Collaborative field study programme

Task 3.3.1 of WP3 from the MERiFIC Project

A report prepared as part of the MERiFIC Project
"Marine Energy in Far Peripheral and Island Communities"

February 2014

Written by
Chloé Sotta
Parc Naturel Marin d'Iroise (Iroise Marine Park)
chloe.sotta@aires-marines.fr

With contributions from
Matthew Witt
University of Exeter
M.J.Witt@exeter.ac.uk

Philippe Le Niliot
Parc Naturel Marin d'Iroise
philippe.leniliot@aires-marines.fr

European Regional Development Fund
The European Union, investing in your future

Fonds européen de développement régional
L'union Européenne investit dans votre avenir

MERiFIC was selected under the European Cross-Border Cooperation Programme INTERREG IV A France (Channel) – England, co-funded by the ERDF.

# CONTENTS

## Purpose of the document

The MERiFIC project is part of the European programme INTERREG IVa, France (Channel) – England. This cross-border project brings together England, more specifically the county of Cornwall, and Brittany, specifically the *département* of Finistère. The purpose of MERiFIC, which stands for "marine energy in far peripheral and island communities", is to study the development of marine renewable energies (MREs). Through various issues governing their development:

- Energy potential,
- Impact on biodiversity,
- Support from public policy and regulatory frameworks,
- Economic development strategies,
- Social acceptability and the involvement of civil society,

MERiFIC aims to prepare for the arrival of this new industrial segment and develop decision-making support tools specific to far peripheral and island communities, which are typical of Cornwall, with the Isles of Scilly, and Finistère with the islands in Parc Naturel Marin d'Iroise.

Parc Naturel Marin d'Iroise is particularly involved in the MERiFIC project in relation to the issues of environmental assessments and environmental impacts. This document is the result of work package 3 within the project: "Technological support". This work package covers all the issues relating to the assessment of energy resources (waves and currents), anchoring techniques for surface wave energy equipment, the assessment of biodiversity and environmental impact studies. The sub-theme, covered here, is "transfer and development of skills on environmental assessment" with a view to a better selection of biodiversity assessment methods.

This document has been produced further to three workshops, under titles 3.3.4a and 3.3.4b within the project, during which the partners involved had an opportunity to present their environmental assessment work. The purpose was to talk about the methods and tools used and to discuss the results, in order to share know-how and develop shared skills on either side of the Channel.

Three themes were considered during these workshops:
- Analysis of the use of the space by grey seals,
- Studying of noise and its impact on the environment, focusing on the study of small cetaceans (particularly the harbour porpoise – *Phocoena phocoena* – and the common bottlenose dolphin – *Tursiops truncatus*),
- Mapping and monitoring of marine habitats.

For further information, all the presentations are available on the project website (www.merific.eu). The first theme, grey seals, was the subject of an information gathering and discussion exercise in document 3.3.2 "Marine biodiversity and habitat surveys" produced by the University of Exeter.

In this document, we have decided to concentrate on the theme of noise and its impact on small cetaceans (dolphins in particular). Acoustic research is becoming more and more widely used. It is a relatively recent addition to the environmental field, and there are still many uncertainties around it when it comes to choosing means and methods. This document takes stock of these activities and concludes by establishing a shared work programme that includes methods of assessment for the presence and distribution of marine mammals.

## INTRODUCTION

Due to the similarity of their biogeographical characteristics, the seas of Cornwall and Finistère report similar problems with the assessment of biodiversity and its vulnerability.

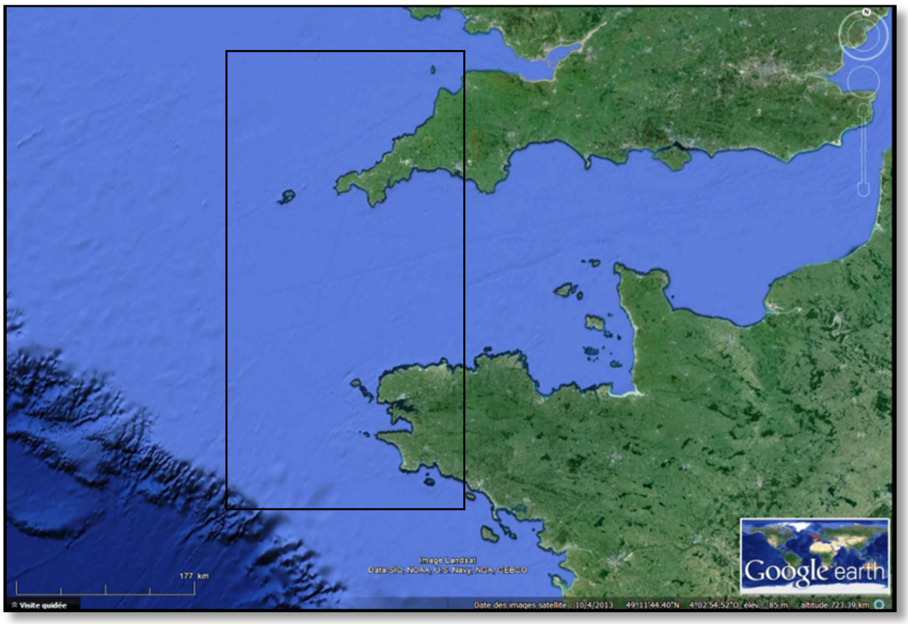


*Figure 1: MERiFIC project study zone*
*Source: Google Earth*

The bathymetric characteristics of these geographical areas, such as plateau ruptures and slopes, shallow ridges, seamounts and island chains, combined with strong tidal currents (Schwing *et al.*, 1991; Strub *et al.*, 1991 in Squires *et al.*, 2012), make them sites with high levels of marine productivity. Consequently, they are focal points for large populations of iconic undersea species such as dolphins and other cetaceans.

The areas of Cornwall and Finistère are governed by the same European directives on environmental protection and monitoring, and through the MERiFIC project, they have had the opportunity to work together and join forces in order to exchange skills around shared issues.

According to the strategy for biodiversity in the European Union, the installation of MRE equipment must take into account Natura 2000 sites and must not detract from the objectives set by these directives. SPAs (Special Protection Areas) and SACs (Special Areas of Conservation), established by the Birds Directive (79/409/EEC, 1979), and the Habitats Directive (92/43/EEC, 1992), form a network of natural sites on land and at sea, also known as the Natura 2000 network, designated due to the rarity and fragility of the wild animal and plant species and their habitats.

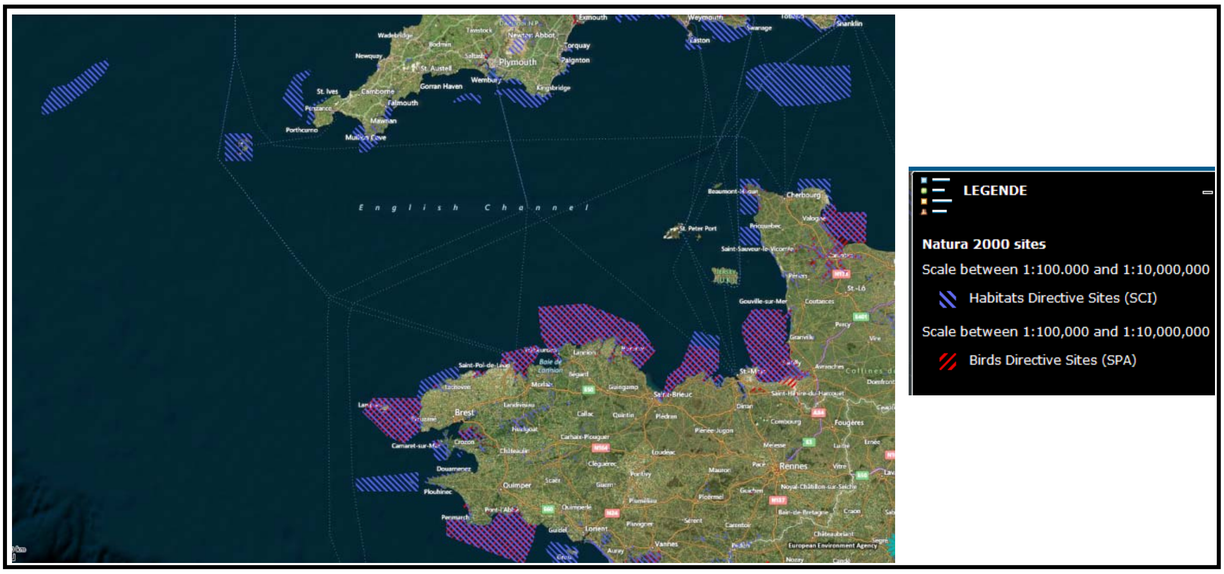


*Figure 2: The Natura 2000 sites in the France (Channel) – England area*
*Source: [http://natura2000.eea.europa.eu/#](http://natura2000.eea.europa.eu/#)*

Project backers therefore have an obligation to assess the impact of their project when it is located in or near a Natura 2000 area.

On the other hand, under the Marine Strategy Framework Directive (MSFD – 2008/56/EC), which promotes the sustainable use of the seas and the conservation of marine ecosystems, Member States have an obligation to constantly ensure the protection and conservation of the marine environment and to avoid its deterioration in order to achieve “good environmental status” by 2021 at the latest. “Good environmental status” is determined based on 11 descriptors (French Decree of 17 December 2012 defining good environmental status of marine waters). Descriptor 11 concerns “the introduction of energy, including underwater noise sources”, indicating that these “must be carried out at noise levels which do not harm the marine environment” and that “good environmental status” is achieved when:

- The acoustic detection and communication capabilities of large cetaceans are not altered by anthropogenic noise disruptions;
- The presence of species sensitive to noise disruptions in the functional ecological areas is preserved;
- Accidental excess mortality directly or indirectly due to anthropogenic noise disruption is marginal.

Finally, this descriptor is broken down into two criteria: the distribution in time and place of loud, low and mid frequency impulsive sounds; and continuous low-frequency sounds.

Environmental assessments make it possible to acquire new knowledge of habitats and species, locate them more precisely and identify them, in order to forestall the risks of alteration that any human development project could bring with it. In this way, the selection of sites for installation of MREs can be facilitated while avoiding fragile habitats and species at the same time as protecting important habitats and species.

Cetaceans benefit from multiple protected statuses. As these are iconic species experiencing a global decline, their protection has become a priority for Europe. The most common species in the coastal waters of France and the United Kingdom are the harbour porpoise (*Phocoena phocoena*), the common bottlenose dolphin (*Tursiops truncatus*) and the short-beaked common dolphin (*Delphinus delphis*), with other species observed more infrequently such as the white-beaked dolphin (*Lagenorhynchus albirostris*), the Atlantic white-sided dolphin (*Lagenorhynchus acutus*), Risso's dolphin (*Grampus griseus*) and the long-finned pilot whale (*Globicephala melas*).

The behaviour and use of the area by cetaceans vary considerably depending on their reproductive status, the availability of prey, the cycles of day and night, the tides and the seasons, and many other variables. One emerging concept for the study of these species is passive acoustics, which consists of measuring and analysing the sounds produced in a given environment.

The discovery of passive acoustics to better understand marine environments has revealed the environment's sensitivity to anthropogenic noise emissions. More and more data suggest that noise can have harmful effects on a whole range of marine taxa, particularly marine mammals.

Marine mammals use sound waves in a very complex way, and sound waves are vitally important to them for communication and also to evaluate the environment where they move, feed and reproduce.

It has been proven in numerous cases that noise emissions of artificial origin have an effect on the behaviour and even on the physical condition of marine mammals (Lurton *et al.,* 2007). There are different types of reactions to noise emissions depending on the species affected, the intensity of the noise and its duration. Anthropogenic noise causes responses with varying levels of severity in cetaceans, from very varied and sometimes imperceptible behavioural reactions to more severe effects concerning activity on a major site or physical traumas (Richardson *et al*., 2005, Southall *et al.*, 2007; Clark *et al*., 2009).

Richardson *et al.* (1995) define four zones of noise influence depending on the distance between the source and the receiver:

- The <u>zone of audibility</u>, defined as the zone in which the animal can detect the sound.
- The <u>zone of masking</u>, defined as the zone in which the noise is loud enough to interfere with the detection of other sounds such as communication signals or echolocation clicks. This is generally smaller than the zone of audibility. Masking becomes significant when the noise level of the masking sound reaches the same level as the ambient noise in the frequency of the signal.
- The <u>zone of responsiveness</u> is the region in which the animal reacts behaviourally and physiologically. The behavioural reactions are very varied, from those that are sometimes imperceptible (starting, changing direction, etc.), to more radical disruptions affecting key survival factors (temporary or permanent abandonment of an area, problems feeding, problems with reproduction, etc.).
- The <u>zone of hearing loss</u> is the zone near the source of the noise where the noise level received is high enough to cause tissue damage leading to hearing threshold shifts. These can mean temporary or permanent hearing loss.

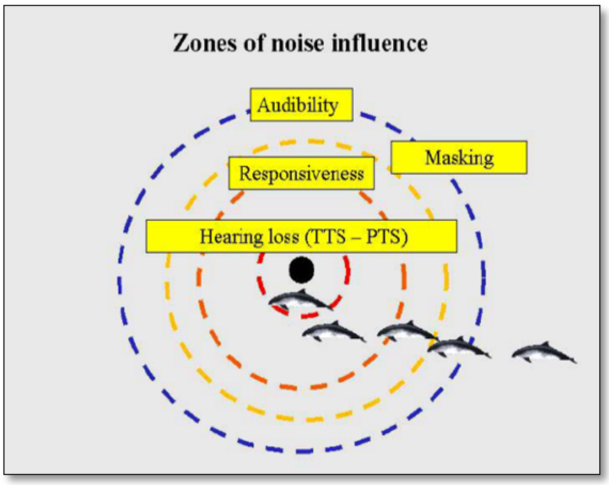


*Figure 3: Zones of noise influence (from Richardson et al., 1995)*
*Source: Thomsen et al. (2006)*

The effects of noise can be:
- Simple hearing, with no particular disturbance
- Disruption translating into a behavioural reaction (starting)
- Population displacement (temporary or permanent)
- Masking of communication and navigation sounds
- Temporary hearing loss
- Permanent hearing loss
- Causing injuries such as tearing of the auditory tissue, which can cause the death of the animal.

These effects depend, on one hand, on the auditory and behavioural sensitivity of each species, and, on the other, on the distance from the source of the noise emission as well as on the site itself – whether or not it propagates the sound wave more rapidly.

At present, we do not fully understand the influence of noise generated by human activities, and more specifically by MREs, on small cetacean species, whether resident or migratory. In order to avoid anthropogenic noise sources interfering with the movement of small cetaceans towards important sites for their development, we need to know more about and quantify the species present.

Thanks to passive acoustic techniques, we will see how to assess the populations present around our coasts and how to study the influence of noise in the environment on populations of small cetaceans, particularly the harbour porpoise (*Phocoena phocoena*) and the common bottlenose dolphin (*Tursiops truncatus*). By comparing different techniques used on either side of the Channel as part of the MERiFIC project, we will attempt to develop a collaborative working scenario in order to optimise research in this field within the western English Channel area covered by the MERiFIC project.

## 1. Study of small cetaceans using passive acoustic techniques

The sensory environment of marine mammals is essentially acoustic. This sense is primarily used for three functions: providing information on their environment, communicating and detecting prey (David, 2006).

They emit a considerable number of sounds, such as bray calls when feeding, whistles for reunions, echolocation clicks for foraging and orientation, burst pulses to indicate emotionality, and low-frequency sounds in social interactions.

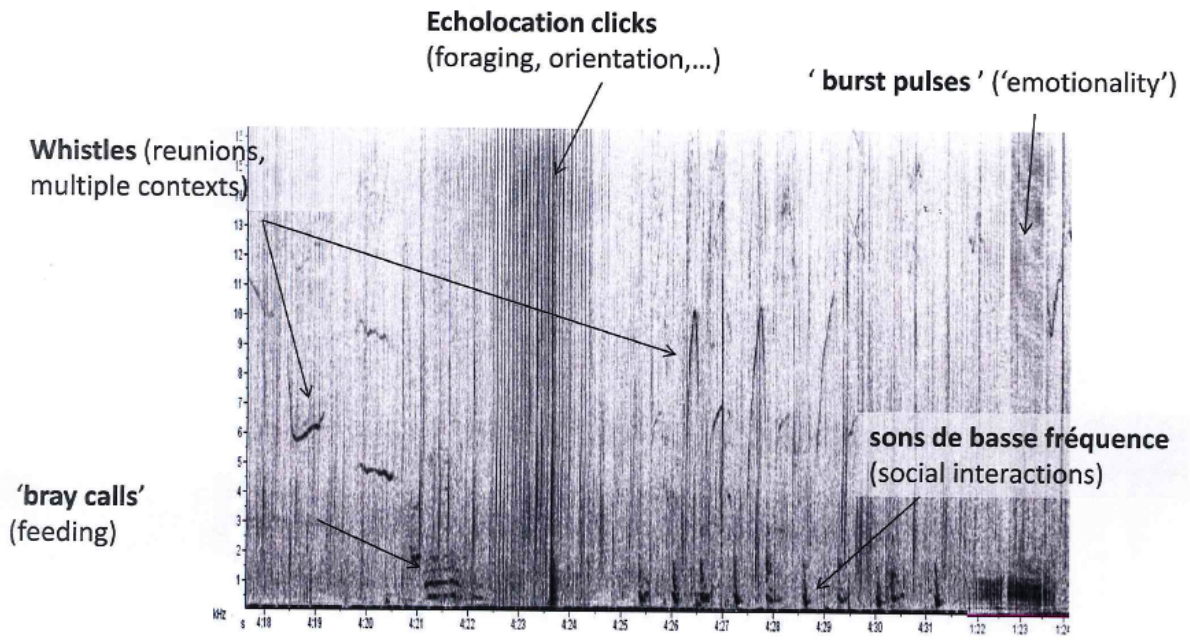


*Figure 4: The various sounds emitted by dolphins, and their appearance on an audiogram*
*Source: Di Iorio et al., 2012*

Passive acoustic monitoring is a technique increasingly used to study the presence of cetaceans, their behaviour and the use of their habitats.

In this document, we distinguish between three main methods of listening to small cetaceans: AURAL hydrophones (*Multi-Électronique (MTE) Inc.)*, C-POD detectors (*Chelonia Ltd*) and AMAR recorders (*AMAR; Jasco Applied Sciences Ltd*).

AURAL systems record sounds with a wide range of frequencies, meaning that they record all sounds received indiscriminately, so the information obtained is unprocessed and requires the production of algorithms to extract specific information.

Conversely, C-POD detectors provide calibrated information based on a built-in algorithm. This algorithm only counts echolocation clicks from animals, emitted at a high frequency. By digitally identifying the form of the emitted wave, the C-POD can record the moment when the click was emitted, its sound pressure level, its duration and its bandwidth. The C-POD then renders the information as the number of clicks recorded. The C-POD, and its previous version the T-POD, has been used widely for ten years or so in Europe (Mellinger *et al*., 2007), for acoustic monitoring of harbour porpoises in relation to issues connected to conservation and the designation of Natura 2000 zones, but also as part of impact studies for renewable energy park projects (e.g. Verfuss *et al*., 2007, Tollit *et al*., 2011 in Samaran *et al.*, 2011).

Further information on AMAR recorders

### 1.1) The AcDau project in Parc Naturel Marin d'Iroise

In Parc Naturel Marin d'Iroise, the purpose of the **AcDau** (Acoustique Dauphins – Dolphin Acoustics) project is to study the potential of passive acoustics for monitoring the resident population of common bottlenose dolphins (*Tursiops truncatus*) in the Molène archipelago and their interactions with nautical activities. The project used AURAL recorders.

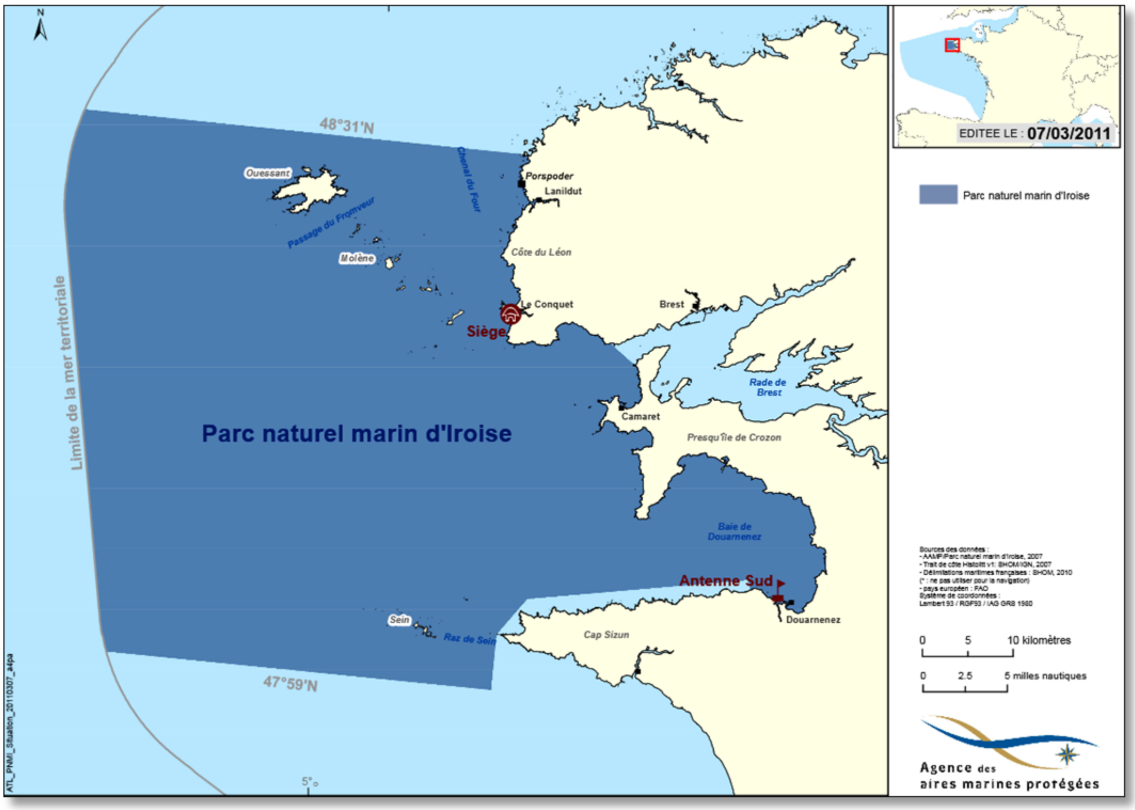


*Figure 5: Location of Parc Naturel Marin d'Iroise, at the tip of Brittany*
*Source: Agence des Aires Marines Protégées [French Marine Protected Areas Agency] (www.cartographie.aires-marines.fr)*

#### *a. Introduction*

This project took place in 2010 and 2011 and was funded in part by the MERiFIC project. Several types of work were carried out, including developing and testing instrumentation, collecting measurements, data processing and analysis, and finally presentation and circulation of the findings.

The Molène archipelago at the tip of Finistère consists of nine islands, only two of which are inhabited. The archipelago is located a minimum of 2.5 nautical miles from the coast (distance from

Béniguet to Le Conquet). Three positions around the island of Béniguet were equipped with autonomous sound recorders capable of detecting the whistles of common bottlenose dolphins (*Tursiops truncatus*) and the noise emitted by small boats.  The recordings were made over a period of six months (June 2011 to November 2011). The average detection radius around the hydrophones is around 350 metres, although this varies depending on what is being listened for (relationship between the wavelengths emitted and the reception areas).

*Photo 1: Placing of an AURAL hydrophone in Parc Naturel Marin d'Iroise*
*Source: Parc Naturel Marin d'Iroise ©Yannis Turpin*

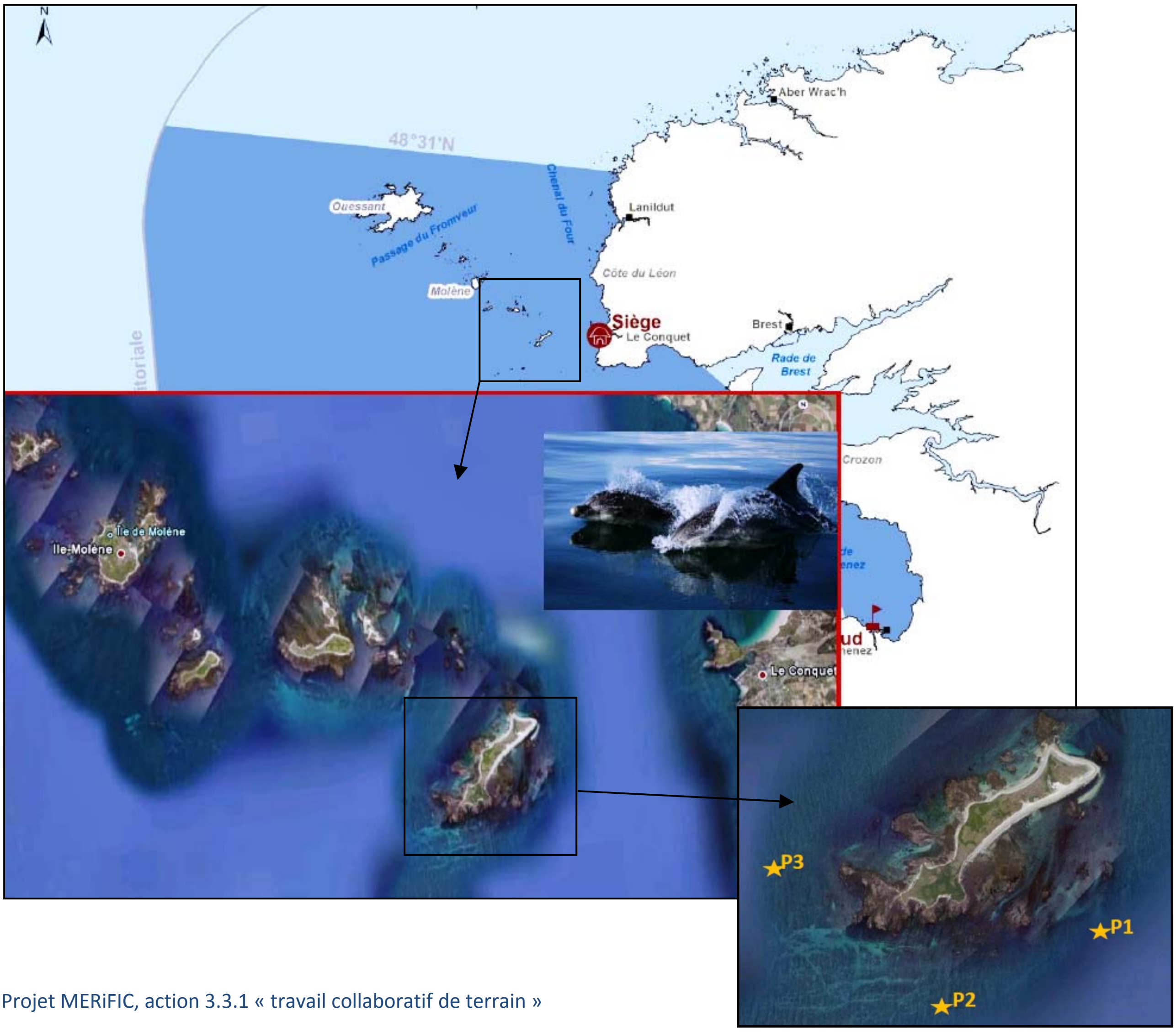

Figure 6: Location of the island of Béniguet in the Molène archipelago and the three hydrophones around the island of Béniguet
Source: Lucia Di Iorio, presentation at MERiFIC workshop 3.3.4a, Le Conquet, May 2012. Montage, Chloé Sotta

b. ***Results***

The acoustic activity of the resident population of common bottlenosed dolphins (*Tursiops truncatus*) presented significant seasonal variability over the six months of recording: more emissions were detected in August and September (with 46% of emissions received in August alone).

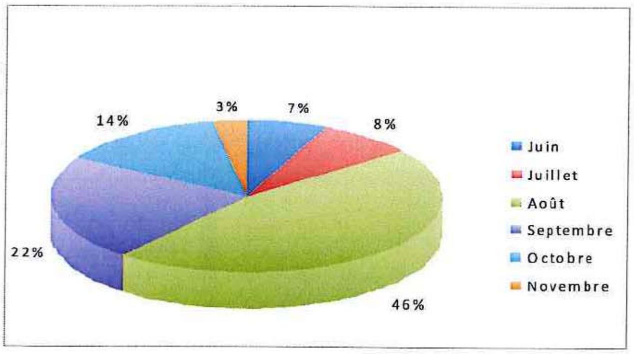


*Figure 7: Distribution of noise emissions per month during the AcDau survey, all sites combined; the differences observed were statistically significant*
*Source: Gervaise et al., 2012*

On the other hand, 46% of the emissions took place during the period between 06:00 and 12:00, strongly placing the animals' activity in the circadian cycle, with them generally emitting noise two to three times more during the day than at night.

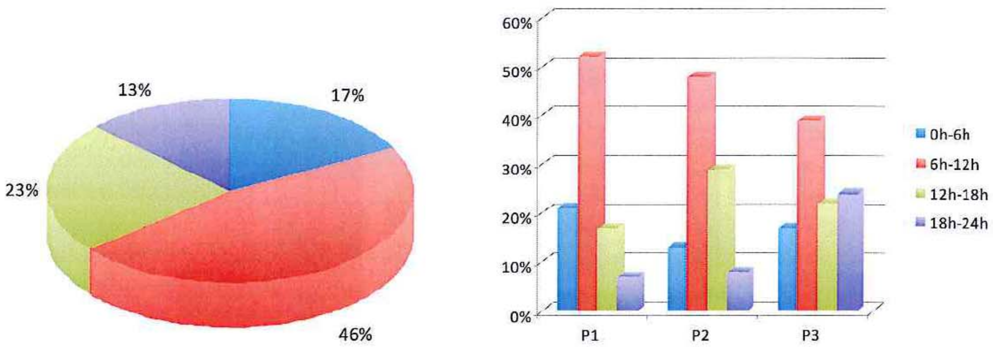


*Figure 8: Distribution of noise detected, based on its position in the circadian cycle; the difference was statistically significant*
*Source: Gervaise et al., 2012*

However, the types of calls emitted by the dolphins differed significantly depending on the site and most importantly the season, with very marked differences between the beginning (June) and the end (October/November) of the summer season. These differences are probably connected to changes in behaviour or context (social groups) and therefore varying functional use of the archipelago. To better describe this functional use, acoustics need to be combined with other methods of observation (identification photos and biopsies) and a sound recorder must be selected that can measure clicks emitted by common bottlenose dolphins.

Regarding surface motorboat activity, the AcDau study did not look at the impact of human activity on common bottlenose dolphins. Its very limited aim was to provide preliminary data for such a study by describing the events when dolphins and boats were present simultaneously. However, the noise levels measured by AcDau should make it possible to determine the probability of producing a physiological impact on the hearing system of common bottlenose dolphins (*Tursiops truncatus*) (Southall *et al.*, 2007, Gervaise *et al.*, 2012), and to study the extent to which dolphin calls are masked (Gervaise *et al.*, 2012).

The figures below show the distribution in space and time of these encounters between dolphins and ships. There were more encounters at P1 (58%) and during the months of July, August and September.

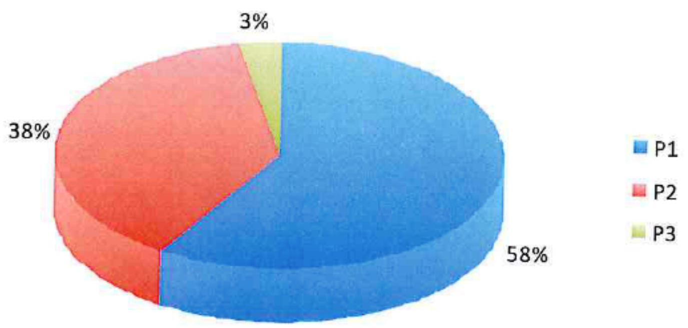


*Figure 9: Distribution of dolphin/ship encounters between sites during the six months of the survey*
*Source: Gervaise et al., 2012*

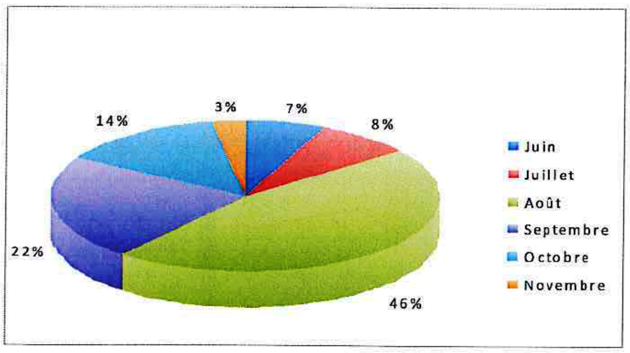


*Figure 10: Distribution of noise emissions per month, with all sites combined*
*Source: Gervaise et al., 2012*

There were therefore more dolphin/ship encounters during the summer months and on the eastern site near Chenal du Four, the channel through which coastal ships pass.

Activities further away were also heard, with activity detected in Brest and the ports that give onto Chenal du Four (Le Conquet, Lanildut), which, over time, allows us to tackle the notion of cumulative impact and to plan works that will have noise influence so as to reduce their effect on the environment. Knowledge of the spatio-temporal presence and variability of the dolphins and boats may also make it possible to establish "sensitive" zones and periods during which access and works are restricted and/or controlled, in order to limit disturbance of the animals or complete blanketing of their emissions.

### *c. Conclusion*

This study made it possible to describe succinctly the spatial and temporal occupation of the Molène archipelago around the island of Béniguet by the permanent group of common bottlenose dolphins (*Tursiops truncatus*). This type of information indicates periods of greater or lesser acoustic activity of both biological and human origin.

The advantage of an AURAL system's detection, with a wide range of frequencies recorded, is that the noise activities of common bottlenose dolphins (*Tursiops truncatus*) can be studied at the same time as anthropogenic noise activities on the study site.

Setting up a study of this type over a longer period, supplemented by additional observations, would make it possible over time to identify behaviours and key periods of use of the space (depending on the day/night cycle, the tides, etc.). This would therefore assist with any planning of projects with an impact.

The inclusive nature of passive acoustics makes it possible to provide time series describing both biological and human activity, based on a single measurement process and with the same time basis, and to use the same statistical tools for analysis and post-processing.

However, analysing the sound tapes of AURAL hydrophones requires the development of processing algorithms to extrapolate ambient sounds. Ambient noise has two characteristic components: natural components (biotic and abiotic) and human components (noise of maritime traffic further offshore, for example). On the sound tape, this translates into two types of noise: background noises (stationary) and temporary impulsive sounds (mobile). Post-processing of the recorded data is therefore more time-consuming.

## 1.2) The use of C-PODs on the Isles of Scilly

On the Isles of Scilly, the University of Exeter has carried out a project to characterise the activity of dolphins and harbour porpoises (*Phocoena phocoena*) by placing C-PODs.

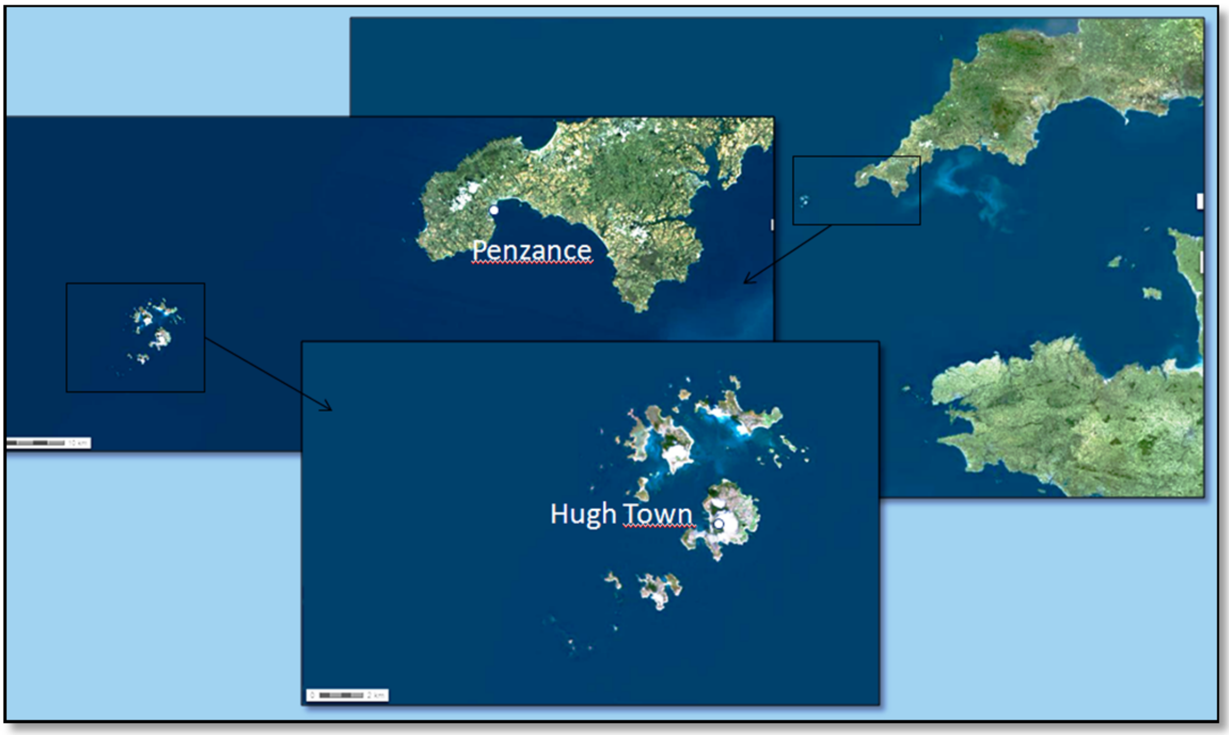


*Figure 11: The Isles of Scilly, off the tip of Cornwall*
*Source: geoportail.gouv.fr, montage C. Sotta*

### *a. Introduction*

Located off the tip of Cornwall, the Isles of Scilly form an archipelago of five main islands around 35 nautical miles from the coast (distance from Penzance to Hugh Town). This study by the University of Exeter received MERiFIC funding to assess the activity of small cetaceans in the archipelago using C-PODs.

As a reminder, C-PODs record the high-frequency clicks of small cetaceans (dolphins and porpoises). A C-POD can record the presence of a porpoise within a radius of 300 metres, with a 100% detection rate if the animal is located within a radius of less than 100 metres (Tougaard *et al.*, 2006 in Samaran *et al.*, 2011). It detects the presence of other dolphins within an average radius of 1,000 metres. It is important to note that C-PODs differentiate between porpoises and dolphins, but not between different species of dolphin.

The C-PODs were deployed in October 2011 at three different sites in the archipelago: the Annet site in the south of the archipelago, the Castle Bryher site in the north-west and the Great Ganilly site in the north-east. The Annet C-POD recorded 98 days of data, the Castle Bryher C-POD 204 days, and the Great Ganilly C-POD 146 days.

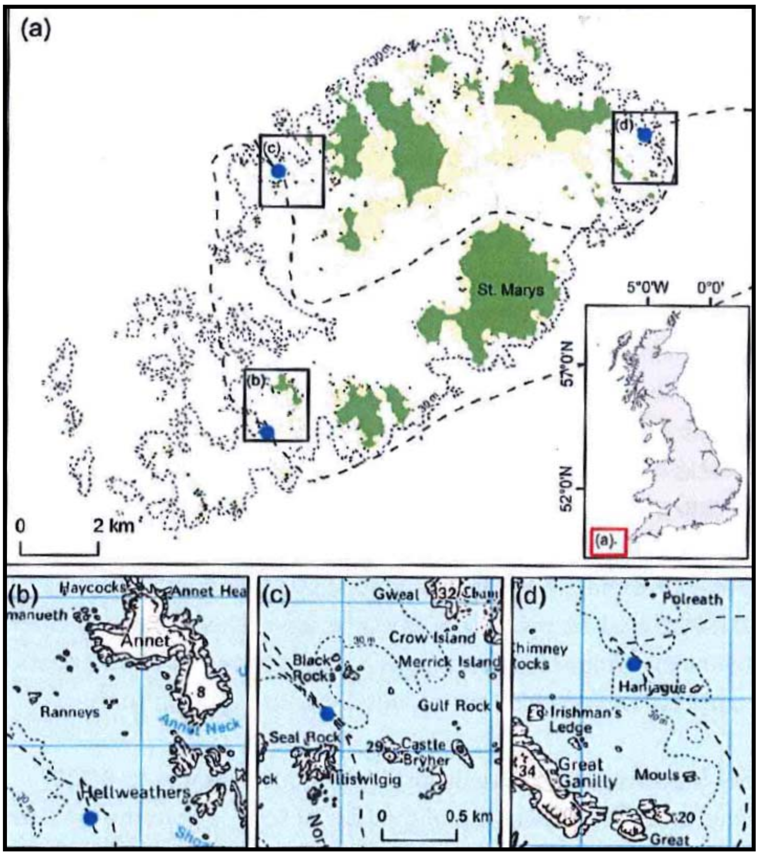


*Figure 12: Location of the three C-PODs in the Isles of Scilly, (b) = Annet site, (c) = Castle Bryher site and (d) = Great Ganilly site.*
*Source: Witt et al (2013)*

### *b. Results*

Most of the clicks detected by all the C-PODs came from harbour porpoises (*Phocoena phocoena*).

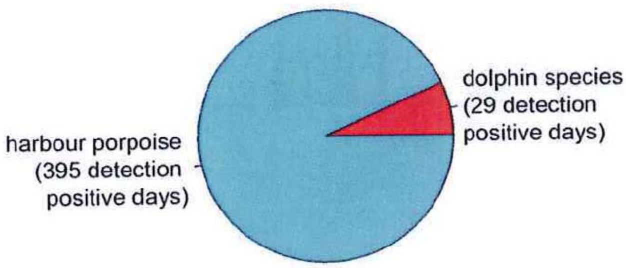


*Figure 13: Proportion of harbour porpoises (*Phocoena phocoena*) and dolphins (all species combined) detected on all the C-PODs.*
*Source: Witt et al. (2013)*

There were also strong variations in the detection levels between the sites. The Annet site, which recorded the highest average daily time (12 minutes), had the highest detection rate on average per day. However, the Castle Bryher site detected the highest number of clicks but with an inconsistent chronological series. The Great Ganilly site recorded the greatest number of consistent chronological series with the greatest total number of cumulative detections.

There is an increase in the daily detection rate on the Castle Bryher and Great Ganilly sites from October to February, declining from March to April at Castle Bryher. Conversely, at Annet, the daily detection rate decreases from October to January. Data are not available for the Annet site from February to March. This may reflect a change in the usage of the various habitats in the archipelago. However, this may also be due to the exposure of the sites; the Annet site is open to the south-west and is therefore more vulnerable to storms, whereas the Castle Bryher and Great Ganilly sites benefit from a certain amount of protection thanks to the rocky reefs and small island chains of the archipelago.

It will also be noted that the models of distribution between the north and south of mainland Cornwall detected by the C-PODs during previous studies are the same as those observed visually (Pikesley *et al*., 2012).

#### *c. Conclusion*

The bathymetric conditions of this type of island system, in shallow waters with multiple reefs, with the addition of major hydrodynamic conditions due to tidal phenomena, make the choice of deployment locations for C-PODs difficult. Knowledge of the area must therefore be increased first of all in order to install the hydrophones in strategic locations where they will not suffer from the environmental conditions and where their detection capacity will be maximised.

Although the study took place over a relatively short period, seasonal and spatial trends emerged corresponding to those observed around mainland Cornwall.

In view of the sensitivity of the Isles of Scilly sites, which have multiple environmental protections (SSSIs, SACs, etc.), the impact-free monitoring method used in this study appears to be very useful in order to map zones frequently visited by small cetaceans. On the other hand, due to the remoteness and the often limiting environmental and meteorological conditions, traditional monitoring methods (visual observations, photo identification, etc.) cannot be applied regularly. Passive acoustic monitoring methods, however, make it possible to monitor a zone during stormy periods. Nonetheless, it would be good to have vessels on the spot in order to regularly check the condition of the C-PODs and to make additional visual observations.

### 1.3) The use of the coastal waters of the island of Lundy by marine mammals

This study was carried out as part of a project to install an offshore wind farm. The University of Plymouth undertook the study to provide a set of basic data on the use of the waters around the island of Lundy by the *Delphinidae* family and harbour porpoises (*Phocoena phocoena*) using C-POD passive acoustic technology. As a reminder, C-PODs do not draw a distinction between species of dolphins, but distinguish porpoise clicks from dolphin clicks.

*Figure 14: The island of Lundy in Bristol Channel*
*Source: geoportail.gouv.fr, montage C. Sotta*

### *a. Introduction*

The Atlantic Array is an offshore wind farm project for power of around 1.2 GW (one of the largest in the world). This site, proposed as part of the third round of wind farm developments in the United Kingdom, is located about 9.6 nautical miles off the north coast of Devon at the mouth of the Bristol Channel, 7 nautical miles from Lundy. Lundy has multiple environmental protections (SSSI, SAC, MCZ) due to the diverse nature of its ecosystems.

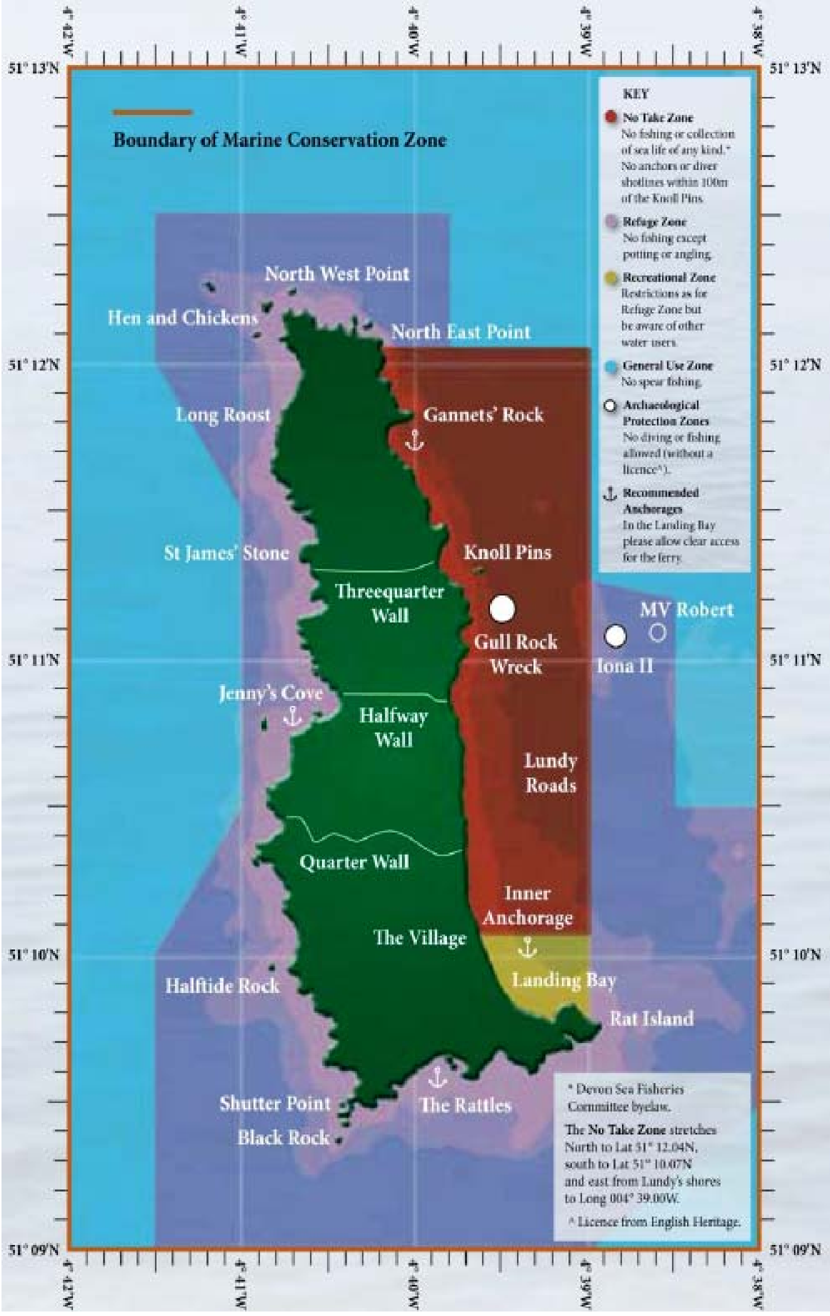


*Figure 15: Borders of the protection zones around Lundy, at the mouth of the Bristol Channel. Source: Simon Ingram, presentation at MERiFIC workshop 3.3.4a, Le Conquet, May 2012*

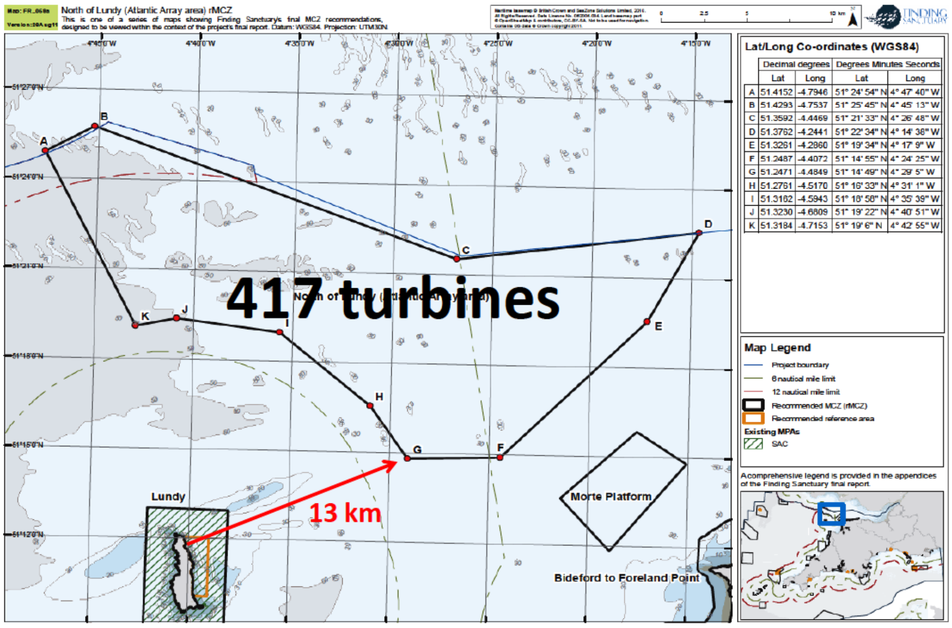


*Figure 16: Installation site of the Atlantic Array wind farm north-east of Lundy.*
*Source: RWE npower renewables, 2011 in Simon Ingram, presentation at the MERiFIC workshop 3.3.4a, Le Conquet, May 2012*

This study was based on two methods. One consisted of visually observing the zone from the coast, the other of deploying C-PODs.

Two C-PODs were deployed on shipwrecks, one to the east on the MV Robert (C-POD 1) and the other to the south of the island on the Ethel (C-POD 2).

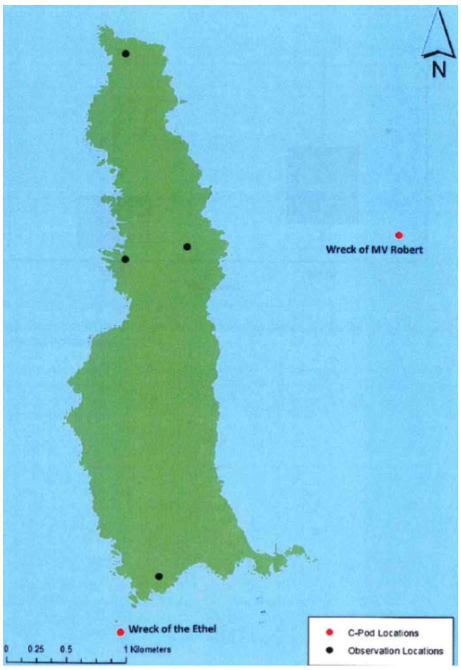


*Figure 17: Location of the observation points on land and C-PODs at sea.*
*Source: Simon Ingram, presentation at MERiFIC workshop 3.3.4a, Le Conquet, May 2012*

C-POD 1 was moored to the MV Robert less than one nautical mile from the coast, in weak tidal current conditions at a depth of between 22 and 28 metres. It was placed on 25 July 2011 and removed on 10 October 2011, i.e. 2.5 months of recording.
C-POD 2 (on the Ethel) was in a high current zone south of the island, moored at a depth of 25-30 metres. It was deployed on 30 July 2011 and removed on 14 May 2012, i.e. 9.5 months of recording.
They were in continuous operation, scanning constantly and similarly recording the water temperature.

For the moment, only the data from C-POD 1 have been extracted and analysed.
A joint data analysis was carried out on the land-based data acquired through visual observations and the underwater data acquired through passive acoustics. The data were correlated in order to highlight: 1) changes in vocal behaviour with the tides, day and night cycle and seasons, and 2) relationships between depth, behaviour and type of habitat during the summer period.

### *b. Results*

Dolphins and porpoises were significantly more active in August 2011 than in September or October 2011, on both sites. A study by Goold (2000) carried out in two consecutive years showed a significant drop in dolphin populations in the Celtic Sea in September and October. However, given the limited duration of the investigations undertaken in 2011 and 2012, it is impossible to identify seasonal activity models. Continuous data over long periods of several years are needed in order to draw any conclusions.

On the other hand, porpoises were significantly more active during strong ebb tidal currents at C-POD 2 south of the island. The same applied to the Robert site where porpoises were more active during ebb tides.

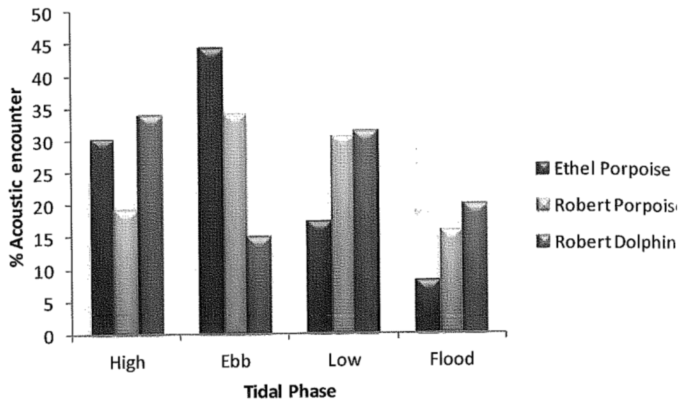


*Figure 18: Percentage of dolphin or porpoise encounters on the Ethel site (C-POD 2) and the Robert site (C-POD 1), during different phases of the tide.*
*Source: Simon Ingram, presentation at MERiFIC workshop 3.3.4a, Le Conquet, May 2012*

.

The data analysing the activity of porpoises according to the tidal cycle suggest that porpoises use these sites to feed when there are strong tidal currents. These observations confirm Pierpoint's observations in 2008.

It should be noted that the ambient noise detected by the C-POD in the highly turbulent south zone must have disrupted the recording of the clicks received, as the noise of the currents can cover echolocation clicks.

### *c. Conclusion*

This study demonstrates the added value of acoustic monitoring in zones with strong hydrodynamic conditions, over long periods and at all times, whereas observations from land are constrained by lack of visibility.

Given that data collection via C-PODs is independent of the environmental conditions, continued use of C-PODs can make an important contribution to understanding the behaviour of these animals. A larger number of C-PODs would make better calibration of each device possible and would optimise continuous detection. Data sets of this kind would, over time, make it possible to validate the hypotheses advanced.

## 2. Study of noise generated by human activity and MREs

The extraction of renewable energy from the seas is a rapidly growing activity. However, there is a lack of knowledge around the noise produced by this activity in each phase of deployment (installation, operation, maintenance, dismantling).

In the life cycle of an MRE park, the equipment installation phase probably causes the most disturbance. The noise generated by levelling (if necessary; this can require the use of explosives), the installation of foundations (particularly if these require pile driving), and the increase in maritime traffic due to the presence of maintenance ships, creates sound power that can intensely disturb some species. Although the heightened effects of the construction phase are temporary, in the case of multiple projects with installation on a much larger scale, the propagation of noise can have a major impact.

The operation phases do not generate as much noise as the installation phase, and can be supposed to cause less disturbance, broadly speaking. On the other hand, the dismantling phase still has many unknowns, since no farm has yet been dismantled.

### 2.1) Study of acoustic pressure on the FaBTest wave energy test site

Passive acoustic equipment was deployed in Falmouth Bay by the University of Exeter on the FaBTest wave energy test site, with a view to analysing the noise generated by the energy conversion mechanism.

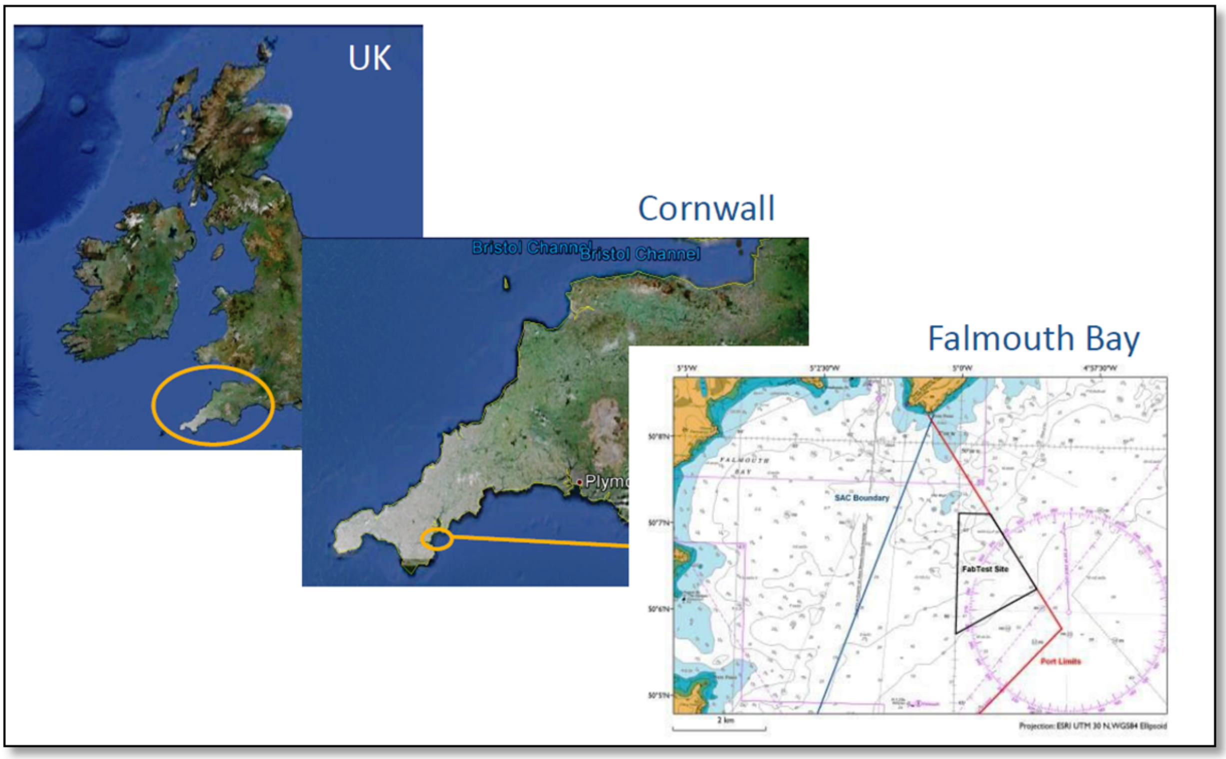


*Figure 19: Location of FaBTest in Cornwall*
*Source: Joanne Garrett, presentation at MERiFIC workshop 3.3.4b, Le Conquet, October 2013*

### *a. Introduction*

The FaBTest site, created in March 2012, is a wave energy test site located in Falmouth Bay in Cornwall. This relatively sheltered site allows developers to test their equipment before trialling it in more open zones. The site is located around 2 nautical miles from the coast, at a depth of 20-50 metres, and covers 2 km². The majority of the substrate is sedimentary (sand banks) and includes some sea grass beds and maerl banks, as well as very diverse fauna.

The site area is already a location for multiple noise-generating activities: commercial traffic, leisure activities (motor boats, sail boats, etc.).

The study took place during experiments to test a wave energy converter and was planned with four stages: establishment of a baseline condition, study while the device was being installed, study of the presence of the device when not in operation and study of the device in operation.

Two "AMAR" systems were deployed alternately in Falmouth Bay. AMAR stands for "Autonomous Multichannel Acoustic Recorders" (*AMAR Generation 2; Jasco Applied Sciences*). They were placed around 200 metres from the wave energy converter and recorded for 30 minutes every hour.

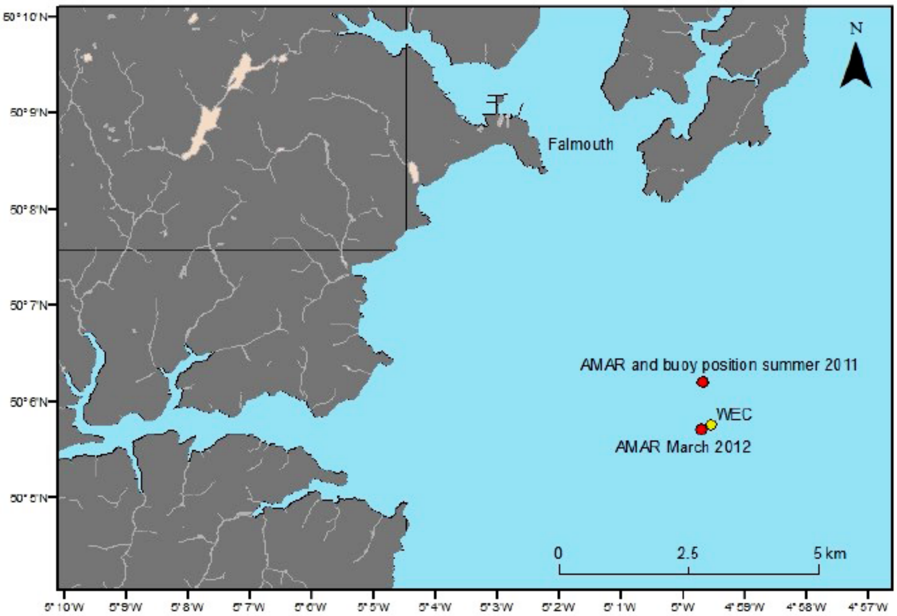


*Figure 20: Position of the two AMAR hydrophones around the wave energy device at the FaBTest site in Falmouth Bay*
*Source: Joanne Garrett, presentation at MERiFIC workshop 3.3.4b, Le Conquet, October 2013*

Different deployment methods were used for each AMAR: a "dome" configuration and a "floating collar method".
The "dome" consists of mooring the hydrophone to a steel frame embedded in a buoy with an opening for monitoring. The buoy serves as protection and the whole ensemble is ballasted and placed on the sea bed.

The floating collar method consists of equipping the hydrophone with a floating gripping collar that makes it possible to keep the hydrophone floating positively while anchored to the sea bed.


*Photo 2: AMAR with floating collar* *Photo 3: C-POD*

*Source: Joanne Garrett, presentation at MERiFIC workshop 3.3.4b, Le Conquet, October 2013*

The initial period, from 11 to 25 March 2012, consisted of establishing the baseline condition of the site. The second, from 26 to 30 March 2012, covered the installation of the wave energy device: placing of the anchorage chain, presence of installation boats, etc. Comparisons were made based on the same hydrodynamic conditions (wave height, current power, etc.) in order to minimise the differences in terms of ambient noise. Subsequently, operational phase monitoring with the system producing energy took place while the mechanical systems were active.

### *b. Results*

There was significant variability in noise levels during the baseline condition phase, particularly at low frequencies. To be completed
During the installation period, an increase in sound activity was noted. However, other noise emission sources may also be the source of the increase in the noise level, such as a temporary increase in maritime traffic. To be completed

During the operational phases, an increase in noise levels was observed compared to non-operational phases. However, during testing of the converter in Sweden, it was accepted that the sound produced by the device could be heard within a radius of 150 metres (Haikonen *et al.*, 2013). The hydrophone here was set up around 200 metres from the converter, so it is possible that the sounds emitted by the converter could not be detected by the hydrophone. However, given the frequencies detected, this remains unlikely. Bassett *et al.* (2011) found that the acoustic signature of a wave energy converter on a 1:7 scale could be detected up to 1.5 km away in the absence of other maritime activities. However, no acoustic signature from the converter was detected at FaBTest.

### *c. Conclusion*

The noise level in Falmouth Bay is variable and strongly affected by human activities (traffic and ships at anchor with generators running) on one hand, and natural conditions (weather, marine organisms) on the other.

The installation phase is considered to be the noisiest. It is difficult to assess the effect of the converter in operation in a variable ambient environment but it is likely that the converter locally increases the noise level at certain frequencies.

The main problem in the study of wave energy devices is that there is a wide variety of mechanisms (buoy with pendulum, Pelamis-type tube sections with joints, etc.). The main sources of noise emissions are primarily the moorings of the systems, the flex point when they are jointed, and the rotational movements for buoys with pendulums.
However, like other MRE types, the installation of the moorings for wave energy systems is considered to be the noisiest phase of their deployment.

The frequency of the loudest sounds during installation is considered to be within the detection range of cetaceans and is within the hearing range of some fish. It is possible that this level of acoustic pressure causes behavioural or physiological damage for some fish, such as temporary hearing loss (TTS – temporary threshold shift).

### 2.2) The notion of cumulative effect

There is constant background noise in the environment, also known as ambient noise. This noise has two components: natural (biotic and abiotic) and human (noise of maritime traffic further offshore, for example).

This is supplemented by nearby human activities. The passage of a ship will generate a particular noise, while a jet ski will generate a different type of noise. Each activity therefore produces its own sound, and with multiple activities, the sounds accumulate, join together and add to the ambient noise with temporary noises. The activity of a port, day and night, will have consequences for the sound environment of its surrounding area within a certain range.

MREs are therefore a new activity in addition to the pre-existing activities. This notion of cumulative activities is important to consider, as it is no longer a matter of studying the impact of an activity but rather studying the impact of a new activity in an environment where activities are already present which, due to their various time frames, are not necessarily the subject of impact studies.

Consequently, a useful concept in view of the multiplication of human projects is that of “human activity indicator”. The higher the indicator, the more the zone is subject to substantial acoustic pressure. This indicator could translate into mapping of sounds and their propagation. Combined with the mapping of small cetacean activity, this could help in selecting sites with fewer environmental constraints for the installation of new high-impact activities. On the other hand, this indicator must be associated with a calendar as the various activities have different time frames. Consequently, the performance of the activities, particularly the installation and maintenance phases of the devices, could be planned based on consideration of the spatio-temporal map of the various noises detected in the zone.

### 2.3) Prediction and modelling

Based on meteorological and oceanographic forecasting methods, it is possible to develop a system for forecasting natural and anthropogenic noise and its propagation, using cartographic representation (Folégot, 2012). This operational platform patented by the company Quiet Oceans shows the spatio-temporal distribution of the noise levels generated by human activity. This technique makes it possible to see the noises already present (ambient background noise) and to forecast the acoustic footprint of future projects and assess the risks they pose.

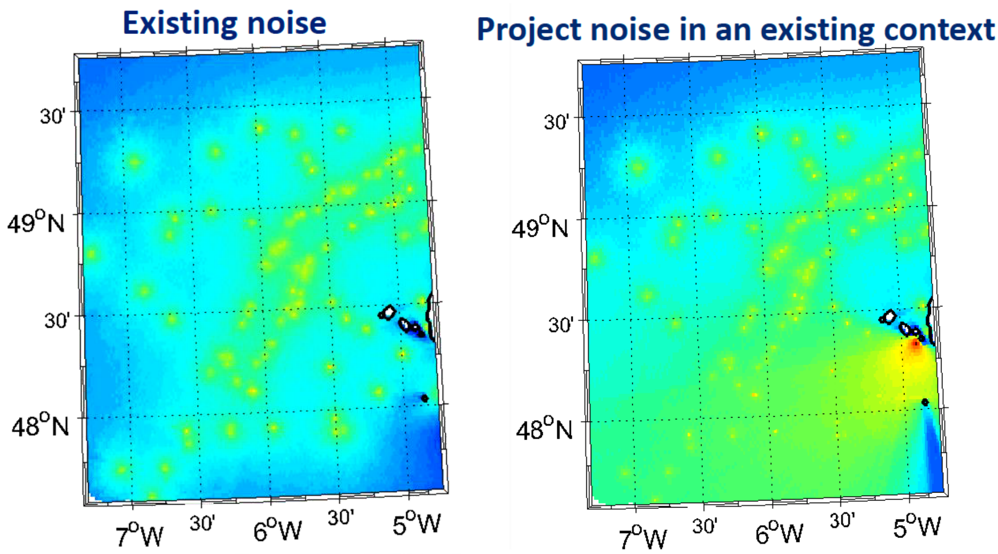


*Figure 21: Maps showing the spatial impact of anthropogenic noises, modelled in the Molène archipelago and the Ushant shipping lane, with a simulation of pile driving for a wind turbine on the right.*
*Source: Folégot, 2012.*

This type of modelling and representation of the noise levels of activities and their propagation is useful for assessing the zone of influence of noise and identifying reference sites (control zone outside the area of impact to enable comparison of sites), and anticipate seasonal variations. They ensure the coherence of monitoring procedures and strategies.

On the other hand, the principle of mapping noise levels makes it possible to assess the risks of physiological damage run by animals in the zones of influence of the noise.

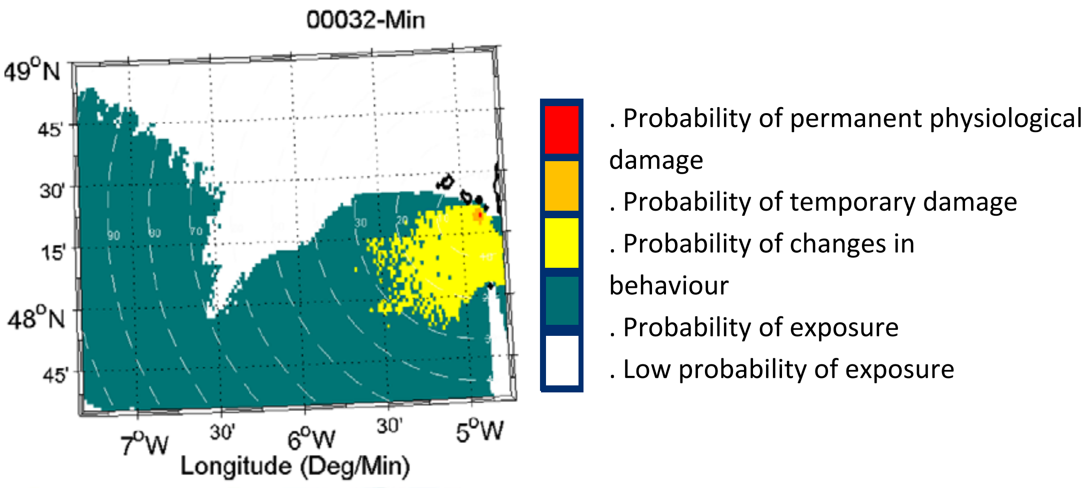


*Figure 22: Modelling the propagation and influence of noise levels.*
*Source: Folégot, 2012.*

# CONCLUSION

The results of this study show that passive acoustics have major potential when studying the use of a site by small cetaceans. This type of monitoring has the advantage of being operational in all types of meteorological conditions, 24 hours a day, 365 days a year (Samaran et *al.*, 2011), and does not require the regular deployment of a team on the ground.

Nonetheless, these tools have a cost and it is preferable to deploy a number of them due to their detection range, in order to cover a large enough zone. AURAL is particularly expensive due to its capacity to record everything, but it makes it possible to go somewhat further when analysing the noise emitted by human activities on one hand and activity by natural fauna on the other, and to identify their interactions.

| | Cost (from reasonable* to expensive***) | Average detection range | Data analysis (from simple* to complex***) | Transparency in acquisition | Volume capacity |
|---|---|---|---|---|---|
| AURAL | *** | 350 metres | *** | *** | ** |
| C-POD | * | 300 metres | * | * | * |
| AMAR | *** | complete | *** | *** | *** |

*Figure 23: Table comparing the criteria differentiating between the various devices examined in this document.*

The information rendered by the C-PODs does not always correspond to reality as certain signals received may come from the rocky substrate or from invertebrates. Consequently, the results may distort reality, as a high number of clicks may be recorded when in reality very few dolphins were present. The C-PODs therefore have to be calibrated effectively by comparing the data received by an AURAL hydrophone and a C-POD in order to check the information recorded. The difficulty of working with an AURAL hydrophone lies in producing its algorithms by extrapolating ambient noise.

A project supported by the Agence des Aires Marines Protégées [French Marine Protected Areas Agency] and backed by the University of La Rochelle involves carrying out a comparative analysis of data acquisition by an AURAL hydrophone and a C-POD. This project, entitled MARSAC, short for "MARSouin ACoustique" [acoustic porpoise], was presented at workshops 3.3.4a and 3.3.4b (*www.merific.eu*). As the project is not yet sufficiently advanced, for the moment no conclusions can be drawn. However, the presentation is available on the MERiFIC project website (*www.merific.eu*).

Static passive acoustic monitoring therefore provides information on the geographical and seasonal distribution of the animals but it does not currently make it possible to assess their numbers (Verfuss *et al.*, 2077 in Samaran *et al.*, 2011). Numerous conclusions suggest combining acoustic observations with other types of monitoring, such as visual observations (identification and behaviour) and tissue sampling in order to carry out genetic studies. These other measures will make it possible to obtain a more fine-grained analysis of the functions of the different habitats.

On the other hand, under water, noise propagates relative to the local bathymetric, temperature and salinity characteristics. Depending on the site (composition and profile of the sea bed, depth, salinity, etc.), the season and the local climate conditions, sound can propagate in the sea over very large distances at a variety of depths, from tens to hundreds of kilometres from the source of the sound (Folégot *et al*., 2011). An essential task before any acoustic study therefore consists of first becoming familiar with the physical and chemical environment in order to understand the basic sound propagation situation. It is therefore worth remembering that the impact of each project must be analysed based on its location and the nature of the ecosystems in which it is established (regional and local characteristics).

It is important to fully understand the context in which the zone is used by species – for feeding or reproduction, as a migration route, in the key stages of the life cycle, in the seasonal use of habitats. If a species has an inherent attraction, from an ecological point of view, it is important to take into account impacts on the structure of the ecosystems and the functional use of this ecosystem (Simberloff, 1998), which may have repercussions on species further up the food chain. It is therefore initially advisable to avoid ecologically significant zones, to minimise the direct impact of construction and to monitor potential development zones, preferably using the BACI method (Before-After Control-Impact*, Sotta et al., 2012*).

Surveys of developments in small cetaceans must also be carried out over the long term. Certain modifications in the distribution of species in terms of numbers should be considered with care. Global changes in large zones (on the scale of an ocean basin) may have an influence at local level and modify the activity of certain species in the medium term. Surveying should begin well before devices are deployed, especially since at present the means of data storage make it possible to store a sizeable volume of data, facilitating spatial and temporal replication. Without coherent data, it is impossible to guarantee the presence or absence of specific effects of noise on marine species.

The noise emitted by MRE devices is new and will add to the anthropogenic sounds already in existence. Classic environmental impact assessments (EIAs) do not always engage with the environmental effects of pre-existing activities or other planned developments. Criteria and methods for assessing cumulative effects must be designed and normalised based on appropriate scales of time and space.

Over time, an understanding of the spatio-temporal use of sites by populations of small cetaceans will make it possible to refine the selection of sites for installation of MREs and to plan the schedule for the works involved.

## Collaborative working scenario

One of the objectives of the MERiFIC project is to develop and share a common vision of environmental assessment techniques. We have chosen to develop a common approach to describing the acoustic landscape and investigating populations of dolphins around Cornwall and Finistère.

The zone covered by MERiFIC is vast, and given the costs and challenge of deploying acoustic devices, carrying out the same type of monitoring throughout the area is not feasible. However, we already know where the most sensitive environmental zones are located thanks to the network of marine protected areas that is already present, and we also know where the future MRE sites for demonstration models and pilot developments will be. Looking at these maps, we can target restricted zones where monitoring must be carried out as rigorously as possible.

### a. Environmental protection zones

In France, Parc Naturel Marin d'Iroise marks the creation of a new form of marine protected area based on the concepts of consultation and sustainable development. A marine natural park is a protection zone but also a sustainable economic development zone, whose large area can contain zones of heightened protection. Its guiding principle is most importantly that decisions are made collectively by all the stakeholders in the sector. The possibility of an industrial development project is not dismissed out of hand, but its environmental impact must be assessed and presented to the marine natural park's management committee so that it can give its opinion on whether or not it is acceptable.

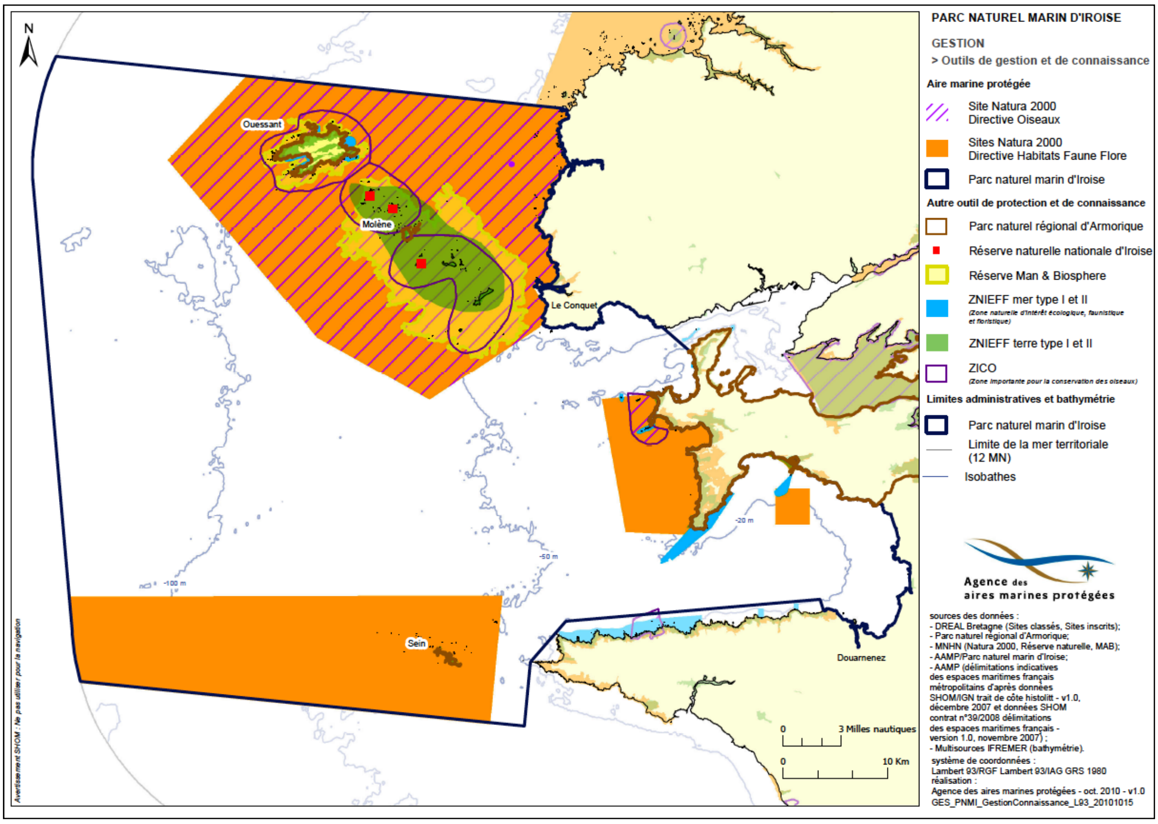


*Figure 24: The management and knowledge tools within Parc Naturel Marin d'Iroise*
*Source: Agence des Aires Marines Protégées, cartomer.fr*

Looking at the map above, it is clearly apparent that the Molène archipelago is the subject of multiple environmental protections, with a heightened protection zone where some small islands can even be described as no-take zones. In these circumstances, it goes without saying that every development project with an influence on the environment is subject to an impact assessment study.

Further afield in France, we can see that the network of marine protected areas is widespread. Over time, this network will help us to better understand the functioning of the coastal environment of continental France as a whole, with the performance of multiple environmental monitoring projects in parallel.

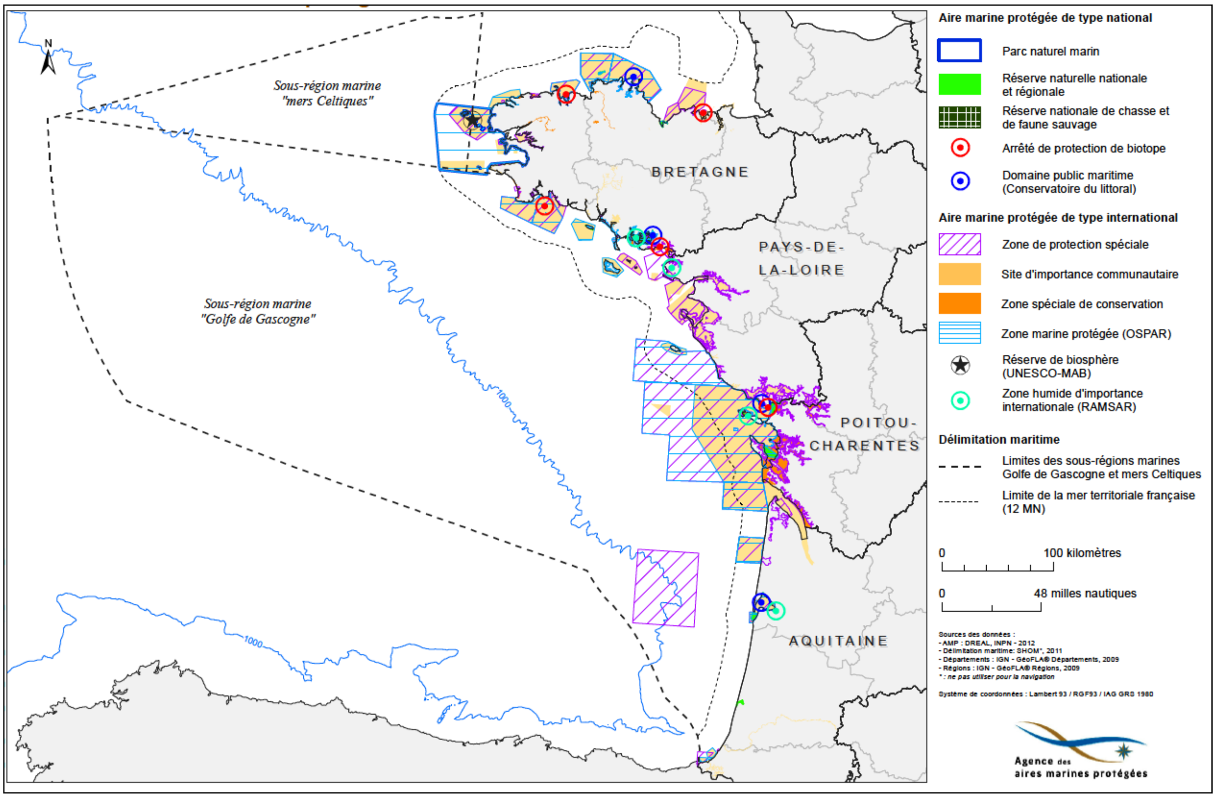


*Figure 25: The network of marine protected areas in continental France*
*Source: Agence des Aires Marines Protégées, cartomer.fr*

The forms of protection differ in France and Great Britain. Although the Natura 2000 network is European, protective statuses adapted to the national legislation have been put in place in France and Great Britain.

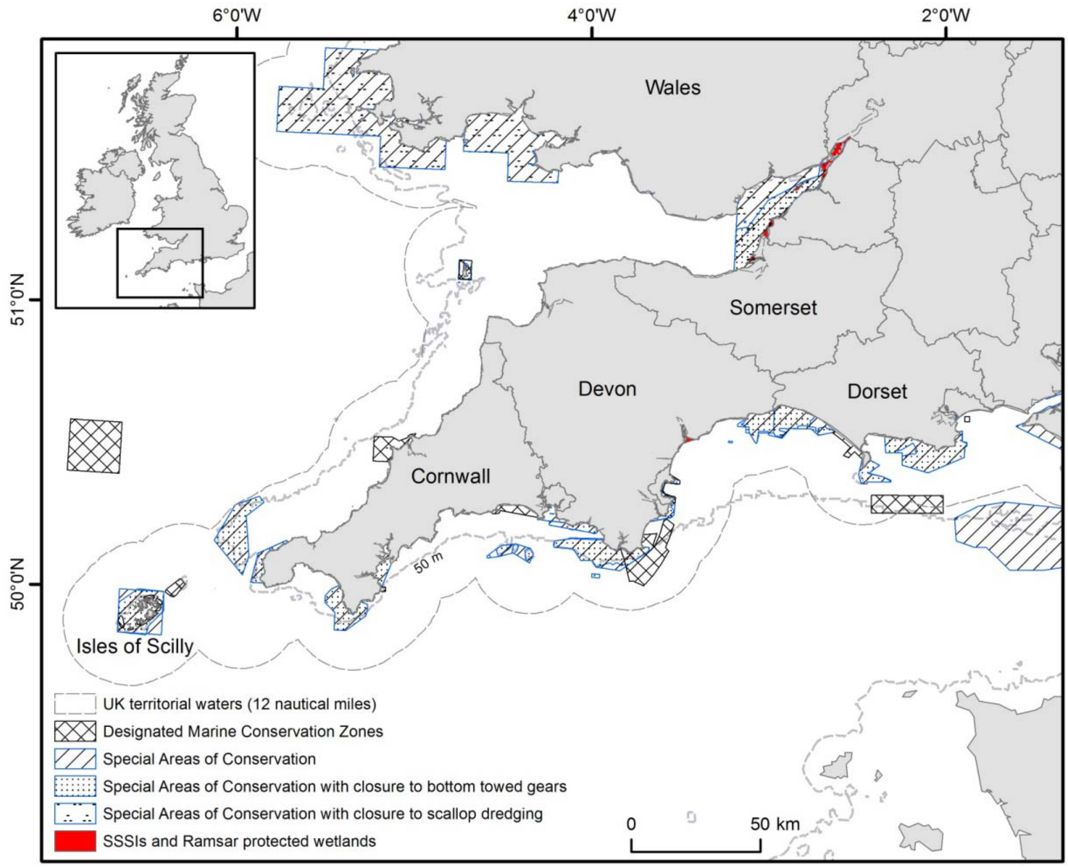


*Figure 26: The network of marine protected areas in the South-West of Great Britain*
*Source: Pikesley and Witt, 2014*

## b. MRE projects

In Finistère, the SABELLA D10 marine current turbine demonstration model project should be operational in Passage du Fromveur by the start of 2015. This project consists of installing an actual-size demonstration model (1:1 scale).

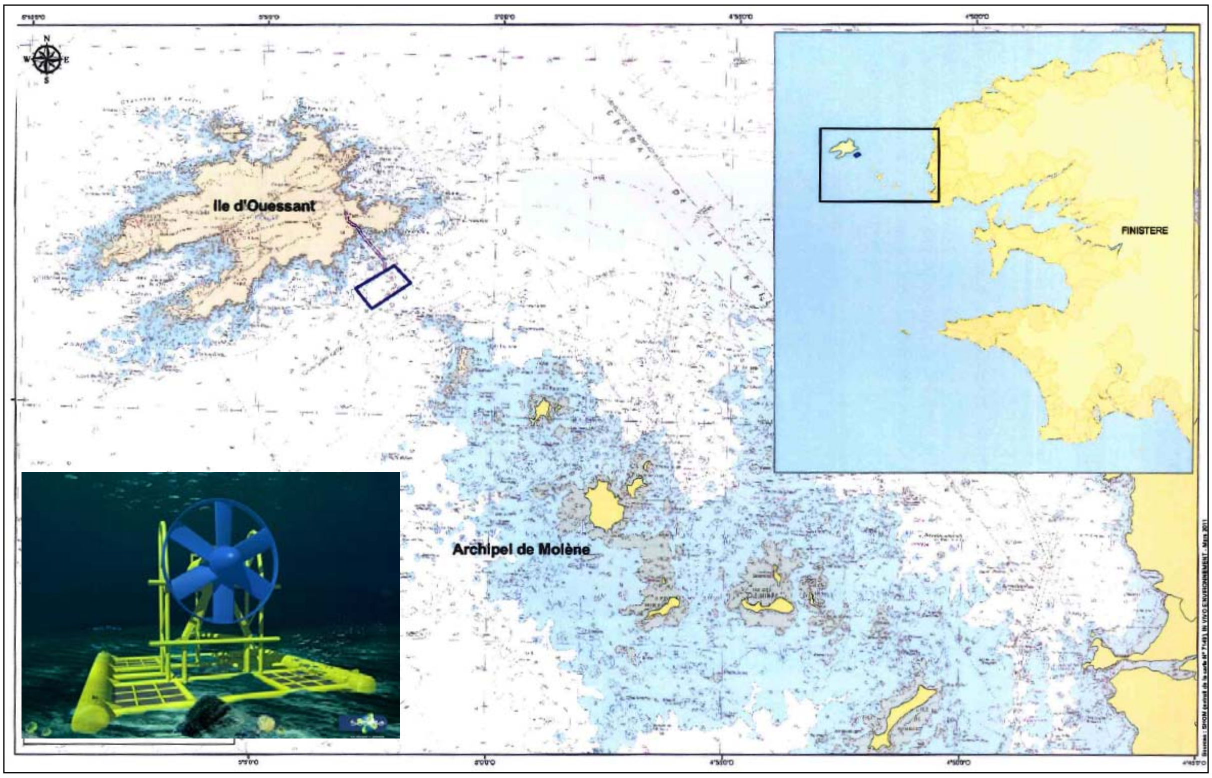


*Figure 27: Map of the location of the demonstration model and computer-generated image of SABELLA D10*
*Source: Impact study for the installation of the Sabella D10 marine current turbine demonstration model, In Vivo Environnement, 2011*

Passage du Fromveur has also just been involved in a Call for Expressions of Interest from ADEME (Agence De l'Environnement et de la Maîtrise de l'Energie – French Environment and Energy Management Agency) for the installation of a marine current turbine pilot farm by the end of 2016. This will conclude on 16 May 2014.

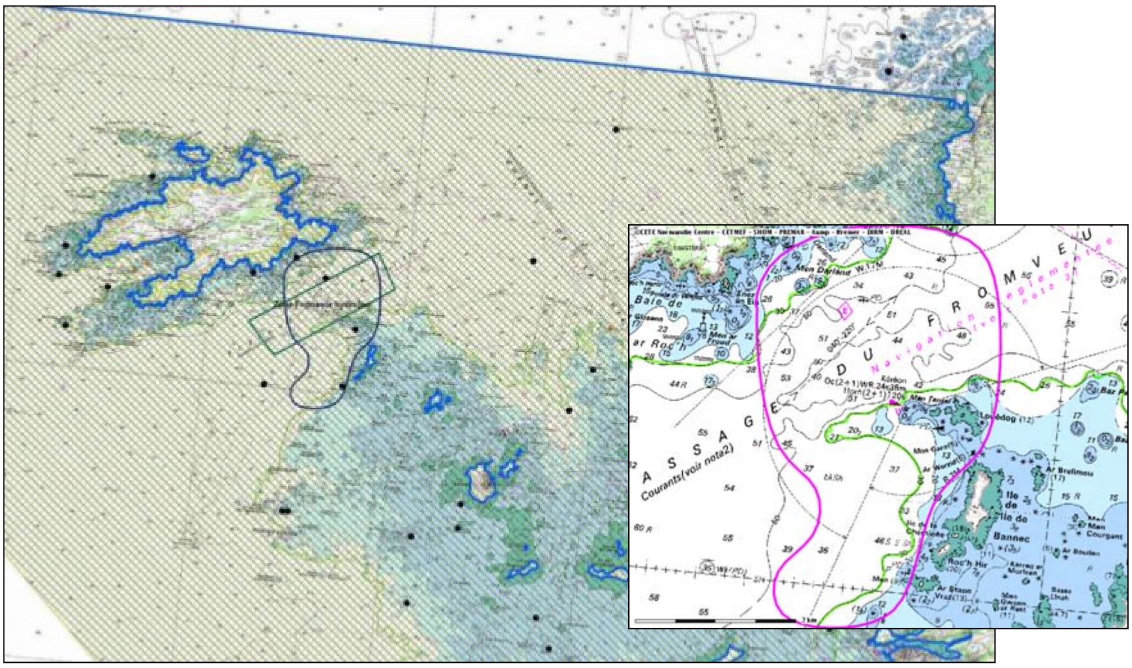

*Figure 28: Potential area for installation of a marine current turbine pilot farm in Passage du Fromveur*
*Source: ADEME*

A marine current turbine test site project is currently being developed for implementation north of Finistère, beside Île-de-Bréhat. This site is split between EDF and France Energies Marines. This partnership makes it possible to get the benefits of shared infrastructure and complementary studies. For the moment, only EDF is carrying out tests on the “Arcouest” marine current turbine, but no element of the assessments has been disclosed.

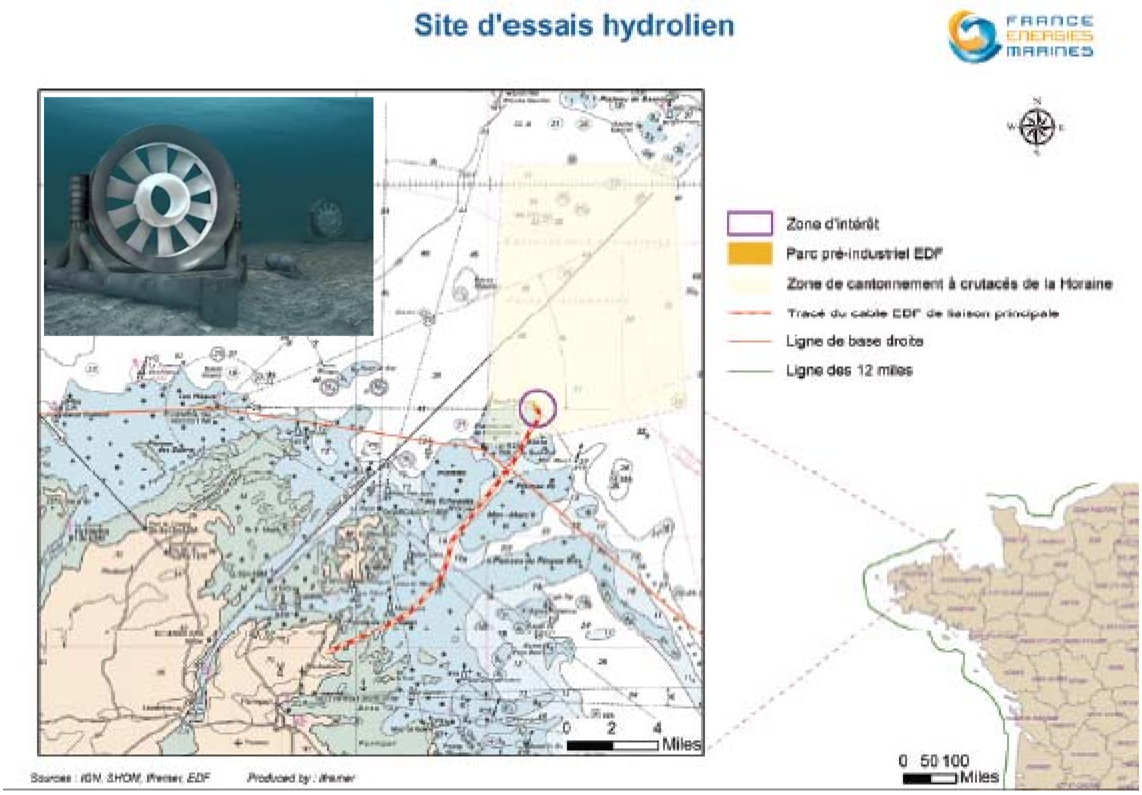


*Figure 29: Location of the marine current turbine test site, France Energies Marines and EDF, at Paimpol-Bréhat and computer-generated image of EDF's Arcouest marine current turbine*
*Source: France Energies Marines*

A wave energy test site project will soon be set up off Audierne in southern Finistère. WaveRoller technology is intended to be used, having already been tested at Peniche in Portugal. However, no precise zone has yet been determined.

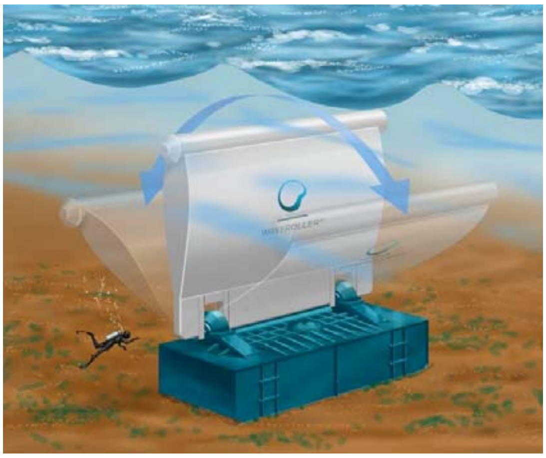

*Figure 30: Computer-generated image of the WaveRoller*

*Source: ladepeche.fr*

There are two wave energy test sites in Cornwall. One is located in the north, off Hayle: Wave Hub. The second, in the south of Cornwall, is in Falmouth Bay: FaBTest.

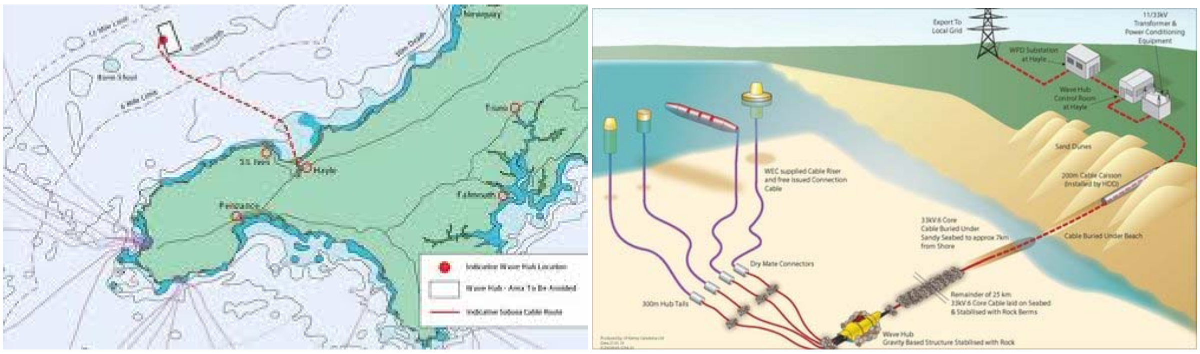


*Figure 31: Location of the Wave Hub test site in the north of Cornwall and image presenting the system*

*Source: bbc.co.uk*

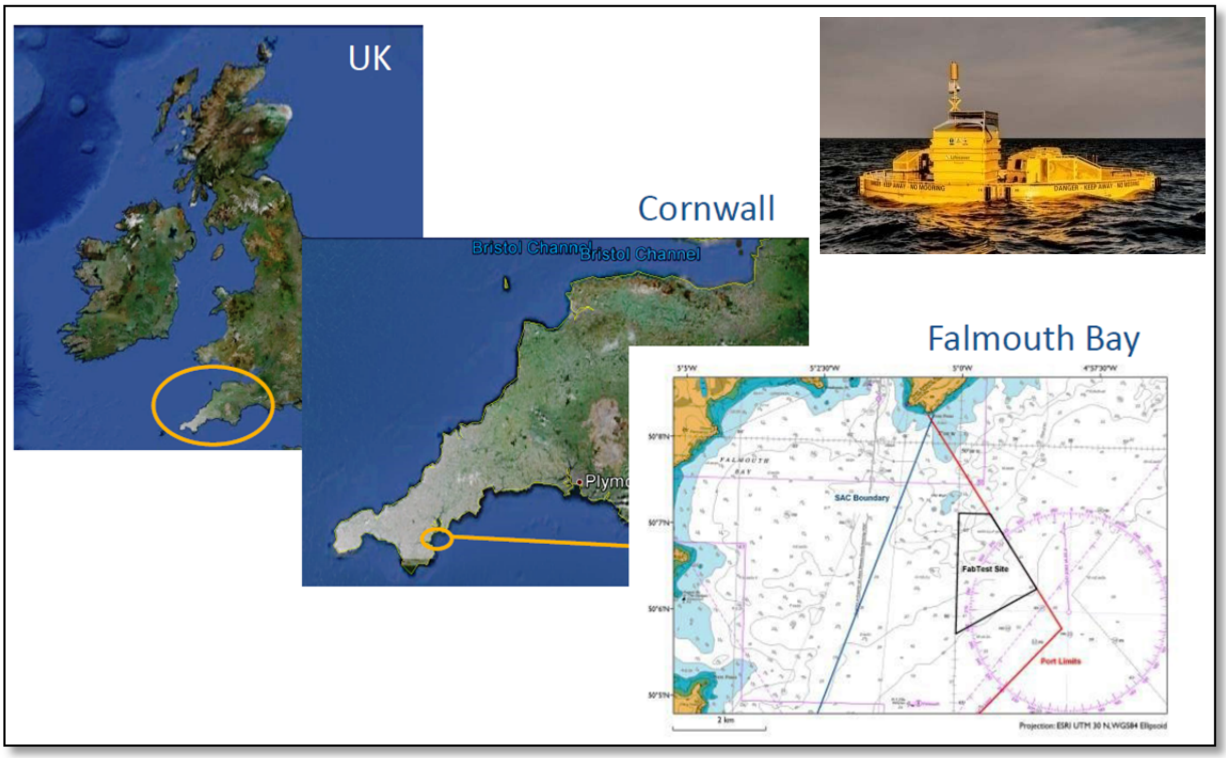


*Figure 32: Location of FaBTest in Cornwall*
*Source: Joanne Garrett, presentation at MERiFIC workshop 3.3.4b, Le Conquet, October 2013*

For the moment, no wave energy device is installed and in operation. At Wave Hub, only the converter (WEC – wave energy converter) is present underwater. The wave energy converter corresponds to a structure placed or anchored on the sea bed, which transforms the mechanical energy of the waves into electrical energy; the wave energy devices are connected to it, and it is then connected to the mainland. At FaBTest, a floating platform equipped with environmental monitoring instruments is installed (*see presentation above*).

### c. Analysis of the terrain and possibility of deploying acoustics

Looking at all the mapping information and the compilation of maps above (for information, a geographic information system assembling the environmental assessment data has been prepared for MERiFIC and is available on the project website: www.merific.eu), certain zones appear to be a priority when studying noise and small cetacean activity. These sectors correspond to project development zones and their surrounding areas, as well as heightened protection zones and their surroundings. A study of small cetacean activity and a study of interactions with anthropogenic noises must be carried out on these sectors. This monitoring will make it possible to fully understand the use of these spaces by small cetaceans and to determine levels of acceptability for development there, provided that the monitoring is repeated regularly and is relatively fine-grained.
In these circumstances, it would be advisable to use techniques that make it possible to listen to the environment as a whole by developing algorithms that enable us to concentrate on detection of animals and human activities, removing the background ambient noise. This technique would allow

us to interpret the scale of the accumulation of various sources of sound. Regarding the modelling method, having developed an index of acoustic pressure coming from human activities, a noise map can be produced. This will give us an overview of the zones from which the loudest noises emanate as well as their propagation.

The recommended tool would be an AURAL hydrophone because this is capable of recording all sounds, based on the algorithms set. AURALs would therefore be deployed in the zones covered by MRE project impact studies and around heightened protection zones, in order to assess the level of direct impact from human activities.

There are fewer issues in the open ocean, but dolphins are nonetheless active there and it is good to have some insight into their movements in these huge areas. The open ocean does not necessarily require costly cutting-edge technology, given that the risk of losing it is relatively significant. Since C-PODs are less expensive and are sensitive to reflected sound waves in rocky environments (rock is much more reflective than sediment, but it is much less present and influential in the open ocean), it would be appropriate to use them in this case. Although their detection range is not very large (around 300 metres), fine-grained monitoring is not obligatory as the aim here is to assess overall activity off the coasts, or even where the Channel meets the Atlantic.

# BIBLIOGRAPHY


GERVAISE C., DI IORIO L. and LOSSENT J. (2012). *Rapport final du projet AcDau [AcDau Project Final Report]*. Parc Naturel Marin d'Iroise, GIPSA-Lab, Chaire CHORUS – Fondation Grenoble-INP and the MERiFIC project. p. 42

LURTON X. & ANTOINE L. (2007). *Analyse des risques pour les mammifères marins liés à l'emploi des méthodes acoustiques en océanographie [Analysis of risks to marine mammals connected to the use of acoustic methods in oceanography]*. IFREMER, Department of Ships and On-board Systems. April 2007 – DOP/CB/NSE/AS/07-07. p. 88

SOTTA C. (2012). *Synthèse documentaire des impacts environnementaux des énergies marines renouvelables [Literature survey on the environmental impacts of marine renewable energies]*. MERiFIC project. Parc Naturel Marin d'Iroise. p. 109

BASSETT C., THOMSON J., POLAGYE B., RHINEFRANK K. (2011). Underwater noise measurements of a 1/7$^{th}$ scale wave energy converter. In: OCEANS 2011, Waikoloa, HI 2011. IEEE, pp 1 – 6

BOEHLERT G.W. & GILL A.B. (2010). *Environmental and ecological effects of ocean renewable energy development, a current synthesis.* Oceanography, Volume 23, Number 2.

BAILEY H., SENIOR B., SIMMONS D., RUSIN J., PICKEN G.B. and THOMPSON P.M. (2010). *Assessing underwater noise levels during pile driving at an offshore windfarm and its potential effects on marine mammals*. Marine Pollution Bulletin, 60(6), 888-897.doi:10.1016/j.marpolbul.2010.01.003.

HAIKONEN K., SUNDBERG J., LEIJON M. (2013). Characteristics of the Operational Noise from Full Scale Wave Energy Converters in the Lysekil Project: Estimation of Potential Environmental Impacts. Energies 6 (5): 2562 – 2582.

HOROWITZ C. & JASNY M. (2007). *Precautionary management of noise: lessons from the US*. Marine Mammal Protection Act. J. Int. Wildl. Law Policy 10, 225-232.

FOLEGOT T. (2010). *Ship traffic noise distribution in the Strait of Gibraltar: an exemplary case for monitoring global ocean noise in real-time – technology now available for understanding the effects of noise on marine life*.

PATRICIO S., MOURA A., SIMAS T. (2009). Wave energy and underwater noise: State of art and uncertainties. In, 2009. IEEE, pp 1 - 5