Elizabeth Rudd

10179606

MSc Marine Renewable Energy

Plymouth University

Faculty of Science and Technology

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Disclaimer

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1. Abstract

By generating energy by renewable means the Bailiwick of Guernsey within the Channel Islands can develop a secure energy supply and reduce carbon emissions, using local and natural resources (GRET, 2013). Guernsey have identified their future within renewable energy technologies (both marine and terrestrial based) stressing that it is “important to move away from producing energy from fossil fuels and to find alternative renewable sources that will provide us with energy security in the future” (GREC, 2010).

The States of Guernsey are committed to reducing Guernsey’s 1990 carbon dioxide emissions by 30% of those level by 2020 and finally 80% on 1990 levels by 2050 (Climate Change Act. 2008). Though this does not have to be solely met by renewable means, renewable energy is being explored to increase the security of supply as well as dramatically reducing the islands carbon emissions (GERC. 2012). For these targets to be obtained the States are looking towards energy production that includes Marine Renewable Energy (MRE) in the form of wind, wave and tidal power featuring increased importation and connectivity for the island.
These new and developing technologies however pose an un-estimated impact to the local environment and ecosystem as a whole (Inger, *et al*. 2009)

The current existing data for the Bailiwick of Guernsey gained from from La Société Guernesiaise and the biological records centre for cetacean data and anecdotal pinniped data from ‘Island Rib Voyages’ is minimal and no analysis of relative abundance can be made due to lack of recorded ‘effort’ and ‘accuracy’ during surveys.

Working in collaboration with Guernsey’s Renewable Energy Team this project has suggested a preliminary mapping of marine mammals within the Bailiwick and wider area. This will identify and quantity the current marine mammal population and in turn allow analysis of impacts from MREI on these populations to better prepare for future proposals and development. A roadmap for critical marine mammal surveys are outlined with key recommendations to be undertaken after this document has been developed.

Significant survey areas are the Big Russel where fixed point vantage point surveys are recommended. Two proposed locations for wind farms are addresses with specific SP LT boat-based surveys recommended. Haul-out sights used by resident pinniped populations should be surveyed via boat-based or land based surveys, taking full advantage of PoOP surveys from ferries and pleasure boats. Finally the

implementation of passive acoustic monitoring devices in the form of CPODS shall be used to monitor the presence of cetacean species at specific and predetermined locations.

2. Introduction

The Bailiwick of Guernsey is heavily reliant on a combination of electricity importation from France via cable connections, (which have on one occasion failed), and on-island diesel generation. In order to create a more sustainable and self-sufficient island, renewable energy can be used to meet the demand for domestic consumption, and eventually exportation. The States of Guernsey are committed to reducing Guernsey's 1990 carbon dioxide emissions by 30% of those level by 2020 and finally 80% on 1990 levels by 2050 (Climate Change Act. 2008). Though this does not have to be solely met by renewable means, renewable energy is being explored to increase the security of supply as well as dramatically reducing the islands carbon emissions (GERC. 2012).

For these targets to be obtained the States are looking towards energy production that includes Marine Renewable Energy (MRE) in the form of wind, wave and tidal power featuring increased importation and connectivity for the island.
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The true abundance, distribution and diversity of marine mammals within the UK Channel Islands are yet to be investigated fully (Inger, *et al*. 2009). Ever increasing development of the Worlds coastline and coastal waters from industry and development has resulted in previously unknown impacts placed on the marine environment and the ecosystems within (Kaschner, *et al.* 2006).

As technology and significance of the marine environment have begun to increase so has corresponding research and understanding of associated impacts of global coastal development. This has resulted in imminent and innovative technologies such as marine renewable energy undergoing increased scrutiny, research and Strategic Environmental Assessments (SEAs) to ensure potential impacts are addressed with vital mitigation techniques (Fox, *et al*. 2006).

Primary amongst emerging technology is wind power, which has rapidly increased in capacity in recent years (Herbert *et al*. 2007; Inger *et al*. 2009). It is now obvious that generation of electricity from renewable energy resources is quickly developing into a key objective of many countries (Gill. 2005).

Around the Channel Isles, tidal currents such as the Little Russell and Big Russell flow at high speeds. The tidal range in the Channel Islands is large; up to 10 m in Guernsey on a spring tide (Siddle et.al. 2006). The Big Russel is a channel located between the islands of Herm and Sark to the East of Guernsey. The channel has very strong tidal currents and it is for this reason that it has potential as a site for the installation of tidal power turbines.

Offshore wind power is currently a viable option in the Bailiwick of Guernsey, with wind blowing west and southwest for 28% of the time with an average speed of 12 knots (Windfinder. 2012). Two proposed wind farm sights are identified in Figure 1. Wave technology is still in its infancy, and is more a long-term future option for development. Wave devices require significant wave heights (GREC, 2010) to be viable for MREI. Potential areas or wave energy development are shown in Figure 2 on the west of the island.

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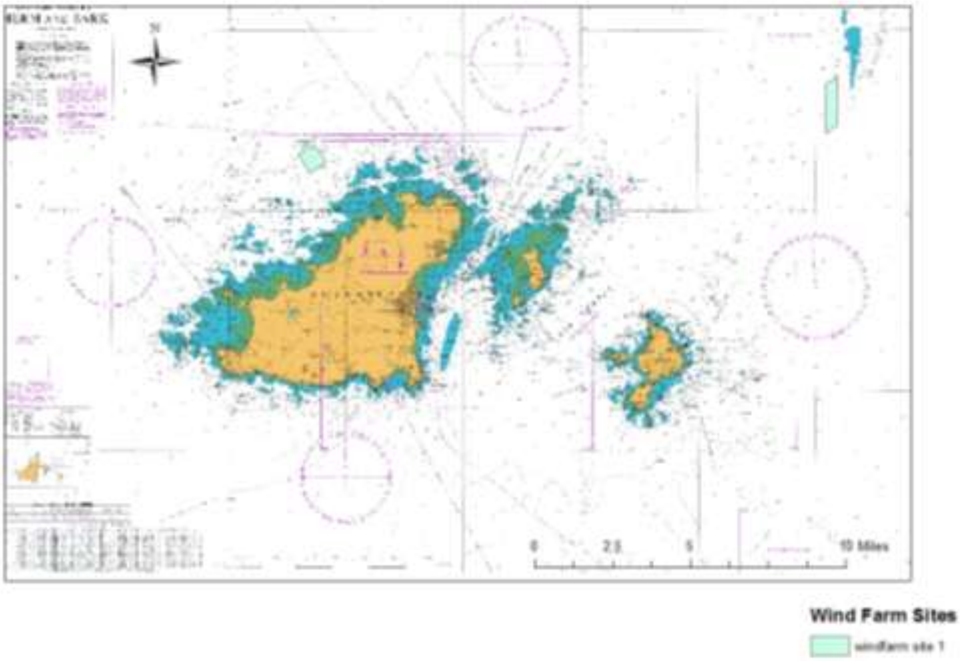


Figure 1 - Current proposals for two potential wind farm locations

Potential known negative impacts to marine ecosystems are varied and as yet some are not fully understood (Inger *et al*. 2009). Main impacts associated with MREI are highlighted below;

1. **Collision and entanglement:**

The collision hazards presented by marine renewable energy structures can be associated with avian collisions above water (Inger *et al*. 2009) such as wind turbine structures and secondly, the collision or entanglement of marine organisms below the water (Desholm and Kahlert. 2005).

2. **Habitat loss and degradation:**

The loss of habitat because of MREI will vary depending on the installation type (wind, wave, tidal) and size and scale of the installation. This will also be affected by the location, whether it is situated in degraded or pristine habitat. The varying life cycle or MREI such as installation, maintenance and decommissioning will also be a critical factor (Inger, *et al*. 2009)

3. Noise

The impact of anthropogenic underwater noise and vibrations on marine life from activities such as oil and gas exploration and ever increasingly MREI is a growing concern (Madsen et al 2006). MREI within Guernsey's waters will undoubtedly introduce extra noise and boat traffic from St Peter port, through construction and transportation involving varying types of activities that can generate high sound pressure such as pile-driving, which is likely to impact on local marine species (Horowitz and Jasny 2007).

4. Electromagnetic fields

Energy created at MREI must be transported back to shore as would be the case within the Bailiwick of Guernsey. The structures used to harness marine energy submarine electrical cables are needed to transfer power between devices, to transformers and onto the mainland. This produces a large amount of cabling at MREI sites. The cables used then produce electromagnetic fields (EMF), which may be detected by a number of marine organisms including electro sensitive fish (Gill. 2005) and alter natural behaviour, feeding, migration and reproduction in marine mammals (Adey. 1993).

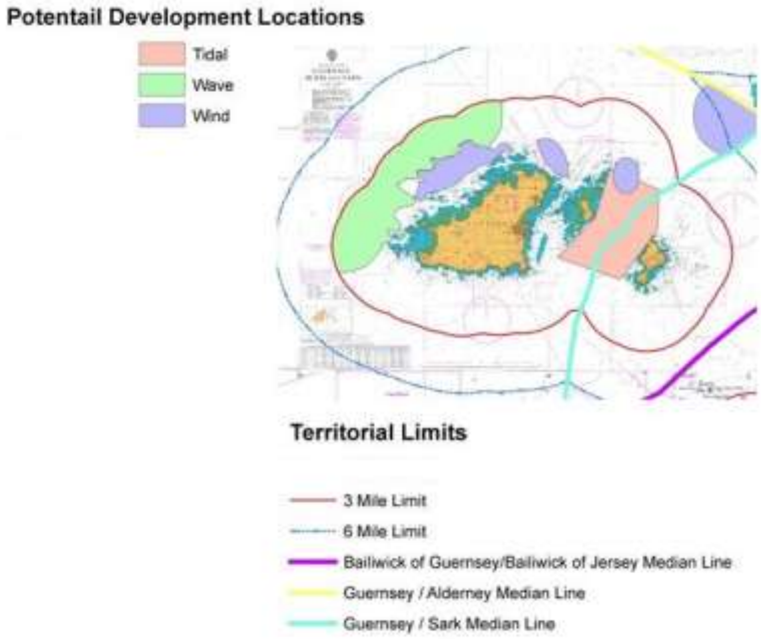


Figure 2 - Areas of potential development on Guernsey due to available resource (GRET, 2013)

More detailed research needs to be conducted to complete baseline studies and environmental surveys, characterising the marine environment, including marine mammal populations prior to developments being installed, and as a basis for post consent monitoring at wind, tidal and wave sites which have been identified by GRET. For the purpose of this study, marine mammals are inclusive of all seals, whale, dolphins and porpoises. Seals species are referred to as pinnipeds, whales, dolphins and porpoises as cetaceans.

The following dissertation research has been developed in order to identify the marine mammal population within the Bailiwick of Guernsey using pre-existing trans-boundary marine mammal survey data from available sources.

This research and identification of marine mammals inhibiting the waters of the Bailiwick will be greatly beneficial for future marine renewable energy developments within Guernsey with specific reference to future developments proposed by Guernsey Renewable Energy Team. By creating a method for collecting baseline data in the early stages will help aid the success of innovative renewable energy projects for the team. It will produce a platform for baseline survey information to inform and shape future developments and a plan for further research which will be the most beneficial output for GRET. It also aims to increase the awareness of the marine mammal population creating a more streamlined process for marine renewable energy solving issues such as delays, added cost and associated challenges which may arise from not developing baseline mapping of the marine mammal population in time.

A detailed assessment of pre-existing data from marine mammal surveys (JNCC. 2012, GECC. 2010 and Evans, P.G *et al* 2003 and data from La Société Guernesiaise and the biological records centre, will be the basis for the initial assessment of marine mammal occurrence and distribution. From this a site map can be developed for the Bailiwick of Guernsey based on the current and existing data. This will only indicate general locations and migration of the marine mammals due to the lack of 'effort' based data.

2.1 Aims

To produce a comprehensive assessment of pre-existing data from marine mammal surveys (JNCC. 2012, GECC. 2010 and Evans, P.G *et al* 2003). The preliminary assessment will identify marine mammal sighting occurrence and location and diversity. From this a developed site map can be developed for the Bailiwick of Guernsey (see **Error! Reference source not found.**) based on existing data and be utilised primarily and most importantly a platform for future survey developments.

Using the data and a detailed assessment of marine mammal occurrence, diversity, distribution and abundance, recommend a suitable road map to increase the quantity and quality of data available by designing numerous options to successfully undertake a baseline survey and to stand as the evidence for further more detailed and specific research projects as specified in the Regional Environmental Assessment (REA) which calls for significant baseline survey and monitoring of marine mammals to be undertaken prior to development (GREC, 2010) as well as recommendations made in Sutton. (2012)

Present methodologies for marine mammal surveying methodologies and survey designs will be analysed with recommendations made.

Current utilised monitoring programs for existing installations will be critically examined drawing examples and further recommendations from successful developments.

2.2 Objectives

- Review of survey effort for marine mammals in the Bailiwick of Guernsey to date, inclusive of minimal data from the Channel Islands as a whole if available.
- Describe the temporal and spatial distribution and relative abundance of all marine mammal species sighted or stranded within the Bailiwick of Guernsey.

This will produce an accurate representation of the marine mammal population on the Bailiwick of Guernsey from current data spanning from 2006-2013.

- Critically analyse the survey methods used internationally, inclusive of boat-based based, aerial based and opportunistic surveys. Current methodologies used by Guernsey and the Alderney Wildlife Trust will also be assessed. Analysis of necessary effort when collecting marine mammal data.
- Propose a roadmap for the survey design for marine mammal with respect to marine renewable energy devices in the short and longer-term (baseline development through to pre-and post-consent monitoring).including more cost effective methods.

2.3 Background

An in-depth review and compilation of current survey effort to date has generated species specific distribution maps of cetaceans and pinnipeds around the bailiwick of Guernsey and surrounding coastal waters.

Relevant literature and data available will be used to complete this and effectively show the distribution of marine mammals sighted between 2006-2013 due data availability.

Once data from all available sources was compiled (JNCC. 2012, GECC. 2010 and Evans, P.G *et al* 2003 and data from La Société Guernesiaise and the biological records centre) GIS maps were used to create accurate maps of marine mammal locations and migratory movement around the study site.

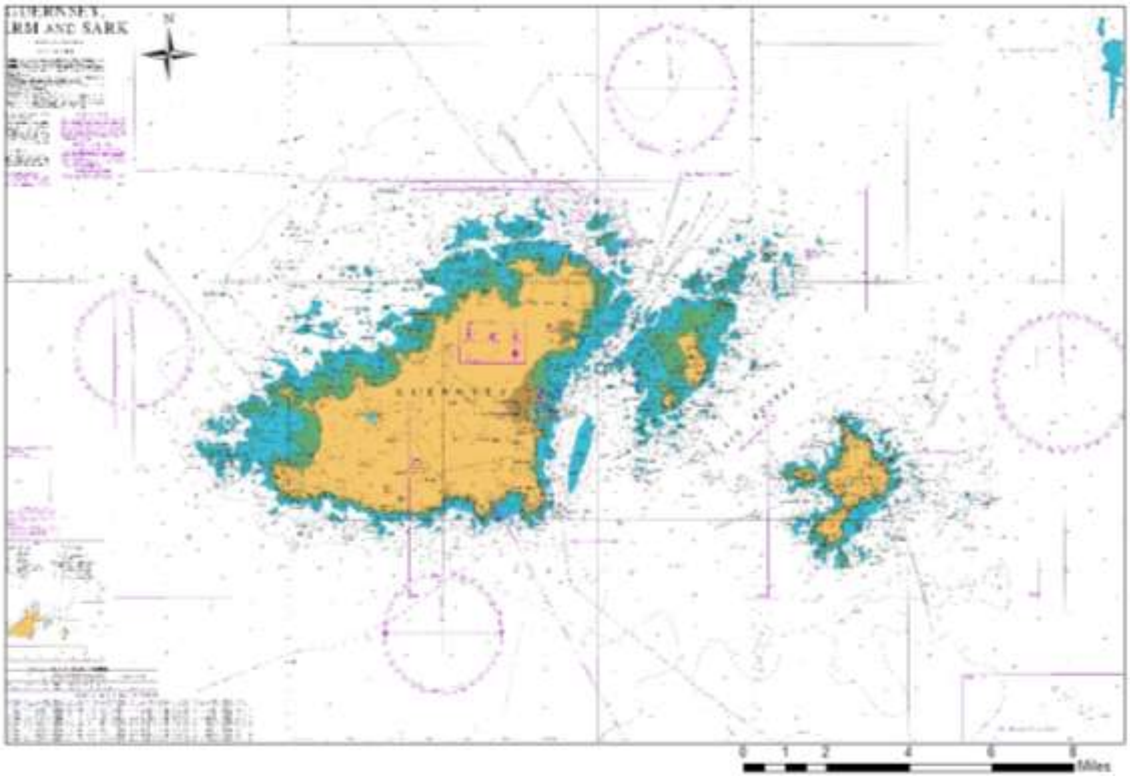


Figure 3- Study site location – Bailiwick of Guernsey

A technical review of existing survey methods within Bailiwick of Guernsey (see **Error! Reference source not found.**) and other case studies will be the basis for developing and improving a system for Guernsey and the Channel Islands to effectively monitor and survey marine mammals in the area.

Survey methods will be assessed in their suitability and effectiveness for the use in monitoring species in the specific location of the Channel Islands (Sandilands. D. *et al* 2007 and SMRU Ltd. 2010). Survey methods inclusive of opportunistic marine mammal surveys and recorded effort will be compared and analysed. New and upcoming methods of surveying via passive acoustic monitoring via C-PODs and other emerging technologies will be critically analysed to ensure GRET can carry out extensive and through surveys.

The key considerations for the assessment of existing surveys are:

- Definition of the survey
- Design parameters
- Sampling frequency
- Field protocols

The main aim of the baseline study is to provide detailed information on marine mammals present in the possible development areas around Guernsey. The baseline report provides information on the following:

- Marine mammal species (cetaceans and pinnipeds) present within the Bailiwick of Guernsey.
- Abundance and distribution of marine mammals, seasonal patterns of distribution and migration within the Channel Islands and west coast of France
- The usage of the Channel Islands by marine mammals (feeding, passage area, calving).
- Identification of any potential seasonal sensitivities (e.g. calving period).
- Knowledge/data gaps relating to marine mammals in the Channel Islands.

Once the most effective survey method has been identified and all available marine mammal data for Guernsey compiled, gaps and anomalies in data can be identified. Due to time limitations of this research no primary data was collected for the purpose of this report.

Key findings of this report will be expressed by offering key recommendations for the future which can be used as the basis for more detailed and specific research into monitoring and surveying the marine mammals in the Bailiwick of Guernsey. These recommendations will include varieties of surveys which could be completed by the Guernsey Renewable Energy Team to increase the quality and quantity of available data minimising future delays and added associated costs in the future when renewable energy technologies could be deployed.

2.4 Current Monitoring of marine mammals

The construction and operation of offshore wind farms such as those outline by GRET in Figure 2 and the development of marine renewable energy such as tidal and wave power are impacting upon the marine environment. This poses a potential threat to marine mammal habitats and the marine mammal populations existing prior to such developments (Carstensen. *et al* 2006). Increased pressure is now being placed to carry out effective marine mammal surveys around the site of prospective renewable energy developments.

Due to the proposed areas of potential developments within Guernsey (indicated in Figure 2), extensive baseline surveys need to be conducted to quantify the population of marine mammals within the Bailiwick of Guernsey and the wider area. Effective conservation of marine mammals depends on knowledge of population ecology, as well as productivity, migration and seasonal distribution. For most cetaceans this is largely non-existent due to them being difficult to observe, only briefly breaking the surface of the water (Evans et al. 2003).

Marine mammal surveys around the coastline of the Channel Islands and the West Coast of France have already been conducted with several documents outlining the results. These include the 2010 and 2011 Yearly Review from the Channel Sea Marine Mammal Sighting Network (GECC. 2012 and GECC. 2013), and the Atlas of Cetacean distribution in northwest European waters by Evans *et al* (2003). Despite this the public availability of data local and specific to Guernsey is minimal and the study by Evans et al (2003) indicates minimal effort regarding marine mammal sightings in the Channel Islands and therefore lower amounts of data with less quality and detail.

The Joint Nature Conservation Committee (JNCC) advocates an international cooperative approach for long-term surveillance and monitoring of cetaceans in UK waters. Consequently this has led to the development of the Joint Cetacean Protocol (JCP) (Evans, P.G *et al* 2003). The JCP delivers information on the distribution, abundance and population trends of cetacean species occurring in UK waters (Evans, P.G *et al* 2003 and JNCC 2012). The data produced from the JCP has led to developments in cetacean sighting datasets, utilised in the Atlas of cetacean distribution in north-west European waters (Thomas. L. 2009 and Evans, P.G *et al* 2003).

The UK Mammal Society Cetacean group, (forming the Sea Watch Foundation) has been collecting data on sightings of UK marine mammals since 1973. This varies between opportunistic sightings to effort related recording of data via boat-based surveys. It is stated though, that monitoring spatial and temporal patterns in cetacean abundance involves a variety of approaches depending upon the target species and the resources available (Evans. P. G. and Hammond. P. S., 2004 and Evans *et al* 2003) therefore indicating that the monitoring process is extremely specific to the desired species.

The Channel Sea Marine Mammal Sighting Network was created in 1995 (Marine Sightings Network. 2012) and utilised the efforts of many local coastal users of the Channel Islands including the coastguard, marine professionals, boat owners, walkers and fishermen. This has resulted in a total of 12 different marine mammal species being sighted in this location (GECC. 2010) since the start of the survey.

In 2010 the network collected 249 observations of marine mammals (GECC. 2010). Observations were spread over the whole year, peaking between the months of April and September (Sandilands. *et al* 2007 and Evans. P. G. and Hammond. P. S., 2004). These months correspond to the period in which the weather conditions are ideal for observing marine mammals due to lighter winds, calmer sea state and the period of time where the greatest amounts of national surveys occur (Sandilands. *et al* 2007).

Fewer observations in winter do not indicate that there are less numbers of marine mammals present but that there is less observer potential and activity on the sea or the shore. Marine mammals, especially cetaceans are difficult to observe, as some species only briefly break the surface of the sea for air. This however, should not disguise the fact that populations of some marine mammal species are very influential to the local ecosystem (Evans, *et al* 2003). The monitoring of pinnipeds also has its complexities such as their moulting and pupping events and SAC protection status (SMRU Ltd. 2010).

Improvement in acoustic marine mammal surveys (passive acoustic monitoring) such as CPODs are increasing the quality and quantity of marine mammal data available (Carstensen *et al* 2006 and Tollit 2010). Acoustic survey methods are now used primarily to augment visual sighting methods during surveys (NOAA. 2003). During line-transect surveys, acoustic observers who monitor towed hydrophone arrays routinely detect more groups of animals than visual observers (Sandilands. *et al* 2007). In some cases, acoustic detections are being used to make more accurate estimates of marine mammal populations than would be possible with visual methods alone either via boat or aerial platforms. Successful monitoring programs using acoustic monitoring of echolocation are identified in SMRU Ltd. (2010) and Carstensen *et al* (2006). The monitoring programs were established as a modified BACI (before, after, control, impact) design, with 6 monitoring stations equally distributed between the impact area and a nearby reference area (Degraer et *al* 2010).

3. Baseline Data review

Data that was collected in 2010 by The Channel Sea Marine Mammal Sighting Network revealed the observation of 8 different species of marine mammals, two pinniped species and six cetacean species in the study area off the west coast of France and around the Channel Islands (namely Jersey).
The influence of future marine renewable energy devices in the area and impacts surrounding aspects of development, installation and maintenance should therefore be

applied to these 8 species for analysis and development of surveys (GECC. 2010 and Brager *et al*. 2003).
Marine Mammals identified in the location of the Channel Islands and specifically the Bailiwick of Guernsey are listed below;

Pinniped:

- Grey Seal – *Halichoerus grypus*
- Common Harbour Seal – *Phoca vitulina*

Cetacean:

- Bottlenose Dolphin - *Tursiops truncatus*
- Harbour Porpoise – *Phocoena phocoena*
- Common Dolphin – *Delphinus delphis*
- Long-finned Pilot Whale - *Globicephala melas*
- Risso’s Dolphin – *Grampus griseus*
- Minke Whale - *Balaenoptera acutorostrata*

Bottlenose dolphins were the most commonly sighted marine mammals within the survey area, representing 70% of observations in 2010 off the coast of Brittany (GECC. 2010).

There are issues and limitations encompassed within the data collected due to the use of networks of volunteer observers that the data has originated from. The extensive variation in capabilities and experience means that surveyors haven’t been trained to an acceptable level to make decisions or have understanding of data quality control (Evans. and Hammond. 2004). More robust monitoring of marine mammals will be needed by trained observers to help achieve accurate species identification. This will then require quantification of effort and amendment for factors that influence detectability, such as sea state and visibility (NOAA. 2003).

Current studies into the impacts of marine renewable energy technologies on marine mammals are being extensively carried out in many areas of the industry. A report by the Crown Estate (SMRU Ltd. 2010) focuses on the impacts to marine mammals throughout the lifecycle of renewable energy devices.

Marine Current Turbines (MCT) are carrying out extensive research in Strangford Lough with 1-2 years baseline and 2 years post installation studies assessing the impacts to the local marine mammal population (Tollit. 2010). Strangford lough is an

EU-designated Special Area of Conservation (SAC). Harbour seals (*Phoca vitulina*) and Harbour porpoise (*Phocoena phocoena) are* also present at this location, which was chosen by MCT as a test location for the world's first full-scale commercial demonstration project for a tidal turbine.

Other test sites include the Falls of Warness site at EMEC (Duck 2006), for the monitoring of marine mammals with respect to the Sea-Gen installation for the Open Hydro technology (SMRU Ltd. 2010).

5.1 Pinniped population - Overview of Seal Ecology

Grey Seals (*Halichoerus grypus*) located within the Bailiwick of Guernsey are found on the southernmost limit of their natural range. Currently documented is a small colony located in the vicinity of the Humps north of Herm, being an important haul out site (GERC, 2010). There are fundamental differences between pinniped species with Grey Seals breeding in colonies during the autumn (SMRU Ltd. 2010). Grey seals are also known to come ashore for extended periods of time during their annual moult during spring.

Grey seals are known to travel between Brittany, the Channel Islands and the west coast of Scotland (Evans. et al 2003). Foraging trips of Grey seals can last up to two to three weeks resulting in a large distribution of the species. Norris. (2009) discusses (with relevance to EMEC test facility in Scotland) that the Grey Seal breeding season is from October to late November, with the moulting period following in January to March.

Infrequent sightings of Harbour Seals (*Phoca vitulina*) have been recorded though sightings are rare. Harbour seals are known to breed during the summer months, and then are thought to disperse at this time, and return for their annual moult during the late summer (July and early August) (SMRU Ltd. 2010 and Norris. 2009).

The distribution of seals around the Bailiwick of Guernsey and the timing of lifecycle for the varying seal species (pupping and moulting) will be potentially significant considerations for the timing and installation of marine renewable energy device surveys and deployment.

Currently the most commonly executed surveys for Grey seals include aerial surveys during pupping and breeding and for Harbour seals are aerial surveys during moult.

A number of national and international agreements and legislation provide the legal basis for the conservation and protection of seals. Both Grey and Harbour seals are listed in Appendix 2 of the Convention of Migratory Species (Bonn Convention) that includes unilateral agreements for the conservation and management of migratory species (Evans. et al 2003).

The EU Habitats Directive states that Special Areas of Conservation (SACs) can be established for the protection of Grey and Harbour seals (SMRU Ltd. 2010). Currently no SACs have been designated within the Bailiwick of Guernsey, as the EU Habitats Directive is not applicable (GREC, 2010 and SMRU Ltd. 2010).

5.2 Distribution of marine mammals:

Inshore areas: Several cetacean species are regularly reported in inshore waters around Bailiwick. Of these, the most frequent are Harbour porpoises (*P. phocoena*) and Bottlenose dolphins (*T. truncates*). Within the inshore section of the study area, shallows, shorelines or strong currents may limit cetacean manoeuvrability.

Coastal waters: Coastal waters are defined as waters inshore of the continental shelf break and therefore compromise the majority of the study area. As described above, there are currently no synoptic population estimates for cetaceans in Bailiwick of Guernsey.

Offshore waters: Offshore waters are considered areas associated with the shelf break (approximately located at the 200m contour and beyond). Species inhabiting offshore waters are therefore outside the immediate study area.

4. Current Channel Islands Marine Mammals Monitoring Status

Channel Islands as a whole have limited historical data and records of the population size and distribution of marine mammals as this research has found.

Most reported sightings to the relevant body for each Island shows failures on effort based sighting information due to the informality of the recording. Alderney Wildlife Trust (AWT) is currently addressing the issue of effort based sightings, by adopting a

Sea Watch Foundation recording methods (see Figure 23, Figure 24, Figure 25) which will hopefully be extended to the region as a whole.

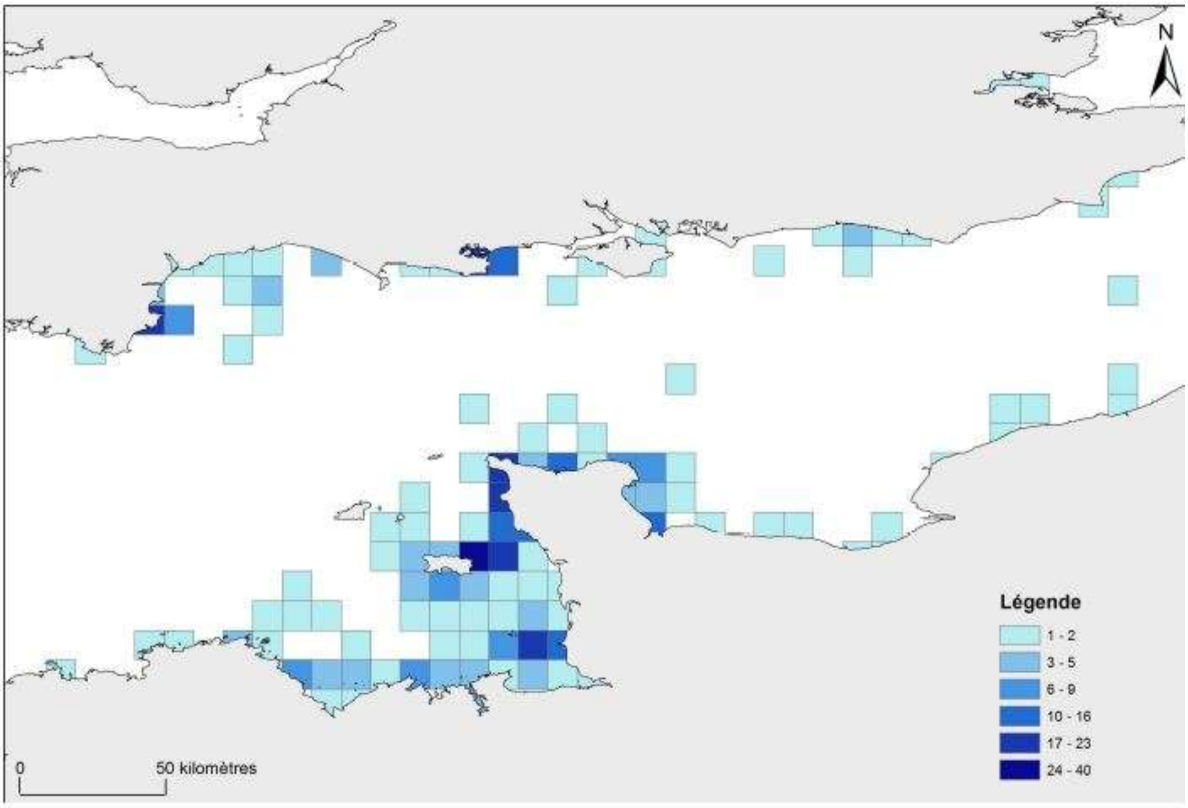


Figure 4 - Distribution of all combined species observations during 2011 (GECC. 2013)

An agreement from all islands indicates that a coherent marine mammal monitoring project/plan needs to occur in a collective manner GRET. (2013b) document the current status in 'Channel Islands Marine Mammals - Monitoring Status - January 2013' which is summarised within this section.

Due to the nature and ecology of marine mammals, they understandably cross-defined maritime boundaries in the sea (such as territorial limits) resulting in shared marine mammal populations. This has been a main feature of the current data available, where national and international regulatory differences have resulted in data sparse areas, which can be seen in Evans *et al* (2003), Evans *et al* (2004), GECC. (2012) and GECC. (2013).

The risk of not collecting such data in advance of development is that essential marine mammal monitoring, to establish a baseline, will be required before any deployment of MRE technologies. It is therefore practical to gather required information now rather than waiting, which may result in delays, increased costs and complex challenges in the future.

Guernsey

Guernsey's principle marine mammal data source is held by La Société Guernesiaise, and holds information that is sightings data reported to the society. Sightings data used in this report can be found in the Appendix.

The Regional Environmental Assessment of Marine Energy, undertaken by RET, has a chapter on marine mammal populations, sighted species and ecology that summarised the knowledge that is contained within the islands for the 3nm limit (GREC, (2010)., Herm and Sark. This utilised data from La Société Guernesiaise.

Jersey

Jersey has a historical data set that is mainly point recordings of sightings going back over a number of years, which are held by Société Jersiaise.

The Jersey Fisheries vessel has been carrying out an effort based record of marine mammal sightings. Recording the sightings number at sea per trip (on average 1 every 3) but also a time based effort calculation.

Jersey has also been proactively working with the French, and have collaborated with the GECC (Groupe d'Edutes des Cétacés du Cotentin) based in Normandie (GECC. 2012), last summer putting out passive acoustic monitoring devices at the Minquiiers for a month.

Alderney

Those who sight marine mammals in Alderney waters are encouraged to report to the Alderney Wildlife Trust (AWT). Information is then recorded by resulting in a cost effective method requiring no surveying costs. On the other hand it relies on accurate reporting from members of the public who in most cases have limited knowledge or experience in marine mammal surveying.

In addition to this Platforms of opportunity (PoOps) are widely used within Alderney waters. For description of PoOps please see Discussion (chapter 7): marine mammal survey methods.

AWT have been undertaking work for the Alderney Commission for Renewable Energy (ACRE) which has the aim of making the recordings more quantitative and utilising monitoring techniques proposed by the Sea Watch Foundation (http://www.seawatchfoundation.org.uk/. The current methodology offers formal training for commercial or recreational boat users who are regular users of Alderney's waters and prepared to take part in the programme. It aims to establish recording and training programme allowing locally resident boat owners and businesses to take part in active recording of marine mammals, a low cost option for undertaking a marine mammal survey.

Alderney's current focus is primarily on the Grey seal (*Halichoerus grypus*) population within Alderney's waters.

France/UK

In 2011 Guernsey Sea Fisheries were sent information of their "Channel Sea Mammal Sighting Network" which includes records around the Channel Islands. Findings from 2011 can be seen in Figure 4. 2011 was a landmark year for the Channel Sea Mammal Sighting Network due to the expansion westwards of the usual French observatory waters, and saw the growth of a partnership with Sea Watch Foundation where data is beginning to merge with species found off the English Coastline (GECC. 2013).

La Société Guernesiaise and the biological records centre are the central organisation and holder of marine mammal data. It is thought they have not shared Guernsey marine mammal sighting records with the French, so this is an independent data set. Contact was made with GECC but no response on the status of their recording status. GECC has a number of initiatives running with findings available in GECC 2012 and 2013. For further information see their website - http://gecc-normandie.org/.

Summary

From the assessment of current efforts for marine mammal surveys within the Channel Islands it is rare for trips to be organised specifically for marine mammal sightings purposes. This means that the data is not comprehensive or structured, and may under estimate the numbers.

A major draw back of the methods used is that of not recording the effort involved in capturing the data. Even if it were assumed that every siting was captured and recorded, and every breach noticed, the amount of effort, that is the number of trips/watches/walks along the coast, per sighting would not be recorded. This ultimately means that the data cannot be quantified, but it is still a useful baseline qualitative data set.

Findings suggest that there is some data available throughout the Channel Islands as a whole mainly managed and collated by non-governmental organisations (NGO's). Despite not being a set of baseline data is does provide circumstantial evidence that marine mammals inhabit the waters within the Bailiwick of Guernsey.

There is scope to work together on whole Channel Island projects, with Alderney, Guernsey, Jersey and Sark all expressing an interest in a detailed and well scoped project, with an understanding that these species are highly mobile.

The outcome of this report is also to generate a platform for future research and act as proof of necessary studies and inputs.

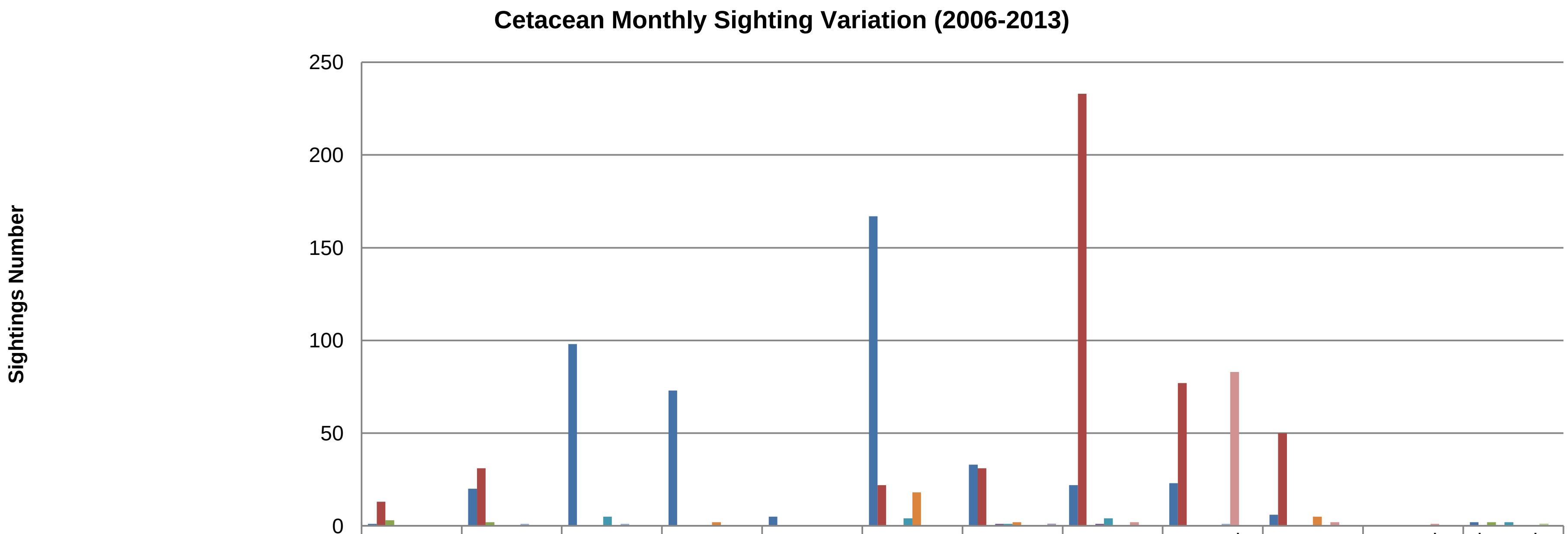
5. Results:

The following results are of reported cetacean sightings between 2006 and 2013. Data used within these maps is held by Société Guernesiaise.

6.1 Cetacean sightings distribution

Cetaceans sighting data was acquired from La Société Guernesiaise and the biological records centre. The data indicated cetacean species that were sighted within the coastal, inshore and offshore waters of the Bailiwick of Guernsey between 2006-2013 due to the availability and generation of data. For the data collected however there is no recorded effort making it difficult to suitable characterise the data and create accurate population estimates. This data however was collected with minimal cost due to the nature of the general public or platforms of opportunity feeding back the sightings data.

The data shown in the following figures for each individual species sighted for which there may be more than one at each site



	january	february	march	april	may	june	july	august	septembe r	october	novembe r	decembe r
Bottlenose	1	20	98	73	5	167	33	22	23	6	0	2
Common dolphin	13	31	0	0	0	22	31	233	77	50	0	0
Common dolphin - stranded / dead	3	2	0	0	0	0	0	0	0	0	0	2
Minke Whale	0	0	0	0	0	0	1	1	0	0	0	0
Pilot Whale	0	0	5	0	0	4	1	4	0	0	0	2
Porpise	0	0	0	2	0	18	2	0	0	5	0	0
Porpoise - stranded / dead	0	1	1	0	0	0	0	0	1	0	0	0
Rissos Dolphin	0	0	0	0	0	0	0	2	83	2	1	0
Rissos Dolphin - stranded / dead	0	0	0	0	0	0	0	0	0	0	0	1
Sperm Whale - Dead	0	0	0	0	0	0	1	0	0	0	0	0

Figure 5 - Graph of individual marine mammal sightings for the Bailiwick of Guernsey, monthly breakdown

Data was analysed to expose monthly trends in sightings of cetacean species, with results are shown in Figure 5. The majority of sightings were during summer months of June – October. The most common cetacean to be spotted is the Common Dolphin (*Delphinus delphis)* with 457 individuals sighted between 2006 and 2013. The Bottlenose Dolphin (*Tursiops truncates)* is the second most common species sighted within the 2006-2013 period with a total of 450 individuals. Though this is individual sightings, there is no way of distinguishing if individual species were spotted on more than one occasion.

Despite the common dolphin being the most commonly sighted species of cetacean, the bottlenose dolphin was sighted during every month excluding November (see Figure 5), which suggests that the population remains in coastal waters of the Bailiwick of Guernsey throughout the year and has less seasonal influences.

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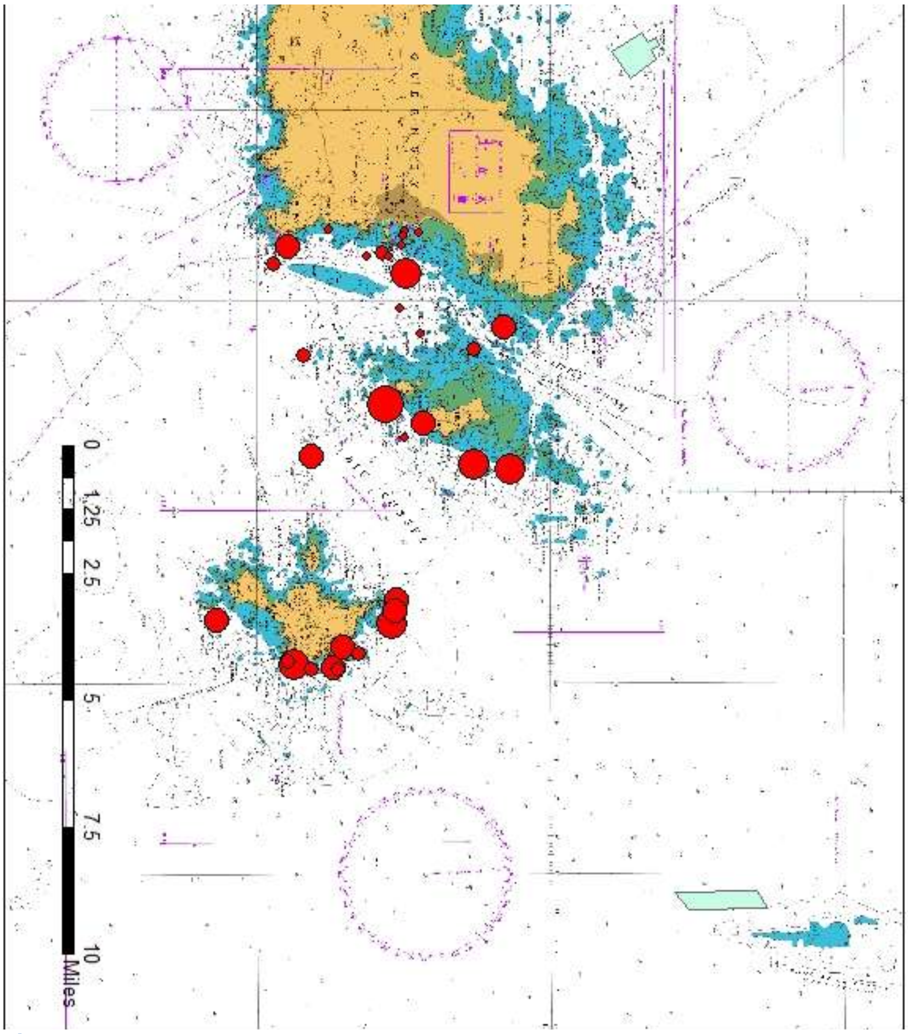


Figure 6 –Bottlenose dolphin distribution.

Bottlenose dolphin distribution in Figure 6 shows all sightings within the Bailiwick of Guernsey. Sightings are concentrated on the north-east coasts of Guernsey, Herm and Sark. There are a high number of sightings reported for the area around St Peter Port. This may be due to significantly higher populations within the vicinity of the Little Russell but is more likely associated with higher population of people and therefore more effort into sightings around the port and therefore more associated effort with survey methods.

This map produced in GIS indicates locations of sightings and the quantity that was sighted at one time. Figure 6 shows that sightings of pods of dolphins with up to 50 individuals have been sighted. There is also proof that there are also solitary individuals.

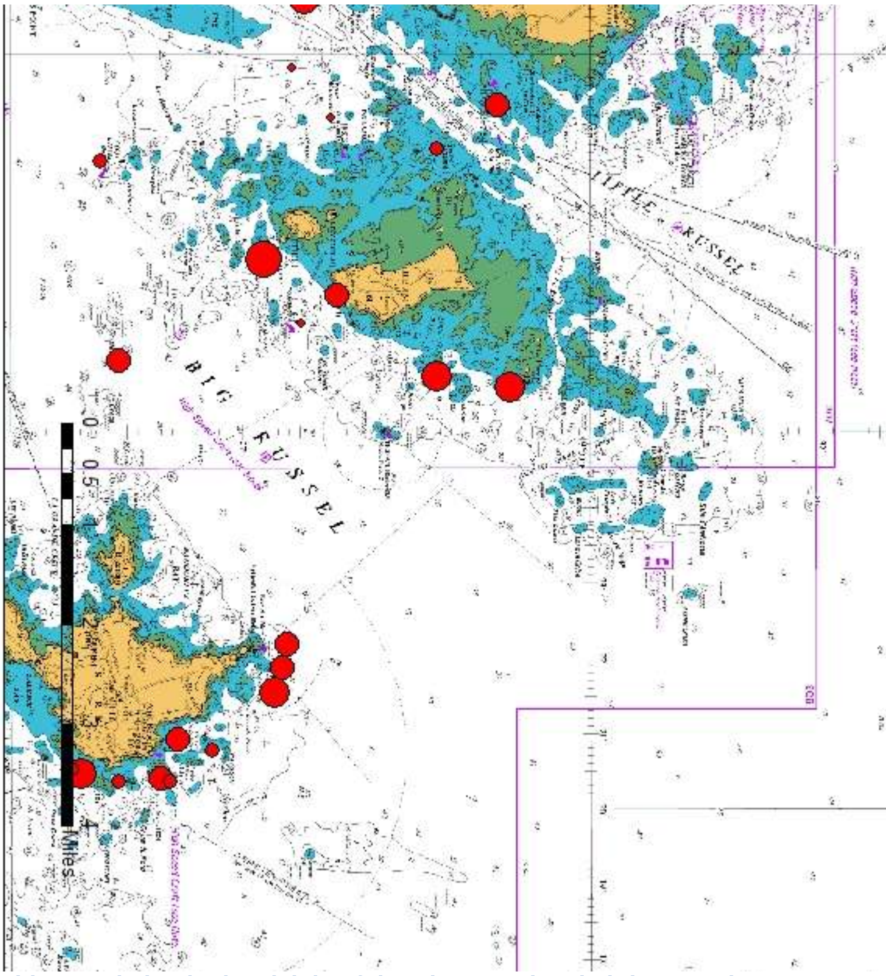


Figure 7 - Bottlenose Dolphin population in the vicinityof the Big Russel and Little Russel

The location of the Big Russel was looked at specifically due to the potential tidal power which could be harnessed here. Figure 7 proves with available data that there are sightings of bottlenose dolphins within the Big Russel. This serves as a basis that more research and surveys must be carried out within this location to formally characterise the resident population.

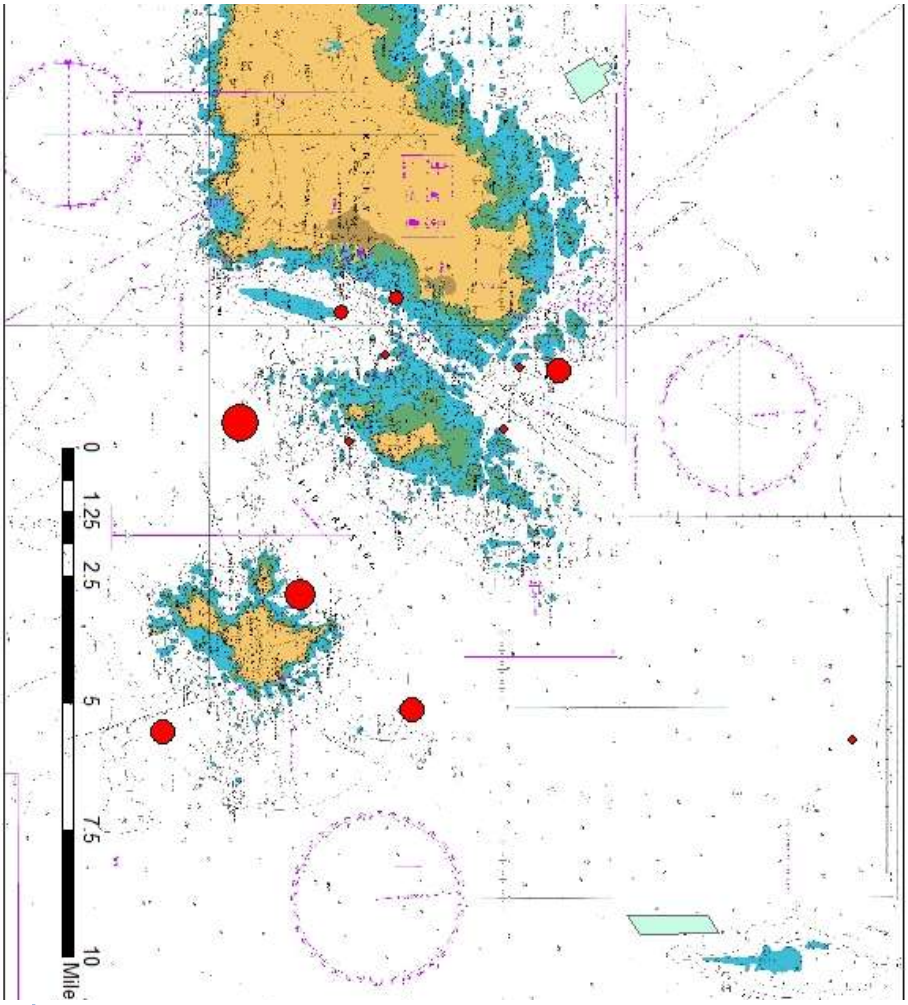


Figure 8 – Common Dolphin distribution

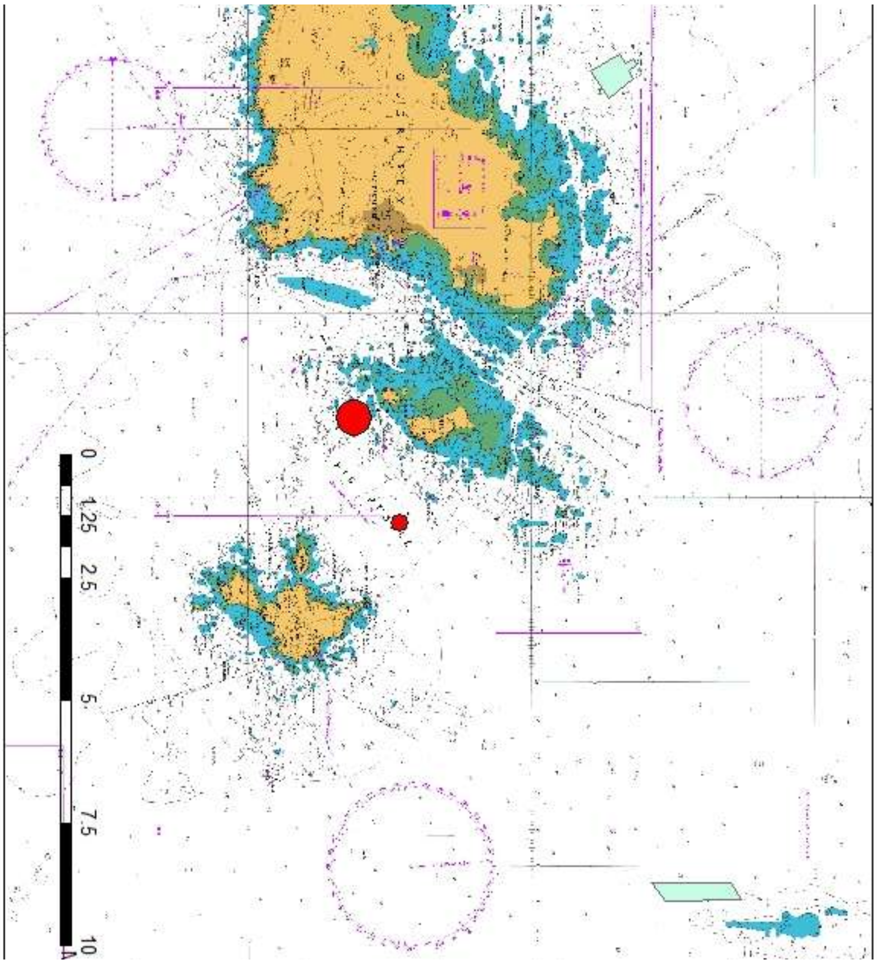


Figure 9 – Pilot whale distribution

Pilot whale sightings shown in Figure 9 are located the Big Russel, a site for potential tidal energy (GREC. 2010). There have been 16 overall sightings during 2006, 2007, 2009 and 2010. There are no recordings of Pilot whales since 2010.

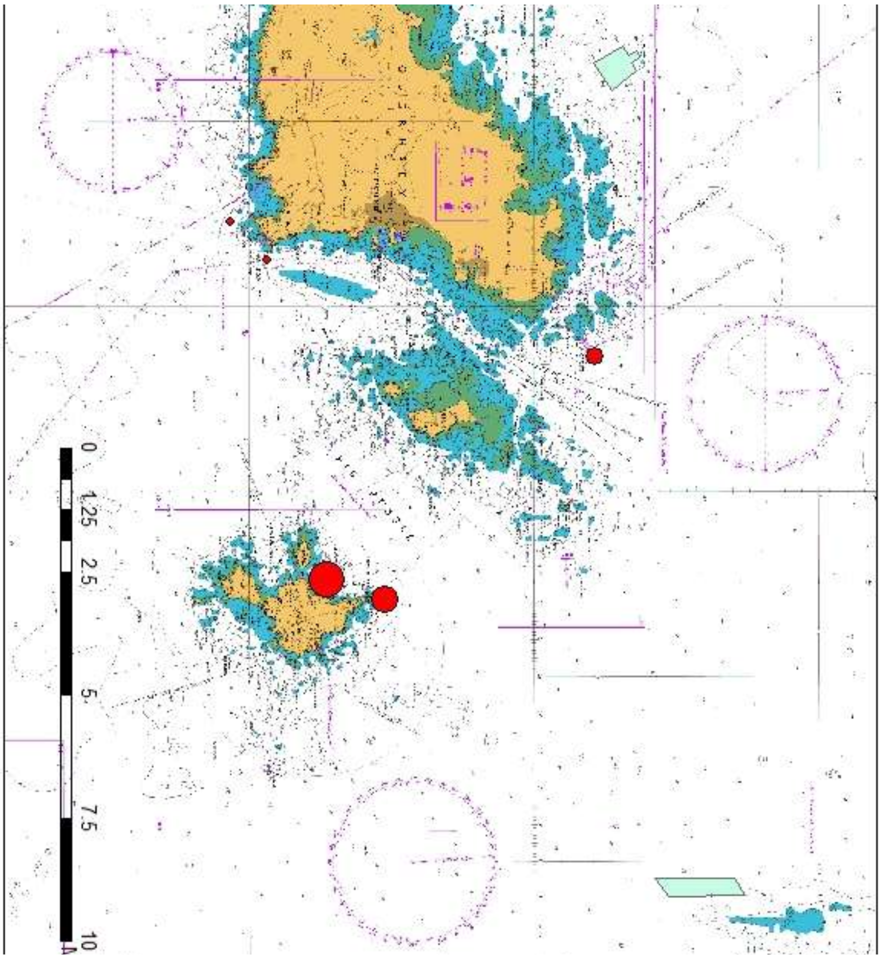


Figure 10 – porpoise distribution

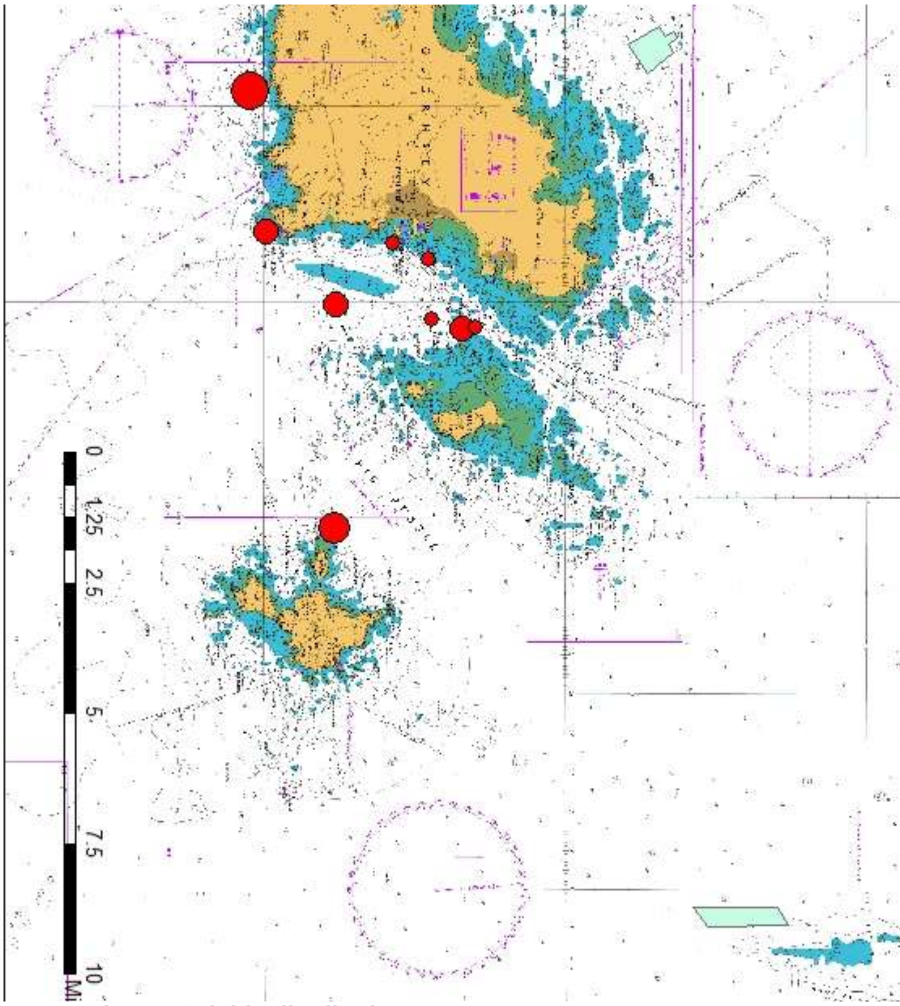


Figure 11 - Risso's Dolphin distribution

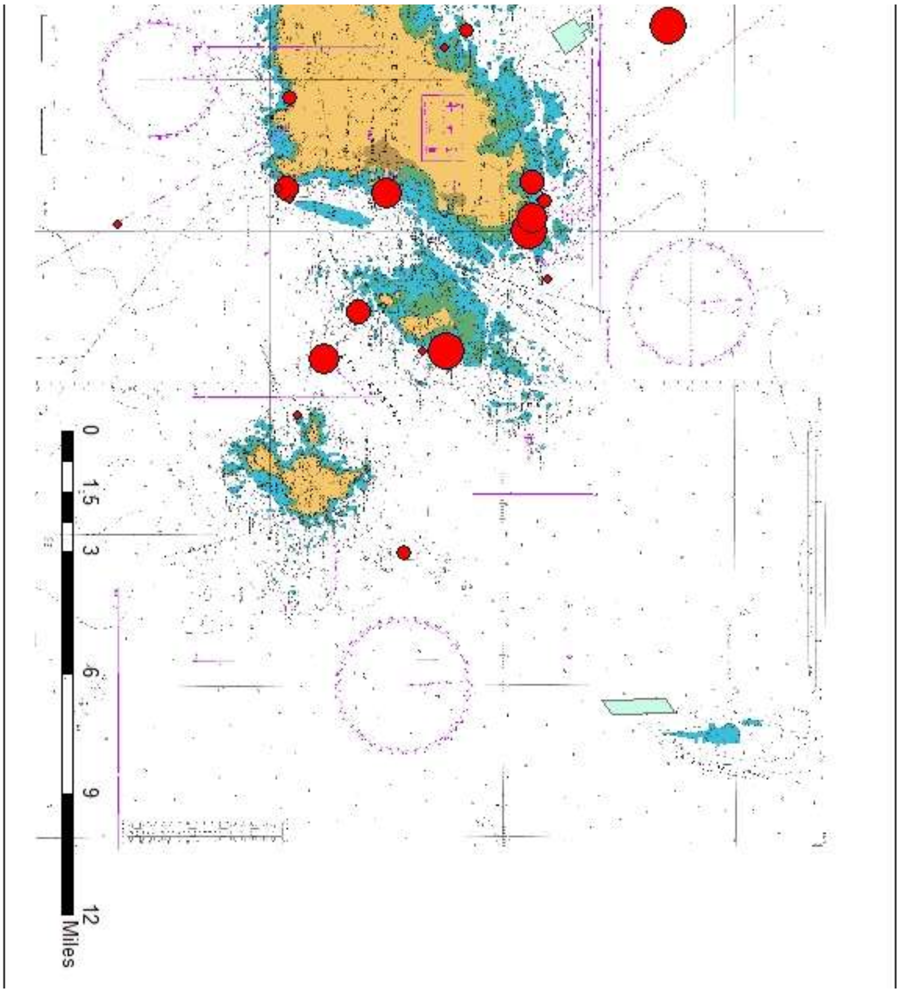


Figure 12 - Unidentified dolphin and porpoise species sightings

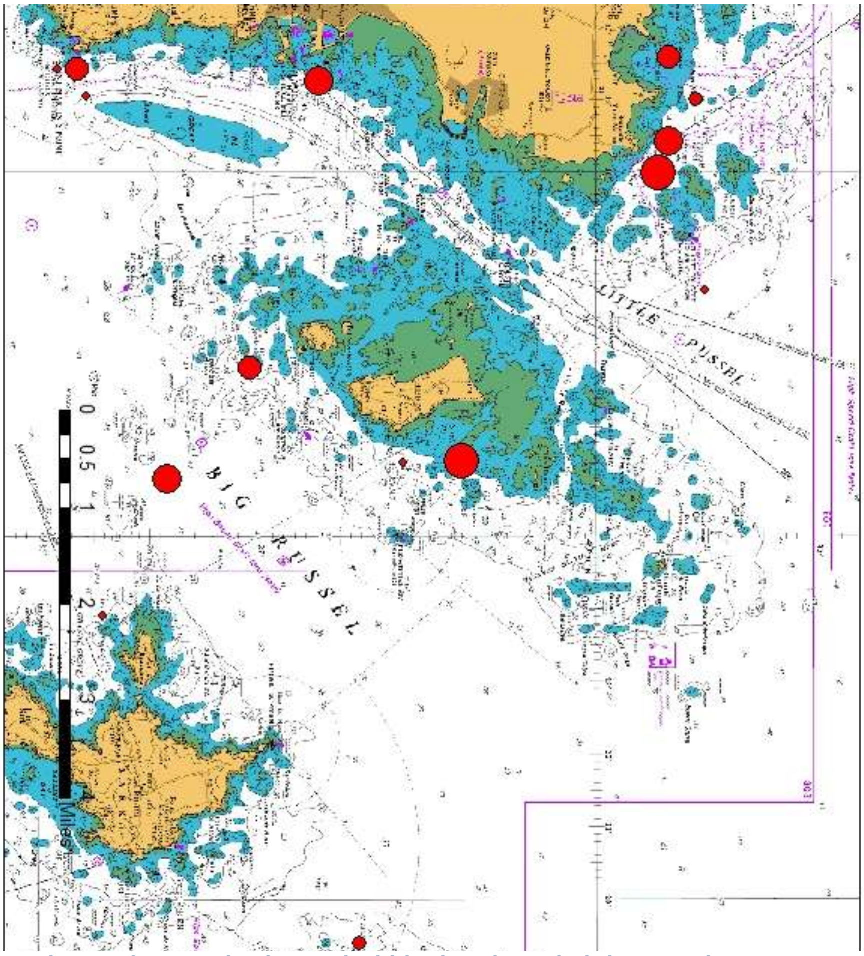


Figure 13 - Unidentified Dolphin and Porpoise species located within the Big and Little Russel

There are a high number of sightings of unidentified dolphins and porpoises as shown in Figure 12 and Figure 13. Figure 13 shows that there are numbers of sighting of unidentified species within the Big Russel. With the use of CPODs these species could be identified as either dolphins or porpoises, but specific species could not be identified.

Unidentified dolphin and porpoise species were recorded by

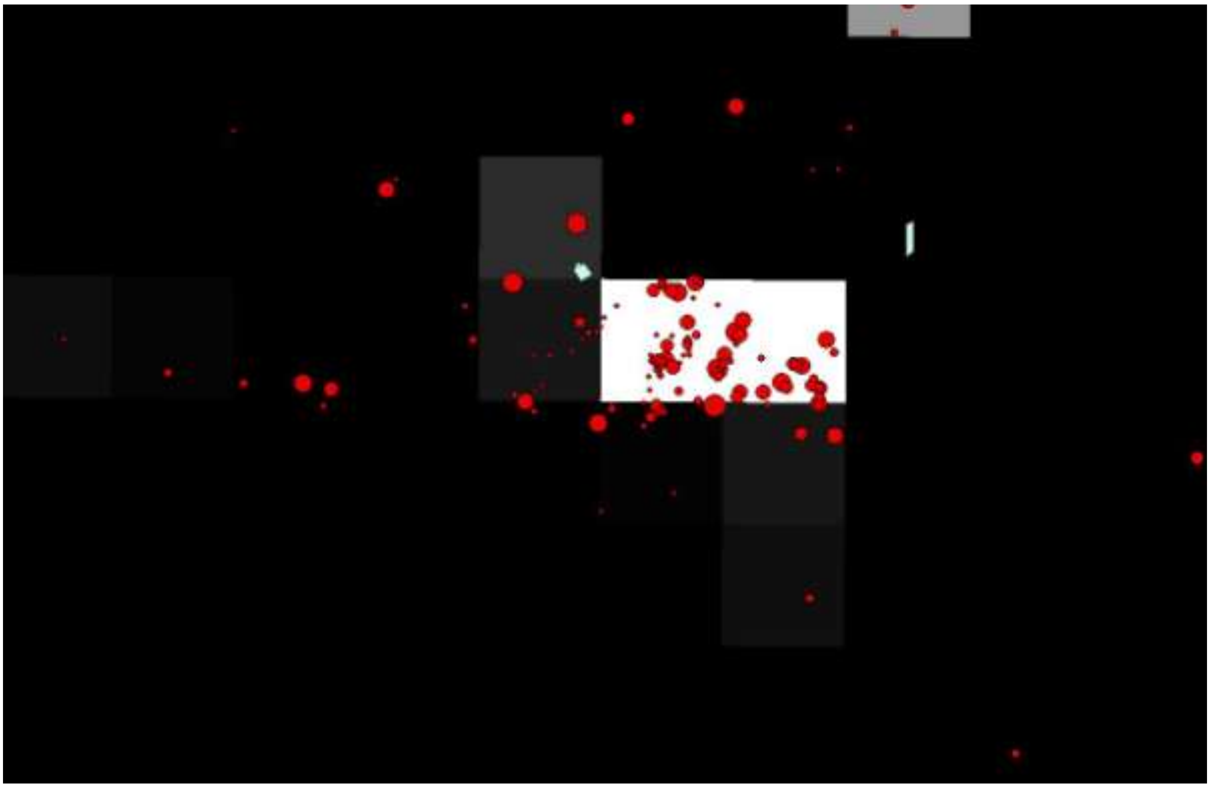


Figure 14 – Cetacean population density estimates for the Bailiwick of Guernsey based on sightings data.

Using GIS software density of cetacean populations can be seen in Figure 14, with lighter colours indicating the more densely populated areas / increased sightings during surveys. As data is sparse and relatively dense in certain areas little diversity can be seen. If this method was used however with larger and more accurate datasets high density areas could be easily identified.

6.2 Pinniped sightings distribution

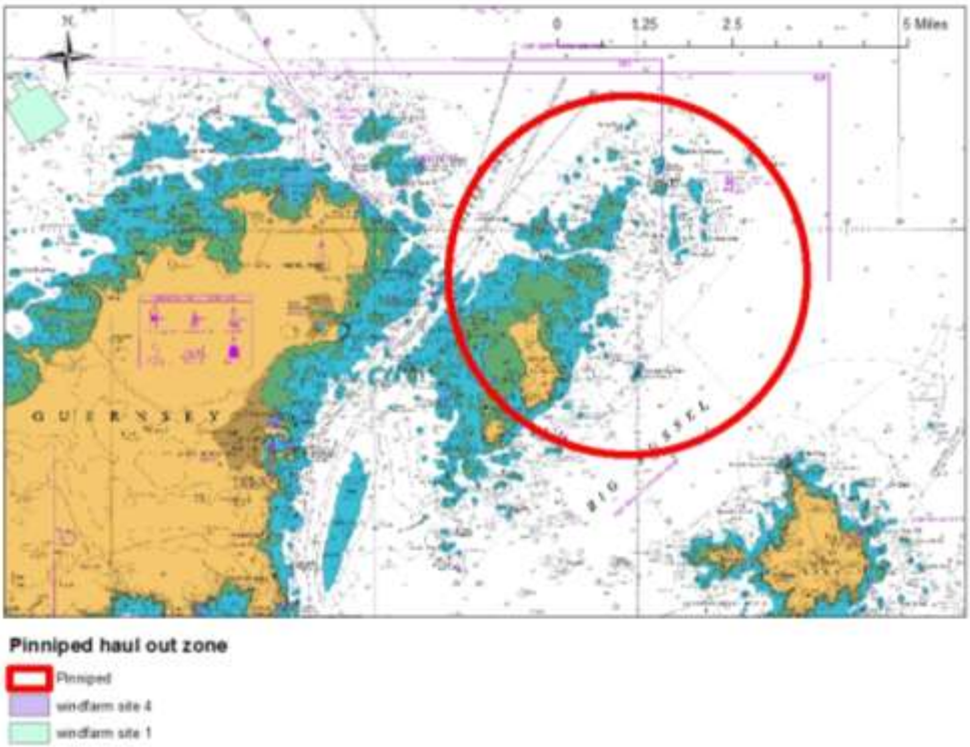


Figure 15 - Location of Pinniped haul out zones and concentration of seal population (GERC, 2010).

The ‘Humps’ north of Herm are an important haul out area for the local Grey Seal population. The Channel Islands and the Coast of Brittany are thought to be the southernmost limit of the Atlantic Grey Seals range (GREC, 2010 and Evans *et al* (2003).

Pinniped species are highly mobile species and therefore matters influencing their conservation are of international concern highlighting why it is important to characterise their population and movements around the Channel Islands by conducting a baseline survey for the Bailiwick of Guernsey.

populations in Strangford Lough have so far reported no measureable impacts on seals, porpoises and seabirds. Environmental monitoring started 4 years prior to device installation in 2008 (Sparling *et al*, 2011).

As the impacts on seals from the installation and operation of MRE devices are not yet confirmed, in the case of this project the precautionary principle will be followed and planning units covering the haul out zones and those within 1km will be excluded from the planning solution.

7. Discussion: Recommendations for GRET

The discussion for this report will incorporate analysis of well-developed survey techniques for use in collecting marine mammal data with regard to cetacean and pinniped species.

Recommendations will also be made to Guernsey Renewable Energy Team with respect to complementary survey areas in order to collect effective baseline data. Specific recommendations will outline and assist with the generation of a roadmap to secure Guernsey's future within marine renewable energy installations and its marine mammal population. .

The data used during this report in order to reflect the current efforts into marine mammal data within the Bailiwick of Guernsey is ultimately generated from incidental data. SMRU Ltd. (2010) does not consider incidental data as a monitoring technique due to the lack of ability to analyse it in quantitative manner. The data provided by La Société Guernesiaise and the biological records centre does contain some detection probability but contains no record of effort. There is no clear indication of what biases to place on this data therefor could be said that this data may be misleading and therefore lacks scientific purpose without the appropriate calibration and application of potential biases.

7.1. Critical analysis of surveys methodologies for marine mammals.

There are many survey methods recognised for the effective collection of data for the assessment of marine mammal populations. There are currently studies being undertaken to quantify and identify the impacts to pinnipeds from marine renewable

energy devices, such as those previously tested at the European Marine Energy Centre - EMEC such as OpenHydro and Pelamis (Aquatera Ltd. No Date).
For some pinniped species are thought to be restricted to locations relatively close to their chosen terrestrial haul out zone. The maximum distances they travel away from these sites are dependent on species, life history and physiological factors (Kaschner. 2006).

Studies so far in Northern Ireland on the impact of MCT's SeaGen tidal stream device on resident seal populations in Strangford Lough have so far reported no measureable impacts on seals, porpoises and seabirds (Fraenkel 2006). Environmental monitoring started 4 years prior to device installation in 2008 (Sparling *et al*, 2011).
These will be discussed in the following with dedicated cetacean and pinniped survey techniques.

7.2 Dedicated surveys for marine mammals.

Systematic sightings surveys are the regular system for estimating density and abundance of marine mammal populations. Despite the standard system the overall methods for pinnipeds and cetaceans greatly differ due to their ecology and life history. Pinnipeds are known to haul-out periodically onto land masses, therefore it is more effective to base survey effort on the counts of individuals found at haul-out sites (Duck. *et al,* 2008; Hammond. *et al,* 2002 and SMRU Ltd. 2010) rather when they are at sea, which is the method undertaken for cetaceans due to their truly maritime existence.

A major complication for marine mammal surveys is the disturbance and the disruption caused by the surveys themselves. Therefore, when designing or undertaking a survey this should be highlighted as a significant problem. This is particularly relevant when designing surveys for monitoring marine mammals using boat-based surveys with high vessel noise disturbance (SMRU Ltd. 2010)

7.3 Cetaceans

When monitoring for cetaceans line- transect (LT) surveys are most frequently and successfully used. Prior to the survey an area is defined and a set of pre-determined transect lines are surveyed (see Figure 16). Observers record the perpendicular distance to each of the sightings (a technique known as distance sampling) together with data on the species and group size.

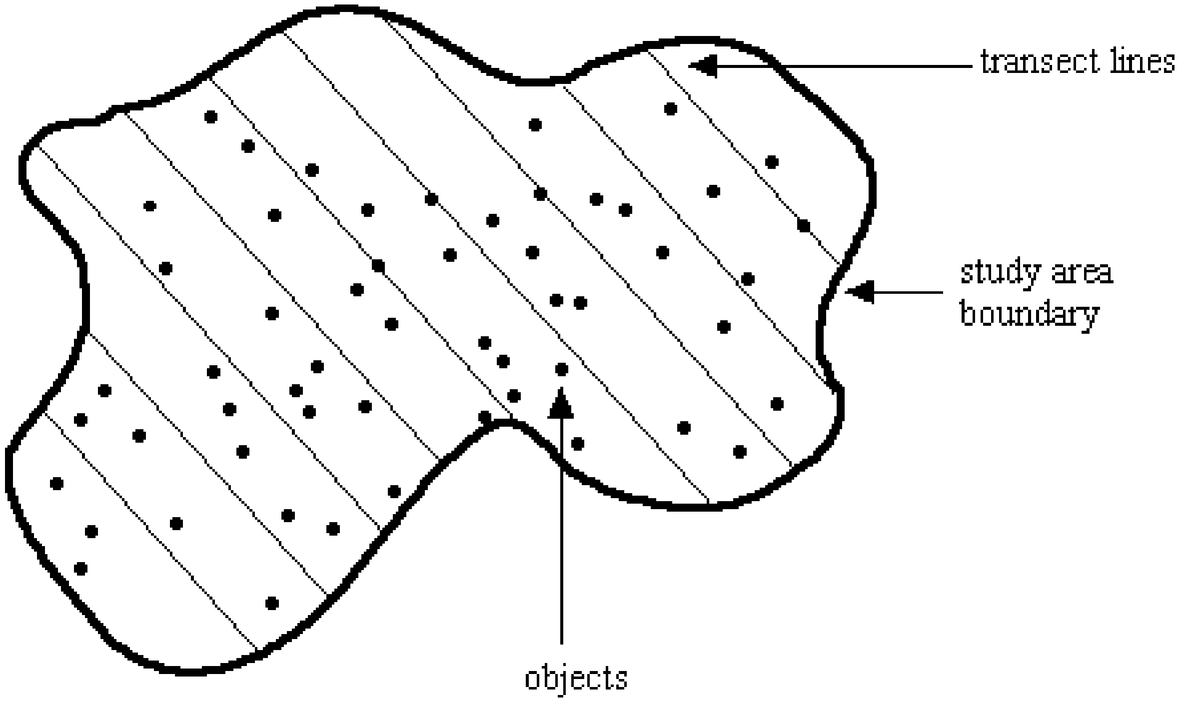


Figure 16 - Example of line transect survey design (SMRU Ltd. 2010).

Surveys can be designed on software called Distance, which is a widely used program for estimating the size or density of biological populations such as marine mammals and sea birds (Marques et al. 2001; Thomas et al 2009b) Distance sampling methods consist of a set of parameters measuring distances from a line or point fixture and making recordings (see Figure 16). This is based on 3 assumptions that;

1. Objects on the line or point are detected with certainty (corrected by double-observer or double-platform surveys methods)
2. Objects do not move (Concept that distance sampling is a snap-shot method of the species being monitored)
3. Measurements are exact (un-trained observers may be poor at estimating distances)

From this the abundance may be estimated and analysed using the software Distance (http://www.ruwpa.st-and.ac.uk/distance/). (Thomas. *et al.* 2010)

By completing surveys in this manner, a detection function can be applied and an effective approximate width of the strip that has been surveyed estimated; thus correcting the figures for marine mammals missed by observers during the transect. The method generates unbiased estimates of density and abundance providing that the key assumptions are met:

1. Distances and angles from the observer to points of interest are measured without bias.

2. Animals are detected at their initial location, prior to any responsive movement to the survey platform.

3. Animals on the transect are detected with certainty, (the detection function g (0) = 1). (SMRU Ltd. 2010).

This is an effective and proven method for surveying marine mammals. Due to the nature of cetaceans to be attracted or deterred from the research vessel this method takes into account potential individuals who cannot be viewed and on the basis that marine mammals spend large quantities of time under the waters surface, only surfacing when necessary for air.

To ensure that assumption 1 is met, reticle binoculars and inclinometers are used during both ship and aerial surveys. Despite not being completely error-free, these methods should be bias-free. Video-range techniques can be utilised though the equipment is more expensive and more difficult to use unless specifically trained adding to cost and funds (Thaxter and Burton. 2009).

Many cetacean species are known to respond to the presence of boats and therefore this can greatly affect boat-based line transect surveys this presents added complexities to reach assumption 2. Marine mammal attraction to the vessel results in positively biased abundance estimates whilst vessel avoidance by marine mammals results in negatively biased estimates. These are not indeterminable complications, but generally require auxiliary data collection involving some sort of double-platform survey method

Assumption 3 is almost never determined (SMRU Ltd. 2010) regardless of species or survey platform such as boat-based or aerial. However, some field methods (e.g. double-platform or double-observer methods) allow for investigational estimation of certainty.

A constraint associated with all visual line-transect surveys, regardless of platform choice, is that surveys need to be conducted in fair weather conditions to make the survey as accurate as possible.

Line-transect methods have been successfully used from both boat and aerial platforms to estimate density and abundance for marine mammals as explained in Hammond *et al*. (2002) and are considered to be the standard for marine mammal population estimations.

7.4 Pinnipeds

The methods used to estimate abundance for harbour and grey seals differ because of fundamental differences in their ecology. Grey seals aggregate at traditional breeding colonies (such as those located on The Humps) in the autumn to give birth to a single pup and mate. Harbour seals breed during summer and disperse after this period, rather than aggregate, during breeding.

Similarly harbour and grey seals come ashore for prolonged periods during their annual moult. In the UK this is during late summer (harbour seals) and spring (grey seals).

For grey seals the main method for monitoring their numbers is counting the aggregation of individuals during the breeding season when the aggregate in a collective location and where white coated pups are relatively easy to count. Pup production is also the main rationale behind SAC designation for this species (not however up help within the Channel Islands). In contrast with grey seals, harbour seals are routinely surveyed during their annual moult (SMRU Ltd. 2010)

7.4.1 Grey seal breeding season surveys

The majority of Britain's grey seal breeding colonies are surveyed annually to undertake pup counts. The most widely used method uses aerial photography as many of the colonies are remote offshore islands. However counts can also be made from boats, which may be the best method with regards to assessing Guernsey's population. Because surveys are carried out annually, population trends can be examined. However, the approach is very time consuming, specialised and can be expensive.

7.4.2 Harbour seal moult surveys

Harbour seals are surveyed annually during their moult in August. Two different methods of aerial survey techniques are routinely applied by the Sea Mammal Research Unit (SMRU Ltd 2010 and Duck et al., 2008). Current surveys of the Scottish coastline commonly include the technique of thermographic aerial photography technique using a helicopter platform. As the technique is relatively expensive, surveying is limited to a 5 yearly cycle.

Estimates of harbour seals abundance are usually expressed in terms of minimum populations size (total number of animals counted). Good survey methodology restricts the timing of the surveys to two hours either side of local low tide to allow individuals in eh water to make an appearance, but a relatively large proportion of the population remains in the water during this time.

Boat-based surveys may be required for pinnipeds in some regions where they are present in caves or gullies that are difficult to photograph from the air but these types of habitats tend to occur mainly in Shetland and not the Channel Islands, they are most relevant for grey seals and they account for a relatively small proportion of the total population.

7.5 Marine Mammal survey methodologies

7.5.1 Boat-based line transect surveys

Boat-based surveys require an elevated and stable platform for which to conduct surveys upon. Boat surveys to estimate certainty (within the detection function mentioned in assumption 3) need to have two survey platforms (duel-platform DP), each being able to accommodate up to four observers (Hammond et al., 2002). Though surveys can occur with a single platform (SP) (SMRU Ltd. 2010)

Subsequently the ships required for these surveys need to be of a large size and tend to consequently come at a high financial cost to those undertaking the survey. Where two platforms are available for visual observation on the survey vessel one platform is required to be higher than the other and the observers on this platform (otherwise known as the tracker) search at a greater distance ahead than the other platform (known as the primary) using binoculars, while the primary team search with the naked eye (SMRU Ltd. 2010 and Hammond et al., 2002)

The detection of cetacean species is heavily dependent on weather conditions when being undertaken by boat-based survey. This is particularly for any higher than Beaufort Sea state 5 which is considered as a 'fresh breeze with winds up to 19 knots' (Met Office. 2010). This is due to an increasing number of white caps or breaking waves obscuring the most common sighting cues (most sighting surveys are discontinued when sea state reaches Beaufort 4) . Understandably surveys can only be conducted during daylight hours due to restricted visibility in the dark, which then further imposes time- restrictions and associated financial uncertainties.

7.5.2 Aerial line-transect surveys

It is assumed by SMRU (2010) that aerial surveys do not suffer from the problems associated with responsive movement with boat-based survey methods. This though depends upon the aircraft type used and the species concerned as many survey methods are specific to species.

Aerial surveys provide an efficient method for multiple species surveyed covering larger areas per survey of approximately 2000km2 per survey. (Diederichs et al. 2008)

Some marine mammals are highly sensitive to the kind of low-frequency pulsed sound from aircraft (which can propagate through water as well as air) such as helicopters and while "responsive movement" is often considered mainly in terms of lateral movement of animals away or towards the track line, marine mammals have the capacity to submerge in response to aircraft noise that can reduce their apparent abundance. (Brower. *et al* 2012).

Aerial surveys are less sensitive to weather conditions and considerable ground can be covered quickly (SMRU Ltd. 2010) therefore lowering overall costs. In comparison to boat-based surveys charter costs for aircraft are much lower making them a more attractive option.

Proximity of suitable airstrips (see Figure 18 and Table 1) and refueling locations are major considerations if considering aerial surveys, and sourcing a suitable aircraft is paramount for an effective survey. SMRU Ltd (2010) have stated that aircraft used for marine mammal surveys must be twin-engines, high winged and feature bubble windows as also recommended by Haelters. (2010).

Figure 17 - Advantageous view from a bubble window, vital on aerial marine mammal surveys (Haelters. 2010)

Considerations such as the distance offshore may means that Ariel surveys are not suitable though the research for the Bailiwick of Guernsey is currently mainly localized and coastal areas. Available and suitable airstrips for aerial based surveys within the Channel Island are indicated in Figure 18 and shown in Table 1. SMRU Ltd. 2010 initially identified these during preparation for R3 wind sites.

Table 1 – Name and lcaotions of suitable air-strips which can be used for aerial based surveys of marine mammals. (SMRU. 2010)

Airfield	Latitude	Longitude

Alderney Airfield	49.70676 N	-2.21538 W
Guernsey Airport	49.43331 N	-2.59421 W
Jersey Airport	49.20607 N	-2.19355 W

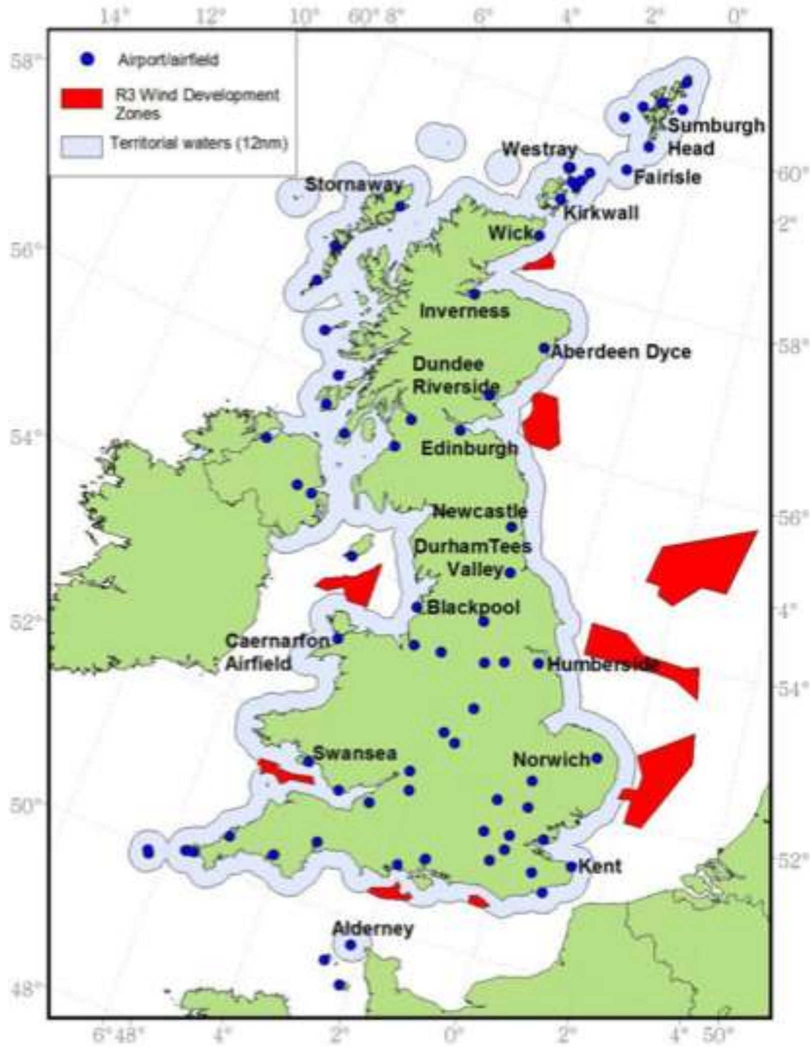


Figure 18 - Locations of suitable airstrips, equipped to deal with aerial survey vessels for marine mammal monitoring (SMRU Ltd. 2010)

All line transect surveys are recommended to be carried out at monthly intervals throughout the survey period (Diederichs et al. 2008). Aerial surveys are suitable for both cetacean species and pinnipeds, but some consideration must be taken due to the differing preferred methods and the fundamental differences in their ecology.

7.5.3 Platforms of Opportunity (PoOPs).

Opportunistic cetacean surveys can be carried out on any vessel with a forward facing, moderately high platform from which to make observations by personnel. However there are differences between opportunistic data collections and data from platforms of opportunity (Williams et al., 2006). The main associated differences are that while the platform is opportunistic, data collection can still happen according to SMRU (2010) 'In a dedicated, rigorous manner'.

Due to the platforms being opportunistic, the overall cost of such data assemblage can be a significantly lower than the costs of a dedicated marine mammal survey. The most common forms of PoOP are cruise ships, cargo ships, pleasure craft such as yachts and ferries. Marine mammal data is also collected on board vessels targeting other species involved in research projects such as seabirds of fisheries organisations.

The main disadvantage of using PoOP is that it is not possible to influence where and when the vessels goes due to an already organised heading. Due to this data collected onboard many platforms of opportunity, cannot be used to create accurate abundance estimates for line transect distance sampling methods such as those generated on Distance software (Thomas. *et al.* 2010) due to unequal coverage of the survey area and therefore is not a true representation.

Recording sheets designed by Sea Watch foundation and used by Alderney Wildlife Trust for recording marine mammal sightings are shown in Appendix 1, 2and 3.

7.5.4 Photo Identification

Photo-identification techniques have been used since the 1970's as powerful cetacean research and more recently have been applied to pinniped populations.
This technique is generally species and location specific. This technique has already been applied to pinniped species in Guernsey, with data being collected on the pinniped population located on The Humps to the North of herm. This is currently being undertaken by Island Rib Voyages (https://www.islandribvoyages.com/) located on Guernsey, who since 2005 have been collecting data and taking photographs of pinniped species using this area for moulting and pupping.

NOAA has adopted the photo ID technique for multiple cetacean species, whereby photographs of dolphin dorsal fins are taken and input into a 'FinBase database'.

These can then be used to compare natural markings on the trailing edge of the dorsal fin, which change very little over time and can be used to identify individuals (NOAA. 2012).

This method is successful as it is non-invasive; as no physical handling of the marine mammals is require reducing stress. SMRU (2010) consider the main advantage of these 'individual-based studies' is that they can be long-term and pictorial data gathered can be utilised in the estimation abundance and life history parameters for individuals such as survival, reproductive success, home range and habitat utilisation.

Drawbacks are that generally only a portion of the population is sampled using photo ID as it is particularly area based. Photo-identification measures the number of marine mammal species that use an area, (though they may not all be present during the same time frame), rather than density, or distribution.

7.6 Acoustic Methods.

Passive acoustic monitoring (PAM) relies on detecting vocalisations of cetaceans. It does not emit acoustic signals – rather it "listens" and is gaining increasing popularity for monitoring cetacean populations.
Acoustic data can be collected on a continuous basis and is much less reliant on weather conditions. Data collection from PAM methods can be automated and is not restricted by the skill of the "observer" as it common with boat-based, aerial and PoOP methods.
The PAM method depends on specific species having vocalisations with a useful detection range – this excludes sperm whales (*Physeter macrocephalus*) (Haelters. 2010).
Pinnipeds do not vocalise underwater in the same way that cetaceans do, therefore PAM methods are not applicable to Pinniped species.

There are currently two systems in use for carrying out passive acoustic monitoring of cetaceans: towed hydrophone arrays and static autonomous acoustic data loggers summarised in

7.6.1 Autonomous acoustic data loggers

Multiple autonomous acoustic data loggers available on the market, all of which record raw data and some which will also carryout real time data analysis (SMRU Ltd. 2010). The recording only type, the Cornell Pop-Up has been widely used. Pop-Ups are intended for deployment on the ocean floor, up to depths of 6,000m, and are designed to “pop up” for retrieval (Clark. 1995).

The Ecological Acoustic Recorder (EAR) monitors biological activity in the water column for periods of one year or longer. They are anchored to the seabed and released, just like a Pop-Up (Lammers, et al. 2008). While EAR’s are simpler to use than Pop-Ups, they cannot be deployed as deep. Studies at the European Marine Energy Centre (EMEC) have been utilised the development of drifting EAR technology, although this has not been designed to detect marine mammals and is optimised for measuring the general baseline acoustic environment.

Within Europe, the most commonly used form of acoustic data logger is the POD, which stores raw data and performs basic analysis of marine mammals. The POD is an autonomous acoustic data logger that detects presence of vocalising cetaceans. PODs are an advantageous tool for gauging the behaviour and movements of cetaceans in response to marine activities (Tougaard and Henriksen, 2009). PODs have been used extensively to monitor the impact of wind farms on harbour porpoises in Europe (Carstensen *et al.*, 2006) and therefor are an exemplary device for monitoring marine mammals. T-PODs being the initial devices ceased production in 2008 and have been replaced by C-PODs (Chelonia Ltd. 2012).

Technical specifications of C-PODs:

C-PODs compose of the following specifications (adapted from the information provided by Chelonia Ltd.; www.chelonia.co.uk):

- Working depth up to at least 100 m;
- Powered by 8 (or 10) alkaline D cells;
- Autonomy at least 3 months (Haelters. 2010)
- Length: 535 mm.

- Weight: 1.7 kg – 2.9 kg (without – with batteries);
- Buoyancy: 0.5 kg (8 alkaline D-cell version);
- Omnidirectional hydrophone, 20 kHz to 150 kHz;
- Removable Secure Digital (SD) memory card;
- Detection radius up to 300 m for porpoises (100 % detection within 70 to 100 m), and at least 1200 m for dolphins;
- Angle sensing: an angle sensor and POD settings allow for the POD to be set and transported (e.g. upside down) without logging; while logging the angle is recorded each minute;
- The temperature is recorded each minute.

(Chelonia Ltd. 2012 and Haelters. 2010).

CPODs are programmable and can be set to record within the frequency range of interest. The most recently developed POD, the C-POD, can detect all toothed cetaceans, which vocalise within the 20-160 kHz range (except sperm whales). Currently PODs are limited to water depths of about 500m (Chelonia Ltd. 2012).

7.6.2 Towed hydrophone array

Towed arrays can be deployed from most boats and by hand; although a winch can be useful for larger arrays. Their use can be restricted by water depth, although this is dependent on the length of the array and speed of the vessel (Miller and Tyack 1998) A minimum water depth of 10m is generally required for these surveys. An extensive guide to towed hydrophone arrays can be found in Barlow et al. (2008) and a comparison between towed hydrophone arrays and autonomous data loggers can be seen in Table 2 - Passive acoustic monitoring technique comparison (SMRU Ltd. 2010)Table 2.

Table 2 - Passive acoustic monitoring technique comparison (SMRU Ltd. 2010)

Towed hydrophone array	
Pros	**Cons**
Data not dependent on daylight hours and weather conditions	Estimating abundance of specific species can only be achieved for harbour porpoise. Species identification difficult for other species.
High spatial resolution data	Noise level of vessel can impact data and performance
	High frequency vocalisations are limited to a 200m-detection range.
Autonomous data loggers	
Pros	**Cons**
High temporal resolution due to 'click detectors'	Abundance estimates are not satisfactorily developed
Data collection inexpensive after initial	High frequency vocalisations are limited to

purchase	a 200m-detection range.
Long term data set	Require retrieval of device to access data
Used to monitor relative abundance of species	

7.6.3 Evolving acoustic technology - PAMBuoy

A new acoustic monitoring system, PAMBuoy, is currently being developed as a real time marine mammal detection system that uses embedded microprocessors to analyse acoustic data at high frequencies. PAMBuoy was owned and developed by SMRU Ltd (SMRU. 2010). In 2012 ownership was transferred to Marine Instrumentation Ltd.

SMRU Ltd was set up in 2006 as the commercial arm of the Sea Mammal Research Unit at the University of St Andrews and is a world leader in applied research and consultancy on marine mammals, providing high quality services and advice on marine environmental issues. St Andrews Bay is currently being used as a test site for PAMBuoy technology.

The system is an autonomous, self-sufficient, moored surface buoy that is powered using a series of solar panels (Barker and Lepper. 2012). Summary detection data can be stored on board or transmitted to shore at user-defined intervals using the GPRS 3G mobile phone system (SMRU. 2010).

Primary data that can be transmitted include timings of marine mammal detections, identification of individual species, and bearings to detections. Secondary data include buoy location (GPS), a summary of background noise levels at pre-defined intervals, and system management data such as battery levels (PAMBuoy. 2013).

7.7 Fixed point Surveys

Fixed-point visual observations for marine mammals can be land or sea based, but is more commonly executed from land. Land-based observations are mainly carried out from cliffs or headlands that are elevated points featuring extensive views of surrounding coastal waters. This can also take place in areas covering constrained migration pathways of narrow channels (SMRU Ltd. 2010), which is applicable to the Big and Little Russel within the Bailiwick of Guernsey.

Fixed-point observations are most successful and applicable to surveys when used as methods of behavioural studies for coastal cetacean species as researchers can observe behaviour of animals from extended periods of time without complexities involving attraction or deterrence from boat-based or aerial surveys.

7.8 Telemetry

Telemetry is a widely used method for studying marine mammals and can help identify important habitats, migration routes and define boundaries used. Marine mammal populations under study can be fitted with GPS tagging systems such as those identified in Figure 19, which include sensors that measure temperature, diving depth and duration, speed and location (using GPS or Argos packages).

By using telemetry researchers can gain vital information about behavior, functions, and their environment. This information is then either stored while in situ on the marine mammal in question (with archival tags) or the tags can transmit recorded information to a satellite or handheld device.

Figure 19 - Satellite-linked tagging device upon a Bottlenose Dolphin (NOAA. 2007).

Associated problems with telemetry include;

- The attachment of a device to species.
- Recovery of the data.
- Power supply.

Obtaining data from marine mammals using telemetry is technically challenging and almost all examples of data collection from this type of activity are still classified as experimentation and fall within the Animals (Scientific Procedures) Act 1982. There are still relatively few examples of operational monitoring using telemetry of marine mammals. The suggested sample size for a telemetry deployment is 12 ‘animals’ based on best practice (SMRU Ltd. 2010) which creates associated high cost.

Despite the suggestion of telemetry for the survey of baseline data for marine mammals within the Bailiwick of Guernsey this method without specific funding could be to high expenditure and technical challenges.

7.9 Cost implications.

In comparison with boat-based surveys, charter costs for aircraft are lower cost. However the logistical considerations for aerial surveys include proximity of suitable facilities such airstrips, refueling stations, finding appropriate craft for the surveys. Survey locations that are further offshore or a long way from airports may not be accessible to planes and therefore cannot be used as a survey method at all.

Survey techniques are heavily reliant of effort, and the amounts of effort undertaken with each survey (see **Error! Reference source not found.**). By documenting effort during marine mammal surveys more effective and accurate results can be obtained.

7.10 Survey Cost:

7.11.1 Basic cost of monitoring: cost/benefit analysis

The overall costs of monitoring marine mammals are greatly dependent on the methods implemented. While GRET is still within the early stages of developing a monitoring program it is important to offset the costs associated with marine mammal surveys against the benefits that the research will produce i.e. baseline survey data availability for GRET.

A cost/benefit breakdown will help to define the most cost effective method in achieving the desired outcome for GRET with the most benefit to potential developments, with regards to data quality and quantity dependent on requirements.

7.11.2 Factors affecting cost

Survey and monitoring methods can be considerably influenced not only by suitability for the required data and species, but also the financial cost implications associated. The overall costs of monitoring methods are affected by a great number of factors inclusive of:

- Equipment cost
- Platform hire (boat-based, aerial)
- Trained personnel

- Associated travel cost
- Analysis (time and complexity)

The more complex the final analysis and the expertise required, the longer the overall process time and associated increased costs. Providing actual costs is difficult to achieve due to the number of associated assumptions.

Standardised costs generated by SMRU Ltd (2010) for The Crown Estate (based on similar amounts of effort) aim to show an example of the scale and relevant cost differences concerning the most commonly utilised methods for cetacean surveys (see Table 3). This is not necessarily applicable for pinniped species, as they require differing monitoring techniques and some methods are only relevant for cetaceans.

Minimum baseline data collection periods are recommended as no less than one year with added benefit of two years (RICS. 2012 and Trendall et al. 2011) increasing costs during this duration.

7.11.3 Dedicated cetacean surveys – Best Method

Aerial surveys complete more survey effort in a given time period than boat-based due to the associated higher speeds (Haelters. 2010). The benefits of this become apparent when the relative costs of the two platforms are compared in Table 3.

Aerial surveys require three (single platform - SP) or five (double platform - DP) observers (one person is acting as navigator). Similarly for ship based line transect surveys, double platform methods require a larger ship with two rather than a single observation platform, twice as many observers as single platform (8 versus 4), and the data processing/analysis is more complex for double platform analysis.

Acoustic based line transect surveys require just a single operator. Equipment costs can vary considerably from high-tech automated systems to those requiring more manual input, but still meeting all requirements.

CPODs are the most widely used autonomous acoustic data logger in the UK. The precise number required for marine mammal surveys in Guernsey will depend largely on the size of the survey area for which marine mammals are to be surveyed (SMRU. 2010). This may result to more specific research in areas such as the Big Russel as the central location for the deployment of CPODs rather than sporadically placed around the island.

7.11.4 Dedicated pinniped surveys – Best Method

SMRU Ltd (2010) suggests the method of telemetry is most effective for pinniped species. A telemetry deployment is thought to be most effective with 12 individuals. As well as the costs of equipment and devices, there are also high costs for the final analysis of resulting data.

Effectiveness for aerial survey methods involving pinnipeds is dependent on the aircraft used (twin-engine turboprop aircraft or helicopter (NOAA. n/d)) and technique. Aerial survey methods allow comparatively large areas of continuous survey lines to be covered during a single survey day in contrast to boat-based or fixed point surveys.

7.11.5 Cost and quality; Dedicated cetacean surveys

The cheapest method for effective cetacean monitoring is the use of CPODs. Each CPOD is moderately cheap (~£3,000.00 Chelonia Ltd. (2012)) and data can be collected over a period of months day and night providing a strong set of seasonal activity. The overall required number of CPODs is site and survey specific. Loss/damage to CPODs (and data) may result in unanticipated costs with related expenditure for deployment and recovery. As the acoustic detections can only be distinguished between "porpoise" and "dolphin" the quality of data could be considered as 'poor' depending on the desired outcome. Despite ever expanding research by Chelonia Ltd there is no means currently to link the number of detections to the numbers of individuals (SMRU Ltd. 2010).

Double platform boat-based surveys are the most costly method but the data generated from them will give 'precise, unbiased absolute abundance estimates if conducted on a monthly basis' as stated in SMRU Ltd. (2010) increasing the overall costs when considering minimum two year baseline survey durations+.

7.11.6 Cost per unit effort (CPUE); Dedicated cetacean surveys

Absolute costs for a marine mammal survey within the Bailiwick of Guernsey is complex to calculate are difficult to evaluate in terms of "value for money" because each method generates different amounts (and quality) of data and metrics. In an attempt to compare the costs of varying methods SMRU Ltd 92010) developed an index based on cost per unit effort (see Table 3). In doing this, costs were based on the same amount of total effort input such as kilometers of lines surveyed.

Table 3 - Standardised cost for marine mammal surveys. Daily cost and CPUE costs are relative to the cheapest method PoOP towed array (SMRU. 2010)

Method	Hour on effort	Daily field costs	Cost per hour of effort	Cost per km of effort
Boat-based duel-platform (DP) line – transect (LT)	5.5	51	205	205
Aerial duel-platform (DP) line – transect (LT)	5	29	158	16
Boat-based single-platform line - transect	5.5	26	103	103
Aerial single -platform line - transect	4	27	147	15
Towed acoustic array	22	6	6	6
PoOP visual survey	5.5	4	16	16

PoOP towed array	22	1	1	1

7.11.7 Summary of survey cost and quality.

Charter cost are some of the biggest outgoings for boat-based surveys; which is avoided for PoOP visual surveys is a fraction of the ship-based DP LT approach for this reason. Aerial surveys also perform well because they can cover a large amount of track line in a relatively short-period of time which reduces charter costs. Again, the difference in cost per unit effort between SP and DP aerial surveys is minimal, and overall aerial surveys are far cheaper than boat-based surveys. The data collection period for acoustic methods is longer than visual methods as data can be collected during the night and in worse sea conditions.

Table 4 – Estimated costs associated with purchasing equipment to carry out the corresponding marine mammal surveys - minimum estimates (SMRU Ltd. 2010)

	Monitoring method	Cost (£)
1	Boat-based DP / LT Data recording devices Reticle binoculars Angle boards External hard drive backup system	13,943
2	Aerial based DP / LT Data recording devices Inclinometers Angle boards External hard drive backup system	6,503
3	Boat-based SP / LT Data recording devices Reticle binoculars Angle boards External hard drive backup system	4,393
4	Aerial based SP / LT Data recording devices Inclinometers	6,503

	Angle boards External hard drive backup system	
5	Towed acoustic array Hydrophone Towing cable Computer Electrics e.g. GPS	7,250
6	PoOP visual survey Data recording devices Inclinometers Angle boards External hard drive backup system	4,393
7	PoOP Towed array Hydrophone Towing cable Computer Electrics e.g. GPS	7,250
8	Photo ID SLR camera External hard drive backup system	1,750
9	Autonomous acoustic data loggers 4 CPODS (recommended) External hard drive backup system	11,970
10	Telemetry 12 GPS tagging devices (dependent of requirements and manufacture costs)	40,000
11	Land based observations Binoculars Data recording laptop External hard drive backup system	7,700
12	Dedicated pinniped surveys Binoculars SLR camera External hard drive backup system	2,000

7.14 Road map for future Surveys in the Bailiwick of Guernsey.

Evidence from this report proves that further research and survey effort needs to be conducted within the Bailiwick of Guernsey by adopting a range of monitoring techniques outlined.

When evaluating the locations of potential MREI within the Bailiwick of Guernsey, these should be the focus of much of the marine mammal surveys being the highest impact sites. Marine mammal surveys should still be completed for the coastal areas of the Bailiwick under a baseline survey suitable for a strategic environmental assessment (SEA) (Department for Communities and Local Government. 2005).

Survey design for the Bailiwick of Guernsey

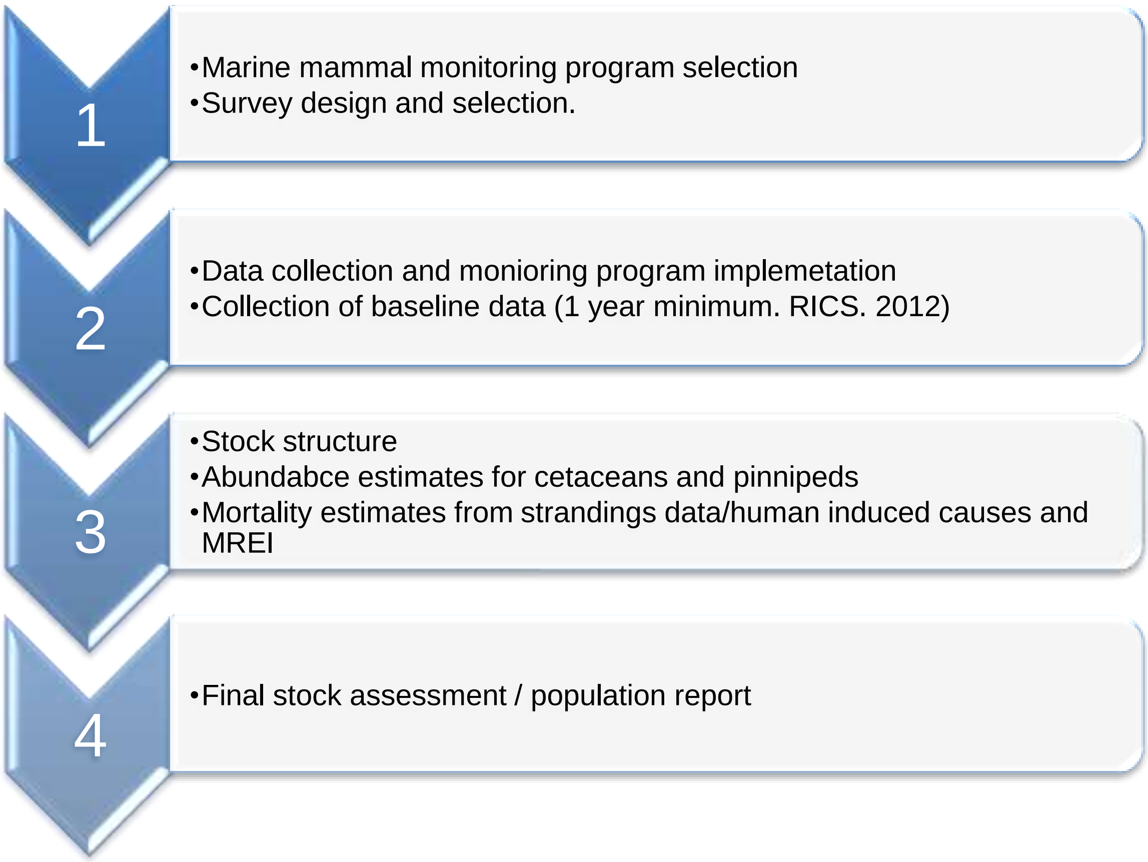
Deciding upon of the most appropriate method to use for a marine mammal survey within the Bailiwick of Guernsey is just one step despite being one of most importance in. In most cases a combination of survey methodologies and technologies will be put in place to obtain the optimum set of results at differing survey locations.
Another important choice is the final survey design. Owing to limited funding for environmental impacts assessment and baseline survey data collection compromise between the ideal design and a more practical one driven controlled by logistics, financial and available resource constraints. The definition of the survey area to be sampled must be clearly defined before any survey work goes ahead (SMRU Ltd. 2010) this could be the three nautical-mile territorial zone off the coast of Guernsey and Sark (GREC. 2010)
Design parameters must be outlines stating the required precision associated with levels of survey effort (km) and potential encounter rates for each species need to be estimated based on available data from La Société Guernesiaise and the biological records centre.

Sampling designs can be developed on design systems such as Distance (http://www.ruwpa.st-and.ac.uk/distance/). (Thomas. *et al.* 2010; Thomas et al 2009a;

Thomas et al. 2009b and Buckland et al 2004). There can be numerous choices for the layout of individual transects or points in a point transect survey.

Due to the collection of baseline data of marine mammals and a suggested monitoring period of an optimum 2 years (RICS. 2012 and Trendall et al. 2011) the sampling frequency will be controlled by this (Duck et al.2008) and surveys should be conducted on a monthly basis (Diederichs et al. 2008).
It is paramount that the collection/sampling methods used in the field corroborative with survey method specifications to produce high-quality data collection (Buckland et al 2004). This assures statistical robustness of the results such as recording effort.

Before-after-control-impact designs (BACI) are often favoured when designing studies to assess impacts of MREI. At least two sites (one for the develomement area and one comparable control area) are monitored before, during, and after the. If alterations in marine mammal populations are seen at the impact site compared to the control site, the suggestion is that the impact of MREI caused that change.
This is perhaps the most compelling reason why Developers who are responsible for adjacent developments need to co-design the environmental surveys. Not only will this have the potential to reduce the overall costs of environmental survey but it may be a necessity if the design of the surveys and monitoring are to be useful or convincing.



Specific survey recommendations:

1. Big Russel

Recommendations for specific surveys of the Big Russel are fixed point survey methods from vantage points of the land achieved from Herm or Sark (see Figure 20). Fixed-point observations are most successful and applicable to surveys when used as methods of behavioural studies and can therefore be applied to both cetaceans and pinnipeds, though as Figure 15 indicates there is little anecdotal evidence of pinnipeds at this site.

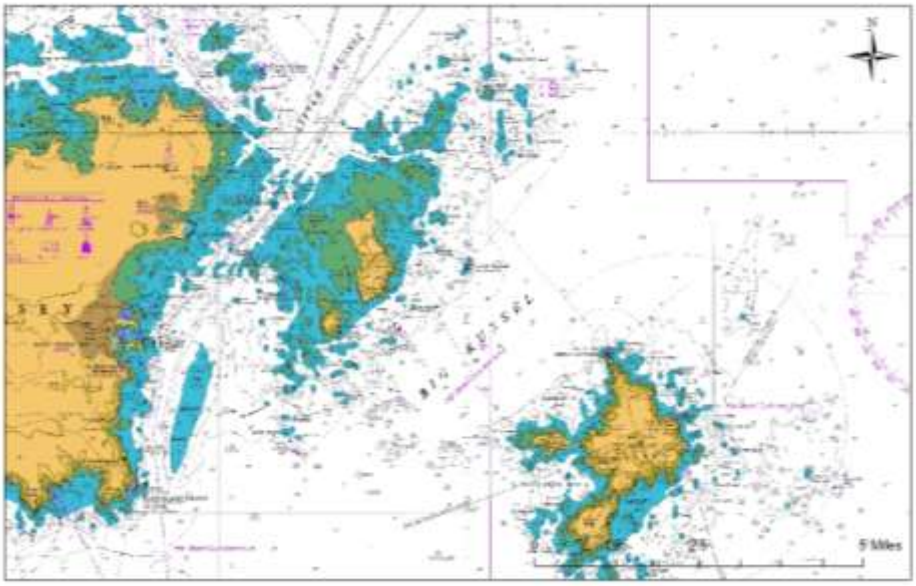


Figure 20 - location of land for fixed point land based surveys of marine mammals within the vicinity of the Big Russel.

The observation of marine mammals can be achieved for extended periods of time without complexities involving attraction or deterrence from boat-based or aerial surveys. Fixed point surveys / land based surveys are low cost and require small equipment and running costs (see Table 3 and Table 4).

2. **Wind farm sites.**

Single platform boat-based survey is recommended for Guernsey to undertake in the collection of data for cetacean and pinniped species. By completing line transect surveys with single platform, initial charter costs are lowered because of the smaller vessel size requirement which enables GRET to keep overall survey cost to a minimum. As suggested in Kaschner et al. (2006) some pinniped species are restricted to terrestrial sites suggesting they may not venture to the two sites shown in Figure 21.

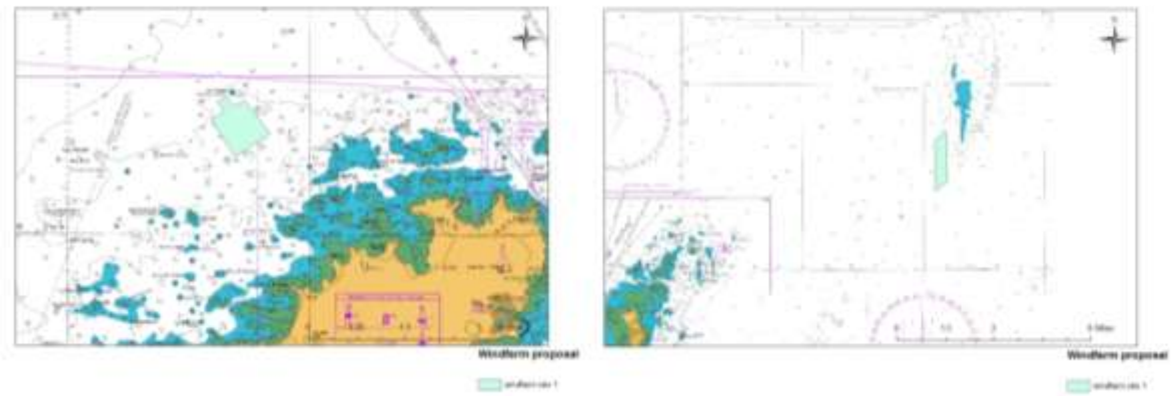


Figure 21 - Locations of wind farm sites to be surveyed

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3. **Pinniped haul-out sites.**

Single platform boat-based surveys could be undertaken at the know haul-out sites located on The Humps, north of Herm (see Figure 22). Again the use of line transect surveys with single platform, maintain low costs and the possibility of combining surveys with the same chartered vessel for wind farm sites, where The Humps are located equidistant to each.

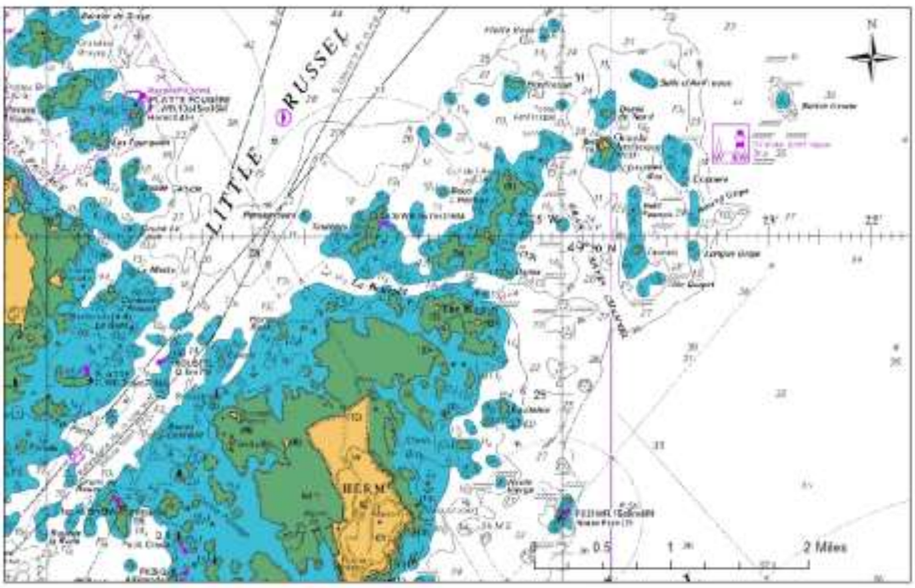

Figure 22 - Location for survey of the haul-out sites for pinniped species. The Humps , Herm

As previously discussed in chapter 2.4 there are specific time periods when it is the optimum time to survey harbour and grey seals which should be taken into account. By using a combined method of land surveys in conjunction with boat-based more sampling effort can take place and seals present in caves or gullies can be counted with better observation techniques.

4. PoOP

As there is a high amount of boat traffic around the Bailiwick of Guernsey PoOP can be incredibly useful and beneficial to the survey program. If a common observatory technique can be implemented such as The Sea Watch monitoring scheme (currently used by AWT, see Appendix Figure 23,Figure 24 and Figure 25) the quantitative data can be produced at little cost to GRET making this an motivating choice.

5. CPODS

PODs have been used extensively to monitor the impact of wind farms on harbour porpoises in Europe (Carstensen *et al.*, 2006) and therefor are an exemplary device for monitoring cetacean's presence, though there are flaws in specific species identification. PODS are only for the detection of cetaceans and pinnipeds and therefore would be best used where the greatest numbers of cetacean sightings are located. The number of CPODS required will greatly depend on the scope for which GRET wishes to achieve with CPODS. This report therefor suggests that 4 CPODS be utilised for the collection of baseline data. Due to the higher density of sightings of cetaceans within and around the Big Russel this may be the most effective location for high amounts of data. As they can be moored and brought up CPODS could essentially be used at multiple locations throughout the data collection process (Carstensen et al. 2006) with two anchored at each wind farm developments site (Figure 21). As Figure 12 and Figure 13 indicate unidentified species, CPODS could be used to differentiate between dolphins and porpoises, but not specific cetacean species.

7.15 Lack of baseline data.

A lack of initial data poses problems for future developments and installations. It is stated by Diederichs et al. (2008) that '*without baseline data the power of any investigation may be considerably reduced and only be useful to detect strong effects'*.

This affects the reliability of data from specific development surveys where minimum baseline data exists and indicates that effective baseline data is invaluable if results are to be taken with scientific confidence and accuracy.

7.16 Guernsey's Regional Environmental Assessment (REA)

Guernsey falls outside the legislation of the UK and EU, therefore Strategic Environmental Assessment legislative requirements do not apply. However, Guernsey has incorporated the basic principles and framework of Strategic Environmental Assessment (SEA).

The REA completed by GRET provides a strategic assessment of the potential impacts that marine renewable energy devices may cause to the environment of Guernsey and the wider area of the Channel Islands, understanding that all systems are integrated.

The REA recognises, evaluates, and defines the possible significant effects, both positive and negative, of developing marine renewable energy (GREC, 2011) including areas for mitigation, which is vital to base the initial development of baseline surveys upon this document.

The area that was covered within the REA consists of the territorial waters of Guernsey and Sark, up to 3 nautical miles of the coastline inclusive of intertidal and coastal areas within 200m of the shore (at MHWS). Due to the area studies for the purpose of the REA this defined area should be the starting base for all marine mammal surveys undertaken. Nonetheless due to the ecology and motile nature of marine mammals and their proven ability to travel large distances in search of food, breeding and nurturing of young, distances further than these designated distances should not be ignored. This is a noticeable occurrence, which has been a feature of many reports by Evans et al (2003) and GECC (2012).

7.17 Additional research and surveys beneficial to marine mammal research

Due to the lack of data currently available for the Bailiwick additional research alongside specifically developed marine mammal surveys should be undertaken. These are to benefit the reliability of the overall findings of any conducted surveys whether boat-based, aerial based or opportunistic surveys. Any additional research will provide stronger basis for results found during the surveys for marine mammal surveys and provide sound scientific proof for those findings.

7.17.1 Oceanic frontal systems: relation to marine mammal occurrence and distribution.

The physical processes within the oceans play a large role in affecting the abundance and distribution of oceanic organisms (Pakhomov et al., 1994, and Hunt et al., 1999). Within these systems the physical structure can develop within which phytoplankton and trophic food webs may develop (Bost. *et al.* 2009).

Oceanic frontal systems exhibit high, horizontal spatial gradients in current speed, temperature, salinity and density, as well as enhanced vertical circulation associated with bathymetric features (Belkin and Gordon, 1996). Increased marine productivity and biomass, sometime at exceptional levels often characterize frontal zones (Hunt et al., 1999).

Mesoscale whale distribution has been directly related to oceanographic features such as oceanic fronts (Bost. *et al.* 2009) due to the nutrient rich waters.

With a small-scale oceanic front located to the south west of Guernsey (Drinkwater and Loder 2001) the overall distribution and population size of marine mammals may be directly linked to this. Consequently research should be carried out on this location to asses' specific marine mammal presence to fully understand the significance.

7.17.2 Bathymetry

It is essential for detailed hydrographic surveys to be carried out for the development of an offshore wind farm or any future marine renewable energy installations. Therefore a detailed hydrographic survey carried our prior to any marine mammal survey will serve as added benefit and multiple use, which can then go on to be used for development and installation.

This survey would provide information on the water depth, seafloor slopes, outcropping and other topographical features that may be present on the sea floor. These accurate and detailed data sets are required for the planning of cable routing, foundation design for turbine support structures, and on-going inspections but are also of particular relevance to marine mammal population, with specific reference to Cetaceans and their migratory patterns.

Yen et al (2004) identified noticeable interactions in the Northern Pacific ocean between cetacean species and bathymetric features at both weekly and inter-annual intervals for species including Risso's Dolphin (*Grampus griseus*) found within the Bailiwick of Guernsey.

The study (despite being in a different location) demonstrates that resident and migrant cetacean species within a specific area are associated with bathymetric features and shallow-water topographies such as near shore intertidal and inshore areas. However there was a clear variation for each species and time period suggesting there is no one clear result for cetaceans in general.

Kaschner et al. (2006) describes clear correlations with bathymetry and bottom depth with many species of pinnipeds and cetaceans. This makes seafloor elevation an interesting representation for generic habitat suitability and therefore location in marine mammals.

A clear understanding into the localised marine productivity in the Bailiwick of Guernsey with a relation to near shore and offshore bathymetry will be key to understanding migratory and resident marine mammal populations.

8. Conclusion:

Guernsey renewable team are continuing forward with renewable energy developments, inclusive of wind in the short to mid term plan, with wave and tidal looking into the long-term plan.

Due to new developments strategic environmental assessments (SEA) will need to be carried out. Under this will include marine mammal surveys (cetaceans and pinnipeds). This is where the development and availability of baseline marine mammal data will need to be present.

This research has proven that there are 8 marine mammal species inhabiting the Bailiwick of Guernsey, 2 pinniped and 6 cetacean species. These will each need to undergo species-specific surveys, which will vary for pinnipeds and cetacean and between cetacean species due to their ecology such as the shy Rissos dolphin.

The current data available for 2006- 2013 does not contain enough information for a baseline survey but serves as the evidence that more dedicated survey work is required for a suggested minimum of one year (RICS. 2012 and Trendall et al. 2011) but a recommendation of two years, allowing seasonal and temporal abundance comparisons.

The current data doesn’t allow for relative abundance calculations or comparisons. There is currently no available measure of ‘effort’ undertaken within the Bailiwick of Guernsey, with data gaps and sparse areas across the island. The majority of sightings are located within the busiest sections of the island such as St Peter Port.

Improved communication and relationship development will need to occur between the Channel Islands, including the sharing of marine mammal data due to the cross boundary nature of marine mammals and the close proximity of the islands. This should also be achieved for the UK coastline (Evans et al. 2003) and the west coast of France (GECC. 2012)

In summary a 2 year baseline data survey needs to be conducted for the Bailiwick of Guernsey to identify and quantify the marine mammal population located there. This will be the best preparation in anticipation for future developments of MREI around the Channel Islands saving time, funding and planning complications in the future.

To support the marine mammal research, complete bathymetry surveys are required for the island to truly understand the local bathymetric features and its possible effects on the marine ecosystem. This is also interrelated with the presence of oceanic frontal systems located within the Channel Islands, which may also have a great impact on the presence, diversity, abundance and location of marine mammals within the Bailiwick of Guernsey. Therefore if disturbed by MREI, the oceanic frontal systems (or lack of) may have a dramatic influence on the future marine mammal survey of the Channel Islands.

Assessing the environmental effects of tidal stream power generators on large bodied animals in the water column is a subject of considerable interest and concern. Most of the species involved are protected under a variety of different national and international legal frameworks. It remains an open question as to what impact tidal steam devices could have on these species and only careful, adaptive approaches to the installation, testing and operation of these devices will provide confidence that any effects have been appropriately mitigated. (Duck. 2006)

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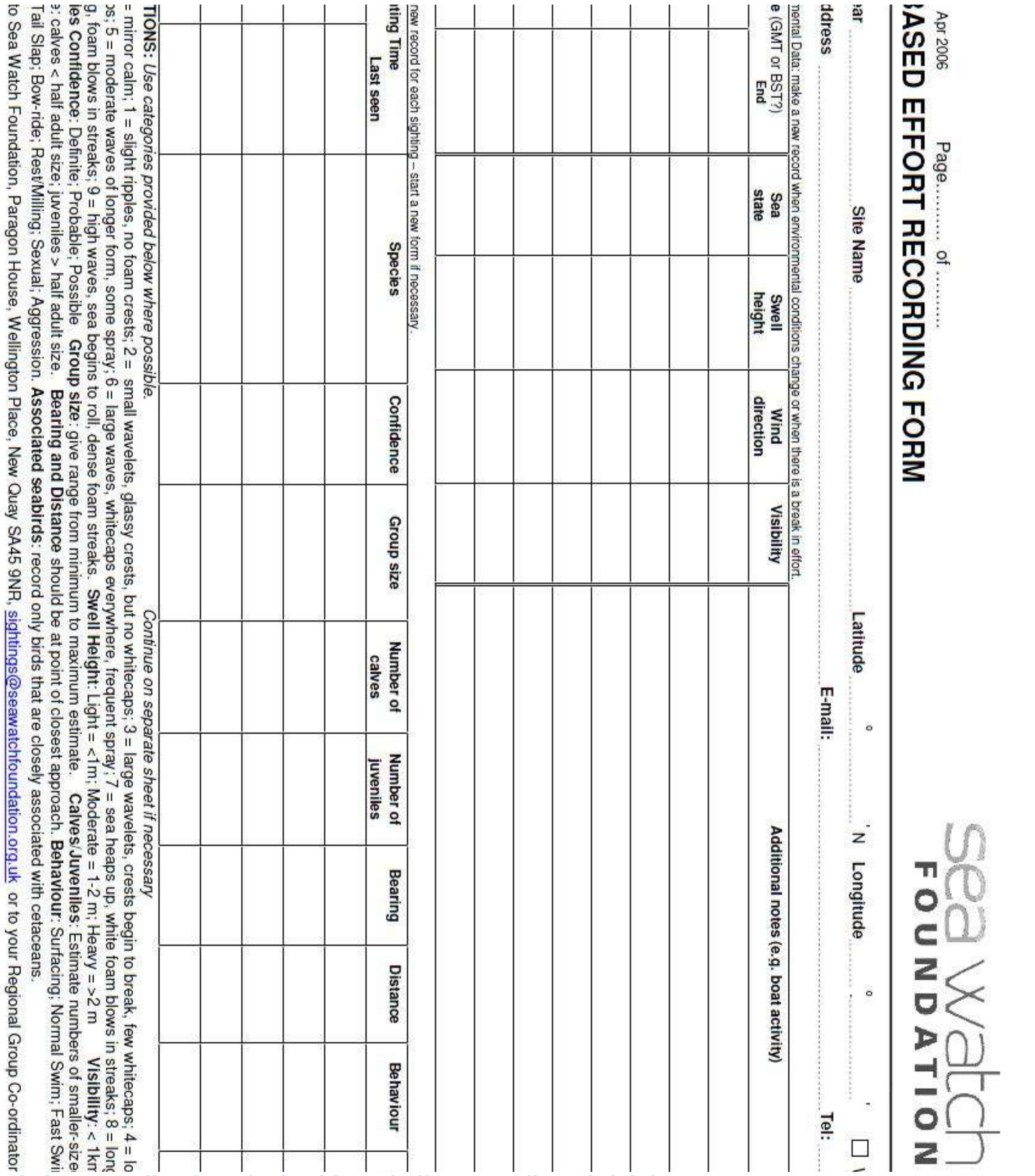
10. Appendix:



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ASED EFFORT RECORDING FORM

ar .... Site Name .... Latitude ° ' N Longitude ° ' ☐

ddress .... E-mail: .... Tel: ...

mental Data: make a new record when environmental conditions change or when there is a break in effort.

e (GMT or BST?)		Sea state	Swell height	Wind direction	Visibility	Additional notes (e.g. boat activity)
	End					

new record for each sighting – start a new form if necessary.

ting Time		Species	Confidence	Group size	Number of calves	Number of juveniles	Bearing	Distance	Behaviour
	Last seen								

Continue on separate sheet if necessary

TIONS: *Use categories provided below where possible.*
= mirror calm; 1 = slight ripples, no foam crests; 2 = small wavelets, glassy crests, but no whitecaps; 3 = large wavelets, crests begin to break, few whitecaps; 4 = lo
es; 5 = moderate waves of longer form, some spray; 6 = large waves, whitecaps everywhere, frequent spray; 7 = sea heaps up, white foam blows in streaks; 8 = long
g, foam blows in streaks; 9 = high waves, sea begins to roll, dense foam streaks. **Swell Height**: Light = <1m; Moderate = 1-2 m; Heavy = >2 m **Visibility**: < 1km
ies Confidence: Definite; Probable; Possible **Group size**: give range from minimum to maximum estimate. **Calves/Juveniles**: Estimate numbers of smaller-size
s: calves < half adult size; juveniles > half adult size. **Bearing and Distance** should be at point of closest approach. **Behaviour**: Surfacing; Normal Swim; Fast Swi
Tail Slap; Bow-ride; Rest/Milling; Sexual; Aggression. **Associated seabirds**: record only birds that are closely associated with cetaceans.
to Sea Watch Foundation, Paragon House, Wellington Place, New Quay SA45 9NR, sightings@seawatchfoundation.org.uk or to your Regional Group Co-ordinator

Figure 23 - Sea Watch Foundation recording form for land-based effort recording of sightings

Appendix 2.

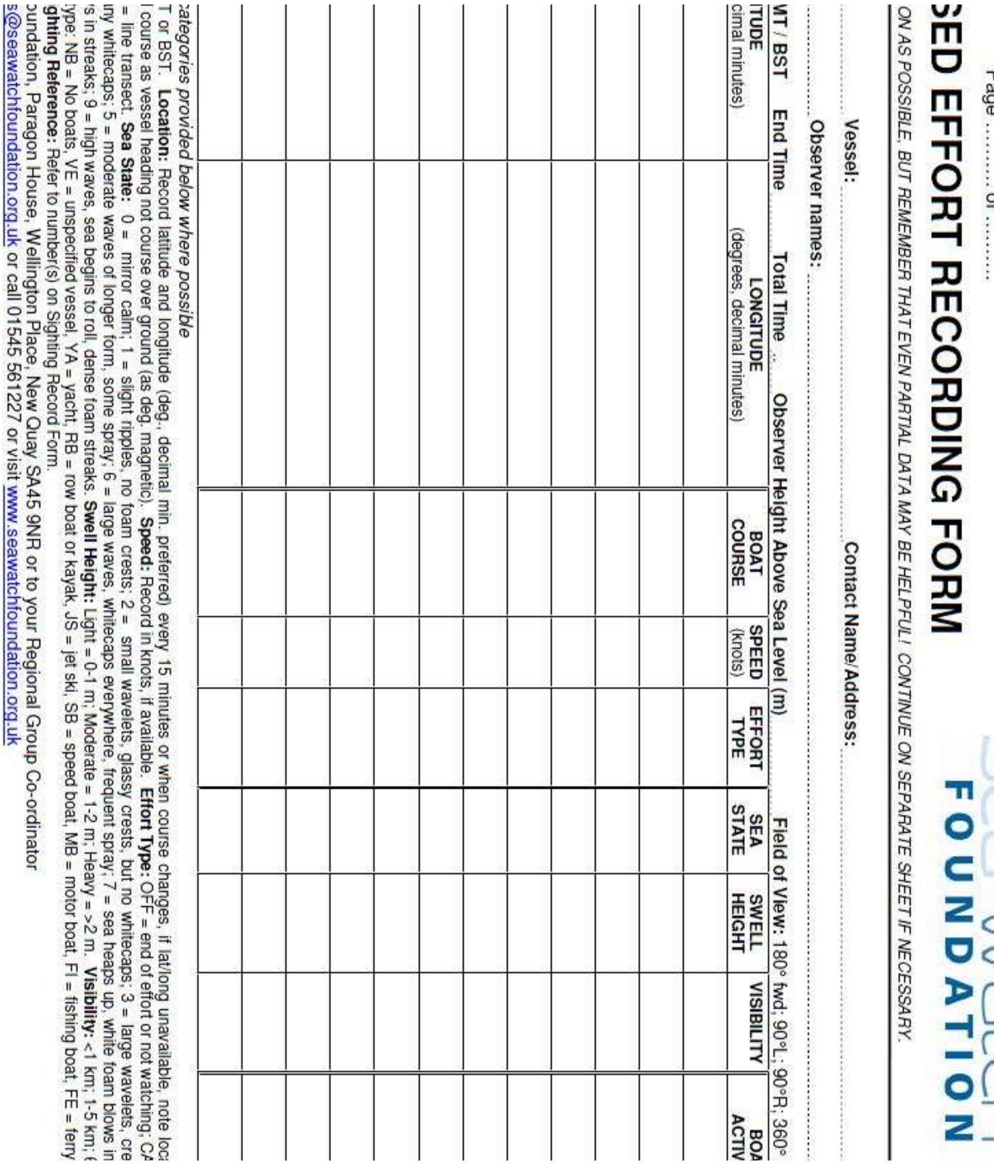

Figure 24 -Sea Watch Foundation recording form for vessel- based effort recording of sightings

Appendix 3.

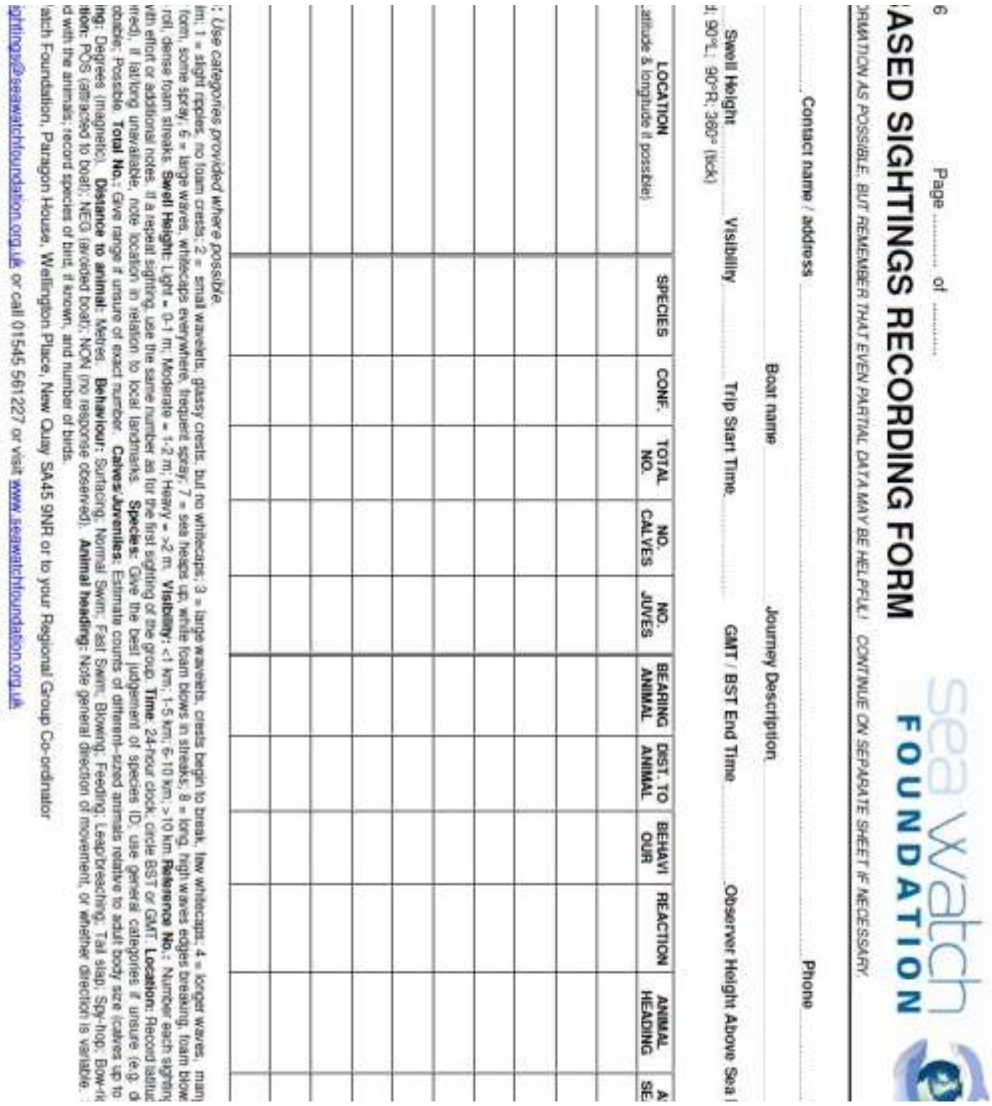

Figure 25 -Sea Watch Foundation recording form for Vessel- based sightings recording form

Appendix 4.

List of all species detected by T-POD and C-POD (Chelonia Ltd. 2012). .

- Atlantic hump-backed Dolphins, *Sousa teuszii*
- Atlantic white-beaked dolphin, *Lagenorhynchus albirostris*
- Atlantic white-sided dolphin, *Lagenorhynchus acutus*
- Australian snubfin dolphin, *Orcaella heinsohni*
- Beluga, *Delphinapterus leucas*
- Boto, *Inia geoffrensis*
- Bottlenose dolphin, *Tursiops truncatus and Tursiops aduncus*
- Burmeister's dolphin, *Phocoena spinipinnis*

- Commerson's dolphin, *Cephalorhynchus commersonii*
- Common dolphin, *Delphinus delphis*
- Cuvier's beaked whale, *Ziphius cavirostris*
- False Killer whale, *Pseudorca crassidens*
- Guiana dolphin, *Sotalia guianensis*
- Harbour porpoise, *Phocoena phocoena*
- Heaviside's dolphin, *Cephalorhynchus heavisidii*
- Indo-Pacific humpback dolphin, *Sousa chinensis*
- Short-finned pilot whale, *Globicephala macrorhynchus*
- Long-finned pilot whale, *Globicephala mel*as
- Maui dolphin, *Cephalorhynchus hectori maui* (subspecies of Hector's dolphin)
- Orca, *Orcinus orca*
- Peale's dolphin, *Lagenorhynchus australis*
- Risso's dolphin, *Grampus griseus*
- Short-finned pilot whale, *Globicephala macr*orhynchus
- Susu, *Platanista gangetica*
- Tucuxi, *Sotalia fluviatilis*
- Vaquita, *Phocoena sinus*