Review of cetacean monitoring guidelines for Welsh wave and tidal energy developments

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Contribution statement

The content and conclusions of this report do not necessarily reflect the views of SEACAMS, NRW, developers or collaborators. SEACAMS funded the work with matched-time funding from NRW. HN, KS, TS conceived the project; developer input was provided by contributors listed in the acknowledgments, with informed consent obtained from all subjects with individual contributions remained anonymous. HN reviewed and collated data, interviewed subjects, analysed information and wrote the report; KS/TS provided comment on draft and final versions.

Contents

Summary

SEACAMS has been engaged on a collaborative project with Tidal Energy Limited (TEL) and Marine Current Turbines (MCT) with technical advice from NRW Marine Advisory Team to review existing marine mammal monitoring guidelines for marine renewable energy (MRE) industry, with particular reference to wave and tidal energy developments in Wales. The rationale for the project arose from the Natural Resources Wales (NRW) Marine Advisory Team and various developers' request to develop a user friendly, practical set of guidelines to cetacean monitoring at wave and tidal developments in order to reduce discrepancies in survey design and data collection methods in particular.

This report is a first step in developing such guidelines for the developers, by reviewing existing information and standard methodologies used in Wales. The aim was to compile available information and summarising current understanding on issues related to cetacean monitoring at tidal sites in order to assist developers with survey design, methodologies used and data analysis and interpretation. Please note this report is not intended to be an exhaustive account of all types of survey and analytical methods appropriate for marine renewable energy sites. Additional information on designing surveys to monitor seals will be published in a follow up report.

The project was divided into several discrete tasks: identifying existing marine mammal and specifically cetacean surveying guidelines, reviewing the identified guidelines and reports; approaching and interviewing stakeholders (developers, consultants and marine mammal observers) for their opinions on current guidelines and practices and finally compiling these into one coherent report.

The main conclusions of the report are listed below:

- Various documents are available which detail marine mammal study methods in renewable energy sites, and specify the kinds of issues encountered by researchers and developers in high tidal areas, but not all developers are necessarily aware of these.
- The problem with practical guidance to developers is that each site differs in its physical environment and poses challenges specific to the location in question, so producing detailed guidelines that fit all is not realistic.
- Key issues identified through interviews and questionnaires were:
    - the *perceived* insufficient advice from regulators or regulatory advisers regarding the level of detail required from developers, which in most cases is due to the lack of research on the actual expected impacts of marine renewable devise on marine mammals
    - the lack of or timing of regulatory guidance
    - insufficient instructions from developers to their consultants conducting monitoring surveys
- The key problems in the actual marine mammal studies identified by both developers and regulators and their advisors relate to difficulties in selecting the correct questions to address and answer and consequent survey design; logistical issues in data collection and the lack of ability to deliver appropriate statistical analysis on data gathered.

The following report describes the most useful guidance documents available at the time of report writing and summarises the results of the literature review and questionnaires. The document also provides summaries of practical guidelines from existing for field observations and survey methodology including detailed guidelines for land based surveys.

1. Introduction

1.1. Renewable energy developments in Wales

Although the majority of advanced tidal and wave developments in the UK are in Scottish or Northern Irish waters, Welsh coasts have been identified having significant potential for generating renewable energy from waves and tides with suitable areas for wave and tidal stream as well as tidal range devices (UK Marine Energy Atlas, Welsh Government's Marine Renewable Energy Strategic Framework (MRESF)). In Wales there are currently several companies with plans to deploy wave and tidal energy devices (tidal stream and wave energy conversion devices, tidal lagoons and a tidal barrage), for both commercial and demonstration scale in various stages of development.

1.2. Possible impacts of marine renewable energy devices on marine mammals

With the increased demands to achieve the European renewable energy targets by 2020 (Directive 2001/77/EC), more and more wind, tidal and wave technologies are being developed which have the potential to cause substantial disturbance to coastal processes, benthic communities, and fish populations (Gill 2005; Hiddink et al. 2007; Shields et al. 2009; Alexander et al. 2013). These in turn can cause adverse effects on seabirds (Langton et al. 2011; Soanes et al. 2012) as well as marine mammals, in the form of reduced prey availability, noise pollution and habitat degradation or loss (Carstensen et al. 2006; Tougaard et al. 2009a; Dolman & Simmonds 2010; Simmonds & Brown 2010).

Cetaceans, as well as many other mobile marine species, are potentially affected by the construction and operation of various types of marine renewable energy extraction devices, which include offshore wind, wave and tidal power generators – both tidal barrages and lagoon as well as tidal stream turbines (Aquatera 2013; Carstensen et al. 2006; Wilson et al. 2007; Evans 2008; Brandt et al. 2011). Many of the expected impacts are likely to be very similar to those associated with established marine industries such as oil and gas exploration, extraction and construction (Macleod et al 2011). Disturbance to cetaceans from renewable energy generators is caused by increased ambient noise, general habitat degradation from presence of the devices, displacement and barrier effects, potential changes in prey availability as well as the very real risk of collision with underwater devices, such as tidal turbines or mooring devices but also from increased vessel traffic during construction and operation, contaminant effects and changes in water flow and turbidity (Richardson et al. 1998; Macleod et al. 2011; Madsen et al. 2006; Teilmann et al. 2006; Carstensen et al. 2006; Tougaard et al. 2009a). These impacts, whether direct or indirect, have the potential to be felt both at individual as well as population level, through decreased viability as well as direct injury (Macleod et al. 2011).

With such projects expected to increase due to the UK government's commitment to the EU to increase energy sourced from renewable resources in the coming years, there will be a real necessity (as well as a legal requirement) to monitor the impacts of such projects on protected cetacean species and habitats (DECC 2011), especially when much of the impacts and the extend of potential impacts is still relatively unknown (Inger et al. 2009).

1.3. Over view of legal monitoring requirements for marine mammals

Under the marine spatial planning and coastal zone management within the EU's Marine Strategy Framework Directive, governments, regulators and developers are required to assess the potential effect of their activities on the marine environment, including marine mammals (European Union 2012; Evans 2012). Furthermore, monitoring of cetaceans is conducted under the European Union's (EU) Habitats Directive (92/43/EEC 1992), and all cetaceans fall under Annex IV of the Habitats Directive requiring national reporting on their favourable conservation status (FCS). Annex II requires the establishment of Special Areas of Conservation (SAC) for harbour porpoise and bottlenose dolphin to form a network of conservation sites (Natura 2000 network) (European Commission 2006; European Union 2007; Evans 2012). The regulators are thus required to assess population trends as part of their monitoring of FCS, and deliver any required Appropriate Assessment. They are also required to determine whether there are significant impacts to protected populations from marine developments, whereas developers are responsible for ensuring that adequate data is being collected during monitoring studies to enable regulators to conduct such assessments.

The government body regulating the industry and granting licenses in Wales is the Natural Resources Wales (NRW). The NRW's role is to ensure the sustainable development of Wales' growing marine renewable energy sector, through the delivery of our regulatory and advisory functions. Currently NRW does not issue standard advice or specific monitoring guidelines for the developers; although they do issue advice on scoping an environmental impact assessment for marine renewable energy developers, which is available from the Marine Advice team. However, in recent years some developers in Wales have been encountering various issues whilst conducting marine mammal monitoring studies, related to the survey design, methodologies used and data analysis. As a consequence, the NRW, as the regulatory and the advisory body has been able to identify knowledge gaps both within developers as well as regulators, especially the apparent lack in standardised guidelines and recommendations offered by the NRW. This report is a first step in developing such guidelines for the developers, with the aim on reducing any discrepancies in survey design and data collection methods which some developers have experienced.

The rationale for this project arose from the regulator's (NRW) and various developers' request to produce a user friendly, practical set of guidelines specific to marine mammal monitoring at wave and tidal developments. This report will serve as the initial step towards producing such guidelines by critically reviewing existing information. The project was divided into several discrete tasks: identifying marine mammal monitoring and mitigation guidelines to date for wave and tidal energy conversion sites; critically reviewing the identified guidelines and reports; approaching and interviewing stakeholders (regulators and developers, consultants and marine mammal observers) for their opinion on current guidelines and finally compiling these into one coherent report.

2. Methodological approach

2.1. Identifying monitoring guidelines to date

The first objective was to locate already existing reports and guidelines for marine mammal and particularly cetacean monitoring at renewable energy sites. Ongoing wave and tidal energy projects were identified and both published and unpublished reports on existing environmental reports covering marine mammal data collection and data analysis methods were reviewed. Due to relatively small number of wave and tidal energy developments to date, this was extended to include guidelines for general papers on coastal cetacean monitoring using similar methodologies as well as descriptions of new emerging techniques for cetacean monitoring at coastal sites. In most cases guidelines reviewed extend to both pinnipeds and cetaceans, as monitoring methods can be very similar, and use the term 'marine mammals' to encompass both, even if most of the literature does focus on cetacean surveys. As a consequence very little specific advice is given on seal surveys regarding marine renewables and therefore this report also focuses mainly on cetaceans, although the term marine mammal is used throughout.

Literature was sourced from various websites which list current marine renewable projects and recent research and development into impacts of renewable energy devices on the environment. Documents which were taken into consideration were openly available online, apart from two confidential reports from developers. These included:

- Environmental statements, impact assessments and monitoring reports of projects involved in development of marine energy extraction - this was mainly limited to wave and tidal projects although a few wind farm project reports were also included if it was clear from outset that they offered general advice on marine mammal surveys which was applicable wave and tidal developments
- Government and stakeholder reports and research papers on expected impacts of marine renewables on cetaceans, marine mammal monitoring approaches and 'lessons learned'
- Peer-reviewed published journal papers from keyword search "*marine mammal/cetacean survey/monitoring*", "*marine renewables and cetaceans*"

2.2. Review of the selected documents

The documents were screened to identify those which were describing results from an existing monitoring project or survey and those which reviewed various methods and offered guidance or advice on different types of surveys (characterisation, baseline or impact and mitigation monitoring). In particular each document was categorized based on whether it:

- Offered general guidelines on planning and implementing marine mammal surveys
- Defined or refined questions to be asked from characterisation, baseline or impact monitoring
- Described or reviewed specific techniques or methodologies in use at MRE sites
- Reviewed impacts and issues to be considered from MRE developments

2.3. Stakeholder questionnaires/interviews

Developers, consultants and marine mammal observers involved in wave and tidal energy projects in Wales (known to the author) were approached and asked whether they would be willing to offer their opinions on how their project had managed to find the appropriate information on marine mammal and cetacean survey monitoring for both characterisation and impact monitoring; how they had interacted with the regulatory body; what issues they had encountered and how they had overcome these. The aim of the interview was to gauge whether each stakeholder had been offered specific guidance and feedback from the developer, whether they were aware of existing guidelines and projects and what they would identify as main obstacles to effective monitoring programmes and what solutions they would recommend to overcome these.

The following questions were asked of each stakeholder:

- Q.1 In what capacity have you/your company been involved in marine mammal monitoring or mitigation project for wave and/or tidal energy development?
- Q.2 Were you given clear instructions on how to proceed with the monitoring/mitigation project, whether this involved survey design, data collection, data handling, data analysis or reporting?
- Q.3 Were you aware of other projects academic or commercial involving marine mammal data collection or journal papers and reference guides dealing with monitoring methods?
- Q.4 Were you able to access the appropriate information to assist with you task?
- Q.5 Were your methods agreed and checked by developer or regulator before proceeding with the tasks?
- Q.6 Did you receive feedback for your work?
- Q.7 What would you identify as the main issues that affected the delivery of your tasks?
- Q.8 What specific information or guidance would have improved the quality of your work, or your ability to deliver the specified tasks?

A database was compiled based on the discussions and interview replies with stakeholders listing the main issues identified. Another table was produced of the main issues identified from both the literature and the interviews along with possible solutions offered as well as key recommendations for to survey design, choice of methodology and data analyses. The documents were assessed according to their accessibility.

3. Findings

3.1. Currently available information

A large body of literature, including unpublished project reports was found, all of which was accessible online through various websites (see Appendix I). The selected documents could be divided into three main categories; those which offered general advice of marine mammal monitoring on tidal sites and those which described existing projects or scientific studies on specific techniques (Table 1).

Several comprehensive guideline documents have been commissioned and compiled by the Scottish Natural Heritage (SNH) and Marine Scotland, Crown Estate and the Natural Environmental Research Council (NERC). In addition there exist various smaller reports on specific topics by Marine Scotland and JNCC. Although most of the project reports are accessible online, in those projects where the consenting process is on-going the documents are yet to be made openly available but were released for this project in confidence. In addition, a large body of peer-reviewed journals exists detailing cetacean monitoring and survey methods – again mostly available through internet search without subscriptions to journals. Here a selection of such papers is presented detailing recent methodological improvements or key review papers on marine mammal monitoring.

Table 1. Overview of the selected literature. Those documents fulfilling three or more categories are marked in bold.

Doc ID	Document citation	General guidelines on planning and/or implementing surveys	Refining questions to be asked prior to surveys	Describing or reviewing a technique or methodology	Reviewing impacts
MRE001	Aquatera (2013) Consolidation of wave and tidal EIA/HRA issues and research priorities. Pentland Firth and Orkney Waters Enabling Actions Report. Technical Report. November 2013.		X		
MRE002	JNCC/CCW/NERC KEP workshop (not dated) Assessing the risks to marine mammal populations from renewable devices - an interim approach		X		X
MRE003	Thompson, D., Hall, A.J., Lonergan, M., McConnell, B. & Northridge, S. (2013) Current state of knowledge of effects of offshore renewable energy generation devices on marine mammals and research requirements. Edinburgh: Scottish Government				X
MRE004	Macleod, K., Lacey, C., Quick, N., Hastie, G. and Wilson J. (2011). Guidance on survey and monitoring in relation to marine renewables deployments in Scotland. Volume 2. Cetaceans and Basking Sharks. Unpublished draft report to Scottish Natural Heritage and Marine Scotland.	X	X	X	X
MRE005	Sparling, C. E., Coram, A. J., McConnell, B., Thompson, D., Hawkins K. R. & Northridge, S. P. (2013) NERC Wave & Tidal Consenting Position Paper Series, Paper Three: Marine Mammal Impacts				
MRE006	RPS Gordon et al. (2011). Assessment of Risk to Marine Mammals from Underwater Marine Renewable Devices in Welsh Waters. Phase 2 - Studies of Marine Mammals in Welsh High Tidal Waters. JER3688	X		X	
MRE007	Macleod, K., Du Fresne, S., Mackey, B., Faustino, C. and Boyd, I., (2010). Approaches to marine mammal monitoring at marine renewable energy developments. MERA 0309 TCE Final Report prepared by SMRU Ltd for The Crown Estate. 110 pp.	X	X	X	
MRE008	Leeney, R.H., Greaves, D., Conley, D. and O'Hagan, A.M. (2014) Environmental Impact Assessments for wave energy developments - Learning from existing activities and informing future research priorities. Ocean and Coastal Management (in press)	X	X		
MRE009	Simmonds, M.P. and Brown, V.C. (2010) Is there a conflict between cetacean conservation and marine renewable-energy developments? Wildlife Research, 37: 688-694				X
MRE010	Wilson, B., Benjamins, S. and Elliott, J. (2013) Using drifting passive echolocation loggers to study harbour porpoises in tidal-stream habitats. Endangered Species Research 22: 125-143			X	

Doc ID	Document citation	General guidelines on planning and/or implementing surveys	Refining questions to be asked prior to surveys	Describing or reviewing a technique or methodology	Reviewing impacts
MRE011	Wilson, B. Batty, R. S., Daunt, F. & Carter, C. (2007) Collision risks between marine renewable energy devices and mammals, fish and diving birds. Report to the Scottish Executive. Scottish Association for Marine Science, Oban, Scotland, PA37 1QA.			X	X
MRE011	Wilson, B. Batty, R. S., Daunt, F. & Carter, C. (2007) Collision risks between marine renewable energy devices and mammals, fish and diving birds. Report to the Scottish Executive. Scottish Association for Marine Science, Oban, Scotland, PA37 1QA.			X	X
MRE012	Robbins, A. (2012). Analysis of Bird and Marine Mammal Data for Fall of Warness Tidal Test Site, Orkney. Scottish Natural Heritage Commissioned Report No. 614.				
MRE013	R Hexter (2009); High Resolution Video Survey of Seabirds and Mammals in the Rhyl Flats Area. Cowrie Ltd.			X	
MRE014	Wilson, B. and Carter, C. (2013). The use of acoustic devices to warn marine mammals of tidal-stream energy devices. Report to Marine Scotland.			X	
MRE015	Dawson, S.M., Northridge, S., Waples, D. and Read, A.J. (2013) To ping or not to ping: the use of active acoustic devices in mitigating interactions between small cetaceans and gillnet fisheries. Endangered Species Research, vol 19 , no. 3 , pp. 201-221 .			X	
MRE016	Mackey, B., Philpott, E., Tollitt, D.J. (2009) Strategic review of Offshore Windfarm Monitoring Data Associated with FEPA Licence Conditions: Marine Mammals. SMRU Limited Report	X	X	X	
MRE017	Keenan, G., Sparling, C., Williams, H., Fortune, F. (2011) SeaGen Environmental Monitoring Programme Final Report	X			
MRE018	MASTS Marine Predator Workshop (2010). Marine top predators and renewables: survey and research requirements	X	X		
MRE019	Dawson, S.M., Wade, P., Slooten, E. and Barlows, J. (2008) Design and field methods for sightings surveys of cetaceans in coastal and riverine habitats. Mammal Rev 38 (1). 19-49	X	X	X	
MRE020	Evans P.G.H.(2010) Baseline Survey Recommendations for Cetaceans and Basking Sharks in the Pentland Firth and Orkney Waters. Scottish Natural Heritage report (iBids and Projects ID 1052)	X	X	X	X
MRE021	Evans P.G.H. and Thomas L.. (2013) Estimation of costs associated with implementing a dedicated	X	X	X	

	cetacean surveillance scheme in UK. JNCC Report No.479				
Doc ID	**Document citation**	**General guidelines on planning and/or implementing surveys**	**Refining questions to be asked prior to surveys**	**Describing or reviewing a technique or methodology**	**Reviewing impacts**
MRE022	Thompson, P.M., Lusseau, D., Barton, T., Simmonds, D., Rusin, J., Bailey, H. (2010) Assessing the responses of coastal cetaceans to the construction of offshore wind turbines. Marine Pollution Bulletin			X	
MRE023	Ocean Renewable Power Company (2013). Cobscook Bay Tidal Energy Project. 2012 Environmental Monitoring report. Final Draft. FERC Project No.12711-005	X		X	
MRE024	Marine Mammal Observer and Reporting Plan for Pile Placement. Incidental harassment authorization Cobscook Bay tidal energy project. FERC Project no 12711	X		X	
MRE025	Proposed methods for the Environmental Impact Assessment of the Wave Energy Site off Annagh Head, Co.Mayo	X		X	
MRE026	Seiche Limited for Channel Energy Limited (2012). Atlantic Array Offshore Windfarm Draft Environmental Statement. Vol.3 Annex 9.1 Marine Mammals	X		X	
MRE027	Shields, M. A., Dillon, L.J., Woolf, D.K. and Ford A.T. (2009) Strategic priorities for assessing ecological impacts of marine renewable energy devices in the Pentland Firth (Scotland, UK). Marine Policy 33: 634-642				X
MRE028	Kastanevakis et al. (2012) Monitoring marine populations and communities: methods dealing with imperfect detectability. Aquatic Biology 16:31-52			X	
MRE029	Berggren et al. (2008) Review of methods previously used in monitoring temporal and spatial trends in distribution and abundance. SCANS report Appendix D2.1	X		X	
MRE030	Harwood, J., King, S., Schick, R., Donovan, C. and Booth, C. (2014) A Protocol to Implementing the Interim Population Consequences of Disturbance (PCoD) Approach: Quantifying and Assessing the Effects of UK Offshore Renewable Energy Developments on Marine Mammal Populations. Report Number SMRUL-TCE-2013-014. Scottish Marine and Freshwater Science, 5(2)			X	
MRE031	Small cetaceans in the European Atlantic and North Sea (SCANS II). Life Project LIFE04NAT/GB/000245	X		X	
MRE032	Dahne, M., Verfus, U.K., Brandecker, A. (2013) Methodology and results of calibration of tonal click detectors for small odontocetes (C-PODs). Journal of Acoustical Society of America, 134(3):2514-2522			X	

Doc ID	Document citation	General guidelines on planning and/or implementing surveys	Refining questions to be asked prior to surveys	Describing or reviewing a technique or methodology	Reviewing impacts
MRE033	Diederich,A., Nehls, G., Dahne, M., Adler, S., Koschinski, S., and Verfus, U. (2008) Methodologies for measuring and assessing potential changes in marine mammal behaviour, abundance or distribution arising from the construction, operation and decommissioning of offshore windfarms. Bioconsult SH report to COWRIE Ltd.	X		X	
MRE034	Dolman, S. and Simmonds, M. (2010) Towards best environmental practice for cetacean conservation in developing Scotland's marine renewable energy. Marine Policy 34: 1021-1027				X
MRE035	Anglesey Skerries tidal stream array; marine mammal monitoring review. Confidential.	X	X	X	
MRE036	Static acoustic monitoring at the DeltaStream deployment site in Ramsey Sound using C-POD and T-PODs. Confidential			X	
MRE037	Cheney, B. et al. (2013) Integrating multiple datasources to assess the distribution and abundance of bottlenose dolphins Tursiops truncatus in Scottish waters Mammal Review 43:71-88			X	
MRE038	Denardo, C., Dougherty, M., Hastie, G., Leaper, R., Wilson, B. and Thompson, P.M. (2001) A new technique to measure spatial relationships within a group of free-ranging coastal cetaceans. Journal of applied ecology, 38:888-895.			X	
MRE039	Boyd, I. L, Bowen, W. D and Iverson, S. J. (Eds.) (2010). Marine Mammal Ecology and Conservation: A Handbook of Techniques. Oxford University Press.	X	X	X	
MRE040	Evans, P.G.H. and Hammond, P.S. (2004) Monitoring cetaceans in European waters. Mammal Review 34(1): 131-156.	X		X	
MRE041	Marine Scotland The Protection of Marine European Protected Species from injury and disturbance				X
MRE042	Embling, C.B., Wilson, B., Benjamins, S., PIkesley, S., Thompson, P.M., Graham., I., Cheney, B., Brookes, K.L., Godley, B.J. & Witt, M.J. (unpublished) Guidance document: Use of Static Passive Acoustic Monitoring (PAM) for monitoring cetaceans at Marine Renewable Energy Installations (MREIs) for Marine Scotland. NERC Marine Renewable Energy Knowledge Exchange (MREKE) program			X	

Of the listed documents above, by far the most comprehensive and informative for planning marine mammal monitoring at tidal energy sites are the SNH document *Guidance on Survey and Monitoring in Relation to Marine Renewables Deployments in Scotland – Volume 2: Cetaceans and Basking Sharks* (Macleod et al., 2011) and the SMRU/MERA report on *Approaches to marine mammal monitoring at marine renewable energy developments* (Macleod et al., 2010), which describe the commonly used methodologies and their suitability for baseline characterization and impact monitoring for marine renewable energy sites, and how the methods for these two may differ, depending on the questions asked.

These reports describe in great detail all aspects of a monitoring project, including relevant legislation, questions to be answered, detailed descriptions of monitoring methods and logistics for organising surveys and issues to be considered for data analysis and interpretation. In addition, Diederich et al. (2008), Evans and Thomas (2013), Evans and Hammond, 2004; Boyd *et al*. (2010), and the SCANS II Final report (Berggren et al. (2008) also offer good generic as well as detailed advice for planning and conducting marine mammal surveys, and there are various books, journal papers and reports which detail and describe specific monitoring methods or offer guidance on standard marine mammal monitoring techniques. Several of the selected documents, including peer-reviewed journal papers (Dolman and Simmons, 2010 and Simmons and Brown, 2010), list potential impacts from marine renewable devices on marine mammals.

3.2. Summary of the general advice offered for monitoring marine mammals at tidal sites

The aim of this document is not to be a detailed guidance document to every possible scenario, but to direct the reader to the most relevant documents which are currently available. The websites where these documents can be accessed are listed in Appendix I. Below is a brief summary of some of the main points highlighted in the documents listed above, which we recommend the reader to thoroughly revise before planning their own mammal survey and monitoring program in a planned wave and tidal energy site. Chapter 4 lists issues specific to land-based visual surveys as well highlights potentially useful new emerging technologies and methods. Chapter 5 details approaches to data analyses typically used with land-based data collection.

Initial assessment

What type of assessment is the data for?

The first thing a developer should be considering when beginning to plan potential marine mammal studies at their development site is to define the question(s) to be addressed. Macleod et al. (2010) describes in concise manner the current legislative requirements for both developer and regulator and provides questions to guide the data collection for developer. In addition Macleod et al. (2011) detail the key questions to be addressed for European protected Species (EPS), Appropriate Assessment (AA) and Post Consenting or Impact Monitoring (IM) in a table format.

To ensure compliance to marine mammal environmental monitoring requirements it is important to understand that there are two different groups of measurements that may be required to satisfy an Environmental Impact Assessment (EIA). The questions answered will depend whether the developer is planning to achieve local characterisation of the marine environment and marine mammals within it, also referred to as pre-consenting surveys, or whether they are planning baseline surveys for post consenting impact monitoring. The first, so called site or environmental characterisation (or pre-construction survey) provides basic information about the ecological features of the site or region, especially those that might have specific protection under current legislation. The other, known as impact monitoring, involves measuring effects that might take place due to disturbance from the development, and this takes place throughout the different phases of the development (Macleod et al. 2010). It is important to note that characterisation surveys may not be required in all cases if sufficient data exists from other sources.

What is the scale of the proposed project?

Once the objective of the survey has been designed, the developer needs to have some idea of the scale of the project. Prior to planning the details for EIA or AA the developer needs to define the potential impacts zone of the device(s) (Macleod et al. 2011). This may be very large in the case of potential acoustic impacts or relatively localised to the site such as risk of collision.

Asking appropriate questions

In Macleod et al. (2011) the key questions are described in detail and divided into to three main sections; those required for an European protected species (EPS) assessment; those needed for the appropriate assessment (AA) for Special Area of Conservation (SAC) and specific questions for impact monitoring. Here I have joined the EPS and AA assessment questions under *site characterisation*, as one of first things that a developer would do, would be to ascertain whether the planned site contains any European protected species or is in a vicinity of an SAC. After site characterisation, *impact monitoring* is then used to measure effects of the disturbance compared to a known baseline.

Site characterisation surveys

Site characterisation can typically utilise existing datasets of marine mammal distribution and abundance whereas impact monitoring requires baseline data to be collected in a specific manner that will allow testing of an expected effect on the population – which typically is not easily answered by the large scale datasets of distribution and abundance. The main reason for this is that they can be difficult to reproduce during disturbance from development, but also that it is very difficult to distinguish an effect of the development from other effects without carefully designed data collection and analytical methods. Even then, natural variability in marine mammal distribution, range, abundance and behaviour may well be larger than the effect of the development, or the effect of the development will be masked by the natural variability, or in most cases, the data collected are not sufficient to show the effect. This is not to say that the effect is absent, merely that it may be very difficult to demonstrate its existence or extent with the types of survey methods available.

The primary goal of the site characterisation is to fulfil requirements for the environmental legislation relating to European Protected Species (EPS) and the Appropriate Assessment (AA) of the Special Areas of Conservation (SAC), if relevant. The key issue is to ascertain whether the development and its associated activities will kill, injure or disturb European Protected Species or adversely affect the integrity of an SAC.

- **Does EPS or Annex II species occur in the area or its impact zone? Is there an SAC in the area or in its vicinity? Are these animals part of an SAC population?**

- **If there are qualifying species in the area - How abundant are they? What is their spatial and temporal distribution within the site? How do they use the habitat?**
- **Is there tidal, diel or seasonal variation in their abundance and/or distribution?**

Impact monitoring: pre-construction baseline surveys and post-construction monitoring

Impact monitoring requires that data is collected before (so called baseline survey) as well as during and after the disturbance. In an ideal situation the characterisation surveys would provide the baseline data for the impact monitoring, however the issue is that site characterisation and baseline monitoring ask different questions (what animals are there, where, when and how many vs. how or to what extent are the animals affected by the development). Because of this they typically require different type of data to be collected, and can rarely be conducted in the same scale, so will require different survey strategies (Macleod et al. 2010). Here we presume that prior to impact monitoring site characterisation surveys would have already taken place and the need to conduct specific EPS or AA assessments would have been established. Before embarking on impact monitoring one must first define the expected potential impacts and their scales and then design the surveys around these.

- **What impacts are expected to result on the target species?**
- **What is the most feasible, cost effective and practical way to measure the impact? What is the metric of interest? What data should the survey collect?**
- **What threshold in this metric would we qualify as an impact?**
- **How much data is needed to ensure the impact at the selected threshold (if present) can be detected?**
- **Is there a significant change in the selected impact metric between baseline and construction or deployment?**
- **Is this change limited to the development footprint?**
- **Does the level of impact change with time or distance?**
- **Can this be attributed to the development?**
- **Does the detected impact affect the Favourable Conservation Status of the target species?**

Survey design

Appropriate survey design is required to ensure the data collected can answer the questions asked. Embarking on data collection without having finalised the survey design and deciding on how to approach the data analysis will inevitably lead to poorly planned field work, data that may not be fit for purpose and a potential waste of money and time. The regulators may well request additional surveys and/or data analyses to be conducted if the data cannot answer the required questions.

The survey design will depend on type of survey required – whether it is characterisation survey, baseline survey for impact monitoring or post impact monitoring. It is important to note that there is no straightforward one-stop solution for deciding on a survey programme. Most survey and monitoring projects are governed by finite resources and restricted time lines, and therefore survey budgets are often low. To recommend a comprehensive monitoring and survey programme, one would first be inclined to ask: how much money is available? The more time (and money) is spent, the more detailed a survey can be conducted – resulting in more reliable results (Macleod et al, 2011). There are several key components to designing an effective survey design which have been covered in detail in both Macleod et al. (2010) and (2011). Here is a brief summary of those.

Selecting the appropriate survey type

As outlined above the purpose and requirements of the survey will have to be decided on in the first instance. This should include some awareness of the device site (location and area) and the expected zone of impacts.

Deciding on questions to be answered

Not all the questions listed in the previous section are relevant to every survey, as there may well be existing datasets that can provide answers to some of them. If the site is located close to or within an SAC the questions will be geared towards requirements of an Appropriate Assessment for SAC. Equally if an European Protected Species is known (or thought) to utilise the area the survey must be able to provide data to fulfil the requirements for an EPS application.

Spatial scale – how large an area to survey?

Once it the objectives of the survey have been agreed upon, the area to be surveyed must be decided. Although many of the wet renewable devices are relatively small, their expected impact zone can be large, particularly from propagation of noise but also due to possible downstream effects on benthic and fish populations. The survey should be able to capture both the deployment site, as well as the expected impact footprint and the design should anticipate the scale of animal movement from temporary disturbance. In essence the developer needs to anticipate the impact zone before going out to measure it – to ensure they are surveying at the correct scale. Study should extend beyond the development site to account for potential impacts from noise and downstream effects on benthic habitats and fish populations (Macleod et al. 2011). Traditionally studies aimed at understanding the impact of an event have been designed using a Before-After-Control-Impact survey, whereby the impact is assessed both *temporally* (before and after impact measurement) and *spatially* (impact and control site, where there effect of impact is not expected). However this type of design can be problematic as natural variability in animal presence can be difficult to assess both before and during impact and often it can be very difficult to identify a site that is truly a 'control' site where the effect of impact is not felt, but which has same characteristics to the impact site.

The current recommendation to assess and understand impacts on a spatial scale is to use a Before-After-Gradient design, which can takes into account the variability in animal presence across the study area and include buffer zones beyond the boundaries of a development site (Thompson et al. 2010).

Temporal scale – when and for how long to survey?

Characterisation surveys may take place a long time before development on site begins. It should be carried out for long enough time scale to collect enough data to reflect natural variation in the system. Marine mammals are extremely mobile with often very seasonal distributions which will not be evident from short one-off survey. Macleod et al (2011) recommends monthly data collection to capture the seasonal variation to be carried out for duration of one year for characterisation surveys with further year's data collection in areas of particular importance to key species. In addition cetaceans often display large inter-annual variation in their abundance and distribution which will affect the site assessment as well as any potential impact monitoring. However this would require several years' of survey effort and is typically not feasible for a developer to achieve, although it may be required in some cases. Instead the developer can use existing datasets to gain a better understanding of natural variability in cetacean data.

For the impact monitoring, baseline data collection needs to be conducted immediately prior to the installation period. Just as for characterisation surveys, it must cover the expected impact zone, and be conducted at frequent enough intervals to capture the seasonal variation so that any changes beyond this natural variation can be detected. In addition the monitoring scheme must take into account that the impacts may differ over time. Impact monitoring must be conducted through all stages of the development. Sampling frequency will depend on the selected survey method; metric measured and amount of data collected at each survey.

Survey effort required - how much data to collect?

Macleod et al. (2011) explains the inherent uncertainty in field data collection of cetacean data, because many species have highly variable distribution and abundance in both temporal and spatial scale leading to large margins of uncertainty for estimates based on such data. To estimate the extent of this uncertainty, the survey needs to produce enough data for a robust assessment of variability. The more data there is, the more precise any estimate generated from it will be. The 'survey effort' required or the number of survey days needed, will depend on the amount of data gathered. This becomes ever more crucial when attempting to detect a change in population trends or habitat use (such as impact from MRE development) from data which already has large inherent natural variability. The smaller the expected change, the greater the effort required to achieve enough data which would detect such a change (Macleod et al. 2010).

In order to decide on a survey design, one must have some idea of how much data will be collected. A useful way to find out how often animals are encountered (i.e. how many data points can be gathered) in a survey is to conduct a pilot study, or examine previous survey data from the area. The estimated encounter rate will allow the survey design to take into account the number of survey days or the length of survey legs required to generate enough sample sizes so that precise estimates of abundance can be made, or impacts can be detected (Macleod et al. 2011).

The extent of survey effort (L) necessary for a line-transect survey with a defined level of uncertainty (coefficient of variation, CV) in an area with a known encounter rate (ER) can be calculated using the following equation quoted in Macleod at al. (2011), from Buckland et al.(2001).

$$L = \frac{b}{CV\ \hat{D}^2}\ x\ \frac{1}{ER}$$

The power to detect change from a given dataset depends on the CV of the metric measured (such as density), the duration of the survey period, the magnitude of change and the significance level required. The larger the change monitored and the lower the CV (natural variability), the higher the power to detect change. Different monitoring methods will generate different types of and different quantities of data, and those that generate large amounts over longer time scales will have increased power to detect change.

Choice of method

Typically primary data of interest for characterization monitoring related to marine renewable energy will be: species presence, distribution and abundance; whereas impact monitoring seeks to detect possible change in presence, distribution, abundance or behaviour during construction and operation, all of which may vary over different spatial and temporal scales. Broadly speaking most baseline and impact monitoring is conducted by visual observations (land, boat or aerial) possibly aided by video or still photographic methods; acoustic monitoring methods (towed or static passive acoustics); telemetry methods (tagging) and stranding schemes (carcass recovery and assessment) (Macleod et al., 2011). Lately there is also research being conducted on the ability of unmanned aerial vehicles (UAVs) to gather photographic or video data.

The choice of method should depend on the questions asked, specifically whether relative or absolute abundance is required to detect trends and the temporal and spatial coverage required. In addition surveys need to be designed to suit the problems associated with the site in question (Macleod et al. 2010) and include consideration for types of species expected to be detected, exposure and distance from land. Each technique will have its specific biases which must be taken into account. Visual surveys can be very expensive and time consuming and are limited to daylight hours and calm seas, and have typically very limited temporal coverage, as they are typically conducted seasonally and often many years apart and thus have a lower ability to estimate long term trends. In contrast, passive acoustic methods can be used in more varied sea states; they can be left to record over long time periods and are hence often the chosen method for long-term monitoring (Macleod et al, 2010). However, acoustic methods do have important limitations. The main disadvantage is that only vocalising animals will be detected and animals that are silent for long periods will be missed, making certain species more suitable for acoustic monitoring, e.g. the harbour porpoise, which echolocates almost continuously (Akamatsu et al. 2007). However porpoises produce very directional, narrow band high-frequency clicks of around 130 kHz, and these are disadvantaged by a high rate of absorption around 40 times higher than those of sperm whale clicks so that they are only functional or detectable at short distances (Kyhn et al. 2009).

Methods to ascertain species presence include stranding reports and existing databases, vantage point surveys, aerial and boat line-transect surveys, towed acoustic surveys, passive acoustic monitoring as well as non-line transect boat surveys. For estimating relative density/abundance the best methods are often a combination of visual line-transect surveys (boat based or aerial), towed acoustic surveys, photo-identification and in some areas fixed vantage point surveys. The method chosen is entirely dependent on the characteristics of the site and the target species. For example, harbour porpoise are not suitable species for photo-identification studies due to lack of individually distinguishable marks, and fixed vantage point surveys require high cliffs for the observation station.

Using vantage point surveys to assess animal abundance requires various assumptions to be met, which are discussed in following chapters. Techniques now exist to use static acoustic methods to estimate animal density, although this has some sever limitations and requires auxiliary information such as call rates and detection probability (Marques et al. 2012). Passive acoustic data loggers which are able to provide long-term datasets are the most effective method in detecting population trends, and, crucially, potential changes in animal presence and habitat use which can be used for impact assessment. Other methods to study how the animals use their habitat include visual observations (from land or boat), including video or photographic methods, theodolite tracking, towed acoustic surveys and photo-identification and telemetry (tagging). The size, behaviour and habitat preferences of the target species will dictate which method of suits them best. For example, focal follows and theodolite tracking works well for bottlenose dolphins but are very difficult to achieve for harbour porpoise (Macleod et al. 2011; Nuuttila et al. 2013a), which lends itself well to acoustic monitoring due its high rate of vocalisation.

Macleod et al. (2010) recommends that each site and situation should have a bespoke research design but that open consultation on these designs should be sought from experts before implementing them, preferably through a specifically appointed scientific advisory body.

Data handling, analysis and interpretation

A crucial part of survey design is a prior understanding of the analyses involved, which builds on a clear vision of the questions that the data needs to answer. Although it might be tempting to begin data collection as early as possible, to ensure long enough coverage, there is little sense is collecting data that may not be useful for the analyses, or is not fit for purpose.

Once the data collection methods and the type of data to be collected has been decided upon, and some idea of the likely amount of data is achieved, it is useful to spare a thought on data storage and handling prior to starting. For example, acoustic data from towed hydrophone surveys or footage from video-tracking will require terabytes of storage space and will need powerful computers to handle and analyse.

There are several analytical tools to process and analyse marine mammal datasets. These include programmes like PAMGuard for processing and interpreting acoustic and photographic data; Logger for collecting data on board visual surveys and DISTANCE (Buckland et al. 2001) for density estimation and survey design for line-transect data. In addition, various specific R and Matlab packages exist, designed specifically to deal with various cetacean related datasets, such as nupoint (Cox et al. 2013) and MRSea (Scott-Hayward et al. 2013).

Macleod et al. (2011) describes current advances in development of collision risk models and management tools such as Potential Biological Removal (PBR). Developers need to ensure that their chosen consultants are up-to speed with latest analytical methods and statistical tools for processing and interpreting cetacean data. Chapter 5 describes issues regarding visual observation data from fixed vantage points and analytical tools to overcome these problems.

Expertise required

One the key points encountered in the literature reviewed regarding the choice of survey methods was the importance in following standardised methodologies to ensure that data collected by each developer is comparable across sites. Designing and conducting marine mammal surveys requires specific expertise and knowledge and developers should make sure that consultants used have sufficient experience in field survey methodologies as well as data analysis and interpretation. There are instances where developers have employed consultants with insufficient expertise in survey design and data analysis which has led to data collected not being of the standard required by the developers. As in any discipline clear distinction should be made between keen and proficient (marine mammal) observers and skilled consultants capable of designing and delivering scientifically robust survey, and monitoring plans. Developers need to ensure that the persons or companies in charge of delivering their environmental assessments or monitoring plans a) have a background in marine fieldwork and specifically in marine mammal studies and b) are capable of delivering/reviewing reports with statistical analyses that can answer questions required by the regulators. Key to successful survey or monitoring program is to engage the regulators early on in the process of setting up a science management or advisory group, and ensuring that any survey work planned meets requirements.

Benefits of regional collaboration and scientific steering groups

Various sources including Macleod et al. (2010 and 2011) stress the importance of collaboration between developers and sites in designing surveys and collecting data so that resources can be pooled across the full range of wind, wave and tidal power sectors. Moreover, Macleod et al (2010) recommends that marine mammal monitoring should be undertaken in coordinated fashion over the whole of the UK regional seas that are affected by renewable energy developments, and that such wide scale surveys should essentially be government lead. Large surveys with wider buffer zones around sites will be more appropriate for mobile marine species and also more useful for detecting and assessing cumulative impact and allow for between site comparisons. Crucially, joint surveys will reduce costs for individual developers. In Wales, Marine Energy Pembrokeshire facilitates collaboration between developers and sites and could be used as a forum via which joint research between developers could be coordinated.

The main recommendation from the reviewed monitoring guidance for independent developers is to not attempt to achieve full marine mammal monitoring programme via a single consultancy, but to set up a steering group (or Science group) made up of regulators, consultants and experts in various aspects of marine mammal science, with knowledge of EU legislation, chaired by an independent chair. The main reason for this is that as there are no set guidelines that would fit every single MRE site, each monitoring programme will require a lot of planning, potentially different data collection methods and analytical techniques. The purpose of the group would be to oversee the environmental monitoring and to continuously review and feedback the results of the project back to the group, enabling the appropriate changes and improvements to be made as and when necessary, rather than producing unsatisfactory results for regulators at the end of several years' hard work. The marine mammal monitoring at Marine Current Turbines (MCT) SeaGen tidal turbine was one such project led by a dedicated 'Science Group', which resulted in significant relaxing of mitigation requirements and increase confidence in the results by regulators (Macleod et al. 2011).

3.3. Stakeholder questionnaires and interviews

The questionnaires sent to some of the key developers and consultants working with developers revealed a variety of issues within the environmental monitoring and survey process. The key problems identified in Welsh MRE sites and projects could be grouped into three categories; those concerning regulatory advice; those concerning developers' capacities in conducting required surveys and those that were to do with external factors such and funding, weather and data access. The main issue identified by most interviewees was the lack of or timing of regulatory guidance and the insufficient instructions from developers to their consultants conducting monitoring surveys. Table 2 below lists the key issues identified during the interviews as well as the solutions offered.

Table 2. Key issues identified during interviews and potential solutions offered by interviewees.

Issues relating to	Problems identified	Possible solutions
Regulatory advice	Lack of guidance from the regulator specific to the project and site, specifically to do with fixed vantage point surveys	Earlier involvement of regulators in a Science Advisory Group specific to each site
	Comments on field methods received several years into data collection	Earlier discussions with regulatory/advisory body to ensure comments are received in good time
	Regulatory requirements on survey coverage not proportional to the risk assessments	Revisiting regulatory requirements?
	Regulatory requirements on data analyses such as collision risk modelling futile when based on inadequate baseline datasets	Revisiting regulatory requirements?
	Poor understanding of costs involved for an independent developer for the types of data/surveys required	More practical approach needed for regulatory requirements
	Current guideline documents either too large or too vague to provide specific advice	Provide more practical and useful guidelines, specific to sites found in Wales
	Lack of understanding of what developers *need* to know and what regulators would ideally *want* to know	Make a clear distinction of what is developer's responsibility and what is regulator's responsibility
Developer capacity	Lack of instructions from developer to consultant on field methodology for data collection	Developer need to seek advice from regulators seek experienced consultants early on in the process to ensure correct survey design and analyses
	Lack of adequate project planning to encompass surveys over seasons and years	As above
	Delays, funding issues and changing plans or specifications for the device hindering consultant' ability to conduct adequate risk assessments	Typically due to issues with external funding or technology development
	Lack of advice (or funding to seek such advice) for survey design and data collection methods	Collaboration between developers may help to ensure adequate funding
	Not aware of similar projects or surveys	Consultants must have the required expertise and knowledge of MRE issues
	Data given for analyses from developer or external sources was not fit for purpose	Survey and analysis of cetacean data must be coordinated and adequately planned from beginning
	Data not collected, recorded or archived in a standard manner leading to issues and restrictions with analyses by consultants	Developers must ensure adequate survey design and data collection takes place

External issues	Consultants and developers unable to access existing datasets – whether reports or raw datasets for re-analyses	Data access could be centralised under one (governmental?) organisation
	Data gaps in understanding the effects of devices (despite years of deployment at EMEC site)	Government lead research and funding required
	Funding for environmental monitoring from external sources meant that timings were not ideal for conducting surveys	
	Lack of resources for individual developers for conducting research to answer key questions, both on effects of devices as well as baseline data collection	More collaboration required between developers to ensure data collected in meaningful way and that data can be shared and compared
	Lack of government-led initiative to support MRE projects, including lack of basic funding	Government lead research and funding required
	Lack of baseline cetacean data for Welsh waters	Government lead research and funding required
	Lack of technology to study species specific interactions between devices and marine mammals to better quantify risks	Government lead research and funding required

4. Survey guidelines and field protocols for marine mammal surveying and monitoring in tidal and wave energy extraction sites from fixed vantage points

This chapter is collated from various Marine Scotland, Scottish Natural Heritage (SNH) and SMRU Marine reports (Macleod et al. 2010 and 2011) as well as few key peer-reviewed articles (Evans and Hammond, 2004) compiling methodological details, practical tips and academic advice into one coherent report, to act as a practical guidelines for environmental advisors and consultants working within the Marine Renewable Energy (MRE) Industry. The key points from the above reports are summarised here, but it is strongly recommended that anyone planning to undertake marine mammal for a MRE development ensures they have a scientific advisory group in place to develop and adapt monitoring methods and data analyses together with marine mammal experts and regulators to ensure successful outcome of a monitoring program. Furthermore it is advisable to consult the original documents along with this document. These should all be available from the NRW advisory team, but are also available from the various websites listed in Table 1 and Appendix I.

4.1. Overview

Survey design and field protocols for visual observations from fixed vantage points have been described in great detail in both Macleod et al. 2010 and 2011. Land-based visual observations are one of the most commonly used techniques for studying costal cetaceans. Vantage point observations are non-invasive (i.e. have typically no effect on the target species) and depending on equipment used can be relatively inexpensive. They are typically used for establishing presence and species diversity of cetaceans in an area, their spatial and temporal distribution and habitat use. Visual observations are also one of the most effective methods to observe animal behaviour without disturbing them, and the same site can be used for surveying cetaceans, pinnipeds and seabirds, although observers must be experienced surveyors for each taxa. Fixed vantage point surveys can be used to assess relative abundance of the area and changes in population trends over time but it is not practical way to estimate absolute abundance, mainly due to the size of the area covered, the large variability in marine mammal distribution and the difficulty in assessing detection probability for fixed vantage point The main limitation of fixed vantage point surveys is the extent of the area covered from any single vantage point – around 1-2 km for harbour porpoise (Koschinski et al. 2008) and 5-10 km for larger whales (Mann et al. 2000). This is dependent on the target species; elevation and topography of the site and the field of view, and not all sites are suitable for surveying. Some areas may require more than one survey point which typically will have differing geographic features which may cause difficulties for data analysis. This methodology is dependent on calm sea sand good visibility so year-round monitoring programs can be severely restricted during bad weather periods. Sightings data from vantage point surveys should always include accurate bearings and distances to the animals to provide accurate positional information of target species, allowing tracking of animals and estimation of the detection probability at each site to assess relative abundance. This is traditionally attained using theodolites but can also be achieved using high-definition video or photogrammetric methods (Gordon et al. 2001; Hastie et al. 2003; Hoekendijk et al.2015).

4.2. Survey design

Before designing a vantage point survey, the developer should already have a clear idea of the objectives of the survey, i.e. whether the survey will be fulfilling requirements for a site characterisation or collecting data for baseline or impact monitoring. They should also have decided which questions they are aiming to answer and how they are going to use the vantage point data to achieve these. The difference between site characterisation and monitoring surveys is highlighted earlier in Chapter 3, along with the different questions the developer should be aiming to answer with the data.

Not all the questions listed are relevant to every survey, as there may well be existing datasets that can provide answers to some of them. If the site is located close to or within an SAC the questions will be geared towards requirements of an Appropriate Assessment for SAC. Equally if an European Protected Species is known (or thought) to utilise the area the survey must be able to provide data to fulfil the requirements for an EPS application.

Most likely the vantage point survey can only answer *some* of the questions, due to the spatial and temporal limitations of any one vantage point and availability of observers (and weather!) It may well be that another method will be more appropriate or required in addition to the fixed vantage point surveys. It is very common to combine boat-based observations, acoustic survey or static acoustic monitoring with land-based visual surveys to achieve desired data.

Traditionally studies aimed at understanding the impact of an event have been designed using a Before-After-Control-Impact survey, whereby the impact is assessed both *temporally* (before and after impact measurement) and *spatially* (impact and control site, where there effect of impact is not expected). However this type of design can be problematic as natural variability in animal presence can be difficult to assess both before and during impact and often it can be very difficult to identify a site that is truly a 'control' site where the effect of impact is not felt, but which has same characteristics to the impact site.

4.3. Site selection

Once the purpose and requirements of the survey have been decided, the developer should gather all the existing information available about the area, the target species and also the development. This should include some awareness of the device site (location and area) and the expected zone of impacts.

Although many of the wet renewable devices are relatively small, their expected impact zone can be large, particularly from propagation of noise but also due to possible downstream effects on benthic and fish populations. The survey should be able to capture both the deployment site, as well as the expected impact footprint and the design should anticipate the scale of animal movement from temporary disturbance. In essence the developer needs to anticipate the impact zone before going out to measure it – to ensure they are surveying at the correct scale. Study should extend beyond the development site to account for potential far-field impacts such as those derived from noise disturbance.

The vantage point needs to have a good view over the target area – i.e. deployment site as well as a large enough area around it to be able to assess animal distribution in a meaningful way. The higher the vantage point, the further the observers will be able to see, and the larger area can be covered, although typically small cetaceans become increasingly difficult to see with increasing distance. For land-based observations for small cetaceans from a 90 m, 4-5 km is typically the limit of observations from a high vantage point with powerful binoculars.

Practical considerations for site selection should include not just elevation but also the field of view both out to sea as well down to the surface level, whilst still allowing ease of access. Observer safety and exposure of the site are important, as observers need to be able to carry equipment to the site, rest between watches and stay comfortable to maintain focus and concentration levels. Sometimes it may be preferable to construct a hide or shelter from wind and rain.

It is unlikely that the entire area of interest can be searched from one vantage point, but it is desirable that different vantage points are of similar height and topography in order for data from two sites to be comparable.

If the objective is to conduct impact monitoring a suitable control site should be selected for comparison, bearing in mind that rarely can a control site provide a real *control* for the impact site, if natural variability in animal distribution and abundance between the sites cannot be accounted for.

4.4. Field of view and scan protocol

Cetacean observations are usually conducted by continuously watching the selected sea area or systematically scanning the area from one side to another. Methodical scanning provides a more even coverage compared to continuously watching the whole area, especially if the view is divided into sections and the observers ensure that each section receives an equal amount of scan time. The survey area is typically a hemispherical in shape, extending from the vantage point to offshore waters encompassing the device site.

Scan protocols for visual surveys vary greatly in published literature and survey guidelines as these often depend on the survey objective. Typically an observer watches continuously for between 30min (Nielsen et al. 2012) to an hour (Nuuttila et al. 2014) and then has a rest or changes tasks (for example from observer to a recorder) although some studies have conducted watches up to 120 min and even 4 hours with the same observer (Pierpoint et al. 2009; Goodwin and Speedie 2008). Watch periods may cover the entire day, but the observers must ensure adequate rest periods are included to ensure data is comparable throughout.

Although single observer studies are relatively common, and can be feasible on some small sites, it is recommended that more than one observer is used. This way scans can be conducted on different sectors simultaneously and record taking can be conducted by dedicated person, without having to disrupting the scanning process.

During a watch several scans are conducted, and it is recommended that a short break is taken after every scan (Macleod et al. 2011) to avoid observer fatigue, and longer rest or change of observer at regular intervals. Scan durations may depend on field of view or the questions asked but are usually between 5 and 15 min long (Pierpoint 2008; Macleod et al. 2011).

During vantage point method trials (Nuuttila et al. 2014) it was found that field of view has a significant effect on the observer's ability to detect animals. If the field of view encompasses a very large area many miles offshore it will be necessary to divide the search area into different sections covering near field, midfield and far field areas. Similarly if the field of view is 60 degrees, a two minute scan can be divided into 3 periods of 40 seconds each, during which time observer scans a 20 degree arc. This will ensure that each sector receives similar temporal coverage.

Although 15 min scan is commonly used in cetacean visual surveys, it may not be the most suitable time period for counting individuals at MRE sites, which are relatively small and only covering the immediate deployment site. Such a long scan period may lead to duplicate sightings of the same individual(s). This may not be a problem if the aim is to track certain individual and assess their habitat use. But if the objective is to estimate animal density, then a shorter 'snapshot' period would be a better unit for sampling. Many studies have used very wide field of views, which means that many animals can be missed when the observer is covering one end of the observer arc. If the viewpoint must cover more than 90 degrees, it may be more useful to use two observers, each covering one side of the arc simultaneously.

Other factors affecting observer's ability to detect animals is the distance from animal to observer (which includes platform height), precipitation, sea state, haze and sun's glare. These and other environmental data must be recorded on the effort data sheet.

4.5. Time scale

Characterisation survey may take place a long time before development on site begins. It should be carried out for long enough time to collect sufficient data to reflect natural variation in the system. Macleod et al. (2011) recommend monthly data collection for duration of one year for characterisation surveys with further year's data collection in areas of particular importance to key species. Marine mammals are extremely mobile with often very seasonal distributions which will not be evident from short one-off survey. Typically visual surveys are used to assess animal distribution, relative abundance and habitat use which for many species of cetaceans can be affected by tidal, diel and seasonal patterns. This means that surveys must be conducted across these patterns to account for the effects of natural variability in the animal presence and distribution. In addition cetaceans often display large inter-annual variation in their abundance and distribution which will affect the site assessment as well as any potential impact monitoring. To account for this, surveys need to be carried out for several years, or existing datasets utilised to assess yearly trends.

For the impact monitoring, the baseline data collection (if site characterisation data is not feasible or fit for purpose) needs to be conducted immediately prior to the installation period. Just as for characterisation surveys, it must cover the expected impact zone, and be conducted at frequent enough intervals to capture the seasonal variation so that any changes beyond this natural variation can be detected. In addition the monitoring scheme must take into account that the impacts may differ over time. Impact monitoring must be conducted through all stages of the development. The main aim of impact monitoring is to measure the presence of and the extent of the expected impact on the site. In order to do this, the assessment would have to be able to detect change in animal abundance, distribution or habitat use, and be able to show that it was caused by the device or its construction. Neither of these are particularly easy to achieve.

Sampling frequency for either site characterisation or impact monitoring will depend on the selected metric measured and amount of data collected at each survey. The amount of data needed will be determined by the level of detail of the questions asked. The expected encounter rate, i.e. the number of sightings per unit of effort (such as an hour's observing) can be gauged from existing data or acquired from a pilot survey. The power to detect change from a given dataset depends on the CV of the metric measured (such as density), the duration of the survey period, the magnitude of change and the significance level required. The larger the change monitored and the lower the CV (natural variability), within a dataset, the higher the ability to detect change. The smaller the expected change the more data will be required to detect it.

In the UK, weather will be one the most restricting factors for efficient data collection. In practice this means that the observer(s) must be able to carry out observations at all times of the day and states of the tide, when suitable weather conditions arise. The effort spent observing (the watches) should be distributed evenly over the sampling period ensuring that all times of the day and states of the tide receive equal coverage to avoid bias.

4.6. Staffing

Observers conducting vantage point surveys should be experienced marine mammal observers, appropriately trained and experienced in marine mammal identification and the data collection methods used and they should ideally have a biology/ecology background. If the marine mammal observers are also expected to device the survey design and protocol they must also be experienced in survey design for marine mammal data analyses. Each site will have its own specific practical limitations, so it is essential that pilot surveys are conducted in order to finalise best practice and review various different methods. Observer experience is crucial and it must be noted that there exists a myriad of cetacean identification courses for keen naturalists and cetacean enthusiasts and whilst these courses are excellent at raising awareness and getting general public involved in cetacean conservation, they are by no means a substitute for a degree in ecology or biology or more specifically in marine mammal science. Designing and conducting an effective survey and analysing the results requires experience and skill and it is important that the developer hires the appropriate staff to conduct and oversee their environmental monitoring if they are to achieve results which will facilitate the consenting process.

4.7. Health and safety

Health and safety of the observers is paramount and many consultancies and research institutes will not approve of lone working in remote areas. In hazardous areas such as cliff edges, it is particularly necessary to use more than one observer ensuring that site has working communication links and that adequate reporting systems are in place.

4.8. Equipment

Basic equipment needed consists of binoculars and recording forms or dictaphones for data entry. If the area spans more than a kilometre from the vantage point, it is recommended that big-eye binoculars, telescope or theodolite is used to capture animals in the far field. Regular binoculars can be used to scan the inner area closer to the observation site, but scope, theodolite or big eye binoculars will aid in species identification even at closer distances. The equipment used depends on site as theodolite requires firm ground to keep the legs steady. Big eye or other heavy binoculars will require tripod legs or monopoles which allow the observer to hold the binoculars steady without having to hold them with both hands. A theodolite may be used to provide positional information of animals (Koschinski et al. 2008; Bailey and Thompson 2006; Nuuttila et al. 2013b) which allows tracking animal paths and getting accurate distances to animal, as well as providing means for estimating station height in tidal areas. Digital theodolite can linked to a laptop running specific software which allows plotting animal tracks in real time. Digital inclinometers and laser range finders can help achieving estimates of distances and observation station height.

Video or camera equipment mounted on tripods can be used to record animal sightings, estimate animal positions track animal paths across the survey area (Gordon et al. 2001; Hastie et al. 2003; Hoedelijk et al. 2015). Video sound recording can also assist in keeping record of information, in addition to noting information on recording forms.

4.9. Equipment calibration and set-up

The observation site and any reference points used for theodolite measurements need to be geo-referenced prior to the survey and theodolite equipment calibrated according to manufacturer's instructions prior to each survey and every time the equipment has been moved. In addition during each survey, positional measurements should be calibrated to correct any errors in sightings data. This can be done using known geo-referenced points in the survey area or a boat based differential (highly accurate) GPS system, where the boat is manoeuvred around the study area and locations calculated using the theodolite angles and compared to the GPS locations. Handheld GPS does not provide very accurate positions, so its inherent error should be accounted for.

4.10. Data recording

Once the equipment has been set up and calibrated, the watch can begin. Throughout the watch the recorders need to note down observer effort and environmental conditions, such as sea state, precipitation and glare, as these will influence the sightings data collected. These need to be recorded at regular intervals for example at beginning of every scan, or when there is any change. Normally cetacean surveys are not conducted in poor visibility or when the Beaufort scale sea state is above 3, although sighting rates for harbour porpoises are likely to be affected already in sea state above 1 on some sites.

As mentioned earlier, the key issue with vantage point data analysis is the problem of how to quantify the ability of observers to sight cetaceans with increasing distance from the observation site and how this varies between sites. Station height and field of view are important factors in determining this, and need to be recorded accurately for each scan.

Typical surveys measure the number of animals per scan, which can be used as an index of animal presence on site and can be related to environmental variables such as state of tide. During scanning the observers should call out when animals are sighted, including species identification, bearing and distance to the animals. These can be recorded into a dictaphone or written down by a designated recorder. Only sightings during a scan or dedicated watch should be accounted for. Sightings outside these times (such as during calibration and set-up) can be noted down as incidental sightings.

However, sighting numbers alone cannot be used to estimate the relative abundance without assessing the effect of increasing distance from observer on the detected sightings. In order to do this, it is essential that distances from observer to animals are recorded accurately. Additionally for estimating animal distribution/habitat use, recording the location of animals within the study area is important. Additional useful information to record is animal behaviour (travelling, feeding or resting), direction of travel, and presence of calves, depending on the study objectives.

If the objective of the survey is to record animal behaviour, either by describing their activity for every encounter or by tracking animal locations, it is important that standard published guidelines for defining behaviour are studies are used as guidelines, to allow comparison between studies. Similarly, if the objective is to describe different age categories (neonates, calves, juveniles or seal pups in various stages of moulting) standard JNCC/NRW monitoring practices should be adhered to.

4.11. Measuring animal locations and distance from observer

The main issue with land based observation is that typically the abundance of recorded animals systematically declines with distance from the vantage point. Usually this is attributed to reflect imperfect detection, as observers' ability to detect animals will decline with increasing distance search area. However it is important to note that the underlying animal distribution may well be influenced by various factors, and the detection rate would most likely be a combination of the two.

In order to assess how detection of animals (or the 'detectability') is affected by environmental variables, topography or distance from observer, accurate distances must be recorded for each sighting. There exist several studies where observations have been conducted without measuring distances to animals and recording animal locations, leading to sightings datasets with possible biases – so it is crucial that observers collect the correct information from start. A useful way to estimate detection probability in some occasions may be to conduct boat-based line-transect surveys in the same area to study animal distribution on the site, and data used to calibrate the vantage point observations (Macleod et al. 2011). Novel methods to assess animal distribution without observer bias in sheltered coastal locations could be achieved by deploying UAVs to map animal presence and distribution.

Taking bearings and estimating distances by eye is not terribly accurate way to record animal locations, so photogrammetric methods (Gordon, 2001; Hastie et al. 2003; Hoekendijk et al. 2015) or theodolite angles (DeNardo et al. 2001) should be used. Several techniques exist in estimating distance from observer to animal from photographs or video footage providing station height is known and the position of the horizon can be measured with precision. If theodolite angles, photographs or video footage is taken, these should be stored linked to the sightings and effort information.

Theodolite angles can be converted into geographic positions using standard trigonometric calculations (DeNardo et al. 2001; Nuuttila et al. 2013b) if the station has been appropriately geo-referenced. There also exists open source software such as PAMGuard which can provide ranges to animals from observer from inputted video footage (PAMGuard User Manual v.1.2.00, 2009, www.pamguard.org).

4.12. Data handling

Data should be entered into an appropriately designed database as soon after the watch as possible, preferably by the observer and all data entry should follow standard protocols, with appropriate checks in place. Typically entered data is double checked by a second observer to ensure minimal errors in final database. Vantage point survey data will consist of sightings, effort information and environmental data and any linked photographic or video footage and theodolite angles (if relevant). The photos and theodolite angles will need to be processed with appropriate software or calculations to achieve animal locations and distances from observer. These can be analysed together with environmental information or oceanographic data to model relationships between animal distribution and variable such as depth or distance from coast. Approaches to data analyses for vantage point data are discussed in the next chapter.

5. Approaches to data analysis of visual sightings data from fixed vantage points

Traditionally, data gathered by developers for marine renewable developments has focused on characterising the abundance and distribution of marine mammal species in and around proposed development sites, with the aim of ultimately quantifying relative or (ideally) absolute density of animals and assessing the effects of these developments (significant or otherwise) on animal populations.

Data for such studies has often been collected from land-based vantage points, although survey work in wave and tidal stream development sites can be challenging for various reasons as discussed earlier. In fact, very few surveys to date have enabled absolute density of animals to be calculated, and most assessments of impacts have been either semi-quantitative, or just descriptive. Furthermore, difficulties can arise when quantifying the actual biological significance of any recorded effect (if statistically significant) and disentangling this from often very large natural fluctuation in animal abundance or distribution (Maclean et al. 2014). This chapter aims to briefly discuss some currently available analytical methods for fixed vantage point data. Anyone attempting to use these methods should have some basic knowledge of R as well as some understanding of the Distance sampling theory and software (Buckland et al. 1993; 2001; Thomas et al. 2010).

5.1. Collecting data that is fit for purpose

Various bodies have attempted to analyse data collected from fixed vantage point, so that it would suit the requirements laid out by regulators, and answer questions on abundance and density in the development site. However, this requires the data to be collected in such a way that the variables affecting detectability can be assessed. Therefore, it is imperative that field data collection is fit for purpose, and data from fixed visual vantage points needs to incorporate information on animal locations and distances from the observer. This can be achieved via photogrammetric methods or by using a theodolite as discussed above.

The developer should be aware that data collection needs to fulfil some requirements in order to be able to answer these questions and they should make sure that the data they are collecting meets these. Firstly, there needs to be enough data, spanning large enough time period to have some understanding of natural variability of animal distribution and abundance on the site – preferably several years. Secondly, the observations need to be spatially referenced, which typically means taking theodolite angles or photographs/video of the sightings so that sightings locations and distances to the observer can be calculated. Thirdly, there needs to be a record of effort spent observing even when no animals were sighted.

5.2. Analysing data

Properly collected sightings data can be used to inform developers about animal presence in the target area, habitat use and associated seasonal, tidal or daily patterns. With robust survey design and appropriate statistical methods the effect of development (the "impact") can be measured and assessed. Methods exist to assess density of animals in a defined area and the associated detection probability through Distance sampling techniques (Buckland et al. 1993; 2001). This comprises a variety of related methods such as line-transect surveys and point sampling, which are based on a concept that even if not all animals can be detected, the proportion of missed animals can be estimated by collecting information about distances to detection as the ability to detect animals is assumed to decline further away from the line or point sampled.

Traditional Distance sampling relies on strict assumptions about data which must be met, which is often the problem with vantage point surveys because some of the assumptions of distance sampling methods simply do not hold. In particular, the assumption of uniform distribution of animals in the vicinity of the sampling point is not likely to be met (Oedekoven, 2013). This is due to the fact that observations are typically made from a land-based vantage point, such as cliff edge, and it is clear to see that the density of cetaceans might increase with the distance from the shore due to physical restrictions of shallow depths near shore or specific habitat preferences within the search area.

Therefore the probability of the observer to detect the animals from the vantage point may initially increase with distance from cliff, but the ability of the observer will still decrease with distance from the vantage point. Any data resulting from fixed vantage points or models fitted to such data will inevitably be a mixture of the detection process and the underlying distribution of animals in the area (Mackenzie et al. 2013).

For the developer and the regulator this poses a serious obstacle: is a recorded decrease of animals due to observers not detecting them, or the fact that animals actually are not there?

5.3. Methods to deal with imperfect detection and non-uniform data

Traditionally, data analyses need to be able to assess the detection probability (i.e. the detection function) of the sightings so that we can understand what proportion of the animals are missed by the observer. For standard distance sampling using line-transect data this is best achieved using double platform (or independent observer) data to assess detections missed by primary observer.

Similar technique can be utilised for vantage point surveys where two observer stations collect simultaneous data for the same area. The resulting detections enable researchers to assess the number of animals missed by any one observer and potentially create a detection function for the data, if animals are assumed to have uniform distribution across the site.

In addition to the imperfect detection there is still the issue of non-uniform animal distribution affecting the results. Recent developments have improved the analyses of fixed vantage point data through a variety of statistical methods such as mark-recapture distance sampling (MRDS) which allows for imperfect detection on the transect line and spatially explicit capture recapture (SECR) which defines density for specifically defined area (Borchers and Efford, 2008) and blends both Distance sampling and mark recapture methods (Marques et al. 2012). DISTANCE software (Thomas et al. 2010) allows its user to deal with these issues as long as distances and radial angles are accurately collected. Some of these techniques can potentially be adapted to suit fixed vantage point data as well but only if certain assumptions about the data are fulfilled. As of yet there are no openly available published documents from studies using MRDS and SECR techniques for fixed vantage point data. It is therefore difficult to find in depth information or instruction on how to use these techniques.

5.4. MRSea R package

One analytical method for assessing vantage point data is the MRSea R package developed at the Centre for Research into Ecological and Environmental Modelling (CREEM) at the University of St. Andrews (Scott-Hayward et al. 2013b). MRSea package is mostly a tool for spatially adaptive smoothing for

Distance sampling data which ignores the issue of detectability by putting the raw data straight into a spatial model. The reason behind this is that there simply is no feasible way of teasing away the detection function from the observation process when animals are not uniformly distributed, which is often the case for near shore observations, such as sounds and headlands where tidal devices might be located.

The MRSea package enables the examination of animal survey data for assessing changes in abundance and distribution from marine renewable or similar development. It models data using spatial and environmental variables to explain distributions of animals. The difference to various other Generalised Additive Modelling (GAM) and Generalised Additive Mixed Modelling (GAMM) packages is that instead of using smoothing functions uniformly distributed over the survey area, MRSea allows these to vary spatially within the survey area using the Spatially Adaptive Local Smoothing Algorithm (SALSA) of Walker et al. 2010.

The package uses functions from other R packages such as mrds (Laake et al. 2015) and geepack (Yan et al.2012) which can be used to fit detection function to distance sampling data. It uses data corrected for imperfect detection (for example by using programme Distance) which has been segmented to allocate covariate values for modelling across the spatial scale. In addition it also allows the modelling of non-distance sampling data, such as vantage point data where no attempt has been made to correct data for animals missed for imperfect detection, although note that no detection function can be fitted if distances to animals are not collected. The user guide (Scott-Hayward et al. 2013a) uses two examples, data from distance sampling line-transect survey and another dataset from a near shore vantage point survey. Both of these datasets are included in the package download.

5.5. Practical tips for MRSea users

MRSea is downloadable from http://creem2.st-andrews.ac.uk/software/. Contact the software developer to ensure you have the latest version of the package, (version 0.2.0 at the time of writing). As with all R packages written using a specific version of R, MRSea may have some problems with newest versions and ensure you install all the other packages upon which MRsea depends on which are detailed in the MRsea help file (Scott-Hayward et al. 2013b), but the software definitely works with the latest R version 3.1.2 as well as the older 3.0.2. There may be workshops available at CREEM to assist with familiarisation with the software, which are well worth attending especially for basic R users. Additionally, it is recommended that the user should be familiar with generalised linear models and their assumptions to fully comprehend the model selection process (Scott-Hayward et al. 2015).

Although MRsea itself has been updated (current version is 0.2.0.) the User Guide has not, but updated code is available from developers at http://creem2.st-andrews.ac.uk/download/. Users may find some inconsistencies especially in the examples provided to describe the coding. Most of these are easy to identify by even a basic user of R. Don’t blindly copy and paste the code but check that databases are correct and use the help file from R to ensure that parameters for each function are valid. The first issue that some users may come across is with the function called “SALSA1D” which has now been superseded by “SALSA1D_withremoval”, and the user must check that all the input parameters are correct according to the help file. Do not follow the guide together without the updated help file version 2. The program will notify the user about most of the issues, but new (or very basic) users of R might find this little tricky. Some may find it difficult when flicking between the User Guide and the Manual and finding the right instructions from the manual if following the User Guide step-by-step.

Furthermore, the example datasets are made up of the 'real' data of animal sightings as well as a "prediction data sets" which can seem slightly confusing to first time basic R user as they have to create a data frame from the predicted values from the initial models; however help files should be able to assist with this. Although the prediction data is not a requirement to fit the model, in order to do so it is important to specify the range of the data and ensure that the boundary of the smooth is not specified to be within the range of the data. If the prediction area is known a-priori (usually a fine-ish grid over the study region) then these issues can be dealt with up-front by including the prediction data set when estimating the 1d smooths.

The examples within the user guide utilise three different datasets (and associated predictions) to illustrate the use of the software; one which has no change following the impact, second with decreased number of animals and the third which displays a redistribution of animals within the area after the impact. These are very useful in depicting the potential uses of the software and how to deal with fixed vantage point detections.

The user will have to have some basic knowledge of creating and handling spatial data in R, in order to input or import set of covariate values which can be used in the model to estimate animal abundance. Additionally they should have some idea of creating and managing graphs and plots as shown in the User Guide. Most of the plots are created by the inbuilt functions and for others the code is simple enough and available from most R guides for spatial use and more advanced user can probably pick the correct code up from help files and manuals to packages like ggplot2.

This is the first and only R package with detailed enough instructions to the layperson to be able to analyse fixed vantage point data with spatial covariates. However, the results can only be considered relative abundance estimates, and assume no change in the detection process before and after. No amount of complicated analyses will be able to deal with poorly collected data. Good understanding of Distance software and Distance R packages would probably aid in understanding the coding for the package.

5.6. Nupoint R package

Another software package developed to deal with issues of vantage point data analyses is the R package *nupoint* (Cox et al. 2013) which provides tools for estimating animal density from point transect surveys in which the conventional point transect assumption of uniform animal distribution in the vicinity of the point is violated. This software enables estimation of density for data where, in addition to radial distances, angles are taken for each detection. These data can then be used to estimate both a detection function and the gradient in animal densities under certain conditions (Oedekoven et al. 2013). Problem with this package is that it is not actively being maintained or developed further.

5.7. Practical tips for nupoint users

The nupoint data is available for download from http://sourceforge.net/projects/nupoint/, it cannot be found through CRAN repository. The package seems to only work with R versions older than 3.0. Although Cox et al. 2013 go through the functions of the package and have helpfully published code for their graphs as well, just following the paper can be slightly tricky for basic R user without further instructions. As with MRSea it is imperative that all dependencies are installed, otherwise the package simply won't work, and installing nupoint doesn't automatically download the required packages, which include at least 'fields' and 'nor1mix'. If using R Studio, remember to tick the box 'install dependencies' when installing packages. The example data used in Cox et al. 2013 is not included as data in the package, which is a shame, as viewing data makes it much easier to understand the data requirement formats and also allows one to practice the use of the code.

5.8. Spatially explicit capture-recapture models (SECR)

As mentioned above, SECR models were designed to be used for modelling animal capture-recapture data when it's collected with arrays of detectors, such as traps or hydrophones, in a defined area where so called 'edge-effects' can affect density estimation (Borchers and Efford, 2008). Recently SECR models have been used to assess and correct for the drop-off in detectability of animals with distance in a confined survey area (such as fixed vantage points) when animals are not distributed uniformly. Recent trials by SMRU ltd for MCT/Siemens in Skerries in Anglesey have shown reassuring results that SECR models can be used create detection functions for double observer data when distances are collected accurately (Plunkett et al. 2014). However the current secr package in R is intended for surveys where data is generated from multiple traps within confined area and where individuals can be clearly recognised (capture histories). There are very detailed instructions provided within the secr package for doing this, but the package doesn't lend itself for vantage point survey data very easily without some modifications and recoding the script, which may be beyond the basic R user. One could modify the script (and input data) so that detectors would be the different observers, but the problem of identifying individuals for small coastal cetaceans remains, unless some assumptions can be relaxed.

5.9. Data requirements for dealing with non-uniform data

For all the packages (MRSea, nupoint and SECR) the sightings need to include associated sighting coordinates. MRSea does not require distance data, however, if you have distance data and wish to use distance sampling then they are needed for the mrds package which is used to fit the detection function. For nupoint the data needs to be in the format of radial distance and angle from observer to the sighting. The observed area or transect lines need to be associated with the correct and appropriate environmental information, such as depth or other variable and the data needs to be divided into segments in case of line transect data and grids in case of vantage point data. If only bearing and estimated distance is recorded for vantage point sightings, the data tends to be lumped into distance bins and can mask effects of distance from observer in the dataset. The actual data requirements and formats for each of these packages are listed on the help file or manual of each package.

6. Conclusions and recommendations

The currently available information consists mainly of guidelines and recommendations commissioned by Marine Scotland and Scottish Natural Heritage. Although these have been specifically written for Scottish sites they are applicable to other regions, although some of the text on regulatory requirements is specific to Scotland. The two main documents (Macleod et al 2010 and 2011) cover the main aspects of survey design and layout clear protocols for the most commonly used survey methods.

One of the main issues identified by some stakeholders and their consultants with the documents covered in this report was that they are not accessible in one clearly identified website and that the guidelines have not been compiled into one easily referenced document. Hopefully this document will solve that issue. Furthermore the guidelines highlight various issues and problems which need to be taken into account but offer no clear practical approach on how to tackle these issues, which are typically site specific. One such case was the issue encountered with vantage point data at three different MRE sites. Despite the fact that land-based visual observation is one of the most common methods for observing cetaceans, there seemed to be a lack of understanding of what constitutes a standard data collection methodology, and how to analyse vantage point data in a way that would answer the questions posed by the regulator.

Macleod et al. (2010) highlights the fact that it is impractical to provide "how-to" guidelines which would fit every possible scenario due to the variety of different marine renewable energy devices and moorings currently in development, and the diversity of possible deployment sites. However it should be possible to construct example scenarios which, together with a single guideline document, would assist the developers in planning their monitoring programs. Any future recommendations, as well as guidelines, reports and journal papers listed here should be made openly available for all developers.

It must be stressed that all the documents referred to in this report (apart from two confidential assessments by developers) *were* all available online, although not always easily accessible. The developers have a responsibility to conduct their environmental assessments and monitoring programmes to the best possible standards, and employ consultants with experience in marine mammal work, who would be expected to be able to access the required information. If guidelines are to be collated by the regulator or another external organisation, the developers need to use these as their main reference point and ensure that their consultants are aware of such materials and that they follow the recommended protocols.

Given the fact that many MRE companies are relatively new (especially those intent on trialling their designs in the newly assigned MRE demonstration zones) and that they have potentially very little experience in conducting environmental impact assessments, the regulators should ensure that companies attempting to conduct scoping studies or EIAs are fully aware of the guideline documents. It might be useful for NRW regulatory and/or advisory team to actually require that surveys and data analyses are conducted according to these recommendations.

A further concern relating to the marine mammal monitoring was the perceived lack of proportionality of the required assessments and analyses to the potential risks identified from the MRE devices. Many developers and consultants feel that MRE devices are being scrutinised too harshly, when comparing to other anthropogenic risk factors such as fisheries by catch which currently poses the biggest threat to coastal cetaceans (Pinn et al. 2009). Typically regulators require that developer need to be able to show potential impact of device on species abundance on the development site. Whilst this seems simple enough task, the reality of a developer being able to estimate even relative abundance with enough power to detect change in that abundance is farfetched without considerable effort and cost. Macleod et al. (2010) recommend that due to the general difficulties in achieving the type of data regulators ask for, developers should be granted licenses with precautionary assumptions, which could be relaxed if and when evidence disproves the precautionary assumptions.

The remaining key issue is that the regulator is still required to understand the impacts of MRE developments on protected species. The seemingly obvious way to do this is to conduct large scale studies spanning across development sites, where collaboration between developers is essential. Such large scale surveys are also the only way to really understand the effect of cumulative impacts of various sites as well as other users of the marine environment whilst ensuring that data is collected at scales which are more akin to natural distribution of the animals. In order to do this, the industry needs to be able to coordinate so that it can pool resources to meet regulator's needs. However large scale studies are expensive and difficult to achieve without proper coordination between various stakeholders and ideally should be regulator led and funded.

It is also worthwhile to note that it not the developers' responsibility to monitor the overall favourable conservations status of marine mammals. Their efforts should be concentrated on site characterisation and/or impact monitoring rather than assessing overall abundance of species in an entire region. There is a need to device and agree upon a set of indices of animal presence and/or behaviour which the developer can easily and cheaply measure and which will fulfil regulatory requirements (Macleod et al. 2010). Statutory nature conservation bodies should work together with regional and national governments to seek funding to achieve monitoring at larger spatial cases, as this would fulfil both regulatory requirements for monitoring but also attract investors and developers to an area where environmental battles may have been overcome – thus demonstrating a clear commitment to MRE development in Wales.

Most of the reports listed here are directed at marine mammal monitoring in wave and tidal turbine development sites, with no specific references to tidal range devices (tidal barrages and tidal lagoons). Although some of the issues are identical, the sheer scale of lagoons and specifically barrages will propose additional environmental concerns and will potentially require different or modified monitoring techniques. Future reports and recommendations should aim to cover wave, tidal stream and tidal range devices in one coherent set of guidelines.

Below are recommended follow-up work to aid future survey and monitoring programmes by MRE developers. These would also facilitate the assessment of such reports by the regulator.

- **Producing NRW recommended guidelines for marine mammal surveys in marine renewable energy sites, including wave, tidal range and tidal stream deployments. These could include:**
  - **Specific guidelines on fieldwork procedures for land based, boat based and acoustic data collection**
  - **Examples of analysing MRE data for density estimation and impact assessments**
- **Ensure all guidelines and related literature is accessible from a single source. If this is not possible, efforts should be made to make links available to the key documents.**

MRE developers and regulators in Wales would benefit from strategic capacity building at local and regional scale, such as increased involvement of Welsh representatives in national research initiatives to facilitate knowledge exchange between research institutes in Wales and the rest of the UK and to ensure Welsh Institutes would have share of the national funding for MRE research. A large part of the MRE research in Scotland has been funded by NERC which has had beneficial impact for Scottish developers and regulators. As the Welsh MRE industry is growing, similar programmes will be required in Welsh waters, to allow local institutions as well as consultancies to deliver appropriate advice to Welsh regulators.

Further suggestions for capacity building and increasing knowledge base in Wales in the field of environmental monitoring around MRE devices:

- **Setting up a NRW endorsed training course(s) for marine mammal observers and environmental consultancies in Wales to increase awareness of the key issues relating to marine mammal observations and data analyses**
- **Encourage developers and their consultancies to work together with Welsh academic institutions and NRW to ensure MRE monitoring contributes to current knowledge of marine mammals in Wales by:**
    - **Encouraging data sharing initiatives between developers – potentially led and coordinated by NRW**
    - **Promptly publishing environmental monitoring reports and MRE related research papers**
    - **Ensuring research papers and unpublished reports are made available (see above for accessibility of guidelines and recommendations)**
- **Collaborate with regional national initiatives (such as SCANS III and future WEFO funded projects) to provide increased survey coverage of marine mammals in and around key MRE sites in Wales**

In Chapter 3, the summary of general advice collated from existing guidelines offers practical tips and guidance for land based visual surveys at MRE sites. It should serve as a starting point for the recommended guidelines. Chapter 4 lists some advanced analytical methods developed to deal with datasets from fixed vantage point surveys. However they require some basic understanding of the programme R and knowledge if distance sampling techniques. The most accessible R package is the MRSea, developed by CREEM, St Andrews, with extensive help files and a User Guide. However it will not produce detection functions for data without accurate distances, and therefore it is paramount that data is collected from start fit for purpose.

Providing guidelines for field monitoring methods will not solve the problems encountered by developers and consultants relating to disproportional research requirements for MRE deployments or the lack of funding or capacity in Wales to deliver such requirements. Whether this is a problem specific to Wales or a UK wide issue, is not clear and is something to be discussed between Welsh and national governments and the Statutory Nature Conservations Bodies who regulate and advice the industry.

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Appendix I – Online portals on marine renewable energy and its impacts on marine mammals

Crown Estate reports
http://www.thecrownestate.co.uk/media/485012/consolidation-of-eia-hra-issues-and-research-priorities.pdf
http://www.thecrownestate.co.uk/media/354799/2009-07%20High%20Resolution%20Video%20Survey%20of%20Seabirds%20and%20Mammals%20in%20the%20Rhyl%20Flats%20Area.pdf

DEFRA
Reid et al. (2013) Atlas of Cetacean distribution in North-West European waters
http://jncc.defra.gov.uk/page-2713#download
Joint Cetacean Protocol http://jncc.defra.gov.uk/page-5657
Evans and Thomas (2013) http://jncc.defra.gov.uk/PDF/479_web.pdf

SCANS-II Final Report. http://biology.st-andrews.ac.uk/scans2/inner-contact.html

Welsh Government
http://wales.gov.uk/topics/environmentcountryside/energy/ renewable/marine/framework/?lang=en

Irish Government
http://www.seai.ie/Renewables/Ocean_Energy/AMETS/

Scottish Government
http://www.scotland.gov.uk/Publications/Recent
http://www.scotland.gov.uk/Resource/Doc/1086/0048989.pdf

Scottish Natural Heritage
http://www.snh.gov.uk/publications-data-and-research/publications/

Department of Energy and Climate Change offshore SEAs
http://www.offshore-sea.org.uk/site/scrpits/sea_arcive.php

Other
https://ke.services.nerc.ac.uk/Marine/Members/Documents/Forms/AllItems.aspx
http://www.renewables-atlas.info/
http://mresf.rpsgroup.com/