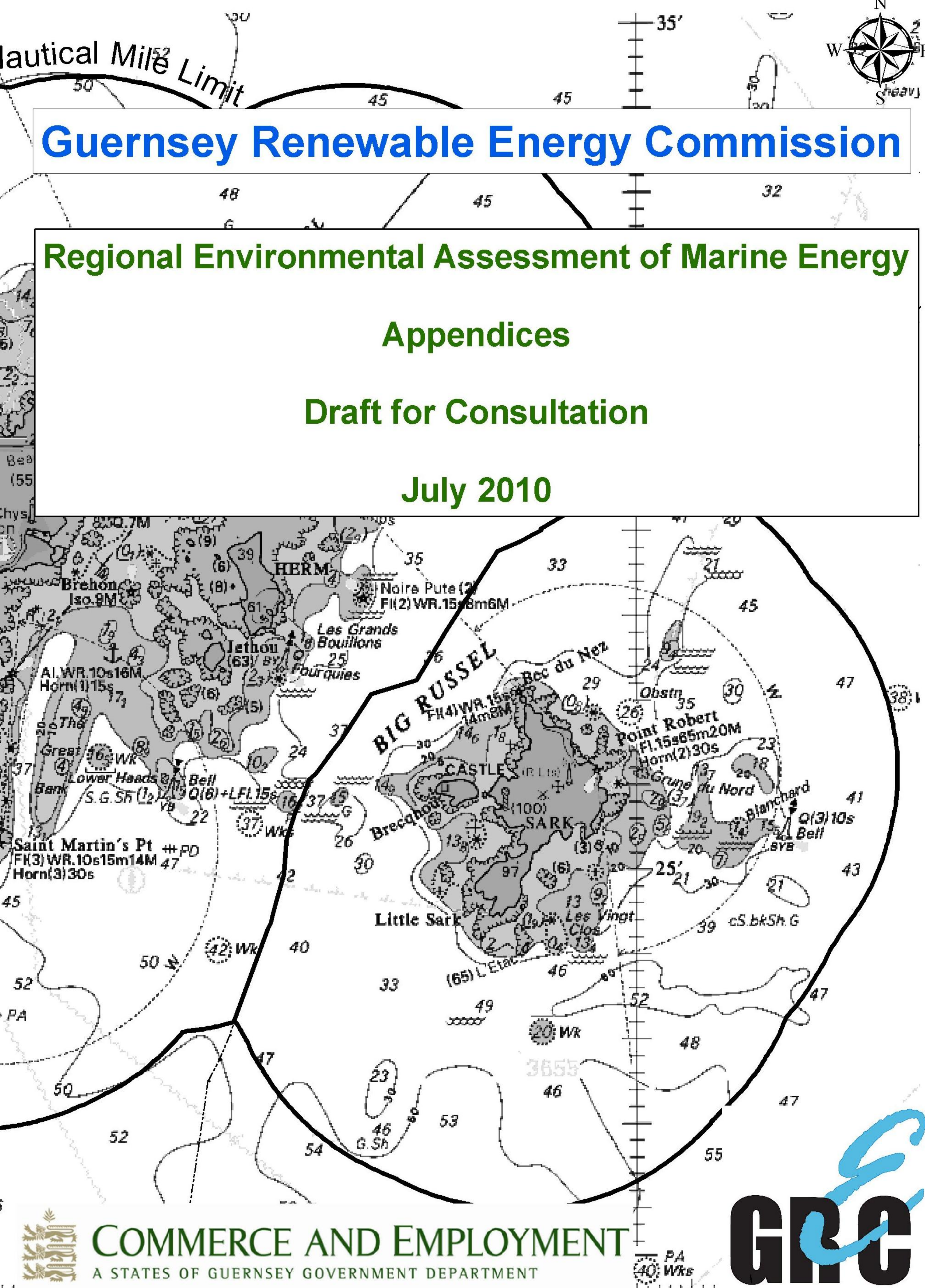


Guernsey Renewable Energy Commission

Regional Environmental Assessment of Marine Energy

Appendices

Draft for Consultation

July 2010

COMMERCE AND EMPLOYMENT
A STATES OF GUERNSEY GOVERNMENT DEPARTMENT

GRC
Guernsey Renewable Energy Commission

Appendices

Appendix A – List of Authors

Chapter Number	Subject	Author
4	Geology and Sediment Transition	David Tappin
5	Marine Processes	Chris Green
6	Water Quality	Peter Barnes
7	Benthic Ecology	Mel Broadhurst
8	Pelagic Ecology	Annie Linley & Karine Laffont
9	Birds	Jamie Hooper
10	Marine Mammals	Martin Gavet
11	Commercial Fisheries	David Wilkinson
12	Recreational Fishing	Peter Perrio, Len Le Page, Peter Barnes
13	Marine and Coastal Historic Environment	Philip de Jersey, Tanya Walls & Christopher Hughes
14	Cables Pipelines and Onshore Grid Connections	Steve Morris
15	Shipping and Navigation	Rob Barton
16	Tourism and Recreation	Peter Barnes
17	Noise	Peter Barnes
18	Air Quality	Peter Barnes
19	Landscape and Seascape Character	Chris Green

Appendix B – Glossary of Terms

General

C & E – Commerce & Employment Department (States of Guernsey)

CO_2 – Carbon Dioxide

DP – Dynamic Positioning (vessel)

EAP – Environmental Action Plan

EIA – Environmental Impact Assessment

EMF – Electro-Magnetic Field

ES – Environmental Statement

FLO – Fisheries Liaison Officer

FLOWW – Fisheries Liaison for Offshore Wind and Wet Renewables

GEL – Guernsey Electricity Ltd

GHG’s – Greenhouse Gasses

GREC – Guernsey Renewable Energy Commission

GREF – Guernsey Renewable Energy Forum

MMO – Marine Mammal Observer

MW – Mega-Watt (unit of electrical power)

NTS – Non-Technical Summary

REA – Regional Environmental Assessment

RMP – Regional Management Plan

SEA – Strategic Environmental Assessment

SeaFish – Sea Fisheries Department (States of Guernsey)

SZ – Safety Zone – An area of sea over which an exclusion is applied to all or particular types of vessel or activity, for reasons of maritime safety

Chapter 7 – Benthic Ecology

BGS - British Geological Survey

Biotope - Refers to a specific, uniform set of environmental conditions in which a particular assemblageof organisms live

EUNIS - European Nature Information System

GBRC - Guernsey Biological Records Centre

JNCC - Joint Nature Conservation Committee

Marlin - The Maritime Life Information Network

MESH - Mapping European Seabed Habitats project

MHWS - Mean high water springs

SeaSearch - UK national volunteer scuba diving ecological research programme

UK BAP - UK Biodiversity Action Plan

Chapter 15 - Navigation and Shipping

AIS - Automatic Identification System. All vessels over 300 gross registered Tonnage are required to carry AIS equipment which transmits information about the ships and its position and intended movements to other similarly equipped ships and coastal authorities.

IMO - International Maritime Organisation

ITZ – Inshore Traffic Zone

GBA – Guernsey Boat Owners Association

GCPUA – Guernsey Commercial Port Users Association

GFA – Guernsey Fishermen’s Association

GHA – Guernsey Harbour Authority

GMTA – Guernsey Marine Traders Association

GYC – Guernsey Yacht Club

MCA - UK Maritime and Coastguard Agency

RCIYC – Royal Channel Islands Yacht Club

RNLI – Royal National Lifeboat Institution

RYA – Royal Yachting Association

TSS – Traffic Separation Scheme

UKHO – UK Hydrographic Office

UNCLOS – United Nations Law of the Sea

Appendix C – Tidal Resource Mapping for the Territorial Waters of Guernsey

Final Draft Report

Tidal Resource Mapping for the Territorial Waters of Guernsey

By Dr Alan Owen

The Robert Gordon University, Aberdeen

For The States of Guernsey

March 2010

1 Introduction

The Channel Isles has long been recognised as a significant area for tidal current energy and attracts considerable developer interest. Due to their particular relationship with the UK, the individual island communities hold ownership of their territorial limits, which allows each island to negotiate the use of its territorial resources according to its own systems of governance.

This idiosyncratic situation makes the region attractive for developers as there is the potential for faster, less complex licensing procedures than currently exist for the UK mainland. The difficulty that is faced by individual island communities, including Guernsey and Sark, is one of knowing where the best tidal current resource is and how to optimise the licensing procedure, whilst remaining attractive to incoming investment.

This report details the methodology employed in assessing the Guernsey tidal current resource location, magnitude, sensitivity to device depth and cut-in speeds, and possible landfall for power transmission. Some information on Sark is also offered though further work is required to fully detail Sark's resource.

The process is based on a completely rewritten and updated version of a software algorithm originally developed and used to quantify the tidal current resource for the Channel Isles region ([i]). The software is provided with a range of data in numerical or graphical format, depending on the source, and maps the data to the area of interest on a 2D Cartesian grid. Utilising the existing data, realistic 'guess' values are generated for areas where no data is available and the software then employs a central differences relaxation method to solve the matrix.

2 Source materials

The full range of source materials for -6 hours to +6 hours relative to St Helier are given in appendices.

Appendix 1: Admiralty tidal stream atlas ([ii])

Appendix 2: Admiralty tidal diamond data

Appendix 3: Local anecdotal tidal vector sketches

Charts

The Channel Isles is a well charted area and considerable detail is available, though much of the bathymetry is based on very old sounding data. Assuming that the initial work was reasonably accurate, the soundings over clean rock can be assumed to be unchanged, but the charts show areas of mud, sand, gravel etc and these are often mobile, though cyclic in their movements.

Tidal chart atlas

The tidal chart atlas covers the .area of the Channel Isles group, but offers little detail at the scale required. Tidal current vectors are referenced to HW at Dover with corrections given for HW at St Helier and it is these latter vectors that are used.

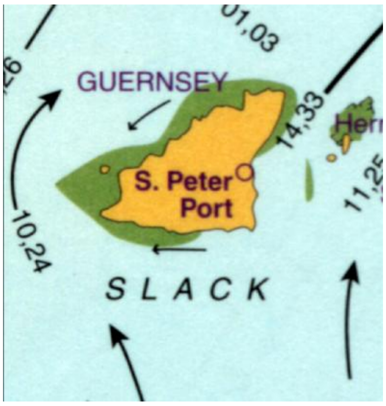


Figure 1: Excerpt from Admiralty Tidal Stream Atlas © 1993

Garmin

Garmin Mapsource ® software offers a digital chart system of the Guernsey area and is an excellent source of bathymetric data.

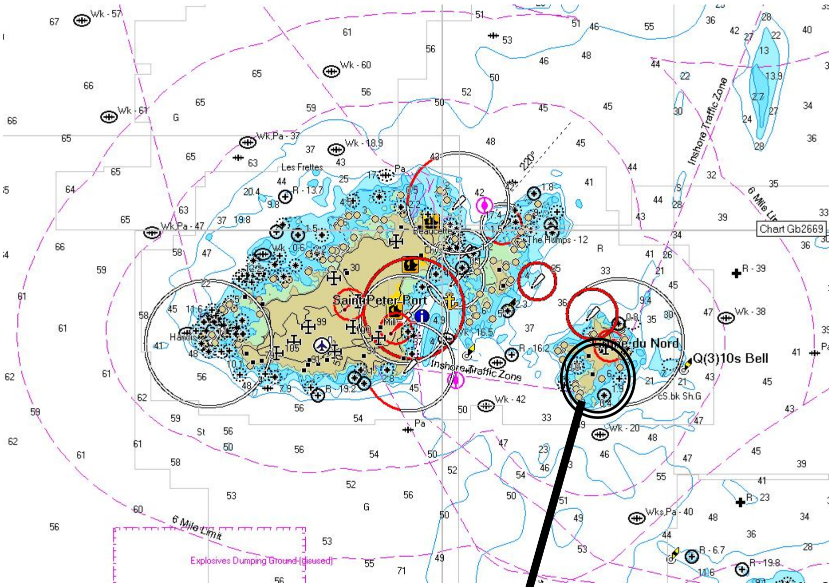


Figure 2: Area of interest from the Garmin Mapsource® software

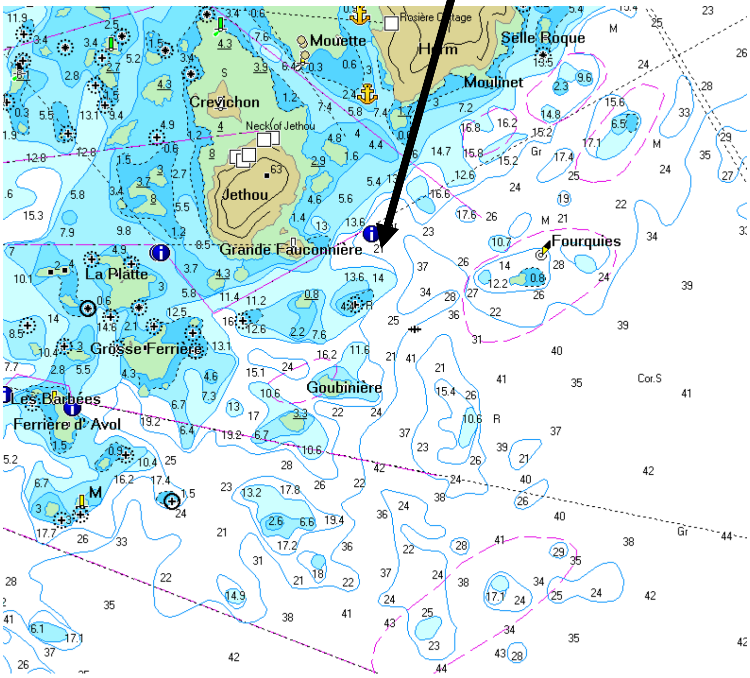


Figure 3: Detail of the Big Russell off the southern tip of Herm.

Admiralty Total Tide

The Admiralty TotalTide® software offers a digitised version of the tidal diamond data supplied on paper charts, in this case referenced to St Helier. Figure 4 shows the relevant area and the location of the 13 tidal diamonds used to provide data for this work. Interestingly, there are combinations of times and locations where the Admiralty tidal stream atlas offers significantly different values than the Admiralty TotalTide software package.

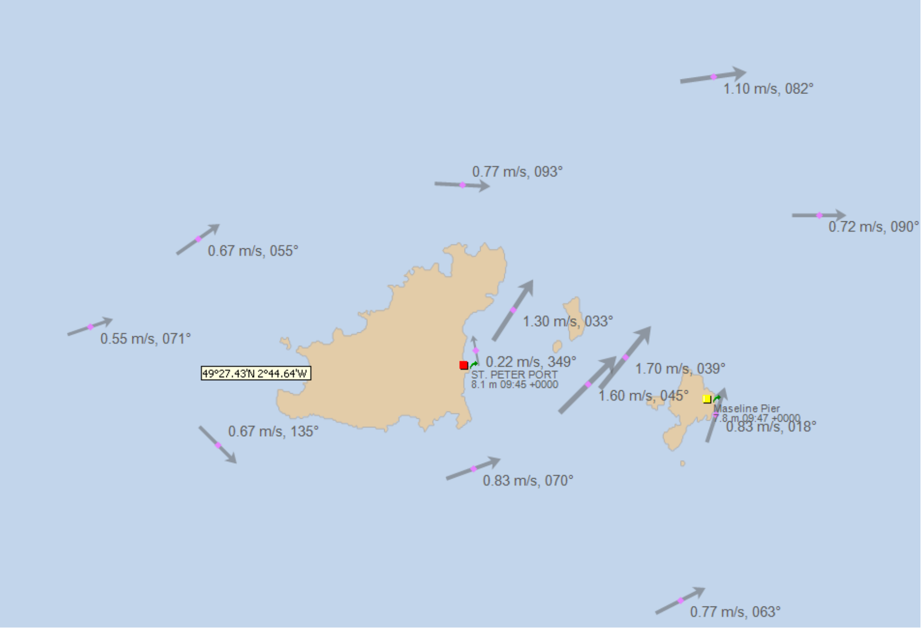


Figure 4: Area of interest from the Admiralty TotalTide® software

Anecdotal sketches

A set of locally produced vector sketches were provided and these introduce a level of detail not available from official publications covering the tidal currents in this region. Figure 5 shows the same time interval as Figure 1.

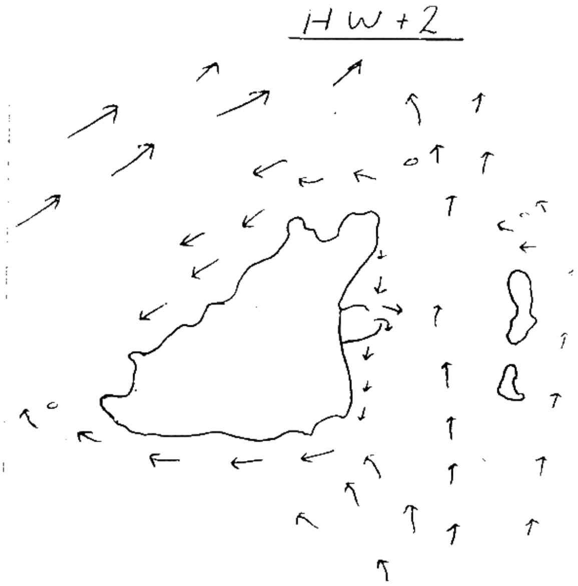


Figure 5: Anecdotal sketch of tidal current vectors around Guernsey

3 Assessment of source material

The level of detail required to give reasonable indications of flows at approximately 50m vertices challenges the interpretation of the source material. The Admiralty Tidal Stream Atlas is very general at this scale but can be used to form the foundations of the sense of the flow. The bathymetric data give reasonable framing of where the best flows are likely to be and the apparent scoured trench off the SE coast of Guernsey suggests that the flows are, or may have been, aggressive through this area. This appearance of a scoured trench is misleading; the deepest part of the 'trench' is no deeper than the seabed it relates to at its southern, northern and eastern edges. It is the presence of the Great Bank that is the anomalous feature.

Bathymetry

As well as dictating the depth of water available for installations, the bathymetry exercises considerable influence over the quality of the flow. Peaks and troughs will superimpose multidirectional flows onto the mean flow and may need to be taken into consideration in any assessment of power quality and equipment service life.

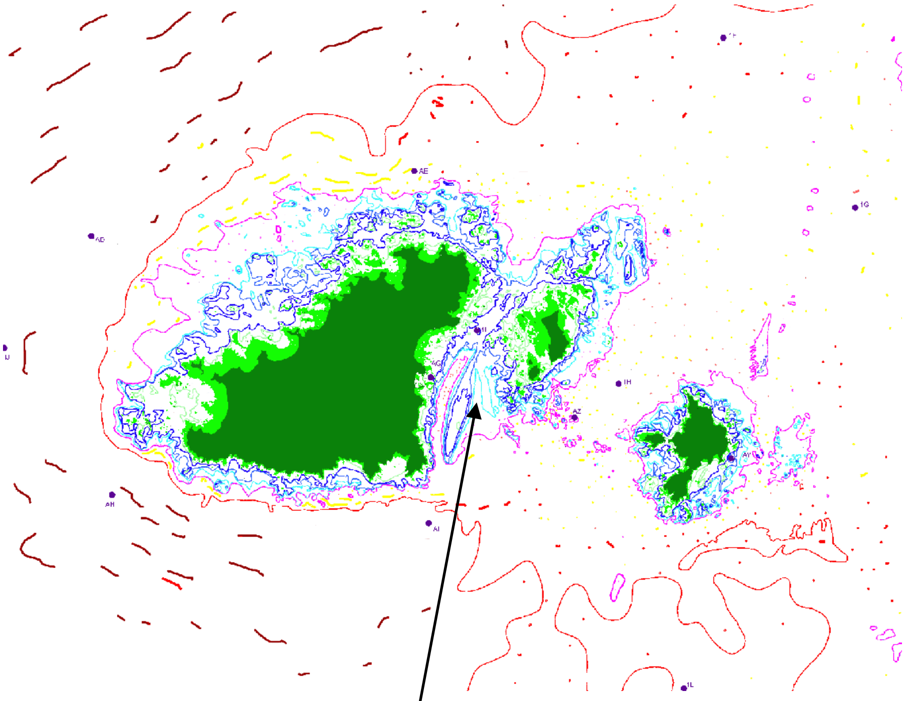


Figure 6: Bathymetric data in graphic format presented to the algorithm

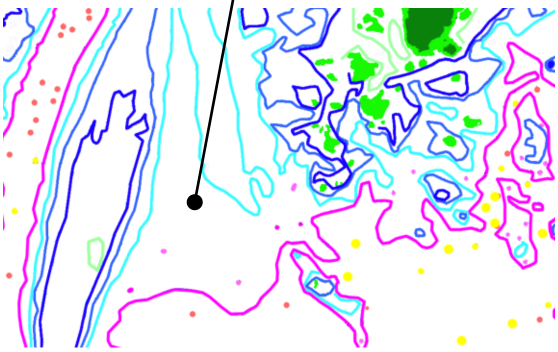


Figure 7: Detail section of main graphic

The bathymetric graphic is generated by hand from over 60 individual map segments and the original work is a 200MB file, which if printed a full scale would be 2.8m X 2.8m. A small section of the area between Herm and Guernsey is shown below.

Incorporating the available chart data at this scale ensures that as much data as possible is included in the final graphic. The graphic is bicubicly re-sampled for subsequent processing by the algorithm, but still measures 870 x 680 pixels, giving a full scale grid resolution of 44.33m.

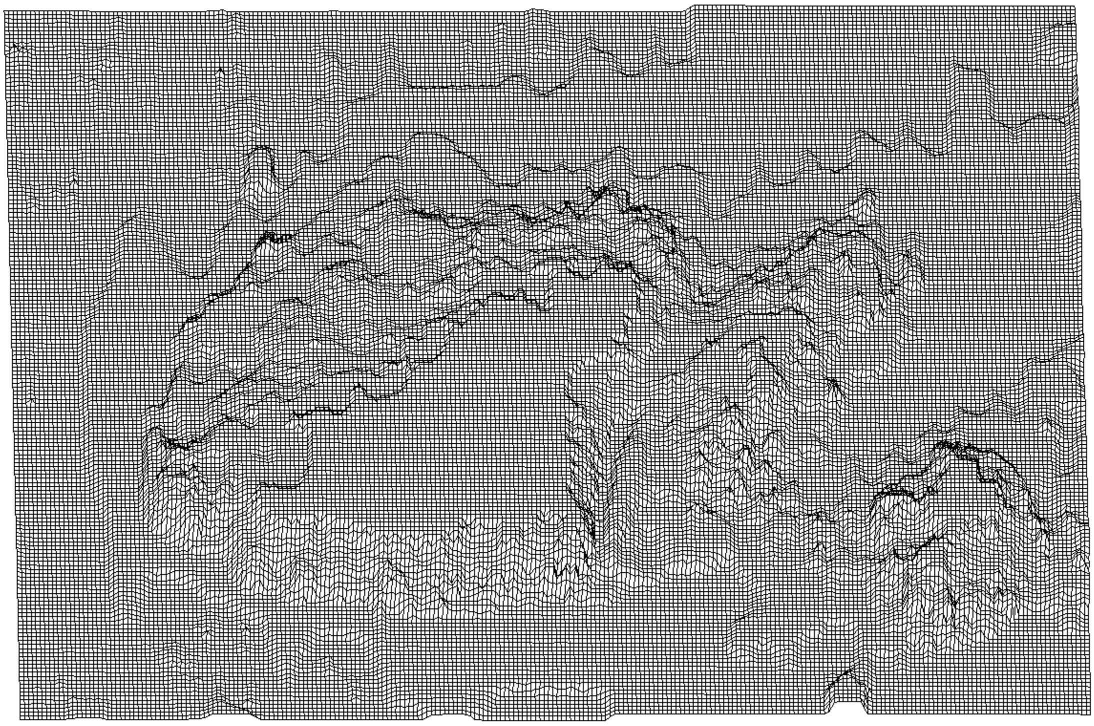


Figure 8: Bathymetric data as read and interpolated by the algorithm

To verify that the algorithm used is generating an acceptable solution, the X,Y,Z co-ordinates are input into a CAD programme and the resulting 3D mesh is checked against the 2D bathymetry on charts and other sources. Figure 8 shows the output, vertically exaggerated by 50% to highlight the principal shapes. The shape of Guernsey is easily visible along with the smaller islands of Herm and Sark. Of particular interest is the channel due east of Guernsey, thought to be created by the scouring effects of the flow between Guernsey and Herm. Additionally, the bathymetry to the north west of Guernsey is clearly very rough, whilst that between Herm and Sark is much flatter.

The present work does not dynamically calculate the water depth above chart datum due to tidal range, but instead assumes the mid-range point as an average addition to chart datum depths. Admiralty and Chart data indicate this mean should be around 5.4m

Tidal Streams

The official data available do not illustrate the flows around Guernsey in sufficient detail to give any particular insights into the likely most energetic locations, other than general indications to the nearest 5-10km. The anecdotal sketches show a potentially very important level of detail, but are roughly drawn and the vectors are not scaled in terms of velocity. It was necessary to establish what level of accuracy, if any, can be attributed to these sketches and a method was devised to attempt this.

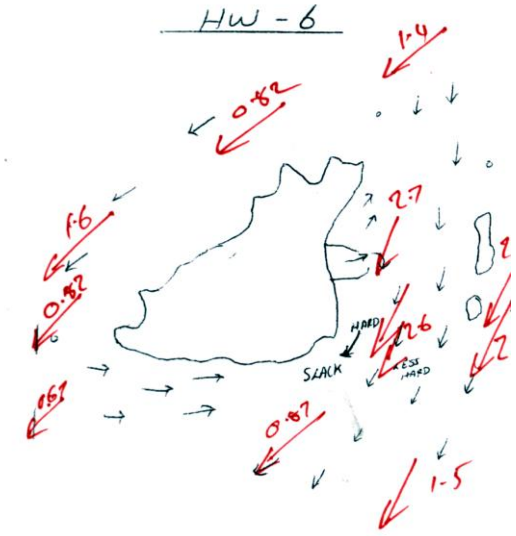


Figure 9: Comparison of sketch vectors with tidal diamond vectors (red)

The sketches cover an area that includes 12 of the 13 tidal diamonds used to calculate the flow vectors, and the hourly intervals noted on the sketches are assumed to refer to St Helier.

By sketching the data from the tidal diamond locations on to the sketch from the appropriate time, the information on the sketches is found to have a high level of compatibility with the official data. Of the 144 time/location combinations, only 6 are found to be at any significant level of disagreement in terms of direction, but there is little help in terms of flow speed.

The most comprehensive result will come from the combination of tidal atlas, tidal diamonds and anecdotal flow sketches; the difficulty is in combining them into a statistically meaningful whole. Since the sketches give good agreement directionally, it can be assumed that they are providing a useful input, but the challenge is how to use the direction without knowing the speed. The algorithm used to interpolate the vectors uses X and Y component vectors which require knowledge of both speed and direction to formulate; otherwise it is a zero vector.

4 Inputs

The algorithm has been largely rewritten using established texts ([iii]) to accommodate the range of data sources and the type of vector information that can be deduced from them. The anecdotal sketches are accepted as being directionally consistent with known data at the tidal diamond locations, and the

Admiralty Tidal Stream Atlas (ATSA) can be used to provide directional boundary conditions. However, at the scale desired, neither can be usefully relied upon to offer velocity magnitude data.

The tidal diamond data is read from a .csv file generated from Admiralty Total Tide software chronologically referenced (as is all data used in this report) to HW at St Helier. This data is assumed to be ‘correct’ and remains fixed throughout the finite differences routine. The anecdotal sketches and the ATSA data are stored as vector components assuming that these comprise a unit vector. This allows the vector direction to be fixed whilst allowing the finite differences approach to vary the vector magnitude to fit the known data. The resulting 850x650 matrix contains about 15%-20% known data (including land). An interpolative approach ([iv], requiring at least two neighbouring point values, is taken to establish realistic guess values for the remaining unknown data points. A number of different computational molecules are used to check for and smooth out any unrealistic values present.

5 Data generation

A central differences algorithm ([v]) is used to relax the vector mesh across the areas that lack fixed information. The known velocities provided by tidal diamond data are used to seed the process and the directional data are used to maintain flow direction where applicable. The relaxation factor is adjusted according to the values of the four points around any given point. This adjustment affects the value of the next iteration. Once the relaxation factor is minimised and holds a reasonably steady state, it can be taken that the mesh is fully relaxed and a solution achieved.

6 Outputs

The outputs are in the form of coloured graphics with arrows indicating strength and direction of flows.

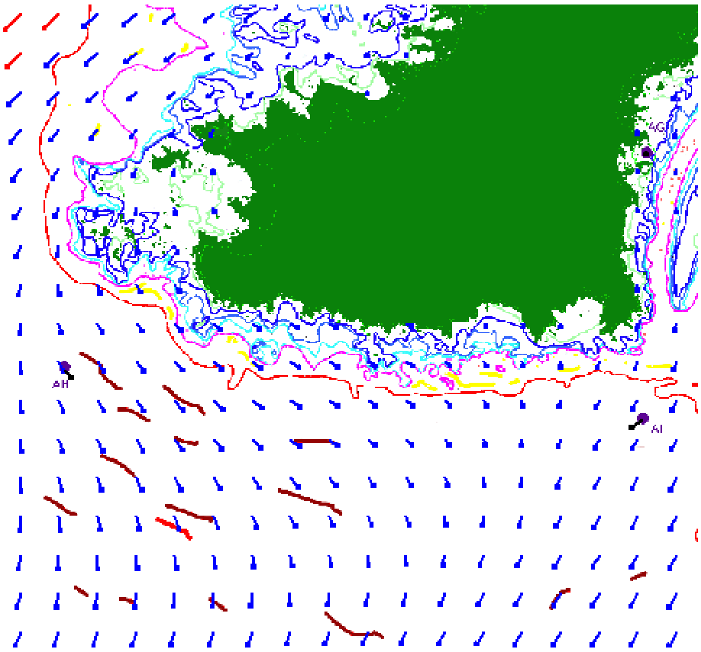


Figure 10: Vector graphic sample

It is easily seen where areas of contra flows and slow flows are present in what might be expected (from ATSA data) to be a fast moving stream.

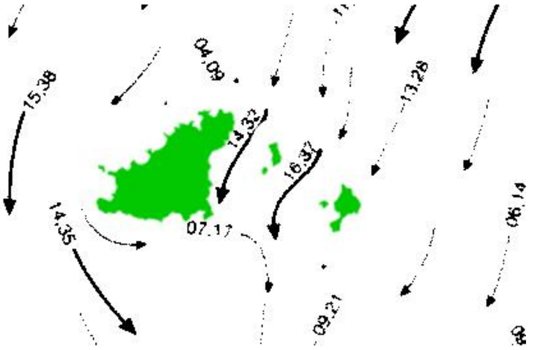


Figure 11: Corresponding ATSA data for Figure 10

Figure 11 shows the ATSA vectors suggesting that a strong flow is running southerly through the Little Russell, apparently being crossed by a weak flow heading east from south Guernsey

A further refinement (Figure 12) shows the use of colour to differentiate flow velocities, in this case, blue denotes flow below 1m/s, red denotes flows over 1m/s and the 13 black vectors denote the tidal diamond value at that point. This allows for the immediate visual check that the algorithm bears an appropriate relation to the source data.

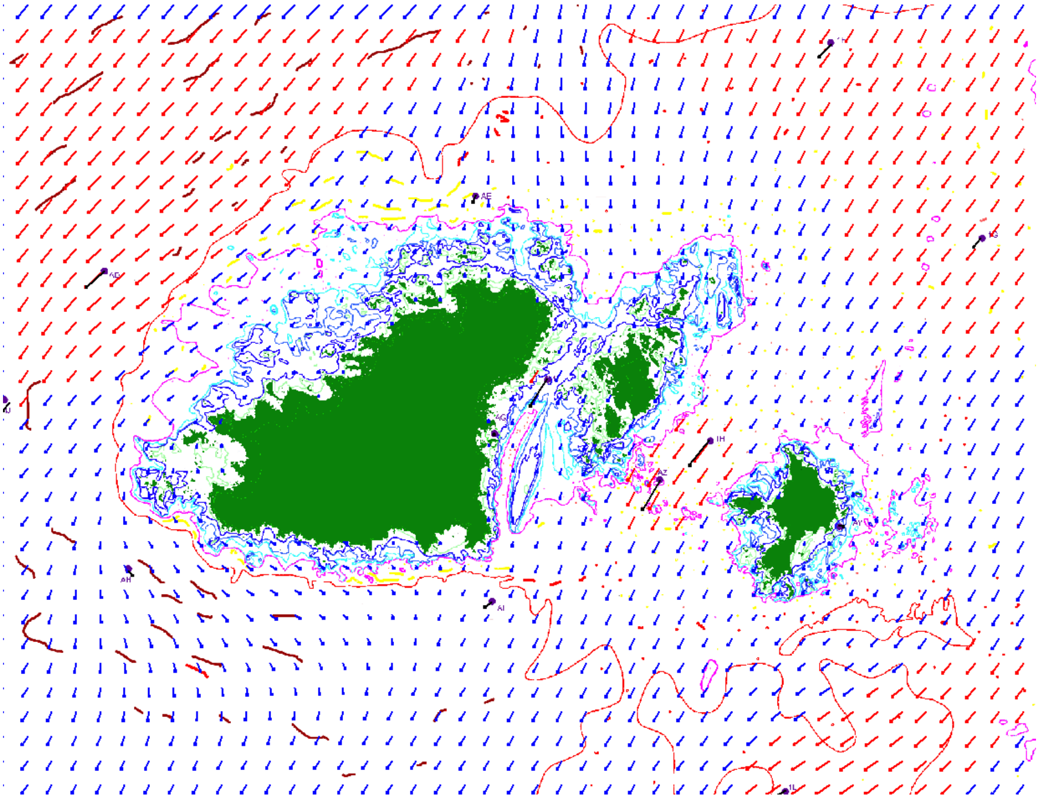


Figure 12: HW-6

The outputs are saved as .BMP files for visual examination and as vector components in .txt files for further automated analysis. Each 1hour dataset is expanded into 4 x ¼ hour datasets using a Lagrangian interpolation routine, giving 52 datasets for the 13 hours (approx) of the Spring HW/LW cycle. The average of the Spring/Neap HW/LW cycles across the area gives a two weekly variation of Neap tides being, on average, 32% of Spring tides.

7 Results

The raw results are in the form of .BMP graphics and very large .txt files and are therefore given in appendices. The highlights are utilised here for discussion purposes. For ease of classification the results will be discussed under three main headings;

- Raw Resource
- Technological Resource
- Economical Resource

Raw resource

For the purposes of this report the raw resource is defined as any movement of water from which energy could potentially be taken regardless of whether or not that extraction is technologically or economically feasible either now or in the future. The raw resource per 1km^2 is given in Figure 13. Each box represents 1km^2 and shows the approximate raw annual energy passing through that volume in GWh per annum. The colour coding shows:-

- White- no resource of an significance
- Blue – < 50GWh/yr, some resource, usually close to land
- Green - < 100GWh/yr, usable but not substantial
- Yellow - < 150GWh/yr, substantial though not attractive for early consideration
- Red - < 200GWh/yr, very substantial
- Magenta- >200GWh/yr, very large, likely to be first considerations

The raw resource passing through the Big Russell is around 700GWh/yr, which is of the same order of magnitude, though slightly more pessimistic than the 810GWh/yr given in (1).

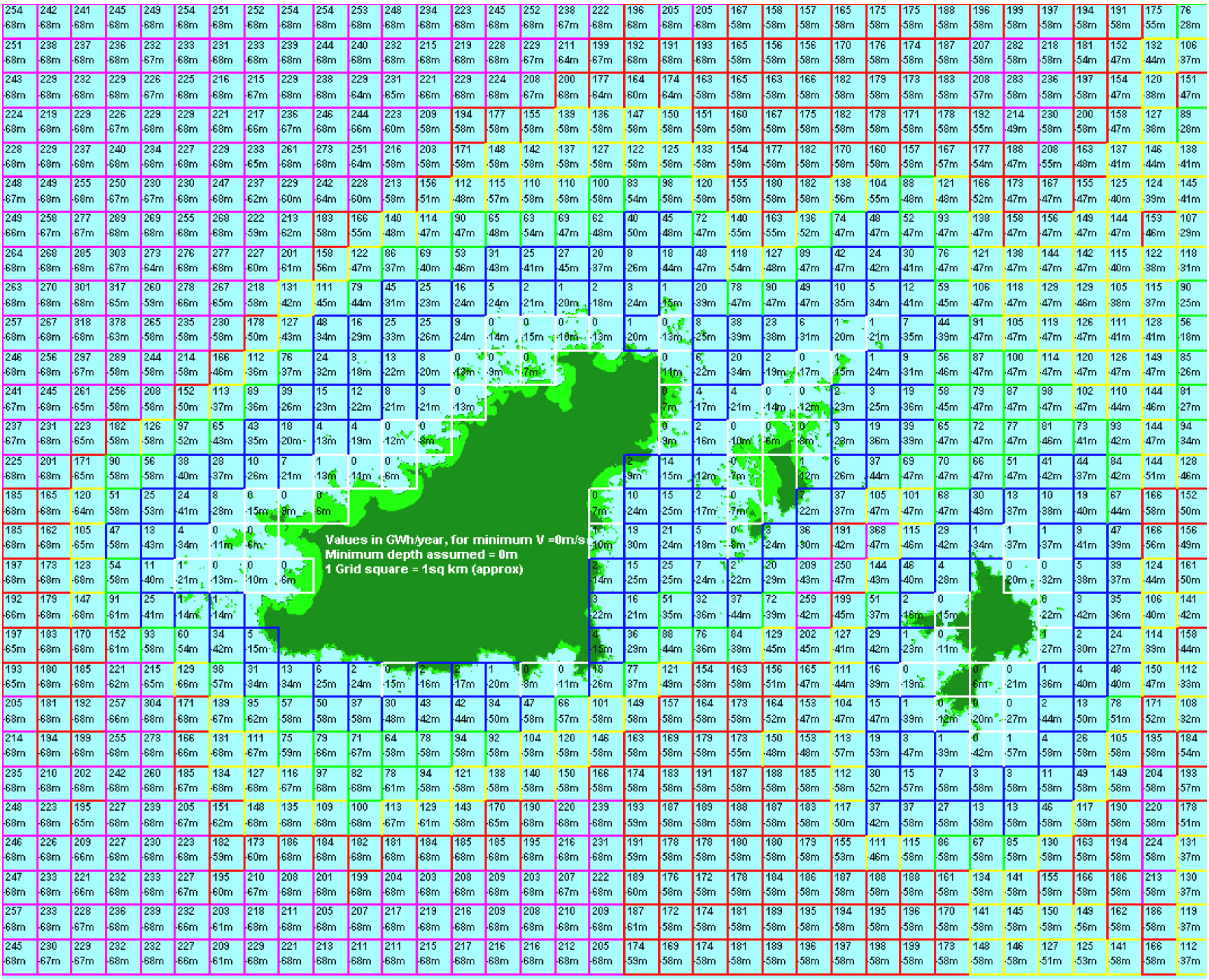


Figure 13: Raw tidal current resource in Guernsey's waters

The area corresponding to CSEC6 (North West of Guernsey) in (1) shows a resource of approximately 2300 GWh/y compared to the earlier paper’s estimate of 2530GWh/y

Technological Resource

The technological resource is that resource which can be exploited by existing or near-ready technologies within the constraints of flow velocities and installation depths applicable.

Assuming that for any device to be considered existing or near-ready, it must have been tested at an appropriate scale and at sea, then referring to the attached Technology Update file, the following devices are potentially applicable:-

Technology update

Marine Current Turbines – max depth -30m

Scotrenewables – buoyant, not depth restricted

Openhydro – 30m depth

Verdant Power – 30m depth

Blue Energy – Tidal fence support structure, not applicable to Guernsey site

Sea Power International – 30m depth

HammerfestStrom turbine, max depth -70m

Clean Current , max depth -50m,

Open Hydro, max depth -50m

GCK Technology, depth unknown, assume 50m

Devices requiring flow speeds 2m/s >:

Since there are no locations within the Guernsey region that combine a flow velocity >2m/s and depths of <30m, then only the Scotrenewable device is applicable out of this selection. The sites exploitable by this device are shown in Figure 14, and suggest a maximum accessible raw resource of 200GWh/y .

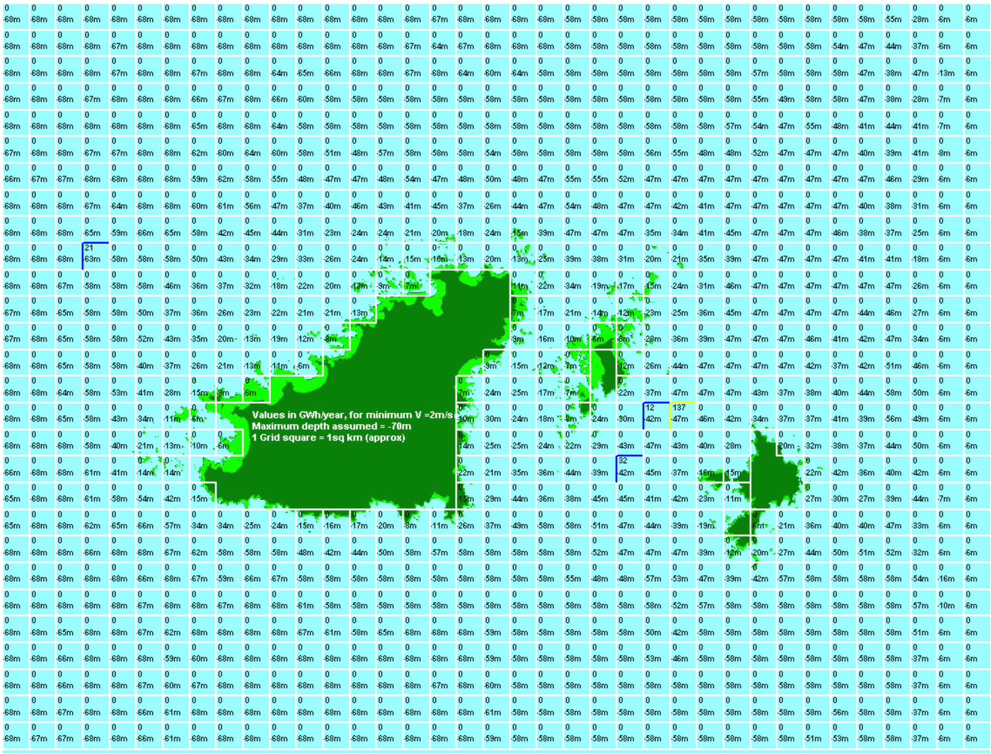


Figure 14: Sites available to Scotrenewables device.

Devices requiring flowspeeds < 2m/s

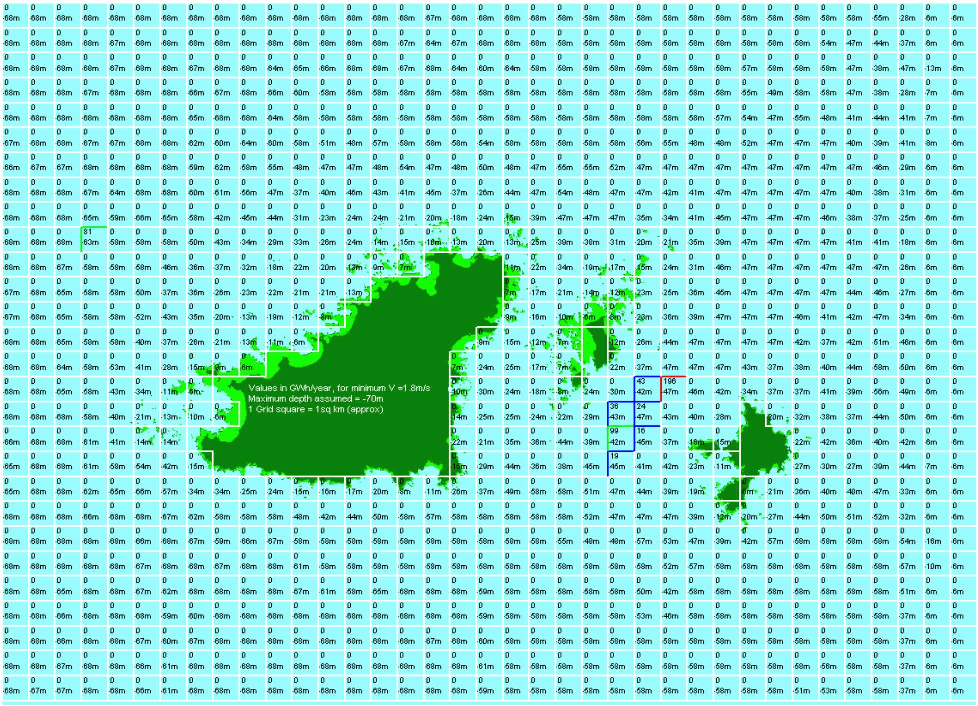


Figure 15: Areas likely to be applicable to Hammerfest Stroem device

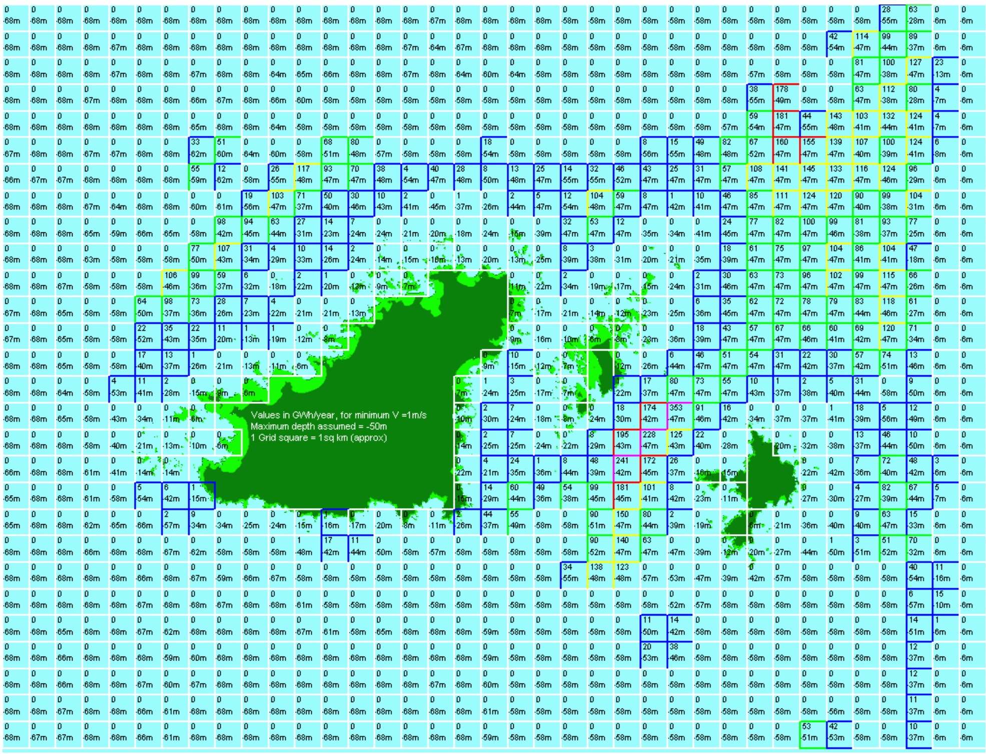


Figure 16: Areas likely to be applicable to a Clean Current device

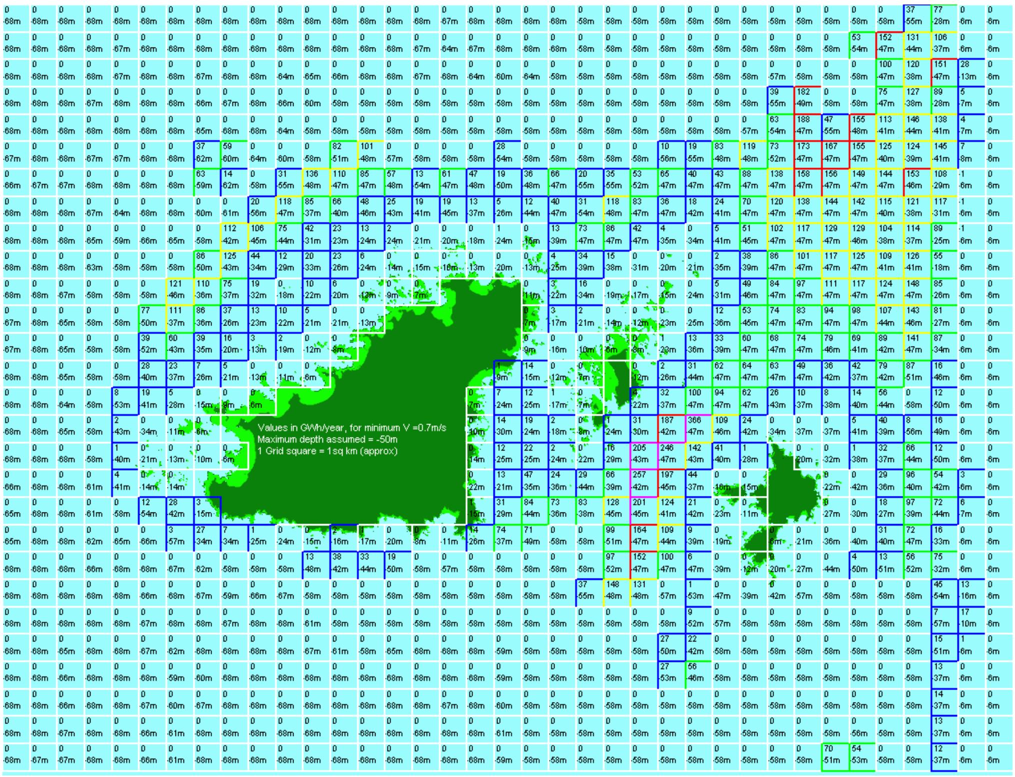


Figure 17: Areas likely to be applicable to a OpenHydro or GCK device

Clearly, the exploitable resource is highly technology sensitive and the sites in the Big Russell are the only ones available to certain devices, therefore making these sites more competitively valuable. Cut-in speed is more important than rated speed or rated output, and it is therefore necessary to obtain

- max/min installation depths,
- cut-in and rated generation speeds
- power curve

from each developer in order to be able to properly assess the technologically exploitable resource.

Economic Resource

The economic resource will require further developed knowledge of device cost, installation costs, servicing costs, cabling, feed-in-tarriffs, etc etc. This work will be available to provide input into that process.

---

[1] Owen A, Bryden IG, A novel graphical approach for assessing tidal stream energy flux in the Channel Isles, Journal of Marine Science and Environment, IMarEST, 2006

[1] UK Hydrographic Office, “Admiralty Tidal Stream atlas NP264”, Crown Copyright, Taunton 1993
[1] Gallagher R.H., et al (ed) “Finite Elements in Fluids”, John Wiley & Sons, Bristol, 1978
[1] Gerald C.F. “Applied Numerical Analysis”, 2nd Ed, Addison-Wesley, Massachusetts, 1978

[1] Dyke P, “Modelling Marine Processes”, Prentice Hall, London 1996,

Appendix D – REA Assessment Process

Introduction

The following method is to be used to assess the environmental effects of wave and tidal marine renewable devices. The aims of the proposed method are as follows:

- Make a judgement on the potential locations of greatest and least effect on the environment from the installation, operation, maintenance and decommissioning of devices;
- Assess the potential environmental effects of wave and tidal devices based on the development scenarios;
- Provide recommendations for mitigation of the potential effects of the devices on the environment.

It must be noted that the REA will not address detailed issues related to site-specific development. The REA does also not replace the need for targeted studies in relevant areas to assess the impacts of specific developments.

Review of Similar Methodologies

The method used in the assessment, and outlined below, is not definitive. It is also expected that there will be modifications and refinements required to the procedures during the assessment process. The method has been informed by reviewing other similar strategic and regional assessments:

- Scottish Marine Renewables SEA;
- Department of Energy and Climate Change: Offshore Energy Strategic Environmental Assessment;
- Regional Environmental Assessment: a Framework for the Minerals Section.

Approach to the Guernsey Marine Renewables REA Assessment

The Assessment is split into 3 main strands:

- Development of the assessment method;
- Topic based examples of issues for consideration in the assessment;
- Application of the assessment method.

Development of Assessment Method

The method proposed for assessing the effects of the marine devices involves a number of stages. It is important to note that the method is an evolving process. Each stage will interact with and inform other stages. In some situations there may be the need for different parts of the assessment to be revisited, for example if new information is provided.

Assessment Method

The assessment method has 4 main stages:

Stage 0: Identification and agreement of a common set of impact significance criteria

Stage 1: Identification of Generic Effects

Stage 2: Assessment of Effect Significance

Stage 3: Assessment Confidence and Monitoring

Stage 0

The aim of this part of the assessment is to establish a common set of impact significance criteria that may be used across all disciplines in the assessment of the severity of any impacts. This will allow a balanced approach to the comparison of impacts and mitigation measures. For example, a 'severe' impact in relation to Marine Mammals should be comparable with a similarly graded impact in another specialist area such as Benthic Ecology, in terms of its overall impact on the colonies in question. The assessment criteria will be established at a workshop held with specialist contributors prior to commencement of the assessment.

Stage 1

The aim of this part of the assessment is to understand the interaction between a device and a specific topic, e.g. Birds. This is a non geographical assessment and so the information can be applied to any marine environment.

Technology 'envelopes' are to be developed, and these will assist with the identification of the generic effects. These are to be based upon the generic characteristics of the marine renewable devices. These envelopes will also allow the assessment to take account of any future advances in the technologies and will take account of the entire lifetime of the devices.

Generic potential impacts of the marine devices will form the basis of Stage 1 of the assessment, with more identification of the effects being informed by consultation with experts and reviews of available research.

Stage 2

This looks at the relationship between the generic effects identified in Stage 1 and the marine environment within the study area. The key issues for consideration are:

- Potential effects on REA topic within the study area;
- Identifying the locations of the entities that are affected within the study area;
- Understanding the characteristics of the affected entities and how they interact with the marine environment;
- Identifying whether and Entity is ‘sensitive’ to the generic effects;
- Assessing the significance of the effects;
- Assessing the likelihood of an effect occurring;
- Identifying mitigation measures that can be used to reduce, avoid or offset potentially significant impacts.

There are three main types of mitigation that could be applied to the assessment of the devices:

- Mitigation incorporated into the device and siting of a development;
- Mitigation based on the implementation of protection measures;
- Recognised mitigation measures

Given that the REA is being undertaken at a still early stage of marine renewable device development it is very hard to know what measure could be incorporated into the design of a device. As well as this, the REA does not know the types of mitigation measures that would be derived from more detailed assessments, such as a targeted EIS. As such, these two mitigation methods cannot be used to inform the assessment of the significance of an effect.

Recognised mitigation measures include:

- Seasonal Restrictions on device installations (such as the avoidance of breeding seasons);
- 500m avoidance zones around pipelines and cables.

Given that these measures are recognised by developers and standard approaches to their application have been developed for a range of developments, these measures can be used to inform the assessment of the significance of an effect.

Stage 3

There is a potential risk that there will be insufficient information available to determine exactly how the devices may affect a given REA topic. The use of the aforementioned technology envelopes will help to reduce any potential risk of error and so increase the assessment confidence.

As well as the potential unknowns with the devices, the REA is to take into account potential gaps in baseline data. As the marine environment is, when compared to the terrestrial environment, relatively inaccessible, the understanding of its characteristics and interactions are limited. Most information for marine environments has either been collected as part of a specific development or study of interest. Information on the uses of the marine environment, such as navigation or recreation, is much more detailed.

Based on the assessment confidence, monitoring will be suggested to fill in the gaps with the baseline data and to improve the levels of understanding of the effects of the marine devices. This part will also identify areas of additional investigation that can be undertaken to increase the levels of understanding of the way the devices interact with the marine environment.

Where significant additional datasets become available, such as new work on the effect of marine devices on collisions or the distribution of fish, the REA could revisit and reassess the potential effects.

Examples of Topic-Based Issues for Consideration in the Assessment

The second part of the assessment method is the identification of topic based issues. Below is a list of example issues, which are not definitive and may be subject to refinement as the assessment process evolves.

Geology and Sediment Transition

The assessment of effects of wave and tidal devices on marine processes and geology is complex. The assessment of effect significance will be based on 4 points, the scale of the effect, effects on the sediment process, changes in levels of sediment suspension and site vulnerability.

Where possible, any arrays where the REA finds that energy regimes will be adversely affected, due to siting of devices, will be mapped and considered in the assessment of development scenarios.

It is the indirect effects that changes in sediment regimes, amongst others, may have on benthic communities that is a key issue connected with this effect. As such, information from this aspect of the assessment will be fed directly into the biological section of the environmental assessment.

Marine Mammals

The assessment will take into account species distribution and activities such as feeding (although there may not be information on specific feeding grounds, any information available on how and when mammals feed will be taken into account), breeding, communication, migrations and abundance. There is not an existing data set that covers all of the above information to a consistent level. However, there is high-level information available on each aspect that can be fed into the assessment. The prediction of specific effects on marine mammals will be based on current understanding of behaviour and assumptions of their reactions with regards to turbines. It will not use evidence specifically related to mammals interactions with devices as there is currently no field-data.

Commercial Fisheries

The assessment of effects on commercial fisheries will take into account the amount of fishing taking place and fishing types (e.g. pelagic, demersal, potting and shell fisheries). The assessment will also take into account seasonal variations in activity. However, any information that is provided by fishermen through the process on the location of their specific (if different from the main grounds) key fishing grounds will not be included in the assessment.

Important area for fishing can change rapidly and fishing methods and locations are very variable. It will therefore be acknowledged in the assessment that more detailed location specific studies will have to be undertaken for individual developments through the project EIA process.

Marine and Coastal Historic Environment

The assessment on areas of potential marine archaeological importance will consider potential sites of submerged landscapes and wrecks. However, it can be assumed that developers will generally avoid wrecks due to the potential difficulties associated with the installation of devices close to wrecks. Any exclusion areas for protected wrecks will also be taken into account. For the purpose of the assessment a risk based approach should be adopted with regards to wrecks and the area buffered around them. This approach should take into account the size of the wreck, such as from a lone cannon up to a full sunken ship, the condition that the wreck is in and the seabed and tidal conditions to assess the dispersal range around the wreck. The method of device deployment also needs to be considered along with the accuracy of the vessel control. All of these factors should be used to asses each wreck on an individual basis in order to ascertain an appropriate exclusion zone

Shipping and Navigation

The effects of devices on shipping is well understood, mainly obstruction and collision. The key issue will be identifying shipping routes of importance within the study area, and their location, width etc. The data ShipRoutes data acquired gives a good overview of key shipping routes and densities, but the routes shown are indicative and not fully representative of the routes taken by vessels. However additional data via the AIS network will also be considered in the assessment giving a more useful mapping of shipping routes.

Recreation

The assessment of effects on recreation will take into account seasonality and key areas of interest.

Application of the Assessment Method

This will be applied in two levels:

Level 1: Assessment of individual arrays (technology envelopes)

Level 2: Assessment of the development scenarios.

Level 1

The main aim of the REA is to assess the impact 260MW+ (the maximum development) and 100MW (the minimum development to meet targets) of marine renewable energy capacity being installed and operating in the Bailiwick of Guernsey on the environment. Based on this the REA will focus on Marine device arrays as these will be the developments that contribute to the electricity production.

The study area will be split into a number of ‘development areas’, which have been identified as:

1. The Big Russel;
2. The Little Russel;
3. St Martin’s Point;
4. East of Sark;
5. The North of Guernsey;
6. The Northwest Coast;
7. The West coast;

The presentation of the results is complex due to the large area of study, the wide range of devices and arrays and the levels of uncertainty involved with the prediction of the effect a device, or array, will have on the environment.

A key objective of the REA is to advise the development of renewable energy in Guernsey and to inform the decision making process. This must be shown by the results. As such, where practical, it will be useful to utilise maps to illustrate the results of the assessment, which will make the results clear and accessible.

Significance mapping will be used to highlight the areas of significance, at all levels from slightly to highly significant effects, for specific receptors. For example a shipping routes map would have the routes highlighted in different colours identifying the significance of an effect.

Level 2

Once the assessment of the arrays has been completed, the REA will consider the cumulative effects of the development scenarios.

The potential grid connections will also be assessed as part of the REA to determine whether there would be an adverse effect on the environment.

The development scenarios will be assessed in two stages as part of the REA:

1. Application of the development scenarios to a development area – calculation of the electoral output that could be generated from each of the development areas based on the development scenarios;
2. Application of the development scenarios to the whole study area – calculation of the potential energy outputs for the study area based on application of the development scenarios, including the cumulative effects that may occur with clusters of devices.

Due to the few numbers of commercial wave and tidal developments, there is a level of uncertainty surrounding the output of wave devices and therefore that of arrays and array size. The energy capacity for wave and tidal devices can vary largely, from well below 1MW to, potential, 5MW+. However, it has been decided that for the sake of the REA an average generating capacity of 1MW per device will be used per device.

The electricity generating potential for each given location will be measured by using the above assumptions and the development scenarios. This will then be assessed considering development in areas where there are:

- No or on slightly significant effects on the environment following mitigation;

- No, slightly or moderately significant effects on the environment following mitigation;
- No, slightly, moderately or highly significant effects on the environment following mitigation.

To apply the development scenarios to the whole study area the assessment aims to find out whether the deployment of devices to generate 200MW of electricity can be generated in areas there will be no or only slightly significant effects, or whether to meet the target development may have to be situated in areas of higher significant effects.

Appendix E – Pre-feasibility Technical Report

Guernsey Renewable Energy Commission

Pre-feasibility Technical Report

November 2009

Contents Amendment Record

This report has been issued and amended as follows:

Rev	Description	Date	Signed
1	Draft for GREC review	04/11/09	C A Green GREC Project Manager

Table of Contents

1. Introduction

1.1 Scope

This report provides a brief study into the Islands of Guernsey, Herm and Sark with regard to their potential for development of Marine Renewable Energy. The report describes the technical engineering constraints presented by the geography of the study area. It provides descriptions of likely components that would make up a renewable energy development, to enable environmental specialists an opportunity to visualise the likely impact of deployment of devices.

1.2 Primary Objectives

- To provide the first technical inputs to the States of Guernsey Marine Renewable Energy project
- To provide background information of a clear and unbiased nature to environmental specialists to aid them in completing relevant sections of the Regional Environmental Assessment, (REA)
- To suggest development scenarios for further detailed assessment

2. Resource

2.1 Tidal Stream

The resource assessment used for this work has been described in the REA scoping document. This was a desk top study based on the BERR Atlas of Marine Renewable Energy Resources and preliminary work undertaken by the Robert Gordon University, Aberdeen. It shows potentially useful tidal energy resources in the Big Russel, Little Russel, off St Martins Point, south of Herm and east of Sark.

2.2 Wave

Again, using data taken from the BERR Atlas of UK Marine Renewable Energy Resources, the REA scoping document shows that there is evidence of a suitable power resource around Guernsey. The exploitation of the more powerful offshore wave resources would be optimised by mooring arrays of devices off the west coast of Guernsey in a depth of approximately 50m. This would coincide with the limit of Guernsey’s territorial seas.

3. Development Strategy

3.1 Capacity Targets

A target installed capacity should be set based upon the available resource, the state of development of the desired technology, and the Island's aspirations toward the proportion that renewable energy should take in the overall supply mix. The detailed allocation of numbers and types of devices to particular deployment areas will be a matter for debate when the next phase of the resource assessment work (by Robert Gordon University) is complete and the environmental constraints are more properly understood by the completion of the REA.

However, for the purposes of the REA, a minimum targeted capacity for installation of 80MW from Tidal Energy and 20MW from wave energy has been assumed. In the provision of information to assist environmental specialists to visualise the impacts of potential renewable energy projects, this report focuses on a typical 40MW tidal array (of which two will be required) and a typical 20MW wave array.

3.2 Development Ownership and Community Benefits

It is likely that the high cost of and commercial risk of manufacturing, installing and operating renewable energy projects will preclude this being done directly by the States. Therefore, any development is likely to be undertaken by existing UK or European utilities, energy generators or by new private companies or consortia. Therefore, it is likely that a significant proportion of the profit from such developments will return to investors. However, recent examples in the UK indicate that some form of local community benefit is generally considered to be essential in the establishment of successful renewable energy farms. This is an important consideration for this study as most residents of the Bailiwick of Guernsey will have some sense of ownership of the seas around the Islands. Methods of returning funds to the community for re-investment in community projects are established and documented by the British Wind Energy Association BWEA. On Guernsey, there is also an opportunity to provide a revenue stream to the Island through the charging of royalties on the value of energy exported through the lease of areas of seabed.

4. Device Technologies

A summary of this section has already been presented in the REA Scoping Report. However, in this report, the commentary has been extended to give greater consideration to the engineering requirements, together with the nature and scale of scheme components.

4.1 Tidal Stream

7.1.1 Tidal Generation Devices

There is a diverse range of tidal device designs currently under development and they can broadly be divided into four main categories based on their principle of energy extraction; horizontal-axis turbines, vertical axis turbines, oscillating hydrofoils and devices utilizing the Venturi effect (it should be noted that although Venturi could perhaps be considered a sub-set of horizontal axis machines, they present different considerations when undertaking Environmental Impact Assessments (EIAs). Therefore, it is appropriate to treat them as a separate category).

- Horizontal-axis turbines work on a similar concept to on-shore wind turbines. The moving water turns the blades in a similar manner to air flowing past a wind turbine. The SeaGen is an example of a horizontal-axis device (http://www.seageneration.co.uk/).
- Vertical-axis turbines work on a similar principle to horizontal-axis turbines, the major difference being that the rotor's axis has been re-orientated by 90o so that it is vertical. The Proteus Mark III is an example of a vertical-axis device (http://www.neptunerenewableenergy.com/).

Horizontal and vertical turbines can also be further sub-classified into lift and drag type turbines, the first of which are characterised by blade speed exceeding water speed and latter having lower blade speed in comparison with speed of water. Lift type devices are known to be more efficient than drag devices [HydroVolts; The evaluation of an axial flow, lift type turbine for harnessing the kinetic energy in a tidal flow, W.J. Swenson, Northern Territory Centre for Energy Research, Northern Territory University]

- Oscillating hydrofoils move due to water flow on either side of an aerofoil section. The tidal current flow over the hydroplane section creates vertical forces which cause it to oscillate. This motion and force is used to drive a hydraulic motor and subsequently turn a generator to create electrical power. The Pulse hydrofoil concept is an example of a device utilizing this technology (http://www.pulsegeneration.co.uk/).
- Venturi Effect devices are enclosed in a duct, whose diameter reduces in order to increase flow rate through the turbine. The orientation can be horizontal or vertical. The accelerated water can either drive a turbine directly or produce a pressure difference which is used to

drive an air-turbine. The Rotech Tidal Turbine is an example of a device utilising the Venturi effect (http://www.rotech.co.uk/).

A range of different systems are used to secure devices to the seabed. Thus tidal devices can also be sub-classified as floating, gravity based or pile mounted. Floating devices can be attached to the seabed using a flexible cable or chain and be allowed to move relatively freely responding to the changes of tidal direction. Alternatively, they can be secured by a fixed rigid mooring to limit movement, or arranged in a group of turbines on a supporting platform which responds to water level changes. Devices that are gravity based are mounted on the seabed or resting on it rigidly due to the device's large weight. Pile mounted devices rest on a pile drilled into the seabed and can often be lifted up for maintenance.

In general, the trend for tidal stream devices (irrespective of the energy capture principle) is for offshore deployment in water depths of up to 100m, with typical depths of approximately 20-50m. This study focuses on an area with a water depth of 20-50m which is suited to most offshore tidal devices. Large scale applications of tidal devices will involve the installation of numerous devices or device arrays known as tidal energy farms. It is anticipated that for an array footprint of 0.5km2 (30-50 devices), the potential generating capacity could be in the order of 30 to 50 MW.

7.1.2 Tidal Turbine Structures

To support the actual turbine itself it is necessary to mount it on some form of suitable sub-structure secured to the sea bed. This structure will have tolerances set on its alignment in both the horizontal and vertical plane to ensure the turbine operates efficiently. These limits are unlikely to be above +/-4 degrees.

There are currently three approaches considered to achieving anchorage to the sea bed, namely gravity based, piling or tension mooring.

- Gravity Base is becoming the design aim of the majority of device developers. It relies on building a structure of sufficient mass in water, or that can be ballasted with sufficient mass, to create frictional drag on the sea bed of a magnitude able to withstand the drag-forces induced by the tidal flow and the overturning forces (moments).
- Pile or pinning. A mono pile is driven into the sea bed or "pins" are driven which pass through and are used to clamp a steel structural frame to the sea bed.
- Tension Mooring. The device is positively buoyant and floats in the water column attached to the sea bed via tension legs which are in turn anchored through either gravity or by pinning. This allows the device to slew and move to its optimum orientation with respect to tidal flow.

Each of these techniques has obvious merits and has been used successfully in other offshore applications. However, there are various difficulties associated with their application to tidal turbines. Gravity bases are, in theory, the simplest and should be the easiest to deploy. To secure a turbine of 1MW capacity with a blade diameter of approximately twelve metres in tidal velocities of approximately 1.75 m/s, it is likely to require ballast weights of approximately 700tonnes. This is approximately 91m3 of steel, or a 4.5*4.5*4.5m block.

Mono piles require driving into the sea bed to a suitable depth to allow them to withstand the over-turning moment and support the weight of structure above. The pile size for a 1MW capacity turbine will require approximately 14m penetration with a maximum diameter of 914mm. The driving operation generally requires some form of jack-up or spread moored vessel. These vessels can generally only work in tidal velocities of 0.5m/s for jacking or piling and 1.5m/s for other working. This results in a very short working window through each tidal cycle requiring vessels to be on site for long periods with the potential for long periods of weather downtime.

Tension mooring of devices that are semi-submerged in the water column is a complex solution. The dynamic forces are difficult to quantify and so assumptions to ensure the design is safely engineered must err on the cautious. Each mooring leg will need expert design but is likely to be made up in sections to deliver the required properties. These are likely to consist of a clump weight or Bruce type anchor, length of chain and then a flexible link. Clump weights are likely to be in the region of 30 to 50 tonnes with the full anchor leg being anywhere from 10 to 80m in length depending on the device attached.

Gravity bases are the design aim as they should, in theory, require simply lowering to the sea bed from a suitable vessel. The operation requires no or limited sea bed preparation and less time to perform the actual installation. The large masses involved mean that deployment often cannot be achieved in a single lift and it therefore must be done in stages at each slack water period and could take up to six lifts to complete.

4.2 Wave Energy Conversion (WEC) technology

7.1.3 Wave Generation Devices

There is a diversity of WEC device designs currently under development. These can be divided into four main categories, based on the principle of energy extraction employed: attenuators, overtopping, point absorbers and oscillating water column (OWC).

- Attenuators are floating WEC devices which have their main axis perpendicular to the wave front. They operate in parallel to the wave direction, riding the waves. The Pelamis device is an example of this type of device (http://www.pelamiswave.com/)
- Overtopping devices store the water from the incoming waves in a reservoir above sea level, using it to drive low-head turbines for energy generation. The Wave Dragon is an overtopping WEC device, using this principle of operation (http://www.wavedragon.net/).
- Point absorbers are floating WEC devices which extract energy in all directions through the vertical movement of a moving part in relation to a fixed base. Examples of point absorber devices include the Ocean Power Technology’s PowerBuoy and the Fred Olsen’s FO3 device (http://www.oceanpowertechnologies.com/).
- Oscillating Water Column (OWC) devices are open to the sea below the water line and enclose a column of air. Moving waves cause the water column to rise and fall, compressing and decompressing the trapped air column. The moving air column drives a turbine to

generate electricity. The onshore Wavegen and offshore Energetech are two examples of OWC devices, along with the Superbuoy concept (http://www.wavegen.co.uk/ and http://www.oceanlinx.com/ previously known as Energetech Australia Pty Ltd.).

In terms of their installed location, WEC devices can also be sub-classified as shoreline, near-shore or offshore. The trend in all types of Offshore WEC device design is for deployment in water depths of up to 100m, with typical depths of approximately 50m. Offshore design is mainly preferred due to the higher annual wave energy available.

This study focuses on an area with a water depth of 20-50m which is suited to 'offshore devices'. However, it is important to note that shoreline and near-shore devices are available and may be suitable for deployment within the region. Aquamarine Power's Oyster and Neptune Renewable Energy's Triton are two examples of devices operating in shallower and near-shore waters (http://www.aquamarinepower.com/ and http://www.neptunerenewableenergy.com/).

Large scale applications of WEC devices will involve the installation of large arrays or wave energy farms. It is anticipated that for an array footprint of 4 km2 (7 to 100 devices) the potential generating capacity will be in the order of 15 to 50 MW [ ].

7.1.4 Wave Energy Convertor Moorings

The different types of wave energy convertors all require a slightly different approach to mooring system design. The amount of positive buoyancy involved, the required motion and depth of water will dictate the system design.

In general, in areas of high energy seas, the sea bed tends to be hard rock or mobile shoals of pebbles/shale. Large boulders are often reported to move along the seabed through such areas. It is unlikely that a simple short length of chain attached to a Bruce or fluke type anchor will obtain sufficient purchase alone. The mooring systems will therefore be of a composite leg type with clump weight or anchor, length of chain and flexible section. The number of legs will be dependent on the device.

Pelamis machines currently use two to three nose anchorages leading into the prevailing wave direction with a single stern leg that is long enough to allow the device to pivot and align with the predominant wave direction within suitable limits. The current devices are 3.5m in diameter with an overall length of 120m for a power output of 750kW.

Point absorbers such as OPT's Power Buoy are more likely to use three or more equally spaced legs. The clump weights and design of moorings will be dependent on the device but a rule of thumb is that mooring lengths should be at least three and a half times the water depth, so for 50m depth this gives 175m per leg. Clump weights will be in the region of 30 to 100tonne depending on the device. The new PB150, a 150kW device will be 10m maximum diameter with an overall height of 44m (34.75m of which is submerged).

One device known to use tension leg moorings, similar to that used by semi-submersible vessels in the oil and gas industry, is being developed by Orecon. This is a 1.5MW wave energy device with a large surface structure. It can therefore be assumed that the sub sea weight required will also be large, possibly thousands of tonnes as opposed to hundreds.

4.3 Infrastructure Equipment

Since each tidal turbine or wave energy convertor is of relatively low capacity in relation to anticipated demand it will be beneficial to connect several together offshore and then to transmit the generated power ashore via either a single cable or two or three smaller ones. A method of isolating either single turbines or small groups is probably required to allow flexibility in operation and to provide a means to isolate machines for maintenance or repair without having to shut down the whole farm. This all requires the deployment of additional equipment either to the marine energy converters or to a connecting hub-structure.

At present sub-sea connection and hub infrastructure for power systems is not fully developed. The systems will need to take from the offshore oil and gas industry which does deploy much of the required building blocks, albeit with lower capacity ratings that will be required for large marine energy schemes. In particular the development of subsea transformers to step the voltage up for efficient transmission to shore is required. Currently they have and are being deployed in similar capacities for the Ormon Lange oil field in Norway. These devices are relatively large, potentially with an 8m diameter footprint, and can weigh in the region of 35 to 50tonne in air. Additional mass for adequate ballast or foundation to retain them in high energy seas such as those around Guernsey, Herm and Sark is also required. Depending on the type and profile of the sea bed this could require complex structures and installation techniques adding to cost and time to deploy.

The requirements of the various developers are likely to be mixed and so requesting data from them as to facilities they would like, whilst necessary, can lead to a complex picture that is difficult to turn into a realistic industry-wide set of specifications. Bearing this in mind and the stated aim of providing input to the REA study, the following list of minimum requirements is given;

- A transmission cable from the offshore site with a path to a grid or transmission network;
- An area of sea consented and marked appropriately as a marine energy zone;
- A form of SCADA (Supervisory Control and Data Acquisition) system capable of providing a sufficient level of control to satisfy the requirement of Marine Guidance Note (MGN) 275 in an emergency situation;
- A set of metering equipment which will accurately measure both power produced and power used;
- Suitable control and safety switch gear for connection to either a local transmission network or private consumer dependent on scheme adopted;
- Appropriate buildings to house the shore-side equipment and control stations as required by the scheme adopted;
- Appropriate structures and housings for any sub-sea equipment required in the scheme adopted;
- Appropriate transformers and associated equipment offshore to step up the generated voltage before transmission to shore to reduce losses.

5. Logistics and Port Facilities

In installing any marine energy conversion devices the offshore logistic requirements are very much dependent on the nature of energy farm to be installed and the local port facilities available. It should also be noted that Guernsey has no existing heavy industry of the sort associated with subsea engineering. It is therefore necessary for the majority of devices and other equipment to be imported to the islands ready for installation. However, some tasks and components will remain common to all types of development with respect to their logistics and their impact on the Island of Guernsey. In particular this includes transmission cable installation, large mooring or foundation deployment and shore control equipment installation.

Large capacity transmission cables will be required for the capacities currently envisaged. It is common practice to load this type of cable directly onto the vessel which will lay it. Suitable manufacturing and loading facilities exist at Hartlepool, Rosyth, or Oslo Fjord in Norway. The vessel will then transit to site, complete the installation, and returns to a convenient home port to de-mobilise. Additional facilities are thus unlikely to be required from any ports in Guernsey.

The installation of foundations, moorings, sub structures and turbine nacelles will require the use of port facilities at a conveniently close location. Many of the turbine manufacturer’s have recognised and wish to establish techniques where prefabricated sections of structure and turbine can be completed close to the deployment sites to reduce transportation costs and ease logistics difficulties. Their sequence of activities would thus be to ship pre-fabricated sections to a vessel mobilisation port, complete assemblies, load installation vessels (probably three at a time), transit to site, deploy and then return to collect more.

It is currently envisaged that the majority of device developers will not be able to make use of existing port facilities in the Channel Islands due to their limited size, exposure of the harbour bed at low water and lack of lay-down areas. This is not considered to threaten the overall feasibility of renewable energy development, as there are existing suitable port facilities in northern France and southern England. The provision of any new port facilities on Guernsey would be a major undertaking, and would present environmental impacts that could be much more significant than the development of Marine Renewable Energy itself. Conversely, such provision would benefit not only the renewable energy industry, but also many other aspects of the Guernsey economy. The provision of new port facilities is not essential to the development of Marine Renewable Energy, and therefore this report, and the REA itself, will not consider this as a consequential impact for assessment within the study area.

6. Grid Connection

6.1 Grid Overview

The description of the grid on the Island of Guernsey is included in documents available to the public on the Guernsey Electricity website, such as the Statement of Opportunity were referenced in compiling this document.

The map and information supplied by Guernsey Electricity highlighted the following bulk supply points; two at Guernsey Electricity's North side site, Les Amballes, Belgrave, and at Kings Mills. All of which serve the north and east of the island with the exception of Kings Mills. No value of available import capacity is available but it can be assumed this would vary and could be substantial due to the sophisticated nature of the grid operation and stability practised on the island.

The site at Kings Mills is closest to the possible sites for development as Wave Energy Farms with the North Side site, Les Amaballes and Belgrave being closer to the main potential tidal resource areas. The tidal resource area to the south of Guernsey may benefit from the proposed upgrade at Ville au Roi, depending on the planned works at this site.

6.2 Potential Cable Routes

It is clear that minimising the length of cables helps to reduce costs and improve system efficiency. However other factors also dictate viable cable routes such as;

- Site location
- Available grid/ distribution network points
- Sea bed type
- Beach landing point

The site and direction of incoming waves or tidal streams will determine the layout of device arrays and subsequently the cable routing into the area. This will be further complicated by avoiding such things as local rocks, wrecks, fishing grounds or other zones which will mean that the route is not a straight run between the selected landing site and the device array. The detailed route engineering will require a full seabed survey to show the depths, seabed type and identify wrecks to be avoided.

In general it is preferred to bury cables across the selected beach and along the route to the offshore site using equipment deployed from the cable lay vessel during the lay process. The simplest form is termed a "plough"; these are towed behind vessels whilst the vessel moves along deploying cable along the route. They have the advantage in that many of them can land cables and allow them to be pulled up the beach to commence burial. A depth of burial of approximately 2m can be achieved in this way in soft sand or clay. Regular beach profile survey data is essential to ensure that the required minimum depth of burial is maintained throughout the life of the cable.

Shore landing sites must be selected carefully and will be dependent on the type of installation vessel proposed. Most large DP class cable vessels for un-coilable cable require a minimum water depth of 10m to operate in. Therefore, the closer that this depth is reached to the low water mark, the better. Anything above 2km is probably prohibitive as floating this length of power cable to shore is difficult. If used, a barge or pontoon can be beached on certain types of seabed to perform the shore pull in, but they can only deploy cable at a relatively low rate. In general, sandy beaches that allow for relatively easy cable burial are preferable. Although pebble beaches can be more stable whilst still allowing burial with more conventional techniques. This is due to the possibility of sand washing away in certain wave climates and thus leaving the cable either nearly or actually exposed and thus susceptible to damage. Rock trenching equipment for cable burial is available but this is slow and therefore expensive to use with additional complexities in operation when compared to traditional cable ploughs.

The Island of Guernsey currently has five subsea cables shown on Admiralty chart 807. The Interconnector with Jersey, a telecoms cable into Saints Bay, a power cable to Platte Fougere, and two into L'Ancresse Bay assumed to be telecoms by their indication on admiralty chart 807. This indicates that deploying and landing cables is perfectly feasible along the coastline, including large power cables. There are no cables, power or telecoms indicated between Guernsey, Herm and Sark on chart 807.

The following photograph shows the difficulties that would be faced in trying to bring cables ashore on many of the beaches on the west coast. It shows the rocky sea bed, with the photograph taken at a time close to low water to illustrate that burial of the cable would require some form of rock trenching tool. It also indicates how it would be difficult for cable vessels to move to within an acceptable distance to float a cable ashore due to the numerous rocky outcrops and shallow slopes toward deeper water. The photograph shows L'Eree bay, which is close to the sites of interest for wave energy farms.

Figure 6.2.1 L'Eree Bay

The photograph below illustrates the reverse and shows how some of the beaches on the island are actually ideal for cable landing. With good sand coverage and water depths that allow cable vessels to approach to a relatively close range for cable pull in. L'Ancresse bay on the northern coast has a good sand coverage, with a depth of water close enough to make cable pull in possible. There is also good access on the landward side with the main roads from St Peter's Port. Unfortunately there are already two cables marked as coming ashore on the beach, meaning, at best, careful survey and deployment would be required. At worst, it will not be possible to use the beach for landing cables whilst the others are in service.

Figure 6.2.2 L'Ancresse Bay

The photograph below of Saints Bay which has telecoms cables and illustrates how cables can be brought ashore on beaches consisting mainly of pebbles and buried for protection with no visible effect other than a small jointing pit and cable marker.

Figure 6.2.3 Saints Bay

From the limited data available at the time of writing, the most promising or obvious beaches for landing power transmission cables from marine energy sites are Saints Bay, Havelot Bay, L'Ancresse Bay, Vazon Bay, Cobo Bay (Although local knowledge would suggest Cobo has some constraints). There is also some potential, through an angled drilling, at Pleinmont Point on the south side. Other beaches along the south coast have potential but are either more remote from the offshore sites or have limited landside access. The limitations of this are illustrated by the photograph below of the road leading to Saints Bay, one of the better served sites. It shows the difficulties of moving land drilling rigs or the size of winch that will be required for pulling ashore power cables of the size envisaged.

Figure 6.2.4 Saints Bay access road

Obviously this list includes beaches which already have cables crossing them and so careful consideration and detailed planning of routes will be required to avoid impacts to existing cables.

The cables would then need to be routed to the nearest bulk supply point or small substation capable of accepting the power import to the Island network.

7.1.5 Wave Sites

For the wave sites to the west this is likely to be the sub-station at Kings Mill close to the water treatment plant. The cable could then be landed at Vazon Bay, buried under the beach passing through the sea defences via a duct installed in a directional drilling to a jointing pit. The cable could then be run in a similar fashion to other cables in ducts underneath the road to the substation.

7.1.6 Tidal Stream Sites

The majority of the tidal energy appears to be at the southern end of the Big Russel and so the cable landfall would be located at the southern end of the island or if possible in Havelet Bay. Although, it must be recognised that a full risk assessment, to ensure damage to the island interconnector is avoided, would be required before this route is taken.

6.3 Cable Size

The initial assessment of cable size would be based on the power to be transmitted, transmission voltage and distance to grid connection point. For the purposes of the cost estimation that accompanies this report, a cable from the Big Russel to Saints Bay on the south of Guernsey has been considered.

In general the overriding controlling factor in installing a cable of this nature is the temperature rise when at full capacity through the splash zone transition. This is because , due to the heat generated by the cable, it is usual to place the cable in some form of ducting, and direct burial is preferred.

For comparison purposes the cable scenarios were investigated to provide size and rough order cost estimates. A cable length of 8.65km is assumed, operating at a voltage of either 11kV or 33kV, and transmitting power of 15MW or 40MW respectively.

Since the sea bed is aggressive in most locations, with a high energy coastline the cable is likely to require double helical galvanised steel armour for protection. A typical cross section of an appropriate cable construction is given below.

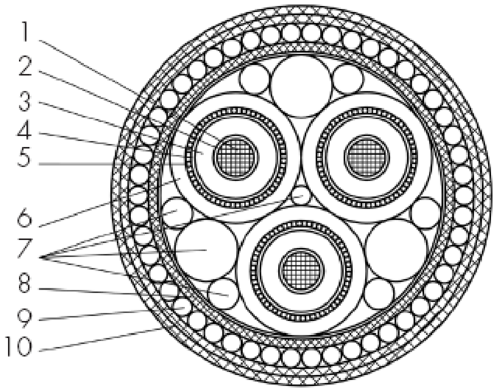


Figure 6.3.1, typical cable cross section

The table below illustrates the results of rough calculations on the cable dimensions and cost. This cost is for the main transmission cable only and does not include connections or installation. It does however highlight the impact of scheme design and transmission voltage on project cost.

Parameter	**11kV, 15MW**	**11kV, 15MW**	**11kV, 15MW**	**33kV, 40MW**	**33kV, 40MW**	**33kV, 40MW**
Length Required	3*8650m	3*8650m	3*8650m	8650m	8650m	8650m
CSA mm	240mm^2	300mm^2	630mm^2	240mm^2	300mm^2	630mm^2
Weight in air, approx kg	19kg/m	24.1kg/m	39kg/m	19kg/m	24.1kg/m	39kg/m

Table 6.3.1 – Cable parameters

Further calculations on the temperature rise through dunes or beachheads would be required but from the above data transmission to shore at 33kV, 40MW with a copper Cross Sectional Area (CSA) per conductor of 300mm2 is a suitable starting point. This allows some capacity for either increase in scheme power output and a safety margin for temperature fluctuations. The probable outside diameter of this size cable is somewhere in the region of 120 to 150mm dependent on the armour and insulation packages. To complete the ambitious target of 100MW by 2020 it is likely that three or four cables of this size will need to be landed.

7. Installation

7.1 Required activities

To install either a Wave or Tidal energy farm a fairly common sequence of activities is required. The overall process will take several years and is very much weather and tide dependent. In addition to the environmental and consenting aspects, the steps below are generally recognised as the basic building blocks of a suitable installation programme;

1. Sea bed survey, bathy and geomorphology, cable route and site
2. Landfall survey with route to grid connection point
3. Scheme design, including required shore facilities
4. Procurement and manufacture
5. Shore-side construction
6. Deploy foundations, moorings
7. Lay cables, main transmission and interconnect
8. Deploy sub-structures
9. Deploy nacelles/ turbines
10. Cable pull-in to turbines
11. Commission and test
12. Handover

The size and complexity of the scheme impacts on the length of time each task takes to complete. Careful scheduling to ensure installation time and cost is minimised is therefore critical to ensuring successful completion.

The following two approaches listed are based on installation of a typical 40MW tidal energy farm located in the Big Russel with cables running ashore at Saints Bay. This gives, on current state of technology the following rough list of equipment to be installed offshore, with cable lengths being very approximate.

7.1.7 Scheme A

Assuming tidal turbine technology has advanced to the production of 1.5MW machines by 2014, this would then require the installation of 27 turbines in the Big Russel. These could then be connected to three hubs, each of 15MVA capacity, with step up transformers, which in turn would be connected to a single Point of Common Coupling (PCC) to transmit the power ashore at 33kV.

This would then require approximately 13.5km of interconnect cable rated at 1.5MVA and 11kV in various lengths with three lengths of 15MVA, 33kV cable and a single length of approximately 8.65km of 45MVA, 33kV shore transmission cable.

7.1.8 Scheme B

Again assuming turbine technology has advanced to the production of 1.5MW machines and a 40MW site is envisaged. This would thus again require 27 turbines to be installed.

Instead of stepping up the voltage, the “hubs” will act as a PCC for nine turbines again and then three cables, each with a capacity of 13.5MVA at 11kV will be run to shore at Saints Bay. This gives 13.5km of 1.5MVA interconnect cable and three 8.65km lengths of 13.5MVA shore transmission cable.

Deployment would be achieved using either a large Dynamic Positioning Vessel, able to hold itself on station in moderate currents and wind during lifting and lowering operations using a variety of directional thrusters, or by using a moored barge.

8. Operation and maintenance

8.1 Operational Approach

The operations approach will considered in reference to a typical 40MW tidal site. Some form of engineering management will be required to ensure a safe and economically successful operation. This is likely to include personnel to observe condition monitoring equipment, perform basic operations to connect, dis-connect and vary power produced etc.. Whether or not these tasks are performed on the island is dependent on the final scheme owner and their company operating procedures/ philosophy. Some form condition monitoring and maintenance activity of the shore-based equipment with the ability to perform some tasks offshore will be required.

In addition, depending on the device characteristics, there may be a requirement for devices to be removed from the sea from time to time for cleaning or replacement of parts.

It is therefore reasonable to assume that some employment opportunities on the island will be created. The more senior roles are likely to require personnel with a reasonable degree of training and academic qualification.

8.2 Emergency Response

If the States Harbourmaster and forthcoming local Marine Health & Safety Legislation require the adoption of UK Marine Guidance Note (MGN) 275 then a remote means of safely shutting down the energy farms in the event of a marine incident will be required. This response must be immediate at the request of the local emergency services and so a physical means to perform this on the islands is likely to be required along with suitably trained personnel who can also coordinate effectively with the emergency services dealing with the incident.

9. Conclusion and Use of This Document

This document has been prepared to describe the nature of likely developments and the engineering constraints that may apply, together with the methods that could be used to address these. It may be used by REA Chapter-Writers as a general reference to help them to understand the likely impacts that development could have on the environment. However, it is anticipated that Chapter-Writers will require further information specific to their specialism. Further information will be available from GREC throughout the preparation of the REA, as required.

Appendix F-1 – Benthic Ecology - Definitions of habitat sensitivities following Marlin guidelines

Sensitivitiy Scale	Definition
Very high	The habitat or species is very adversely affected by an external factor arising from human activities or natural events (either killed/destroyed, 'high' intolerance) and is expected to recover only over a prolonged period of time, i.e. >25 years or not at all (recoverability is 'very low' or 'none'). The habitat or species is adversely affected by an external factor arising from human activities or natural events (damaged, 'intermediate' intolerance) but is not expected to recover at all (recoverability is 'none').
High	The habitat or species is very adversely affected by an external factor arising from human activities or natural events (killed/destroyed, 'high' intolerance) and is expected to recover over a very long period of time, i.e. >10 or up to 25 years ('low' recoverability). The habitat or species is adversely affected by an external factor arising from human activities or natural events (damaged, 'intermediate' intolerance) and is expected to recover over a very long period of time, i.e. >10 years (recoverability is 'low', or 'very low'). The habitat or species is affected by an external factor arising from human activities or natural events (reduced viability, 'low' intolerance) but is not expected to recover at all (recoverability is 'none'), so that the habitat or species may be vulnerable to subsequent damage.
Moderate	The habitat or species is very adversely affected by an external factor arising from human activities or natural events (killed/destroyed, 'high' intolerance) but is expected to take more than 1 year or up to 10 years to recover ('moderate' or 'high' recoverability). The habitat or species is adversely affected by an external factor arising from human activities or natural events (damaged, 'intermediate' intolerance) and is expected to recover over a long period of time, i.e. >5 or up to 10 years ('moderate' recoverability). The habitat or species is affected by an external factor arising from human activities or natural events (reduced viability, 'low' intolerance) but is expected to recover over a very long period of time, i.e. >10 years (recoverability is 'low', 'very low'), during which time the habitat or species may be vulnerable to subsequent damage.
Low	The habitat or species is very adversely affected by an external factor arising from human activities or natural events (killed/destroyed, 'high' intolerance) but is expected to recover rapidly, i.e. within 1 year ('very high' recoverability). The habitat or species is adversely affected by an external factor arising from human activities or natural events (damaged, 'intermediate' intolerance) but is expected to recover in a short period of time, i.e. within 1 year or up to 5 years ('very high' or 'high' recoverability). The habitat or species is affected by an external factor arising from human activities or natural events (reduced viability, 'low' intolerance) but is expected to take more than 1 year or up to 10 years to recover ('moderate' or 'high' recoverability).
Very low	The habitat or species is very adversely affected by an external factor arising from human activities or natural events (killed/destroyed, 'high' intolerance) but is expected to recover rapidly i.e. within a week ('immediate' recoverability). The habitat or species is adversely affected by an external factor arising from human activities or natural events (damaged, 'intermediate' intolerance) but is expected to recover rapidly, i.e. within a week ('immediate' recoverability). The habitat or species is affected by an external factor arising from human activities or natural events (reduced viability, 'low' intolerance) but is expected to recover within a year ('very high' recoverability).
Not sensitive	The habitat or species is affected by an external factor arising from human activities or natural events (reduced viability, 'low' intolerance) but is expected to recover rapidly, i.e. within a week ('immediate' recoverability). The habitat or species is tolerant of changes in the external factor.
Not sensitive	The habitat or species may benefit from the change in an external factor (intolerance has been assessed as 'tolerant').
Not relevant	The habitat or species is protected from changes in an external factor (i.e. through a burrowing habit or depth), or is able to avoid the external factor.

Appendix F-2 – Benthic Ecology - Significance Assessment Criteria following Marlin and JNCC guidelines

Significance Level	Definition
High	Impact on a known area of ecological importance designated as a cSAC or pSAC under the habitats directive, where a species/habitat that has a high to very high sensitivity to the impact in question is within the zone of influence of that impact.
Moderate	Impact on a potential area of ecological importance (possible Annex I Habitat - pAIH), or on a UKBAP priority habitat where a species/habitat that has a high – very high sensitivity to the impact in question is within the zone of influence of that impact, or, Impact on a known area of ecological importance designated as a cSAC or pSAC under the habitats directive, or a UKBAP priority habitat where a species/habitat that has a low to moderate sensitivity to the impact in question is within the zone of influence of that impact.
Minor	Impact on a potential area of ecological importance (pAIH), where a species/habitat that has a low - moderate sensitivity to the impact in question is within the zone of influence of that impact.
Negligible/No Impact	No species/habitats that are sensitive to the impact in question are within the zone of influence of that impact.
Unknown	Impact on an area of unknown importance for benthic ecology

Appendix G – Marine Mammal Species Data

Species Accounts

Harbour porpoise (*Phocoena phocoena*) are observed occasionally in Bailiwick waters typically in small numbers of 4-5. Porpoises swim in small groups or singly and are thought to breed and give birth to calves in the summer. They are characteristically shy of boats and other anthropogenic activities and consequently are likely to be easily disturbed. They feed on a variety of fish and cephalopod species (e.g. squid).

It is about 67-85 cm (26-33 in) long at birth. Both sexes grow up to be 1.4 m to 1.9 m (4.6-6.2 ft). The females are correspondingly heavier, with a maximum weight of around 76 kg (167 pounds) compared with the males' 61 kg (134 pounds). The body is robust and the animal is at its maximum girth just in front of its triangular dorsal fin. The beak is poorly demarcated. The flippers, dorsal fin, tail fin and back are a dark grey. The sides are a slightly speckled lighter grey. The underside is much whiter, though there are usually grey stripes running along the throat from the underside of their body.

The species is widespread in cooler coastal waters in the Northern Hemisphere, largely in areas with a mean temperature of about 15°C. In the Atlantic, Harbour Porpoises may be present in a concave band of water running from the coast of western Africa round to the eastern seaboard of the United States, including the coasts of Spain, France, the United Kingdom, Isle of Man, Ireland, Norway, Iceland, Greenland and Newfoundland.

Threats include pollution from bio accumulating chemicals and compounds; entanglement in fishing gear, drive hunts (Faroe islands), use of underwater sonar for military purposes, oil and gas exploration and surveying for new offshore renewable energy projects, and noise disturbance. Electromagnetic disturbance from sub-sea cables may also affect this species. The species may also be threatened from collision from shipping.

Harbour Porpoise are on the IUCN Red List as a “Least concern” species, and are particularly susceptible to entrapment in gill nets. This has led to concerns about declines in populations in the North-east Atlantic, particularly in the Baltic, North, Irish and Celtic seas. The species is also protected under Article 12 of the EU Habitats Directive (92/43/EEC) which prohibits inter alia the “deliberate *disturbance of these species, particularly during the period of breeding, rearing, hibernation and migration*”.

The Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS) also affords protection to this species. Under the auspices of the Convention on Migratory Species (CMS or Bonn Convention) ASCOBANS entered into force in 1994. In February 2008, an extension of the agreement area came into force which changed the name to "Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas". The Secretary

General of the United Nations has assumed the functions of Depository of the Agreement. ASCOBANS is open for accession by all Range States (i.e. any state that exercises jurisdiction over any part of the range of a species covered by the Agreement or whose flag vessels engage in operations adversely affecting small cetaceans in the Agreement area) and by regional economic integration organisations.

Originally only covering the North and Baltic Sea, as of 3 February 2008 the ASCOBANS Area has been extended as follows:

"… the marine environment of the Baltic and North Seas and contiguous area of the North East Atlantic, as delimited by the shores of the Gulfs of Bothnia and Finland; to the south-east by latitude 36°N, where this line of latitude meets the line joining the lighthouses of Cape St. Vincent (Portugal) and Casablanca (Morocco); to the south-west by latitude 36°N and longitude 15°W; to the north-west by longitude 15° and a line drawn through the following points: latitude 59°N/longitude 15°W, latitude 60°N/longitude 05°W, latitude, 61°N/longitude 4W;latitude 62N/ longitude 3W; to the north by latitude 62°N; and including the Kattegat and the Sound and Belt passages."

Any State that becomes a Party to the Agreement after the entry into force of the Amendment shall, unless a different intention is expressed by that State, be considered as a Party to the Agreement as amended.

Ten countries have so far become Parties to the Agreement:

- Belgium
- Denmark
- Finland
- France
- Germany
- Lithuania
- The Netherlands
- Poland
- Sweden
- United Kingdom

All non-Party Range States are encouraged to join the ASCOBANS Parties in their efforts to conserve the small cetacean species they share with other countries in the ASCOBANS Area, conscious that the management of threats to their existence, such as by-catch, habitat deterioration and other anthropogenic disturbance, requires concerted and coordinated responses.

Bottlenose dolphins (*Tursiops truncatus*) are abundant in Channel Island waters with populations in the shallower waters around Jersey frequently observed. They are known to visit Bailiwick of Guernsey waters, and there is a resident population of 20+ individuals frequently observed around Sark.

There are two forms of Bottlenose Dolphin in the North Atlantic, an offshore and a coastal form, are distinguishable on the basis of morphology and ecological markers (e.g., Mead and Potter 1995), have fixed genetic differences and, therefore, eventually may be assigned to different species (Leduc and Curry 1997, Hoelzel *et al*. 1998, Reeves *et al*. 2003).

The Common Bottlenose Dolphin is grey in colour and can be between 2 and 4 metres (6.6 and 13 ft) long, and weigh between 150 and 650 kilograms (330 and 1,400 lb). Males are generally larger and heavier than females. In most parts of the world the adult's length is about 2.5 metres (8.2 ft) with weight ranges between 200 and 300 kilograms (440 and 660 lb). Newborn Common Bottlenose Dolphins are between 0.8 and 1.4 metres long and weigh between 15 and 30 kilograms. It has a short and well-defined snout, that looks like an old-fashioned gin bottle, which is the source for the common name, Bottlenose Dolphin. Like all whales and dolphins, though, the snout is not a functional nose; rather, the functional nose is the blowhole on the top of its head. Its neck is more flexible than other dolphins' due to 5 of its 7 vertebrae not being fused together as is seen in other dolphin species.

They are a highly social species with complex relationships and are therefore found in large pods. However, solitary dolphins are also observed in local waters.

Dolphins also have sharp eyesight. The eyes are located at the sides of the head and have a tapetum lucidum, or reflecting membrane at the back of the retina, which aids vision in dim light. Their horseshoe-shaped double-slit pupil enables the dolphin to have good vision both in air and underwater, despite the different densities of these media. When underwater the eyeball's lens serves to focus light, whereas in the in-air environment the typically bright light serves to contract the specialized pupil, resulting in sharpness from a smaller aperture (similar to a pinhole camera).

By contrast their sense of smell is poor, as would be expected since the blowhole, the analogue to the nose, is closed in the underwater environment, and opens only voluntarily for breathing. The olfactory nerves as well as the olfactory lobe in the brain are missing. Bottlenose dolphins are able to detect salty, sweet, bitter (quinine sulphate), and sour (citric acid) tastes, but this has not been well-studied. Anecdotally, some animals in captivity have been noted to have preferences for food fish types although it is not clear that this preference is mediated by taste.

The average gestation period is 12 months. Births can occur at any time of year, although peak births occur in warmer months. The young are born in shallow water, sometimes assisted by a "midwife" (which may be male). A single calf is born, about 1 m (3 ft) long at birth.

To speed up the nursing process, the mother can eject milk from her mammary glands. The calf is nursed for 18 to 20 months, and continues to associate closely with its mother for several years after weaning. Females become sexually mature between age 5 and 13, males a little later, between age 9 and 14. Females reproduce every 2 to 6 years.

Young calves are often observed with their parents in pods, although little is known about their breeding patterns in Channel Island waters.

Bottlenose dolphins have a varied diet and studies have shown that areas with strong tidal currents are favoured for foraging (Mendes *et al 2002;* Hastie *et al 2004)*. Target prey species include: fish (mackerel, mullet, bass), invertebrates (e.g. cephalopods i.e.squid, etc.) and crustaceans. The echolocate their prey using sonar and communicate through squeaks, whistles and body language. Marine noise from anthropogenic activities is therefore likely to disrupt them.

They are not averse to close approaches to shore and shorelines, tidal fronts or submarine features which are often used to herd prey. In contrast to porpoises, they are curious and frequently approach boats and other marine machinery. One solitary dolphin recorded in the Channel Islands was very inquisitive to underwater propellers and scars were noted as a result of this male bottlenose dolphin coming too close to outboard motors, etc. There is a danger therefore that underwater turbines could pose a significant threat to this species, although this is untested.

The bottlenose dolphin has a single blowhole located on the dorsal surface of the head consisting of a hole and a muscular flap. The flap is closed during muscle relaxation and opens during contraction. A bottlenose dolphin can store almost twice as much oxygen in proportion to its body weight as a human can. The dolphin can store 36 millilitres of oxygen per kilogram of body weight, compared with 20 millilitres per kilogram for humans. This is an adaptation to diving. The bottlenose dolphin typically rises to the surface to breathe through its blowhole 2-3 times per minute; if necessary, it has the ability to remain submerged for up to 20 minutes. As a direct result of the voluntary breathing requirement scientists have determined that during the sleeping cycle one brain hemisphere remains active while the other hemisphere shuts down. The sleeping cycle lasts for approximately 8 hours during each 24 hour period, in increments of several minutes (or less) to several hours. During the sleeping cycle dolphins remain near the surface swimming slowly or "logging", occasionally closing one eye.

Threats include pollution from bio accumulating chemicals and compounds; entanglement in fishing gear, drive hunts (Faroe islands), use of underwater sonar for military purposes, oil and gas exploration and surveying for new offshore renewable energy projects, and noise disturbance. Electromagnetic disturbance from sub-sea cables may also affect this species. The species may also be threatened from collision from shipping.

Bottlenose dolphins are listed on CITES Appendix II. Appendix II includes species identified as threatened, or likely to become endangered if trade isn't regulated. All toothed whales are protected by CITES. The species listed in the IUCN Red List of threatened species as being a “Least concern species”. It is also protected under Article 12 of the EU Habitats Directive (92/43/EEC) which prohibits inter alia the “deliberate *disturbance of these species, particularly during the period of breeding, rearing, hibernation and migration*”. The species is also protected under the ASCOBANS agreement, which means that there needs to be a co-ordinated and concerted response to threats to the species’ existence (e.g. by-catch, anthropogenic factors such as disturbance, habitat destruction or degradation, etc).

Short-beaked Common Dolphin (*Delphinus delphis*) is a gregarious species. Often found in deeper pelagic waters, short-beaked common dolphins are often recorded around the Bailiwick of Guernsey in groups varying from a few individuals of around 15-20+ to "super pods" of over 100 animals.

Figure 18 Common Dolphins near Le Hanois by Mark Page

The species length varies from a maximum of 8'6" (2.6m) in females to 8'10" (2.7m) in males. Weight in mature adults is estimated at probably 330 lb or 150kg.

Short-beaked common dolphins appear to have a preference for upwelling-modified waters, areas with steep sea floor relief, and extensive shelf areas.

Short-beaked common dolphins are often observed around the coast of Guernsey, particularly off St. Martin's Point (a known foraging area for mackerel) to Les Hanois, and off the island's north coast (Pembroke) and the Little Russel between Guernsey and Herm. They have also been observed regularly off Shell beach in Herm in the Big Russel. Key prey species include: bass, mackerel, bream and other round fish, as well as cephalopods such as squid.

This species is the most likely to come into conflict with any marine device due to the comparatively large number of common dolphin observed in contrast with other cetacean species.

Young calves are often observed with their parents in pods, although little is known about their breeding patterns in Channel Island waters.

Indeed, common dolphin casualties have frequently been observed as a direct result of pair trawling in the Bailiwick of Guernsey. Post mortems of common dolphins carried out by the Institute of Zoology in London cite that pair trawling was the cause of mortality in 70% of dolphin deaths. This “by-catch” or unintentional capture of non-target species by fisheries led to the British Government enforcing cetacean by catch mitigation measures, following representation by lobbying environmental groups and scientific studies carried out by DEFRA.

In the Atlantic, abundance in European continental shelf waters was estimated at 63,400 (95%CI=27,000-149,000) in 2005 (SCANS-II project; P. Hammond pers. comm.). Offshore, abundance in a block bounded by 53-57ºN and 18-29ºW was estimated at 273,000 in 1995 (Cañadas et al. in press). West of the Bay of Biscay, 62,000 common dolphins were estimated in the fishing grounds of the albacore tuna fishery in 1993 (Goujon 1996). In the western North Atlantic, 121,000 were estimated to occur (Waring et al. 2006).

Threats include pollution from bio accumulating chemicals and compounds; entanglement in fishing gear, drive hunts (Faroe islands), use of underwater sonar for military purposes, oil and gas exploration and surveying for new offshore renewable energy projects, and noise disturbance. Electromagnetic disturbance from sub-sea cables may also affect this species. The species may also be threatened from collision from shipping.

The short-beaked common dolphin is listed in Appendix I of CITES and is listed in the IUCN Red List of threatened species as being a “Least concern species. It is also protected under Article 12 of the EU Habitats Directive (92/43/EEC) which prohibits inter alia the “deliberate *disturbance of these species, particularly during the period of breeding, rearing, hibernation and migration*”. The species is also protected under the ASCOBANS agreement, which means that there needs to be a co-ordinated and concerted response to threats to the species’ existence (e.g. by catch, anthropogenic factors such as disturbance, habitat destruction or degradation, etc. The species is also protected under the ASCOBANS agreement, which means that there needs to be a co-ordinated and concerted response to threats to the species’ existence (e.g. by-catch, anthropogenic factors such as disturbance, habitat destruction or degradation, etc).

Northern Minke Whales (*Balaeonoptera acutorostrata*) are the smallest of the baleen whales. Upon reaching sexual maturity (6-8 years of age), male and female minke whales measure an average of 6.9 and 7.4 metres (22'8" to 24' 3") in length, respectively. Estimates of maximum length vary from 9.1 m to 10.7 m (28'10" to 35'1") for females and 8.8 m to 9.8 m (28'8" 10" to 32'5") for males. Both sexes typically weigh 4-5 tons at maturity, and the maximum weight may be as much as 14 tons. The gestation period for minke whales is 10 months and babies measure 2.4 to 2.8 metres (7'10" to 9'2") at birth. The newborns nurse for five months.

Common minke whales (northern hemisphere variety) are distinguished from other whales by a white band on each flipper. The body is usually black or dark-grey above and white underneath. Most of the length of the back, including dorsal fin and blowholes, appears at once when the whale surfaces to breathe. The whale then breathes 3-5 times at short intervals before 'deep-diving' for 2-20 minutes. Deep dives are preceded by a pronounced arching of the back. The maximum swimming speed of minkes has been estimated at 20-30 km/h. Minke whales have between 240 and 360 baleen plates on each side of their mouths. Sexual maturity is reached at 7 or 8 years. Breeding peaks during the summer months. The gestation is 10 to 11 months and calving is thought to occur every two years. Minke whales typically live for 30-50 years; in some cases they may live for up to 60 years.

Threats include pollution from bio accumulating chemicals and compounds; entanglement in fishing gear, drive hunts (Faroe islands), use of underwater sonar for military purposes, oil and gas exploration and surveying for new offshore renewable energy projects, and noise disturbance.

Classified as Least Concern (LC) on the IUCN Red List (1). Listed on Annex IV of the EC Habitats Directive. All whales are listed on Annex A of EU Council Regulation 338/97 and are therefore classed as if they are listed on Appendix 1 of CITES. Under the Fisheries Act of 1981 whaling is illegal in UK waters. All cetaceans (whales and dolphins) are fully protected under the Wildlife and Countryside Act, 1981 and the Wildlife (Northern Ireland) Order, 1985.

Whilst sightings of **Killer Whale** (*Orcinus orca*) in Channel Island waters are extremely rare (one sighting by fishermen in the last decade off the west coast of Guernsey), they are known to inhabit the north east Atlantic. Guernsey's only sighting of killer whales took place a few days before they were spotted off the south west coast of the Republic of Ireland, and could have been the same group. The animals were probably foraging for bass and other round fish species. Orcas are often recorded in the Bay of Biscay area by transiting shipping.

Killer whales also known as Orcas, are the largest of the delphinid family, and are among the best known cetaceans. It is considered to be the most widespread cetacean species, and is not limited by such habitat features as water temperature or depth. It occurs in high densities in high latitudes, particularly where there is an abundance of prey. Its movements generally track those of its target prey species, or take advantage of prey abundance and vulnerability (e.g. fish spawning times and seal pupping).

Killer Whales are presently considered to form a single cosmopolitan species, Orcinus orca (Rice 1998). Separate species status has been suggested for different morphological forms found in the southern Ocean (Mikhalev et al. 1981, Berzin and Vladimirov 1983, Pitman and Ensor 2003). Pitman et al. (2007) describe one of these as a dwarf form of Killer Whale. Killer Whales in the eastern North Pacific are known to consist of at least two and maybe three distinct forms, colloquially known as 'resident', 'transient' and 'offshore' Killer Whales (Ford 2002). Separate species status has also been suggested for at least two of these different forms, based on colour pattern, diet, association patterns and morphological traits (Baird et al. 1992, Baird 1994). Genetic differences are found among these forms, with particularly marked differences between resident and transient forms (Stevens et al. 1989, Hoelzel and Dover 1991, Hoelzel et al. 1998, Barrett-Lennard 2000). The taxonomy of this genus is clearly in need of review, and it is likely that O. orca will be split into a number of different species or at least subspecies over the next few years (Reeves et al. 2004).

The male killer whale can grow to at least 12,000lb or 5,600kg, and the female at least 8,400lb or 3,800kg. The life-span varies from 50-60 years in males and 80-90 years in females in their natural environment (i.e. non-captive).

Killer whales eat a variety of food from small schooling fish to large baleen and sperm whales. They also take seals, sea turtles, sharks, rays among other species.

Killer whales are social animals and groups are matrilineal, consisting of two to four generations of two or nine related individuals. Like dolphins they also co-operate closely in catching prey, through rounding fish into "bait balls" and allowing each other to slice through the bait ball to feed on the fish. They also eat discarded fish from by-catch.

Threats include pollution from bio accumulating chemicals and compounds; entanglement in fishing gear, drive hunts (Faroe islands), use of underwater sonar for military purposes, oil and gas exploration and surveying for new offshore renewable energy projects, and noise disturbance. Electromagnetic disturbance from sub-sea cables may also affect this species. The species may also be threatened from collision from shipping.

The species is in Appendix II of CITES and Appendices I and II of Convention on Migratory Species (CMS). The eastern North Atlantic as well as the eastern North Pacific subpopulations are included in Appendix II of CMS.

The species is listed in the IUCN Red List of threatened species as being a "Data Deficient" species. It is also protected under Article 12 of the EU Habitats Directive (92/43/EEC) which prohibits inter alia the "deliberate *disturbance of these species, particularly during the period of breeding, rearing, hibernation and migration*". The species is also protected under the ASCOBANS agreement, which means that there needs to be a co-ordinated and concerted response to threats to the species' existence (e.g. by-catch, anthropogenic factors such as disturbance, habitat destruction or degradation, etc).

Risso's Dolphin *(Grampus griseus)* has a distinctive beakless head shape, and the body is noticeably more robust in the front half rather than the back. The melon is broad, squarish in profile and creased in front by a characteristic longitudinal furrow. The dorsal fin is tall, erect and moderately falcate. The flippers are long and sickle-shaped. The coloration is variable but always striking. The dorsal surface ranges within a single school from pale buff to dark brown to grey. Young calves are grey to brown dorsally and cream ventrally; they become silvery grey, then darken to almost black before lightening as they age. The lip margins and chin are often white. Extensive scarring makes the adults look almost white, except for the dorsal fin and flippers. Most of the linear scars are assumed to be made by the teeth of Risso's Dolphins or by their squid prey.

Risso's dolphin are usually seen in groups of 12-40 individuals, averaging 25. They are regularly sighted in the Channel Islands. The maximum length recorded for a male Risso's Dolphin is 12'6" or 3.83m, and 12' or 3.66m for females. Calves are born between 3'7" and 4'11" (1.1 – 1.5m) in length. Maximum weight data is unavailable. Weight varies from 300-500kg in adults. Risso's dolphin usually are found at the steep upper continental shelf, but it is thought that they migrate into coastal waters during the summer months in pursuit of prey.

Scientists have no knowledge about the reproductive habits of these animals. The species feeds primarily on squid. They occasionally consume other cephalopods (cuttlefish) as well, but there is little evidence that they regularly eat fish or crustaceans. Much of their feeding takes place at night, possibly because some prey species migrate towards the ocean surface at that time.

Figure 19 Risso's Dolphin off St. Peter Port by Catherine Veron

Threats include pollution from bio-accumulating chemicals and compounds; entanglement in fishing gear, drive hunts (Faroe Islands), use of underwater sonar for military purposes, oil and gas exploration and surveying for new offshore renewable energy projects, and noise disturbance. Electromagnetic disturbance from sub-sea cables may also affect this species. The species may also be threatened from collision from shipping.

The IUCN Red List lists Risso’s Dolphin as a “Least concern” species The species is also listed under the EU Habitats Directive and the Bonn Convention (also known as CMS. Risso’s dolphin is also named in Appendix II of CITES. The species is also protected under the ASCOBANS agreement, which means that there needs to be a co-ordinated and concerted response to threats to the species’ existence (e.g. by-catch, anthropogenic factors such as disturbance, habitat destruction or degradation, etc.

Fin Whale (*Balaenoptera physalus*) are occasionally observed in pelagic waters around Guernsey and Alderney, especially around the Hurd Deep, by transiting shipping. The Fin whale is the second largest mammal on Earth, after the Blue Whale. Measuring 79’ (24 metres) and weighing up to 260,000 lb or 120,000 kg, it is known as the “Greyhound of the Seas”, as it is a sleek, fast animal. Calves are born at around 19’6”-21’ in length weighing between 4,000-6,000lb (1,800-2,700kg).

Fin whales are a cosmopolitan species inhabiting all the world's oceans. Although Fin whales tend to concentrate on coastal and continental shelf waters, where there is an upwelling of nutrients, they are also found in the deep ocean.

The fin whale's body is dark grey above and white or cream coloured below. The flukes are bordered with grey underneath. Most individuals have swirls called a "blaze" on the right hand side of the head and a "v" shaped chevron across the back behind the head.

These whales are usually found alone or travelling in small groups, although large aggregations can occur in feeding grounds.

No distinct breeding or calving grounds have been identified for the fin whale, and scientists know very little about this species' mating system. Females usually give birth every two or three years to a single calf; while twins have been recorded in utero, there is no evidence that any survive.

Calving occurs in winter after a gestation of 11-12 months. Calves stay with their mothers for 6-8 months. Breeding is seasonal in winter. Repetitive, low frequency vocalisations have been recorded from fin whales and interpreted as male breeding displays, similar to Humpback Whale songs.

The fin whale feeds mainly on krill and various small schooling fish. Fin whales feed by lunging into schools of prey, mouth agape. Some of these lunges may involve speeds of up to 25 knots.

Fin whales were hunted in larger numbers than any other whale species during the 20th century, with 725,000 killed in the Southern Hemisphere alone.

Threats include pollution from persistent bio accumulating chemicals and compounds; entanglement in fishing gear, drive hunts (Faroe islands), use of underwater sonar for military purposes, oil and gas exploration and surveying for new offshore renewable energy projects, and noise disturbance. Electromagnetic disturbance from sub-sea cables may also affect this species. The species may also be threatened from collision from shipping.

The species is listed as "Endangered" on the IUCN Red List, a classification which has recently been challenged in respect of northern hemisphere populations. It is also protected under Article 12 of the EU Habitats Directive (92/43/EEC) which prohibits inter alia the "deliberate *disturbance of these species, particularly during the period of breeding, rearing, hibernation and migration*". Fin whales are included on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Long-finned Pilot Whale (*Globicephala melas*) are frequently found in Bailiwick waters especially during the summer months of August and September, sometimes in large pods of 20+ individuals.

An abundant species, with an extensive global distribution, long-finned pilot whales are pelagic, occurring in especially high densities in winter and spring over the continental slope, before moving inshore and onto the shelf in the summer and autumn. Their movements follow the squid and mackerel population.

The species mate and calve mainly between late spring and autumn (April-September) in the North Atlantic. Gestation lasts for around a year, and lactation between 1-2 years. North Atlantic females can become pregnant even late in their lives at 55 years old, although pregnancy after 40 years of age is rare. Calves weigh approximately 165lb (75kg) at birth. Fully grown males weigh up to 5,000lb or 2,300kg, and females 2,900lb or 1,300kg. Adult long-finned pilot whales grow up to 21' (6.3m) in length in males and 15'6" (4.7m) in females.

Life expectancy for males is 45 years and 60 years in females.

Pilot whales have a prominent bulbous forehead or "melon" and the dorsal fin has a long characteristic profile, set ahead of the mid-body. The flippers are long (about one quarter of the total body length) and tapered. Coloration is simple, basically dark grey to black or dark brown. There is also a large white or light grey "saddle" behind the dorsal fin.

Threats to long-finned pilot whales include pollution from bio accumulating chemicals and compounds; entanglement in fishing gear, drive hunts (Faroe islands), use of underwater sonar for military purposes, oil and gas exploration and surveying for new offshore renewable energy projects, and noise disturbance.

Electromagnetic disturbance from sub-sea cables may also affect this species. The species may also be threatened from collision from shipping.

The IUCN classifies this species as "Data Deficient" under its Red List. The long-finned pilot whale is protected by the IWC treaty, which bans commercial whaling (1986); Annex IV of the EU Habitats Directive; Appendix II of the Bern Convention; Appendix II of the Bonn Convention (CMS); and Appendix II of CITES.

The species is also protected under the ASCOBANS agreement, which means that there needs to be a co-ordinated and concerted response to threats to the species' existence (e.g. by-catch, anthropogenic factors such as disturbance, habitat destruction or degradation, etc).

The **Sperm Whale** (*Physeter macrocephalus*) is a toothed whale (odontocete) and has the largest brain of any mammal. The name comes from the milky-white waxy substance, spermaceti, found in its head and originally mistaken for sperm.

A bull can grow up to 20.5 metres (67 ft) long. It is the largest living toothed animal. The head can take up to one-third of the animal's length. It has a cosmopolitan distribution across the oceans. The species feeds on squid and fish, diving as deep as 3 kilometres (9,800 ft), which makes it the deepest diving mammal. Its diet includes Giant squid and Colossal Squid. It is the largest living predator and possibly the largest ever, not in terms of its taking animal matter (which is true of all cetaceans, including the larger baleen whales) but in that it actively preys on self-functioning animals. The sperm whale's clicking vocalization is the loudest sound produced by any animal, but its functions are uncertain. These whales live in groups called pods. Pods of females and their young live separately from older males. The females cooperate to protect and nurse their young. Females give birth every three to six years, and care for the calves for more than a decade.

Sperm Whales are rare in Channel Island waters, but have been recorded by transiting shipping.

The sperm whale's distinctive shape comes from its very large head, which is typically one-third of the animal's length. The blowhole is located very close to the front of the head and shifted to the whale's left. This gives rise to a distinctive bushy, forward-angled spray (around 45 degrees).

The sperm whale's flukes are triangular and very thick. The whale lifts its flukes high out of the water as it begins a dive. It has a series of ridges on the back's caudal third instead of a dorsal fin. The largest ridge was called the 'hump' by whalers, and can be mistaken for a dorsal fin because of its shape.

In contrast to the smooth skin of most large whales, its back skin is usually knobbly and has been likened to a prune by whale-watching enthusiasts. Skin is normally a uniform grey in colour, though it may appear brown in sunlight. Albinos have also been reported.

Sperm whales can live 70 years or more. They are a prime example of a species that has been K-selected, a reproductive strategy associated with stable environmental conditions, a low birth rate, significant parental aid to offspring, slow maturation and high longevity.

How they choose mates has not been definitively determined. There is evidence that males have dominance hierarchies and there is also evidence that female choice influences mating. Gestation requires 14 to 16 months, producing a single calf. Lactation proceeds for 19 to 42 months, but calves may suckle up to 13 years (although usually less). Calves can suckle from females other than their mothers. Females generally have birth intervals of three to six years.

Females reach sexual maturity between 7 and 13 years, males follow beginning at 18 years. Upon reaching sexual maturity, males move to higher latitudes, where the water is colder and feeding is more productive. Females remain at lower latitudes.

Males reach their full size at about age 50.

Populations are denser close to continental shelves and canyons. Locally sightings have been reported near the Hurd Deep and in pelagic waters around Guernsey. Sperm whales are usually found in deep off-shore waters, but may be seen closer to shore in areas where the continental shelf is small and drops quickly to depths of 310–920 metres (1,000–3,000 ft).

Sperm Whales usually dive between 300 to 800 metres (980 to 2,600 ft), and sometimes 1–2 kilometres (3,300–6,600 ft) to search for food. Such dives can last more than an hour. They feed on several species, notably the Giant Squid, the Colossal Squid, octopuses, and diverse fish like demersal rays, but the main part of their diet consists of medium-sized squid.

During the past 2 centuries, commercial whalers took about 1 million sperm whales. Despite this high level of "take", the sperm whale remains the most abundant of the large whale species. Currently, there is no good estimate for the total number of sperm whales worldwide. The best estimate, that there are between 200,000 and 1,500,000 sperm whales, is based on extrapolations from only a few areas that have useful estimates.

Threats include pollution from bio accumulating chemicals and compounds; entanglement in fishing gear, drive hunts (Faroe islands), use of underwater sonar for military purposes, oil and gas exploration and surveying for new offshore renewable energy projects, and noise disturbance. Electromagnetic disturbance from sub-sea cables may also affect this species. The species may also be threatened from collision from shipping.

The IUCN Red List regards the sperm whale as being "vulnerable". Current threats include the accumulation of toxic pollutants such as organic pesticides in the whales' tissue and organs, entanglement in fishing nets and marine litter, and noise disturbance, which interferes with their complex echolocation and use of sound. Sperm whales are protected under UK and EU law, principally under Schedule 5 of the UK Wildlife and Countryside Act 1981, the Nature Conservation (Scotland) Act 2004 and by the 1992 EU Habitats and Species Directive.

Appendix H – Locations of designated fishery areas

Locations of designated fishery areas. These correspond to the general areas shown in fig 1.

1. Rocquaine: an area bounded within

Latitude 49º26.28N	Longitude 002º39.45W
Latitude 49º26.3N	Longitude 002º39.56W
Latitude 49º26.220N	Longitude 002º39.574W
Latitude 49º26.259N	Longitude 002º39.610W

2. Rocquaine: an area bounded within

Latitude 49º26.518N	Longitude 002º39.263W
Latitude 49º26.526N	Longitude 002º39.258W
Latitude 49º26.526N	Longitude 002º39.326W
Latitude 49º26.6N	Longitude 002º39.46W
Latitude 49º26.578N	Longitude 002º39.482W
Latitude 49º26.541N	Longitude 002º39.450W
Latitude 49º26.58N	Longitude 002º39.33W

3. Grande Havre: an area bounded within

Latitude 49º29.817N	Longitude 002º33.051W
Latitude 49º29.837N	Longitude 002º33.054W
Latitude 49º29.825N	Longitude 002º33.004W
Latitude 49º29.813N	Longitude 002º33.005W

4. Grande Havre: an area bounded within

Latitude 49º29.773N	Longitude 002º32.968W
Latitude 49º29.778N	Longitude 002º32.936W
Latitude 49º29.791N	Longitude 002º32.931W
Latitude 49º29.793N	Longitude 002º32.966W

5. Port Grat: an area bounded within

Latitude 49º29.945N	Longitude 002º33.563W
Latitude 49º29.959N	Longitude 002º33.532W
Latitude 49º22.982N	Longitude 002º33.540W
Latitude 49º29.958N	Longitude 002º33.598W

6. Chouet: an area bounded within

Latitude 49º30.13N	Longitude 002º32.61W
Latitude 49º30.123N	Longitude 002º32.615W
Latitude 49º30.122N	Longitude 002º32.639W
Latitude 49º30.14N	Longitude 002º32.63W

7. Houmet Paradis: an area bounded within

Latitude 49º29.793N	Longitude 002º30.009W
Latitude 49º29.806N	Longitude 002º29.921W
Latitude 49º29.899N	Longitude 002º29.994W
Latitude 49º29.899N	Longitude 002º29.914W

8. Herm Island: an area bounded within

Latitude 49º28.404N	Longitude 002º27.354W
Latitude 49º28.437N	Longitude 002º27.373W
Latitude 49º28.627N	Longitude 002º27.532W
Latitude 49º28.616N	Longitude 002º27.649W
Latitude 49º28.334N	Longitude 002º27.681W

9. Torquetil: an area bounded within

Latitude 49º27.215N	Longitude 002º39.264W
Latitude 49º27.226N	Longitude 002º39.285W
Latitude 49º27.213N	Longitude 002º39.322W
Latitude 49º27.197N	Longitude 002º39.318W
Latitude 49º27.158N	Longitude 002º39.375W
Latitude 49º27.164N	Longitude 002º39.436W
Latitude 49º27.230N	Longitude 002º39.501W

Appendix I – Historic wreck around Guernsey, Sark and Herm

The following table lists basic details of historic wreck recorded in the SMR at Guernsey Museum; only wrecks with at least some information on their position are listed here. Vessels which were wrecked but which reached harbour under their own power are not listed.

MGU	*name*	*date*	*location*
MGU2766	Roman Ship in St Peter Port Harbour (Asterix)	third century AD	St. Peter Port Harbour Entrance
MGU4370	Abbey Town (ex Ida)	1892	Perelle Bay
MGU4374	Active	1849	Castle Rocks
MGU4379	Adele	1851	Goubeau
MGU4398	Albro	1840	Rocque à Deux Tetes
MGU4404	Alfred Anne	1836	L'Erée
MGU4407	Alliance	1858	Black Rock
MGU4411	Maritime Roman findspot	1st - 4th century AD	South of Platte Fougère
MGU4413	Lead Ingot Wreck	c.1720	Fermain Bay
MGU4420	Ancona	1848	Col du Pont
MGU4423	Ann Elizabeth	1888	the Becquets
MGU4426	Anna Felicia	1865	Goubeau
MGU4427	Anne	1903	Black Rock
MGU4431	Antoinette	1900	49°23'N 02°31'W
MGU4436	Arcana	1858	Hanois
MGU4438	Arguenon	1930	Black Rock
MGU4446	Auguste & Louise	1890	Les Tielles/Pleinmont
MGU4450	Banshee	1892	Crabière
MGU4452	Batavier VIII	1932	Platte Cove
MGU4457	Beauport	1930	Agenor 49°27'N 02°31'W
MGU4460	Berceaux	1853	Rocque au Nord
MGU4461	Berthe-Marie	1861	Roustel
MGU4462	Bess Mitchell	1921	49°31'N 02°32'W
MGU4463	Bessie	1926	Bordeaux
MGU4464	Big Apple	1977	Beaucette
MGU4468	Blanche Marie	1859	Sardrette

MGU4474	Boreas	1807	Hanois
MGU4475	Bostonian	1861	Les Grunes
MGU4476	Branch	1869	Hanois
MGU4478	Brighton	1887	Brayes
MGU4480	Briseis	1937	49°29'30"N 02°37'30"W
MGU4481	Brisk	1844	Castle Cornet
MGU4484	Britannic	1917	49°36'N 02°53'W
MGU4486	British Queen	1855	Cavale
MGU4488	Buccleugh	1834	Grunes
MGU4493	Busy Bee	1914	Black Rock
MGU4494	Buzulzo	1896	49°26'30"N 02°40'33"W
MGU4498	Camilla	1852	Castle Rocks
MGU4500	Capri	1932	Pezeries Point
MGU4501	Captain Niko	1973	49°32'47"N 02°35'20"W
MGU4506	Causette	1972	Hanois
MGU4509	Champion	1853	Glategny
MGU4510	Channel Queen	1898	Black Rock
MGU4512	Charles	1918	49°30'N 02°45'W
MGU4520	City of Winchester	1918	49°28'N 02°55'W
MGU4521	Clarrie	1918	Roustel
MGU4522	Clementine	1860	Salerie
MGU4527	Colbert	1835	Belle Greve Bay
MGU4529	Comet	1845	North Beach
MGU4531	Concordia	1858	Rocquaine
MGU4532	Concordia	1819	Cobo Bay
MGU4534	Constant	1860	Rocquaine
MGU4544	Cruizer	1845	Vale Castle
MGU4547	Dagenham	1909	49°24'55"N 02°32'10"W
MGU4548	Dambuster	1875	49°31'N 02°29'W
MGU4555	Diana	1849	North Beach
MGU4557	Diane	1789	Brayes
MGU4558	Dispatch	1789	Sardrette
MGU4560	Dolphin	1839	Castle Rocks

MGU4582	Roman Amphora from the Little Russel - Site A	second century AD	Little Russel
MGU4583	Dora	1893	Icart
MGU4586	Dr. Rudolf Wahrendorf (formerly Prince Rupert)	1944	St. Peter Port Harbour
MGU4592	Dunsinane	1904	49°27'N 02°40'W
MGU4597	Edward	1845	North Beach
MGU4598	Effort	1869	Gross Ferrière
MGU4599	Elisa	1836	Glategny
MGU4601	Eliza	1836	Creve Coeur
MGU4602	Eliza	1823	L'Ancresse
MGU4607	Ella	1887	Spur Point
MGU4611	Elphonsine Lucille	1837	Havelet Bay
MGU4612	Elwood Mead	1973	Les Grunes de Nord-Ouest
MGU4615	Emmanuel	1848	Les Grunes de Nord-Ouest
MGU4617	Endymion	1860	L'Erée
MGU4623	Europe	1849	Fort Houmet
MGU4624	Evasion	1933	49°26'N 02°43'W
MGU4625	Excelsior	1861	Hanois
MGU4627	Experiment	1833	Jean Jehan Rocks
MGU4628	Experiment	1850	Boue Petite
MGU4629	Fame	1805	Castle Rocks
MGU4630	Fancy	1840	Brayes
MGU4631	Fanny	1815	Ferrières
MGU4635	Fermain	1953	Vale Castle
MGU4636	Figaro	1918	49°22'N 02°45'W
MGU4638	Five Sisters	1848	Perelle Bay
MGU4643	Forth	1906	Petite Longue Pierre
MGU4649	Frederic	1850	Les Grunes de Nord-Ouest
MGU4651	Frederick William	1865	Black Rock
MGU4653	Friendship	1835	Cavale
MGU4657	G Player	1911	Roustel
MGU4659	Galiot	1776	Pleinmont
MGU4660	Gem	1910	Little Black Rock
MGU4661	General Foy	1828	Longstore

MGU4663	George and Elizabeth	1852	Portelet, Rocquaine Bay
MGU4664	George and William	1834	L'Ancresse
MGU4665	George William	1835	Hanois
MGU4669	Glencregagh	1929	Perelle Bay
MGU4670	Globe	1862	L'Ancresse
MGU4672	Godnock	1887	Havelet Bay
MGU4678	Goureux	1892	Hanois
MGU4680	Grace	1864	Ferrières
MGU4681	Grandest	1920	Hanois
MGU4690	Heathery Brae	1852	Petils
MGU4695	Henrietta	1771	Hanois
MGU4697	Henry	1867	Creve Coeur
MGU4699	Hero	1828	Castle Cornet
MGU4707	Hope	1830	Fermain
MGU4710	Horatio	1841	Black Rock
MGU4712	Ibex	1900	Platte Fougère
MGU4716	Industrie	1870	Portinfer
MGU4719	International	1908	Musée
MGU4720	Iris	1918	Fort Le Marchant
MGU4721	Iris	1848	Les Terres Point
MGU4725	Jane Williams	1868	Brayes
MGU4728	Jean Marie	1843	Tremies
MGU4729	Jeanne	1913	Corbière
MGU4731	Jeanne Marie Joseph	1828	Pointe de la Moye
MGU4732	Jesmond	1884	49°24'N 02°35'W
MGU4733	Jethou	1851	North Beach
MGU4737	Jeune Marie	1884	49°30'N 02°38'W
MGU4740	Johan Collett	1963	49°39'N 03°00'W
MGU4758	Juliana	1841	Castle Cornet
MGU4759	Julie	1845	Les Grunes de Nord-Ouest
MGU4767	Kondor	1973	49°36'N 02°40'W
MGU4771	La Jeune Sophie	1836	Hougue à la Perre
MGU4774	La Marie Fracoise	1831	Portelet

MGU4776	La Paix	1821	Glategny
MGU4777	La Rose Victoire	1820	Hanois
MGU4778	La Salle	1965	49°29'16''N 02°39'21''W
MGU4781	Lady Cecilia Hay	1911	Spur Point
MGU4784	Laura Ann	1882	Hanois
MGU4785	Lawence au Desire	1896	Goubeau
MGU4788	Le Cheval de Troyes	1866	Glategny
MGU4789	Le Jeune Alexandre	1838	North Beach
MGU4795	Le Rival	1853	Les Grunes de Nord-Ouest
MGU4798	Leon	1855	Castle Rocks
MGU4802	Les Deux Amis	1860	Hanois
MGU4808	Liberty	1788	Tautenay
MGU4811	Little Britain	1849	Brayes
MGU4812	Little Gem	1842	North Beach
MGU4814	Lively	1847	Ferrières
MGU4818	Looe	1835	Sardrette
MGU4822	Lovely Cruiser	1857	Castle Cornet
MGU4829	L'Ami des Grecs	1830	Spur Point
MGU4831	L'Ange	1821	Glategny
MGU4832	L'Edouard	1853	Les Banques
MGU4833	L'Elisa	1836	Salerie
MGU4835	L'Entreprenante	1835	Grande Havre
MGU4837	L'Ursule Cherie	1824	Fort Richmond
MGU4841	Major	1770	Castle Cornet
MGU4842	Margaret	1868	Port Soif
MGU4844	Margaret	1856	Salerie
MGU4847	Maria Ann	1841	North Beach
MGU4848	Marie Elizabeth	1816	Rocquaine
MGU4849	Marie Elizabeth	1862	Les Grunes de Nord-Ouest
MGU4852	Marie Joseph	1763	Belle Greve Bay
MGU4855	Marie Rose	1852	Rocquaine
MGU4861	Marshall	1861	Grande Rocque
MGU4875	Mary	1828	Corbin Rock

MGU4879	Mary Ann	1825	Castle Rocks
MGU4882	Matilda	1859	Platte Rock
MGU4884	Melita	1854	Castle Rocks
MGU4887	Merrimack	1806	Goubeau
MGU4891	Minerva	1834	Brayes
MGU4893	Minesweeper 2070	1951	Chouet
MGU4898	Nancy	1835	Belle Greve Bay
MGU4904	Navigateux	1836	Glategny
MGU4907	Neuha	1846	Belle Greve Bay
MGU4908	New Ann	1851	Castle Cornet
MGU4909	New Hope	1842	Belle Greve Bay
MGU4911	Nora Creina	1860	Long Pierre
MGU4912	Nord	1871	Sambule
MGU4915	Nordenskjold	1910	Spur Point
MGU4917	No 275	1900	Platte Fougère
MGU4918	Ocean Queen	1906	Les Tielles
MGU4919	Offspring	1859	Grand Havre
MGU4921	Oneida	1849	Perelle Bay
MGU4923	Oost Vlaanderen	1943	49°26'24''N 02°29'47''W
MGU4924	Orion	1978	Grandes Rocques
MGU4931	Paul	1841	South Pier
MGU4932	Paul	1838	St. Martin's
MGU4935	Pecheur	1826	Goubeau
MGU4937	Pere de Famille	1821	L'Erée
MGU4941	Phoenix	1823	Brayes
MGU4942	Pilote 1	1891	South Vazon
MGU4943	Pitt	1819	Perelle Bay
MGU4949	President Garcia	1967	Saints Bay
MGU4951	Prinz Rudolf	1939-45	49°27'N 02°30'W
MGU4952	Progress	1942	St. Peter Port Harbour
MGU4954	Prosperity	1974	La Conchée Rock
MGU4957	Prudent	1818	Grosse Rock
MGU4962	Radient Med	1984	St. Martin's Point

MGU4968	Ravensdale	1930	Platière Rock
MGU4970	Reformation	1851	Les Grunes de Nord-Ouest
MGU4972	Reindeer	1853	Sambule
MGU4973	Reliance	1860	Vale Castle
MGU4981	Robert Bradford	1849	Rocquaine
MGU4982	Roebuck	1788	Castle Rocks
MGU4983	Roman	1904	Hanois
MGU4984	Romp	1888	Le Petit Homptol
MGU4985	Rontegue	1880	49°32'N 02°33'W
MGU4986	Rose	1847	Grune au Rouge
MGU4988	Rose	1819	L'Erée
MGU4991	Sabine	1916	Spur Point
MGU4993	Saint Pierre	1876	Havelet Bay
MGU4994	Sainte Anne	1849	Fort Pezeries
MGU5015	Samuel	1845	St. Martin's Point
MGU5016	San Nicola	1916	49°33'N 02°40'W
MGU5018	Sarnia	1897	Parfonde
MGU5020	Savage	1814	North Rock
MGU5022	Sea Witch	1848	Grand Saut Rocher
MGU5025	Secret	1881	Jean Jehan Rocks
MGU5027	Shark	1982	Platte Fougère
MGU5033	Silvia	1867	Rocquaine Bay
MGU5042	Sorciere	1852	North Beach
MGU5043	Sovereign	1843	Spur Point
MGU5044	Sovereign	1849	Spur Point
MGU5045	Sprightly	1777	SE of Hanois
MGU5048	St. Anne	1826	Paradis
MGU5053	St. Louis	1884	Les Tielles
MGU5054	St. Lukas	1887	Pezeries
MGU5056	St. Pierre	1889	St. Martin's Point
MGU5059	Stella	1881	Vivian
MGU5061	Stockton	1823	Bordeaux
MGU5062	Sultana	1851	Cobo

MGU5064	Susan	1843	Vazon Bay
MGU5065	Susanna	1818	Grande Lieuse
MGU5066	Swansea	1906	Les Grunes de Nord-Ouest
MGU5067	Tandil	1917	49°36'N 02°57'W
MGU5078	Tommeliten	1938	Platte Beacon
MGU5079	Tommy	1838	Hougue à la Pere
MGU5097	Trignac	1905	Souffleuresse
MGU5098	Trio	1915	Hanois
MGU5101	Trois Susannes	1853	Rocquaine Bay
MGU5103	29th of May	1844	Glategny
MGU5109	Typhis	1879	Albecq
MGU5113	Ulysses	1881	49°29'N 02°29'W
MGU5114	Union	1889	St. Martin's Point
MGU5116	United Kingdom	1854	Banque de Mouton
MGU5119	Unity	1834	Brayes
MGU5120	Urania	1836	South Beach
MGU5122	Vedanta	1914	49°26'40"N 02°40'00"W
MGU5123	Venner	1893	49°25'N 02°36'W
MGU5125	Vertueux	1840	Rocquaine Bay
MGU5127	Victoria	1850	Rocquaine Bay
MGU5129	Victorine	1852	Rocque au Nord
MGU5133	Vigoureaux	1892	Hanois
MGU5138	Vixen	1878	Paradis
MGU5139	Vrou Catharina	1835	Crocq Bay
MGU5140	Walker	1900	Breakwater
MGU5145	Waverley	1873	49°31'17.5"N 02°25'13"W
MGU5146	Wear	1910	49°24'55"N 02°32'10"W
MGU5149	Western Belle	1922	49°28'N 02°37'W
MGU5151	William	1806	Jerbourg
MGU5153	William der Erste	1821	Videclin Bay
MGU5156	York Valley	1935	Platte
MGU5158	Young Hero	1835	Fermain Bay
MGU5161	Unidentified French Vessel	1278	Castle Rocks

MGU5165	Unidentified vessel	before 1309	Perelle Bay
MGU5166	Unidentified vessel	before 1309	Saints Bay
MGU5167	Unidentified vessel	before 1309	Cobo Bay
MGU5168	Unidentified vessels	c.1309	Les Trois Grunes
MGU5169	Unidentified vessel	1309	Castel Cornet
MGU5185	Unidentified vessel	1770	Jerbourg
MGU5186	Unidentified vessel	1770	Les Terres
MGU5187	Unidentified vessel	1773	Icart Point
MGU5188	Unidentified vessel	1776	Pleinmont
MGU5194	Unidentified vessel	1786	Castle Rocks
MGU5198	Unidentified vessel	1817	Rocquaine Bay
MGU5200	Unidentified vessel	1820	Rocquaine Bay
MGU5201	Unidentified vessel	1823	Castle Cornet
MGU5202	Unidentified vessels	1823	Castle Rocks
MGU5210	Unidentified vessel	1840	Rocquaine Bay
MGU5211	Unidentified vessel	1840	Hougue à la Pere
MGU5215	Unidentified vessel	1843	Brayes
MGU5218	Unidentified vessel	1852	Hanois
MGU5223	Unidentified vessel	1865	Vale Castle
MGU5228	Unidentified vessel	1869	Hanois
MGU5230	Unidentified vessels	1893	Castle Rocks
MGU5231	Unidentified vessel	1894	49°26'30"N 02°31'30"W
MGU5237	Unidentified vessel	c.1911	La Mauve
MGU5240	Unidentified vessel	c.1942	49°26'24"N 02°29'56"W
MGU5249	Unidentified vessel	unknown	49°25'34"N 02°29'07"W
MGU5250	Unidentified vessel	unknown	49°27'33"N 02°30' 58"W
MGU5251	Unidentified vessel	unknown	49°27'33"N 02°30'58"W
MGU5252	Unidentified vessel	unknown	49°27'20"N 02°30'34"W
MGU5253	Unidentified vessel	unknown	49°27'26"N 02°31'04"W
MGU5282	Unidentified vessel	1771	Hanois
MGU5311	Sorak	1977	49°26'N 02°31'W
MGU5403	Roman Amphora	1st - 4th century AD	Little Russel - Site B
MGU5415	Medieval wrecks	11th - 16th century AD	St Peter Port Harbour

MGU5462	Roman Amphora	1st - 4th century AD	Little Russel - south east
MGU5463	Roman Finds	1st - 4th century AD	Boue Penney (Goubeau) Rocks

Lihou

MGU4377	Adele	1854	Lihou
MGU4587	Dragour Lech'it	1932	Lihou
MGU4738	Jeune Marie	1858	Lihou
MGU5115	Union	1846	Lihou
MGU5157	Yorouba	1888	Lihou
MGU5221	Unidentified vessel	1858	Lihou
MGU5232	Unidentified vessel	1894	Lihou

Herm, Brehon, Jethou & Crevichon

MGU4405	Alfred Rooker	1922	Grosse Ferrière
MGU4459	Belfort	1886	49°28'00"N 02°26'30"W
MGU4469	Boadicea	1857	Tautenay
MGU4603	Elizabeth	1870	Humps
MGU4644	Fox	1888	Belvoir Bay
MGU4675	Gosforth	1872	Petit Creux
MGU4708	Hopper	1932	West Jethou
MGU4754	Jules	1880	Tautenay
MGU4862	Martin Heinrich	1823	North Point
MGU4864	Mary	1858	Percée Passage
MGU4929	Paolo	1893	North Herm
MGU5052	St. Joseph	1749	Brehon
MGU5214	Unidentified vessel	1843	Brehon
MGU5219	Unidentified vessel	1854	Belvoir Bay

Sark

MGU4392	Agenoria	1913	Sark

MGU4417	Ambassarice (formerly Chasseur)	1895	49°25'N 02°20'W
MGU4637	Firequeen	1866	Grunes
MGU4641	Ford Power	1972	49°27'N 02°21'W
MGU4691	Helper	1926	Creux Harbour
MGU4730	Jeanne Marie	1918	49°20'N 02°19'W
MGU4748	Joseph and Margaret	1887	49°25'33"N 02°18'00"W
MGU4751	Joy Bell II	1933	La Maseline
MGU4752	Joybell III	1933	Creux Harbour
MGU4782	Lady of Sark	1847	Creux
MGU4792	Le Poilu	1832	49°26'N 02°20'W
MGU4876	Mary	1848	Creux
MGU4979	Rival	1861	Creux Harbour
MGU5102	Twelve Apostles	1863	Havre Gosselin
MGU5160	Three Unidentified French Vessels	780	off Sark
MGU5203	Unidentified vessel	1835	Derrible Bay
MGU5208	Unidentified vessel	1839	Pointe du Nez
MGU5238	Unidentified vessel	1917	off Sark
MGU5245	Unidentified vessel	before 1960	49°23'08"N 02°21'45"W

Appendix J – Coastal sites and monuments on Guernsey, Sark and Herm

Guernsey

MGU100	Castle Cornet
MGU460	Half Moon Battery (La Valette)
MGU2920	German Tunnel Entrance
MGU3466	Gentlemen's Bathing Places, La Valette
MGU3468	Horse Shoe Pool, La Valette
MGU2998	Site of 2cm Flak Emplacement at La Valette
MGU2999	Site of 2cm Flak Emplacement at La Valette
MGU2997	Site of 2cm Flak Emplacement at La Valette
MGU3465	Ladies Bathing Places, La Valette
MGU3467	Children's Bathing Places, La Valette
MGU814	Resistance Nest "Tunnel" at Soldiers' Bay
MGU102	Clarence Battery at Fort George
MGU3423	Outer Gun Emplacement at Clarence Battery, Fort George
MGU3412	Quay below Fort George
MGU3411	Kiln below Fort George
MGU3409	Outer Battery at Fort George
MGU853	Resistance Nest "Wuerzburg" at Fort George
MGU3410	Defensive Outwork at Fort George
MGU559	Becquet Lower Battery at Fermain
MGU2222	Submerged Wooden Structure at Fermain
MGU813	Resistance Nest "Fermenbucht" at Fermain Bay
MGU103	North Battery at Fermain Bay
MGU104	No.15 Pre-Martello Tower at Fermain
MGU260	Fermain Bay South Battery
MGU2769	Le Grande Creux Emplacement, Fermain Bay

MGU262	Bec du Nez Battery, Jerbourg
MGU264	Main Earthworks on Jerbourg Headland
MGU2547	Breakwater at Divette
MGU296	Mont au Nord Battery, Jerbourg
MGU3430	Breastwork at St Martin's Point, Jerbourg
MGU872	St Martins Point Earthwork
MGU3429	Seamark / Flag Pole at St Martin's Point, Jerbourg
MGU304	St. Martin's Point Gun Platform at Jerbourg
MGU723	Navy Battery "Strassburg" at Jerbourg Point
MGU871	Jerbourg Point Earthworks
MGU295	La Moye Battery, Jerbourg
MGU303	Cannon Rock Gun Platform, Jerbourg
MGU297	Moulin Huet Left Battery
MGU298	Moulin Huet Watch House
MGU267	Moulin Huet Right Battery
MGU299	Moulin Huet Magazine
MGU306	Bon Port Gun Platform
MGU302	Saints Bay Left Battery
MGU3629	Stone Axes from Saints Bay
MGU3469	Gosselin Memorial, Saints Bay
MGU300	Saints Bay Right Battery
MGU3298	Cave at Icart Point
MGU589	Chateau d'Icart, Icart Point
MGU3613	Flints and Stone from Icart
MGU3269	Quartz Scatter, Icart Point
MGU457	Icart Battery
MGU573	Findspot: La Jaonnet
MGU3522	Mont Hubert Battery
MGU3521	Petit Bot Battery
MGU266	No.13 Pre-Martello Tower at Petit Bot

MGU2736	Petit Bot Lower Mill
MGU777	Resistance Nest "Grune Bucht" at Petit Bot Bay
MGU292	St Clair Battery, Petit Bot
MGU5332	Fortification at Les Sommeilleuses
MGU290	Les Sommeilleuses Magazine
MGU291	Les Sommeilleuses Watch House
MGU2825	Flak Battery at La Moye
MGU587	Pointe de la Moye Earthworks
MGU867	Point de la Moye Gun Platform
MGU1419	Corbiere Skeleton
MGU1416	Corbiere Cave
MGU775	Strongpoint "Rabenstein" at Corbiere
MGU533	Corbiere Castle
MGU169	Corbiere Beacon
MGU675	Army Artillery Observation Post M5 at La Prevote (Stp. Rabenstein)
MGU2135	Findspot: La Prevote Cliff Path #1
MGU4155	Findspot: La Prevote Cliff Path #2
MGU774	Resistance Nest "Schützenhof" at Les Tielles
MGU2140	Findspot: Les Tielles, Torteval
MGU843	Le Long Cavaleux
MGU246	Mont Herault Watch-house
MGU282	Naval Direction and Range Finding Tower MP4 at L'Angle
MGU2814	2cm Flak Emplacement at Pleinmont (Batterie Generaloberst Dollman)
MGU724	Army Coastal Battery Generaloberst Dollmann at Pleinmont
MGU2797	60cm Searchlight Position at Generaloberst Dollmann, Pleinmont
MGU842	Chateau de la Mouette
MGU701	Minefield Marker (Punkte) at Pleinmont (Batterie Gen. Dollman)
MGU247	Narron Battery, Pleinmont
MGU5084	Breastwork at Pleinmont (south)
MGU259	Pleinmont Battery

MGU2566	Slipway at Les Portes, Pleinmont
MGU5083	Breastwork at Pleinmont (north)
MGU257	Fort Pezeries, Pleinmont
MGU288	Slipway at Fort Pezerie
MGU771	Resistance Nest "Unter Westberg" at Portelet Harbour
MGU3435	Findspot: Stone Axe from Portelet
MGU770	Resistance Nest "Kaiserhof" at the Imperial Hotel
MGU245	Fort Grey at Rocquaine Bay
MGU796	Resistance nest "Gruene Dune" at Rocquaine
MGU255	Brock Battery at Rocquaine Bay
MGU3229	Personnel Shelter and Tobruk Pit at L'Eree, Wn. Ehren
MGU795	Strongpoint "Langenberg" at Fort Saumarez (L'Eree)
MGU2231	Findspot: Camp Varouf, L'Eree
MGU2232	Findspot: Camp Varouf, L'Eree
MGU553	Camp Varouf, L'Eree
MGU4363	Findspot: L'Eree Headland
MGU585	Flint Findspot: L'Eree Headland
MGU5424	Minefield No25 at Fort Saumarez (Stp Langenberg)
MGU4196	Roman Coin from L'Eree
MGU5425	Minefield No24 at Fort Saumarez (Stp Langenberg)
MGU2683	Lihou Fish Traps
MGU228	Lihou Priory, Lihou Island
MGU3329	Earthwork on Lihou Island
MGU3332	Lihou Flint Find Spot
MGU583	Lihou Lithic Find Spot
MGU3349	Lihou Flint Find Spot
MGU3333	Lihou Flint Find Spot
MGU582	Lihou Mesolithic Site
MGU5432	Flint Findspot on Lihou Island
MGU3559	Terrace on East Coast of Lihou Island

MGU3331	Wall on Lihou Island
MGU4192	Flint Findspot near Fort Sausmarez
MGU3634	Findspot: Briquetage near Fort Saumarez
MGU233	Fort Saumarez, L'Eree
MGU5437	L'Eree Barracks
MGU5428	Minefield No113 at Fort Saumarez (Stp Langenberg)
MGU4570	Roman Coin from L'Eree #2
MGU4347	Le Catioroc Briquetage Site
MGU2225	Findspot: Bank below Le Trepied tomb
MGU2639	Pak 36(t) Casemate at Le Catioroc
MGU2640	Machine Gun Post at Le Catioroc
MGU231	Perelle Battery
MGU4872	Perelle Beach: Roman and Prehistoric Findspot
MGU689	10.5cm K331(f) Gun Casemate at Fort Richmond (Stp. Reichenberg)
MGU2542	Medieval Settlement / Maladerie on Fort Richmond Headland
MGU3171	Findspot: Pottery and Flint at Le Crocq Headland
MGU2548	Slipway (west) at Richmond Headland
MGU2541	Shell Midden at Fort le Crocq Headland
MGU2527	Le Crocq Briquetage Site
MGU2549	Slipway (north) at Richmond Headland
MGU810	Resistance Nest "Krossen" at Fort Le Crocq
MGU2550	Slipway (west) at Richmond Headland
MGU2626	Machine Gun Post, Vazon Bay
MGU686	4.7cm Pak36(t) Gun Casemate in Vazon Bay (Wn. Margen)
MGU2561	Fosse aux Feves Earthwork
MGU212	Vazon Bay Left Battery
MGU684	4.7cm Pak36(t) Gun Casemate in Vazon Bay
MGU2623	Machine Gun Post, Vazon Bay
MGU483	Blondel Battery
MGU4204	Roman Coin from Vazon #1

MGU685	4.7cm Pak36(t) Gun Casemate in Vazon Bay (Wn. Rundbucht-Mitte)
MGU2555	Vazon Bay Peat Deposits
MGU4414	Roman Coin from Vazon #2
MGU213	Vazon Bay Right Battery
MGU806	Resistance Nest "Rundturm" at Vazon
MGU805	Strongpoint "Rotenstein" at Fort Hommet
MGU578	Flint Findspot: Hommet Headland #1
MGU579	Flint Findspot: Hommet Headland #2
MGU196	Fort Hommet at Hommet Headland
MGU580	Flint Findspot: Hommet Headland #3
MGU5427	Flint Findspot: Hommet Headland #3
MGU3553	Flint Findspot: Hommet Headland
MGU3639	Flint Findspot: Albecq #1
MGU4210	Medieval findspot on Hommet Headland
MGU3523	Earthwork on Hommet Headland
MGU224	Medieval Settlement at Albecq
MGU221	Chateau d' Albecq
MGU2599	German Sea Wall, Albecq
MGU4175	Flint Findspot: Albecq #2
MGU2598	German Sea Wall, Cobo Bay
MGU2597	German Sea Wall, Cobo Bay
MGU2596	German Sea Wall, Cobo Bay
MGU577	Flint Findspot: Cobo
MGU800	Resistance Nest "Coboufer" at Cobo
MGU3376	1200 Yard Marker at Rifle Range, Grandes Rocques
MGU3375	950 Yard Marker at Rifle Range, Grandes Rocques
MGU3374	900 Yard Marker at Rifle Range, Grandes Rocques
MGU3373	850 Yard Marker at Rifle Range, Grandes Rocques
MGU3372	800 Yard Marker at Rifle Range, Grandes Rocques
MGU3371	750 Yard Marker at Rifle Range, Grandes Rocques

MGU3370	700 Yard Marker at Rifle Range, Grandes Rocques
MGU3369	650 Yard Marker at Rifle Range, Grandes Rocques
MGU3365	600 Yard Marker at Rifle Range, Grandes Rocques
MGU3368	550 Yard Marker at Rifle Range, Grandes Rocques
MGU479	Saline Battery
MGU3367	500 Yard Marker at Rifle Range, Grandes Rocques
MGU3364	450 Yard Marker at Rifle Range, Grandes Rocques
MGU3366	400 Yard Marker at Rifle Range, Grandes Rocques
MGU4171	Slipway at Grandes Rocques
MGU2589	Mortar Bunker at Grandes Rocques
MGU2588	4.7cm Pak 36 (t) Casemate, Grandes Rocques
MGU2587	Searchlight Emplacement, Grandes Rocques
MGU2546	Grandes Rocques Flint Scatter
MGU3363	100 Yard Marker at Rifle Range, Grandes Rocques
MGU3356	Wall for Rifle Targets at Grandes Rocques
MGU1417	Roman Samian Mortarium from Grandes Rocques
MGU2579	10.5cm K331(f) Casemate, Grandes Rocques
MGU530	Grandes Rocques Flint Findspot
MGU3562	Flint Findspot at Grandes Rocques
MGU203	Grandes Rocques Battery
MGU2580	Machine Gun Post, Grandes Rocques
MGU2581	Ammunition Shelter, Grandes Rocques
MGU2582	Machine Gun Post, Grandes Rocques
MGU2584	Concrete Lined Trench, Grandes Rocques
MGU2583	Machine Gun Post, Grandes Rocques
MGU2585	German Shelter, Grandes Rocques
MGU2476	Findspot: Grandes Rocques Battery
MGU3561	Flint Findspot at Grandes Rocques
MGU2578	RFO Emplacement, Grandes Rocques
MGU2577	10.5cm Casemate, Grandes Rocques

MGU236	Medieval Settlement at Grandes Rocques
MGU3357	Wall for Rifle Targets at Grandes Rocques
MGU3360	250 Yard Marker at Rifle Range, Grandes Rocques
MGU3359	300 Yard Marker at Rifle Range, Grandes Rocques
MGU2592	Mortar Pit and Trench, Grandes Rocques
MGU4203	Flint Findspot: Port Soif
MGU519	Flint Findspot: Port Soif Islet (East)
MGU576	Flint Findspot: Port Soif Islets (west)
MGU4199	Flint Findspot: Bay west of Port Soif
MGU4194	Paved Platform at Portinfer
MGU162	Portinfer Battery
MGU4387	Findspot: Port Soif
MGU488	Portinfer Skeleton
MGU789	Resistance nest "Fischerburg" at Pecqueries Bay
MGU537	Findspot: Pecqueries Headland
MGU4169	Prehistoric Findspot: Pulias Headland (West)
MGU554	Flint Findspot: Pulias Headland (West)
MGU4200	Prehistoric Findspot: Pulias Headland (West)
MGU521	Flint Findspot: Pulias Headland (North)
MGU2228	Prehistoric Findspot: Pulias Headland (PH84/US)
MGU4191	Flint Findspot: Port Grat
MGU158	Cists at La Rousse
MGU3641	Flint Findspot at Rousse
MGU166	Rousse Battery
MGU3176	Findspot: Flint from Houmet du Nord
MGU2423	Mortar Pit, part of GU832
MGU2422	Tobruk Bunker at Picquerel
MGU2425	Multi loop-holed turret 'Mehrschartenturm' bunker
MGU4172	Flint Findspot: Picquerel Point
MGU2424	Site of Machine Gun, part of GU832.

MGU2774	Picquerel Barrow, L'Islet
MGU831	Resistance Nest "Garen" at Grande Havre
MGU3476	Stone Enclosure on Chouet Beach
MGU2139	Flint Findspot: Chouet Headland
MGU830	Strongpoint "Kraehennest" at Chouet
MGU2430	Telephone Switching Post N (C3)
MGU588	Chouet Magazine
MGU171	No.10 Pre-Martello Tower at Chouet
MGU450	Chouet Battery No. 2 (La Lochande)
MGU449	Chouet Battery No. 1 (La Lochande)
MGU565	Flint Findspot at Chouet Point
MGU566	Flint Findspot: Creve Coeur
MGU3577	Flint Findspot: Creve Coeur #4
MGU3551	Flint Findspot: Jaonneuse Bay #1
MGU4159	Findspot at Creve Coeur
MGU4170	Flint Findspot: Jaonneuse Bay #5
MGU3576	Flint Findspot: Jaonneuse Bay #3
MGU3575	Flint Findspot: Jaonneuse Bay #2
MGU2119	Findspot: Pembroke Bay, opposite Jaonneuse Bay
MGU520	Flint Findspot: Jaonneuse Point, Pembroke
MGU4201	Findspot: Jaonneuse Point, Pembroke
MGU154	Fort Pembroke
MGU3322	Findspot: Flint from Fort Pembroke
MGU486	Platon Battery at L'Ancresse
MGU152	Star Fort at Pembroke
MGU3547	Flint Findspot, Pembroke Star Fort
MGU2413	Anti-Tank Wall (Panzermauer) at L'Ancresse
MGU752	4.7cm Pak36(t) casemate at L'Ancresse
MGU5453	Roman Sherd from L'Ancresse
MGU4142	Human Remains from L'Ancresse

MGU837	Resistance Nest "Dohlenturm" at L'Ancresse
MGU164	Nid de L'Herbe Battery
MGU165	Magazine at Nid de L'Herbe Battery
MGU3673	Findspot at Nid de L'Herbe, L'Ancresse
MGU2450	Naval Strongpoint (Marinestuetzpunkt) Grosshuegel
MGU567	Findspot: Banque a Barque, L'Ancresse
MGU827	Strongpoint "Marschen" at L'Ancresse
MGU4184	Flint Scatter north of La Hougue Catelain
MGU151	Fort Le Marchant, L'Ancresse
MGU4190	Flint Findspot at Fort le Marchant #2
MGU3565	Flint Findspot at Fort le Marchant #2
MGU1906	Flint Findspot at Fort Le Marchant #1
MGU4182	Findspot near Fort le Marchant
MGU4188	Flint Findspot: West side of Fontenelle Bay
MGU4183	Medieval Findspot in Fontenelle Bay
MGU4187	Flint Findspot: Hougue Patris
MGU615	Fontenelle Bay Structure
MGU3257	Machine Gun Emplacement at Fort Doyle (Stp. Nebelhorn)
MGU3552	Flint Findspot: Banque au Mouton #2
MGU788	Strongpoint "Nebelhorn" at Fort Doyle
MGU568	Findspot: Banque au Mouton #1
MGU4185	Flint Findspot: Banque au Mouton #3
MGU150	Fort Doyle, L'Ancresse
MGU3249	Machine Gun Emplacement at Fort Doyle (Stp. Nebelhorn)
MGU163	Beaucette Battery
MGU569	Flint Findspot: Beaucette Marina
MGU3598	Cross Inscribed Stone at la Croix Besnard
MGU3599	Iron Age Findspot at la Croix
MGU617	Cremation burial at Paradis
MGU572	Findspot: La Vieille Islet, Bordeaux

MGU452	Hommet Benest Battery
MGU2478	Findspot: Hommet Benest Island (Bordeaux)
MGU522	Flints from Hommet Benest
MGU564	Hommet Islet, Bordeaux
MGU2136	Findspot: Hommet Island, Bordeaux (3)
MGU3676	Stone Axe from Bordeaux Harbour
MGU5420	Concrete Holdfasts on Bordeaux Beach
MGU149	Vale Castle
MGU143	Parish Boundary Stone on the Bridge
MGU140	De Lisle Brock Memorial Stone
MGU141	Obelisk at South Side, St. Sampson
MGU783	Resistance Nest "Simsonhafen" at St Sampson Harbour
MGU2022	'Harbour Office', South Side
MGU137	Mont Crevelt Fort
MGU2363	Personnel Shelter and Covered Trench at Mont Crevelt
MGU666	Detonation Control Bunker at Mont Crevelt Fort (Wn.Krevelberg)
MGU2362	Minefield Bunker at Mont Crevelt
MGU834	Resistance Nest "Richardseck" at Spur Point
MGU222	Spur Point Battery
MGU3455	Slipway at Richmond Corner, Belle Greve
MGU3449	Belle Greve Breakwater 1
MGU3450	Belle Greve Breakwater 2
MGU4193	Chateau des Marais Drainage System
MGU825	Resistance Nest "Schoenbucht-Mitte" at Kempt Battery
MGU5402	Medieval Coin from Belle Greve Bay
MGU3456	Slipway North of Hougue a la Perre
MGU824	Resistance Nest "Gemaeuer" at Hougue a la Perre
MGU1	Hougue a la Perre Battery
MGU661	4.7cm Casemate at Hougue a la Perre Battery (Wn. Gemauer]
MGU3457	Slipway South of Hougue a la Perre

MGU3478	Belle Greve Bay Peat Deposits
MGU3451	Enclosure on Belle Greve Beach
MGU2384	Pillar Machine Gun Emplacement
MGU2383	German Power Station Outlet
MGU3458	Slipway at the Long Store, Belle Greve
MGU823	Resistance Nest "Peterseck" at Salerie Corner
MGU3460	Salerie East Pier
MGU3461	Salerie West Pier
MGU3459	Slipway at the Salerie
MGU464	Salerie Battery
MGU2220	North Beach Findspot
MGU3670	Stone Axe from St Peter Port Harbour
MGU4388	Memorial to Foreign Workers
MGU4389	German Air Raid Memorial
MGU3163	Holocaust Memorial at the White Rock
MGU4409	Liberation Monument
MGU821	Resistance Nest "Nordmole" at the White Rock
MGU2221	Salerie Roman Findspot
MGU819	Resistance Nest "Viktoria Pier" on Victoria Pier
MGU69	Victoria Landing Memorial Stone
MGU818	Resistance Nest "Albert Pier" on Albert Pier
MGU815	Resistance Nest "Havelet Bay" at Havelet Bay
MGU816	Resistance nest "Modellhafen" on the Castle Pier
MGU2219	Cow Bay Findspot

Herm

MGU127	Conical Stone Building, Herm
MGU4160	Flint Findspot on Hermetier
MGU2229	Findspot: Fisherman's Beach, Herm

MGU525	Findspot: Fisherman's Field, Herm
MGU2230	Findspot: Fisherman's Beach, Herm
MGU3567	Shell Midden on Herm
MGU5456	Roman pottery from Herm
MGU5384	Findspot at Le Plat Houmet, Herm
MGU4408	Burial Chamber at Oyster Point, Herm
MGU3441	Findspot: Mouissonnière Beach, Herm
MGU4195	Prehistoric Land Surface on North Coast of Herm
MGU5359	Amphora from Tautenay
MGU4211	Flint Findspot: Longue Pierre, Herm Humps
MGU4355	Flint and Lithic Findspot, Godin, Herm Humps
MGU4362	Flint Findspot, Beach, Herm Humps
MGU4356	Findspot, Galleu, Herm Humps

Jethou

MGU3556	Stone Alignment on Jethou
MGU3554	Midden Site on West Coast of Jethou
MGU2754	Crevichon Beach, Jethou

Sark

MGU5392	Cannon at Creux Harbour, Sark
MGU5378	Tunnel at Creux Harbour, Sark
MGU3136	Star Fort at Chateau des Queneves, Sark
MGU5394	Cannon at the Hogsback, Sark
MGU4212	Cannon above Rouge Terrier, Sark
MGU3153	Possible Roman Landing, Little Sark
MGU3147	Earthworks at L'Eperquerie (3), Sark
MGU3146	Earthworks at L'Eperquerie (2), Sark

MGU3151	Guardhouse at L'Eperquerie, Sark Sark
MGU3150	Post-Medieval Defences L'Eperquerie
MGU5396	Cannon as bollards at L'Eperquerie Landing, Sark
MGU3145	Battery and Defensive Wall at L'Eperquerie, Sark

Appendix K – Environmental Action Plan (EAP)

Environmental Action Plan (EAP)		
Topic	**Action Points**	**Who to Action**
Navigation	Creation of Marine Guidance Notes	Developer
	Mark devices with buoys etc.	Developer
	Inform map/chart producers of device deployment areas	GREC
	Designation of safety zones to prevent access to certain areas of the sea	Developer/GREC/Harbour Master
Noise	Use best practice when using piling installation – eg. Soft Starting, Bubble Curtains	Developer
	Use the least intrusive deployment method available	Developer
	Structure of device to reduce noise	Developer
	Timing and siting of development to avoid potentially affecting breeding/feeding grounds etc.	GREC
	Maintenance intervals timed to reduce noise	Developer
	Deterrent noise Measures – e.g. acoustic avoidance devices	Developer
Commercial Fisheries and Mariculture	Identify opportunities for the use of local fishing boats for the operation and maintenance of devices	GREC
	Siting/zoning to avoid certain areas	GREC
	Micro Siting to avoid specific sensitive areas	Developer
	Industry wide compensation measures – e.g. the provision of a crane for the industry to use	Developer
	Exclusive and controlled access within a site	Developer
	Financial compensation to fishermen	Developer
Archaeology	Watching Brief	Developer
	Micro Siting	Developer
	Avoidance of sensitive areas	GREC
Birds	Timing and siting of work	GREC
	Height of structures and depth from surface	Developer

Environmental Action Plan (EAP)		
Topic	**Action Points**	**Who to Action**
Benthic Ecology	Zoning	GREC
	Micro siting	Developer
	Construction method – to reduce the area and sedimentation	Developer
	Anti pollution measures	Developer
	Provision of structures for habitats	Developer
	Exclusion Zones	GREC/Developer
	Seasonal Work	Developer
Geology	Scour protection	Developer
Pelagic Ecology	Actions to reduce pollution risk	Developer
	Action to reduce Sediment risk	Developer
	Noise risk – see above	
Marine Mammals	Seasonal Work	Developer
	Colour of devices to prevent collisions	Developer
	Marine Mammal Observer	Developer
	Sea Mammal Research Unit Protocol	GREC/Developer
Tourism	Creation of a visitor centre for marine renewable energy	GREC + Developer
	Public education on renewable energy	GREC
Marine Processes		
Sediment contamination and water quality	Identify defined areas of sediment contamination.	GREC
Recreational fishing	Siting and Zoning to avoid certain areas	GREC
Cables and grid connections	Siting of cables	GREC
	Micro-siting of cables	Developers
Air Quality	Maintenance Intervals timed to reduce unscheduled maintenance	Developer
Landscape and Seascape	Project-specific landscape impact assessment	Developer

Appendix L – Regional Monitoring Plan (RMP)

Monitoring Plan (MP)		
Topic	**Monitoring Points**	**Who to Action**
Navigation	Project specific Navigational Risk Assessment (NRA)	Developer/GREC
	Marine Traffic Survey	GREC/Developer (dependant on timing)
Noise	Device specific Noise Study	Developer
	Baseline Noise survey	GREC
	Post development monitoring	Developer
	Acoustic Avoidance device studies	GREC/Developer/Other
Commercial Fisheries and Mariculture	Fisheries Valuation Study	GREC/Developer
	Reflect on UK Marine Protected Area (MPA) studies	GREC
	Use catch records to provide a baseline for fishing activity	GREC
Archaeology	WSI	Developer
	Geophysical Survey	Developer
	Monitoring of scour	Developer
Birds	Identify foraging areas	GREC
	Togging and logging surveys	GREC
	Boat based and shore based observations	GREC
	Post installation monitoring	Developer
Benthic Ecology	Baseline surveying of the benthic environment	GREC
	Benthic Monitoring post development	Developer
	Investigate the impact of energy extraction on the Benthic habitat	DECC/GREC/Developer
Geology	Fill in data gaps from existing states projects	GREC
	Identify the soil and rock parameters	

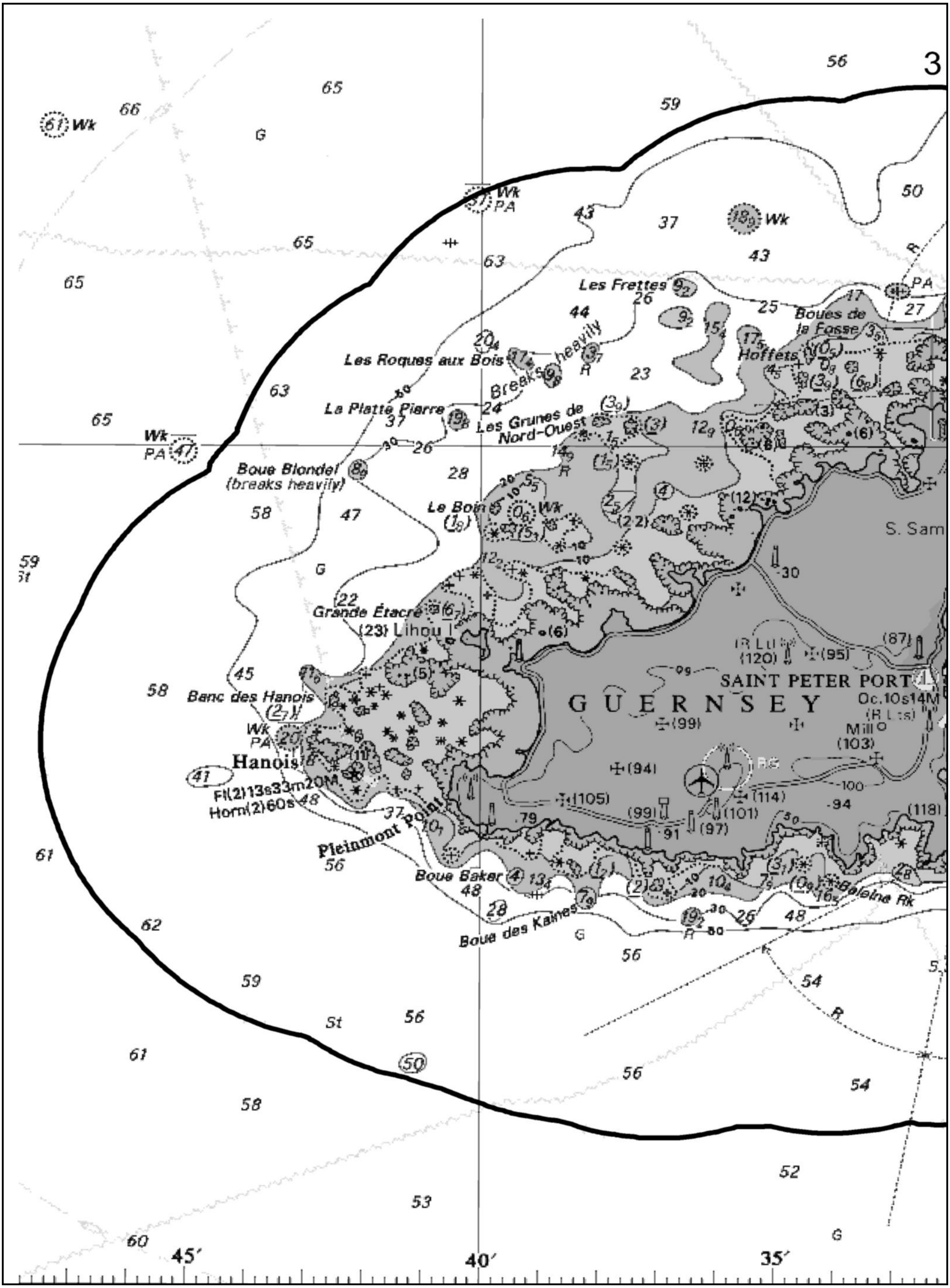
Monitoring Plan (MP)		
Topic	**Monitoring Points**	**Who to Action**
	Project specific Geology information – Boreholes, Grabs, Geophysical data	Developer
	Sediment modelling and device data	Developer
	Information from historic maps	GREC
	Beach Surveys	GREC/Developer
Pelagic Ecology	Sightings Data and surveys	GREC – Possible public appeal
	Research on collision risks	GREC/Developer
	Understanding noise risks on fish	GREC – review studies
	Noise production, both passive and active	GREC/Developer
	Frontal Mapping	GREC – as part of zoning
Marine Mammals	Research on collision risks	Developer
Tourism	Survey to identify tourists opinions of Guernsey developing marine renewables	GREC
	Other issues relate to noise, seascape etc.	N/A
Marine Processes	Post development monitoring of wave and tidal energy extraction and sediment interaction	Developer
Sediment contamination and water quality	Baseline monitoring of all contaminants in the REA area	GREC
	Monitoring of potential specific contaminants	Developer
	General post development monitoring	Developer
Recreational fishing		
Cables and grid connections	None Identified	N/A
Air Quality	Baseline Air Quality monitoring at sea	GREC/Developer
	Post development monitoring	On land – HSSD, at sea GREC/Developer

Monitoring Plan (MP)		
Topic	**Monitoring Points**	**Who to Action**
Landscape and Seascape	Baseline survey from all available sources	GREC
	Ongoing monitoring of landscape and seascape during deployment	GREC/Developer
	Post development monitoring of factors such as night time light levels and changes to the landscape/seascape	GREC/Developer
Social Aspects	Monitoring of the Marine renewables industry to understand costs	GREC liaising with developer
	Investigation into the likely cost of energy	GREC liaising with developer
	Investigation of the likely impacts of increased energy prices on businesses.	GREC

---

[i] Owen A, Bryden IG, A novel graphical approach for assessing tidal stream energy flux in the Channel Isles, Journal of Marine Science and Environment, IMarEST, 2006

[ii] UK Hydrographic Office, “Admiralty Tidal Stream atlas NP264”, Crown Copyright, Taunton 1993
[iii] Gallagher R.H., et al (ed) “Finite Elements in Fluids”, John Wiley & Sons, Bristol, 1978
[iv] Gerald C.F. “Applied Numerical Analysis”, 2nd Ed, Addison-Wesley, Massachusetts, 1978
[v] Dyke P, “Modelling Marine Processes”, Prentice Hall, London 1996,


3
Wk
Wk
PA
Les Frettes
Boues de la Fosse
Hoffets
Les Roques aux Bois
Breaks heavily
La Platte Pierre
Les Grunes de Nord-Ouest
Wk
PA
Boue Blondel (breaks heavily)
Le Boin
Wk
Grande Étacre
(23) Lihou I
Banc des Hanois
Wk
PA
Hanois
Fl(2)13s33m20M
Horn(2)60s
Pleinmont Point
Boue Baker
Boue des Kaines
Baleine Rk
S. Sam
GUERNSEY
SAINT PETER PORT
Oc.10s14M
(R Lts)
(R Lts)
(120)
(95)
(87)
(99)
Mill
(103)
(94)
(105)
(114)
(99)
(101)
(97)
(118)
RG
St
St
G
R
45′
40′
35′