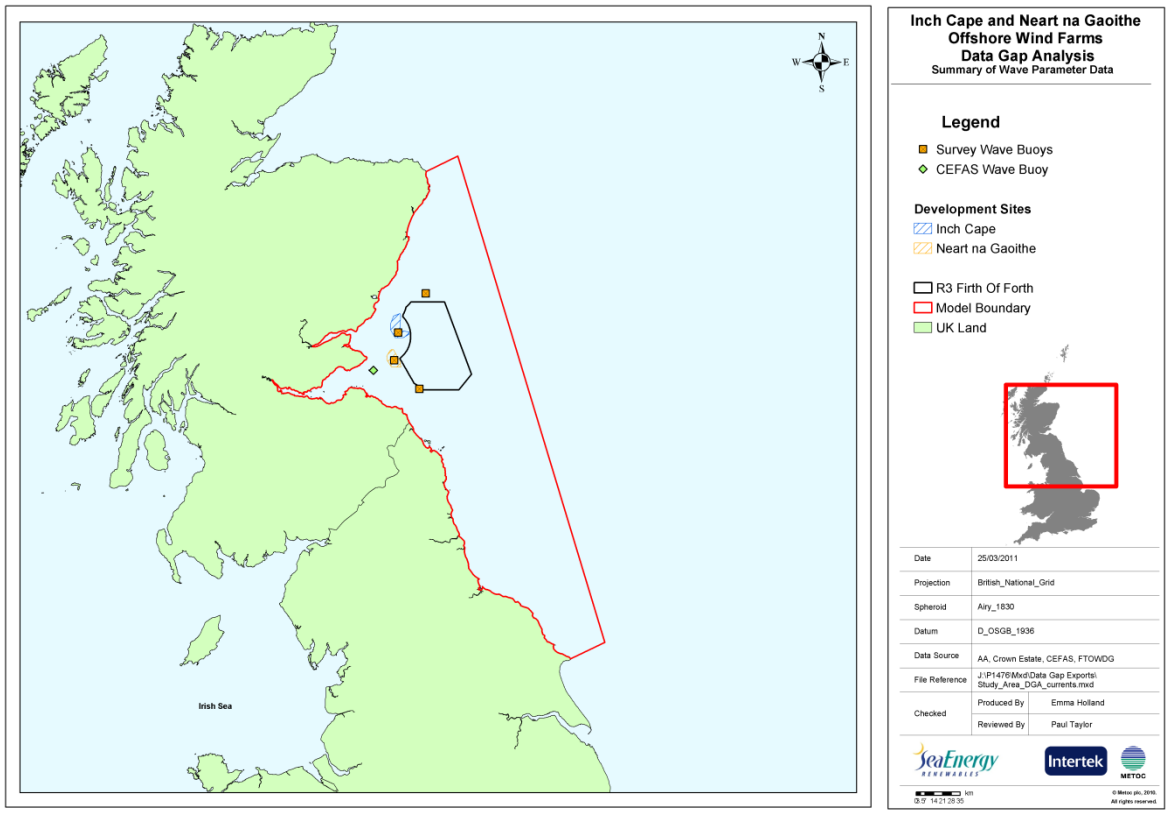
- Wave parameter data collected in site specific surveys by FTOWDG
- Wave parameter data recorded at CEFAS WaveNet Firth of Forth wavebuoy
- Data from UKMO wave models

A summary of the available wave parameter data are given in Table 2-5, and their locations are shown in Figure 2-7.

Table 2-5: Summary of Wave Parameter Data

ID	Site	Easting	Northing	Start Date	End Date	Source	Interval
Partrac 1	Forth Array	405325	684932	08/12/2009	12/07/2009	FTOWDG	60 mins
Partrac 2	Neart na Gaoithe	385337	707755	10/12/2009	12/07/2009	FTOWDG	60 mins
Partrac 3	Inch Cape	388367	729664	10/12/2009	26/06/2009	FTOWDG	60 mins
Partrac 4	North Offshore	410348	760833	10/12/2009	26/06/2009	FTOWDG	60 mins
62045	Firth of Forth	368818	699693	19/08/2008	20/07/2010	CEFAS	30 mins
NA	Various	NA	NA	NA	NA	UKMO Models	60/180 mins

Figure 2-7: Locations of Wave Parameter Data



2.3.2.2 Data Appraisal

As can be seen from Figure 2-8, there are plenty of data available for the calibration and validation of the FTMS HD and SW models. The data provide good spatial coverage around the development locations. Each dataset selected for model calibration and validation is also available at the required temporal resolution. The data locations, types and sources are summarised in Table 2-6.

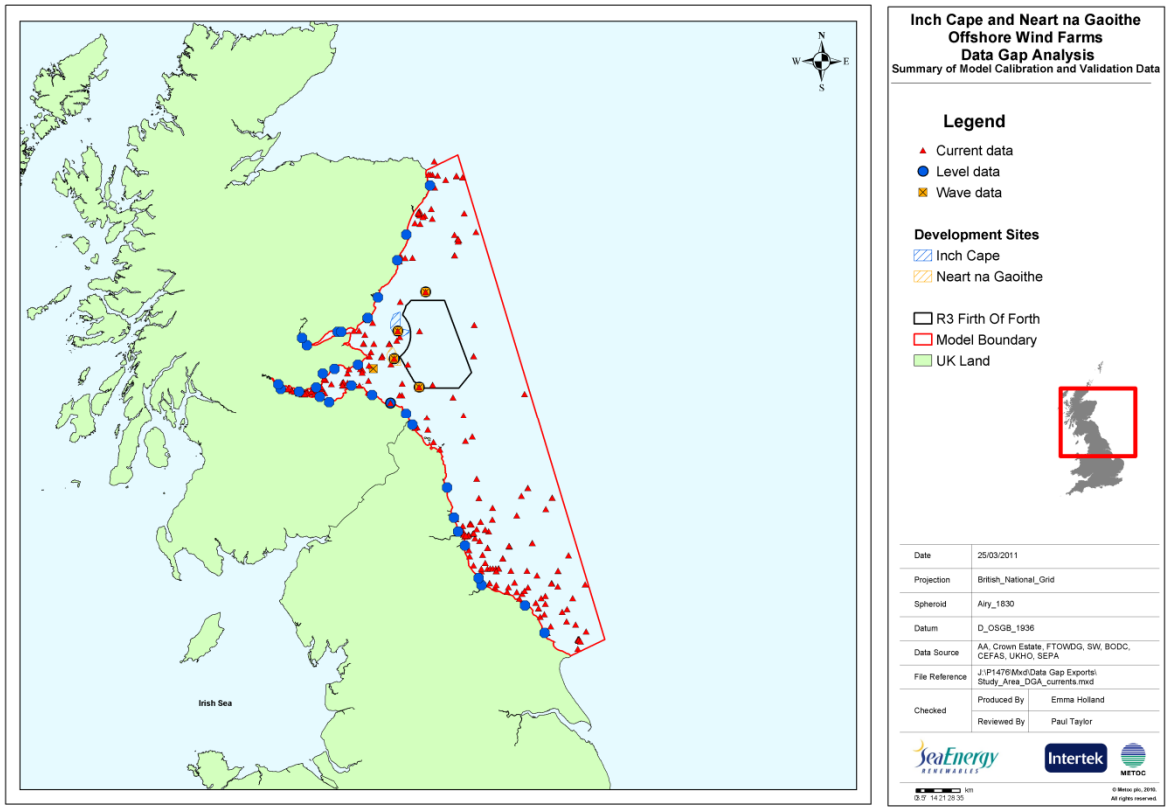
Table 2-6: Summary of HD and SW Model Calibration and Validation Data

Type	Source	Number
Tidal Level	FTOWDG, Scottish Water, UKHO, SEPA, POL, BODC	17*
Tidal Current	FTOWDG, Scottish Water, UKHO, BODC	602
Waves	FTOWDG, CEFAS, UKMO	4**

* excluding BODC data

** excluding UKMO data

Figure 2-8: Locations of Model Calibration and Validation Data



2.4 DATA FOR COASTAL PROCESSES ASSESSMENTS

2.4.1 Local Sediment Regime

Key parameters in the coastal process assessment are tidal currents and wave data that are used to describe the amount of energy in the water column. These parameters will be generated from the FTMS model which will be converted to equivalent bed shear stress values across the area of interest and the wider model domain. Details of the local sedimentary environment, bedload and suspended sediment, are also required to describe the spatial variation in sediment transport rate and direction. A review of the sedimentary data is presented in the following sections.

2.4.1.1 Seabed Sediments, Sedimentary Environment and Sedimentary Structures

A range of sources of seabed sediments, sedimentary environment and sedimentary structures data have been collated. They are:

- PSD data collected from the site specific benthic survey at Neart na Gaoithe OWF
- PSD data collected from the site specific geotechnical survey at Neart na Gaoithe OWF
- Suspended PSD data collected from the sediment trap deployed (at the AWAC site) at Neart na Gaoithe OWF

- Detailed seabed features interpreted from information collected by side scan sonar and hydrographic (MBES) surveys for the Inch Cape and Neart na Gaoithe OWFs.
- Sediment thickness maps have been generated from seismic surveys completed for the Inch Cape and Neart na Gaoithe OWFs.
- Seabed features identified from Admiralty Charts 2-0, 1192-0; 1407-0
- Digitized seabed sediments maps are available from BGS charts that provide general seabed characteristics.
- Coastal Cell reports published by SNH that include information on coastal geology, geomorphology and littoral processes
- Shoreline Management Plans held by local councils that include information on sediment pathways on a regional scale.

2.4.1.2 Suspended Sediment Concentration

A range of sources of suspended sediment concentrations (or turbidity) data have been collated. They are

- TSS concentration data collected from bed mounted AWAC at Neart na Gaoithe. It should be noted that these data are derived from the backscatter signal recorded by the AWAC, assuming there is sufficient samples, and are not directly recorded by the AWAC.
- TSS concentration data collected from water samples taken at three positions vertically in the water column (taken adjacent to the AWAC site) at Neart na Gaoithe.
- Suspended sediment concentration data for Scottish Territorial Waters published by the Scottish Government.
- TSS concentrations data collected from spot samples taken by SEPA at various riverine locations

The location of the AWAC is presented in Table 2-7.

Table 2-7: Summary of AWAC deployment

Site	Partrac ID	Instrument	Deployment	Recovery	Easting	Northing
Neart na Gaoithe	AWAC	AWAC	05/05/2010	20/07/2010	385963	709482

2.4.2 Data Appraisal

The AWAC instrument was deployed in two installments. The first deployment (05/05/2010 – 20/07/2010) was successful and the data have been recovered. Unfortunately, there was a problem with the second deployment, and no usable data was collected.

There are sufficient PSD and suspended sediment concentration (SSC) data available for the Neart na Gaoithe OWF to progress with the coastal processes element of the study for this site. However, there are no SSC data for the Inch Cape OWF (none were commissioned within the FTOWDG metocean contract),

which may create difficulties in the coastal processes assessment where bottom sediments differ significantly from those at Neart na Gaoithe.

It is considered that the additional geophysical and benthic surveys planned for the Inch Cape OWF will provide further information to corroborate the assessment, which will be based on the data currently available. The geotechnical and benthic surveys have not yet been completed for Inch Cape OWF but are planned for August 2011 and June 2011 respectively.

It is recommended that some TSS data is obtained for the Inch Cape site, if possible. This can be part of the forthcoming geophysical and benthic surveys to provide Spring-Neap-Spring-Neap data with an additional 2-3 wave events data. If required, Intertek METOC and Partrac can provide further advice for this survey element.

There is also an adequate amount of extant data to provide supporting sediment regime information for the OWFs and the wider model domain. This includes information on shoreline processes (via local Shoreline Management Plans) and on incident river flows from major discharging rivers.

2.5 DATA FOR SCOUR ASSESSMENT

Scour is a dynamic interplay between the foundation type/geometry, water depth relative to foundation geometry, local hydrodynamics (current magnitudes, wave climate), and the seabed down core (vertical) characteristics.

Gravity foundations, which are being increasingly used (e.g. recently installed at Thornton Bank), rest on the seabed and are more squat in form. Chief amongst the considerations for scouring potential are the width of the gravity base, and the width-height in relation to the flow depth. These data can be used in conjunction with flow magnitudes to infer whether flow separation will occur and this will indicate the likely severity of scour.

Jacket structures are also being used e.g. at the Beatrice Demonstrator in the Moray Firth. For jackets, the main considerations are the relative size and spacing of the legs (in addition to knowledge of the local geo-marine conditions), and this will point toward individual scour pit formation or, alternatively, global scouring (so called ‘dish-pan’ scour) beneath the entire foundation. Which of these is more likely to be adopted for these developments dictates which equations and formulae might be used within the analysis.

Information on the type of structure and development envelope (density of development, build-out plan, layout) has yet to be obtained from the developers. However, this is an iterative process and this information will become available before it is required for the impact assessments and subsequent to the baseline study.

3 CONCLUSIONS

Data availability for the Inch Cape OWF, Neart na Gaoithe OWF and the wider FMTS domain has been reviewed. The available data have been collated where possible both the quantity and quality of the data has been reviewed and assessed for the purpose of model construction and calibration/validation. The main conclusions are:

- A combination of multi-beam surveyed bathymetry data, SeaZone data and C-MAP data will provide good quality of bathymetric data for model construction.
- There are sufficient data available for the HD and SW model boundaries.
- There are sufficient data available for the calibration and validation of HD and SW model.
- There is a sufficient resolution and coverage of sediment regime data available for the Neart na Gaoithe and a suitable resolution and coverage of sediment data for the wider model domain.
- There is currently insufficient information on TSS at the Inch Cape OWF to fully characterise the site. The assessment will utilise the available data (such as that collected for the Neart Na Gaoithe site) in order to represent conditions at Inch Cape as far possible. A recommendation here is that some information is collected (at least Spring-Neap-Spring-Neap), perhaps in conjunction with or as part of the forthcoming geophysical/benthic survey work.
- The additional geophysical and benthic surveys planned for the Inch Cape OWF will provide further information to corroborate the assessment, which will be based on the data currently available. This survey campaign is planned for the spring of 2011.
- Data on the structure types and development envelopes for both OWFs have not yet been obtained but will be made available subsequent to the baseline study. A sufficient level of hydrodynamic and geological data exists to underpin this analysis.

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