Techniques for Marine Biological Baseline Data Collection at Offshore Renewable Energy Developments and How Best to Apply These to Guernsey Waters

By

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Disclaimer

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Executive Summary

The States of Guernsey are committed to reducing their carbon emission by significant levels by 2020 and 2050. Another aim is to improve their security of energy supply following recent cable failures. One way in which they are aiming to achieve these targets is through the introduction of offshore renewable energy generators by the second half of this decade. In order for this deployment to go ahead, the Guernsey Renewable Energy Team (GRET) has set several conditions, one of which is to make sure a well-established environmental baseline understanding is in place. The collection of high quality baseline environmental data has been linked to the success of a renewable project as it forms the basis of the environmental impact assessment (EIA) process from which predictions and decisions are made. EIAs are currently immature for offshore renewable energy developments; there is a lack of understanding of precisely what needs to be surveyed and monitored. This leads to a burdensome approach where everything is surveyed and monitored. It is therefore vital that there is convergence of the guidance from the governing bodies in order to identify the necessary surveys which will enable an early understanding of what is necessary to survey, which is in turn greatly beneficial to a project. It is therefor considered vital for Guernsey to achieve its renewable energy and carbon emission targets.

This report discusses the guidance given by CEFAS, DEFRA and SNH regarding marine biological baseline data collection along with discussing the survey techniques used at offshore renewable energy developments across the UK and Europe. The recommendations given by the governing bodies, combined with those presented in appropriate scientific reports, were then applied to Guernsey, using the Regional Environmental Assessment of Marine Energy as a source for environmental information. This report provides convergence of the guidance given by the governing bodies to provide recommendations for baseline data collection in Guernsey waters. This report focuses on a potential wind farm site to the north west of Guernsey and a potential tidal site within the Big Russel. A summary of the recommendations made by this report along with flow charts explaining the basis behind selecting these techniques can be found overleaf.

Survey Recommendations Summary

Benthic Habitat

- Acoustic Mapping of wind farm site, Big Russel and potential cable routes
- Drop down video, grab and 2m beam trawl surveys
- Infaunal and epifaunal analysis
- Sedimentary chemical and particle size analysis
- Dedicated eelgrass survey as part of a monitoring plan
- Annual sampling for a minimum of 2 years

Fish & Shellfish

- Scientific surveys mimicking commercial fishing techniques at the wind farm site, Big Russel and the potential cable routes
- Surveys of spawning grounds and feeding grounds
- Surveys of plankton community and of contaminants in shellfish
- Fish surveys carried out 3 times per year
- Monthly shellfish surveys
- All sampling to be carried out for a 2 year period

Marine Mammals

- Vantage point surveys in the Big Russel
- Single platform line transect boat based surveys of the wind farm site
- Surveys should study seals, cetaceans and basking sharks
- Dedicated haul out site counts from land or boat
- Use of the platform of opportunity technique on the ferries travelling in and out of St Peter Port
- All surveys should be carried out monthly for a minimum of 2 years
- Deploy 4 CPODs off the NE, SE, SW & NW coasts for a minimum of 2 years prior to construction

Ornithology

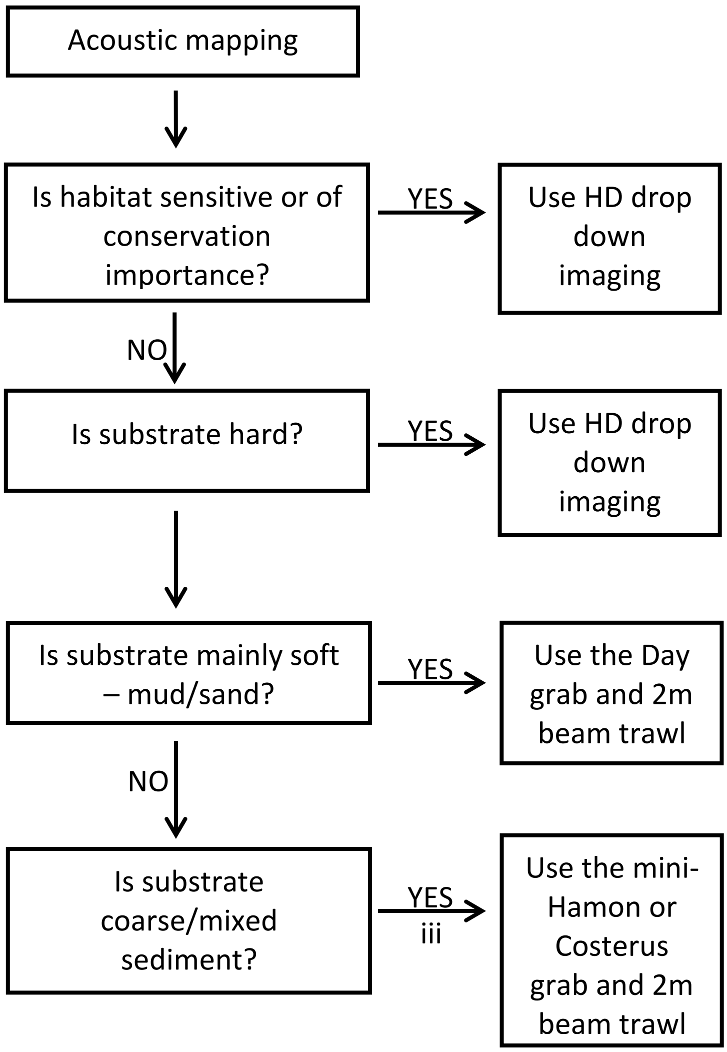
- Boat based survey of wind farm site
- Vantage point survey of Big Russel
- HD aerial survey using a company such as HiDef Aerial Surveying Ltd.
- Breeding site surveys of the areas identified in the REA
- All surveys should be carried out monthly for a minimum of 2 years
- Future studies following collection of baseline data may include: vantage point migration surveys and GPS tagging studies.

Decision Flow Charts

The documents reviewed stated that the techniques selected for surveying were dependent on site characteristics. The following flow charts are a combination of all the recommendations given by the guidance documents and show a clear reasoning for the selection of the recommended techniques to be used at the sites in Guernsey waters. The process highlighted in the flow charts follows an in depth desk study of the local environment which facilitates the decision making process. Fish & shellfish technique selection is not included as it involves mimicking local fishing techniques which occur in the development areas. In depth justification for the techniques recommended for use in Guernsey waters can be found in the Recommendations for Marine Biological Baseline Surveys of Guernsey Waters section of this report.

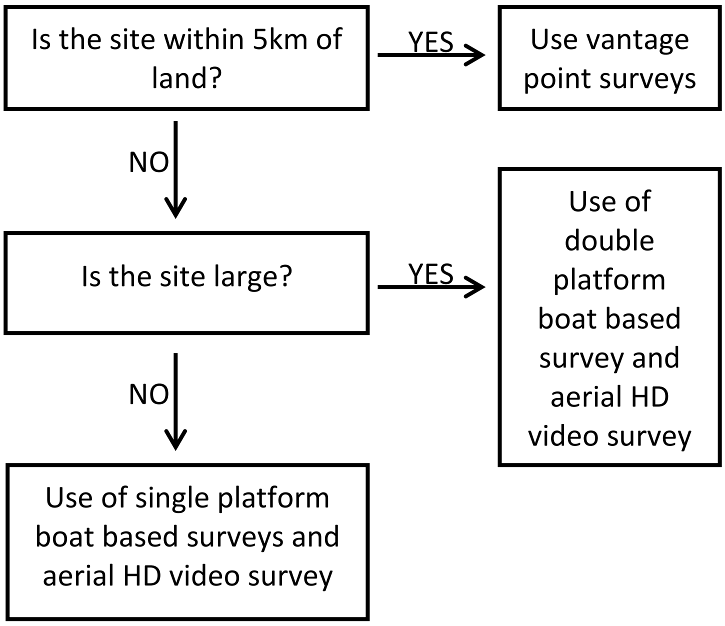
Benthic Habitat

Technique selection for baseline benthic habitat surveys.

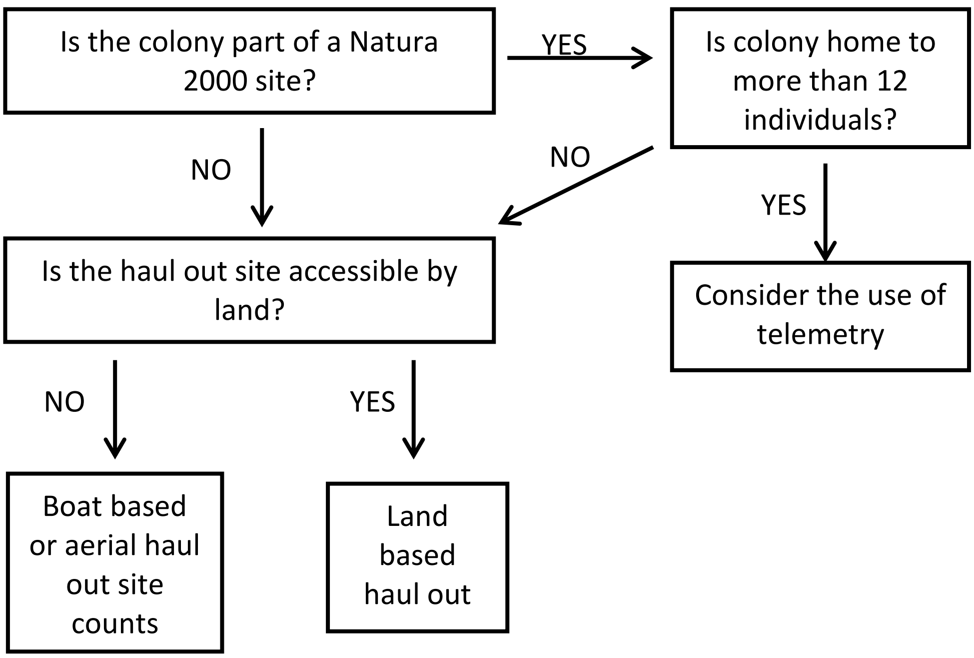


Marine Mammals

Technique selection for baseline cetaceans, seals and basking shark surveys within the development site.

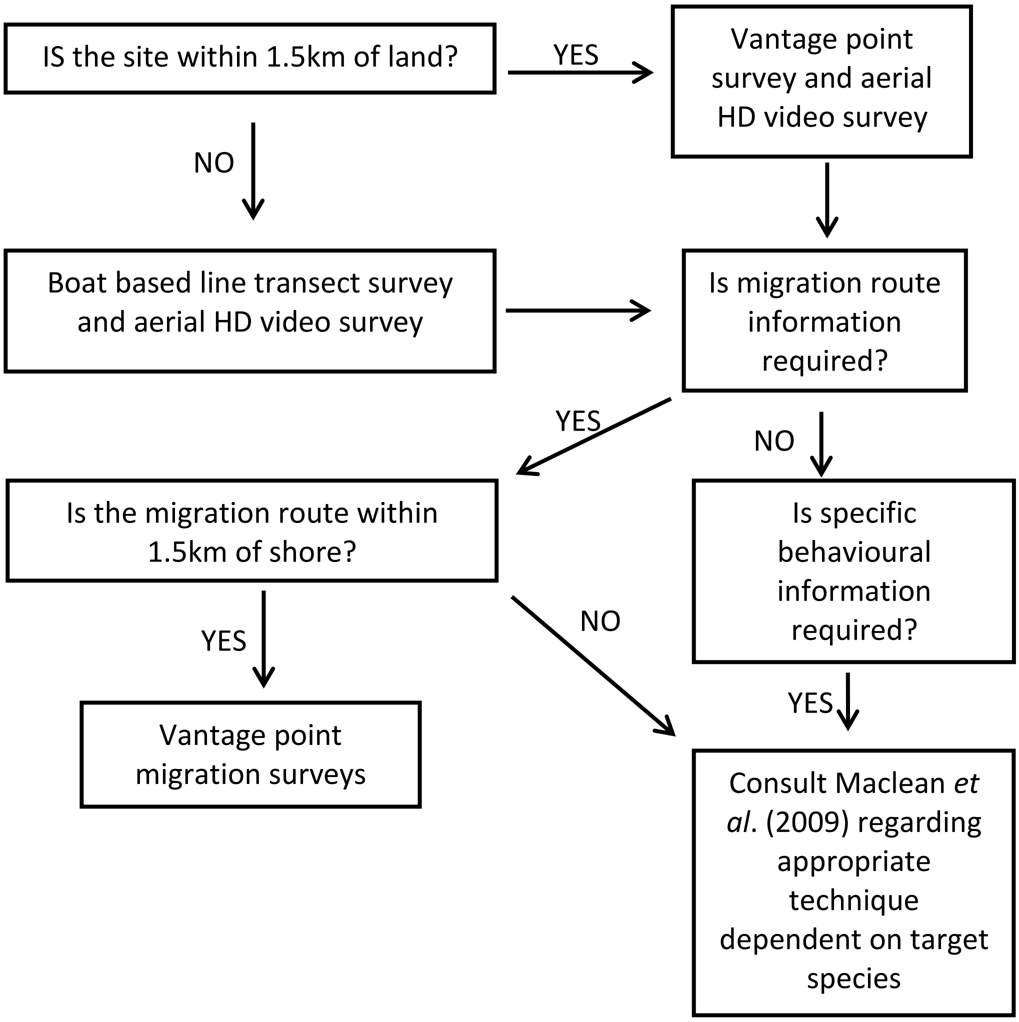


Technique selection for baseline seal haul out site surveys.



Ornithology

Technique selection for ornithological baseline and supplementary surveys.



Acknowledgments

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1. Introduction

Guernsey and Offshore Renewable Energy

The Guernsey Renewable Energy Team (GRET) has a long term vision of Guernsey being a sustainable island, generating renewable energy to supply the island and also for export (GRET, 2013). This long term vision is for several reasons; primarily as targets of reduced carbon emissions of 30% on 1990 levels by 2020 and 80% by 2050 have been set and increased security of electricity supply is sought after following recent cable failures (GRET, 2011; BBC, 2012). The GRET are looking into multiple sources of renewable energy to achieve these targets, including projects utilising the natural resources of offshore wind and tidal stream. GRET have commissioned several reports to investigate the opportunity of an offshore renewable energy project, with a recent study carried out by the MSc Marine Renewable Energy students at Plymouth University finding that Guernsey has an excellent resource of both offshore wind and tidal stream (Plymouth University, 2012). GRET are aware of the resources available and express in their mission statement that they aim to have a renewable energy generator in local waters by the second half of this decade (GRET, 2013a).

With regards to an offshore wind development, various sites have been suggested from several studies and GRET have recently highlighted four potential sites upon which to focus their investigations. Following a review of the information available, GRET identified the four potential sites according to several factors (GRET, 2013b):

- Visibility from shore
- Access to cabling
- Distance from shore
- Depth
- Geology
- Wind Data
- Potential impacts on other resources
- Potential environmental impacts

Following the investigation, which was purely desk based, the four potential sites have been narrowed down to two. One site is located off the north west coast, at around a maximum distance of 3 nautical miles (nm) from Guernsey. The second site is currently out with Guernsey's territorial waters and is considered a long term option (GRET, 2013b).

Potentially the most commonly discussed source of offshore renewable energy in Guernsey waters is the tidal resource in the Big Russel. Several studies have stated the potential for energy extraction though no definitive site within the channel has been identified. However, it is currently thought that the tidal resource is greater on the Guernsey side of the channel (P. Barnes. pers. comm.). Figure 1 shows the potential site boundaries for both the offshore wind farm and the tidal stream sites.

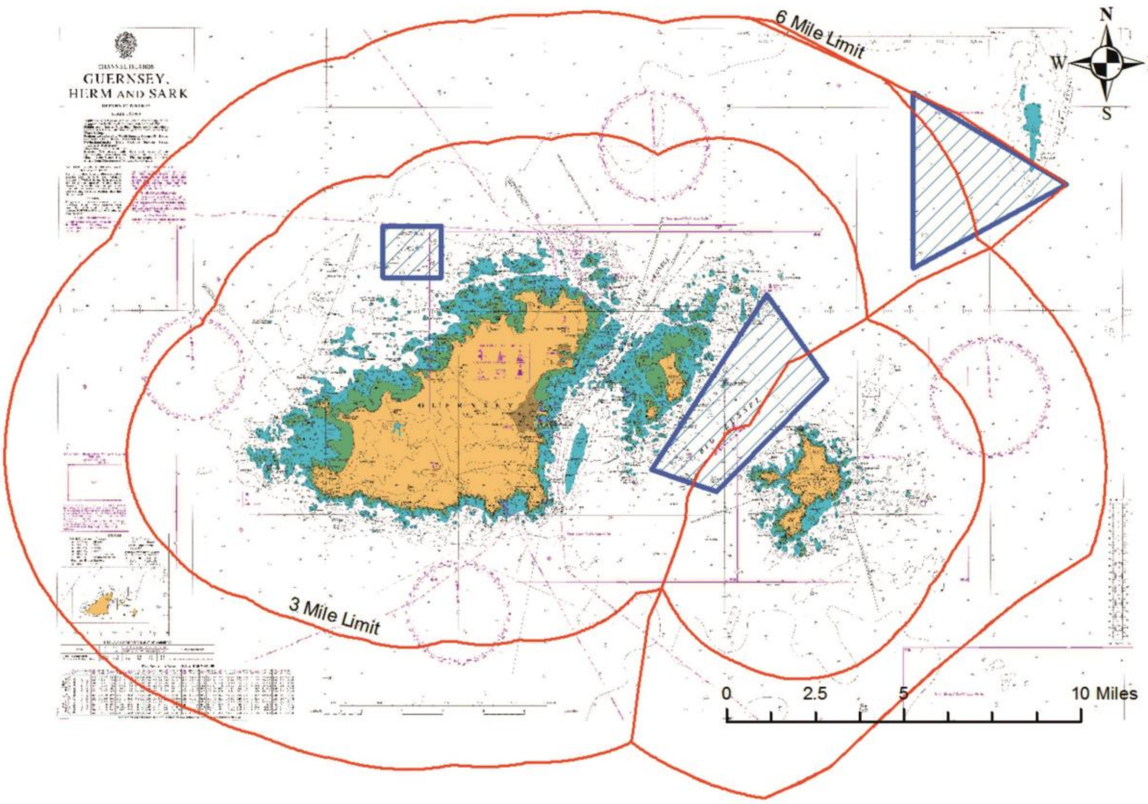

Figure 1: Map of the potential wind farm sites and the potential tidal site in the Big Russel.

In order to achieve its targets, the GRET set objectives for the year in its annual statement (GRET, 2013a). One of the top three objectives is to create a business case for a 30MW offshore wind farm and one of the conditions associated with this objective is to develop a baseline understanding of the environment at the potential offshore wind farm sites. However, the establishment of an environmental baseline understanding is not limited to the offshore wind farm sites; it is identified in the GRET mission statement for all offshore renewable energy developments. The GRET mission to have a long term understanding of the baseline environment is with hope of allowing Guernsey to move to deployment of devices without unnecessary delay. It is also hoped that with a baseline understanding of the environment, Guernsey will become more attractive as a potential deployment site due to reduced data collection effort required by developers.

Importance of Baseline Data Collection

Baseline data collection forms an integral part of the environmental impact assessment (EIA) process which any project planned by Guernsey will be subject to. EquiMar (2010) describe baseline data collection surveys as being the “backbone” of the EIA. The data collected in the baseline surveys acts as a reference point for all impact predictions and future monitoring studies of the project. Therefor any inadequacies in baseline data can have significant effects on the success of a project.

The establishment of high quality baseline environmental data is considered to be one of the most important aspects towards a successful renewable energy development (Khan, 2000). The baseline data collection process is a vital part to any project and when carried out appropriately, the natural environment and its variability trends can be understood (ODPM, 2005). This initial process of data collection plays an important role to project development. The baseline data set can be used to identify the most suitable area for device placement according to the local environmental sensitivities (EquiMar, 2010); emphasising the importance of high quality baseline data collection.

When baseline data collection is not carried out to as high a level as is required, future environmental work associated with the project will be greatly affected. When poor data is collected, it is due to regularly made errors (EMEC & Xodus, 2010). The most common errors leading to inadequate baseline data collection are due to: relying on out-of-date data, a focus solely on the development site rather than the wider area, the use of inappropriate personnel, and the lack of adequate time and funds to collect robust data (EMEC & Xodus, 2010). It is vital that these, along with the other common errors stated in the EMEC & Xodus (2010) report are considered and avoided.

Aim

The aim of this report is to identify the most effective techniques to use for baseline data collection relating to the marine biological aspects of offshore wind and tidal stream renewable energy developments, in Guernsey waters.

Objectives

The objectives of this report are to:

- gain an understanding of the guidance given by governing bodies regarding marine biological baseline data collection
- identify the techniques used at offshore renewable energy developments in order to understand why they were used
- apply the knowledge gained to state the most appropriate baseline data collection survey techniques which should be used in Guernsey waters in relation to the offshore wind farm and tidal sites

Report Structure

This report first reviews the general guidance documents from leading advisory bodies regarding data collection for the benthic habitat, fish and shellfish, marine mammals and birds at offshore renewable energy developments. Specific guidance documents on these sub topics are then reviewed along with appropriate scientific papers and renewable energy publications. These guidance recommendations are then applied to the current data available for Guernsey.

Resources Used

The main resources utilised in this report are guidance documents from the Centre for Environment, Fisheries and Aquaculture Science (CEFAS), Scottish Natural Heritage (SNH), the Department for Environment, Food and Rural Affairs (DEFRA) and documents published by the Collaborative Offshore Wind Research into the Environment (COWRIE). In terms of gaining information regarding individual offshore renewable energy developments, CEFAS review documents were utilised along with environmental statements and scoping reports. With regards to environmental information about Guernsey, the Regional Environmental Assessment of Marine Energy (GRET, 2011) and its updates were used.

2. General Guidance Documents

Offshore Wind Farms: Guidance Note for Environmental Impact Assessment in Respect of FEPA and CPA Requirements - CEFAS, 2004

The CEFAS document was written by the Marine Consents and Environmental Unit prior to the creation of the Marine Management Organisation - which is now responsible for the majority of marine consents and licensing (MMO, 2013a). The document was created principally to aid those involved in the offshore wind industry by providing them with scientific guidance regarding the gathering, interpretation and presentation of data involved with an EIA (CEFAS, 2004). It is particularly useful as it considers the requirements associated with a FEPA license for any deposits of structures in the marine environment; which would be required for a development in Guernsey waters under the Food and Environmental Protection Act (FEPA) (Guernsey) Act 1987. The document gives scientific guidance for data collection from the earliest stage of the EIA for all aspects of the marine environment which may be impacted by offshore wind farm developments. CEFAS state that due to the lack of knowledge of the effects of the offshore wind industry upon the marine environment, a precautionary approach should be adopted. This means that all aspects of the marine environment are monitored in order to create an overall understanding of the impacts associated with the industry. An overall recommendation from this document is the suggestion and emphasis on the importance of collaboration and consistency in data collection between offshore wind farm sites. This is an important recommendation as it enables cumulative effects to be considered, a best practice approach to be generated and also provides the ability to compare any effects found (CEFAS, 2004).

Benthic Habitat

The initial recommendation regarding benthic data is that of a desk based study; taking into account all available knowledge of the seabed habitats and any pressures it is currently experiencing. Following this, the survey design process is discussed, with the main resource utilised for planning the surveys being the sediment distribution data from the initial acoustic mapping survey (CEFAS, 2004). By using the data from the acoustic mapping survey, appropriate techniques can be selected for the collection of data within sediments and habitats.

With regards to the specific techniques to be utilised, it is noted that guidelines for benthic sampling at offshore wind farm sites do not exist due to the relative infancy of the industry. However, long established appropriate guidelines for other activities in the marine environment, such as marine aggregate extraction, exist and it is suggested that these guidelines (Boyd, 2002) are adopted. The 2nd edition of this document (Ware & Kenny, 2011) will be reviewed in detail in the Specific Guidance Documents section of this report. These guidelines are summarised within the document with recommendations for soft sediments being sampled with grabs and corers for the infauna, particle size and chemical analysis, and trawls and dredges used for the epifauna. For the surveying of rocky or coarse terrain it is recommended that underwater photography is used along with diver surveys. It should also be noted that there is a recommendation for sites that include environmental sensitivities to adapt their methodologies accordingly (CEFAS, 2004).

It is recommended by CEFAS (2004) the minimum survey area should encompass one full tidal excursion from either edge of the site boundaries. Tidal excursion is the net movement of a water particle during a full tidal cycle (McGraw-Hill, 2003). This is in order to obtain data to identify any impacts caused by resettlement of particles following installation and is a vital consideration in survey design (CEFAS, 2004). In order to have an appropriate amount of data for statistical analysis, it is recommended that a minimum of three replicates are taken at each sample station and that the precise locations of turbines are also sampled. These are important recommendations as they ensure that post installation surveys can duplicate the baseline sampling methods in order to assess impacts and recovery.

Fish & Shellfish

There are several ecological aspects regarding fish & shellfish that are recommended for study, these include:

- Spawning grounds
- Nursery grounds

- Feeding grounds
- Overwintering areas (crustaceans)
- Migration routes

It is suggested that the species for which these are studied are: those of commercial, recreational and conservational importance, elasmobranchs and species which are of restricted distribution but are locally abundant.

Prior to any survey work, a desk based study is recommended and may in some cases be adequate as a baseline dependant on the depth of the information available; as a minimum, 5 years' worth of landing data is recommended to be studied (CEFAS, 2004). Along with landings data and ecological information of species, effort data should also be collected in order to identify areas which are of importance to the local fishing industry. Early interaction with local fishermen is stated as important with a specific note to use local fishermen and vessels where possible when carrying out any survey work. This follows the recommendation to utilise local commercial fishing techniques during any survey work for adult fish species.

The specific survey work to be carried out and the techniques to be used are entirely dependent on what data needs to be collected. For adult fish, as mentioned above, it is suggested to mimic local commercial fishing techniques which may include: otter trawls (for demersal species, some pelagic species and flatfish), beam trawls (for flatfish), potting or dredging (for shellfish). In order to survey juvenile species, a scientific 2m beam trawl, which may have been used in benthic epifauna sampling, is recommended. It should be noted that smaller mesh sizes are required for this juvenile survey and special dispensation must be requested from DEFRA. This is due to the fact that non-regulation mesh sizes will be used and fish under the legal size limit will be caught and retained for species identification. If spawning grounds are to be studied, video surveying or grab sampling is recommended for species which lay eggs in substrate - such as herring. The appropriate protocols for the site specific scientific survey work are stated in detail in the CEFAS (2004) document.

Marine Mammals & Ornithology

There is a distinct lack of specific guidance on survey techniques for marine mammals and ornithology in this document. The aspects associated with marine mammals that are recommended to be studied are mentioned as detailed below:

- Species in the area
- Number, distribution and location of sightings
- Known routes and movements in the vicinity of the site
- Relative importance of the site to each species
- Specific uses of the site including temporal and spatial use e.g. feeding and breeding grounds.

Though this is all vital information to collect, the lack of details regarding precise survey techniques hinders the value of this document as a guide. In order to get more detailed information on marine mammal and marine bird surveys, CEFAS (2004) recommend that the Joint Nature Conservation Agency guidance on offshore wind farm development document (DEFRA, 2005) is consulted.

Nature Conservation Guidance on Offshore Windfarm Development - DEFRA, 2005

This document was primarily written to make developers aware of the potential effects which could result from the construction of an offshore wind farm in a Natura 2000 site – Special Areas of Conservation (SACs) or Special Protection Areas (SPAs) which fall under the EU Habitats Directive (European Commission, 2013). Even though the EU Habitats Directive does not apply to Guernsey and the government has not designated any SACs or SPAs (GRET, 2011), the guidance given is for carrying out surveys using the most environmentally friendly techniques and is therefore of great use.

Benthic Habitat

Benthic surveys have been categorised into two stages: the acoustic seabed mapping and the benthic sampling. DEFRA state that acoustic mapping should be done of all areas which may be affected during installation and operation. This initial part of the benthic survey, as discussed in CEFAS (2004), is carried out to map the habitats on the seabed which in turn allows all habitats to be studied and that the appropriate sampling technique is used (DEFRA, 2005). The main recommendation for the acoustic mapping is to avoid surveying following extreme weather events and to survey at slack water, in order to improve the quality of data. It is stated that for the benthic sampling, the procedures and techniques detailed by Boyd (2002) should be used and only altered in presence of sensitive habitats i.e. reefs.

Fish & Shellfish

The guidance on data collection for fish & shellfish is similar to that of CEFAS (2004) stating that an initial desk study is essential using as many sources as possible, including university studies, marine laboratories and the local sea fisheries committee (DEFRA, 2005). One specific point raised states a requirement to identify spawning grounds. Following this, guidance is given regarding how to gain “a broad description of the species and habitats present in the area and along the cable route” including what data should be collected and which technique should be used; the key factors of which are detailed below (DEFRA, 2005).

Fish Surveys:

- In project areas greater than $100km^2$ a minimum of 30 hauls should be done
- Surveys should be carried out at a minimum of twice a year (spring, autumn) or three times (spring, summer, autumn)
- Surveys should be done for a minimum of 2 consecutive years up to the beginning of construction activities
- The data analysis carried out on the samples should include: total number of individuals per area, total biomass per area, number of individuals per species and area, biomass per species and area, dominance ratios, diversity, length frequency and community analysis

Shellfish Surveys:

- Aim to gather data to decipher the distribution, seasonality and density of shellfish species
- Use of mesh pots to catch crustaceans
- Sample shellfish for contaminants
- A minimum of 12 months information should be obtained with surveys occurring monthly
- The data analysis carried out on the samples should include: total numbers, size range and sex ratio

The document also discusses the selection of a reference site, which can be used for comparison purposes. The natural requirements of the control site are that the conditions are very similar to those of the development site, including: current conditions, water depth, sediment properties, distance from the coast, size and species diversity (DEFRA, 2005). The identification of this reference site would forms an integral part of the baseline surveys as it would need to be surveyed concurrently, using the same techniques.

Marine Mammals

As with all the other sections within the guidance document, the initial recommendation associated with marine mammals is to conduct a desk survey. The aims of this desk study should be to identify the distribution, numbers, species and behaviour of marine mammals in the area, along with any environmental factors influencing them e.g. tide, season or prey availability. Following the desk study, it is recommended that site and project specific surveys are conducted in order to gain detailed information on aspects which may be impacted due to construction and operation of the wind farm. The specific techniques to be used are determined by what information is sought, with the species to be studied having the greatest influence on the technique used.

It is recommended that aerial, boat based and hydrophone surveys are carried out for a minimum of two years. The surveys should relate to: seasonal, tidal, diurnal and prey availability variation. Flyover surveys at low water are recommended twice a month for 6 months, which is presumed to be for surveying seal haul out sites. It is also recommended that where possible, surveys should try to relate marine mammal numbers to environmental factors – there is however no advice given on the best method to achieve this.

Ornithology

The DEFRA (2005) document is strong in its detail of the techniques for monitoring seabirds. It takes the majority of its guidance from a COWRIE published paper (Camphuysen *et al*, 2004) which will be discussed in the Specific Guidance Documents section of this report. Again, the initial guidance is to carry out a desk based review in order to identify the current level of knowledge and aid the planning of surveys. Following this, the recommendations for surveys are detailed below:

- Aerial surveys of the area to provide information on numbers, distribution and density of birds
- The area surveyed should be the site plus a 2km buffer zone
- Boat based survey may be used to supplement the information gained from the aerial survey

- Information gained from the boat based surveys should include behaviour, movements and flight heights. Species may also be recorded which aerial surveys had not been able to identify
- A control area, with similar environmental conditions, at a minimum of 1.5km from the nearest turbine should be selected and surveyed
- All survey types should use line transects running perpendicular to depth contours where possible
- At least four flights should be carried out during the winter months (Oct-Mar)
- For bird breeding areas it is recommended that a minimum of 3 surveys are carried out between May to July/August
- The possibility of further surveys to cover important time periods such as migration is also mentioned
- 2 boat based surveys are recommended per month during important periods i.e. migration
- A minimum of 2 years' worth of data is required to account for natural variability (ideally 3 in areas of high variance)

The use of radar to supplement the data collected was discussed. Radar could be used at night, dawn and dusk, in order to identify bird movement. However, its use was not recommended due to the fact that at the time this report was written, the technology was in its infancy (DEFRA, 2005). As is evident from the above summary of the recommended survey methods, a combined approach of both boat based and aerial surveys is advised. The use of a combined approach allows for the weaknesses of either individual technique to be compensated for by the other. The associated strengths and weaknesses discussed by DEFRA (2005) are presented in Table 1.

Table 1: A comparison of how boat based and aerial bird survey fullfil differing objectives. Taken from DEFRA, 2005.

Key Factors	Ship-based	Aerial
Distribution	Poor in terms of obtaining a snapshot of distribution at any one time. Poor in terms of defining limits of distribution.	Good in terms of obtaining a snapshot of distribution at any one time. Good - birds encountered within a few seconds (at most, 300 metres) from their original position and thus allows good estimate of relative densities.
Number	Moderate in terms of identifying unobtrusive species (auks, gulls, terns and shearwaters). Good accuracy of counts - though less suitable for Common Scoter and Red-throated Diver which take flight at great distances. Poor in terms of estimating total numbers - birds can move position significantly if survey period for a site takes several days, thus reducing reliability of count.	Poor in terms of identifying unobtrusive species. Moderate – accuracy of counts of birds in individual flocks (Common Scoter, Eider) is reduced due to speed of the aircraft. Moderate in terms of estimating total numbers.
Type of birds	Moderate in terms of identifying unobtrusive species (auks, gulls, terns and shearwaters). Good in terms of identifying to species level a relatively high proportion of birds encountered (particularly important for auks, terns and gulls). Moderate in terms of recording of age/sex of birds.	Poor in terms of identifying unobtrusive species. Poor to moderate in terms of identifying to species level (depending on species). Poor in terms of recording of age/sex of birds.
Links to environmental factors	Moderate with simultaneous collection of oceanographic data.	Good – accurate relative density information can be correlated with environmental variables.
Behaviour	Moderate – possible under certain circumstances (feeding, movements between roosts, flight heights) although influence of presence of boat needs to be established.	Poor – not suitable for behaviour, flight height or direction.

Guidance on Survey and Monitoring in Relation to Marine Renewables Deployments in Scotland - Scottish Natural Heritage

Scottish Natural Heritage (SNH) and Marine Scotland had this guidance document created as a recommendations document of the techniques for surveying and monitoring wave and tidal marine renewable energy sites in Scottish waters. The "recommendations document" status attached to the document is due to the fact that it is still in a draft stage with consultations regarding its format, structure and key issues discussed. This document provides detailed information on several aspects relating to the deployment of wave and tidal devices. The most valuable aspects of this document for the purpose of this report are the discussions of the techniques used to establish a suitable baseline characterisation, considering the species and habitats present, and the collection of relevant robust baseline information to aid the EIA of the development. The document is split into five volumes; the first volume sets the general concepts and principles and is classified as an overview. This is followed by dedicated volumes on: cetaceans & Basking sharks, seals, birds and the benthic habitat.

Volume 1: Context & General Principles (Trendall *et al.* 2011)

This volume discusses the major opportunities within Scottish waters regarding offshore renewables and the fact that in the future there will be a large number of projects within their waters. It is emphasised that baseline surveys are required to gain an understanding of the habitat and species using the area of the development site; this understanding will be used to help decision making in the consents process. It is also required to provide a reference point against which any changes within the natural habitat can be compared to. Trendall *et al.* (2011) warns that it may be a "waste of time" and lead to inadequate data collection if the questions which will be asked of the development by the regulator are not considered. The questions which should be considered prior to planning surveys are:

- Is there sufficient data for the main receptors to identify the habitats and species present, their distribution and the use of the site?
- Is initial data collected to act as baseline for future comparison or simply to characterise the site?

- Using current knowledge, which receptors will require on-going monitoring and which receptors will only require a single description to enable assessment of potential impacts?
- What metrics will be measured for monitoring purposes and why?
- Will the data collected suitable to enable any changes over time to be measured?

Consideration of these questions whilst planning the survey work will vastly improve the data collection process and support the consenting process (Trendall *et al.* 2011). It is stated that the minimum time period for baseline studies considered suitable by the SNH is two years; this is deemed to cover temporal and seasonal variation for mobile species (Trendall *et al.* 2011). It should be noted that the stated minimum of two years' worth of data may not be suitable in allowing annual variation to be observed. Longer term surveying may however lead to a waste of resources as the data collected may still not provide the opportunity for such analysis (Trendall *et al.* 2011).

The impact that the size of a site has on the survey technique is discussed and vital points are raised with regards to placement of devices within the site. The baseline surveying is recommended to encompass the site as a whole, rather than the specific deployment area: this in an effort to locate the most environmentally suitable area (Trendall *et al.* 2011).

If the data collected is to act as a baseline against which future monitoring is to be compared, it is vital to consider the monitoring strategy. It is recommended in this document that a Before-After-Gradient (BAG) approach to monitoring is utilised for mobile species, but not the benthic habitat, due to the natural diversity of the seabed (Trendall *et al.* 2011). This recommendation comes following a discussion regarding the problems of control site based monitoring approaches, mainly the difficulty of finding a suitable control site and problems associated with the large area coverage of mobile marine species. The BAG approach is considered useful for identifying the extent of habitat loss and species displacement. BAG monitoring requires samples to be taken at set intervals from the site in order to monitor any changes on a gradient away from the site. The main recommendation from Trendall *et al.* (2011) is to seek professional statistical advice regarding the details of the BAG survey design.

Volume 2: Cetaceans & Basking Sharks (Macleod *et al.* 2011)

Again, the initial recommendation prior to any survey work is for a desk study to be carried out in order to gain knowledge of the animals in the area and to help plan survey work. Macleod *et al.* (2011) suggest that the main data which should be collected is that of species present and the abundance and distribution of these species. The techniques used for data collection also allow for habitat use to be calculated if data is interpreted appropriately. The main techniques suggested and discussed in the document are detailed in Table 2.

Table 2: Techniques for collecting various forms of data relating to Cetaceans (C) and Basking Sharks (BS) at wave and tidal energy sites (Macleod *et al.* 2011). AAM – autonomous acoustic monitoring.

	Strandings	Vantage Point	Line Transect Surveys	Towed Array	AAM	Photo ID	Telemetry
Species Present	C + BS	C + BS	C + BS	C	C		
Density/ Abundance		C + BS	C + BS	C	C		
Habitat Use		C + BS	C + BS	C	C	C	BS

The document has the benefit of being produced following a publication commissioned by the Crown Estate (SMRU, 2010) regarding approaches to the study of marine mammals in relation to marine renewable energy developments. The Crown Estate report will be discussed in the Specific Guidance Documents section of this report, therefore only the advice relevant to Basking sharks will be discussed in this section. It should be noted that Macleod *et al*. (2011) have, in majority, directly copied the tables regarding pros and cons from the SMRU (2010) report, highlighting its strength as a standalone guidance document.

Macleod *et al.* (2011) state that Basking shark surveys vary hugely in terms of the technique used. The main issue associated with the use of visual surveys is that they are dependent on the animal being visible. This is said to lead to biases in assessment as there is a lack of understanding of Basking shark behaviour, for example it is unknown if they exhibit basking behaviour in all habitats. Their behaviour is known to change between well stratified areas and tidal fronts (Sims *et al.* 2005), a prime example where sightings data will differ. A specific technique discussed to analyse Basking shark behaviour is telemetry. No direct recommendations are made with regards to implementation of a telemetry survey of Basking sharks. However, it is stated that in current telemetry studies, the number of animals studied is small and in order to have adequate data for a renewable energy development there would be a need an increase in effort (Macleod *et al.* 2011). It should be noted that the techniques of vantage point and transect line surveys discussed in the document by SMRU (2010) are recommended for use in surveying Basking sharks.

Volume 3: Seals (Sparling *et al.* 2011)

The value of this volume of the document is greatly enhanced by the fact that it was produced partly by the Sea Mammals Research Unit (SMRU). Again this volume has a lot of similar material to the document commissioned by the Crown Estate (SMRU, 2010) which was written by the SMRU, however more specific detail on techniques and their advantages and disadvantages for seal monitoring is provided.

The first recommendation is to carry out a desk study in order to identify data gaps and plan future surveys. Sparling *et al.* (2011) state that the information required for an initial baseline understanding of seal activity in the vicinity of a marine renewable energy deployment is as follows:

- Which species are present
- Their distribution and abundance on land and at sea
- Their movements in and around the site
- Their uses of the land and sea in the area of the site
- The variations in the above information for between tides, seasons and years

The techniques suggested are used in order to acquire this information are highlighted in Table 3. Aerial surveys of haul out sites are said to be a cost effective technique of surveying if a large area is to be covered. It enables seals to be counted quickly and identified without influencing their behaviour. Land or boat based counts of haul out sites are however stated as the technique most likely to be utilised. Although easily repeatable, this technique is limited by tides and weather, and may disturb the seals.

Haul out site counts are recommended to be carried out monthly to gain information on seasonal variation (Sparling *et al.* 2011). Vantage point surveys are considered useful for gaining information on the species present and how their numbers vary with time of day and tidal cycles. Further useful information which vantage point surveys can provide is distribution data, which may influence the positioning of device in order to minimise the impact on important areas for local seals (Sparling *et al*. 2011). Vantage point surveys are considered cost effective in comparison to other methods but are limited by the fact that the vantage point must be within 1-2km of the site (Sparling *et al.* 2011). The advantages of using line transect surveys are discussed, with boat and aerial techniques considered. The main advantages of this type of survey are that density and abundance can be calculated along with providing information on distribution. The disadvantages include the potentially high costs, weather restrictions and most importantly, there is limited use to the seal data collected (Sparling *et al.* 2011).

The use of high definition (HD) photography during aerial surveys of marine mammals is mentioned but due to issues such as inability to distinguish between seal species, it is currently not recommended as the main survey method (Sparling *et al.* 2011, SMRU, 2010). Photo ID is discussed as a useful, non-invasive technique to monitor the individuals within a species. This technique is considered useful as it enables information to be gathered about the individuals in the population, such as reproduction rates (Sparling *et al.* 2011). This could be useful as baseline information against which any potential changes can be compared. Telemetry is considered a very useful technique for monitoring seals as it provides important information on habitat use (Sparling *et al.* 2011). Examples of relevant information which can be provided through telemetry studies are: usage maps, behaviour (can be useful for calibration of haul out counts) and links between individual haul out sites and the development area (Sparling *et al.*2011). It should be noted that in order to make population estimations a large enough sample group should be tagged, a minimum of 10-12 individuals is recommended. A further important detail is that such work requires a license under the Animal (Scientific Procedures) Act 1986 and specifically trained personnel (Sparling *et al.* 2011).

Full details of the modifications for wave and tidal developments made by Sparling *et al.* (2011) to the SMRU (2010) tables of the advantages and disadvantages of certain techniques for surveying seals can be found in Appendix 1.

Table 3: Techniques for collecting various forms of data relating to seals at wave and tidal energy sites (Sparling *et al*. 2011)

	Aerial surveys of haul out sites	Land/Boat counts of haul out sites	Vantage point surveys	Boat based line transect survey	Photo ID	Telemetry
Species Present	✓	✓	✓	✓		
Density/Abundance	✓	✓		✓	✓	
Habitat Use			✓		✓	✓

Volume 4: Birds (Jackson & Whitfield, 2011)

Jackson & Whitfield (2011) state that there are generic and specialised techniques to use in order to establish baseline information regarding birds at a marine renewable energy deployment site. Standard techniques for surveying birds at sea are considered to be land based vantage point surveys and line transect survey either by boat or plane; these are used to gather abundance and distribution data (Jackson & Whitfield, 2011). For these techniques, the use of the Camphuysen *et al*. (2004) and the Maclean *et al*. (2009) documents are recommended. More specialised techniques are required to gather specific bird information from, for example, breeding sites (Jackson & Whitfield, 2011).

Choice of which technique to use is dependent primarily on site characteristics but also on the objectives of the survey and the data available. Jackson & Whitfield (2011) state that if a site is more than 1.5km from land, the use of boat based surveys is more suitable than a vantage point surveys due to human visual restraints. The latter are however considered useful if the entire site is within 1.5km of a suitable vantage point (Jackson & Whitfield, 2011). Aerial surveys, both observer and digital imaging techniques, are generally not used on small sites for frequent sampling; this is however thought to be due to the costs involved (Jackson & Whitfield, 2011). The main advantage of this technique is stated to be the opportunity to survey in difficult environmental conditions including strong tides and poor weather, which are unsuitable for boat based surveys (Jackson & Whitfield, 2011). It is recommended that the technique to be used is chosen at the beginning of the whole project, following the suitability checks, and is replicated at all stages of monitoring (Jackson & Whitfield, 2011).

Should more detailed information regarding bird behaviour be required, specific surveys techniques such as those from land or boats can be used or more advanced methods such as telemetry or radar studies may be deemed appropriate. Tagging studies are said to be particularly useful in providing information which could link activity between the proposed development site and other sites, for example an SAC or important breeding area. Known bird breeding areas should be surveyed using the guidelines set out by Walsh *et al.* (1995); Jackson & Whitfield (2011) state that fledgling counts are a useful method for determining population productivity. It is recommended that the response to human activity, along with the occurrence of dead birds washed ashore, is measured prior to the commencement of any construction activities (Jackson & Whitfield, 2011). This is in order to provide additional information which will increase the strength of the baseline data collected. With regard to beached dead birds, surveys should be well organised and note cause of death where possible. Detailed information on the occurrence of beached dead birds is available from the RSPB (RSPB, 2013).

Volume 5: Benthic Habitats (Saunders *et al.* 2011)

Saunders *et al.* (2011) quote the recommendation given by the Scottish Executive (2007) Strategic Environmental Assessment regarding the collection of baseline data for the benthic habitat. It is recommended by the Scottish Executive (2007) report that benthic data is collected to gain information regarding the benthic ecology at the site, to avoid sensitive areas during site selection and to provide information against which any potential impacts can be compared. It is stated that a successful benthic baseline assessment should provide:

- A map of the seabed detailing the substrate type and its distribution
- A large scale map of biological communities or biotopes
- Precise details of any protected or important species within the area

- Details of potential monitoring targets and any possible obstacles limiting the use of certain techniques

A valid point is raised by the authors regarding choice of survey technique. The techniques which will be utilised are likely to be chosen by cost, the expected substrate type and the physical conditions, rather than device type (Saunders *et al* 2011). A general recommendation to reduce cost, time and effort is made regarding combining data collection efforts for compatible surveys. Acoustic seabed data is needed for biological and physical investigations and it is recommended that the data is collected considering both investigations, where possible.

An acoustic survey of the proposed site using the International Hydrographic Organisation standards (IHO, 2008) is recommended. In terms of the acoustic techniques to use, swath bathymetry measurement combined with an acoustic ground discrimination system is suggested as being most effective for providing suitable baseline data (Saunders *et al.* 2011). It is stated that the acoustic survey should encompass the entire site along with a buffer zone and a control site. Following the collection of the acoustic data, it is considered essential that the data is ground truthed (verified) using various benthic sampling techniques.

Considered as the primary method for ground truthing, grab samples are suggested for use on course sediment. Saunders *et al.* (2011) name the three most commonly used grabs as: the van Veen grab – a good all-round option, the Day grab – efficient and simple to use, and the Hamon grab – particularly effective in loose, coarse sediment. The data collected in the grabs can be used to calculate species abundance and diversity, along with allowing biotopes to be assigned to defined areas. Particle size analysis (PSA) and chemical analysis on substrate samples is also recommended. Saunders *et al.* (2011) recommend that details of raw data are kept as these may be used as part of the baseline data. It should be noted that difficulty occurs when deploying grabs in fast currents or large swells, as this hinders the quality of the data collected.

Drop-down video is the considered the method of choice by the authors for ground truthing acoustic data: it is fast, almost non-destructive, easy to use and with the advances in imaging quality and data storage it is recommended as a cost-effective technique (Saunders *et al.* 2011). A disadvantage of this technique is that the quality of the data collected may deteriorate in strong tides and high swells (the use of stills photography can be used to counteract this). This technique may initially be used as part of a general observation of the seabed to map biotopes and habitats. Following this, it can be used to gather presence, abundance and distribution data along with precise information about the substrate; this substrate information can also be used to plan grab surveys should they be required (Saunders *et al.* 2011).

The use of remotely operated vehicles (ROVs) is discussed in terms of determination of species present, habitat and biotope identification and substrate distribution. This technique is said to be useful for steep or vertical substrates or if precise positional stability is required. However, for environmental surveys it is considered to have few advantages over the drop-down video technique (Saunders *et al* 2011). The use of diver sampling surveys is discussed and it is this technique which is said to provide the best level of taxonomic detail along with good epifaunal and digital image data (Saunders *et al.* 2011). This technique is however limited by safety and financial issues; divers may only operate up to certain depths and are very limited by local environmental conditions such as strong currents (Saunders *et al.* 2011).

Two main survey designs were discussed relating to the majority of the techniques mentioned: the use of a grid to choose sample sites or random sampling. If a grid is used and evenly spaced sample stations are selected, a continuous distribution across the site can be presented; a random sampling approach is however recommended as a baseline for future monitoring as it is statistically more robust (Saunders *et al.* 2011). This may involve sampling over the entire site, depending on its size, or is more likely to be random samples taken within defined areas of similar substrate or habitat (Saunders *et al.* 2011). A further technique discussed by the authors is the use of a belt transects which surveys along the line of the predicted impact zone. This, when compared to future monitoring surveys, produces a gradient of the impact from the development site to the extent of the impact zone. This technique was however not recommended by Trendall *et al.* (2011) in Volume 1 of this document.

Guidelines for Data Acquisition to Support Marine Environmental Assessments of Offshore Renewable Energy Projects - Judd, 2012

CEFAS were commissioned by the MMO to create this guidance document relating to data acquisition for environmental assessments of offshore renewable energy projects. The MMO wanted the document to essentially be a "how to do it" manual and to cover all aspects of the project lifeline (Judd, 2012). This guidance document from CEFAS, the most recent of its kind, is mainly aimed at the offshore wind industry but does include relevant information for other offshore renewable energy projects. It describes the techniques used for data acquisition and often refers to and suggests the study of well-established guidance documents for specific study topics. The document is part of a proposed initiative by the Offshore Renewable Energy Licensing Group (ORELG) to produce best practice guidelines for the industry (MMO, 2013b). The ORELG is chaired by the MMO and comprised of industry representatives, regulators, government bodies and examining authorities (MMO, 2013b; Judd, 2012); full details of the ORELG members and general information regarding the group can be found on the MMO website (MMO, 2013b).

Judd (2012) discusses the fact that the terms site characterisation and baseline data collection are often interchanged; he goes on to accurately define both in order to avoid misinterpretation and errors in data collection. Baseline data is a set of "defined parameters against which change can be measured" and therefore requires multiple samples to enable statistical analyses to be carried out. Site characterisation is a description of the environment and therefore does not require several samples for statistical analyses (Judd, 2012). Considering the definitions stated by Judd (2012) it could therefore be assumed that baseline data acquisition surveys follow similar approaches to site characterisation surveys only with larger sampling in order to allow for statistical analyses. Judd (2012) also states that should there be a significant time period between baseline data collection and commencement of construction, it is suggested that the data be updated or completely recollected.

Benthic Sampling

Judd (2012) states that for site characterisation, the information required is as follows: a broad scale description of the seabed of all site areas, identification of species and habitats of significance and an understanding of the seasonal, temporal and spatial variations. It is then recommended that the information gathered during characterisation is used to plan the baseline data collection survey.

The information regarding benthic sampling techniques is taken from the Ware & Kenny (2011) Marine Aggregate Extraction Levy Sustainability Fund (MAELSF) guidelines on benthic sampling document, previously mentioned in this report. As the details of the Ware & Kenny (2011) guidance document will be discussed in the Specific Guidance Documents section of this report, only the techniques discussed by Judd (2012) will be mentioned in this section. An acoustic survey is detailed as the primary stage of surveying, followed by grab and trawl surveys or drop-down video surveys, dependent on the substrate identified by the acoustic survey (Judd, 2012). A precise description of equipment and techniques is provided as part of the annexes of the document.

In order to allow for future statistical analyses to identify any changes in the habitat, sampling stations need to be established. Sampling stations are recommended throughout the project area including the defined site, the cable route and a buffer zone (Judd, 2012). Survey design is discussed, with recommendations coming from the MAELSF guidance document (Ware & Kenny, 2011).

Fish & Shellfish

The guidance and recommendations given by Judd (2012) are the same as those given in the CEFAS (2004) document discussed at the beginning of this section; with the main focus suggested to be on ecology and life stages present within the area. An emphasis is put on the involvement of the local fishing industry in the project from as early a stage as possible. One update to the CEFAS (2004) guidelines is that dispensation for the use of non-regulation mesh sizes to survey nursery grounds is now required from the MMO, rather than DEFRA (Judd, 2012). In depth details of the questions which should be considered prior to and once data has been collected for site characterisation are highlighted in Table 4.

Marine Mammals

This document has the advantage of being published following the dedicated guidance document regarding marine mammal monitoring (SMRU, 2010) created by the SMRU for the Crown Estate. As a result of this, the key aspects of the report by SMRU (2010) are discussed and presented by Judd (2012). Judd (2012) states the data considered relevant to collect for site characterisation as:

- A description of the distribution and abundance of species within the entire development area
- A description of any locally abundant or important species identified
- A description of the distance to haul out sites close to the development area

The specific marine mammal monitoring guidance document (SMRU, 2010) will be discussed in the Specific Guidance Documents section of this report. Judd (2012) raises a key point regarding the quality of the data collected, especially that of abundance data. Relative abundance or absolute abundance may be calculated, the type of data collected is dependent on the technique used. Relative abundance is a measure of the number of individuals detected per unit of sampling effort; this type of data is the cheaper of the two to collect and when methods are kept consistent, may be used as the baseline data set (Judd, 2012). Absolute abundance is considered the more useful data set as it is a population estimate giving the number of individuals per unit area; it is however more expensive (Judd, 2012). The author also discusses the importance of studying the background levels of underwater noise as these are closely linked to marine mammal behaviour; this is however not part of this report.

Table 4: Information which should be considered during the characterisation of fish & shellfish of the development area. Taken from Judd (2012).

What species of fish and shellfish are present at the site and surrounding area?
• Which of these species are of high importance in commercial and/or recreational fisheries? • Which of these species are of high conservation importance? • Which of these species is of high importance as prey to species of commercial and conservation importance? • Are there any other species that are locally abundant in the area?
For those species of commercial and recreational importance:
• Are there locally important spawning grounds? • Are there locally important nursery grounds? • Are there locally important feeding grounds? • Do their migration routes pass through the area? • Are there locally important areas for their prey species?
For those species of conservation importance:
• Are they present in the area, and if so how abundant are they? • Do they have any critical habitat in the area, or are they occasional vagrants?
If a species has spawning grounds in the area:
• When does the species spawn? • Will construction affect the physical habitat used by egg-laying species? • How will construction activities least impact on spawning behaviour and the physical nature of spawning grounds? • What is the relative importance of the area in the context of the wider spawning area for each species?
If a species has a nursery ground in the area:
• What is the relative importance of the habitat for the species in the region as a whole? • Will wind farm construction reduce available habitat or enhance the habitat?
If a wind farm site is in close proximity to an estuary:
• What is the status of diadromous fishes in the area? • Will the site pose a serious threat to the migratory pathway of diadromous fish, taking other estuarine and coastal developments into consideration? • What are the timings of migrations through the site? • Is the site important for estuarine fish species for spawning, such as the flounder, which spawn in the open sea?

Ornithology

Judd (2012) emphasises that the study of local ornithology as a whole, rather than just the study of marine birds, is essential as there are species which use both the marine and terrestrial environments at different stages throughout the year. In terms of site characterisation, a broad description of the distribution and abundance of seabird and migratory birds is required, along with the identification of important species. This information should take into consideration spatial, temporal and seasonal variations (Judd, 2012). For precise guidance information on collecting this data it is recommended that Camphuysen *et al.* (2004) and Maclean *et al.* (2009) are consulted; both these documents will be discussed in the Specific Guidance Documents section of this report.

Judd (2012) discusses the traditional approaches as being boat based and aerial surveys, with a combination of the two often providing the best data. The recommendation for ornithological surveys from the UK SEA is stated by Judd (2012) as being a minimum of 2 years' worth of survey data from monthly boat surveys throughout the year and 8 aerial surveys per year – 3 in the winter months and 5 in the non-winter months. A final statement which is reiterated by the author is that prior to any survey work, including the design of a survey, the statutory nature conservation agency should be contacted for advice (Judd, 2012). This is particularly important as aspects of any guidance documents may be considered out of date.

The use of high definition photography and video deployed from aircrafts is also discussed by Judd (2012); due to recent advances in research, this technique has been used to survey the larger Round 3 offshore wind farm sites. Judd (2012) states that there is a necessity for precise survey protocols to be established to enable this technique to be utilised frequently to survey birds; details of this technique will be discussed in the Specific Guidance Documents section of this report.

3. Specific Guidance Documents

Benthic Sampling

In terms of benthic sampling at offshore renewable energy developments, the majority of the guidance has identified the lack of industry specific guidance documents. The main recommendation from the documents reviewed has been to use the guidance documents created by the Marine Aggregate Extraction Levy Sustainability Fund (MAELSF) regarding the conduct of benthic studies at extraction sites (Ware & Kenny, 2011; Boyd, 2002). Also of interest is the study of Eelgrass beds in relation to an offshore renewable energy development, carried out by Lundgren (2010). Details of the baseline techniques used for the study are discussed.

MAELSF - Guidelines for the Conduct of Benthic Studies at Marine Aggregate Extraction Sites, 2nd Edition - Ware & Kenny, 2011

This document is an updated version of the 1st edition, published in 2002, which was used by many offshore wind farms as guidance documents. At its time of publishing, it was considered to be the “best practice” guidelines for undertaking benthic surveys in British water (Ware & Kenny, 2011). The document is particularly useful is in its advice on survey design and the various techniques which can be used.

Survey Design

Ware & Kenny (2011) state that prior to any baseline survey work, characterisation work should be carried out. This should include an acoustic survey followed by single ground truthing samples; this is then used to plan the baseline survey work. Details of various acoustic mapping systems which may be used can be found in Appendix 2. It is recommended that survey work is carried out between February and April in order to avoid key stages for fish larvae (Ware & Kenny, 2011).

Following the characterisation survey, the status of the seabed will have been identified. Ware & Kenny (2011) classify the seabed as either: heterogeneous - with distinct biotopes; or homogeneous - with no distinct biotopes. For a heterogeneous seabed, random stratified sampling is recommended. This involves taking several samples from a predetermined sample area, within the varying biotopes which have been identified by the characterisation survey (Ware & Kenny, 2011); an example of this can be seen in Figure 2. For a homogeneous seabed, transect stratified random sampling is recommended; samples are taken from within predetermined areas along a transect from the point of interest. If there is a strong tidal influence, transects are recommended to follow the path of the current as this is the most likely zone of any impact (Figure 3). If however, there is likely to not be a clear gradient along which impacts may occur, a systematic radiating grid format should be adopted (Figure 4) (Ware & Kenny, 2011).

The number of samples taken from each area is site and time specific and is dependent on two factors: the level of statistical analysis required and the sensitivity of the habitat. Enough samples should be collected to be able to identify a change; however a balance must be reached as too many samples may have a negative effect on the seabed habitat (Ware & Kenny, 2011). Communication with the advisory body is suggested to decide upon replicate numbers. If a year passes between sampling and the commencement of any work in the area, it is recommended that up to date data is collected (Ware & Kenny, 2011).

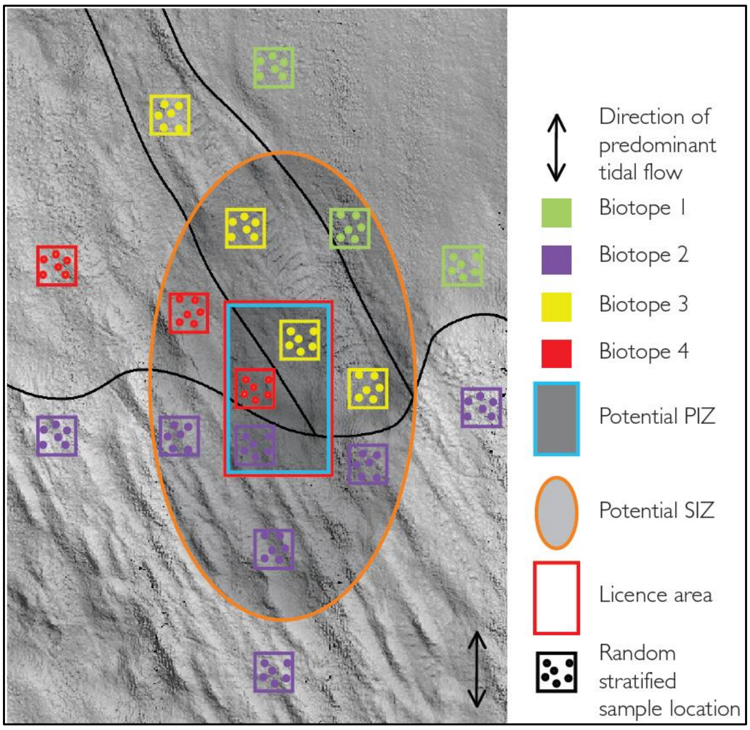

Figure 2: Example of random stratified sampling of a heterogeneous seabed. PIZ – Primary Impact Zone, SIZ – Secondary Impact Zone. Taken from Ware & Kenny, 2011.

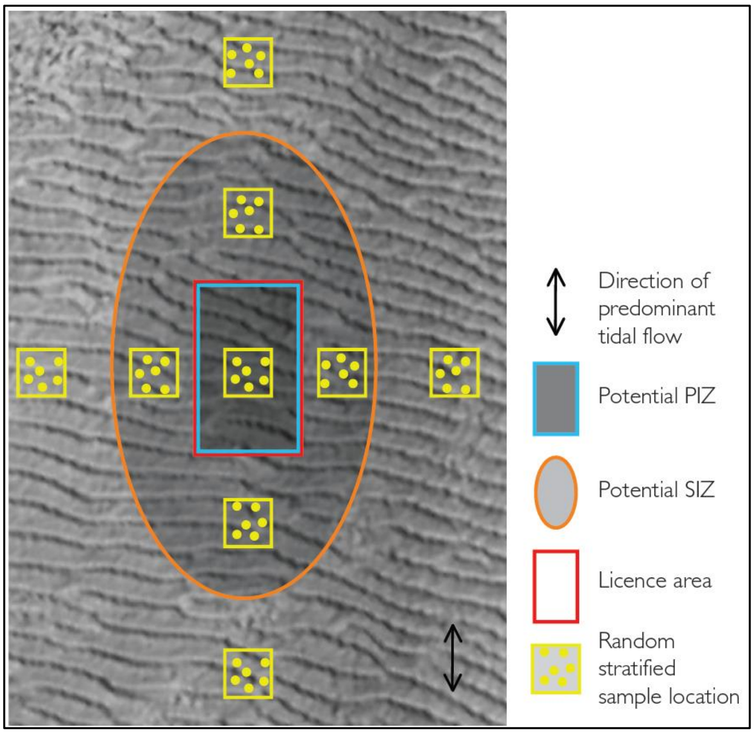

Figure 3: Example of transect stratified random sampling of a homogeneous seabed. PIZ - Primary Impact Zone, SIZ - Secondary Impact Zone. Taken from Ware & Kenny, 2011.

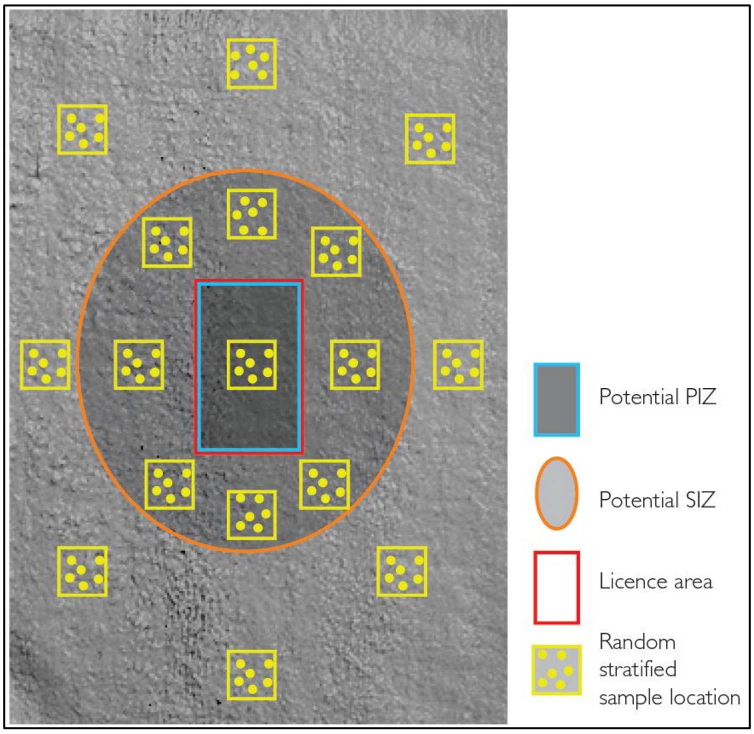

Figure 4: Example of systematic grid stratified random sampling of a homogeneous seabed. PIZ – Primary Impact Zone, SIZ – Secondary Impact Zone. Taken from Ware & Kenny, 2011.

Optical Techniques

The use of underwater optical techniques is stated as a "valuable, non-destructive" technique which may be used to sample any substrate; though is most useful on hard substrates where other equipment is unable to sample (Ware & Kenny, 2011). This technique is considered particularly useful in areas where there are sensitive or commercially important species. Optical techniques come in four categories: remotely operated vehicles (ROVs), sediment profile imaging cameras, drop-down stills cameras and drop-down video sleds. Drop-down video and photography methods are stated as the most commonly used; however, ROVs have the advantage of manoeuvrability which may make them more useful in certain circumstances (Ware & Kenny, 2011). Drop-video was used as part of the Mapping European Seabed Habitats (MESH) project and therefor precise details and protocols can be accessed through the project publications (Coggan *et al.* 2007).

Grabs

Grabs are used to sample the substrate and infauna of seabed habitats in areas which are not rocky. These devices vary in terms of the substrate they are suited to and also in the way they collect the sample (Ware & Kenny, 2011). These devices, though useful for providing information on the seabed habitat, have their associated disadvantages: they cannot sample on hard substrate, they only capture a small area sample, they cannot sample fast moving species and samples can easily be rendered invalid if the closing mechanisms becomes jammed (Ware & Kenny, 2011). Ware & Kenny (2011) detail the most commonly used grabs, with their general attributes detailed in Table 5.

Table 5: Description of the most commonly used grabs for sampling the seabed. Taken from Ware & Kenny, 2011.

Sampling Device	Surface Area Sampled	Approximate Weight	Suitable for coarse sediments
Mini-Hamon Grab	0.1 m^2	300 kg	Yes
Day Grab	0.1 m^2	80 kg	No
Small van Veen Grab	0.1 m^2	80 kg	No
Costerus Grab	2 x 0.1 m^2	400–480 kg	Yes

The Mini-Hamon grab is the device most commonly used for sampling coarse sediments. It is a cost effective, robust and easy to use grab and with the standard sample volume of $0.1m^2$, it is comparable to other devices (Ware & Kenny, 2011). The Day grab is considered best suited to the sampling of soft sediments such as sands and muds. It is able to collect the standard volume of sediment up to a depth of 14cm (Ware & Kenny, 2011). The small van Veen grab is commonly used for sampling benthic macrofauna in soft sediments (Judd, 2012). The Costerus grab is a newly developed grab aimed at sampling all sediments but in particular course sediments. It collects two samples of $0.1m^2$ which enable infauna and sediment analysis samples to be collected simultaneously whilst maintaining compatibility with other sampling devices. Its use of air pressure to operate the grab mechanism makes it particularly effective (Ware & Kenny, 2011).

Trawls

The use of trawls is discussed in terms of sampling the epifauna present at a site. Trawls are considered useful, though their variance in application means that data quality is often lower than would be hoped for (Ware & Kenny, 2011). A combination of techniques may be the most effective way for sampling epifauna as not all methods are suitable for all habitats. Again, there are precise details and protocols for the use of trawls detailed in the MESH project documents (Curtis & Coggan, 2006).

The only trawl device discussed in detail by Ware & Kenny (2011) is the 2m beam trawl, though an anchor dredge and rock dredge are mentioned. The 2m beam trawl, which may be referred to as the Jennings or Scientific 2m beam trawl, is the most commonly used trawl for sampling epifauna on various sediment types. It is considered easy to deploy and usually collects an appropriate sample size; therefore it is recommended by the authors for sampling epifauna (Ware & Kenny, 2011).

Lillgrund Offshore Wind Farm - Environmental Monitoring of Marine Flora & Fauna – Eelgrass Beds - Lundgren, 2010

Within close proximity of the Swedish Lillgrund offshore wind farm are eelgrass beds. Eelgrass beds can act as: spawning areas for fish, nursery grounds for young fish, feeding areas for birds and primary coastal protection (Lundgren, 2010). As this habitat is one of such importance, an environmental monitoring plan was established in order to note any impacts to the habitat. In order to monitor the health of the eelgrass beds, surveys were carried out by divers and certain parameters were recorded in situ along with samples being taken for laboratory analysis. The monitoring program recorded: shoot density; carbohydrate levels in roots; shoot length; area coverage by eelgrass; biomass and various environmental parameters. Baseline surveys were carried out over five years, with samples taken in early summer and primarily in late autumn (Lundgren, 2010).

Techniques Used at Offshore Renewable Energy Development Sites for Benthic Surveys

As mentioned by Ware & Kenny (2011) and also Saunders *et al*. (2011), the techniques utilised for data collection is primarily dependant on the environmental characteristics of the site in question, rather than development type. Table 6 highlights the techniques used at various offshore development sites, from wind farms to wave and tidal sites (CEFAS, 2010; Natural Power, 2013; Henson, 2010; RWE, 2012; Royal Haskoning, 2011; Moore, 2009). The use of the Day grab featured strongly, primarily due to the fact that the majority of the first offshore wind farm sites were situated in shallow waters with sandy substrates. Drop-down video use is seen at the two tidal sites and also the Atlantic Array, this is likely due to the fact that substrates at sites with high tidal velocities may be tidal swept rocky habitats – unsuitable for grabs. As is visible from Table 6, the only technique used for sampling benthic epifauna was the 2m beam trawl.

Table 6: Benthic survey techniques at various offshore renewable energy development sites. WF - Wind Farm

Offshore Renewable Energy Development Site	Techniques Used
North Hoyle - WF	Day grab, 2m Beam trawl
Burbo Bank - WF	Day grab, 2m Beam trawl
Barrow - WF	Day grab, 2m Beam trawl
Scroby Sands - WF	Day Grab, 2m Beam trawl
Robin Rigg - WF	Day Grab
Kentish Flats - WF	Hamon grab, 2m Beam trawl
London Array - WF	Hamon Grab, 2m Beam trawl
Atlantic Array - WF	Hamon Grab, 2m Beam trawl, drop-down video
Strangford Lough - Tidal	Diver surveys, drop-down video
Pentland Firth - Wave & Tidal	Drop-down video & photography

Fish & Shellfish

No individual specific guidance documents relating to fish and shellfish data collection were extensively referenced in the general guidance documents previously reviewed. CEFAS (2004) along with DEFRA (2005) provided a very in depth guide as to the data which should be gathered to establish a baseline understanding of the fish and shellfish communities at offshore renewable development sites. The strength of these guidelines is emphasised by the fact that Judd (2012), though several years later, stated the same guidelines for fish and shellfish surveys.

Techniques Used at Offshore Renewable Energy Development Sites for Fish & Shellfish Surveys

It is recommended that the techniques used at offshore development to characterise fish and shellfish primarily mimic the commercial activities in such areas (CEFAS, 2004; Judd, 2012). As can be seen from Table 7, a vast range of techniques have been used at a number of offshore renewable energy development sites. An important fact which should be mentioned is the appointment of project specific fisheries liaison officers at the Atlantic Array and Lynn & Inner Dowsing wind farm sites. The previously discussed guidance documents (CEFAS, 2004; Judd, 2012) recommend early interaction with the fisheries industry; a dedicated fisheries liaison officer is a very useful tool to facilitate this interaction.

Table 7: Techniques used at offshore renewable energy developments for surveying fish & shellfish. WF - Wind Farm

Offshore Renewable Energy Development Site	Techniques Used
Barrow - WF	2m beam trawl and Otter trawl
Kentish Flats - WF	2m beam trawl, Oyster dredge, Oyster contaminants surveys
Gunfleet Sands - WF	2m beam trawl and Otter trawl
Rhyl Flats - WF	2m beam trawl
Thanet - WF	2m beam trawl and Otter trawl
Lyn & Inner Dowsing - WF	2m beam trawl, Otter trawl, shrimp trawl, long lines, potting and mussel dredge
Atlantic Array - WF	2m beam trawl, Otter trawl, whelk potting, crab potting and bongo nets (fish larvae)

Marine Mammals

The study of marine mammals around offshore renewable energy developments has become one of the most important aspects of the EIA process. Specific guidance documents regarding the surveying and monitoring of marine mammals have been published by COWRIE (Diederichs *et al,* 2008) and the Crown Estate (SMRU, 2010). Scientific studies have also established guidelines for acoustic monitoring techniques (Verfuß *et al*. 2010) as well as verifying the use of a combination of techniques to monitor various marine mammals and megavertebrates (Leeney *et al*. 2012).

Methodologies for Measuring and Assessing Potential Changes in Marine Mammal Behaviour, Abundance or Distribution Arising from the Construction, Operation and Decommissioning of Offshore Windfarms - Diederichs *et al,* 2008

The authors of the document combine their experience from German and Danish offshore wind farm monitoring to analyse the techniques available for surveying marine mammals. In terms of baseline monitoring recommendations, calculation of species abundance using visual line transect surveys - either aerial or boat based - are considered a "standard requirement". The use of static acoustic monitoring devices is recommended and the surveying is recommended to be done monthly for 1-2 years in order to cover seasonality. In terms of survey design, a Before-After/Control-Impact (BACI) is recommended; this is where a suitable control site is identified (Diederichs *et al.* 2008) and any changes noted at the development site can be compared to the control site.

With regards to the specific methods, aerial surveys are stated as the most commonly used technique for gathering baseline information for German offshore wind farms. They are considered to provide the highest probability to gather enough data; however, they are restricted by weather and the small scale resolution of the data may not be adequate (Diederichs *et al*. 2008). The use of boat based surveys complemented by towed hydrophones is recommended to increase the efficiency of the survey. These surveys are also limited by weather and cover smaller areas, though are considered as standard for marine mammal monitoring (Diederichs *et al.* 2008). Double platform boat based survey are stated as providing more accurate data, though are not recommended for small sites where fewer than 60 sightings will occur (Diederichs *et al.* 2008). Advantages of using the towed hydrophone technique include the opportunity to survey at night or adverse weather conditions and a smaller boat may be used (Diederichs *et al.* 2008). The use of static acoustic monitoring devices is recommended as an efficient way to survey vocalising cetaceans. Although this technique does not provide abundance data, it a useful technique which is not limited by weather and can therefore be deployed for long periods of time. Diederichs *et al.* (2008) recommend that a minimum of 3 devices are used and are regularly rotated in order to reduce any bias created by inaccuracies in specific models. Seal haul out sites counts are also recommended either using aircraft or other methods; these are considered “highly efficient” at generating abundance data and identifying abundance changes (Diederichs *et al*. 2008). Telemetry data is considered as useful for gathering behavioural data and may supplement the line surveys. It is however stated as not being suitable to small scale single projects (Diederichs *et al*. 2008). In depth details about the techniques described by Diederichs *et al*. (2008) are available in Appendix 3.

Approaches to Marine Mammal Monitoring at Marine Renewable Energy Developments - SMRU, 2010

The Crown Estate commissioned the Sea Mammal Research Unit (SMRU) at St Andrews University, Scotland, to create this document and it is the most appropriate document to refer to in terms of surveying marine mammals at renewable energy developments in British waters. Details of all the potential techniques and what type of data they are best recommended for collecting are given, along with advice on what type of data to collect at the various stages of the project. The document also discusses a cost benefit analysis of the various techniques for data collection.

Prior to any data collection, a review of existing data should be done; the SMRU (2010) discuss the potential issues associated with this certain forms of data collected in this way. In terms of existing data, location and sightings data is considered the most useful, though data should be treated with caution. This is because this type of data is dependent on several variables, including the skill of the observer and also where an observer goes. This means that data is limited to where the observers visit rather than providing overall distribution and abundance data (SMRU, 2010). These types of incidental sightings are therefore not considered valuable due to the lack of a protocol, rendering them unreliable (SMRU, 2010). Data collected from the discovery of stranded carcasses should also be treated with caution. This is due to the influences which the ocean has upon these carcasses, meaning that strandings data can be misleading (SMRU, 2010).

With regards to baseline data collection, it is recommended that the species present, along with their temporal and spatial distribution and density are described (SMRU, 2010). The data which is considered most valuable is the density and distribution data. It is stated that this data needs to be collected to a suitable level in order to detect any potential changes during any stage of the project. It is recommended that following baseline data collection and prior to the commencement of any construction work, a reassessment should be carried out on the data collected in order to check whether it is still accurate; if differences are found, there should be a full review of the data. This is important as it may affect the assumptions and statements made in the environmental statement (SMRU, 2010).

Through the cost benefit analysis of the main techniques for data collection, aerial surveys were considered as the most cost effective method compared to boat based surveys (SMRU, 2010). In order to collect accurate data, a double aerial platform survey was highlighted as most effective, though it should be noted that double platform boat based surveys are considered to give the best data, though they are also the most expensive (SMRU, 2010). The pros and cons of boat based and aerial line transect surveys for cetaceans are highlighted in Table 8.

Table 8: Pros and cons of visual line transect surveys of cetaceans. Taken from SMRU, 2010.

Pros	Cons
Line-transect surveys	
• Data allow for estimation of absolute or relative density & abundance • Can provide information on distribution • Can be long-term • Can cover entire range of population	• Often expensive • Restricted by weather conditions and to daylight hours • Variability often high – can be difficult to detect trends • Provide "snapshots" over relatively short time periods
Boat-based surveys	
Offshore and near-shore • Additional data can be collected • Well established and robust methods for assumption violations, especially for large vessels Near-shore only • Small boats can take advantage of good weather in some circumstances	Offshore and near-shore • Large vessels expensive • Responsive movement Near-shore only • Small boats range-restricted • Small boats reduced effective strip width and survey team size/effectiveness for line-transects • Small boats highly constrained by weather
Aerial surveys	
• Fewer issues with responsive movement • Can cover large areas quickly • Can take advantage more readily of good weather windows • May already be taking place to carry out bird surveys	• Logistical limitations • Responsive movement may be a problem for some aircraft types or some species • Height limitations around wind farms

For monitoring Grey seals, the use of aerial surveys photographing haul out sites is discussed. This is considered a useful though expensive method and it is stated that boat based or vantage point counts of haul out sites may suffice (SMRU, 2010). Haul out site counts are recommended to be carried out during the pupping season which occurs in autumn. The use of aerial thermal imaging and photography to survey Harbour seals is discussed; the latter is the more commonly used method due to the high costs of thermal imaging.

The use of telemetry is discussed as a useful technique for gathering behavioural data, highlighting movement paths and important habitats (SMRU, 2010). One issue associated with telemetry is that it is, as previously mentioned, considered as an experiment and requires a license under the Animals (Scientific Procedures) Act 1986 (SMRU, 2010). The pros and cons of these techniques are state in Table 9 and Table 10.

Table 9: Pros and cons of seal monitoring techniques. Taken from SMRU, 2010.

Pros	Cons
Aerial surveys	
• Data allow for estimation of relative abundance (or absolute abundance in association with telemetry data) • Can provide information on distribution (on land) • Should have limited disturbance to haul out site • Can be long-term • Can cover entire range of population • Photographic or video records can be kept for verification after surveys	• Often expensive • Restricted by weather conditions and to daylight hours • Variability often high – can be difficult to detect trends • Time consuming and labour intensive • Land based information only • Health and safety • Responsive movement
Boat-based surveys	
• May be cheaper than air surveys • Data allow for estimation of local relative abundance (or absolute abundance is association with telemetry data) • May be more flexible to local weather conditions	• Range-restricted (limited elevation) • Quality of counts may be poor • Responsive movement • May cause disturbance to site
Land based surveys	
• May cause disturbance to site • Data allow for estimation of local relative abundance (or absolute abundance is association with telemetry data) • May be more flexible to local weather conditions • Could be combined with other fine scale or individual based studies	• Logistical limitations – sites may not be accessible or only partly visible • Quality of counts may be poor

Table 10: Pros and cons of seal telemetry studies. Taken from SMRU, 2010.

Pros	Cons
• Can provide information on movements, migration and range of individuals • Can provide information on behaviour • Can provide information on habitat preferences and areas of special importance • Detailed information on animals without human disturbance (after release)	• Many individuals need to be tagged to make general conclusions • Invasive - potential animal welfare issues from tagging process • Equipment is relatively expensive

Platforms of opportunity for surveying marine mammals come in the form of any vessels with a forward facing platform from which the observations can be made. The SMRU state that potential platforms of opportunity are: ferries, cruise shops, yachts, cargo ships or research vessels such as those studying fisheries or seabirds. It is a cheap technique which utilises trained observers and standard protocols, though due to the fact that the route of the vessel cannot be influenced, the data quality is limited (SMRU, 2010). The pros and cons of this technique are detailed in Table 11.

The use of fixed point surveys is also discussed. These surveys are considered useful in coastal areas where a suitably elevated vantage point is available (SMRU, 2010). Although limited by the observers visual range, normally <5km, this technique can provide useful behavioural data for both cetaceans and seals (SMRU, 2010). The pros and cons of fixed point surveys are highlighted in Table 12.

Table 11: Pros and cons of platform of opportunity surveys. Taken from SMRU, 2010.

Pros	Cons
• Cheap way of collecting data • Can provide good temporal coverage • Data can be used to investigate relative abundance and habitat preference • May be possible to generate density surface maps	• Generally not possible to estimate absolute abundance • Not good for seals • Effort is generally restricted spatially • Un-calibrated responsive movement • No control over the area/region surveyed

Table 12: Pros and cons of fixed point surveys. Taken from SMRU, 2010.

Pros	Cons
• Inexpensive (compared to boat based or aerial methods) • Observers not influencing behaviour of animals • Can provide spatial and temporal data on usage and distribution • Can collected data for seals, cetaceans and sea birds using the same approach • Established analysis frameworks • Can be extended to assess long-term trends	• Generally not possible to estimate abundance • Experienced observes are required • Weather restricted • Need to find a suitable site/vantage point • Often confined to coastal strips or channels

The use of acoustic monitoring is also discussed, with the main techniques being passive acoustic monitoring – towed hydrophones - and autonomous (static) acoustic monitoring. Cornel Pop-Up devices are stated as being regularly used. The most commonly used device in Europe is the POD, which have been used at offshore wind farms in Germany, Denmark and Holland (SMRU, 2010). The pros and cons of acoustic monitoring techniques are detailed in Table 13.

Table 13: Pros and cons of acoustic survey techniques. Taken from SMRU, 2010.

Pros	Cons
Towed hydrophone array	
• Data are independent of daylight and most weather conditions • Can provide high spatial resolution data	• Methods to estimate abundance are only developed for harbour porpoises and sperm whales; species identification is currently difficult for other species • Performance is dependent on the noise level of the vessel • High frequency vocalisations have a limited detection range of approximately 200m
Autonomous data loggers	
• Stationary click detectors provide high temporal resolution • Data collection can be relatively inexpensive • Long-term data sets can be collected • Data can be used to monitor relative abundance if click rates are assumed to be constant over time	• Methods to estimate abundance are not well developed • High frequency vocalisations have a limited detection range of approximately 200m • Devices require retrieval to obtain the data • No background noise compensation • Limited ability for most designs to provide detection range

AMPOD: Applications and Analysis Methods for the Deployment of T-PODs in Environmental Impact Studies for Wind Farms: Comparability and Development of Standard Methods – Verfuß *et al.* 2010

This project was funded by the German Federal Ministry for the Environment, Nature conservation and Nuclear Safety with an aim of developing standard guidelines and methods for the deployment of static acoustic monitors, in particular T-PODs. This document is very useful to aid the deployment of a static acoustic monitoring device, in particular a T-POD or the updated C-POD. A few key recommendations from the document include making sure the devices are accurately calibrated and deployed at the same depth; this is to minimise differences between devices (Verfuß *et al*. 2010).

Marine Megavertebrates of Cornwall and the Isles of Scilly: Relative Abundance and Distribution – Leeney *et al.* 2012

Leeney *et al*. (2012) carried out an interesting study of the mega vertebrates found between Cornwall and the Isles of Scilly; the study combined the techniques of platform of opportunity surveying and aerial surveying, for a period of two years. Twice a month between April and October, experienced observers journeyed between Penzance (Cornwall) and St Mary's (Isles of Scilly) on the passenger ferry recording sightings of marine megavertebrates. During the winter months, data was collected from a cargo vessel. Enough data was collected to provide distribution data of: Basking sharks, Harbour porpoises, common dolphins, Bottlenose dolphins, Minke whales, Grey seals and Sunfish. Aerial surveys were carried out near monthly along the Cornish coastline, encompassing areas on the north and south coast surrounding Land's End. Although the study was surveying primarily for conservation reasons, it did provide information on the spatial and temporal patterns on both distribution and abundance of these species (Leeney *et al*. 2012). This study shows that the combination of these techniques was able to gather valuable information, which would be useful as part of an offshore renewable energy deployment baseline data set.

Techniques Used at Offshore Renewable Energy Development Sites for Marine Mammal Surveys

As is visible from Table 14, a mixture of techniques have been used at various offshore developments. The older wind farms, North Hoyle, Burbo Bank and Barrow highlight that very minimal data was collected regarding marine mammals at early offshore wind farms (CEFAS, 2010). Scroby sands underwent intensive surveying of seals, due to its close proximity to a large seal colony (ECON, 2004). The use of C-PODs is seen in the more recent studies. The Atlantic Array carried out in-depth surveying through the combination of boat based surveys with towed hydrophones, C-PODs and data collected from bird surveys (RWE, 2012). The use of a large number of C-PODs by the SeaGen project (Royal Haskoning, 2010) was due to the fact that the device is situated in an SAC and SPA partly for marine mammals and therefore an intensive monitoring programme was established. The Danish wind farms at Nysted and Horns Rev also had rigorous surveying and monitoring, particularly of seals (Teilmann *et al.* 2006). The Minas Passage C-POD deployments were at an OpenHydro device test site. They were part of a primary study of species present in late summer and were able to create C-POD site specific recommendations, of which some could be applied to other projects (Tollit *et al*. 2010). The two EMEC sites surveyed, Fall of Warness (SMRU, 2013) and Ness of Duncansby (ScottishPower Renewables, 2012), highlight how surveys for different species groups can be carried out simultaneously.

It should also be noted that Marine Scotland (2013) currently has a proposed cetacean monitoring strategy for the east coast of Scotland. Working with both the University of Aberdeen and the University of St Andrews, an array of acoustic devices is planned to be deployed along the majority of the east coast. They intend to deploy C-PODs along with SM2Ms wildlife ambient noise recorders. This combination will enable presence/absence data of dolphins and porpoises to be collected and due to the inclusion of the SM2Ms, the differentiation between dolphin species will also be possible (Marine Scotland, 2013).

Table 14: Techniques used at offshore renewable energy developments for surveying marine mammals. WF - Wind Farm

Offshore Renewable Energy Development Site	Techniques Used
North Hoyle - WF	No specific marine mammals surveys – sightings recorded during bird surveys
Burbo Bank - WF	No specific marine mammals surveys – sightings recorded during bird surveys
Barrow - WF	Log of numbers and behaviour during piling activity
Scroby Sands - WF	Aerial photography surveys of seal haul out sites twice per month - April-September
Robin Rigg - WF	Almost monthly boat based surveys carried out alongside bird surveys
Atlantic Array - WF	Monthly boat based survey towing 4 hydrophones. C-PODs in 4 locations for 12 months. Sightings data also collected on bird surveys
Strangford Lough - Tidal	Vantage point survey - 8 per month. T-PODs in 10 locations. Aerial thermal imaging surveys. Telemetry. Sonar to monitor large invertebrates close to turbine
Nysted & Horns Rev, Denmark - WF	Monthly aerial surveys using video and visual techniques. Telemetry. Boat based Harbour porpoise surveys.
Minas Passage, Canada - Tidal	3 C-PODs for 3 months
Ness of Duncansby, EMEC - Tidal	Monthly boat based surveys integrated with bird surveys
Fall of Warness, EMEC - Tidal	Vantage point multispecies survey

Ornithology

The document which has been most widely used by the offshore renewable energy industry is the COWRIE commissioned report by Camphuysen *et al.* (2004). This document provides in depth details regarding all aspects of the surveying and monitoring of birds around wind farms in the UK. Due to the age of the Camphuysen *et al.* (2004) document, Maclean *et al.* (2009) were commissioned by COWRIE to review and "refine" the recommendations made in the 2004 document. There is a definitive improvement in the techniques available to survey birds, examples being HD imaging and remote techniques, and these evolving techniques are discussed in two other COWRIE commissioned documents (Hexter, 2009; Walls *et al*., 2009).

Towards Standardised Seabirds at Sea Census Techniques in Connection With Environmental Impact Assessments for Offshore Wind Farms in the U.K. - Camphuysen *et al*. 2004

This document has been used by the majority of offshore wind farms constructed in UK waters (Maclean *et* al. 2009; CEFAS, 2010) as it provides very detailed guidance for the main surveying techniques used for surveying birds. Primarily, it provides in depth details of protocols for both boat based and aerial surveys; the two techniques recommended for baseline data collection (Camphuysen *et al*. 2004). Boat based surveys are said to provide greater accuracy in species identification and in collection of bird attributes and behaviour (Camphuysen *et al.* 2004). Details such as plane and boat specifications, number of observers, speed and transect spacing specifications are detailed. In terms of vessel recommendations, one which should be noted is that the use of fishing vessels is strongly advised against due the fact that they are known to influence bird behaviour (Camphuysen *et al.* 2004). The baseline data set is recommended to comprise of information from an in depth desk study and data regarding the spatial and temporal occurrence of birds in the area of site (Camphuysen *et al.* 2004). Overall, the aim of surveying should be to gain a good understanding of the distribution and abundance of birds in the area throughout the year. It is therefore recommended that data is collected throughout the year on a monthly basis, in order to identify the natural variability of sea birds. The natural influences upon bird activity, such as food availability, should be taken into consideration as these can greatly influence the data collected (Camphuysen *et al.* 2004). Full details of the recommended survey methodology for the boat based and aerial survey techniques can be found in Appendix 4. Camphuysen *et al*. (2004) also discuss the possibility of combining bird surveys with marine mammal surveys in order to make surveying more cost effective. Trained observers for both animal groups are still required and the protocols followed must be for the group most likely to be observed more frequently. This combined approach was also mentioned by Jackson & Whitfield (2011).

A Review of Assessment Methodologies for Offshore Windfarms - Maclean *et al.* 2009

This report was commissioned by COWRIE in order to determine whether the guidelines set out in the Camphuysen *et al.* (2004) had been followed during the surveying of offshore wind farms and if the guidelines were still appropriate for future wind farm developments. A review of the use of HD imaging technology was also one of the objectives set for this document by COWRIE.

Maclean *et al.* (2009) state that for boat based surveys, all of the sites reviewed followed the majority of the guidelines set out in Camphuysen *et al*. (2004). Following their review of the methodologies from various offshore wind farms, Maclean *et al.* (2009) made recommendations as to how to improve the technique from the methodology stated by the Camphuysen *et al.* (2004) document. Maclean *et al.* (2009) report that the majority of the aerial surveys were carried out by the Wildfowl and Wetlands Trust using a marginally different approach to those recommended by Camphuysen *et al.* (2004), though were still considered compatible. The minimum survey time period is stated as two years, with a minimum of 8 aerial surveys per year and monthly boat based surveys (Maclean *et al.* 2009). A long time frame for surveying would be preferred by the authors, in order to gauge the inter-annual changes due to food availability, though a balance must be achieved to enable a cost efficient surveying process (Maclean *et al.* 2009).

Maclean *et al.* (2009) recognise the fact that there are several advantages to the use of HD imaging to survey birds at offshore wind farm sites; such as the ability to pause and rewind video footage to aid the identification of birds to species level. The requirement for further tests to improve compatibility with current techniques is required before this technique can be recommended as standard; a set of defined protocols is also stated as a requirement (Maclean *et al.* 2009). Maclean *et al.* (2009) state that the rate of advancement in the technology used by this technique mean that it could be a useful tool for use in future assessments.

High Resolution Video Survey of Seabirds and Mammals in the Moray Firth, Hastings, West Isle of Wight and Bristol Channel Areas in Periods 5, 6 and 7, Technical Report - Hexter, 2009

The use of high definition imaging for surveying birds and marine mammals at offshore renewable energy developments has been mentioned by several other reports (Sparling *et al*., 2011; Judd, 2012; Maclean *et al.,* 2009). In most cases, it has been stated that advances in technology and the creation of specific protocols are needed in order for this to be a viable surveying technique. Following several trials, HiDef Aerial Surveying have established the most effective equipment set up and the appropriate protocols to make this technique viable (Hexter, 2009). The advances in the technology and methodology of this technique mean that is has become compatible with previous studies, is cost effective and was the preferred option of the Crown Estate for the round 3 offshore wind farm baseline surveys (HiDef, 2013).

Hexter (2009) states several limiting factors to the human observer aerial survey technique described by Camphuysen *et al.* (2004). If a development site is in close proximity to a shoreline, the ability to fly in these areas is hindered due to the low flying height required; airspace restrictions can also be limiting in certain areas. The speed and altitude mean that precision of observations is hindered along with the ability to detect distances. Due to the required speed, there may be insufficient time to count birds and correctly identify age, sex and behaviour. Hexter (2009) discusses how many of these limitations can be overcome with the use of HD video surveying. The ability to pause and watch the footage at slower speeds means that the trained analysts have increased accuracy. The increased height at which the plane operates means that behaviour is less likely to be impacted by the presence of the plane and that coastal areas and operational wind farms can be surveyed. The recent advances in the technique also mean that flight height of the birds can be established and collision risk determined (HiDef, 2013). A strong positive of this technique is that the quality of the data collected will only improve as equipment improves and more surveys are carried out. It should also be noted that this technique has been endorsed by Joint Nature Conservation Committee, Scottish Natural Heritage, Countryside Council Wales and Natural England (HiDef, 2013).

Revised Best Practice Guidance for the Use of Remote Techniques for Ornithological Monitoring at Offshore Windfarms – Walls *et al.* 2009

Walls *et al.* (2009) discuss the potential use of several remote techniques for monitoring birds at renewable energy developments. With regard to the collection of baseline data, the use of boat based and aerial surveys are still recommended as standard though these may be complimented by remote techniques (Walls *et al.* 2009). Walls *et al.* (2009) do however state that the use of remote techniques should not be considered a standard requirement at all developments.

Remote techniques are very site specific, they can be used to determine flight characteristics, feeding habits and migration patterns. They are also useful in that they can provide information over a long period of time and during periods of poor visibility, bad weather and darkness (Walls *et al.* 2009). As previously stated, the techniques are very site specific, including the species present at these sites. Walls *et al*. (2009) provide step by step guidance to the choice of remote technique, if they are in fact required and if so, which is best suited according to the site characteristics and the species present.

Techniques Used at Offshore Renewable Energy Development Sites for Bird Surveys

As with all the survey subjects discussed, the technique used is entirely dependent on the site characteristics. The most commonly used techniques are a combination of boat based and aerial surveys; though due to unique characteristics at each site, the statutory nature conservation authority may impose more intensive surveying regulations (CEFAS, 2010). This trend can be seen in Table 15, with all studies following the COWRIE guidance documents (Camphuysen *et al*. 2004; Maclean *et al.* 2009). The more recent surveys show the use of the HiDef aerial survey technique, emphasising how this technique appears to be the future of bird monitoring at offshore development sites (RWE, 2012; Marine Scotland, 2012).

It should be noted that a tagging study is currently underway on Shags and Gannets from the breeding colony off the north-west coast of Alderney. This study is looking at how renewable energy developments may impact the breeding colony, particularly the foraging behaviour (University of Liverpool, 2012).

Table 15: Techniques used at offshore renewable energy developments for surveying birds. WF - Wind Farm

Offshore Renewable Energy Development Site	Techniques Used
North Hoyle - WF	Boat based, aerial and radar tests
Burbo Bank - WF	Boat based and aerial surveys
Barrow - WF	Boat based, aerial and migration surveys
Kentish Flats - WF	Boat based and aerial surveys
Gunfleet Sands - WF	Boat based and aerial surveys
Robin Rigg - WF	Boat based surveys
Atlantic Array - WF	Regional aerial surveys, HiDef aerial surveys of site, boat based surveys and nocturnal thermal imaging trial.
West Coast of Lewis - Wave	HiDef aerial and vantage point surveys
Ness of Duncansby, EMEC - Tidal	Boat based and vantage point surveys
Fall of Warness, EMEC - Tidal	Vantage point multispecies survey

4. Recommendations for Marine Biological Baseline Surveys of Guernsey Waters

This section will consider the recommendations given by the previously discussed documents and combine these with the information currently available from the GRET Regional Environmental Assessment of Marine Energy (REA) (GRET, 2011) and other relevant documents. Following this, recommendations on which techniques are best suited to survey the potential development sites around Guernsey will be discussed. As the wind farm site to the north east of Guernsey is currently outside of territorial waters and not covered by the REA, it is considered as a long term option (GRET, 2013b). Therefore, the recommendations made in this section will be aimed at the wind farm site to the north west of Guernsey and the Big Russel as a tidal development site.

Benthic Habitat

GRET (2011) have a broad scale understanding of the benthic habitats surrounding Guernsey. The REA exercise gathered information from a wide range of sources, though the data available is on the most part dated. The most recent benthic information was gathered in 2011 by Sheehan *et al.* (2013) who carried out an epibenthic assessment of the Big Russel. The technique used in the study was a drop-down video sled which analysed species assemblages and habitats. The study states that it is a baseline against which future changes can be compared, though it does identify the fact that infauna are not sampled and that grabs should be used to complete the data set (Sheehan *et al.* 2013). This assessment however, does not fully fulfil all the recommendations of baseline data collection from the reviewed documents and therefore, further work is still required to generate a comprehensive understanding of the Big Russel.

As mentioned by Ware & Kenny (2011) and Saunders *et al*. (2011), the type of device at the development does not determine which survey technique is used, it is usually dependent on cost and substrate. Therefore, the recommendations that will be made will relate to the potential wind farm site and also the Big Russel as a tidal development site.

The initial stage of gathering baseline information for a site is through acoustic mapping (CEFAS, 2004; DEFRA, 2005; Saunders *et al.* 2011; Ware & Kenny, 2011; Judd, 2012). This is a vital step for any project and can provide data for both biological and physical surveys. The GRET currently have an acoustic survey planned using a combination of multibeam swath bathymetry and sidebeam sonar (P. Barnes. pers. comm.). This survey will provide precise bathymetric data along with an identification of habitats which can then be used to inform the sampling survey. The acoustic surveys should cover the wind farm site and the potential cable route. For the Big Russel, the survey area should cover the development area in the channel and potential cable route. When this data is combined with that collected by Sheehan *et al.* (2013), there will be a good baseline understanding of the Big Russel, though grab sampling will still be required.

At the wind farm site, according to JNCC data and the GRET (2013b), the sediment is classed as coarse mixed sediment, though this will be clarified by the acoustic survey. The recommended grab for such sediment would be either the mini-Hamon or the Costerus grab. The Costerus grab may be the best option as it is newly designed and due to its design, is more effective and simultaneously collects samples for infaunal and sedimentary analysis, in turn saving time and effort. The epifauna at the site should be sampled using the 2m beam trawl; this technique is easy to deploy and commonly used. If possible, the use of a local fishing vessel with the suitable equipment is recommended for these surveys.

For the sampling within the Big Russel, Sheehan *et al.* (2013) identified a sandy area to the north of the channel which should be sampled with either: the Day grab, the van Veen grab or the Costerus grab. The Costerus grab, though most efficient in coarse sediments (Ware & Kenny, 2011), can be used in all sediment types and could therefore, based on current information, be suitable for the sampling requirements at both sites.

The REA identified eelgrass beds as a priority habitat to protect due to their importance to the ecosystem as a whole (GRET, 2011). As the eelgrass beds are found on all coasts of Guernsey, along with sites on both Herm and Sark, a monitoring program should be established. The monitoring program should follow the same procedures as Lundgren (2010) and would therefor require baseline data collection on parameters such as shoot length and density.

With the information which is currently available, no recommendation regarding survey design can be made other than to follow the MAELSF guidelines in the Ware & Kenny (2011) document following the completion of the acoustic surveys. Sheehan *et al.* (2013) highlight the fact that a suitable control site for the Big Russel has yet to be determined; further surveying of the channel is required to identify this area. With regards to sampling, enough samples must be collected in order to allow statistical analysis to be carried out; statistical analysis prior to the survey can determine the amount of samples required. It is recommended that sampling is done annually, with a minimum of two surveys prior to construction.

Fish & Shellfish

The most in depth guidance on baseline data collection regarding fish and shellfish is given by CEFAS (2004) and Judd (2012). When this is combined with the guidance given by DEFRA (2005), there is a strong guidance framework upon which to plan data collection. The REA (GRET, 2011) complies almost completely with the recommendations given by CEFAS (2004), DEFRA (2005) and Judd (2012) regarding characterisation and desk based studies.

Key areas are defined within the REA regarding the ecology and life stages of the fish and shellfish of Guernsey; these include: spawning areas, nursery areas, feeding grounds, overwintering areas and migration routes. These are considered by CEFAS (2004), DEFRA (2005) and Judd (2012) to be key parts of the baseline data set.

Bass overwintering spawning grounds are discussed to the south west of Guernsey; key feeding areas are identified within the same area along with sand eel grounds to the south east of Guernsey. Nursery grounds have, as previously mentioned, been identified as the eelgrass bed habitats around Guernsey. The REA also states the migration patterns of Breem, Bass, Mackerel, Spratt and Spider crabs. When the recommendations made by Judd (2012) regarding the information which should be collected for site characterisation are considered (Table 4: Information which should be considered during the characterisation of fish & shellfish of the development area. Taken from Judd (2012).), the REA provides the majority of the relevant information recommended. The only area in which the REA is lacking, is in the knowledge of fish and shellfish of conservational importance. This issue has been identified in the REA, along with a lack of data on local plankton concentrations. The REA also describes the most locally important commercial species and in providing 6 years' worth of landings data for the development areas, exceeds the recommended 5 years stated by CEFAS (2004) and Judd (2012). It is recommended that the monitoring of the landings data is continued so as to develop a well-established baseline data set for this area.

The desk based characterisation information presented in the REA proves useful but quantitative data is required to describe parameters such as abundance and diversity. These are recommended by DEFRA (2005) but not by CEFAS (2004) and Judd (2012) who recommend an approach of identifying and monitoring life history stages of the fish present at the site. Establishing a baseline data set on the parameters discussed by DEFRA (2005) is considered to be risky and to be treated with caution due to high variation (CEFAS, 2004; Judd 2012). If however, there is a long enough data set, this variance can be understood and then such data would be of great value. Scientific fishing surveys should be carried out mimicking the local commercial fishing techniques and gather the information stated by CEFAS (2004), DEFRA (2005) and Judd (2012). This means that for the wind farm site, potting and pelagic trawling studies will be required and it is recommended that although the cable route is yet to be established, netting, dredging and longlining surveys are carried out along the potential cable route. For the tidal site, the main commercial fisheries are potting, longlining and netting and scientific fishing surveys using these techniques should be carried out. The scientific nature of these surveys will also allow greater information to be gathered regarding any species of conservational importance in Guernsey waters.

In terms of surveying the identified spawning area at Boue Blondel, useful spawning data can be collected during the spring. These surveys should mimic commercial techniques and will require the identification of any fish present which are in spawning condition. This will be a vital survey in order to identify whether the wind farm site to the north has any impact to spawning numbers. A prey survey should also be carried out at the known sand eel fisheries areas; this will be useful to identify any changes to feeding patterns in the area. Contaminants surveys should also be carried out on the flesh of shellfish; this was recommended by DEFRA (2005) and is a good measure of ecosystem health as shellfish of commercial importance are filter feeders. The REA states that Guernsey is a very productive area particularly due to its high levels of plankton. It is therefore recommended that baseline plankton surveys are carried out using bongo nets; this is a simple technique which provides plankton abundance data.

With regards to survey design, difficulties can arise in the identification of suitable control areas for mobile species. In order to solve this issue, Trendall *et al*. (2011) recommend a Before-After Gradient (BAG) survey design, this design is therefore recommended for the surveying of the fish and shellfish of the two development sites. This eliminates the issue of finding a suitable control site and provides more conclusive evidence of any potential changes which may occur to the fish and shellfish populations at the two sites. It is recommended that professional statistical advice is sought regarding the BAG survey design.

In terms of survey frequency and timings, it is recommended that scientific fish surveys are carried out for a minimum of 2 years, at 3 separate occasions per year - spring, summer and autumn. Shellfish surveys should be carried out monthly for 2 continuous years.

Marine Mammals

The REA provides a substantial amount of baseline data regarding seals but is lacking in information regarding cetaceans, emphasising the necessity to collect site specific data. This requirement was highlighted by the GRET (2011) in the REA, detailing the guidance given regarding baseline data collection from the Scottish Executive (2007). More recent guidance is available from the SMRU through both a COWRIE commissioned document (SMRU, 2010) and the volume in the SNH guidance document regarding seals (Sparling *et al*. 2011). Recommendations will therefore be made in line with the guidance given in these documents.

One issue with the information stated in the REA as baseline data is that some of it has been gathered from strandings and incidental sightings. Though this data is considered useful, it should be treated with caution (SMRU, 2010). Although both these forms of data can provide information on species present (along with behaviour, through incidental sightings), the quality of such data should be questioned. In the case of the data presented in the REA, none has been collected using appropriate survey techniques following specific protocols. In the case of strandings data, the ocean has such influences on the carcasses that the data cannot be considered entirely useful (SMRU, 2010). The information regarding cetaceans is mainly based upon these two forms of data. Though not ideal, they can be of use if sightings are of a regular occurrence, such as the dolphin pod off the east coast of Sark.

The existing data regarding seals is of relatively good standard and the REA provides information considered appropriate as the desk study of a baseline data set. The guidance given by Sparling *et al*. (2011) regarding seals is that a baseline data set should include information on: species present, distribution and abundance on land and sea, movements in and around the site, uses of land and sea surrounding the site, and the tidal, seasonal and annual variation of these parameters. The REA has already provided information on the species present stating that a colony of Grey seals live off the north coast of Herm, with sightings ranging between 3-8 individuals. The knowledge regarding their use of this haul out site fulfils the need to identify distribution and abundance and use of land surrounding the site. Data is still lacking regarding the distribution, abundance and use of areas at sea, along with the seasonal, tidal and annual variation of these. In order to solidify the existing information regarding seals, site specific surveys need to be carried out. Land or boat based counts of the haul out sites should be done on a monthly basis; this will gather quantitative data regarding species present and distribution on land. Vantage point surveys should be carried out for surveying the Big Russel tidal site. This technique is useful as it can provide information on behaviour, uses of the site and movements through the site whilst not influencing animal behaviour. The position of the tidal site is expected to be on the Guernsey side of the Big Russel and therefore this technique would be suitable as the entire site will be within 5km of land, the maximum distance stated by SMRU (2010). This technique is only possible if a suitable vantage point on Herm can be identified. The use of telemetry to survey and monitor seal behaviour is not recommend at this site due to several reasons. Primarily there are too few animals in the colony for the data collected to be considered useful, a minimum of 10-12 is required (Sparling *et al.* 2011). Further reasons not to use telemetry include the fact that the colony is not part of an SAC or SPA, the high costs involved and the complications involved due to the requirement for a scientific animal experiment license.

With regards to cetaceans, as previously mentioned, the existing data is surprisingly poor. As part of the baseline data set, information regarding species present, temporal and spatial distribution and density are stated by SMRU (2010) as requirements for cetaceans. In order to accomplish all of these, monthly boat based line transect surveys towing acoustic hydrophones are recommended as the most suitable survey technique. This technique is recommended for the wind farm site; however, due to the environmental conditions of the Big Russel, a vantage point survey carried out at the same time as the seal vantage point survey is recommend. The vessel specifications for the boat based survey are an issue due to the size of the wind farm site and the likely occurrence of sightings. The double platform set up provides absolute abundance data which is of higher quality (SMRU, 2010); though this technique is not recommended for small sites which will experience fewer than 60 sightings as discussed by Diederichs *et al.* (2008). It is therefore recommended that for the wind farm site, the single platform technique is used.

Other recommended surveys include the use of platforms of opportunity and static acoustic monitoring. Platform of opportunity surveys when organised correctly can provide valuable data regarding spatial and temporal distribution and abundance. This was seen in the study of megavertebrates carried out by Leeney *et al.* (2012) where ferries and cargo ships were used. It is recommended that a similar study, where trained observers travel on ferries, is carried out in Guernsey waters on the many ferry routes which originate from St. Peter Port. The routes which have the potential to allow useful data collection include the destinations of: Dielette - FR; Saint-Malo - FR; St. Helier - JR and the Channel Islands area of Portsmouth/Weymouth - GB. The use of static acoustic monitoring to enhance the understanding of cetaceans is being widely used in the offshore renewable energy industry. The use of long term monitoring unaffected by weather and uninfluenced by humans is of great value. It is therefore recommended that 4 CPODs are placed at locations off the north east, south east, south west and north west coasts. Ideally these should be moored in areas where there will be the least disruption to the local fishing techniques. The positioning of these acoustic devices should give a good coverage of the animals using both the wind farm site and the Big Russel. In terms of guidance for the use of acoustic monitors, it is recommended that the guidelines established by the AMPOD project (Verfuß *et al*. 2010) are followed. It is recommended that the use of the SM2M wildlife ambient noise recorder by the industry is monitored. It is currently being used in conjunction with the CPOD by Marine Scotland (2013) in order to differentiate between dolphin species. This technique may become standard procedure if the project is a success, as the ability to differentiate dolphin species from static acoustic monitors is of high value.

It is recommended that the visual surveys are carried out monthly for a minimum of two years. It is also recommended that the occurrences of Basking sharks area recorded during the visual surveys. With regards to the static acoustic monitoring, it is recommended that the CPODS are deployed a minimum of two years prior to construction.

Ornithology

The recently updated chapter regarding ornithology in the REA provides a substantial amount of information regarding the species found in the Bailiwick of Guernsey as a whole. Details of species present, breeding species and areas, migration routes and species of international importance are all detailed in the REA. The REA also provides details on all types of birds, not just seabirds, which as stated by Judd (2012), is an important aspect of the baseline data set. One of the main sources for information on seabirds and their breeding activity comes from 3 surveys carried out as part of UK wide seabird survey projects. Although relatively dated, these surveys provide good information regarding the natural variability and presence of seabirds in the Bailiwick as a whole and are useful in terms of baseline information. Several types of birds are known to migrate through the area, though exact proportions of these birds are unknown. A migration route for Gannet, Shearwaters, Terns and Storm Petrels is known to be along the north and west coasts of Guernsey, though precise details of the route are not fully understood. This large amount of information provides a good basis of the desk study, which is consistently recommended, though further research, into species foraging activity for example, would be advantageous. The REA is also useful as it has identified gaps in knowledge which will need to be gathered in order to have a good all round understanding of bird activity in the area. The most important information which needs to be collected is regarding bird activity at sea, including the understanding of migration routes and foraging areas.

With regards to the guidance on the collection of baseline data, the most relevant documents are Camphuysen *et al.* (2004) and the refinements to the 2004 document made by Maclean *et al*. (2009). Camphuysen *et al*. (2004) recommend that information regarding the spatial and temporal occurrence of birds in the area of the site, along with data regarding their abundance, is gathered and corresponding recommendations are given by the SNH (Jackson & Whitfield, 2011). In order to gather this information in Guernsey waters, it is recommended that boat based surveys are carried out at the wind farm site, along with the use of HD aerial video surveys, such as those carried out by HiDef Aerial Surveying (discussed by Hexter, 2009). In terms of surveying the tidal site in the Big Russel, a combination of vantage point surveys and aerial HD video surveys are recommended; the same techniques are currently in use at the Isle of Lewis wave site (Marine Scotland, 2012). The vantage point survey for the Big Russel may prove challenging, Jackson & Whitfield (2011) state that it is only recommended if an entire site is within 1.5km of a suitable vantage point; the use of this technique is therefore dependent on the placement of the site - though its use is still recommended prior to a decision being made as it will gather valuable data. It is also recommended that the potential landfall sites for the cables are monitored using the vantage point technique and that data from the on-going local volunteer ornithological surveys is utilised where possible. With regards to the bird breeding sites identified in the REA on Guernsey, Herm and Sark, it is recommended that they are surveyed monthly using the Walsh *et al*. (1995) guidelines, as recommended by Jackson & Whitfield (2011); this will gather up to date data on the breeding numbers.

In terms of survey period and frequency, it is recommended that boat based and vantage point surveys are carried out monthly and a minimum of 8 aerial surveys are carried out per year – 3 during winter months and 5 during non-winter months. These baseline surveys should be carried out for a minimum of two years.

The use of combined boat based surveys for birds and marine mammals is one which should be considered. This combined approach was discussed by both Camphuysen *et al*. (2004) and Jackson & Whitfield (2011) and may be considered as an appropriate cost saving effective technique. The data collected for the individual groups may not be of as high quality using this combined approach; it is therefore not directly recommended without further in depth investigations. However, it is recommended that the occurrences of marine mammals and Basking sharks are noted during regular boat based surveys, but only when this will not affect the quality of the ornithological data collection process. A combination approach should definitely be adopted during the HD aerial video surveys as it is possible to analyse the data collected during ornithological surveys for marine mammal and Basking sharks. This will add to the data collected using the boat based and vantage point techniques and will strengthen the data set.

The techniques recommended above will gather site specific data, including behavioural data, and will highlight if any of the proposed development areas are of high importance for foraging activity. These techniques are those recommended for the collection of the baseline data set; further more specific data collection, considered supplementary by Walls *et al.* (2009), may be deemed necessary following these initial baseline surveys.

Walls *et al*. (2009) state that not all projects will require the use of remote techniques for studying birds. As the Bailiwick is home to a substantial percentage of species of international importance, the use of remote techniques may, as discussed by the REA, be required. The REA states the potential use of radar to gather information regarding the migration activity of birds around the island. It should be noted that this technique, according to the guidance from Walls *et al*. (2009), is of limited benefit for the species currently known to use the migration pathway off the north and west coasts. It is therefore recommended that several vantage point survey positions are established along these coastlines to begin to gather information regarding the use of this flyway. The use of radar may be deemed appropriate once more detailed up to date information is available from the vantage point, boat based and aerial surveys. With regards to the use of GPS tagging surveys, Wall *et al*. (2009) state that there are clear advantages to the use of these tags on species such as Terns and Auks, both of which breed in the local area. The Gannet study carried out in Alderney by the University of Liverpool (2012) also attached tags to Shags. Due to the great value of the data which can be used to identify behaviour and important feeding areas, it is recommended that the possibility of using GPS tags on Terns, Auks and Shags is explored – all of which are breed in Guernsey waters. Further species may be identified as suitable for tagging and other remote techniques may be deemed appropriate following the standard baseline data collection surveys detailed previously.

5. Conclusions

The importance of high quality baseline data collection has been emphasised in many sections of this report. The collection of such data is vital to the success of a project for several reasons; it enables a project to have a minimum impact on the environment through identification of less sensitive areas for device placement within a site and provides a pre-construction understanding of the environment, against which, future monitoring results can be compared in order to identify any impacts which have occurred. The common errors associated with the collection of poor baseline data, such as inadequate funding and a narrow focus, have been mentioned and it is vital these are avoided.

This report discusses both general and specific guidance regarding the collection of high quality marine biological baseline data. Convergence of the recommendations given in these documents has enabled specific surveys to be recommended for Guernsey waters in line with the information currently available in the REA. This process will enable the often burdensome EIA process to be more efficient.

The GRET are aiming to deploy offshore renewable energy generators in the second half of this decade; in order to do that, a baseline understanding of the environment is necessary. For this aim to be achieved, it is vital that data collection begins as soon as possible. The collection of high quality baseline data will provide Guernsey with several benefits and is a vital step for towards the renewable energy and reduced carbon emission targets.

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7. Appendices

Appendix 1 - Advantages and disadvantages of seal survey methods taken from Sparling *et al* (2011).

Summary of pros and cons of aerial surveys of seal haul-out and pupping sites

Pros	Cons
• Cost effective for large areas (compared to boat based or land-based methods) • Can collect data from a large area relatively quickly • Observers not influencing behaviour of animals • Can provide large-scale spatial and temporal trends • Established analysis frameworks • Long term monitoring data from other sources (SMRU) readily available and may be incorporated to provide context.	• Restricted window of opportunity for surveys each year. • Data on Grey and Harbour seal pupping collected in different seasons • Requires different approaches in different habitats/different species • Well trained and experienced surveyors and pilots required. • Specialised imaging cameras may be required. • Desk-based processing of images to extract data may be time consuming. • Weather restricted

Summary of pros and cons of vantage point surveys.

Pros	Cons
• Inexpensive (compared to boat based or aerial methods) • Observers not influencing behaviour of animals • Can provide spatial and temporal data on usage and distribution • Can collect data for pinnipeds, cetaceans and sea birds using the same approach • Established analysis frameworks • Can be extended to assess long-term trends/impact monitoring	• Generally not possible to estimate abundance unless additional methods are employed • Experienced observers are required • Weather restricted • Need to find a suitable site/vantage point • Often confined to coastal strips or channels i.e. near shore sites • May need more than 1 VP

Summary of pros and cons of visual line-transect surveys for seals.

Pros	Cons
Line-transect surveys	
• Data allow for estimation of absolute or relative density & abundance • Can provide information on distribution • Can be long-term • Can cover entire range of population	• Can be expensive (depending on spatial and temporal scale required) • Restricted by weather conditions and to daylight hours • May be difficult to implement (especially boat-based) during operational phases of wave/tidal sites • Currently very limited use with seal data. • Impacts of availability bias currently unclear
Boat-based line-transect surveys	
Offshore and near-shore • Additional data can be collected • Well established and robust methods for assumption violations, especially for large vessels Near-shore only • Small boats can take advantage of good weather in some circumstances	Offshore and near-shore • Large vessels expensive • Responsive movement Near-shore only • Small boats range-restricted • Small boats reduce effective strip width and survey team size/effectiveness for line-transects • Small boats highly constrained by weather
Aerial line-transect surveys	
• Fewer issues with responsive movement • Can cover large areas quickly • Can take advantage more readily of good weather windows • May already be taking place to carry out bird or cetacean surveys	• Logistical limitations • Responsive movement may be a problem for some aircraft types or some species • Can't identify to species

Summary of Pros and cons of Telemetry.

Pros	Cons
• Large amount of data on animal location collected • Usage maps can be produced • Data on connectivity can be collected • Dive profiles (and behaviour) data can be collected • Data can be collected on habitat use to inform collision risk modelling • Data on interactions with installed devices and device arrays can be collected. • Observers not influencing behaviour of animals • Can provide spatial and temporal data on usage and distribution • Not weather restricted • Established analysis frameworks • Data can help correct haul out counts to account for proportion of animals at sea	• Expensive • Only a small (potentially unrepresentative) proportion of population tagged • Limited life of tags • Catching of animals for tagging can be difficult. • Home Office licence required for catching and tagging. • Very experienced team required • Not possible to estimate abundance • Animals tagged at haul out sites may not enter area of interest • Location data resolution may not allow small-scale movement of animals in proximity to devices/ arrays to be determined • Data analysis and interpretation highly specialised

Appendix 2 - Summary of remote acoustic systems - taken from Ware & Kenny, 2011.

Further details are available in Eleftheriou & McIntyre, 2005.

System	Use	Resolution	Relative Cost	Environmental Applications
Sidescan Sonar	Sediment texture and features	Very High (100% coverage possible)	Low to High (depending on system)	Identification and monitoring of specific habitats, sediment transport pathways etc. Broadscale base map to inform direct sampling survey design
Acoustic Ground Definition System (AGDS)	Line bathymetry and sediment discrimination	Low spatial resolution (>10 m), full coverage requires interpolation	Low	Habitat mapping Can help inform direct sampling survey design
Echo-Sounder (single line bathymetry)	Line bathymetry	<100% – poor spatial coverage	Low	Detection of broadscale features Broadscale base map to inform direct sampling survey design
Swath Bathymetry	Bathymetry and sediment discrimination (from backscatter)	Very High (100% coverage possible)	Moderate to High (entry level system). High performance systems very expensive	100% bathymetric coverage and detection of topographical features
Sub-Bottom Profiling	Sediment layers and shallow geology	Vertical resolution varies with frequency	High	Can help to infer habitat distribution through identification of geological features

Appendix 3 – Summary of methods for monitoring marine mammals (From Diederichs et al. (2008)

	Line Transect			Point Transect		Tracking				Other	
	Aerial Surveys	Ship Surveys		Static Monitoring		Telemetry					
methodology	***aircraft***	***visual***	***acoustic***	***visual (platform)***	***acoustic***	***Satellite***	***Satellite + GPS***	***Satellite + Datenlogger + GPS***	***VHF***	***Haul-out site Counting***	***Photo ID***
platform	high winged, double engine aircraft (e.g. Partenavia P68)	ship (minimum 30m long, observer heigth >5m	ship (also smaller ships)	observer heigth > 30m (platform/coast/...)	T-POD / PCL						
manpower											
data collection	3 observer	4 observer	1 observer	1-2 observer	1 technician + 1 assistant per maintenance a 1-2 days	well-rehearsed team for telemetry	well-rehearsed team for telemetry	well-rehearsed team for telemetry	well-rehearsed team for telemetry	2 observer	1-2 observer, 1 photographer/ technician
data analysis	1 scientist	1 scientist	1 scientist	1 scientist	1 scientist	1 scientist	1 scientist	1 scientist	1 scientist	1 scientist	1 scientist
dependency on weather and daylight	seastate 0-3, only during day time	seastate 0-2, only during day time	seastate 0-5 independent of daylight	seastate 0-2, only during day time	seastate 5-7, dependent to substrat & shiptraffic, independent of daylight	low	low	low	low	seastate 0-5, low tide	seastate 0-2 for small ceatacean
spatial scale	***aircraft***	***visual***	***acoustic***	***visual (platform)***	***acoustic***	***Satellite***	***Satellite + GPS***	***Satellite + Datenlogger + GPS***	***VHF***	***Haul-out site Counting***	***Photo ID***
unit	density/animals per transect	density/animals per transect	animals per transect (density)	animals per time	presence/absence (="detection positive time")						
coverage	high	moderate	moderate-high	low	very low	complete homerange	complete homerange	complete homerange	up to 50 km	high	na
	500-1000 transect kilometres per day	80-120 transect kilometres per day	160-240 transect kilometres per day	sight radius (~1000m)	effective detection range <400m per device	without limitation	without limitation	without limitation	dependent on antenna and transmitter range	from a population point of view	-
resolution	low	very low	very low	very low	very low	very low	high	high	high	high	na
	(>2 km, dependent on transect length and interval)	(>2 km, dependent on transect length and interval)	(>2 km, dependent on transect length and interval)	dependent on no. of observer/platforms	dependent on no. of devices in an specific area	Argos-positions				only for resting animals	
temporal scale	***aircraft***	***visual***	***acoustic***	***visual (platform)***	***acoustic***	***Satellite***	***Satellite + GPS***	***Satellite + Datenlogger + GPS***	***VHF***	***Haul-out site Counting***	***Photo ID***
coverage	low	low	low	low-moderate	100%	high	high	high	moderate	low	high
	= observation time/ total time of the year	= observation time/ total time of the year	= observation time/ total time of the year	= observation time/ total time of the year	= observation time/ total time of the year	limited by batterylife	limited by batterylife	limited by batterylife	limited by batterylife	= observation time/ total time of the year	whole lifetime
resolution	low	very low	low	very low	very high	moderate	moderate	high	high	low	very low
between single surveys	time between two surveys (>1day)	time between two surveys (>1day)	time between two surveys (>0.5 day)	time between two surveys (>1day)	time between consecutive clicks = µs; time between encounters > 10min	limited by surface rate and sattelite coverage	limited by surface rate and sattelite coverage	limited by surface rate and sattelite coverage	limited by surface rate	limited by no. of surveys	na
within single surveys	na	low-moderate	low-moderate	high	high	na	na	na	na	high	na
explanatory power on population level	very high	moderate	moderate	very low	low-moderate (dependent to no. of devices)	dependent on no. of animals und lenght of recorded time (normally low)	dependent on no. of animals und lenght of recorded time (normally low)	dependent on no. of animals und lenght of recorded time (normally low)	dependent on no. of animals und lenght of recorded time (normally low)	very high	moderate-high
behaviour	***aircraft***	***visual***	***acoustic***	***visual (platform)***	***acoustic***	***Satellite***	***Satellite + GPS***	***Satellite + Datenlogger + GPS***	***VHF***	***Haul-out site Counting***	***Photo ID***
classifiable behaviour	swimming (without and with direction), diving, resting at the surface, fast swimming at the surface (flying)	swimming (without and with direction), diving, resting at the surface, fast swimming at the surface (flying)	maybe prey catching	swimming (without and with direction), diving, resting at the surface, fast swimming at the surface (flying), spy hopping	feeding, travel orientation, social behaviour, (sea bed orientation)	nothing	nothing	dive duration, dive depth, resting behaviour, pitch- and rol angle, swim speed, dive speed, echolocation	nothing	nothing	swimming (without and with direction), diving, resting at the surface, fast swimming at the surface (flying), spy hopping
Quality of behavioural observations	low	moderate	future research needed	high	moderate-high	na	na	very high	na	na	high

Appendix 4 – Recommended Methodology from Camphuysen *et al.* 2004

Recommended methodology for boat based surveys from Camphuysen *et al.* 2004.

Recommended census techniques for ship-based seabird surveys, as part of an EIA, are line-transects with subbands and with snap-shots for flying birds, and incorporating the full behaviour module recording detailed information on species, sex and age where feasible, foraging behaviour, flying height. Whenever possible, hydrographical data, such as sea surface temperature, salinity, water depth should be continuously and synoptically monitored. For a minimum set-up, the following techniques and qualifications are recommended.

- Line-transect methodology is recommended with a strip width of 300m maximum.
- Subdivision of survey bands to allow corrections for missed individuals at greater distances away from the observation platform (recommended subdivision for swimming birds: A= 0-50m, B= 50-100m, C=100-200m, D= 200-300m, E= 300+m or outside transect; all distances perpendicular to the ship).
- No observations in sea state 5 or more to be used in data analysis for seabirds, data not usable for marine mammals above sea state 3.
- Survey time intervals are recommended to be 1 or 5 min intervals (range 1-10m, longer time intervals are acceptable when less resolution of data is required; short intervals are preferred in small study areas), with mid-positions (Latitude, Longitude) to be recorded or calculated for each interval.
- Preferred ship's speed should be 10 knots (range 5-15 knots).
- Preferred ship type is a motor vessel with forward viewing height possibilities at 10m above sea level (range 5-25m), *not* being a commercial or frequently active fishing vessel.
- Preferred ship-size: stable platform, at least 20m total length, max. 100m total length
- Bird detection by naked eye as a default, except in areas with wintering divers *Gaviidae.* Scanning ahead with binoculars is necessary, for example to detect flushed divers.
- Two competent observers are required per observation platform equipped with range-finders (Heinemann 1981), GPS and data sheets; no immediate computerising of data during surveys to maximise attention on the actual detection, identification and recording.

- Observers should have adequate identification skills (i.e. all relevant scarce and common marine species well known, some knowledge of rarities, full understanding of plumages and moults).
- Observers must be trained by experienced offshore ornithologists under contrasting situations and indifferent seasons.
- A high resolution grid should be deployed, covering an area at least 6x the size of the proposed wind farm area, including at least 1-2 similar sized reference areas (same geographical, oceanographical characteristics), and preferably including nearby coastal waters (for nearshore wind farms only).
- Survey grid lines are recommended to be at least 0.5nm apart, maximum 2nm apart, and the grid should be surveyed such that time of day is equally distributed over the entire area (changing start and end time over the area to fully comprehend effects of diurnal rhythms in the area)
- The cost-effectiveness of the ship-based surveys are greatly enhanced if the vessel can be equipped with an Aquaflow (logging surface water characteristics including temperature, fluorescence (chlorophyll), and salinity logging hydrographical information simultaneously).
- The cost-effectiveness of the ship-based bird surveys can be greatly enhanced if combined with other surveys, such as those of marine mammals, for which a specialist observer and different methods will be required.
- The cost-effectiveness can be further enhanced by counting birds on both sides of the ship, i.e. cover two strips, for which additional observers will be required.

Recommended methodology for aerial surveys from Camphuysen *et al.* 2004.

- For a minimum set-up, the following techniques and qualifications are recommended.
- Twin-engine aircraft (for safety and endurance)
- High-wing aircraft with excellent all round visibility for observers (e.g. twin-engine Partenavia P-68
- Observer)
- Line-transect methodology is recommended with sub-bands.
- Transects should be a minimum of 2 km apart to avoid double-counting whilst allowing the densest coverage feasible
- Flight speed preferably 185 km h_{-1} at 80 m altitude
- Subdivision of survey bands to allow calculations of detection probabilities (recommended are 44-163m,164-432m, 433-1000m, with a declination in degrees from the horizon being 60-25°, 25-10°, and 10-4° respectively for the Partenavia P-68 at 80m)
- Use of an inclinometer to measure declination from the horizon

- Two trained observers, one covering each side of the aircraft, with all observations recorded continuously on Dictaphone
- GPS positions are recorded at least every 5 seconds (computer logs flight track)
- The time of each bird sighting should be recorded, ideally to the nearest second, but within 10 seconds accuracy, using a watch attached to the window of the plane.
- No observations in sea states above 3 (small waves with few whitecaps)
- All waterbirds should be recorded to the best level of identification (species or group)
- Sampling units are single birds or groups of birds within the three transect bands