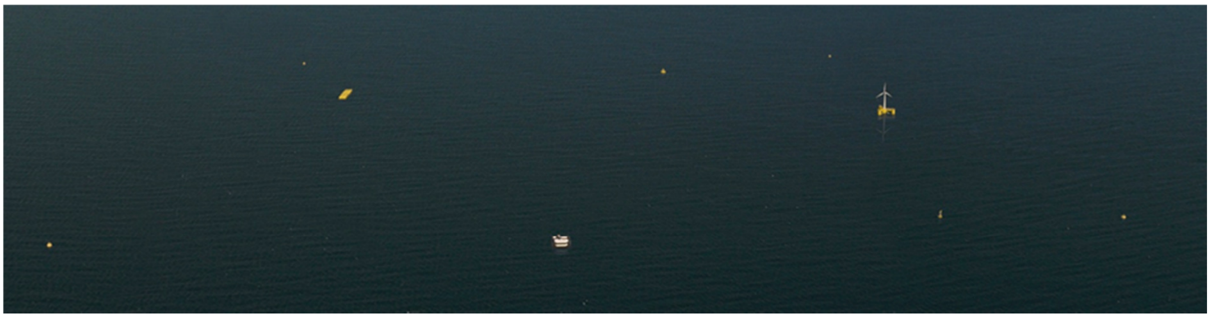
Galway Bay
Marine and Renewable Energy Test Site

Foreshore Lease Application

Environmental Report

February 2016



Marine Institute Foras na Mara   seai SUSTAINABLE ENERGY AUTHORITY OF IRELAND   SMARTBAY IRELAND

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1. Non-technical summary

INTRODUCTION

Marine renewable energy is an emerging industry which has very considerable potential for economic growth and job creation. With an exceptional marine resource, Ireland is in a unique position to capitalise on its natural advantages in the area of marine renewable energy. This will happen through the development, manufacture, deployment and operation of wave, tidal and offshore wind technologies and the creation of an indigenous supply chain in Ireland.

The Department of Communications, Energy & Natural Resources published the Offshore Renewable Energy Development Plan (OREDP) in 2014. It provides a framework for the exploitation of wave, tidal and offshore wind and renewable energy resources in Ireland's marine territory. The OREDP has established scenarios for the development of offshore renewable resources in Irish waters up to 2030, and provides a description of developing policy, which will affect the context that they may develop in. It aims to establish Ireland as a leader in ocean energy technologies and to develop facilities that will enable the commercialisation of ocean energy products and services.

As part of the implementation of the original Ocean Energy Strategy (2006), a ¼ scale wave energy test site has been operational in Galway Bay for 10 years. This proposed foreshore lease application for the Galway Bay Marine and Renewable Energy Test Site (MARETS) is an evolution of the original test site and will provide enhanced research capabilities and test infrastructure. The upgrade of the test site is an integral component of Ireland's OREDP and will facilitate testing and validation of various ocean energy converters and prototypes in conditions that represent ¼ scale of the open Atlantic Ocean environment.

The proposed development will provide a national cabled test facility, to which wave energy converters can be connected during testing phases, and where other marine technologies and componentry can be tested and evaluated. The experience gained from deployment at the test site will assist commercial scale wave energy production in the future at suitable locations around the Irish Coast.

THE PROJECT

The Marine Institute is applying for a Foreshore Lease for a Marine and Renewable Energy Test Site. It is located at the existing test site offshore of Spiddal, Co. Galway and will provide developers and researchers with a cabled and a leased area in which to test and demonstrate their prototype ocean energy converters and related technologies.

The application provides for an upgrade of infrastructure to improve the service offered to end-users. The following list details the proposed long term deployments at the site:

- Upgraded cardinal marks to allow for safer navigation;

- A databuoy to provide wave measurements;
- Buoys for testing marine technologies and scientific sensors;
- A 'SeaStation' which will provide power to, and dissipate power from, ocean energy devices as well as provide data communications to shore;
- An acoustic array for monitoring underwater sound;
- Interlocking modular gravity base(s);
- A variety of scientific sensors and instruments;
- Cables which will connect the instruments, sensors, and ocean energy devices;

The proposed upgrade of the site will enable periodic deployments of up to three individual devices, of the following types, for test and evaluation purposes for a maximum period of 18 months:

- Surface ocean energy converters;
- Sub-surface ocean energy converters;
- Seabed ocean energy converters;
- Prototype floating wind turbines;
- Novel marine technologies and scientific sensors.

It is proposed that the upgraded test site will operate for up to 35 years, with devices on site intermittently throughout the year. The test site has been structured into three berths, designed to only allow a maximum of 3 prototype ocean energy convertors to be deployed and tested at any one time. The fourth berth will be for the Cabled Observatory and related projects.

The deployment of wave energy converters, tidal turbines, floating devices and other innovation projects will take place in accordance with the strict conditions described in the Galway Bay Test and Demonstration Site Manual.

The document explains the procedures to be followed by any company or researcher wishing to use Galway Bay Marine and Renewable Energy Test Site to test their ocean energy conversion prototypes or devices. It also states the "Conditions for Use" of those facilities, as well as the services provided to assist the users of the test site.

It provides the legal, marine safety, environmental and operation conditions the users must satisfy prior to a device being granted access to the test site.

Devices will most likely be deployed at the test site during the months of April to September for periods of testing ranging from weeks to months. The maximum duration of testing for any one device at the test site will be 18 months. Devices can be periodically removed for adjustments and maintenance purposes. The actual deployment of devices will likely occur over a series of two to three day periods. Initially the anchoring and moorings will be deployed at the test site. The device will subsequently be towed to the test site and the device secured to the moorings.

Decommissioning of the test site leasehold area will be subject to agreement between MI/SEAI, the Minister for Environment Heritage and Local Government, and other appropriate authorities, and will be in line with relevant legislation and industry best practice at the time.

Decommissioning of individual devices or technologies will be the responsibility of the developer and will be subject to agreement with the Marine Institute, and be in line with relevant legislation and industry best practice at the time.

An assessment of the impact of decommissioning devices will be undertaken. This will include options for the recovery of anchoring systems, or leaving them in-situ.

ALTERNATIVES

Other potential sources of renewable energy could be developed to achieve the governments agreed 2050 targets – for example, onshore and offshore wind, biomass, solar, geothermal or hydro power for example. These sources are limited either by resource and/or potential issues such as:

- Considerable loss of potential economic benefits from the development of a new industrial sector;
- Increased pressure on aquatic environments and potential loss of status under the Water Framework Directive;
- Increased pressure on sensitive habitats such as moorlands;
- Increased adverse effects on landscape character and visual amenity;
- Increased cumulative effects on birds, bats and other wildlife through habitat loss and disturbance;
- There would also be limitations relating to intermittency of electricity supply from onshore wind. By contrast, marine renewable energy is much more consistent;
- Security of supply and increased portfolio diversity.

The provision of the test site is required to meet one of the key initiatives set out in the Government publications Offshore Renewable Energy Development Plan and Harnessing Our Ocean Wealth. It will help underpin the Government’s stated objective of producing 50GW from ocean energy by 2050. It will do this by providing a test facility where ocean energy devices can demonstrate their survivability. This testing is a necessary phase before commercial scale ocean energy development can proceed.

Successful marine renewable energy development will lessen Ireland's dependence on imported fossil fuels, will lead to greater security of energy supply, and will provide viable alternatives to meeting Ireland's energy needs.

Successful prototype testing will also lead to potential future economic development associated with the development of a larger ocean energy sector in Ireland.

Although guidelines recommend considering alternatives for the choice of the development, the fact remains that the existing Galway Bay ¼ scale wave energy test site has been established at the present location for the past ten years, is an accepted part of the maritime landscape in Galway Bay, and has had negligible impact on the marine environment since its inception. No alternate locations have been considered

IMPACTS OF THE PROJECT

The possible impacts of the Galway Bay Marine and Renewable Energy Test Site were examined. This was done by assessing the environment in terms of the existing conditions, the impact of the proposed development, and the measures taken to mitigate these impacts. When applicable, environmental impacts were assessed for worst case scenarios based on the infrastructure, devices, and technologies proposed for deployment at the test site. This determined the impact thresholds for the different environmental receptors and provided the maximum scope of potential environmental impacts.

Human Activity

The Galway Bay Marine and Renewable Energy Test Site does not contain a residential component, nor any land based infrastructure, and therefore will not have any direct impact on the composition of the population in the immediate area.

During the operational phase of the test site there will be visits by device development teams to the area which will promote economic activity in the local hotel and catering industries. Workboats and marine contractors will be needed to assist the installation, monitoring and maintenance of the test devices. There is the potential that the area could become a hub for ocean energy development and research in Ireland. Long term employment opportunities will be associated with the operational phase of the development and overall long term positive impact on employment is expected with economic benefits, including supplementing existing incomes and generating new employment opportunities.

During the operational phase of the test site, increased traffic to the new pier in Spiddal will be very low in volume with an estimated two to four vehicles per week using the facilities when devices and projects are using the test site.

Flora and Fauna
There are no designated Special Areas of Conservation (SAC), proposed Natural Heritage Areas (pNHA) or Special Protection Areas (SPA) at the location of the Galway Bay Marine and Renewable Energy Test Site.

Benthic habitats
All of the species present at the test site are typical of the area. No rare, sensitive or unusual species were recorded. The appraisal established baseline benthic fauna present at the test site and found a high level of similarity between the sampled locations and the results of a benthic faunal study carried out in 1981, suggesting that there has been no noticeable changes in benthic fauna in this area since the establishment of the original test site in 2006. Sediment Profiling Images indicated a healthy stage community present within the test site with both infaunal and epibenthic species reworking and oxygenating the upper sediment to such a degree that no discontinuity in oxygen levels were noted.

The loss of habitat and species will arise in the footprint of scaled devices, gravity bases, clump weights and anchors on the seabed (or scouring associated with structures on the seabed). While this loss of habitat cannot be mitigated, the actual area lost is so small that the impact on the benthic community will be negligible. In addition, following the removal of the infrastructure (if removal is required) the impacted area will immediately begin to recover through recruitment from neighbouring undisturbed areas. The disturbance to sediment and the resultant increases in suspended sediments and turbidity and the subsequent deposition of sediments will be of such a scale that impacts on the benthos will be negligible.

There is the potential for contamination from the use of anti-fouling compounds, oil leakages, and the erosion of sacrificial anodes. As the quantities and toxicities associated with these are generally expected to be extremely small, the potential effect will be of negligible significance. There are no sensitive habitats in the vicinity of where these compounds may be used and as a result any impacts will be negligible.

Marine Mammals
The Galway Bay Complex SAC (000268) supports an important common seal colony and a breeding otter population, both of which are listed under Annex II of the EU Habitats Directive but no cetacean species are listed as qualifying interests of the site. The presence of seals and cetaceans (whales, dolphins and harbour porpoises) was assessed as part of on-going research activity at the existing test site. Datasets from the test site are the longest recorded in Ireland with c.900 days monitored across all studies.

Marine mammal monitoring to assess the effect of a ¼ scale ocean energy device on harbour porpoise presence was carried out at the Marine and Renewable Energy Test Site (MaRETS) between 2009 and 2010 when an ocean energy scaled device was on site. Monitoring was also carried out at 2 control sites, one 1km east of the test site and the second was 500m west of the test site. Results from this short-term deployment and monitoring failed to show a significant difference in detections between sites, suggesting that the ocean energy device did not influence harbour porpoise presence, either positively or negatively.

The small number of scaled devices that will be deployed in the test site at any one time and the open water extending for *c.* 1km between the test site and the northern shore of Galway Bay make the likelihood of any exclusion or barrier effect occurring remote and the consequence would be negligible.

Given the scaled size of the devices, the slow speed of any turbines blades, the low number of devices likely to be in operation at any one time and the short-term intermittent nature of the installation/service vessels the likelihood of a collision occurring is unlikely.

Operational noise from individual devices is unlikely to have large-scale effects on the behaviour or survival of marine organisms. As a result of the studies carried out to date and the nature and use of the Galway Bay Marine & Renewable Energy Test Site, the impact of three operating scaled energy test devices on marine mammals in the area will be negligible.

A hydrophone and acoustic array will facilitate the measurement of sound generated from experimental devices and will facilitate the recording of cetacean vocalisations allowing the Marine Institute to assess the impact on an ongoing basis. This monitoring will add to current scientific knowledge on noise impacts and it will add to the industries knowledge of potential impacts using scaled prototype devices in the test site.

Avifauna

There are no designated Special Areas of Conservation (SAC), proposed Natural Heritage Areas (pNHA) or Special Protection Areas (SPA) at the location of the Galway Bay Marine and Renewable Energy Test Site. Within 15km of the test site, there are SPAs designated under the EU Birds Directive (Inner Galway Bay, Lough Corrib and Connemara Bog Complex) and there are also cSAC areas such as Lough Corrib, Galway Bay Complex, Black Head - Poulsallagh Complex, Ballyvaughan Turlough, and Connemara Bog Complex. Important species at these sites include great northern diver, red-breasted merganser, black-headed gull, common gull, sandwich tern, common tern, Arctic tern and cormorant.

The installation of surface objects may provide additional roosting, perching, nesting or breeding sites for birds. While an increase in habitat is seen as a positive benefit, there is a chance that this may increase their risk of collision and therefore the benefit is cancelled out and in reality will have a negligible impact overall.

There is also a risk of birds colliding with the single 25m high scaled wind turbine that may be erected at the site. The greatest risk is collision with the rotating blades as opposed to the tower. It is highly unlikely that a single, temporary, scaled wind turbine will have any impact on bird populations in Galway Bay.

Given the scaled size of the devices, the slow speed of any turbines blades, the low number of devices likely to be in operation at any one time and the short-term intermittent nature of the installation/service vessels the likelihood of a collision occurring is unlikely.

Water Quality
The Galway Bay Marine and Renewable Energy Test Site is not anticipated to present any risks to water quality during installation, operation or decommissioning. In the marine environment, the main threat to water quality is oil pollution arising from accidental leakage from the vessels used in installation and deployment and from devices in operation. Vessels engaged in installation and operational activities will be required to have appropriately trained staff to implement an oil pollution emergency response plan and to have appropriate emergency response equipment in line with the accredited HSEQ Management System. This will minimise the impact of any oil spill that might occur. Devices will be designed so that on-board oil leaks are contained within the hull, and only oils with low environmental impact will be used.

Overall, any impact on water quality from the project will be short-term and of low significance, and the development does not present any significant risks to water quality.

Seabed and Geology
All prototypes on test at the Galway Bay Marine and Renewable Energy Test Site will be anchored to the seabed using gravity anchors, or embedment anchors. The placement of anchoring systems may give rise to some small-scale sediment displacement. Scour protection using rock deposition may also be required to prevent erosion around anchoring systems. This is not anticipated to have any impact on the nature and distribution of marine sediments. Given the type of works, the nature of the project and the environmental setting, it is not anticipated that the marine aspect of the proposed development will have any discernible impact on sediments and geology.

Air Quality
Offshore activities by their nature are weather-dependent, and the estimates for the duration of installation and vessel operation on-site are based on acceptable weather conditions. Based on the analysis undertaken for the full scale Atlantic Marine Energy Test Site in Belmullet, Co. Mayo, even if the maximum number of devices is deployed at the site at any one time, the overall impact from operations at the Galway Bay Marine and Renewable Energy Test Site would be negligible.

Cultural Heritage
Following review of the Galway Bay Marine and Renewable Energy Test Site data, no archaeological features were identified. It is suggested that the proposed development will not have any impact on any known archaeological features and only a specific but limited direct impact on the seafloor within the footprint of any anchors or gravity foundations.

Visual Impact
In clear viewing conditions the proposed Galway Bay Marine and Renewable Energy Test Site will be a noticeable concentration of variant, but apparently associated, structures covering a small geometric section of Galway Bay. The structures may appear slightly ambiguous compared to vessels and structures that might be more familiar in the marine environment this far offshore.

Given that the proposed Galway Bay Marine and Renewable Energy Test Site does not represent significant bulk, visual impacts will result almost entirely from visual 'intrusion' rather than visual 'obstruction'. The proposed structures may contribute a minor degree of visual clutter to the seaward view. Nonetheless, this is a living and working section of coastline that hosts an array of structures and land uses and it is not considered that the Galway Bay Marine and Renewable Energy Test Site conflicts with the character and values associated with the coastal vistas in this area.

Important ameliorating factors are the temporary nature of the installations for the devices and the fact that it will be uncommon for all of the structures to be in place at any one time. Overall, it is not considered that the proposed Galway Bay Marine and Renewable Energy Test Site will give rise to any significant impacts.

Material Assets
Fishing and Aquaculture
There may be some very short-term disruption to fishing activity during device deployment and recovery operations; however due to the small amount of ocean energy devices that will be tested at any one time the impact on fishing will be negligible.

During inclement weather, fishermen's gear may drift and become entangled with the mooring systems of the test area marker buoys or with the device mooring arrangements, leading to gear damage. Similarly, during severe weather, devices under test might break loose from their moorings and damage deployed fishing gear.

The Galway Bay Marine and Renewable Energy Test Site, with its effective exclusion on fishing activity, may result in the development of nursery areas which could enhance fish and shellfish stock. Mooring systems may also create artificial reef structures which could also lead to enhanced fish and shellfish stock in the area. Such nursery areas may lead to increased catch in future, enhancing fishermen's income on a sustainable basis.

Tourism and Leisure
Spiddal has swimming beaches that are popular with both local and tourist visitors in summer months and have important amenity value. Other activities include shore angling, boating and canoeing and sailing that take place especially in the Spiddal area where there are good services and two piers.

The impact of the test site on recreation activities is likely to be negligible because operations will not affect water quality in the area. The site is not in the path of shipping ensuring that no additional costs are incurred to passenger or freight services that operate out of ports in Galway Bay and Rossaveel. During decommissioning there may be some short-term disruption to the amenity value of the area. However, due to its uniqueness however, the test site may indeed result in an increase in visits to the area as well as providing a first-hand opportunity to view marine renewable resources in operation in a near-shore environment.

Navigation

The proposed Galway Bay Marine and Renewable Energy Test Site will be located at the existing ¼ scale wave energy test site located off the coast of Spiddal, Co. Galway. The existing wave energy test site has been in existence for ten years. The site is demarcated by four cardinal marks, one at each corner of the test site. The test site is marked on all navigation charts as an “ocean energy test site”. Nonetheless, ocean energy converters and other marine technologies will be placed in the test site. Deep sea shipping, fishing vessels and pleasure craft routinely operate in the environs of Galway Bay.

The assessment of all maritime traffic in the area found that no un-authorised vessels interacted with the test site. All vessels in Galway Bay observed the cardinal marks demarcating the test site area. An assessment of fishing vessels in Galway Bay found no interaction of fishing vessel activity within the demarcated limits of the test site over a ten year period.

The Galway Bay Marine and Renewable Energy Test Site has been classed as a low risk small scale development in an area where the potential risks are low because the location of the test site is outside commercial shipping routes, the site has been operating for ten years, knowledge of the site location within the local fishing community, the cardinal marking scheme demarcating safe passage routes around the test site, and the inclusion of the test site on all Admiralty Charts for navigation purposes.

The Galway Bay Marine and Renewable Energy Test Site will be operated in accordance with the accredited HSEQ Management System based on the BSi Occupational Health and Safety, the ISO International Standards Quality and Environmental Management Systems. The system takes into account recommended Offshore Wind and Marine Energy Health and Safety Guidelines, International and National maritime safety and environmental regulations, codes and guidelines.

Coastal Processes

The impacts of the Galway Bay Marine and Renewable Energy Test Site are confined to the physical presence of the devices, equipment, infrastructure and cables within the site, either on the seabed, in the water column or at the surface. The operation of the devices and associated equipment may impact on hydrodynamics and sediment processes. Given the scale of the proposed test site, and the fact that the devices are scaled and not full size (taking up less than 1% of the surface area), the likelihood of any actual impact occurring is remote and there would be no change to the physical environment.

Indirect and Cumulative Impacts and Interaction between
In any development with the potential to impact on the environment, there is also the potential for interaction between those impacts. The level of impact for all interactions is considered to be *none, negligible or minor* for both the installation and operational phases of the Galway Bay Marine and Renewable Energy Test Site. No environmental interaction will lead to a high level of potential impact.

Any impact that is classed as *None-Moderate* is considered non-cumulative as the frequency of disturbance is less than the recovery time. Human activity has the potential to interact with most environmental impacts as non-compliance with specified requirements or standards could cause disturbance. The potential for interactions with the environmental impact of water quality arises for example with accidental spills could lead to secondary effects on aquatic communities. The potential for interactions arises with material assets in that a change in food sources could affect the invertebrates, fish, birds, mammals and to a lesser effect fishing.

The interaction between impacts, indirect or cumulative are primarily concerned with ecology, accidental events, vessel traffic and fishing. The indirect and cumulative impacts are largely low and are considered non-cumulative.

MANAGEMENT

SmartBay Ireland Ltd. is the organisation established by the Marine Institute to manage the promotion and development of the Galway Bay Marine and Renewable Energy Test Site. An internationally accredited Health, Safety, Environment & Quality (HSEQ) Management System has been developed to support operations.

The HSEQ Management System is based on the BSi Occupational Health and Safety, the ISO International Standards Quality and Environmental Management Systems taking into account recommended Offshore Wind and Marine Energy Health and Safety Guidelines, International and National maritime safety and environmental regulations, codes and guidelines.

The marine operations at the Galway Bay Marine and Renewable Energy Test Site will be undertaken by P&O Maritime who have vast experience in marine operations. All marine operations will be undertaken in accordance with the HSEQ Management System developed.

Environmental monitoring will also be a major responsibility. Critical to successful environmental monitoring will be the design and implementation an Environmental Management System (EMS) to ensure that environmental conditions (as characterised during the baseline studies), will be monitored on an on-going basis, so that any negative impacts can be addressed at the earliest possible stage. Close consultation with the relevant statutory and non-statutory bodies will ensure an appropriate EMS is put in place.

CONCLUSION

The main benefit from this project will be to enable ocean energy converter technology developers to test and modify their equipment in an open ocean national test site facility, thereby attracting developers to the site and encouraging the growth of an indigenous ocean energy industry in Ireland.

Proving ocean energy converter technology in a benign environment like Galway Bay is critical to the future development of the industry as a whole. It will give confidence to investors to proceed to full scale commercial development, in support activities at the full scale Atlantic Marine Energy Test Site in Belmullet, Co Mayo.

The equipment deployed at the test site will have undergone rigorous assessment and certification processes and will have complied with procedures laid down in the Galway Bay Test and Demonstration Site manual.
The environmental impacts from the project have been examined and the best available mitigation measures have been proposed and will be adopted in an integrated manner. As a consequence, there will be no significant adverse impacts on the environment arising from the development.

An accredited Health, Safety, Environmental and Quality Management System has been developed for the Galway Bay Marine and Renewable Energy Test Site operations to allow the broadest variety of activity to take place in a safe and controlled manner.

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2. Introduction

2.1. Scope

Marine renewable energy is an emerging industry which has very considerable potential for economic growth and job creation. With an exceptional marine resource, Ireland is in a unique position to capitalise on its natural advantages in the area of marine renewable energy. This will happen through the development, manufacture, deployment and operation of wave, tidal and offshore wind technologies and the creation of an indigenous supply chain in Ireland. The Offshore Renewable Energy Development Plan (OREDP) was published in 2014 to provide a policy context for the development of marine renewable energy in Ireland. It aims to establish Ireland as a leader in ocean energy technologies and to develop facilities that will enable the commercialisation of ocean energy products and services.

As part of the implementation of the original Ocean Energy Strategy (2006), a ¼ scale wave energy test site has been operational in Galway Bay for 10 years. This proposed foreshore lease application for the Galway Bay Marine and Renewable Energy Test Site (MARETS) is an evolution of that test site and will provide enhanced research capabilities and test infrastructure. The upgrade of the test site is an integral component of Ireland's OREDP and will facilitate testing and validation of various ocean energy converters and prototypes in conditions that represent ¼ scale of the open Atlantic Ocean environment.

The proposed development will provide a national cabled test facility, to which ocean energy converters can be connected during TRL 4-6 testing phases, and other marine technologies and componentry can be tested and evaluated. The experience gained from deployment at the test site will assist commercial scale ocean energy production in the future at suitable locations around the Irish Coast.

Alternative international test sites that meet other network requirements already exist (Table 2-1). In Orkney, nursery test sites for both wave and tidal converters have been established at the European Marine Energy Centre (EMEC) with EU and UK funding. EMEC provides for the installation of a total capacity of 7MW. This capacity is connected to the local electricity network and has the facility to connect four separate wave energy converters simultaneously in a maximum water depth of 50m. At the other end of the UK, Cornwall's 'Wave Hub' obtained planning approval in September 2007, which proposes a 20MW capacity cable extending 16km off-shore in 50m water depth.

Table 2-1: Comparison of similar ¼ scale wave energy test sites

Site	Conditions	Status
Galway Bay	Scale: ¼ scale Depth: 20-25m Connections: non-grid, cabled comms & power	Operational since 2006

EMEC Wave energy site Scapa Flow	Scale: ¼ scale Depth: 21m-25m Connections: non-grid, power buoy	Operational
Pacific Marine Energy Center (NNMREC)	Scale: 1/7th scale & full scale Depth: variable Connections: non-grid, power buoy	Operational; Cabled site at permitting phase
Danish Wave Energy Test and Demonstration sites DanWEC	<u>Nissum Bredning</u> Scale: ¼ scale Depth: 6-140m Connections: grid <u>Hanstholm</u> Scale: ½ to fullscale Depth 6-30m Connections: 4-5 berths connected to grid	operational approx. 30 WECs tested. Infrastructure Under establishment.
Wave Energy Test Site in Hawaii	Scale: full Depth: 30m, 80m in development Connections: grid	Hosted OPT device 60
National Ocean Technology Center: Tianjin, China	Scale: full Depth: various Connections: 3 berths connected to grid	Plan for Marine Energy Device Testing Sites in China
France Energies Marine	Scale: all Depths: various Connections grid connected	Operational since 2009
Bimep: Basque Country, Spain	Scale: full Depth: 50-90m Connections:4 berths 20 MW connected to the grid	Recently operational

2.2. Objective

The Marine Institute is applying for a Foreshore Lease for a Marine and Renewable Energy Test Site. It is located at the existing wave energy test site and will provide developers and researchers with a cabled and a leased area in which to test and demonstrate their prototype ocean energy converters and related technologies.

The application provides for an upgrade of infrastructure to improve the service offered to end-users. The following list details the proposed long term deployments at the site:

- Upgraded cardinal marks to allow for safer navigation;
- A databuoy to provide wave measurements;
- Buoys for testing marine technologies and scientific sensors;
- A 'SeaStation' which will provide power to, and dissipate power from, ocean energy devices as well as provide data communications to shore;

- An acoustic array for monitoring underwater sound;
- Interlocking modular gravity base(s);
- A variety of scientific sensors and instruments;
- Cables which will connect the instruments, sensors, and ocean energy devices.

The proposed upgrade of the site will enable periodic deployments of up to three individual devices of the following types for test and evaluation purposes for a maximum period of 18 months:

- Surface ocean energy converters;
- Sub-surface ocean energy converters;
- Seabed ocean energy converters;
- Prototype floating wind turbines;
- Novel marine technologies and scientific sensors.

2.3. Test Site Management Team

The project development team and main roles are shown in Figure 2-1 below.

Figure 2-1: Test Site Management Team

2.3.1. Sustainable Energy Authority of Ireland (SEAI)

The Sustainable Energy Authority of Ireland (SEAI) was set up by the Irish Government in 2002 as Ireland's national energy authority. Its mission is to play a leading role in transforming Ireland into a society based on sustainable energy structures, technologies and practices.

SEAI's key strategic objectives are

- **Energy efficiency first**: implementing strong energy efficiency actions that radically reduce energy intensity and usage
- **Low carbon energy sources**: accelerating the development and adoption of technologies to exploit renewable energy sources
- **Innovation and integration**: promoting evidence-based responses that engage all actors, supporting innovation and enterprise for our low-carbon future.

The Sustainable Energy Authority of Ireland manages programmes aimed at:

- Supporting Government decision-making through advocacy, analysis and evidence;
- Driving demand reduction and providing advice to all users of energy;
- Driving the decarbonisation of energy supply;
- Raising standards in sustainable energy products and services;
- Building markets based on quality, confidence and proven performance;
- Fostering innovation and entrepreneurship;
- Improving the coherence of Irish energy research and development.

The Ocean Energy Development Unit, operating with the support and assistance of the Marine Institute, oversees the implementation of the OREDP, coordinating the many diverse interest groups involved in ocean energy, and focuses them to achieve the objective of placing Ireland in pole position worldwide in the development of ocean energy technologies.

2.3.2. Marine Institute

The Marine Institute is the national agency for marine research, technology, development and innovation (marine RTDI). Its primary role is to undertake, coordinate, promote and assist in marine research and development. It provides services related to the assessment and realisation of the economic potential of Ireland's marine resource. It also provides essential scientific services; including marine research and monitoring that underpin the promotion of economic development to create employment while protecting the marine environment.

The essential marine research services provided by the Institute include:

- National research and development funding programmes;
- Fish stock assessment;
- Fish health services;
- Marine food safety monitoring;

- Environmental monitoring;
- Research vessel operations;
- Seabed mapping;
- Data management.

The Marine Institute work closely with SEAI to implement the OREDP, and related to this, to foster advanced technology R&D. The Institute led the installation of the Galway Bay Cabled Observatory at the test site.

2.3.3. SmartBay Ireland

SmartBay Ireland, under contract to the Marine Institute, provide users of the national marine test and demonstration facility with the scientific, technological, ICT and business development support necessary to develop, test and validate innovative solutions for the maritime sector.

The team is comprised of engineers and software developers, supported by marketing and business development professionals with extensive industry knowledge. This combination of skills allows SmartBay to offer its users an end-to-end service from initial product conception to validation.

SmartBay supports commercialisation initiatives to develop ICT products and services for the global maritime sector. This involves collaboration with local Higher Education Institutes (HEI's), SME's and MNC's. SmartBay brokers partnerships which include both national and international Higher Education Institute's, SME's and MNC's. The ultimate aim is to translate research into innovative products and services which will result in economic growth and job production for Irish companies.

2.3.4. P&O Maritime

P&O Maritime offers a complete range of marine services to all users of the national marine test and demonstration facility. The experienced technical team can provide bespoke innovative solutions to the unique problems that testing in a marine environment presents. This allows users to focus on data analysis, device validation and product development, secure in the knowledge that marine activities are being managed by the experienced P&O Maritime technical team. Services to users of the national marine test and demonstration facility include:

- Mobilisation support;
- Device deployment;
- Health, safety and environmental management;
- Day-to-day marine operational support;
- Project management;
- Vessel support;

- Specialist technical and engineering support;
- Electronics and electrical support;
- Dive support;
- Testing and validation;
- Device demobilisation and decommissioning

2.4. Applicable Legislation and Regulations

2.4.1. EIA Legislative Requirements

EIA requirements derive from EU Directive 85/337/EEC (as amended) on the assessment of the effects of certain public and private projects on the environment. The primary objective of the EIA Directive is to ensure that projects which are likely to have significant effects on the environment are subject to an assessment of their likely impacts.

The approach adopted in the Directive is that EIA is mandatory for all Annex I projects on the basis that these project classes will always have significant environmental effects. In the case of Annex II projects, the Directive gives Member States considerable discretion in determining the need for EIA. The determination of the need for EIA can be made on a case-by-case basis or on the basis of thresholds or criteria set by the Member State. The EIA Directive does not refer specifically to ocean energy projects and no specific guidance has been formulated for developers or regulators.

Some countries (for example, Spain – Bald *et al.*, 2010) have produced specific guidance, and likewise some test centres have also issued EIA guidance, for example, EMEC in Scotland (2008). Other European projects, such as EquiMar, provide good models of the EIA process.

The Irish EIA system implements the EIA Directive through the integration of its requirements into the land-use planning consent system (Planning and Development Regulations 2001, as amended), the foreshore consent system (Foreshore Act 1933, as amended) and several other development consent systems covering, for example, roads/motorway construction, light rail systems and the laying of gas pipelines.
Irish EIA legislation fully reflects the Annex I requirements of the European EIA Directive. In transposing the Annex II requirements of the Directive, Ireland chose to set mandatory thresholds for each of the project classes in Annex II.

In setting thresholds, account was taken of the relevant circumstances in Ireland, including the general nature, size and location of projects and the condition of the receiving environment. The thresholds were then set at levels which distinguish between those projects which, by virtue of their nature, size or location, would be likely to have significant effects on the environment and those which would not.

The key issue for the Licencing Authority in the context of possible need for EIA of sub-threshold developments or of developments for which thresholds have not been set is whether or not such development is "*likely to have significant effects on the environment by virtue, inter alia, of their nature, size or location.*"

Based on the findings of the Environmental Screening exercise it was determined that a full EIA was not a requirement for the Galway Bay Marine and Renewable Energy Test Site.

While there is no specific requirement for an EIA for the Galway Bay Marine and Renewable Energy Test Site Project, an Environmental Report has been prepared, in line with the European Communities Environmental Impact Assessment Regulations 1989 to 1999, the Foreshore (Environmental Impact Assessment) Regulations, 1990 and the European Communities (Foreshore) Regulations 2009 (S.I. No. 404 of 2009).

Reference has also been made to the 'Guidelines on the Information to be contained in Environmental Impact Statements' published by the Environmental Protection Agency (EPA) in 2002 and 'Advice Notes on Current Practice in the preparation of Environmental Impact Statements', also published by the EPA in 2003.

2.4.2. Department of the Environment, Community & Local Government

In Ireland, the foreshore is owned and administered by the State. The foreshore is defined as the seabed and resources below the line of high water of ordinary or medium tides and extending outwards to the limit of the territorial seas for 12 nautical miles (22.224 kilometres), the zone within which the proposed development will be operated.

The required consent for the project is a foreshore lease from the Irish Government's Department of the Environment, Community &Local Government (DECLG) for all installations between the high water mark and the 12 nautical mile limit.

- A **Lease** is generally issued for a development that requires exclusive occupation of the foreshore.

The Environmental Report is submitted under the European Communities (Foreshore) Regulations 2009 (S.I. No. 404 of 2009).

The focus of foreshore management in Ireland is the sustainability of the licensed activity or development with regard to the environment and sound marine spatial planning. In addition there is a need to ensure a fair return to the State for permitting activities or developments licensed on this State property resource.

2.4.3. National Parks and Wildlife Service

Consent is required from the National Parks and Wildlife Service (NPWS) to undertake works in protected areas. There are no designated Special Areas of Conservation (SAC), proposed Natural Heritage Areas (pNHA) or Special Protection Areas (SPA) at the location of the test site. There are SACs, pNHAs and SPAs in the general locality of the project.

Screening for Appropriate Assessment under Article 6.3 of the Habitats Directive was required (See below).

2.4.4. Habitats Directive requirement

Article 6.3 of the Habitats Directive states:

“Any plan or project not directly connected with, or necessary to, the management of the site but likely to have a significant effect thereon, either individually or in combination with other plans or projects, shall be subject to appropriate assessment of its implications for the site in view of the site’s conservation objectives”

Within 15km of the area, there are SPAs designated under the EU Birds Directive (Inner Galway Bay, Lough Corrib and Connemara Bog Complex) and there are also cSAC areas such as Lough Corrib, Galway Bay Complex, Black Head - Poulsallagh Complex, Ballyvaughan Turlough, and Connemara Bog Complex (Figure 3-2). In this context, a review of the potential, residual (direct and indirect) and cumulative impacts was required to be undertaken and a Screening Report for the Galway Bay Marine and Renewable Energy Test Site has been prepared.

2.4.5. Water Framework Directive

The European Communities (Water Policy) Regulations, 2003, (S.I. 722 of 2003) is the enabling Irish legislation of the European Communities Water Framework Directive (Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000, establishing a framework for Community action in the field of water policy).

In brief, the enabling legislation provides for the protection of the status of all waters (surface and groundwater), the establishment of River Basin Districts (RBDs), coordination of actions by all relevant public authorities for water quality management in an RBD including cross-border RBDs, characterisation of each RBD, establishment of a Register of Protected Areas, establishment of environmental objectives and the development of programmes of measures and River Basin Management Plans (RBMP).

The RBMP is coordinated provided by Galway County Council. A full description of the river basin and its characteristics as well as the WFD objectives can be found on www.wfdireland.ie and on www.westernrbd.ie.

The Western River Basin Management Plan (2009) established four core environmental objectives to be achieved generally by 2015:

- Prevent deterioration of water status
- Restore good status where status is assigned as less than good by the EPA
- Reduce chemical pollution
- Achieve water related protected areas objectives.

These include the objective to maintain water status for High and Good status waters and to restore all waters to at least Good status by 2015. In addition, the Surface Waters Environmental Objectives Regulations (SI 272 of 2009) and the Groundwater Environmental Objectives Regulations (SI 9 of 2010) were made to give effect to the measures needed to achieve surface water and groundwater environmental objectives established in river basin management plans. These regulations place a legal obligation on public authorities to aim to achieve those objectives in the context of their statutory functions.

The proposed project comes within the WFD designated coastal water body of *Outer Galway Bay,* within the Western River Basin District River Basin Management Plan management area.

2.5. Relevant Policy

2.5.1. Innovation 2020

Innovation 2020 is the national strategy for research and development, science and technology. The vision is for Ireland to be a Global Innovation Leader driving a strong sustainable economy and a better society underpinned by research, competitive enterprise base, pool of talent and a joined up innovation ecosystem. Energy and ICT are two of six priorities of the policy. The objectives of the Galway Bay Marine and Renewable Energy Test Site directly respond to these themes. Innovation 2020 specifically identifies the opportunity for marine energy research, development and innovation facilities.

2.5.2. Action Plan for Jobs 2015

The Action Plan for Jobs is a whole-of-Government initiative with five strategic ambitions:

- To support 100,000 additional jobs by 2016;
- To get Ireland back to a top-five ranking in international competitiveness;
- To stimulate the domestic economy and generate employment in locally traded sector;
- To build an indigenous engine of growth that drives up the export market share of Irish companies;
- To build world-class clusters in key sectors of opportunity.

An Action Plan for Jobs is published every year, setting out clear actions and targets to help create positive conditions for job creation. The Action Plan for Jobs 2015 specifically identified the development of test beds that would be used nationally and internationally for Energy research. The Action Plan for Jobs also recommended the development of facilities for trial/test and demonstration of new technologies by large and small companies; making it easier for SMEs to engage with RD&I and/or at a minimum to adopt technologies in the workplace and encouraging new technology.

2.5.3. Harnessing Our Ocean Wealth

Harnessing Our Ocean Wealth (2012) is an Integrated Marine Plan for Ireland. It sets out the Government's Vision, High-Level Goals, and Key 'Enabling' Actions to put in place the appropriate policy, governance and business climate to enable our marine potential to be realised. It sets out 5 strategic thematic areas one of which is *Energy from the Ocean.* Early initiatives to establish Ireland as a test-bed for early stage prototype development and pilot array deployments will create a cluster of SME and FDI industrial and service capabilities.

2.5.4. Ocean Renewable Energy Development Plan (OREDP)

The Department of Communications, Energy & Natural Resources published the Offshore Renewable Energy Development Plan (OREDP) in 2014. It provides a framework for the exploitation of wave, tidal and offshore wind and renewable energy resources in Ireland's marine territory. The OREDP has established scenarios for the development of offshore renewable resources in Irish waters up to 2030, and provides a description of developing policy, which will affect the context within which they may develop. The OREDP area covers all Irish waters from the Mean High Water Mark out to the 200m water depth contour off the west and south west coast of Ireland and the Exclusive Economic Zone (EEZ) off the north, east and south east coasts of Ireland.

2.5.5. Previous Ocean Energy Strategy

Ireland's Ocean Energy Strategy (2005) was developed to advance Ireland's capability to deploy ocean energy technology and develop an industry sector in this field of emerging energy technology. It proposed a four phase strategy to capitalise on Ireland's marine energy resource.

Phase 1 (2005 to 2007)	This phase focuses on development by supporting product R&D and research facilities with an objective to develop and test prototype concepts and develop technical leadership in this area.
Phase 2 (2008 to 2010)	This phase supports the development of pre-commercial grid connected devices with the objective of demonstrating the potential for a cost-effective fully functional wave energy converter operating in the Irish electricity market.
Phase 3 (2011 – 2015)	This phase could provide support for a 10MW large-scale array of devices to be connected to the grid.
Phase 4 (2016 onwards)	This phase sees large-scale market deployment for ocean energy.

This phased strategy aimed to introduce ocean energy into the renewables portfolio in Ireland and to develop an Irish ocean energy industry sector.

2.5.6. Draft Galway County Development Plan 2015 –2020

The Draft Galway County Development Plan 2015–2020 encourages marine renewable energy. It contains a specific reference to wave, tidal and offshore wind and recognises that natural resources are a vital element of the county's resource base and that they have not been developed to their full potential.

The development of renewable resources is specifically addressed as part of the its overall strategy for transport and infrastructure developments, where it aims to optimise the development of appropriate renewable energy sources that make use of the natural resources of the area concerned in an environmentally acceptable and sustainable manner.

The plan also recognises the importance of the 'SmartBay Project' (which includes marine observation, advanced technology sensor and data management systems, communication projects and R&D) and offers significant opportunities for large multinationals and Irish-based SME's.

2.6. Format of Environmental Report and Methodology

The Environmental Report has been prepared in the grouped-format structure with each category of environmental receptor having a dedicated chapter (Human Activity, Seabed & Geology, Flora & Fauna, and so on) and being considered under the separate headings: Description of existing environment; Impact of the development; Mitigation (where appropriate); and Conclusions (where appropriate). The contents of the report are detailed in Table 2-2.

The Environmental Report considers the installation, operation and decommissioning of the Galway Bay Marine and Renewable Energy Test Site, as necessary. There will be no construction operations associated with the establishment of the Galway Bay Marine and Renewable Energy Test Site.

Every effort has been made in the preparation of the document to keep it as concise as possible while also ensuring that relevant material is adequately covered.

One challenge in the preparation of the environmental report for the Galway Bay Marine and Renewable Energy Test Site was to predict the exact devices to be deployed over the life of the project, with sufficient accuracy to enable environmental impacts to be properly assessed.

In order to overcome this, the different environmental impacts were assessed for the worst case scenarios, when applicable, based on current device technologies, in order to establish impact thresholds for the different environmental receptors and provide an envelope of potential environmental impacts.

The worst case scenario assessment for each environmental receptor assumed that all permanent infrastructure was deployed at the site, all recurring short term infrastructure was deployed at the site, and that the three device testing berths were occupied by those devices which would be expected to have greatest impact on the receptor under consideration. The various components contributing to the worst case scenarios for each receptor are detailed in Chapter 4.7: Worst Case Scenarios for Impact Assessment

Appropriate methodologies have been used to assess the effects relating to each of the environmental topics that have been investigated as part of the report. These methodologies are based on recognised good practice and guidelines specific to each subject area, details of which are provided within each individual technical section.

Table 2-2: Contents of Environmental Report

Chapter	Subject	Compiled by
1	Non-technical summary	Marine Institute
2	Introduction	Marine Institute
3	Project Rationale and Alternatives	Marine Institute
4	Project Description	Marine Institute
5	Human Activity	SEMRU, NUI Galway
6	Flora and Fauna	Aquafact
7	Water	Marine Institute
8	Seabed and Geology	Marine Institute Aquafact
9	Air Quality	Marine Institute
10	Cultural Heritage	Geomara
11	Visual Impact Assessment	MacroWorks
12	Material Assets	SEMRU, NUI Galway, Marine Institute
13	Navigation	Marine Institute
14	Coastal Processes	Marine Institute
15	Indirect and Cumulative Impacts and Interactions Between	Marine Institute Aquafact
16	Summary of Impacts and Mitigations	Marine Institute Aquafact
17	HSEQ Management System	SmartBay
18	Conclusion	Marine Institute
	Appendices	Various

2.7. Consultations

2.7.1. Consultation meetings

Throughout the project development stage, meetings were held with key stakeholders at local and national level and with representatives in the Spiddal area. A list of consultations undertaken is provided in
Table 2-3.

Table 2-3: List of consultation meetings

Group Consulted	Date	Purpose
Galway Harbour Master Marine Operations	12/01/2105	Upgrade of cardinal marks on test site
Galway Harbour Master Marine Operations	08/04/2015	Upgrade of cardinal marks on test site
Foreshore Licencing Unit	26/05/2015	Pre-application meeting
Foreshore Licencing Unit	13/07/2015	Pre-application meeting (follow-up)
Colaiste Chroi Mhuire	12/10/2015	Introduction to test site upgrade
Local Fisherman	03/11/2015	Introduction to test site upgrade
Comhlacht Forbatha an Spideal	03/11/2015	Introduction to test site upgrade
Udaras na Gaeltachta	04/11/2015	Introduction to test site upgrade
Local Fisherman	06/11/2015	Introduction to proposed test site upgrade
Foreshore Licencing Unit	18/11/2015	Pre-application meeting (update on progress)
Irish Whale & Dolphin Group	24/11/2015	Introduction to test site upgrade and scoping of environmental assessments

Group Consulted	Date	Purpose
Colaiste Chroi Mhuire	27/11/2015	Update on project progress
National Parks & Wildlife Service	30/11/2015	Introduction to test site upgrade and scoping of environmental assessments
Udaras na Gaeltachta	30/11/2015	Update on project progress
Comhlacht Forbatha an Spideal	04/01/2016	Update on project progress
Colaiste Chroi Mhuire	08/01/2015	Update on project progress
Udaras na Gaeltachta	08/01/2015	Update on project progress
Public Information evening in Spiddal village	19/01/2016	Presentation on test site activity and test site upgrade
Galway Harbour Master & Marine Survey Office	29/01/2016	Lighting requirements for devices on site.

2.7.2. Stakeholder groups and issues raised

The following is a summary of the main stakeholders groups consulted and the issues raised:

Fishermen — Concerns expressed that Galway County Council upgrade works on the local old pier "sean-ceibh" were done to facilitate heavy cranes and large vessels using the sean-ceibh; issues concerning any expansion of the existing test-site leasehold area; test-site impacting on fishing grounds and fishing gear; lack of information around location and depth of telecommunications cable to test-site.

Local residents — Issues raised included possible light pollution at night from devices and navigation lights at the test; impacts of noise from wave energy devices and the Seastation; the height, number and duration of testing of floating wind turbines.

Local residents & — Issues raised in relation to prospects for local job opportunities

business	in support of test-site operations, impacts of the test-site on tourism trade, visual impact of proposed devices on coastal scenic views.
Other, including Public Information Day	Other issues included the opportunities for the creation of goodwill by improving access road to the new pier; the installation of cctv cameras to monitor activity on the new pier; the duration of the proposed lease at 35 years was raised as being too long; concerns around privatisation of the test-site; concern that testing floating wind turbines was the "thin end of the wedge" and a precursor to the establishment of an offshore wind farm in Galway Bay.

In addition to the above meetings with various stakeholders, numerous telephone conversations and email correspondences were had with local representative organisations, state agencies, and non-governmental organisations informing them of the foreshore lease application and soliciting their observations on the proposed test-site upgrade. All the issues raised during the public consultation have informed the Environmental Report.

2.8. Data availability and constraints

Data and knowledge gaps can affect the level of confidence with which potential effects on the environment are identified and evaluated. An environmental baseline has been established for the project area through detailed surveys over the past decade, hence knowledge of the receiving environment is comprehensive.

In addition to the detailed surveys over a decade long period, the existing test site has had two separate wave energy devices deployed for periods of testing during that time. Various environmental assessments have been undertaken prior to, during, and after the deployment of those devices, and thus a very good understanding of the nature of impacts arising from marine renewable energy devices has been developed. Impacts that may arise that have not previously been studied at the Galway Bay wave energy test site rely on knowledge and observations from existing marine industries such as oil, gas, shipping, from limited information from prototype wave energy convertors deployed at other test site internationally, and from independent expert judgement.

3. Project Rationale and Alternatives

3.1. Need for the Project

3.1.1. Introduction

Climate change impacts are one of the key environmental concerns within the EU. Renewable sources of energy are essential alternatives to fossil fuels, which are a major contributor to greenhouse gas emissions. In 2014, the EU agreed new climate and energy targets to be achieved by 2030. These include a 40% cut in greenhouse gas emissions compared to 1990 levels, at least a 27% share of renewable energy consumption and at least 27% energy savings compared with the business-as-usual scenario.

Since the adoption of the Kyoto Protocol in 1997 there has been increasing concern over the security of supply of energy from fossil fuels and a growing awareness of their impact on the environment and climate. The overarching goal of the recent COP21 in Paris is to reduce greenhouse gas emissions to limit the global temperature increase to 2 °C above pre-industrial levels. The agreement calls for zero net anthropogenic greenhouse gas emissions to be reached during the second half of the 21st century.

With this as a motivation, new sources of energy, such as marine renewables, are being developed. The technology to harness the wave energy resource is still at development and testing stages and no commercial full-scale device is yet in operation. Ireland is in a unique position with regard to developing this new industry forward.

On the critical path for proving technology is the requirement for test and demonstration of prototypes. The Marine and Renewable Energy Test Site in Galway Bay will deliver this requirement and will also deliver the following benefits:

- It will support the delivery of Government and EU policy for implementation of the Offshore Renewable Energy Development Plan (OREDP) and job creation initiatives. Evidence shows that an Irish Ocean Energy industry could support 17,000-52,000 jobs and a net present value of around €4–10bn by 2030 (SQW 2011).
- It will facilitate the development of new technologies, thus supporting the Government's commitment to develop the marine economy and research.
- It will provide a catalyst for new commercial opportunities to ensure Ireland and Irish companies are at the forefront of developments in ocean energy.
- It will provide a means to reduce dependence on fossil fuels, reduce emissions and develop an indigenous secure and renewable energy source.

3.1.2. Need for renewable energy

Global energy demand is predicted to increase by 50% to 2030 and fossil fuels will remain the dominant source to meet this energy requirement. Ireland's population and economic development is also resulting in increased energy demand. To ensure that Ireland's energy demand is met sustainably into the future in a manner that allows climate change to be tackled while maintaining social and economic growth, alternative sources of future energy supply need to be developed and implemented. To meet the national renewable energy target, Ireland has committed that by 2020, 40% of electricity will be generated from renewable sources. In 2014, the amount from renewables was 34.46% (Figure 3-3).

Over the period 2012 – 2014, the reliance on fossil fuels as source of energy in Ireland is reducing and that renewable energy is progressing towards the 40% target in 2020 (Figure 3-4). The development of home-grown renewable sources of energy will ensure future sustainable growth and for that reason is central to overall energy policy in Ireland. Such development will lead to the following:

- Reduction in dependence on fossil fuels;
- Improvement in security of supply;
- Reduction in greenhouse gas emissions.

Renewable energy creates environmental benefits, delivers green jobs to the economy, and makes a contribution to national competitiveness.

3.1.3. Renewable energy resource in Ireland

Ireland has excellent renewable energy resources, which will be a critical and growing component of Irish energy supply to 2020 and beyond. Indigenous renewable energy already plays a vital role in our domestic fuel mix. It also increases sustainability through the use of clean power sources and enhances energy security by reducing Ireland's dependence on imported fuels.

In 2013, renewable energy contributed 7.8% of Gross Final Energy Consumption, almost halfway towards Ireland's binding 2020 target (Dineen *et al.,* 2015). The vast majority of renewable energy came from wind (47%) and bioenergy (42%) with the remainder coming from hydro, geothermal and solar. Renewable electricity accounted for 58% of renewable energy, renewable heat 30% and renewable transport fuels 12%. The share of electricity generated from renewable energy sources increased fourfold between 1990 and 2013.

Over 80% of renewable electricity generated came from wind power, with installed generating capacity reaching 1,941 MW. Ireland's Gross Final Consumption of renewable energy amounted to 839 thousand tonnes of oil equivalent, five times more than in 1990, largely due to the increasing contribution from wind energy. This led to a corresponding reduction in the use of fossil fuels. Renewable electricity generation avoided the combustion of approximately 963 thousand tonnes of oil equivalent of fossil fuels, displacing imports of €300 million. 2.9 million tonnes of CO_2 emissions were avoided through renewable energy use in all sectors.

According to the Strategic Environmental Assessment (SEA) of the Offshore Renewable Energy Development Plan (OREDP, 2014), the potential amount of accessible wave energy development is greater than 17,500MW, nearly three times the current generation capacity from all sources in Ireland. The wave energy resource of the Irish coast is vast, available and greatly exceeds that available to other EU states. This means that Ireland is in a unique position to harness this renewable resource and to develop this new industry.

3.1.4. Targets for renewable energy in Ireland

The EU Directive (2009/28/EC) on the promotion of the use of energy from renewable sources establishes the basis for the achievement of the EU's 20% renewable energy target by 2020. By 2012 the EU realized a 14.1% share of energy from renewable sources. In seeking to achieve the overall EU goal, it also sets individually binding renewable energy targets on each member state. Under this Directive, Ireland has been set a mandatory target of 16% of gross final consumption (heat, transport and electricity) to come from renewable energy by 2020. In addition, the Irish Government set its national targets for the production of electricity from renewable sources at 40% by 2020.

Ireland is using five times more renewable energy than in 1990 and is halfway towards EU 2020 targets (Dineen *et al.,* 2015). In 2013, renewable energy contributed 7.8% of final energy demand, almost halfway towards Ireland's binding target of 16% under the European Union's Renewable Energy Directive.

3.1.5. National Renewable Energy Action Plan (Ireland)

Article 4 of European Union's Renewable Energy Directive requires each Member State to adopt a National Renewable Energy Action Plan (NREAP) to be submitted to the European Commission. The NREAP sets out the Member State's national targets for the share of energy from renewable sources to be consumed in transport, electricity and heating and cooling in 2020, and demonstrates how the Member State will meet its overall national target established under the Directive. Ireland's NREAP sets out a target of 16% of energy from renewable sources across the electricity, heat and transport sectors by 2020. This is made up from a 12% share of heat from renewable sources (RES-H), 10% share of transport from renewable sources (RES-T) and 42.5% share of electricity from renewable sources (RES-E). Member States are required to submit a report on progress to the European Commission every two years.

With regard to the targets set out in the NREAP, the Government has identified offshore renewable energy (offshore wind, wave and tidal energy) to make a significant contribution to the RES-E element of Ireland's overall renewable energy target. The NREAP makes reference to:

- The Government's target of 500MW for ocean energy (wave and tidal) by 2020;
- Ocean Energy Prototype Development Fund to stimulate the development and deployment of Ocean Energy (OE) devices and systems;

- Planning for grid connected test facilities;
- Strategic environmental assessment (SEA) for offshore wind, wave & tidal development scenarios;
- Future consenting processes for Ocean Energy development.

3.1.6. Delivering offshore renewable energy in Ireland

The Offshore Renewable Energy Development Plan (OREDP) was published in February 2014. It sets out three high level goals, based on the concept of sustainable development, as follows:

- To harness market opportunities presented by offshore renewable energy in order to achieve economic development growth and jobs;
- To increase awareness of the value, opportunities and societal benefits of developing offshore renewable energy;
- To ensure that offshore renewable energy developments do not adversely impact Ireland's rich marine environment.

The OREDP acknowledges that given the current state of development and readiness of the various technology options for capturing ocean energy, previously projected levels of installed capacity for 2020 will not now be achieved. Despite this it maintains that the potential identified in those earlier projections remains valid over a longer time-scale, looking out to 2030 and beyond. Among the many recommendations contained within the OREDP to promote the continued development of ocean energy technology in Ireland is the proposal to introduce a market support scheme for wave and tidal energy equivalent to €260/MWh for the first 30 MW of installed capacity. An offshore renewable energy steering group has been established to oversee the implementation of the OREDP (Dineen *et al.,* 2015).

The SEAI Ocean Energy Roadmap proposes that by 2050, there will be 50GW production electricity from MRE sources, €15 billion electricity exports and the creation of 70,000 jobs. The components to the implementation of the OREDP are outlined in Figure 3-5.

The function of the Ocean Energy Development Unit (OEDU) of SEAI is to oversee the implementation of the OREDP. Implementation is based around a number of work streams, including environmental monitoring, infrastructure development, R&D programmes and market support development of the supply chain for the offshore renewable industry and attraction of national and international investment in the sector.

For the purposes of the OREDP, the Irish coast has been divided into 6 distinct assessment areas based on the available marine renewable resource (
Figure **3-6**). A Strategic Environmental Assessment (SEA) was undertaken and an Environmental Report and a Natura Impact Statement (NIS) have been published on the draft OREDP.

3.2. Alternatives to the project

A number of alternatives to the project are discussed in the following sections. These include the ‘no action’ option (no development takes place), and also the option of meeting Ireland’s renewable energy targets from other renewable energy sources.

3.2.1. No action option

In the context of evaluating alternatives, it is necessary to consider the potential effects of discontinuing the development of the test site. The consequence of this is that the marine renewable energy sector as a whole would not develop off the west coast of Ireland. This in turn would mean that the OREDP would not be developed to the same extent (only the offshore wind and some tidal energy components would be developed), with consequent non-displacement of fossil fuels in energy provision. The potential effects of not developing wave energy include the following:

- The Government’s stated objective of achieving 50GW by 2050 would not be achieved;
- Ireland will be a risk of not achieving its proposed national target of 40% of energy from renewable sources by 2020 as set out in NREAP;
- EU targets for 27% of all energy consumed to be from renewable sources will be at risk;
- There will be continued reliance on fossil fuels for energy needs with less reduction of carbon emissions. Extraction and transportation of fossil fuels such as oil and coal also have other environmental impacts associated with them including:
    - Loss of physical habitat through mining operations;
    - Solid waste generation requiring disposal;
    - Risk of oil spills;
- The significant potential wave energy resource off the west coast would remain unutilised;
- There would be a missed opportunity for developing indigenous industry;
- Reliance on external manufacturers;
- A final critical piece of testing infrastructure would be missing – this would seriously compromise the OREDP.

The test site represents an important phase in the development of ocean energy. Failure to develop this renewable energy resource could be a missed opportunity to address some of the environmental effects of climate change, including:

- Continued effects on temperature, sea levels, precipitation, storminess, and sea temperatures
- Continued climate change effects on species and habitat distribution and abundance – this could lead to long-term changes in the marine environment

particularly in waters off the coast of Ireland, which are regarded as being among the most biologically diverse due to their position in the Gulf Stream.

3.2.2. Alternatives to marine renewable energy

Other potential sources of renewable energy could be developed to achieve the 2050 targets – for example, onshore and offshore wind, biomass, solar, geothermal or hydro power for example. These sources are limited either by resource and/or potential issues such as:

- Considerable loss of potential economic benefits from the development of a new industrial sector;
- Increased pressure on aquatic environments and potential loss of status under the Water Framework Directive;
- Increased pressure on sensitive habitats such as moorlands;
- Increased adverse effects on landscape character and visual amenity;
- Increased cumulative effects on birds, bats and other wildlife through habitat loss and disturbance;
- There would also be limitations relating to intermittency of electricity supply from onshore wind. By contrast, marine renewable energy is much more consistent;
- Security of supply and increased portfolio diversity.

3.2.3. Implications of not developing the test site

There are wider implications of not developing the Galway Bay Marine and Renewable Energy Test Site relating directly to the risk that long-term development of commercial marine renewable energy would not occur. The risks to commercial investment in large-scale wave energy off the west cost would be too high in the absence of technology proven suitable for this environment.

There will be reduced diversification of energy supply, and Ireland will continue to rely heavily on imported fossil fuels for energy needs, with implications for security of supply. This in turn could lead to economic implications for businesses, enterprises and domestic users arising from price volatility.

Potential economic development associated with the development of offshore renewable energy technology will not occur, representing a significant lost opportunity. Substantial economic investment is required to achieve wave energy – at all stages from technology development through to manufacturing, installation and maintenance – and there is also considerable potential for employment opportunities. If the test site is not developed, the opportunity to develop a substantial indigenous industry in offshore renewables could be lost.

3.2.4. Conclusion on need for Marine and Renewable Test Site (MaRETS)

The provision of the test site is required to meet one of the key initiatives set out in the Offshore Renewable Energy Development Plan and Harnessing Our Ocean Wealth. It will help underpin the Government's stated objective of producing 50GW from ocean energy by 2050. It will do this by providing a test facility where WECs can demonstrate their survivability. This testing is a necessary phase before commercial scale ocean energy development can proceed.

Successful marine renewable energy development will lessen Ireland's dependence on imported fossil fuels, will lead to greater security of energy supply, and will provide viable alternatives to meeting Ireland's energy needs.

Successful prototype testing will also lead to potential future economic development associated with the development of a larger ocean energy sector in Ireland.

3.3. Alternative solutions examined

3.3.1. Introduction

The consideration of alternatives to the proposed development is central to the environmental assessment process. The EPA Guidelines (2002) in relation to EIS advise that consideration of the main alternatives for the choice of the development is the most effective process for avoiding environmental impacts. Alternatives may be described at three levels; alternative locations, alternative processes and alternative designs as appropriate.

The applicants are of the opinion that there are no feasible alternative options to the Galway Bay Marine and Renewable Energy Test Site. This section of the Environmental Report provides a justification for this.

3.3.2. Alternative locations

The principal elements on which the Galway Bay site was selected in 2006 are set out below:

- The site should be located in a bay demonstrating ¼ of the wave resource experience in the open ocean to the west of Ireland and within the 12nm limit;
- Appropriate logistical support should be available locally;
- Minimal impact on the environment and stakeholders;
- A non-rocky seabed to facilitate cabling and anchoring.

No alternative locations were considered for the Galway Bay Marine and Renewable Energy Test Site. The reasons for this are:

- The test site has been operating successfully at this site for 10 years, with negligible impact on the environment.

- The Galway Bay Cable Project (licence awarded 16th March 2015) was deployed from Spiddal Pier and terminates at the test site. The safe operation of the cable end equipment is dependent on installation of infrastructure under this proposal.
- Galway Bay and SmartBay are recognised (nationally and internationally) as a world leading marine test facility for the development of innovative products and services for the global maritime sector.
- Research by UCC shows that the wave resource at the test site, represents a ¼ of that found in open Atlantic conditions; ideal for testing WEC prototypes at TRL 4-6.
- The availability of a long term time series dataset from the site is crucial for wave energy research. This dataset also provides for temporal assessment of environmental quality and impacts of climate change. It is important for this to be maintained.
- The availability of a range of experienced support and marine services nearby.

3.3.3. Alternative process

For the testing of WECs and associated technology, there is no alternative development process. For wave energy devices the development from concept to commercial is through 9 stages. These are defined as Technology Readiness Levels (TRL) (OES-IA)

- TRL 1-3: Concept validation. Prove the basic concept from wave flume tests in small scale
- TRL 4: Design validation. Subsystem testing at intermediate scale, Flume tests scale 1:10, Survivability; Computational Fluid Dynamics; Finite Element Analysis Dynamic Analysis; Engineering Design (Prototype); feasibility and costing
- TRL 5-6: Testing operational scaled models at sea + subsystem testing at large scale
- TRL 7-8: Full-scale prototype tested at sea
- TRL 9: Economic validation; several units of pre-commercial machines tested at sea for an extended period of time.

The Marine and Renewable Test Site (MaRETS) will facilitate testing of prototypes at TRL 4-6.

3.3.4. Alternative designs

The test site area size and location were agreed in consultation with local stakeholders as part of the site design process for the original Foreshore Lease (2006). As a result, no other alternatives have been considered for the new foreshore lease application.

The site provides space for short to medium term testing of up to three WECs and another berth for the Cable End Equipment, buoys and technology prototypes.

3.3.5. Conclusion

While EPA Guidelines recommend considering alternatives for the choice of the development, the fact remains that the Galway Bay ¼ scale wave energy test site has been established at the present location for the past ten years, is an accepted part of the maritime landscape in Galway Bay, and has had negligible impact on the marine environment since its inception. Therefore, no alternate locations have been considered.

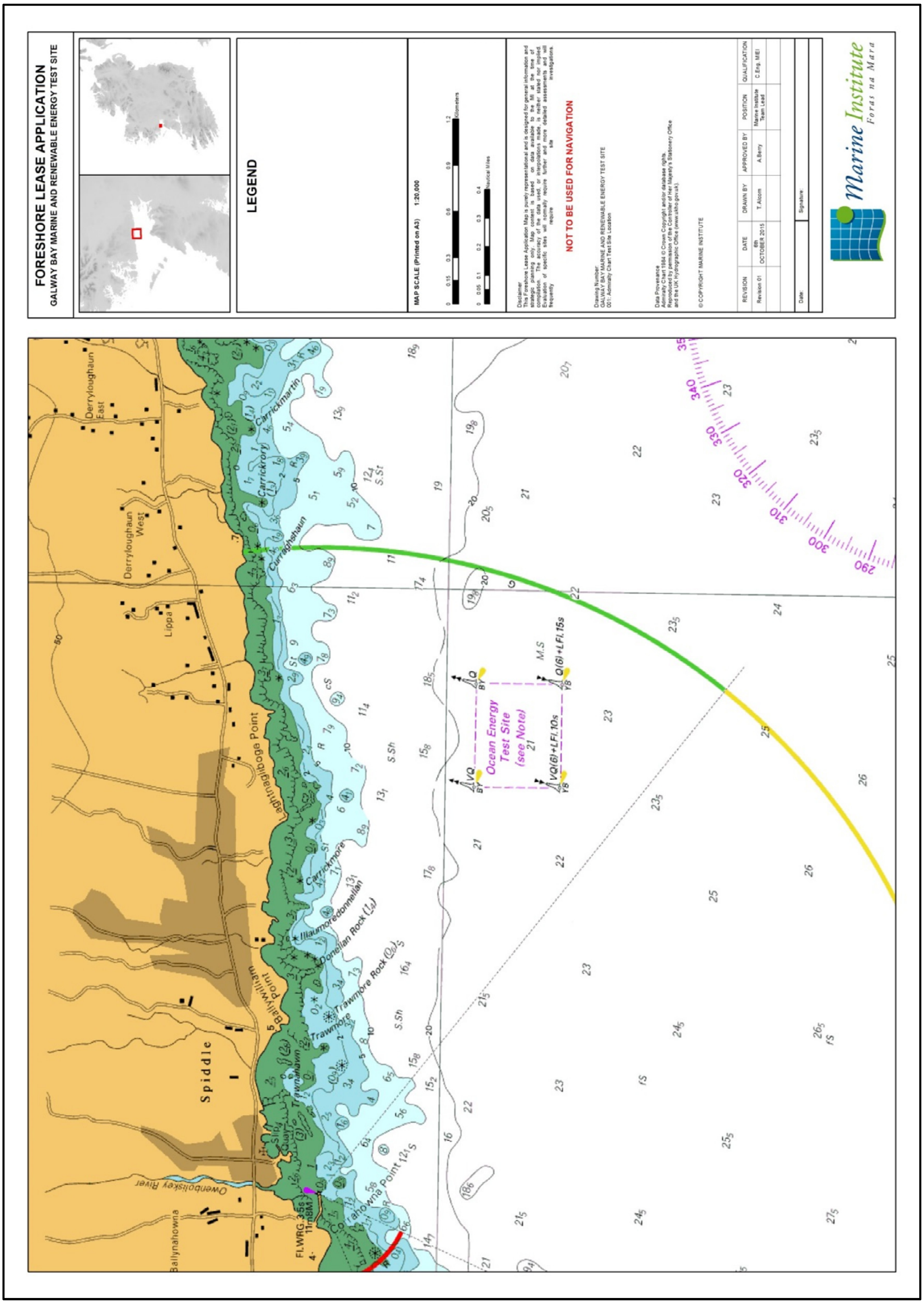

Figure 3-1: Location of existing ocean energy test site, and location of proposed Galway Bay Marine and Renewable Energy Test Site.

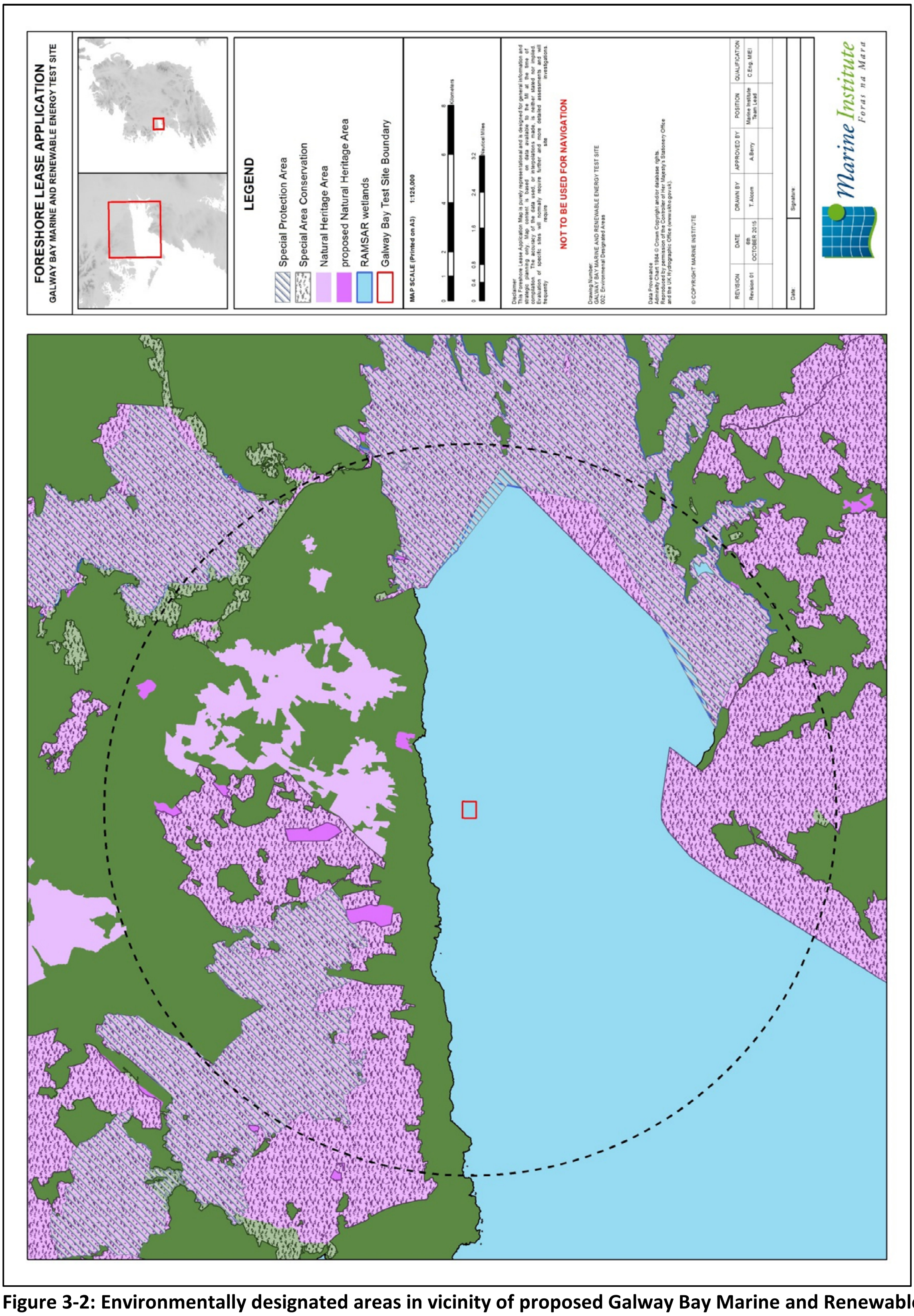

Figure 3-2: Environmentally designated areas in vicinity of proposed Galway Bay Marine and Renewable Energy Test Site. (15km limit marked as dashed black line)Project Rationale and Alternatives

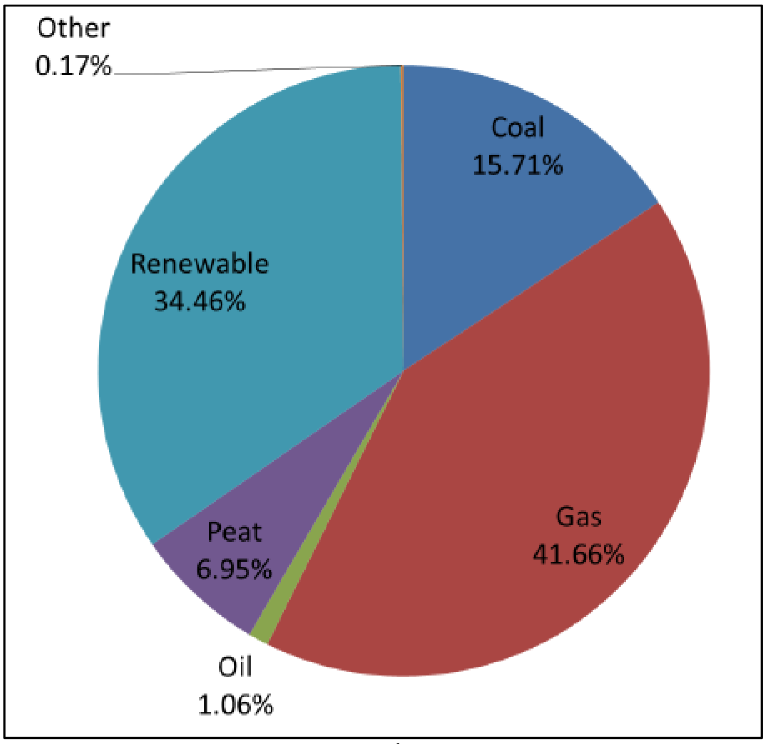

Figure 3-3: All Ireland fuel mix 2014[1]

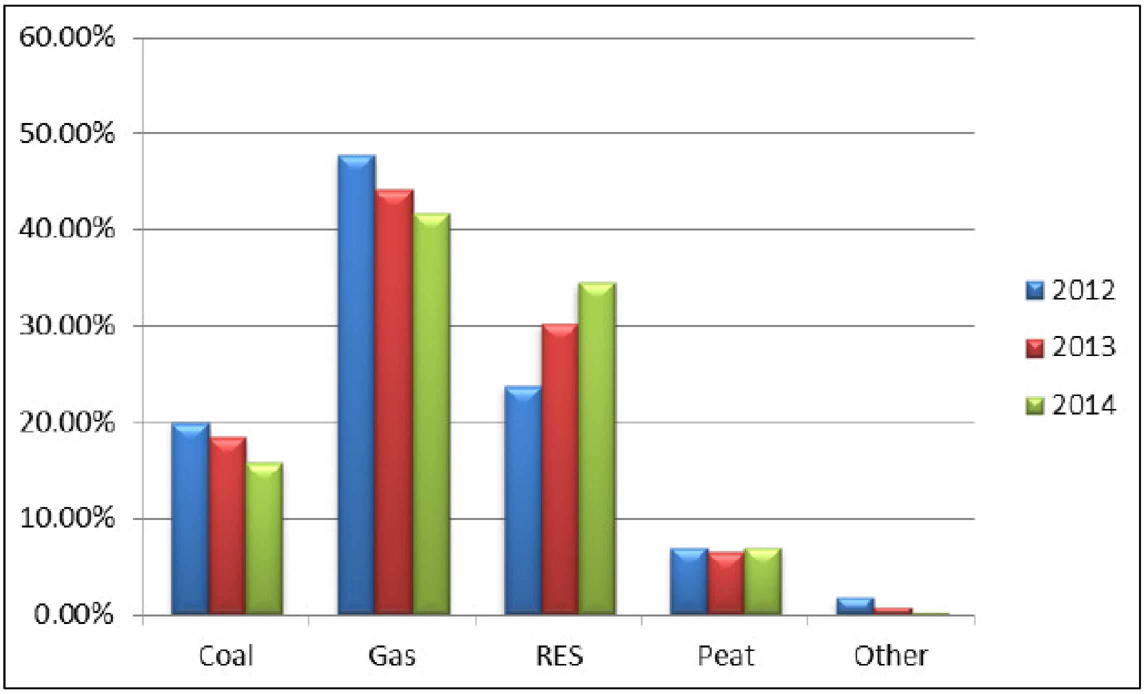

Figure 3-4: All Ireland fuel mix 2012 – 2013

[1] Source: Commissioner for Energy Regulation (CER) - Fuel Mix Disclosure and CO_2 Emissions 2014, CER/15/181

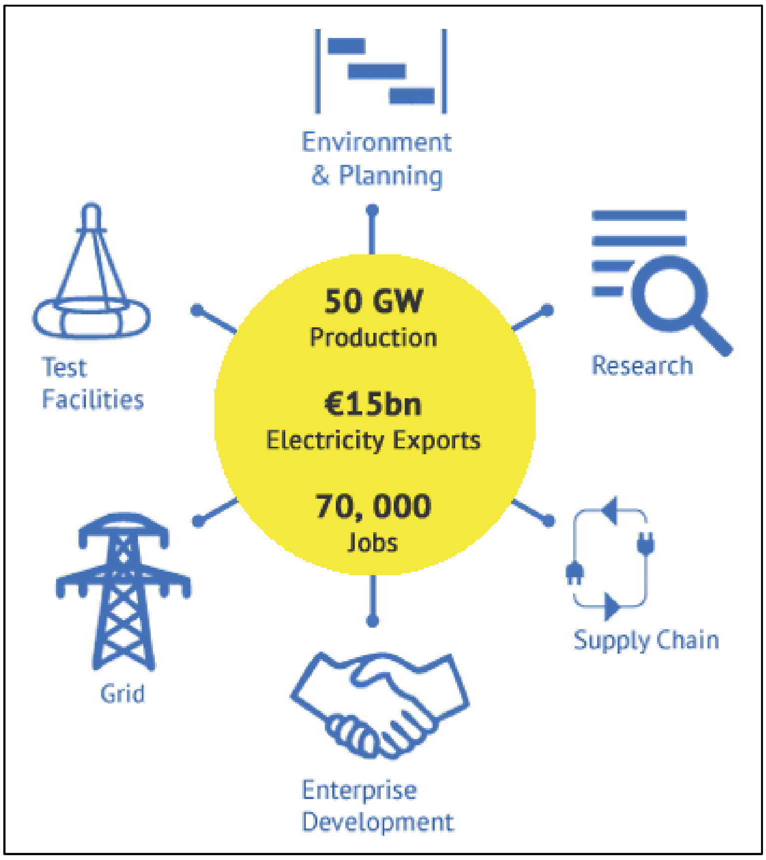

Figure 3-5: Components of the implementation of the OREDP

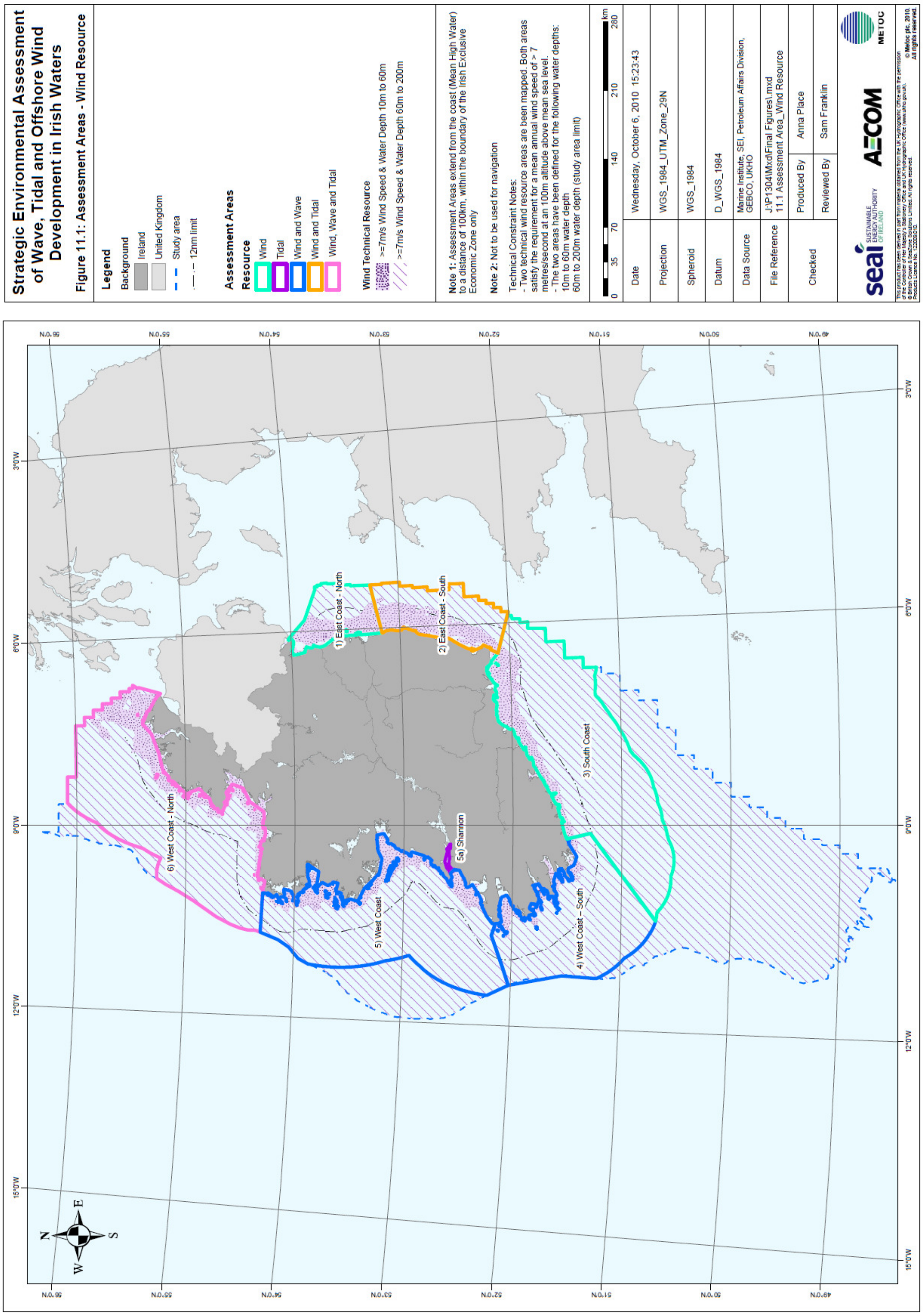

Figure 3-6: OREDP Assessment Areas[2]

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[2] Offshore Renewable Energy Development Plan (2014)

4. Project Description

4.1. Marine and Renewable Energy Test Site Location

The Galway Bay Marine and Renewable Energy Test Site is located at the existing ¼ scale ocean energy test site on the north side of Galway Bay (Figure 4-1). The test-site is located 2.4 km southeast of the village of Spiddal which is located 19 km west of Galway City. The coordinates of the test site are provided in Table 4-1.

The area of the Galway Bay Marine and Renewable Energy Test Site will be the same as the existing site, at 37 hectares and located in water depths of 21-24 metres. Its east-west extent is approximately 670 m and its north-south extent approximately 560 m. The test site area is demarcated by four cardinal marks, one at each corner. A fibre optic telecommunications and power cable was installed from the test-site to shore in April 2015 under Foreshore Licence No. 2014/02786.

Within 15km of the test site, there are SPAs designated under the EU Birds Directive (Inner Galway Bay, Lough Corrib and Connemara Bog Complex) and there are also cSAC areas such as Lough Corrib, Galway Bay Complex, Black Head - Poulsallagh Complex, Ballyvaughan Turlough, and Connemara Bog Complex.

Table 4-1: Coordinates of Galway Bay Marine and Renewable Energy Test Site

Location	Longitude	Latitude
1 North West	53^{o} 13.90’ N	9^{o} 16.15’ W
2 North East	53^{o} 13.90’ N	9^{o} 15.55’ W
3 South West	53^{o} 13.60’ N	9^{o} 16.15’ W
4 South East	53^{o} 13.60’ N	9^{o} 15.55’ W

4.2. Wave resource at the test site

The wave resource off the west coast of Ireland has been internationally recognised as one of the most energy-intense in the world, and it is estimated at 70kW per metre of wave front, off the NW coast. The wave climate at the Marine and Renewable Energy Test Site represents ¼-scale that found in the open Atlantic conditions. The north shore of Galway Bay is exposed to the prevailing west and south west winds. Wave data has been collected by the Marine Institute at the ocean energy test site since 2006 using a wave rider buoy. The wave climate summary statistics are in Table 4.2, based on 10 years of data. The mean significant wave height is 0.8m and the max is 4.94m. The highest wave recorded was 8.63m (HMax) in December 2006

Table 4-2: Summary wave data from 2006-2015

Parameter	Min	Mean	Max
Hs (m)	0.07	0.80	4.94
Hmax (m)	0.020	1.24	8.63
Tz (s)	1.47	3.99	8.70
Tp (s)	1.31	7.28	22.0
Dirp (degrees)	n/a	230.81	n/a

The wave resource at the Galway Bay Marine and Renewable Energy Test Site is characterised in the probability plot in Figure 4-2 (based on 2006-2015 data). Waves with a Significant Wave Height (Hs) between 0.5m and 1m and a Period (Tz) between 3 and 5 seconds occur 19% of the time. 45% of waves are within the 0.5m and 1m range (Hs). The prevailing wave direction is in a NW direction (See Chapter 14 for further detail).

The Hydraulics and Maritime Research Centre carried out a resource characterisation of the Galway Bay ¼ Scale Wave Energy Test Site in 2011 (Appendix 11). Device developers who will deploy WECs at the Galway Bay quarter scale test site will wish to extrapolate test results to gain an understanding of how their device will operate at full scale. The Galway Bay and Atlantic Marine Energy Test Site (AMETS) experience a similar range of sea states. It can be seen that the extreme sea states measured at both sites are analogous, indicating that developers who deploy devices in Galway Bay are likely to discover how their device will respond in the equivalent of the storm conditions experienced off the west coast of Ireland.

4.3. Project components

4.3.1. Proposed Project

The Marine Institute, with the Sustainable Energy Authority of Ireland, plan to upgrade the existing wave energy test site facility located off the coast of Spiddal in Co. Galway.

The upgrade will allow for the deployment and testing of a wider range of prototype marine renewable energy devices, innovative marine technologies and novel sensors. The facility will also provide access to a subsea observatory allowing researchers and scientists to conduct research in the marine environment.

It is proposed that the upgraded test site operate for up to 35 years, with devices on site intermittently throughout the year. The site will be structured into three berths for testing of ocean energy prototypes. The fourth berth will be for the Cabled Observatory and related projects.

The upgrade of the site will involve deploying a range of supporting infrastructure to the site, including:

- An acoustic array for monitoring underwater sound
- A ‘Sea Station’ to provide power to, and dissipate power from, ocean energy devices
- Buoys for testing of marine technologies and scientific sensors
- A Waverider buoy for wave measurements
- Interlocking modular gravity foundations
- A variety of scientific sensors and instruments
- Cables to connect the instruments, sensors, and ocean energy devices
- Upgraded cardinal marks to allow for safe navigation.

Upgrading the site will enable a maximum of three devices of the following types to be deployed at the test site for a period of testing no greater than 18 months in any one instance:

- Surface ocean energy converters.
- Sub-surface ocean energy converters
- Seabed ocean energy converters
- Prototype floating wind turbines
- Novel marine technologies and scientific sensors

These components are discussed in detail in Environmental Impact and Mitigation Desk Study for the Galway Bay Marine and Renewable Energy Test Site, undertaken by Aquafact (Appendix 1). The type of infrastructure that will be deployed on site can be classed as long term infrastructure, recurring/short term infrastructure and, test and demonstration devices (Table 4-3). These are described in detail in the following sections.

It is important to note that these prototypes may never be tested on-site, but they represent the suite of technologies that could potentially be tested.

A visual representation of the types of proposed devices that may be deployed on site is shown in Figure 4-3. The arrangement of the types of proposed devices, scaled to the actual dimensions of the test site, is presented in Figure 4-4.

Table 4-3: Galway Bay Marine and Renewable Energy Test Site infrastructure

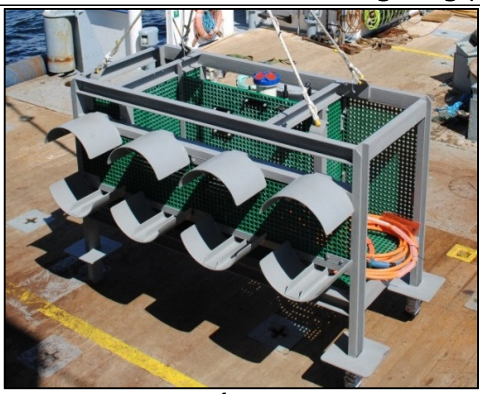
Long Term Infrastructure	Cardinal Marks Subsea Observatory (Cable End Equipment [CEE]) Waverider Data Buoy SeaStation Platform Gravity Base
Recurring/Short Term Infrastructure	SmartBay Data Buoy Acoustic Array ADCP Cables and Cabling
Test and Demonstration Devices	Oscillating Water Column WEC Point Absorber WEC Attenuator WEC Oscillating Wave Surge Converters WEC Pressure Differential WEC Water Pressure / Bulge System WEC Rotating Mass Point Absorber WEC Rotational Tidal Turbine Floating Wind Turbine Innovation Projects

4.3.2. Long Term Infrastructure

4.3.2.1. Cardinal Marks

Description	Anchored floating marks delimiting extent of proposed Galway Bay Marine & Renewable Energy Test Site to ensure safe navigation around the site. Two north and two south cardinal marks.
Dimensions	3m diameter x 7m (2m draught).
Location	Four corners of the site
Position	Floating at the surface
Deployment Duration	Long term (35yrs)
Mooring	Single point chain/rope affixed to 2 tonne clump weight (2m wide x 2m long)
Footprint	Sea surface: $7.07m^2$ x 4 = $28.28m^2$ Seabed: $4m^2$ x 4 = $16m^2$
Installation Method	From service vessel (either towed to site or craned into position) and clump weight dropped.
Lighting	IALA Guidelines: North cardinals have a continuous white flashing light and the south cardinals have 6 short flashes and one long. The western marks (VQ) have a different sequence to the eastern marks (Q).
Visualisation	 **Image for visualisation purposes only © Commissioner for Irish Lights**

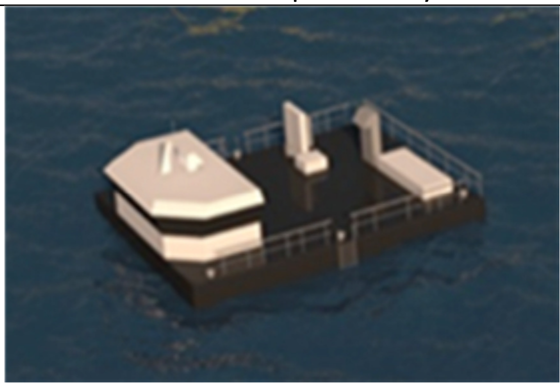
4.3.2.2. Subsea Observatory (Cable End Equipment [CEE] and Frame)

Description	The subsea observatory consists of Cable End Equipment (CEE), frame and connected equipment. It is a stationary device with ports into which sensors, SeaStation, WECs and HDTV cameras are plugged to receive power. All equipment deployed within or attached to the frame. Associated Equipment: • CEE Frame • Cable End Canister – deployed within the CEE frame • CTD (Conductivity, Temperature and Depth [Pressure]) sensor • DO (Dissolved Oxygen) Sensor • Turbidity and fluorescence sensor • Hydrophone – measure underwater sound • ADCP (Acoustic Doppler Current profiler) • Acoustic receiver – monitor tagged fish • HD Television Camera – Record underwater video footage • Underwater light – 1600Lux@1m intermittent use
Dimensions	3m length x 1.5m width x 1.7m high, 1.5 tonne
Location	Southwest corner of test site
Position	Seabed
Deployment Duration	Long term (3 - 5yrs+)
Mooring	Self-mooring under own weight
Footprint	Sea surface: 0.0 m^2 Seabed: CEE 4.5m^2 Cable Termination Equipment (CTE) 2.0m^2
Installation Method	Craned into position from service vessel
Lighting	Periodic use of underwater lighting (1600Lux@1m)
Visualisation	 **Image © Diarmuid Ó Conchubhair**

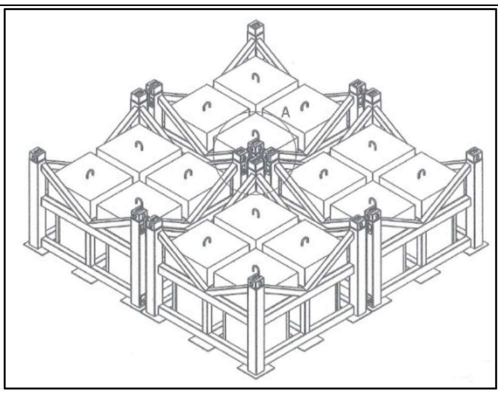
4.3.2.3. Waverider Data Buoy

Description	Stationary floating device which continually records wave climate
Dimensions	0.9m diameter
Location	Western edge of test site
Position	Floating at the surface
Deployment Duration	Long term (3 - 5yrs+)
Mooring	Anchored via single point rope mooring affixed to a 0.5 tonne clump weight / sinker (1m wide x 1m long)
Footprint	Sea surface: $2.54m^2$ Seabed: $1m^2$
Installation Method	Craned into position from service vessel
Visualisation	 **Image ©Mark Wemyss**

4.3.2.4. Sea Station Platform

Description	Floating platform connected to the shore via the CEE. Can provide power to 3 energy converters connected via umbilical cables. SeaStation will have a permanent hydrophone attached to measure underwater noise.
Dimensions	25m x 8m or 12m x 12m.
Location	Within 100m of the CEE
Position	Floating at the surface
Deployment Duration	Long term (10yr+) Annual recovery for scheduled maintenance.
Mooring	Maximum of a 4 point chain mooring affixed to three-tonne high hold Danforth anchors. Three-tonne anchor dimension are 2m wide, 3.5m long and 1m high.
Footprint	Sea surface: 200m^2 (maximum) Seabed: 56m^2 (maximum for 8 anchors)
Installation Method	Towed to site by service vessel. Anchors lowered into position by service vessel.
Visualisation	 **Image for visualisation purposes only © Macroworks**

4.3.2.5. Gravity Base

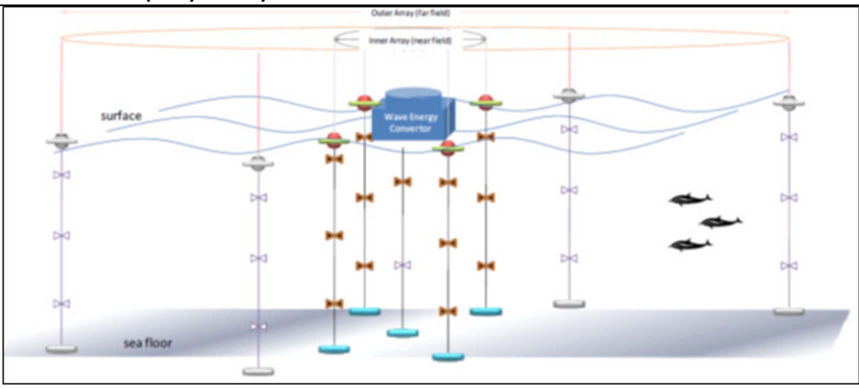
Description	Individual 9 tonne frames or a series of interlocking 9 tonne frames to a maximum of 81 tonnes. Prefabricated concrete weights placed into the frame(s). Devices are either mounted directly to gravity base or slack moored by means of single/multipoint moorings to the gravity base
Dimensions	9No. x 2.5m length x 2.5m width x 2m height (maximum)
Location	Potentially anywhere within the test site
Position	Seabed
Deployment Duration	Long term (3-5yrs+)
Mooring	Self-mooring under own weight
Footprint	Sea surface: n/a Seabed: $56m^2$ (maximum for 9 units)
Installation Method	Craned into position from service vessel
Lighting	none
Visualisation	 **Image for visualisation purposes only © Marine Technology Ltd.**

4.3.3. Recurring / Short Term Infrastructure

4.3.3.1. SmartBay Data Buoy

Description	Floating, moored device which continually records environmental data at the test site from a variety of on-board sensors.
Dimensions	2.5m diameter x 7m (2m draught)
Location	Potentially anywhere in the test site
Position	Floating at surface
Deployment Duration	Regular short to medium-term deployments (6-12 months)
Mooring	Single, bridle or multipoint rope, wire or chain moorings affixed to one or two 3 tonne clump weights (1.5m x 1.5m x 1.5m)
Footprint	Sea surface: 4.91m^2 Seabed: 4.5m^2 (max for two clump weights)
Installation Method	Towed into position from service vessel
Visualisation	 **Image © SmartBay Ireland Ltd.**

4.3.3.2. Acoustic Array

Description	A system of 6 individual landers positioned on the seafloor connected via 17mm diameter cabling to a central hub (containing the associated electronics and ICT components) which in turn is connected via a 25mm diameter cable directly to the CEE. Each lander will have an acoustic monitoring hydrophone affixed to it and one hydrophone floating at mid water by means of an in-line float. A particle velocity sensor will also be attached to each lander. The purpose is to monitor underwater sound levels from ocean energy devices and monitoring the presence of cetaceans and other sea life.
Dimensions	Landers: Triangular base of 1m side x 0.75m height, weight 0.05 tonne Central Hub: 1.5m length x 1.5m width x 1.0 m height, weight 1 tonne Cabling: 400m long x 0.025m diameter
Location	Central hub will be within 150m of CEE with individual landers deployed throughout the test site
Position	Seabed with hydrophones floating mid water
Deployment Duration	Regular medium-term deployments (12 - 18 months) to monitor ocean energy devices
Mooring	Self-mooring under own weight
Footprint	Sea surface: 0.0 m^2 Seabed: Landers 0.5m2 x 6 = 3 m^2 Central Hub: 2.25 m^2 Cabling: 10 m^2
Installation Method	Central Hub craned into position from service vessel. Landers deployed by divers.
Visualisation	 **Image for visualisation purposes only ©IBM**

4.3.3.3. Trawl resistant ADCP

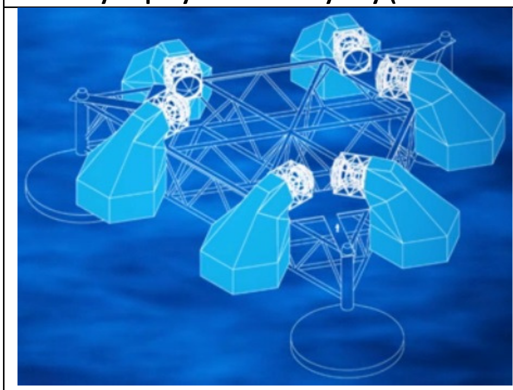
Description	An Acoustic Doppler Current Profiler (ADCP) to measure water currents
Dimensions	Trawl resistant frame: 2m x 2m x 1m
Location	Potentially anywhere within the test site
Position	Seabed
Deployment Duration	Regular short to medium-term deployments (6-12 months)
Mooring	Self-mooring under own weight
Footprint	Sea surface: 0.0 m^2 Seabed: $2m^2$
Installation Method	Deployed from service vessel
Visualisation	 **Image © Diarmuid Ó Conchubhair**

4.3.3.4. Cables and Cabling

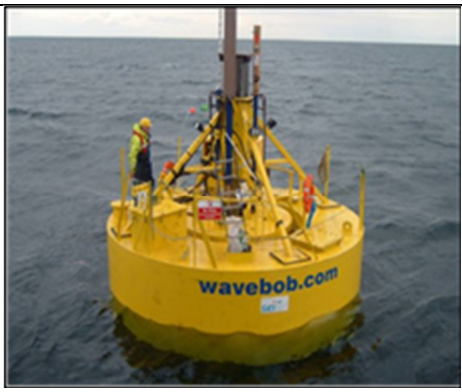
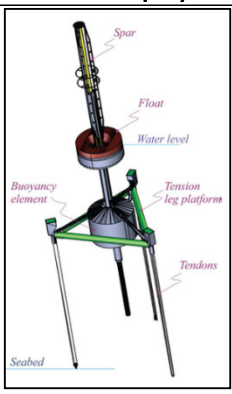
Description	Interconnecting cables will be designed for specific applications with embedded strength members and a protective jacket commensurate with its intended use and performance requirements. The umbilical cables between the SeaStation and a WEC will be designed to float within the water column and not touch the seabed to avoid any interference with the sea bed and to reduce wear and tear on the cable. The riser cable from the CEE to the SeaStation will, for a portion of its length, rest on the seabed before rising to meet the SeaStation floating at the surface. All cables will be designed with EMF shielding.
Dimensions	600m long x 0.025m diameter (maximum single cable)
Location	Between test devices, SeaStation and CEE
Position	Floating mid water column, with some cabling resting on the seafloor
Deployment Duration	Regular medium-term deployments (12 - 18 months)
Mooring	none
Footprint	Sea surface: 0.0 m^2 Seabed: 5 m^2
Installation Method	Deployed from vessel

4.3.4. Test and Demonstration Devices

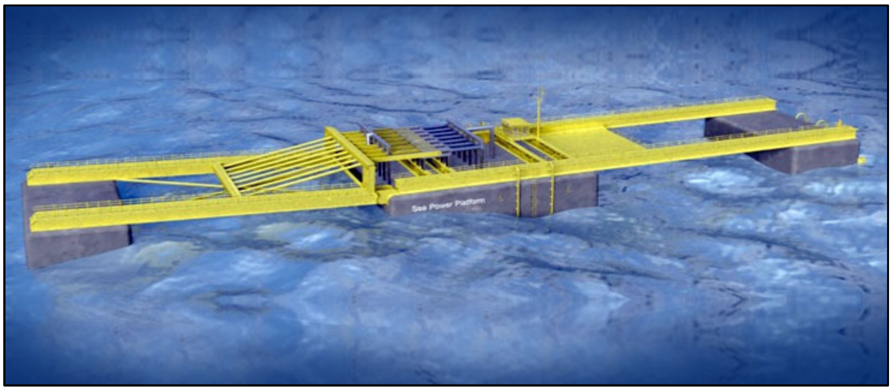
4.3.4.1. Oscillating Water Column Wave Energy Converter (WEC)

Description	Floating, hollow structures open to the sea below the water line.
Dimensions	Various depending on device 20m length x 10m width, or triangle base of side 30m (maximum)
Location	Within test site
Position	Floating at surface
Deployment Duration	Periodic short – medium term deployments (6 - 18 months)
Mooring	Multipoint chain moorings affixed to high hold embedded anchors.
Footprint	Sea surface: 400.0 m^2 (device maximum) Seabed: 56 m^2 (mooring maximum)
Installation Method	Towed into position from service vessel
Visualisation	 **OE buoy deployed in Galway Bay (2007 – 2011) ©Marine Institute**
	 **Image for visualisation purposes only ©GRSI**

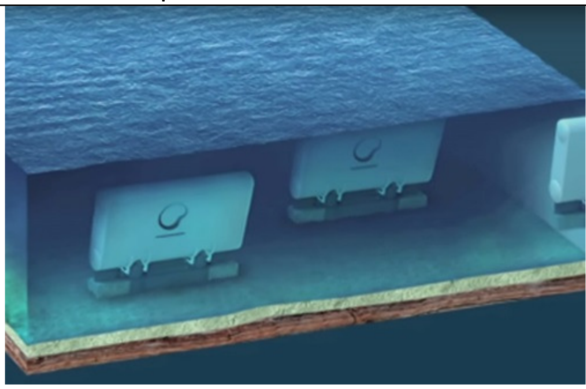
4.3.4.2. Point Absorber WECs

Description	Floating structures which absorb energy from all directions through their movements at/near the water surface.
Dimensions	Various depending on device Maximum 5m diameter
Location	Within test site
Position	Floating at surface, extending through water column, moored to the seabed
Deployment Duration	Periodic short – medium term deployments (6 - 18 months)
Mooring	Multipoint chain moorings affixed to high hold embedded anchors, or affixed to gravity base
Footprint	Sea surface: 20.0 m^2 (device maximum) Seabed: 56 m^2 (mooring maximum)
Installation Method	Towed into position from service vessel
Visualisation	 **Wavebob deployed in Galway Bay (2006 – 2007) ©Marine Institute**
	 **Image for visualisation purposes only ©Sigma Energy**

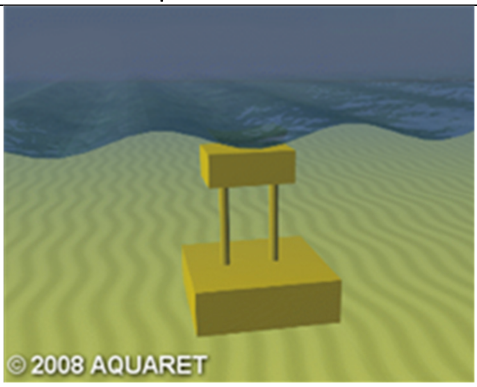
4.3.4.3. Attenuator WECs

Description	Floating structures that capture energy from the relative motion of the two arms as the wave passes them.
Dimensions	Various depending on device 30m length x 10m width x 3m high (maximum)
Location	Within test site
Position	Floating at surface
Deployment Duration	Periodic short – medium term deployments (6 - 18 months)
Mooring	Multipoint chain moorings affixed to high hold anchors
Footprint	Sea surface: 300.0 m^2 (device maximum) Seabed: 56 m^2 (mooring maximum)
Installation	Towed into position from service vessel
Examples	 **Image for visualisation purposes only © SeaPower Ltd.**
	 **Image for visualisation purposes only © PerpetuwavePower Pty Ltd.**

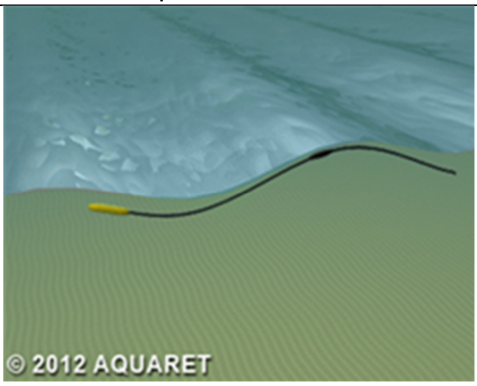
4.3.4.4. Oscillating Wave Surge Converters WEC

Description	Devices mounted to the seabed and the arm oscillates as a pendulum mounted on a pivoted joint in response to the movement of water in the waves. Most devices are all subsea with some devices having only top of the flap above the waterline.
Dimensions	Various depending on device 5m length x 10m width x 10m high (maximum)
Location	Within test site
Position	Fixed to the seabed and extending through the water column.
Deployment Duration	Periodic short – medium term deployments (6 - 18 months)
Mooring	Self-mooring under own weight
Footprint	Sea surface: $10.0m^2$ Seabed: 50 m^2 (maximum)
Installation	Towed into position from service vessel
Examples	 **Image for visualisation purposes only © AW Energy**
	 **Image for visualisation purposes only © Aquamarine Power**

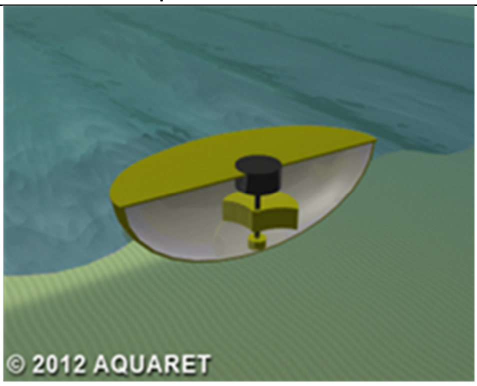
4.3.4.5. Pressure Differential WEC

Description	Devices attached to the seabed using gravity base The motion of the waves causes the sea level to rise and fall above the device, inducing a pressure differential in the device.
Dimensions	Various depending on device
Location	Within test site
Position	Fixed to the seabed and extending through the water column.
Deployment Duration	Periodic short – medium term deployments (6 - 18 months)
Mooring	Two point taught mooring to gravity base
Footprint	Sea surface: 20.0m^2 (maximum) Seabed: 50 m^2 (maximum)
Installation	Towed into position from service vessel
Examples	 **Image for visualisation purposes only © Aquaret**

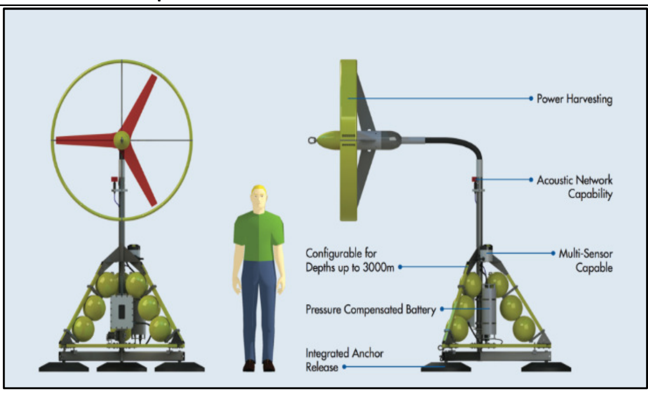
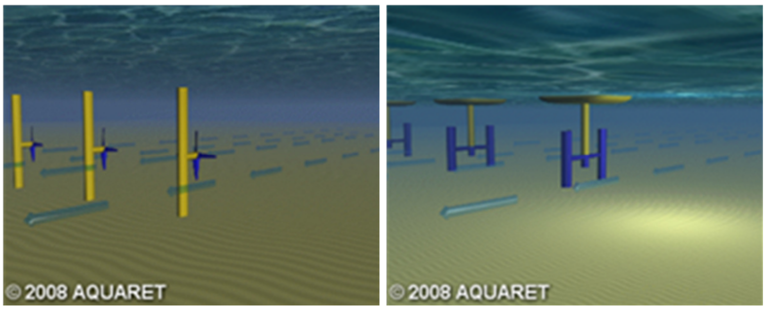
4.3.4.6. Water Pressure / Bulge System WEC

Description	Device consisting of a rubber tube filled with water, moored to the seabed heading into the waves. The water enters through the stern and the passing wave causes pressure variations along the length of the tube, creating a 'bulge'. As the bulge travels through the tube it grows, gathering energy which can be used to drive a standard low-head turbine located at the bow, where the water then returns to the sea.
Dimensions	Various depending on device 20m length x 4m width x 1m height (maximum)
Location	Within test site
Position	Floating near sea surface
Deployment Duration	Periodic short – medium term deployments (6 - 18 months)
Mooring	Multipoint mooring affixed to embedded anchors or clump weights
Footprint	Sea surface: 32.0m^2 (maximum) Seabed: 56 m^2 (maximum)
Installation	Towed into position from service vessel
Examples	 **Image for visualisation purposes only © Aquaret**

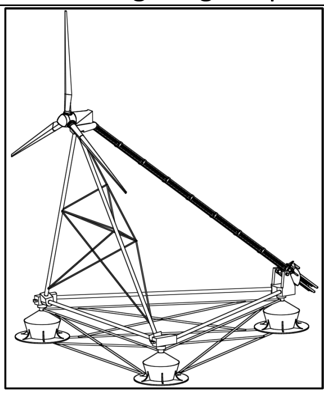
4.3.4.7. Rotating Mass Point Absorber

Description	Large buoy like structure that is on the sea surface, inside a rotating mass is connected to a pump and/or generating system. Two forms of rotation are used to capture energy by the movement of the device heaving and swaying in the waves. This motion drives either an eccentric weight or a gyroscope causes precession. In both cases the movement is attached to an electric generator inside the device.
Dimensions	Various depending on device 10m length x 4m width x 3m height (maximum)
Location	Within test site
Position	Floating at surface
Deployment Duration	Periodic short – medium term deployments (6 - 18 months)
Mooring	Multipoint mooring affixed to embedded anchors or clump weights
Footprint	Sea surface: 40.0m^2 (maximum) Seabed: 56 m^2 (maximum)
Installation	Towed into position from service vessel
Examples	 **Image for visualisation purposes only © Aquaret**

4.3.4.8. Rotational Tidal Turbine

Description	Devices can be either seabed mounted, within the water column or at the surface. Omni-directional turbine that can generate power from ocean currents. Devices may also support multiple sensors for wide area, real-time environmental monitoring.
Dimensions	Various depending on device 10m length x 4m width x 3m height (maximum)
Location	Within test site
Position	Seabed mounted, within the water column or at the surface
Deployment Duration	Periodic short – medium term deployments (6 - 18 months)
Mooring	Deployed on the seabed with a gravity base or, Taut mooring to gravity base or, Attached to another structure on site.
Footprint	Sea surface: 0.0 m^2 Seabed: 5 m^2 (maximum)
Installation	Towed into position from service vessel
Examples	 **Image for visualisation purposes only © Seaformatics**
	 **Image for visualisation purposes only © Aquaret**

4.3.4.9. Floating Wind Turbine

Description	Floating platforms which are designed to accommodate wind turbines (and associated turbine tower)
Dimensions	Various depending on device Triangular base of 20m sides x 25m hub height (maximum) Blade diameter of 20m (maximum)
Location	Within test site
Position	Floating at surface and moored to the seabed
Deployment Duration	Periodic short – medium term deployments (1 - 12 months)
Mooring	Multipoint mooring affixed to embedded anchors or gravity bases
Footprint	Sea surface: $200m^2$ (maximum) Seabed: 56 m^2 (maximum)
Installation	Towed into position from service vessel
Lighting	Aviation lighting as specified by Irish Aviation Authority
Examples	 **Image for visualisation purposes only © TetraFloat**  **Image for visualisation purposes only © Macroworks**

4.3.4.10. Innovation Projects

Description	Innovation projects that may require the deployment and testing of innovative sensors and marine equipment. These may be mounted to the CEE frame, be self-deployed with a gravity base or utilise other existing infrastructure on site (i.e. SeaStation, data buoy etc.).
Dimensions	Various depending on device
Location	Within test site
Position	On the seabed, attached to CEE frame or other infrastructure
Deployment Duration	Periodic short – medium term deployments (1 - 12 months)
Mooring	Attached to CEE, small lander frames, or affixed to gravity bases
Footprint	Sea surface: 10 m^2 (maximum) Seabed: 10 m^2 (maximum)
Installation	Lifted / towed into position from service vessel
Examples	Deployment and testing of novel moorings. These maybe in conjunction with standard sinkers or a gravity base Artificial reef material tested on site to analyse biological and chemical effects in the marine environment Various WECs may want to include a self-contained generator on their devices (device and project specific) for the duration of their deployment

4.4. Project Installation

The following are the main activities that will be associated with the implementation of the project:

- Marking of the designated test areas with cardinal marks
- Deployment of test infrastructure

4.4.1. Deployment of cardinal marks

Cardinal marks will be placed at each corner of the test site. The cardinal marks indicate the safe side of a danger to navigation. The marks will be anchored to the seabed using clump weights. The southwest cardinal mark will be fitted with an antenna and an automatic identification system (AIS) transmitter. This will allow data transmission from the test site to shore based facilities and identify the test area location to shipping and other vessels electronically and visually.

The operation to deploy the cardinal marker buoys will be undertaken by the Commissioner of Irish Lights over a period of approximately one week and will require the ILV *Granuaile* to be present on site. The marks will be maintained by the Marine Institute for the lifetime of the project.

4.5. Deployment of test and demonstration devices

The deployment of wave energy converters, tidal turbines, floating devices and other innovation projects will take place in accordance with the strict conditions described in the Galway Bay Test and Demonstration Site Manual included in (Appendix 2).

The document explains the procedures to be followed by any company or researcher wishing to use Galway Bay Marine and Renewable Energy Test Site to test their ocean energy conversion prototypes or devices. It also states the “Conditions for Use” of those facilities, as well as the services provided by SmartBay to assist the users of the test site.

It provides the legal, marine safety, environmental and operation conditions the users must satisfy prior to a device being granted access to the test site.

The test site has been designed to only allow a maximum of 3 prototype ocean energy convertors be deployed and tested at any one time.

4.5.1. Mooring of devices

Mooring systems for devices are still largely at the developmental stage. Although the experience gained from mooring systems is limited, a number of anchoring solutions are in development. These take into account the size and needs of different devices as well as seabed substrate type, mooring depth, static and dynamic forces, and economic factors. The experience gained from previous devices deployed and from other offshore applications such as wind farms, ship anchoring, general marine construction and the offshore oil industry has also been considered.

Devices are required to operate in high-energy environments where they can maximise the potential to generate electricity. The design of mooring systems must therefore take into account the typical requirements of such conditions with a view to ensuring the survivability of the device and the optimisation of power output.

In line with the Galway Bay Test and Demonstration Site Manual, the mooring system(s) shall be designed for the expected loading and in accordance to the appropriate standards in use at the time of application submission. All mooring materials must be certified, or proven as such.

The mooring design is to be undertaken by recognised and competent third party naval architect, marine surveyor or accreditation bureau. The design and the report of any inspection or certification made by a third party naval architect, marine surveyor or accreditation bureau are to be submitted for analysis with the signed application or, that not being the case, within three weeks of further documentation being requested for the complete assessment of the application. All welding shall be carried out by certified welders.

The Marine Institute, as leaseholders of the proposed Galway Bay Marine and Renewable Energy Test Site, reserves the right to have moorings inspected by a certified marine surveyor at any time, at the expense of the developer. In case the information provided is deemed insufficient to guarantee the safety of the mooring, the device and the test site, or if visual inspection to the moorings reveals any discrepancies between the approved mooring design and the moorings provided.

4.5.2. Anchoring systems

There are a number of likely anchoring systems for devices which would be suitable for use at the test site. These include gravity bases and drag embedment anchors (including vertical load anchors); these are described below.

Gravity anchors keep the unit in place solely by the weight of the anchor. In medium to soft seabed sediment, the friction force between the gravity base’s surface and the surrounding sediment will add to the holding capacity. The weight of the gravity base must be sufficient for it to withstand horizontal forces and it must also remain stable and not tilt over when exposed to forces that present at an angle.

The proposed gravity bases consist of precast concrete pins with steel frames. They are suitable for both seabed-mounted and floating devices and for both catenary and taut mooring configurations.

Drag embedment anchors are used with mooring systems without vertical loads, such as catenary mooring systems. When installed, the anchor is embedded in the seabed substrate and the connector is attached at the seabed surface to the catenary mooring line. Drag embedment anchors are only suitable for floating devices that use a catenary mooring line system. They are suitable for most soft and medium seabed substrate conditions where it is possible to lower the anchor into the substrate at installation.

The actual deployments will depend on a range of factors that cannot all be determined until technology-specific design work is undertaken by prospective users of the site. Almost all of the technologies proposing to utilise the test site are at different stages of prototype development and numerous challenges are likely to impact on their future deployment strategies and designs.

4.5.3. Commissioning of devices

Once the device is anchored in position, a dynamic cable riser will be lifted from the seabed and connected to the device, if connecting to the cable or the Sea Station. This will give rise to a small amount of seabed disturbance as the temporary cable protection is removed.

4.5.4. Duration and Phasing

Devices will most likely be deployed at the test site during the months of April to September for periods of testing ranging from weeks to months. The maximum duration of testing for any one device at the test site will be 18 months. Devices can be periodically removed for adjustments and maintenance purposes. The actual deployment of devices will likely occur over a series of two to three day periods.

Initially the anchoring and moorings will be deployed at the test site. The device will subsequently be towed to the test site and the device secured to the moorings. Connection of the devices to the SeaStation (if required) will be the last stage of the deployment process. Deployment of anchors, moorings and devices to the test site will be very weather dependant.

4.6. Overall project timescale

The site will be maintained in an operational capacity for 35 years from the date of commissioning.

4.7. Worst Case Scenarios for Impact Assessment

When applicable, different environmental impacts were assessed for worst case scenarios based on the infrastructure, devices, and technologies detailed above. This determined the impact thresholds for the different environmental receptors and provided an envelope of potential environmental impacts.

The worst case scenario assessment for each receptor assumed that all permanent infrastructure and all recurring short term infrastructure was deployed at the site, and that the three device testing berths were occupied by those devices which would be expected to have greatest impact on the receptor under consideration. The various components contributing to the worst case scenarios for each environmental receptor are presented in Table 4-4.

4.8. Decommissioning

Decommissioning of the test site leasehold area will be subject to agreement between MI/SEAI, the Minister for Environment Heritage and Local Government, and other appropriate authorities, and will be in line with relevant legislation and industry best practice at the time.

Decommissioning of individual devices or technologies will be the responsibility of the developer and will be subject to agreement with the Marine Institute, and be in line with relevant legislation and industry best practice at the time.

An assessment of the impact of decommissioning devices will be undertaken. This will include options for the recovery of anchoring systems, or leaving them in-situ.

Table 4-4: Worst Case Scenario deployments per Environmental Receptor.

		Surface Footprint (m^2)	Seabed Footprint (m^2)	**Human Activity**	**Flora & Fauna**	**Water**	**Seabed & Geology**	**Air**	**Cultural Heritage**	**Visual**	**Material Assets**	**Navigation**	**Coastal Processes**
Permanent	Cardinal Marks	7	4	x4	x4	x4	x4	x4	x4	x4	x4	x4	x4
	Observatory	0	7	1	1	1	1	1	1	1	1	1	1
	Waverider	3	1	1	1	1	1	1	1	1	1	1	1
	SeaStation	200	56	1	1	1	1	1	1	1	1	1	1
	Gravity Base	0	7	x9	x9	x9	x9	x9	x9	x9	x9	x9	x9
Recurring	Databuoy	5	5	1	1	1	1	1	1	1	1	1	1
	Acoustic Array	0	15	1	1	1	1	1	1	1	1	1	1
	ADCP	0	2	1	1	1	1	1	1	1	1	1	1
	Cabling	0	5	1	1	1	1	1	1	1	1	1	1
Devices	OWC	400	56	1	1	1	1	1	1	1	1	1	3
	Point Absorber	20	56			1	1	1	1				
	Attentuator	300	56	1	1	1	1		1	1	1	1	
	Oscillating Surge	10	56										
	Pressure Differential	20	56										
	Bulge	32	56										
	Rotating Mass	40	56										
	Tidal Turbine	0	5		1								
	Floating Wind Turbine	200	56	1	1			1		1	1	1	

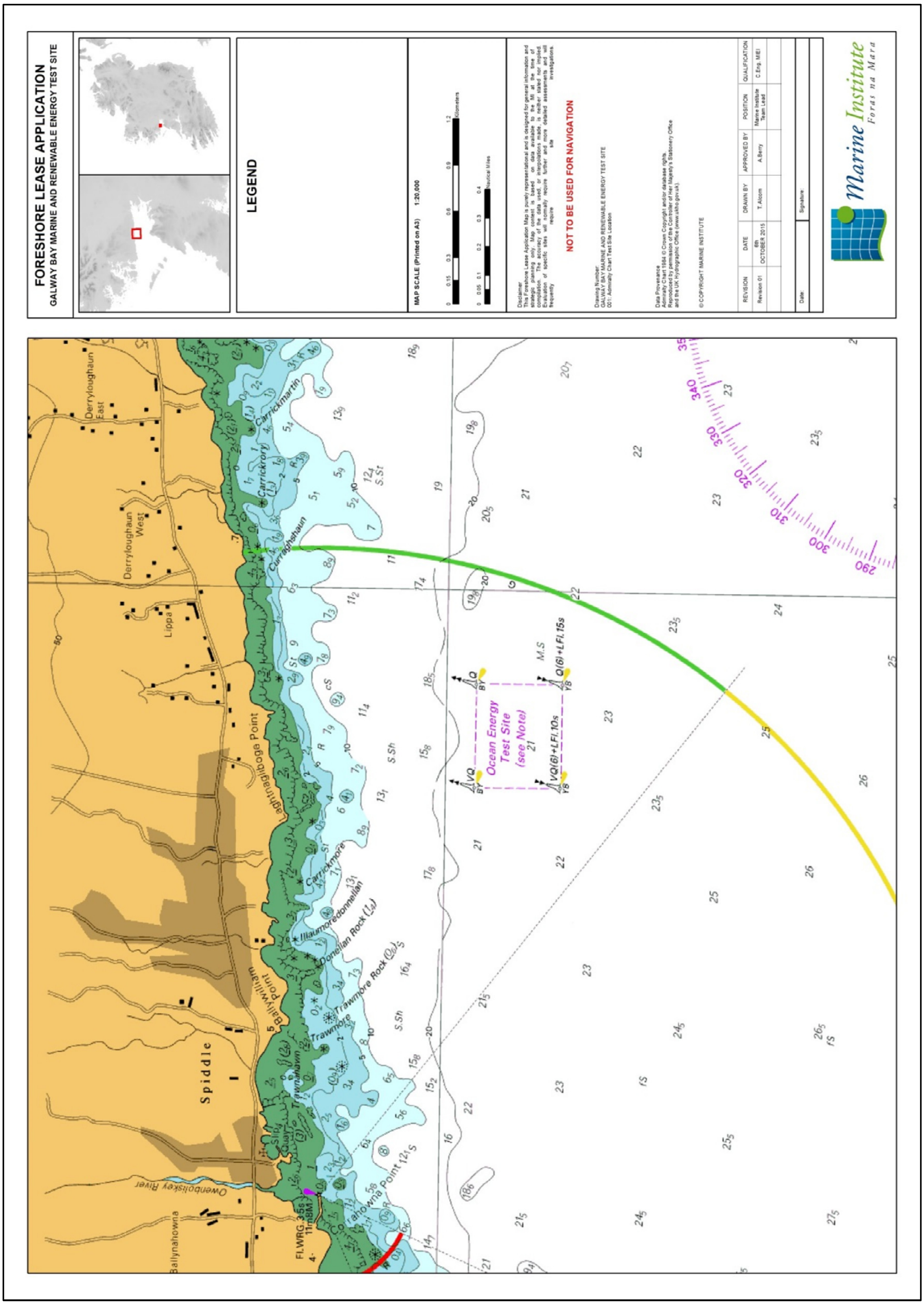


Figure 4-1: Location of existing ocean energy test site, and location of proposed Galway Bay Marine and Renewable Energy Test Site.

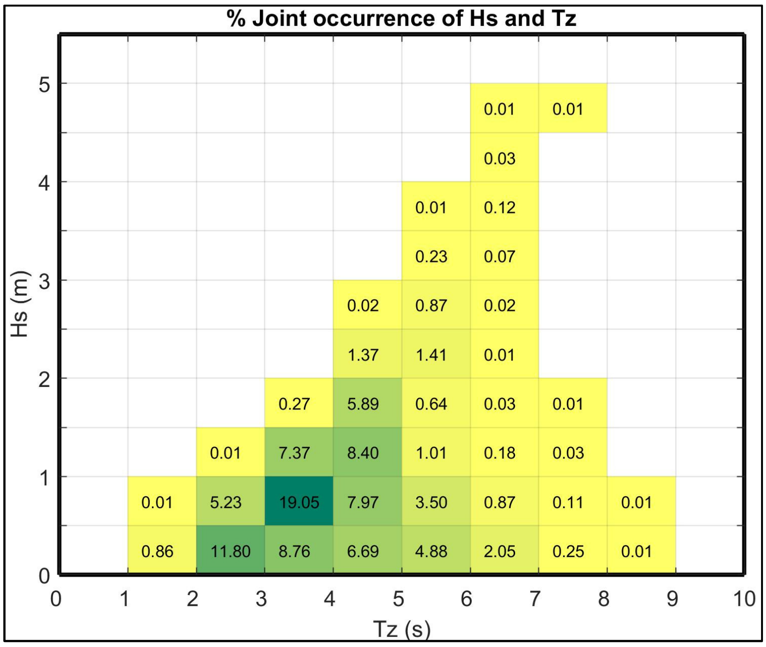


Figure 4-2: Joint occurrence of Hs and Tz (percentage occurrence) 2006 – 2015

Figure 4-3: Proposed marine energy test equipment (does not reflect actual arrangement on site)

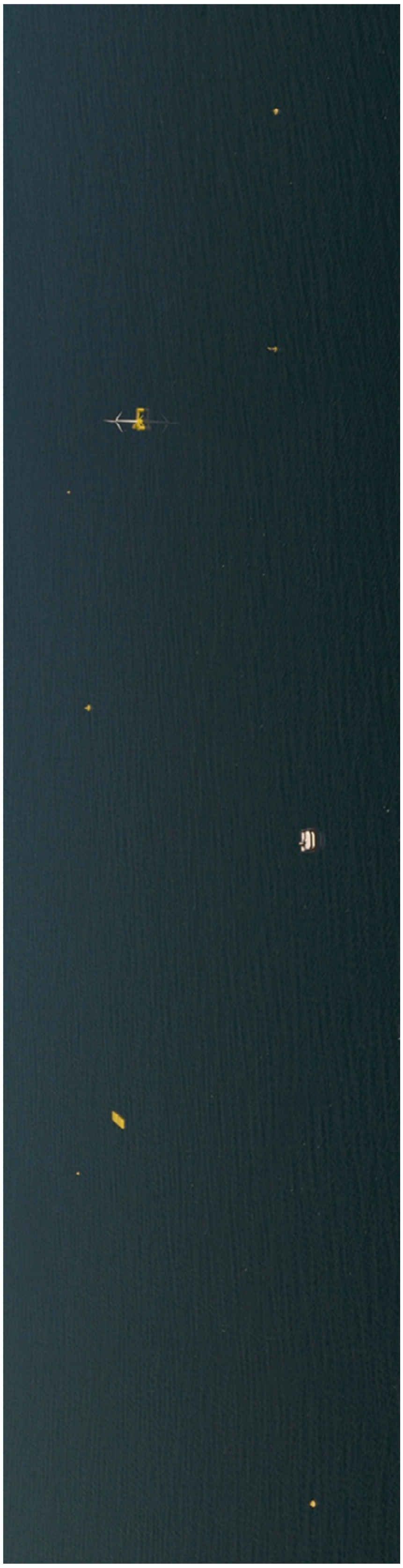


Figure 4-4: Actual arrangement of proposed test equipment on site

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5. Human Activity

5.1. Introduction

This section evaluates the potential impact of the proposed project on human activity in the area surrounding An Spidéal (Spiddal). It addresses the potential consequences of the test site on the local population and the socio-economic activity in the area.

5.2. Population

5.2.1. Receiving environment

The test site is located off the Spiddal coast in Connemara, County Galway. Table 5-1 provides a summary of the population of Spiddal as well as that of the surrounding areas. For reference, state, county and city populations are also included. All data are from the Central Statistics Office Census of Ireland results 2002-2011.

The project is located off the north coast of Galway Bay and is accessed via ports and piers located in Rossaveal, Spiddal and Galway City. Surrounding the pier infrastructure and town of Spiddal are the electoral divisions of An Spidéal, Cill Aithnín and Na Forbacha. These three areas are deemed to constitute the receiving environment of the project for the purposes of this section, due to fact that the project is visible and accessible from these zones.

Table 5-1: Population change in areas surrounding test site 2002-2011

Area	Persons (number)			Percentage change	
	2002	2006	2011	2002-2006	2006-2011
051 Na Forbacha, Co. Galway	1272	1239	1312	-2.6	5.9
055 Cill Aithnín, Co. Galway	831	963	1000	15.9	3.8
063 An Spidéal, Co. Galway	1253	1357	1450	8.3	6.9
State	3917203	4239848	4588252	8.2	8.2
County Galway	143245	159256	175124	11.2	10.0

The areas around the test site have seen almost uniform population growth over all study years. The electoral divisions of An Spidéal, Cill Aithnín and Na Forbacha have seen their populations grow between 2002 and 2011. In the 4 years following the 2002 census population fell in Na Forbacha by 2.6% whilst An Spidéal and Cill Aithnín saw changes in population that were superior to the national average. From 2006 to 2011 the population of Na Forbacha increased by 5.9%, during the same period population growth slowed in Spidéal and Cill Aithnín to 6.9% and 3.8% respectively. This resulted in all three electoral divisions having rates of population growth inferior to state and county levels.

The project is located in the Connemara Gaeltacht; this is an especially vibrant Gaeltacht region with Irish being spoken extensively and on a regular basis. Table 5-2 provides a summary of the population variations within in the electoral divisions surrounding the test site which make up part of this Gaeltacht area. For reference the changes in population have been included for Gaeltacht areas in Galway County and in Ireland as a whole. This information was gathered by the Central Statistics Office from Census of Ireland data for the years 2002 to 2011.

Table 5-2: Population change in Gaeltacht areas surrounding test site 2002-2011

Area	Persons (number)			Percentage change	
	2002	2006	2011	2002-2006	2006-2011
051 Na Forbacha, Co. Galway	1272	1239	1312	-2.6	5.9
055 Cill Aithnín, Co. Galway	831	963	1000	15.9	3.8
063 An Spidéal, Co. Galway	1253	1357	1450	8.3	6.9
All Gaeltacht Areas	90048	95503	100716	6.1	5.5
Galway Gaeltacht Areas	40267	45052	48907	11.9	8.6

The health of the Galway Gaeltacht as a whole is illustrated in this table by high rates of population increase. The EDs that constitute the receiving area around the test site generally had lower rates of population increase than that of the Galway Gaeltacht areas in recent years.

5.2.2. Impact of the development

As the project contains no land based infrastructure in the area surrounding the site, there will be no impact on local population composition.

Impacts of a visual nature on the population of Spiddal, Furbo and surrounding areas have been assessed in Chapter11: Visual Impact Assessment.

5.2.3. Conclusion

The project does not contain a residential component and therefore will not have any significant direct impact on the composition of the population in the immediate area.

5.3. Employment and socio-economic benefits

5.3.1. Receiving environment

Census of Ireland 2011 data compiled by the CSO indicates that the proportion of people at work in the immediate receiving area is lower than national and county averages. Table 5-3 shows the distribution of persons older than 15 years of age in the electoral divisions of An Spidéal, Cill Aithnín and Na Forbacha alongside reference figures from

County Galway and the state across the various types of economic status. There are 1,160 working age people in the electoral district of Spiddal with just over 50% of those in work. Cill Aithnín and Na Forbacha EDs have fewer working age persons (806 and 1009 respectively) due to their smaller populations.

Table 5-3: Distribution of the Principal Economic Status of persons in the year 2011

Principal Economic Status	Persons (number)				
	Cill Aithnín	An Spidéal	Na Forbacha	Co. Galway	State
Persons at work	391	581	519	69,207	1,807,360
Unemployed looking for first regular job	8	6	4	1,188	34,166
Unemployed having lost or given up previous job	106	124	87	14,123	390,677
Student or pupil	93	140	145	14,192	408,838
Looking after home/family	65	90	85	13,356	339,918
Retired	122	189	127	17,161	457,394
Unable to work due to permanent sickness or disability	20	28	37	5,749	156,993
Others not in labour force	1	2	5	455	13,316
Total	806	1,160	1009	135,431	3,608,662

Table 5-4 features the proportion of persons in each category of economic status. It indicates that the employment rate is lower in the receiving areas than in the county as a whole. An Spidéal and Cill Aithnín have more retirees as a proportion of their population (16.3% and 15.1% respectively) than both the county and the state (both 12.7%), while Na Forbacha is in line with county and national averages. This area contains more students per working age person than in Galway County and the State, in addition there are fewer persons who look after their home or family as a principal occupation. In the study area there are lower rates of persons unable to work due to sickness or disability in the receiving area, indicating a healthy population in this area.

Figure 5-1 describes the different economic status of the workforce in the electoral divivisions of Cill Aithnín, An Spidéal and Na Forbacha as well as in County Galway and in the Irish State as a whole. It provides an overall picture of the principal economic status of the inhabitants of the study areas with reference to Galway County and the State. It is notable that Cill Aithnín ED features significantly higher unemployment rates than the other study areas. In absolute terms the number of unemployed persons in Cill Aithnín ED (122 unemployed persons) is approaching that of neighbouring Spiddal ED (189) and Na Forbacha ED (127) even though the latter have larger working age populations.

Table 5-4: Distribution of the principal Economic Status of persons in the year 2011 as a proportion of total working-age population

Principal Economic Status	Share of workforce (%)				
	Cill Aithnín	An Spidéal	Na Forbacha	County Galway	State
Persons at work	48.5	50.1	51.4	51.1	50.1
Unemployed looking for first regular job	1	0.5	0.4	0.9	0.9
Unemployed having lost or given up previous job	13.2	10.7	8.6	10.4	10.8
Student or pupil	11.5	12.1	14.4	10.5	11.3
Looking after home/family	8.1	7.8	8.4	9.9	9.4
Retired	15.1	16.3	12.6	12.7	12.7
Unable to work due to permanent sickness or disability	2.5	2.4	3.7	4.2	4.4
Others not in labour force	0.1	0.2	0.5	0.3	0.4
Total	100	100	100	100	100

CSO data from the 2006 and 2011 census of Ireland indicate that the total labour force in County Galway (excluding city of Galway) grew by 10% between 2006 and 2011, during this period however the amount of persons in work diminished by 2%. The distribution of labour across the various industries is shown in Table 5-5.

The reduction in employment rates in County Galway overall was largely fuelled by steep declines in employment in the construction and manufacturing sectors in 2008 with an estimated 6918 jobs lost in these two sectors alone. Although there was a net reduction of 2% in employment in the county, 11 of the 15 sectors that feature in this dataset do see growth during between the study years, particularly in the areas of education and public administration and defence with over 1000 persons finding employment in each sector.

The project is relatively insignificant on the county level but will have some impact at the local level. Using Small Area Population Statistics provided by the CSO we can see the distribution of persons working in the electoral divisions of An Spidéal, Na Forbacha and Cill Aithnín across various industries, shown in Table 5-6.

The professional services industry represents the principal source of employment for the populations living in the Electoral Divisions that are closest to the test site. It is likely that these professionals and many others work in the City of Galway which is around 18km away. Figure 5-2 provides an overview of the professions and trades that feature in these electoral divisions. It can be seen that all areas have a broadly similar proportion of their population working in each industry with the major difference resulting from higher levels of manufacturing in the ED of Cill Aithnín.

Table 5-5: Distribution of persons employed in Galway County 2006-2011

Sector	Persons (number)		Percentage change
	2006	2011	2006-2011
Agriculture, forestry and fishing	5749	6034	5.0
Mining, quarrying and turf production	389	293	-24.7
Manufacturing industries	10329	9352	-9.5
Electricity, gas and water supply	338	405	19.8
Construction	10383	4442	-57.2
Wholesale and retail trade	8329	9187	10.3
Hotels and restaurants	3422	3511	2.6
Transport, storage and communications	2777	2729	-1.7
Banking and financial services	1736	1871	7.8
Real estate, renting and business activities	4528	5267	16.3
Public administration and defence	2669	3735	39.9
Education	5452	7136	30.9
Health and social work	7651	8539	11.6
Other community, social and personal service activities	2712	2848	5.0
Industry not stated	4153	3858	-7.1
Unemployed - looking for first regular job	938	1188	26.7
Unemployed - having lost or given up previous job	4965	14123	184.5
Total at work	70617	69207	-2.0
Total in labour force	76520	84518	10.5

Table 5-6: Distribution of persons employed in the surrounding EDs 2011

Industry	Persons in work (number)		
	Cill Aithnín	An Spidéal	Na Forbacha
Agriculture, forestry and fishing	15	20	35
Building and construction	18	30	48
Manufacturing industries	67	72	139
Commerce and trade	54	91	145
Transport and communications	34	61	95
Public administration	28	44	72
Professional services	130	200	330
Other	45	63	108
Total	391	581	972

Industry	Share of workforce (%)		
	Cill Aithnín	An Spidéal	Na Forbacha
Agriculture, forestry and fishing	3.8	3.4	3.6
Building and construction	4.6	5.2	4.9
Manufacturing industries	17.1	12.4	14.3
Commerce and trade	13.8	15.7	14.9
Transport and communications	8.7	10.5	9.8
Public administration	7.2	7.6	7.4
Professional services	33.2	34.4	34.0
Other	11.5	10.8	11.1
Total	100.0	100.0	100.0

5.3.2. Impact of the development

5.3.2.1. Installation phase

The test site is already well established with no additional proposals for land based components therefore there will be no impact on employment due to the installation of the site.

5.3.2.2. Operational phase

The expected operational lifetime of the test site is 35 years. During the operational phase of the site energy production and testing devices will be deployed typically for 2 to 18 months. The devices require installation as well as regular monitoring and maintenance which will bring device development teams to the area. There will be an increase in visits to the area which will promote economic activity in the local hotel and catering industries.

Workboats and marine contractors will be needed to assist the installation, monitoring and maintenance of the test devices and smaller sensors that will be deployed on the site. There are two main ports from which the devices can be deployed; the port of Rossaveel (Ros a' Mhil) located 20km to west of the site and the port of Galway located 15km east of the site. Smaller work boats would be able to mobilise/demobilise from the new pier in Spiddal. Maintenance of the assorted oceanographic equipment, sensors and instruments will require regular service visits. Frequent promotional visits to the test site will also be required.

The site will also be used by universities and industry for research projects. Due to the fact that the test site concerns an area of energy production that is in its infancy, there is the potential that the area could become a hub for ocean energy development and research in Ireland. Long term employment opportunities will be associated with the operational phase of the development and overall long term positive impact on employment is expected with economic benefits to the Spiddal / Furbo area, including supplementing existing incomes and generating new employment opportunities.

5.3.3. Mitigation measures

Local employment opportunities should be identified and local businesses should be encouraged to avail of any opportunities that arise in the project. The Marine Institute will work with Udaras na Gaeltachta to maximise long term benefits for the region.

5.3.4. Conclusion

There are no significant negative impacts of the proposed project on the populations that live and work in the area. On the contrary, the ocean energy test site is expected to stimulate the local economy and contribute to the vitality of the local community.

5.4. Traffic

Some foreshore developments can lead to congestion of the local road network during operational and decommissioning phases. The Galway Bay Marine and Renewable Energy Test Site is located 1.5 km from the nearest shore point. No part of the development will be on land.

5.4.1. Impact of the development

The Galway Bay Marine and Renewable Energy Test Site will have no landside components. The test site will have negligible impact on traffic or transport in the area. During the operational phase of the test site, traffic to the new pier in Spiddal will also be very low in volume with an estimated two to four vehicles per week using these facilities when devices and projects are using the test site. During the decommissioning phase of a device, there is likely to be a minor increase in use of the new pier at Spiddal for short periods.

5.4.2. Mitigation

Although there is predicted to be negligible impact of this development on local traffic movement, the local access road to the new pier in Spiddal should be maintained in good condition (Figure 5-3).

5.4.3. Conclusion

There are no significant impacts of the proposed project on local traffic movement.

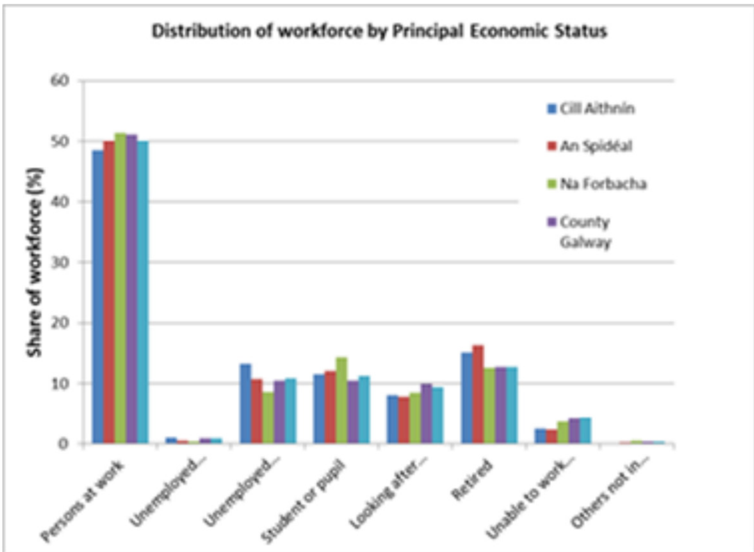

Figure 5-1: Distribution of working age persons 2011

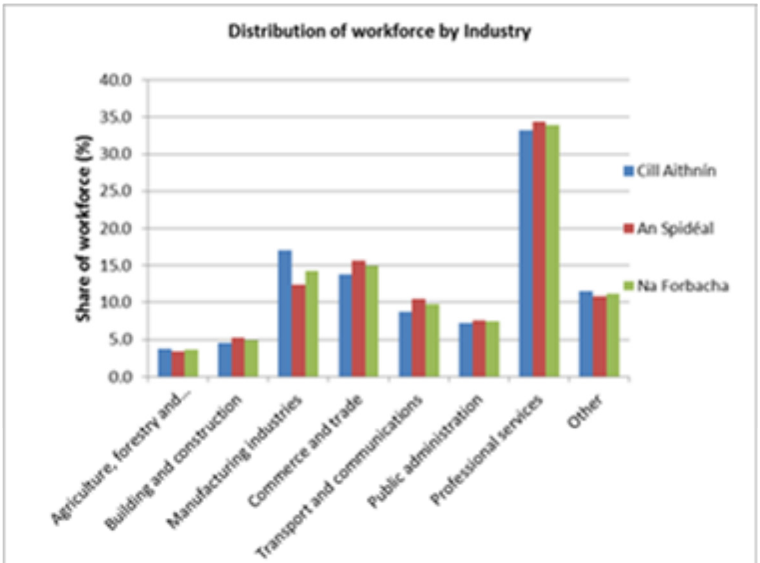

Figure 5-2: Distribution of persons working in the immediate area by industry

Figure 5-3: View down local access road to new pier in Spiddal.

6. Flora and Fauna

6.1. Introduction

Baseline ecological assessments and the consideration of potential impacts of the development of the Galway Bay Marine and Renewable Energy Test Site were conducted between 2010 and 2015 by Aquafact International Services Ltd, Galway Mayo Institute of Technology and NERC Sea Mammal Research Unit.

Ecological assessments included surveys of the following:

- Subtidal benthos at the site;
- Use of the site by marine mammals;
- Use of the site and environs by birds;
- Presence of seals at the site and environs;

The reports for all ecological assessments are available in Appendix 3, Appendix 4 & Appendix 5. This section presents a summary of each of the habitats surveyed and the potential impacts of the Marine and Renewable Energy Test Site (MaRETS) on those habitats.

6.2. Benthic habitats

6.2.1. Approach and methodology

In September 2010, Aquafact completed a marine environmental appraisal of the existing test site, on behalf of Hydraulics and Maritime Research Centre, UCC. They sampled a total of 6 stations; 5 stations within the existing test-site lease area and one control station approximately 650m south of the test-site (Figure 6-1). The full report is available in Appendix 3.

Stations were located using DGPS. Two replicate benthic samples were collected using a $0.1m^2$ Day Grab. Data on each sample, e.g. station number, date, time, depth of sediment, surface features and visible macrofauna were logged in a field notebook. The faunal returns were sieved on a 1mm mesh sieve, stained with Rhodamine dye, fixed with 10% buffered formalin and preserved in 70% alcohol. Samples were then sorted under a microscope (x 10 magnification), into four main groups: Polychaeta, Mollusca, Crustacea and others. The 'others' group consisted of echinoderms, nematodes, nemerteans, cnidarians and other lesser phyla. The taxa were then identified to species level where possible.

An additional sample was taken at each station and used for sediment granulometric analyses. The sediment samples were taken through the opening on the top of the grab. All samples were stored immediately in a cold room on board the vessel and were frozen at – 20^oC on return to the lab.

Particle size analysis was carried out by dry sieving approximately 100g of sediment using a series of Wentworth graded sieves. The sediment retained on each sieve was later weighed and calculated as a percentage of the total. Aquafact provided underwater photographs of the sea floor at the test site. These included photographs of the seafloor and mooring chains and sediment profile imagery.

6.2.2. Receiving environment

The test site is located c. 1.5km from Spiddal in Galway Bay. Water depths at the test site range between 21 and 25m. The mean bottom current speed at the test site is 9cm/s with a maximum speed of 34cm/s (Marine Institute, 2013). Current speed throughout the water column average 10cm/s with a maximum estimated at 33cm/s. Very fine to fine sand dominates at the site with c. 10% silt-clay (AQUAFACT, 2010).

Taxonomic identification of the benthic infauna across all 6 stations sampled in the ocean energy test site in inner Galway Bay yielded a total count of 117 species accounting for 1,746 individuals, ascribed to 7 phyla. Of the 117 species enumerated, 56 were polychaetes (segmented worms), 31 were crustaceans (crabs, shrimps, prawns), 18 were molluscs (mussels, cockles, snails etc.), 6 species were echinoderms (brittlestars, sea cucumbers), 2 species were cnidarians (sea anemones, corals), 2 species were sipunculids (peanut worms) and 1 species was a phoronid (horseshoe worm).

The dominant species from this survey were the polychaetes *Tharyx sp., Scalibregma inflatum, Spiophanes kroyeri, Glycera alba, Spiochaetopterus typicus, Chaetozone setosa*, the amphipod *Photis longicaudata* and the molluscs *Thyasira flexuosa* and *Phaxas pellucidus*. Species richness and evenness was high at each station.

Sediment Profiling Images indicated a healthy stage community present at the site with both infaunal and epibenthic (decapods) species reworking and oxygenating the upper *ca* 15 cms of sediment to such a degree that no discontinuity in oxygen levels were noted on any of the images collected.

Table 6-1: Benthic diversity of test site (AQUAFACT, 2010)

Station number	Sediment type	Species	Individuals	Richness	Evenness	Diversity
1	Slightly Gravelly Muddy Sand	60	358	10.03	0.87	5.12
2	Muddy Sand	59	295	10.2	0.88	5.17
3	Muddy Sand	51	192	9.51	0.89	5.08
4	Muddy Sand	51	296	8.79	0.89	5.04
5	Sand	49	216	8.93	0.89	4.98
6	Slightly Gravelly Sand	59	389	9.73	0.88	5.2

Species richness is a measure of the total number of species present for a given number of individuals. Evenness is a measure of how evenly the individuals are distributed among different species. The diversity index incorporates both of these parameters. Richness ranges from 0 (low richness) to 12 (high richness), evenness ranges from 0 (low evenness) to 1 (high evenness), diversity ranges from 0 (low diversity) to 5 (high diversity). Table 6-1 presents the benthic diversity.

The results of the statistical analyses indicate a high level of similarity between the sampled locations and suggest that there has been no noticeable change in benthic fauna within the site.

The SPI images were taken within the location where the ocean energy device had been deployed and were uniform in many respects. The sediment was found to be a fine, muddy sand with well bioturbated sediments giving rise to deep redox layers throughout the site. Where present, surface boundary roughness was biologically-generated. These images indicated a biologically active benthos with a Stage III community present.

All of the species present are typical of the area. No rare, sensitive or unusual species were recorded. This appraisal established baseline benthic fauna present at the test site and found a high level of similarity between the sampled locations and the results of a benthic faunal study carried out by O'Connor & McGrath (1981), suggesting that there has been no noticeable changes in benthic fauna in this area since the establishment of the original test site in 2006.

6.3. Marine mammals

Irish waters have a rich diversity of marine mammals. 24 species of whales and dolphins have been recorded around various parts of the coast. Under Article 12 of the EU Habitats Directive, all cetaceans occurring in the Irish Exclusive Economic Zone (EEZ) are strictly protected. Under Article 4, cSACs must be proposed for the protection of Bottlenose Dolphins, Harbour Porpoises, Common and Grey Seals. National Parks and Wildlife Service (NPWS) have also developed codes of practice for protecting marine mammals during acoustic seafloor surveys in Irish waters.

The Galway Bay Complex SAC (000268) comprises a diverse range of marine, coastal and terrestrial habitats and includes some of the best examples of shallow bays, reefs, lagoons and salt marshes in the country (Galway Bay Complex, Site Synopsis, www.npws.ie). The site supports an important common seal colony and a breeding otter population, both of which are listed under Annex II of the EU Habitats Directive but no cetacean species are listed as qualifying interests of the site.

Historically, cetacean species recorded visually in Galway Bay include: Bottlenose dolphin *Tursiops truncates*, Harbour Porpoise *Phocoena phocoena*, Common dolphin *Delphinus delphis*, Killer whale, Minke whale, Pilot whale *Globiocephala melas*, Risso's dolphin

Grampus griseus, Sperm whale *Physeter microcephalus* and false killer whale *Pseudorca crassidens*,

The additional species recorded as strandings include Atlantic white-sided dolphin, Cuvier's beaked whale, Fin whale, Humpback whale, Northern bottle nose whale, Pygmy sperm whale, Sowerby's beaked whale, Striped dolphin and Trues beaked whale. There are limitations associated with strandings data, as it may be that the animals washed up originated outside of the study area, and therefore provide false data on the presence of certain species in an area.

Several species of cetaceans are known to breed in Irish waters including the harbour porpoise, common dolphin, bottlenose dolphin, Risso's dolphin.

6.3.1. Approach and methodology

The presence of seals and cetaceans (whales, dolphins and harbour porpoises) was assessed as part of on-going research activity at the test site. Marine Mammal surveys were conducted using both land-based and at-sea survey methods.

6.3.1.1. Seals

The Sea Mammal Research Unit (SMRU) carried out surveys of harbour seals by helicopter using a thermal imaging camera (Appendix 4), following the standard SMRU survey protocol:

- Surveys were restricted to within two hours either side of low tides occurring between approximately 12:30 and 19:30;
- Surveys were restricted to the harbour seal moult season;
- There was no surveying on days with moderate or persistent rainfall;
- The footage obtained by the thermal imaging camera was recorded to a digital video recorder and groups of hauled-out seals were reviewed and recounted on a computer at SMRU's base at the Scottish Oceans Institute in St Andrews, UK;
- High resolution digital still photographs were taken of almost all groups of harbour seals and grey seals recorded ashore, in order to improve the accuracy of counts and to confirm species identification;
- A detailed track of each day's progress was recorded on a GPS unit. This enabled the placement of capture locations for the high-resolution digital images onto the survey track. Combining this with an accurate low-water GIS map of Ireland and viewing detailed satellite imagery of the Irish coast, enabled accurate positioning of all groups of seals encountered.

6.3.1.2. Cetaceans

O'Brien (2013) undertook a review of 'Cetacean presence at the Ocean Energy Test Site Spiddal: as determined through land-based visual monitoring and static acoustic monitoring using PODS.' The full report is available in Appendix 5

Archived visual and acoustic datasets held at the Galway-Mayo Institute of Technology (GMIT) were accessed as well as data from the PReCAST project 2009-2010 (O'Brien et al., 2012) to meet Foreshore Licence Unit requirements.

Monthly dedicated land-based visual surveying was carried out from Spiddal Pier to monitor the seasonal occurrence, distribution and abundance of cetacean species in the vicinity, between March 2005 and May 2007.

Static Acoustic monitoring (SAM) instruments (T-Pod and C-Pod) were deployed on the test site for two phases of monitoring, 2006-2007 and 2009-2010.

The SAM datasets from the test site are the longest recorded in Ireland with c.900 days monitored across all studies. The report sets out how all data were collected and explores the distribution and occurrence of small cetaceans at the test site. Such information will inform managers when are suitable times to target works in the area to ensure disturbance is mitigated against and kept to a minimum.

6.3.2. Receiving environment

6.3.2.1. Seals

Two species of seal commonly occur in Irish waters, the harbour seal *Phoca vitulina* and the grey seal *Halichoerus grypus*. Both species have established haul-out sites along the shores in various bays and inlets and on rock outcrops and small islands. The local seal populations forage for fish locally and are thought to move extensively between areas. They usually return to the haul-out sites to breed and rear their pups. The harbour seals are found more in sheltered bays and inlets whereas the grey seals are located on exposed rocky shores and steeply shelving sandbanks. Both harbour seals and grey seals are protected species under the Wildlife (Amendment Act 1976 - 2005) and Annex II of the EU Habitats Directive.

In Inner Galway Bay, much of the harbour seal population occur on the south shore with haul-out sites located around Tawin, Island Eddy, Kinvara Bay and Deer Island (Figure 6-2). Very few seal haul-out sites occur along the exposed north shore of Inner Galway Bay and are not known to occur in the Spiddal area. The species is present throughout the year during all aspects of its annual life cycle, which includes breeding (May to July approx.), moulting (August to September approx.) and non-breeding foraging and resting phases. The most recent survey in Galway Bay recorded 130 individuals hauled out in Kinvara Bay and 159 individuals in Oranmore Bay (NPWS, 2012). In 2003, an all-Ireland aerial survey of seal populations found that 17% of all harbour seals occurred in Co. Galway with up to 62 haul-out sights being observed throughout the region (Cronin *et al*., 2004).

The grey seal *Halichoerus grypus* does occur in Galway bay. They were recorded breeding on Deer Island and Farthing Rock in the 2005 population assessment (O'Cadhla *et al*.,

2007) however no individuals were record in the 2007 moult survey (O'Cadhla & Strong, 2007). These locations can be seen in Figure 6-2.

In August 2011 and August 2012 the Sea Mammal Research Unit (SMRU) of the University of St. Andrews carried out aerial surveys of seal populations in the north and north-west of Ireland. SMRU was previously involved in a similar survey in August 2003. Comparison of harbour seal numbers between the 2003 and 2011/12 surveys showed increases in population numbers for Galway Bay North (2003 – 49, 2011 – 55), Inner Galway Bay (2003 – 200, 2012 – 221), and Aran Islands (2003 – 39, 2012 – 53). This report is included as Appendix 4.

6.3.2.2. Cetaceans

A total of 28 dedicated land-based visual watches were carried out from Spiddal Pier (2700 minutes/45 hours) between March 2005 and February 2007 (O'Brien, 2013). Cetaceans were recorded during 10 of the 27 watches (37%). A total of 16 sighting were recorded during watches comprising of three species; including, harbour porpoise (81%), bottlenose dolphin (13%) and Minke whale (7%).

All sightings recorded were within a 5km radius of Spiddal pier. Most sightings (75%) were recorded between the months June to December with only 25% of sightings recorded in the period January to May, highlighting mid-summer through to December as the months when porpoises are most active at the site (Figure 6-3). These results are similar to results from SAM 1 and SAM 2 (see below for Static Acoustic Monitoring results). However, when data is compared to other sites in the bay, Spiddal isn't the most important (O'Brien, 2013).

Table 6-2 Calculations of harbour porpoise relative abundance from Black Head, Spiddal and Fanore, 2005-2007 (O'Brien, 2013).

Site	No.of watches	No. of watches when HP recorded	%	Total no. of HP	Relative abundance (harbour porpoises hour^{-1})
Black Head	31	18	58	110	2.12 hr^{-1}
Spiddal	28	8	29	32.5	0.69 hr^{-1}
Fanore	29	10	36	38.5	0.79 hr^{-1}

Harbour porpoises were detected on average during 88% of days monitored at Spiddal, while dolphin detections were only recorded 3% of the time. The highest number of harbour porpoise was recorded from Spiddal in October, 2006.

Research by O'Brien (2010) at the test site indicated that the OE platform did not influence harbour porpoise presence.

The aim of the study conducted by O'Brien (2013) was to compile archived data from available sources and to explore the presence of small cetaceans in the vicinity of the OE Test Site, east of Spiddal on the north shore of Galway Bay. These results were taken from O'Brien (2009) and from the PReCAST project designed to address a wide range of issues and will contribute to developing policy advice on meeting Irelands' statutory obligations (O'Brien *et al., (*2012).

Table 6-3 Detection Details from T-POD Deployments at Spiddal (O'Brien, 2013).

Details				Porpoise detections		Dolphin detections	
Year	Location	Month	No. days deployed	% of days with porpoise detections	Total PPM	% of days with dolphin detections	Total DPM
2006	Spiddal	May	20	100	241	5	1
	Spiddal	June	17	94	165	0	0
	Spiddal	July	28	100	271	4	1
	Spiddal	August	17	94	129	6	1
	Spiddal	October	29	97	1001	0	0
	Spiddal	November	31	100	637	5	1
	Spiddal	December	23	100	265	0	0
2007	Spiddal	February	28	43	22	0	0
	Spiddal	March	26	58	50	4	1
	Spiddal	April	19	100	179	0	0
	Spiddal	May	31	97	373	0	0
	Spiddal	June	19	100	136	0	0
	Spiddal	July	10	100	102	0	23
	Spiddal	September	30	73	104	7	2
	Spiddal	October	5	80	16	0	0

Results from visual and acoustic monitoring are very similar as all show that autumn and winter months are when porpoises are most active at the site. Visual data shows that in comparison with other sites in the bay subjected to land-based watches, Spiddal is not the most important, with a greater relative abundance recorded from Black Head on the south shore.

Porpoises are present at the site on an almost daily basis, 88% of days (total 333 days) using T-PODs and on 95% of days (total 572 days) using C-PODs. This information was gathered independent of weather conditions and darkness but is limited due to lack of information on abundance. Galway Bay supports an important population of harbour porpoise (Berrow *et al.,* 2008), with an adult to calf ratio similar to other sites around Ireland. Through SAM further valuable information can be gathered on how animals use a monitored site by looking for behaviour characteristics in the dataset. Behavioural analyses from Spiddal show that porpoises are found to occur in all months but spring was found to have the lowest number of detections.

Additionally exploring the train characteristics of porpoises at the site show it to be regularly used as a feeding location (41% (60,386 trains) of the total click trains fell under the category foraging), especially during the winter months during night-time hours.

It is important to note that during the C-POD study 2009-2010, a wave energy device was in place at the OE Test Site and hence facilitated an experiment under the PReCAST programmed to determine if this artificial structure had an impact on presence.

Results failed to show a significant difference in detections between sites suggesting the OE platform did not influence harbour porpoise presence.

Clearly the area at Spiddal is an important habitat for the Harbour porpoise with the almost daily presence at the site. This presence is influenced by seasonal, diel and tidal factors. As harbour porpoises (Annex II species of the Habitats Directive) are present throughout the year and entitled to strict habitat protection, care must be taken to ensure this development does not degrade this habitat or cause undue disturbance.

6.4. Avifauna

For the purposes of assessing the bird populations in the environs of the Marine and Renewable Energy Test Site (MaRETS), the study site area encompassed the wider Galway Bay area. MaRETS does not overlap with any designated sites of European importance (i.e. SPA or cSAC) or of National importance (i.e. NHA). SPAs are specifically designated for the protection of birds.

Within 15km of the test site, there are SPAs designated under the EU Birds Directive (Inner Galway Bay, Lough Corrib and Connemara Bog Complex) (Figure 6-5). These sites and their QIs/SCIs which have the potential to be impacted are listed below:

- Inner Galway Bay SPA (IE004031): A003 Great northern diver (*Gavia immer*), A017 Cormorant (*Phalacrocorax carbo*), A069 Red-breasted merganser (*Mergus serrator*), A179 Black-headed gull (*Chroicocephalus ridibundus*), A182 Common gull (*Larus canus*), A191 Sandwich tern (*Sterna sandvicensis*) and A193 Common tern (*Sterna hirundo*);
- Lough Corrib SPA (IE004042): A179 Black-headed gull (*Chroicocephalus ridibundus*), A182 Common gull (*Larus canus*), A194 Arctic tern (*Sterna paradisaea*)
- Connemara Bog Complex SPA (004181): A191 Sandwich tern (*Sterna sandvicensis*) and A193 Common tern (*Sterna hirundo*): A017 Cormorant (*Phalacrocorax carbo*) and A182 Common gull (*Larus canus*).

6.4.1. Approach and methodology

AquaFact (2015) undertook Appropriate Assessment Stage I Screening under Article 6(3) of the EU Habitats Directive (92/43/EEC), of potential impacts the proposed Galway Bay Marine and Renewable Energy Test Site could have on birds in general and more specifically on the avian conservation interests of Natura 2000 sites within 15 km of the site. This report is included as Appendix 6.

6.4.2. Receiving environment

6.4.2.1. Inner Galway Bay SPA (IE004031)

The Inner Galway Bay SPA is located in the inner, shallow part of a large bay of Galway Bay. It overlaps closely the cSAC. Galway Bay is one of the most important ornithological sites in the western region (NPWS, 2005). It supports an excellent diversity of wintering wetland birds, with divers, grebes, cormorants, dabbling duck, sea duck and waders all well represented. There are internationally important wintering populations of great northern diver (83) and Brent goose (676), and nationally important populations of an additional sixteen species, i.e. black-throated diver (25), cormorant (266), mute swan (150), wigeon (1,157), teal (690), shoveler (88), red-breasted merganser (249), ringed plover (335), golden plover (2,030), lapwing (3,969), dunlin (2,149), bar-tailed godwit (447), curlew (697), redshank (505), greenshank (20) and turnstone (182) – all figures are average peaks for the 5 seasons 1995/96-1999/00.Of note is that the populations of red-breasted merganser and ringed plover represent 6.7% and 3.3% of the respective national totals. Black-throated diver is a scarce species in Ireland and the Galway Bay population is the most regular in the country. Other species which occur in notable numbers include little grebe (35), grey heron (102), long-tailed guck (19) and scaup (40). The bay is an important wintering site for gulls, especially black-headed gull (1,815), common gull (1,011) and herring gull (216). In addition, the following species also use the site: red-throated diver (13), great crested grebe (16), mallard (200), shelduck (139), common scoter (79), oystercatcher (575), grey plover (60), black-tailed godwit (45) and great black-backed gull (124). The site provides both feeding and roost sites for most of the species, though some birds also commute to areas outside of the site. The wintering birds of Galway Bay have been monitored annually since 1980/81. The site has several important populations of breeding birds, most notably colonies of sandwich tern (81 pairs in 1995) and common tern (99 pairs in 1995). A large cormorant colony occurs on Deer Island – this had 205 pairs in 1985 and 300 pairs in 1989.

The SCIs of relevance to this assessment are the great northern diver, cormorant, red-breasted merganser, black-headed gull, common gull, sandwich tern and common tern.

6.4.2.2. Lough Corrib SPA (IE004042)

The Lough Corrib SPA overlaps part of the Lough Corrib cSAC. Lough Corrib is of international importance for wintering pochard (10,182) - all figures are average peaks for the 5 seasons 1995/96-1999/00 (NPWS, 2004). It is one of the top five sites in the country for wintering waterfowl and also qualifies for international importance because it regularly supports well in excess of 20,000 waterfowl. It is the most important site in the country for pochard, tufted duck (5,521) and coot (14,473), supporting 21%, 46% and 13% of the respective national totals. It also has nationally important populations of wintering mute swan (182), gadwall (48), shoveler (90), golden plover (1,727) and lapwing (2,424). The lake is a traditional site for Greenland white-fronted goose (62).

Relatively small numbers of whooper swan (35) occur, along with wigeon (528), teal (77), mallard (155), goldeneye (74), curlew (114) and cormorant (36). Lough Corrib is a traditional breeding site for gulls and terns, with various islands being used for nesting each year. There are important colonies of common tern (37 pairs in 1995) and Arctic terns (60 pairs in 1995), both populations being of national importance. The site supports substantial colonies of black-headed gull (856 individuals in 1999) and common gull (181 pairs in 1999), these representing 11% and 17% of the respective national totals. Lesser black-backed gull (51 individuals in 1999) and great black-backed gull (16 individuals in 1999) also breed, with a few pairs of herring gull. Considerably higher numbers of breeding gulls occurred in the recent past, as shown by surveys in 1977 and 1993; the reasons for the continued declines are, however, not fully known. Whilst only colonised in the 1970/80s by nesting common scoter, Lough Corrib now supports approximately half of the national population of this rare duck, a Red Data Book species. The population has been stable since the mid-1990s, with 36 pairs recorded in the most recent survey in 1999.

The SCIs of relevance to this assessment are the black-headed gull, common gull, Arctic tern and common tern.

6.4.2.3. Connemara Bog Complex SPA (IE004181)

The Connemara Bog Complex SPA is a large site encompassing much of the south Connemara lowlands of Co. Galway (NPWS, 2010). The site consists of three separate areas - north of Roundstone, south of Recess and north-west of Spiddal. It is underlain predominantly by a variety of igneous and metamorphic rocks including granite, schist, gneiss and gabbro. The whole area was glaciated during the last Ice Age which scoured the lowlands of Connemara. The Connemara Bog Complex SPA is characterised by areas of deep peat surrounded by heath-covered rocky outcrops. The deeper peat areas are often bordered by river systems and the many oligotrophic lakes that occur, resulting in an intricate mosaic of various peatland/wetland habitats and vegetation communities; these include Atlantic blanket bog with hummock/hollow systems, inter-connecting pools, Atlantic blanket bog pools, flushes, transition and quaking mires, as well as freshwater marshes, lakeshore, lake and river systems. The site is a Special Protection Area (SPA) under the E.U. Birds Directive, of special conservation interest for the following species: Cormorant, Merlin, Golden Plover and Common Gull. It is also of note for the regularly occurring species, Greenland White-fronted Goose.

The SCIs of relevance to this assessment are the cormorant and common gull.

6.4.2.4. General Marine Environment

Key species that are common to the rocky coastline in the Spiddal – Furbo region are gulls (Black-headed Gull, Common Gull and Herring Gull), waders (Oystercatchers, Curlew, Redshank and Turnstone) and fish eating species such as Grey Heron and Cormorant (O'Donoghue, 2011). Duck such as Mallard are also recorded with Great Northern Diver and Common Scoter occurring more offshore. Rock pipit and Pied Wagtail are likely to be found along the shoreline as well as migrating Whimbrel en route to other parts of Ireland. Where the shore line is more varied, species such as Dunlin, Bar-tailed Godwit, Ringed Plover and Sanderling may occur. Along the proposed cable route to the south and east of Spiddal, the most notable species observed were Cormorant, Oystercatcher, Redshank, Herring Gull and Black-header Gull. No notable aggregations of Great Northern Diver were present. Unlike muddy estuaries, the number of birds found along rocky shorelines such as Spiddal and Furbo are low and well dispersed, concentrating in small numbers where suitable habitats occur. Fully marine species such as gannet, storm petrel, fulmar, common shearwater, sooty shearwater, auks and skuas are also present at the site.

6.5. Impact of the development

The impacts of the Galway Bay Marine and Renewable Energy Test Site can arise in two ways:

- Installation of foundations to support the devices and the actual installation of the devices, sensors and equipment; and
- Operational impacts arising from the working devices, sensors or equipment interacting with the environment.

6.5.1. Flora and Fauna Worst Case Scenario

The impacts of the Galway Bay Marine and Renewable Energy Test Site project have been assessed under the following worst case scenario deployment of items at the test site in Table 6-4.

Table 6-4: Flora and Fauna worst case scenario

Permanent	Recurring	Devices
4 x cardinal marks	Data buoy	1 x OWC
Subsea observatory	Acoustic Array	1 x Point Absorber
Waverider	ADCP	1 x Floating Wind Turbine
SeaStation	Cabling	1 x Tidal Turbine
9 x gravity bases		

6.5.2. Installation

The vast majority of devices will require anchorage to the seafloor. Some will be anchored under their own weight (CEE Frame), some will require a gravity base (e.g. oscillating wave surge and pressure differential devices) and some will simply require clump weights or anchors (e.g. SeaStation, SmartBay data buoy). Devices anchored under their own weight, clump weights and anchors will be lowered to the seafloor from a service vessel. The gravity foundation will consist of either individual 9 tonne frames or a series of interlocking 9 tonne frames which will be lowered to the seabed from a support vessel.

6.5.2.1. Direct Physical Disturbance to the Seafloor

The lowering of objects to the seafloor will result in the **disturbance of natural sediments** on the seafloor and temporarily resuspend them; and a **loss of substratum and disturbance to species** in the installation area.

When sediments get resuspended, the coarser fraction of the disturbed sediment tends to settle out close to the works but can remain mobile. The fine material tends to disperse widely at high energy sites and eventually settle out over wide areas.

The direct impacts from the loss of substratum and disturbance to species will include localised mortality or displacement of species where objects come into direct contact with the sediment. Any potential damage to the benthos and disruption of sediment locally could lead to changes in invertebrate fauna and fish stocks which may reduce food availability for birds at least in the short term (BirdLife International, 2003).

6.5.2.2. Contamination during Installation Works

Installation works have the potential to release contaminants into the water column if the sediments in the installation area are historically contaminated. Sediments can build up contaminants over time from industrial or domestic waste, radionuclides, munitions etc. While impacts on water quality would most likely be temporary, depending on the type and amount of material released, potential contaminants could be dispersed over a much wider area and persist within the environment .

6.5.2.3. Suspended Sediments

The lowering of any object (clump weight, anchor, CEE frame, gravity base, mooring chains/ropes, jack-up rig etc.) on to the fine muddy sand seafloor of the test site will result in the **temporary resuspension of particulate materials.**

Indirect impacts include **smothering and increased suspended sediment and turbidity**. The smothering of sensitive benthic species, fish spawning habitat and shellfish habitat can occur due to the subsequent settlement of the resuspended sediments. Increased suspended sediment and turbidity levels can impact on sensitive filter feeding organisms such as king and queen scallop, cockles and mussels. Fine particles can travel great distances from the disturbed area due to tidal currents and depending on the quantities of remobilised sediments this impact could be widespread. Increased turbidity could affect the foraging and predator/prey interactions of birds due to reduced visibility. In addition, herring, sprat, grey and common seals are sensitive to reduced visibility.

6.5.2.4. Noise

Noise sources during the installation works will be confined to that generated by the installation vessels. Vessel noise is a combination of tonal sounds at specific frequencies (e.g. propeller blade rotational frequency and its harmonics) and broadband noise (Vella *et al*., 2001). Propeller cavitation noise is the primary source of sound from underway vessels, whilst noise from propulsion machinery originates inside a vessel and reaches the water via the vessel hull. Noise from shipping is roughly related to vessel size: larger ships have larger, slower rotating propellers, which produce louder, lower frequency sounds (SMRU, 2001).

Overall, vessel noise covers a wide range of frequencies from 10Hz to 10kHz. Source levels and dominant frequencies range from 152 dB re 1 µPa@1m at 6300Hz for a 5m Zodiac with offboard motor, through 162dB re 1 µPa@1m at 630Hz for a tug/barge traveling at 18km/hr, through to a large tanker with source level around 177dB re 1 µPa@1m in the 100Hz third octave band (Richardson *et al*., 1995). The use of bow thrusters increases broadband sound levels.

Birds

Diving birds could also be affected by shipping noise causing them to become disorientated and affecting their foraging success (AECOM Ltd., 2010). Effects on surface feeding birds are likely to take the form of disturbance effects. This could cause birds to temporarily avoid the immediate area which may have implications for foraging and breeding success, stress on individuals and energy budgets.

Cetaceans & Pinnipeds

Marine mammals use acoustics to navigate, locate prey and maintain social contact and as a result they are very sensitive to anthropogenic noise. Underwater hearing sensitivity in harbour seals indicates a fairly flat frequency response between 1kHz and about 50 kHz, with hearing threshold between 60 and 85 dB re 1 µPa (Richardson *et al.,* 1995). Toothed whales are most sensitive to sounds above about 10 kHz and below this sensitivity deteriorates. Harbour porpoises exhibit a very wide hearing range with relatively high hearing thresholds of 92 – 115 dBrms re 1 µPa below 1 kHz, good hearing with thresholds of 60 – 80 dBrms re 1µPa between 1 and 8 kHz, and excellent hearing abilities with thresholds of 32 – 46 dBrms re 1 µPa from 16 – 140 kHz (Kastelein *et al*., 2002). Behavioural audiograms for the bottlenose dolphin (Johnson, 1967; Ljungblad *et al.,* 1982; Au, 1993) indicate that hearing ranges from approximately 75Hz to 150kHz with the best sensitivity between 10kHz to 60kHz. It is assumed that baleen whales are sensitive to sound of low and medium frequencies because they predominantly emit low frequency sounds, primarily at frequencies below 1 kHz and in many cases predominantly infrasonic sounds (Richardson *et al.,* 1995).

In essence, cetaceans and pinnipeds have the ability to detect ship noise and it may elicit a temporary avoidance behaviour for some of the more sensitive species (larger baleen whales) whereas many toothed whales appeared to be tolerant of vessel noise and are regularly observed in areas where there is heavy traffic (Thomsen *et al.,* 2006). Seals hauled out on land may also be disturbed by the presence of installation vessels. In general, ships more than 1,500m away from hauled out grey or common seals are unlikely to evoke any reactions from seals, between 900 and 1,500m seals could be expected to detect the presence of vessels and at closer than 900m a flight reaction could be expected (Brasseur & Reijnders, 1994). These impacts would be most significant if they occurred during the sensitive breeding and moulting seasons. Breeding seals if disturbed could exhibit flight reactions and temporarily abandon their young and moulting seals maybe scared into the water and may lose condition as a result of additional energetic costs (AECOM Ltd., 2010). Disturbance of otters could also occur should maintenance works occur close to the coastal areas where they are present (AECOM Ltd., 2010).

6.5.2.5. Installation Vessels and Equipment

There is a risk of marine birds, seals, cetaceans and turtles colliding with installation machinery and vessels during the installation phase.

Birds
While birds are generally more manoeuvrable than marine mammals they are at **risk of colliding** with vessels especially at night (AECOM Ltd., 2010). Birds can typically collide with surface structures of ships or the ships can collide with birds rafting on the surface. The physical presence of vessels and installation equipment can have a temporary **disturbance effect** on birds due to physical and visual intrusion. This could cause birds to avoid the immediate area which may have implications for foraging and breeding success, stress on individuals and energy budgets.

Mammals
Shipping **collision** is a recognised cause of marine mammal mortality worldwide and the major factors influencing injury or mortality are vessel size and speed. In addition there is always a risk of corkscrew injuries to marine mammals from vessel propellers.

Seals hauled out on land may be **disturbed** by the presence of installation vessels and equipment. In general, ships more than 1,500m away from hauled out grey or common seals are unlikely to evoke any reactions from seals, between 900 and 1,500m seals could be expected to detect the presence of vessels and at closer than 900m a flight reaction could be expected (Brasseur & Reijnders, 1994). These impacts would be most significant if they occurred during the sensitive breeding and moulting seasons. Common seals moult from August to September and breed from May to July and grey seals moult from November to April and breed from late August to December. Breeding seals if disturbed could exhibit flight reactions and temporarily abandon their young and moulting seals maybe scared into the water and may lose condition as a result of additional energetic costs (AECOM Ltd., 2010). Physical disturbance of otters could also occur should disturbing works occur close to the coastal areas where they are present (AECOM Ltd., 2010).

6.5.2.6. Accidental Events

There is the potential of accidental pollution events from service and support vessels required during the installation works. These vessels will have fuel tanks and hydraulic systems for cranes and winches. These pollution events could include the release of fuel and lubricating oil, cleaning fluids, paints, specialised chemicals and litter. Any potential spillages could impact water quality and contaminate seabed sediments.

6.5.3. Operation

The impacts of the operational phase of the test site are confined to the physical presence of the devices, equipment, infrastructure and cables within the site, either on the seabed, in the water column or at the surface. The operation of the devices and associated equipment may generate noise, EMF fields and heat and may impact on hydrodynamics and sediment processes.

In addition to the permanent equipment that will be deployed in the site (4 cardinal markers, waverider, SeaStation and CEE frame with associated sensors, hydrophone, acoustic receiver, HDTV camera and underwater light), the site has a capacity to hold 3 energy converters which will be connected to the SeaStation.

6.5.3.1. Physical Presence

Sediment transport pathways could also be impacted in the immediate vicinity of devices or foundations and **sediment accretion or erosion (scour) of the sediment** could occur. ABPmer (2002) have estimated the extent of scour to be between 6-10 times the tower diameter. The scouring of sediments could have impacts on the existing benthic communities at the site as the fine sediments will be transported away leaving behind coarser sediments which can be recolonised by a different group of species not found in the fine sedimentary communities. The recolonisation can modify and consolidate the sediment making it suitable for further recolonisation success.

The physical presence of devices, gravity bases, clump weights and anchors on the seabed (or scouring associated with structures fixed to the seabed) will result in a **direct loss of benthic habitat and sessile species** in the footprint of the infrastructure. This can also result in a loss of suitable substratum (particularly for benthic spawners) and foraging ground for birds and mammals.

This infrastructure will also **introduce a hard substrate** to the sedimentary environment of the test site. This hard substrata will be available to benthic algae, invertebrates and fish and could encourage the establishment of a community of rocky reef fish and invertebrates (including biofouling species) that would not normally exist at the site. The impact of this can be seen as positive in that biodiversity, food availability and foraging opportunities for fish, shellfish, birds and mammals is increased, however the introduction of exotic benthic species or fouling communities could have a negative impact in that these communities differ significantly from the surrounding soft bottom community.

Birds are also at risk of collision particularly with wind turbine towers and blades. The risk depends on a number of factors including species sensitivity, weather and visibility, location of bird populations adjacent to the devices, bird flight behaviour (height above sea level etc.), migration routes and flight routes to feeding areas.

Wave and tidal devices can also pose a collision risk to birds although those devices without rotating blades pose less of a risk that those with blades (e.g. horizontal and vertical axis tidal turbines). Diving species are at greater risk of collision with subsurface turbines and mooring cables than surface feeding species, which are at a lower risk of interaction with floating devices and surface strictures as these do not use rotating blades (AECOM Ltd., 2010). As areas of high flow attract birds due to good foraging opportunities (Daunt *et al.,* 2006), the risk of collision can be increased if the renewable devices change the flow characteristics which may affect manoeuvrability and underwater swimming agility of birds.

Birds can also be impacted by the presence of wind turbine structures. Bird collision risk is predominantly confined to the operational phase and is influenced by species sensitivity, weather and visibility, bird flight behaviour, location of bird populations adjacent to the turbines, migration routes and feeding areas etc. The layout of the wind turbines, the spacing between them and the associated lighting can also have an influence on the collision risk to birds.

Marine mammals and reptiles also have the potential to collide with renewable energy devices as they must transit the water column to breath at the surface (AECOM Ltd., 2010). That said, marine mammals are highly mobile and have the ability to both avoid and evade these devices as long as they detect the object, perceive it as a threat and take appropriate action at long or short range. There are a number of factors that can interfere with this and they include detection failure, diving constraints, group effects, attraction, confusion, distraction, illogical behaviour, disease and life stage, size and season.

Mooring equipment will likely act like other natural or artificial seabed structures and pose few novel risks for vertebrates in the water column (AECOM Ltd., 2010). Cables, chains and powerlines extending up through the water column will have smaller cross sectional areas than vertical support structures and so produce reduced flow disruption and fewer sensory cues to approaching diving birds. Instead of being swept around these structures, mammals are more likely to be entangled in them. Areas of high turbidity can pose more of a risk for diving birds and marine mammals due to reduced visibility.

The presence of devices may provide a **barrier to movement** which may result in avoidance behaviour by birds and marine mammals which will ultimately result in **habitat exclusion**. While this avoidance behaviour would reduce the collision risk it may result in limiting access to feeding areas which could ultimately affect feeding and breeding success. It may also result in barriers to the usual migration and transit patterns of birds. This could result in increased energy expenditure.

Renewable devices with surface structures have the potential to **provide roosting, nesting and/or breeding sites** for birds (AECOM Ltd., 2010). Man-made structures are regularly used by gulls, terns, cormorants and gannets as perching posts.

Seals have the potential to use horizontal surface structures as **haul out sites**. This may be beneficial by increasing the area upon which seals can haul out on, however it may put seals at risk of injury getting on and off the structures and from exposure to moving or articulating parts.

The metal structures deployed at the site will have sacrificial anodes attached (e.g. chain moorings, metal constructed devices, SeaStation, gravity bases etc.). Sacrificial anodes are designed to corrode in seawater in preference to these metal structures. Zinc and aluminium anodes are the most commonly used and these metals are potentially toxic to marine life if concentrations are high enough.

Some of the devices/equipment installed at the site may contain **anti-fouling compounds**, which may impact on water and/or sediment quality, benthic communities, birds and marine mammals. As top predators seals and cetaceans are more susceptible to various substances building up in their bodies (AECOM Ltd., 2010).

6.5.3.2. Energy Extraction

Sediment transport pathways and coastal processes could be impacted by localised hydrodynamic changes associated with wave or tidal energy removal by the operating device. This can have impacts in the immediate vicinity of devices or foundations and sediment accretion or erosion (scour) of the sediment could occur. The effects of energy extraction on sediment processes could result in changes to suspended sediment levels and turbidity and occur up to 50m from the operating device and operating devices could potentially have significant adverse effects on coastal processes particularly in areas with high levels of erosion, accretion and long-shore drift (Scottish Executive, 2007). King scallop, queen scallop, cockle, mussel, herring and sprat are sensitive to this and increased turbidity can affect visibility for diving birds and marine mammals and increase their likelihood of collision. Grey and harbour seals have been identified as having a high sensitivity to reductions in visibility and cetaceans have a moderate sensitivity to it (AECOM Ltd., 2010).

The extraction of tidal energy causes a decrease in water flow and this can potentially impact habitats and species that are sensitive to changes in tidal flow. Water currents typically carry food and nutrients into a community and carry waste material and fine sediments away. Any interruption to this pattern can therefore affect flora and fauna.

Birds and mammals could be impacted by any changes to the benthic communities and fisheries. Seals use their vibrissae in hunting prey to sense small-scale hydrodynamic vibrations and flow vortices in the water column. Changes to tidal flows could impact their ability to catch prey. Based on limited existing projects and modelling studies, the extent of the potential on tidal energy can extend for up to 0.5km from the tidal device (AECOM Ltd., 2010).

Extraction of wave energy can result in a decrease in wave exposure and this can impact benthic communities that are sensitive to wave exposure levels (e.g. maerl and *Modiolus* beds). In addition cockles are highly sensitive to changes in wave exposure and nearshore juveniles of plaice, cod and saithe have a low to medium sensitivity to changes in wave exposure. Birds and mammals could be impacted by any changes to the benthic communities and fisheries. It is estimated from limited existing projects and modelling studies that the potential effect on wave energy can extend for up to 20km from the wave device (AECOM Ltd., 2010).

The extraction of wave and tidal energy can affect sedimentation pattern and result in increases or decreases in suspended sediments, turbidity and sediment deposition. These impacts can extend for up to 50m from devices (Bryden, 2006). These impacts could affect benthic communities (e.g. maerl beds) and fish and shellfish species (king scallop, queen scallop, cockle, mussel, herring and sprat) depending on the degree of change and the nature of the receiving environment.

6.5.3.3. Noise

The potential noise sources from operating devices include rotating machinery, flexing joints, structural noise, moving air, moving water, moorings, electrical noise and instrumentation noise (AECOM Ltd., 2010). Noise from these devices could potentially disrupt prey location and underwater navigation in marine birds and prey location, navigation and social interaction in marine mammals or even result in temporary or permanent hearing damage. This noise also has the potential to affect fish, species in the immediate vicinity of the devices. The operational noise generated from these devices will be considerably lower than that generated by vessel noise; however it could result in avoidance behaviour and exclusion from an area. This may result in limiting access to feeding areas which could ultimately affect feeding and breeding success.

The noise generated by maintenance vessels also has the potential to impact sensitive species in the area and this may elicit temporary avoidance behaviour by sensitive fish, birds and mammals. This could cause birds to temporarily avoid the immediate area which may have implications for foraging and breeding success, stress on individuals and energy budgets.

Seals hauled out on land may also be disturbed by the presence of maintenance vessels. In general, ships more than 1,500m away from hauled out grey or common seals are unlikely to evoke any reactions from seals, between 900 and 1,500m seals could be expected to detect the presence of vessels and at closer than 900m a flight reaction could be expected (Brasseur & Reijnders, 1994). These impacts would be most significant if they occurred during the sensitive breeding and moulting seasons. Breeding seals if disturbed could exhibit flight reactions and temporarily abandon their young and moulting seals maybe scared into the water and may lose condition as a result of additional energetic costs (AECOM Ltd., 2010).

Disturbance of otters could also occur should maintenance works occur close to the coastal areas where they are present (AECOM Ltd., 2010).

6.5.3.4. Electro-Magnetic Fields (EMF)

Electric charge in movement (electricity) results in a magnetic field. Electromagnetic fields (EMF) are only present when an electric current is present. Electricity involves both a voltage and a current: the higher the voltage the stronger the electric field and the higher the current the stronger the magnetic field. The direction of the magnetic field is perpendicular to the direction of the electric current. EMF strength increases proportionally to the current intensity and decreases by the square root of the distance from the cable.

The cables connecting the energy converters to the SeaStation, the SeaStation to the CEE and the CEE to shore will produce EMFs as a result of power transmission. The devices themselves will also have an electrical signature which will be specific to the individual devices e.g. whether the power generator is in the water or on a platform and if there is a riser cable from a device on the seabed. These EMFs can affect migration and prey detection in certain electro-sensitive fish species such as elasmobranchs (sharks, skates and rays), lamprey, some bony fish such as Atlantic salmon and eel and some cetaceans (whales and dolphins).

6.5.3.5. Maintenance Vessels

There is a risk of marine birds, seals, cetaceans and turtles colliding with maintenance vessels during the operational phase. While birds are generally more manoeuvrable than marine mammals they are at **risk of colliding** with vessels especially at night (AECOM Ltd., 2010). Birds can typically collide with surface structures of ships or the ships can collide with birds rafting on the surface. Shipping collision is a recognised cause of marine mammal mortality worldwide and the major factors influencing injury or mortality are vessel size and speed. In addition there is always a risk of corkscrew injuries to marine mammals from vessel propellers.

The physical presence of maintenance vessels can have a temporary **disturbance effect** on birds due to physical and visual intrusion. This could cause birds to avoid the immediate area which may have implications for foraging and breeding success, stress on individuals and energy budgets.

Seals hauled out on land may also be disturbed by the presence of maintenance vessels. In general, ships more than 1,500m away from hauled out grey or common seals are unlikely to evoke any reactions from seals, between 900 and 1,500m seals could be expected to detect the presence of vessels and at closer than 900m a flight reaction could be expected (Brasseur & Reijnders, 1994). These impacts would be most significant if they occurred during the sensitive breeding and moulting seasons. Common seals moult from August to September and breed from May to July and grey seals moult from November to April and breed from late August to December. Breeding seals if disturbed could exhibit flight reactions and temporarily abandon their young and moulting seals maybe scared into the water and may lose condition as a result of additional energetic costs (AECOM Ltd., 2010).

Physical disturbance of otters could also occur should maintenance works occur close to the coastal areas where they are present (AECOM Ltd., 2010).

6.5.3.6. Accidental Events

There is the potential of accidental pollution events from service and support vessels required during routine maintenance of the equipment and devices installed at the site. The SeaStation will house a diesel generator and fuel will need to be delivered to the SeaStation when a device is under test. These pollution events could include the release of fuel and lubricating oil, cleaning fluids, paints, specialised chemicals and litter. Any potential spillages could impact water quality and contaminate seabed sediments.

The renewable energy test devices will have hydraulic fluid in them and there is the possibility of **minor leakages which may contaminate** water, benthic communities and potentially fish and shellfish if the nature and quantity of material lost is sufficient. The SeaStation will also contain an external diesel generator and there is the potential for leakages from this. The SeaStation may also house transformers which can sometimes be filled with oil. Contamination can be in the dissolved phase or in the form of a slick forming low solubility liquids. Marine birds are particularly sensitive to contamination by oil based compounds (AECOM Ltd., 2010).

6.6. Impact Assessment

6.6.1. Impact Analysis

Impact analysis involves the establishment of the impact classification criteria followed by impact analysis based on these criteria. Impact analysis tables evaluate and rank the impacts compared to each other. They form the basis for rating the likelihood (Table-6-5) of an impact occurring and the consequence of the impact (
Table 6-6).

The likelihood and consequence ratings are combined to form a score for impact evaluation. Table 6-7 shows the Impact Matrix based on likelihood and consequence and the impact scores vary between from Low, Medium and High

Table-6-5: Impact Classification Table - Likelihood

Rating	Likelihood	
	Category	**Description**
1	Remote	1% likelihood of impact occurring
2	Unlikely	1-20% likelihood of impact occurring
3	Possible	20-50% likelihood of impact occurring
4	Probable	50-95% likelihood of impact occurring
5	Highly Likely	>95% likelihood of impact occurring

Table 6-6: Impact Classification Table – Consequence

Rating	Consequence	
	Category	**Description**
0	None	No change due to impact occurring
1	Negligible	Individuals in the population/characterising species in a habitat affected but effect not detectable against background natural variability
2	Minor	Direct or indirect mortality or sub-lethal effects caused to individuals by the activity/up to 15% of habitat disturbed seasonally but population remains self-sustaining. Seasonal change in characterising species and community structure and function
3	Moderate	*In situ* population depleted by the activity but regularly sub-vented by immigration/over 15% of habitat disturbed seasonally. Seasonal change in characterising species and structure and function. Frequency of disturbance < recovery time. Non-cumulative
4	Major	Population depleted by impact and immigration insufficient to maintain local populations/over 15% of habitat disturbed persistently leading to cumulative impacts. Persistent change in characterising species, structure and function. Frequency of disturbance> recovery time. Cumulative
5	Severe	Population depleted and supporting habitat significantly depleted and unable to support the population. Biodiversity reduction associated with impact on key structural species. Impact is effectively permanent due to severe habitat alteration. No recovery or effectively no recovery.

Table 6-7: Risk matrix

Likelihood	Highly Likely	5						
	Probable	4						
	Possible	3						
	Unlikely	2						
	Remote	1						
			0	1	2	3	4	5
			None	Negligible	Minor	Moderate	Major	Severe
				Consequence				

6.6.1.1. Loss of Habitat and Species

The loss of habitat and species will arise in the footprint of scaled devices, gravity bases, clump weights and anchors on the seabed (or scouring associated with structures on the seabed).

An attempt to quantify the footprint of the infrastructure in the test site estimates that *c.* 170m^2 will be occupied by the permanent or recurring/short-term devices. The footprints of some scaled test devices (that require moorings other than the gravity foundations already included) can also be seen in Table 6-8**.**

Assuming worst case scenario, if three scaled GRS power platforms were deployed simultaneously the footprint would increase to *c.* 460m^2. Taking a conservative approach, this study will assume a maximum footprint of 500m^2. This footprint accounts for 0.13% of the test site (the test site covers an area of 375,200m^2 [670m x 560m]).

While this loss of habitat cannot be mitigated, the actual area lost is so small that the impact on the benthic community will be negligible. In addition, following the removal of the infrastructure (if removal is required) the impacted area will immediately begin to recover through recruitment from neighbouring undisturbed areas. The species characteristic of the test site (AQUAFACT, 2010) include opportunistic spionids and cirratulids which are able to recolonise disturbed areas quickly. A follow up survey 24 months later indicated no impact on the seafloor from the operation of the test site (AQUAFACT, 2011). Recovery rates from other types of benthic habitat disturbances range from 40 days following hydraulic dredging for razor clams (Hall *et al.,* 1990) to 6-12 months following trawling (Jennings & Kaiser, 1998). Coates *et al.* (2015) reported rapid recovery within a year following dredging and gravity base installation associated with an offshore wind farm in the North Sea.

In addition the loss of such a small area of seabed is extremely unlikely to cause any reduction in fish stocks or spawning and nursery areas. The only fish species feeding on the benthos are likely to be demersal and as birds are more likely to feed on pelagic species there will be no knock on effect for birds. Marine mammals in the area are extremely unlikely to be impacted upon given the very small area of seabed impacted and the extremely unlikely impact on fish stocks in the area.

Likelihood = Highly Likely;
Consequence = Negligible;
Impact = Low

Table 6-8: Maximum estimated seafloor footprint

Device	Footprint	Total
Cardinal Marker Mooring	$4m^2$ x 4	16.0 m^2
Subsea Observatory	$4.5m^2$ plus $2m^2$ CTE	6.5 m^2
Waverider Mooring	$1m^2$	1.0 m^2
SeaStation Mooring	$7m^2$ x 8	56.0 m^2
Gravity Base (Max)	$6.25m^2$ x 9	56 m^2
SmartBuoy Mooring	$4.5m^2$	4.5 m^2
Acoustic Array	$0.5m^2$ x 6 landers	3.0 m^2
	$0.2m^2$ (central hub)	0.2 m^2
Cabling	$10m^2$	10.0 m^2
GRS Power Platform	$36m^2$ x 3	108.0 m^2
Oscillating Wave Surge	$56m^2$	56.0 m^2
Seaformatics	$1.62m^2$	1.6 m^2

6.6.1.2. Disturbance to Seabed

The placement of any infrastructure on the seabed will disturb and remobilise sediments in the immediate footprint of the object. This will result in a short-term (minutes), localised increase in suspended sediment levels and turbidity. Small localised sediment plumes are generated frequently in the marine environment by a variety of activities e.g. remote sampling, fish emerging from and burial in the seabed, dolphin and porpoise foraging and feeding, storm events etc. It is not possible to quantify the volumes of sediment that would be mobilised during the placement of infrastructure on the seabed, however they will be so low as to have no effect on water quality, habitats or species.

It is worth noting that naturally high suspended sediment background levels of 65,000mg/l have been recorded in Galway Bay under storm conditions (Galway Harbour Company, 2014a) and these volumes are orders of magnitude greater than what would be generated by the proposed activities.

The subsequent settlement of the remobilised sediment will also have no impact on the habitats and communities in the immediate vicinity of the object as volumes will be so low.

Sediment disturbance during the operational phase could include scour around the gravity bases; however, given the relatively low velocities[3] in the area any impact from this is likely to be minimal. Movement of the catenary mooring lines and any other cables which will continuously or periodically rest of the seafloor have the potential to disturb and remobilise sediments. It is estimated that up to 5m either side of the lines/cables could be affected. The sediments disturbed by this activity will be orders of magnitude lower than that generated during storm events. Any short term temporary impacts from this will have a negligible impact on the environment.

The maximum footprint on the seabed of the combinations of worst case scenario infrastructure and devices has been assessed conservatively to be 500 m^2. This represents less than 1% of the total area of seabed within the test site.

In summary, disturbance to sediment and the resultant increases in suspended sediments and turbidity and the subsequent deposition of sediments will be of such a scale that impacts on the benthos, fisheries, birds and mammals will be negligible.

The likelihood of these disturbances occurring is highly likely however the consequences are negligible (i.e. not detected against natural background variability).

Monitoring at the commercial scale SeaGen turbine in Strangford Lough reported that the changes observed appeared to be gradual and in line with natural variation (Keenan *et al.,* 2011).

Likelihood = Highly Likely;
Consequence = Negligible;
Impact = Low

6.6.1.3. Addition of New Substrata/Structures

All new hard surfaces installed in the test site will provide surfaces for colonisation e.g. underside of surface buoys or scaled devices, gravity bases and mooring chains etc. Previous studies at the test site have showed that the mussel *Mytilus edulis* colonised anchor chains and the scaled test devices (AQUAFACT, 2010). The moorings were found to be heavily settled by epifauna such as anemones, mussels, star fish and echinoids.

[3] Mean bottom current speeds in the test site are 0.09m/s on a flooding spring tide and 0.06m/s on an ebbing spring tide (Marine Institute, 2013).

The types of colonising plants and animals depends on a number of parameters including size, height, shape, profile, scale, morphological complexity, material used and rugosity (roughness of the surface) (Connell & Glasby, 1999; Rilov & Benayahu, 1998; 2000). Of these, complexity is the primary factor determining attractiveness of a structure to fauna and flora (Pickering & Whitmarsh, 1997; Hoffman *et al*., 2000). Highly complex structures provide a greater surface area for colonisation and more 'nooks and crannies' for shelter from predators and physical conditions. This allows a more diverse and dense assemblage including organisms that are more fragile or light sensitive to colonise an area from which they were previously excluded (Vella *et al*., 2001).

Recruitment would primarily occur in two ways; through migration from the surrounding substrate or by the settling of larvae, spat, algal spores etc. from currents (Vella *et al*., 2001). The first species to colonise would be algae (if depths allow) and invertebrates. Colonisation would often have a characteristic succession with microscopic and filamentous algae initially settling, followed by rapidly settling species and thereafter, a more diverse community would develop.

Furthermore, community composition would vary with depth. With an increase in species diversity there may also be an increase in the general productivity of the area (Wickens & Barker, 1996 cited in Hoffman *et al*., 2000; Grossman *et al*., 1997). This is probably due to the fact that a greater diversity of fixed colonising species would attract various free-living invertebrates and small fish, which in turn attract larger organisms up to and including marine mammals (Vella *et al*., 2001). These increases in biodiversity and biomass can enhance crustacean fisheries (e.g. lobster); molluscan fisheries (e.g. scallops) and aquaculture (e.g. mussels) (O'Leary *et al*., 2001). It is also likely that detritivores living in the local sediments would migrate to the structures and would feed on the increased organic detritus in the area. Therefore, it is highly likely that the infrastructure at the site would increase the local species diversity, biomass and productivity.

Growth of marine grass occurred on a commercial scale tidal device in Cobscook Bay after slightly more than two months of submergence (ORPC, 2013). Following 16 months deployment, the main generator had 75% cover of tubularian hydroids, lesser barnacles and filamentous algae (ORPC, 2014). An investigation at the Horns Rev offshore wind farm in Denmark (Bio/consult, 2000 cited in Leonard, 2000) reported fouling by invertebrates on the monopile masts, five months after construction. The fouling species included bryozoans, several species of sea anemone, sea squirts, star fish, polychaete worms and the common mussel. After the establishment of the turbines at the Nysted offshore wind farm, a considerable increase in the number of cod present in the wind turbine area was noted. The increase was explained by the development of a reef fauna, namely a larger density of small crustaceans and fish (Birklund, 2005). The invertebrate fauna was mostly comprised of mussels and barnacles with *Gammarus* associated with the mussel.

The species that will colonise the infrastructure at the test site will be epifaunal species originating from the numerous rocky reef communities within the greater Galway Bay area such as benthic algae and invertebrates. The development of epifaunal communities, while different to the baseline infaunal community within the fine muddy sand habitat, will be consistent with those found throughout Galway Bay and they will serve to increase species diversity at the site, which in turn will attract larger organisms up to and including marine mammals.

While colonisation of the structures will begin immediately, it is anticipated that at least 12 months will be required before a functional community has been established (i.e. individuals begin reproducing). Up to this point, structures can be removed from the site.

Consideration should be given to leaving any long-term structures in place (e.g. interlocking gravity base frames *in situ* for >12 months) if significant functional communities have been established on them, as these communities would function as artificial reefs and serve as shelter, habitat and food source for fish and larger species. Monitoring at the commercial scale SeaGen tidal turbine in Strangford Lough reported that colonisation of the device since its installation has replaced the community lost at the device foundations during construction.

While the addition of new substrata will provide new surfaces for colonisation, the degree to which equilibrium communities will establish will depend on the level of disturbance at the site (i.e. recovery/ maintenance of structures etc.). While increases in species diversity is a positive impact, it is predicted that this positive impact will balance out the community lost during the construction stage and in reality will have a negligible impact overall.

The installation of surface objects may provide additional roosting, perching, nesting or breeding sites for birds and potentially haul-out sites for seals (is structures are <0.5m above the sea surface). While an increase in habitat is seen as a positive benefit, there is a chance that this may increase their risk of collision and therefore the benefit is cancelled out and in reality will have a negligible impact overall.

The maximum footprint on the sea surface of the combinations of worst case scenario infrastructure and devices has been assessed conservatively to be 1200 m^2. This represents less than 1% of the total area of water surface within the test site.

Likelihood = Highly Likely;
Consequence = Negligible;
Impact = Low

6.6.1.4. Collision Risk

Rotating blades are typically associated with wind and tidal devices however some wave energy converters use rotating surfaces that could also pose a collision risk. Tidal devices operate within the range of 5 to 30 RPM (compared to 80-600 RPM for conventional hydroturbines) (Copping *et al.,* 2013a) and slow the flow of water and remove energy.

Studies carried out to date (although limited) provide no evidence that direct interaction of marine mammals, birds or fish with tidal blades was causing harm to the animals (Copping *et al.,* 2013a). Five short-term deployments provided the information for this assessment by Copping *et al.* (2013a); commercial scale SeaGen in Strangford Lough, ORPC's commercial scale demonstration TGU unit in Cobscook Bay, Verdant 5m diameter full-scale turbines in New York, HGE commercial scale turbine in Minnesota and the OpenHydro prototype turbine in EMEC.

The risk to marine mammals from turbines could be somewhat increased by their natural curiosity, but this interaction could be mitigated by their intelligence and the habituation that is likely to take place as more devices are deployed (Copping *et al.,* 2013a).

There is also a risk of birds colliding with the single 25m high scaled wind turbine that may be erected at the site. The greatest risk is collision with the rotating blades as opposed to the tower. The species of greatest concern are those which fly at the height of the rotor (14-26m height) e.g. great northern diver, sandwich tern and common tern.

Lighting on the turbine may attract birds and increase risk of collision (Winkleman, 1992) however the intermittent nature of the navigational lighting that will be required on the turbine may reduce the risk of bird attraction (Richardson, 2000). It is highly unlikely that a single, temporary, scaled wind turbine will have any impact on bird populations in Galway Bay.

There is also the potential risk that seabirds and marine mammals may collide with installation or service vessels. However the risk is likely to be low for all species (Daunt *et al.,* 2006) and the collision risk during construction is likely to be lower than that posed by commercial shipping traffic (AECOM, 2010).

Given the scaled size of the devices, the slow speed of the turbines blades, the low number of turbines likely to be in operation at any one time and the low number and short-term intermittent nature of the installation/service vessels the likelihood of a collision occurring is unlikely but even if it did the impact would be minor (direct or indirect mortality or sub-lethal effects caused to individuals).

Likelihood = Unlikely;
Consequence = Minor;
Impact = Low

6.6.1.5. Barrier to Movement

The small number of scaled devices that will be deployed in the test site (including a potential 25m high scaled wind turbine) at any one time and the open water extending for *c.* 1km between the test site and the northern shore of Galway Bay make the likelihood of any exclusion or barrier effect occurring remote and the consequence would be negligible.

Monitoring at the commercial scale SeaGen device in the Strangford Narrows has not presented a barrier to movement of seals or porpoises in and out of the Lough (Keenan *et al.,* 2011).

Likelihood = Remote;
Consequence = Negligible;
Impact = Low

6.6.1.6. Installation Noise

Noise from the installation vessel(s) has the potential to impact marine animals in the area. Hearing in marine animals varies between groups. Cetaceans consist of toothed whales (odontocete) and baleen whales (mysticete). The toothed whales are the group most likely to feature in Galway Bay, the dominant species being harbour porpoise and bottlenose dolphin (Marine Institute, 2013). This group communicates at moderate to high frequencies (1-20kHz) and they have highly developed echolocation system operating at high and very high frequencies (20-150kHz). Grey and harbour seals have flat audiograms from 1 to 30-50kHz, with thresholds between 60 and 80 dB re 1µPa. Harbour seals can detect underwater sounds up to 180kHz if it is sufficiently loud but their sensitivity drops off significantly above 60kHz (Richardson *et al.,* 1995). With regards to fish, salmon and eels are limited to the low frequency <600Hz) end of the spectrum. Underwater noise levels of 185 to >200 dB re 1 µPa with peak frequency between 100 to 1000 Hz will be heard by both fish and marine mammals in Galway Bay.

The study carried out for the Galway Port expansion project (Galway Harbour Company, 2014b) showed that permanent (non-recoverable) and temporary (recoverable) injury do not occur for dolphins and porpoises due to shipping activity. The study also shows that permanent (non-recoverable) injury does not occur for seals and otters and that temporary (recoverable) injury will only occur within <2m of the ship. Disturbance, which may instigate temporary avoidance behaviour will be experienced further afield. The addition of a small number of vessels to the area is not expected to have any significant impact on marine fauna given the levels of ship traffic that currently exist.

Richardson *et al*. (1995) reviewed the published literature on the response of marine mammals to vessel noise. Many toothed whales appeared to be tolerant of vessel noise and were regularly observed in areas where there is heavy traffic. Harbour porpoises are normally considered shy and their reaction to disturbance is often flight (Flaherty, 1981; Taylor & Dawson, 1984; Barlow, 1988; Parker, 1993). However, they are often observed in areas of intense shipping activity (Hoffman *et al.,* 2000).

Thomsen *et al*. (2006) noted that harbour porpoises (Hearing threshold = 115 dBrms re 1 µPa at 0.25 kHz; Ambient noise = 91 dBrms re 1 µPa at 2 kHz) would detect ship noise around 0.25 kHz at distances of 1km and ship noise around 2 kHz would be detected at a distance of approximately 3km. For harbour seals (ambient noise = 94 and 91 dBrms re 1µPa at 0.25 and 2 kHz respectively), the zone of audibility would be approximately 20km for the 0.25 content of ship noise and identical to harbour porpoises for the 2 kHz content. In addition, seal haul out sites are *c.* 13km from the test site and any airborne noise from the vessel activity will not disturb harbour seals on land. The likelihood of a noise related impact occurring is possible and the consequence would be negligible (direct or indirect mortality or sub-lethal effects caused to individuals).

Likelihood = Possible;
Consequence = Negligible;
Impact = Low

6.6.1.7. Operational Noise

An important consideration when examining the impacts of the operation noise of an energy device is the existing levels of background ambient noise. Typical ambient noise for shallow coastal waters range from 115 to 125 dB re 1 µPa (average 120 dB re 1 µPa) (Keenan *et. al.,* 2013). Depending on the sound level from an operating device it may be masked by ambient noise. Operational noise has been measured for a number of small-scale or single energy conversion devices.

The commercial scale SeaGen tidal energy device consists of two 16m open blade rotors attached to a pile in the seabed in waters 26.2m deep. Throughout normal SeaGen operations, SeaGen is likely to be audible to marine mammals up to about 1.4km (Keenan *et al.,* 2011). Monitoring showed that harbour seals and porpoises swim freely in and out of the Lough while the turbine was operating. In addition, no significant displacement occurred although marine mammals did tend to avoid the centre of the channel when the turbine was operating and harbour seals displayed some small scale redistribution (few hundred metres) during turbine operation (although it is unclear if this was due to noise emanating from the operating device or avoidance due to disturbance of water flow around the device). The operating device did not cause any significant changes in the use of harbour seal haul out sites. While model predictions were made to determine when the SeaGen device would elicit behavioural responses in porpoises and seals, monitoring showed that that these animals were regularly sighted within the range of predicted behavioural avoidance as a result of noise.

Acoustic monitoring of a demonstration commercial scale tidal turbine in Cobscook Bay in coastal Maine showed that the sound from the barge-mounted turbine was less than 100 dB re $\mu Pa^2/Hz$ at 10m from the turbine (Copping *et al.,* 2013a). At 200 and 500m from the turbine the turbine sound was undetectable above ambient sounds within the bay.

A $1/7^{th}$ scale SeaRay wave buoy in the Puget Sound, Washington was recorded as having a sound pressure level (SPL) of 126 dB, which was the equivalent of a tugboat passing at a range of 1.25km (Copping *et al.,* 2013a). This device could be acoustically identifiable within 500m when there was no ship traffic in the area. When ships were present, the high ambient noise levels masked the wave device sound (ambient levels of 116 dB, peaking at 132dB in a frequency band of 20 Hz to 20 kHz when ship traffic was close by).

Tougaard (2015) recorded underwater noise from the Wavestar wave energy converter; a full-scale hydraulic point absorber, placed on a jack-up rig on the Danish North Sea coast. The noise levels recorded from the operating wave converter were so low that they would barely be audible to marine mammals and the likelihood of negative impact from the noise appears minimal.

Haikonen (2014) studied the noise generated from 4 different full-scale wave energy converters (point absorbing linear generators) at a site in the Skagerrak on the Swedish west coast as part of the Lysekil Wave Power Project. Harbour seals and harbour porpoises have rather poor hearing in the frequencies where the noises from the WECs have their peak energy ≤400 Hz (Haikonen *et al.,* 2013a; 2013b). However, the noise levels at 1m from the WEC, are well above the hearing threshold of both harbour seal and harbour porpoise in these frequencies. Generally, marine mammals have shown first signs of being disturbed at noise levels around 120 dB re 1 μPa for continuous noise (Richardson *et al.,* 1995). Noise level thresholds (SPLpeak) for minor behavioural disturbance for harbour seal is 160 dB re 1 μPa, and can be as low as 90 dB re 1 μPa for harbour porpoise (Bailey *et al.,* 2010). This indicates that harbour seal can express behavioural disturbance if in the immediate vicinity of the WEC, but at a distance of 15m away (in the Lysekil research site) a behavioural response is improbable. However, the harbour porpoise, being much more sensitive, is likely to express disturbance in greater distances. However, no major disturbance is expected at distances >150m from the WECs (Haikonen *et al.,* 2014). In general for marine mammals, no disturbance is expected at 2km from the WECs (Haikonen, 2014).

Masking effects are difficult to predict; however most teleost fishes produce sound that have most of their energy in frequency < 1 kHz (Hastings & Popper, 2005). This indicates that there is a risk of masking effects on fish vocalizations if close enough to the WEC (Haikonen, 2014). The sound production of harbour porpoise ranges in frequency between 120 to 130 kHz with SPL up to 180 dB re 1 μPa (Clausen *et al.,* 2010) and the sound production of harbour seal is in frequency considerably lower than that of the Harbour porpoise. Much of their vocalization is in frequency between *c.* 15 and 1000Hz, but may range up to 5 kHz. This indicates that the noise from the devices will not mask the vocalization of harbour porpoise but it may mask the vocalizations of the harbour seal (Haikonen, 2014).

Marine mammal monitoring to assess the effect of a ¼ scale ocean energy device on harbour porpoise presence was carried out at the Marine and Renewable Energy Test Site (MaRETS) between 2009 and 2010 when an ocean energy scaled device was on site (O'Brien *et al.,* 2012; O'Brien, 2013). Monitoring was also carried out at 2 control sites, one 1km east of the test site and the second was 500m west of the test site. The presence of the wave platform, which was of a substantial size (28t), could have had a positive or negative effect on the occurrence of harbour porpoises in the area:

- The presence of the structure may have deterred animals as they may not be able to sufficiently forage for food as the structure may impact on their echolocation ability. This event is highly unlikely at Spiddal given the high percentage of days with detections (O'Brien, 2013).

- Or the platform itself may act as a cover for many fish species and therefore attract fish to the area and in turn feeding porpoises. International studies have found that wave buoys can serve as artificial reefs and attract fish and other marine life. In fact, in some parts of the world conventional buoys are deployed to serve as 'Fish Attracting Devices' (FADs) (Nelson, 2013).

Results from this short-term deployment and monitoring failed to show a significant difference in detections between sites, suggesting that the OE platform did not influence harbour porpoise presence, either positively or negatively.

Noise impacts from the maintenance vessels will be the same if not lower than that from the installation vessels.

Operational noise from individual devices or small arrays of devices is unlikely to have large-scale effects on the behaviour or survival of marine organisms (Copping *et al.,* 2013a). As a result of the studies carried out to date and the nature and use of the Galway Bay Marine & Renewable Energy Test Site, the impact of 3 (max) operating scaled energy test devices on marine animals in the area will be negligible.

It should be noted that the CEE hydrophone and acoustic array will facilitate the measurement of sound generated from experimental WEC devices and will facilitate the recording of cetacean vocalisations allowing the Marine Institute to assess the impact on an ongoing basis. This monitoring will add to current scientific knowledge on noise impacts and it will add to the industries knowledge of potential impacts using scaled prototype devices in the test site.

Likelihood = Possible;
Consequence = Negligible;
Impact = Low

6.6.1.8. Electro-Magnetic Fields

It is anticipated that there could be up to 3 cables connecting scaled test devices to the SeaStation and a 4th cable connecting the SeaStation to the CEE. These cables will be free floating between the devices. The CEE will provide 400V DC (3.5kW) power supply to the sensors, SeaStation, test devices and HDTV cameras through a standard 25mm single conductor telecommunications type cable which was laid between the CEE and the shore in April 2015. This cable was fitted with 12 fibres and the single power conductor will require the use of seawater as a return path from the CEE. This cable was double armoured and buried to a depth of 700mm where substrata allowed or laid directly on the seabed and protected with either cast iron protection or concrete bags.

Shielded electric transmission cables do not directly emit electric fields, but are surrounded by magnetic fields that can cause induced electric fields in moving water (Gill *et al*., 2012). EMF could also disturb fish migration patterns by interfering with their capacity to orientate in relation to the geomagnetic field, as indicated by empirical studies on eel (Westerberg & Begout-Anras, 2000; Westerberg & Lagenfelt 2008; Gill *et al*., 2012). The extent of EMF can potentially be mitigated by adequate cable design. Only few studies have addressed electroreception in marine mammals (Czech-Damal et al., 2012) or invertebrates (Karlsen & Aristharkhov, 1985; Aristharkhov *et al.,* 1988, Bochert & Zettler 2004) and no significant effects have been shown to date. Probable negative impact from electromagnetic fields (EMF) is generally rated as low (Bergstrom *et al.,* 2014).

In addition, Olsen & Larsson (2009) conducted an extensive review of the impacts of electromagnetic fields from sub-sea power cables on marine organisms and concluded that research to date has found that sub-sea power cables pose no threat to the marine environment due to EMF. Additional work commissioned in the UK on behalf of the Collaborative Offshore Wind Energy Research into the Environment (COWRIE) concluded that there was no solid evidence to suggest that EMF associated with high voltage cables have either positive or negative effects on cetaceans, fish or elasmobranches.

At 3.5kW and 400V the power and voltage of the proposed cables are a fraction of those found in high power undersea cables. For instance the East West interconnector which was recently laid in the Irish Sea connecting the Irish and UK electrical grids can transmit up to 500,000kW at up to 200,000V (Marine Institute, 2013). The low power levels in the proposed cables mean that the magnetic field and induced electric field from the proposed cables will not have any significant impact on marine species in the area. The likelihood of an impact occurring is unlikely and the consequence would be negligible.

Likelihood = Unlikely;
Consequence = Negligible;
Impact = Low

6.6.1.9. Accidental Events / Contamination

Accidental events or spillages from marine vessels and equipment e.g. fuel/oil leaks, cleaning fluids, paint, specialised chemicals, litter etc. have the potential to occur. In addition, fuel spillages could occur when the diesel tank on the SeaStation needs refuelling. The fuel stored on the SeaStation will be in a secure container and leakages from this will be unlikely.

All vessels employed to carry out any work onsite will have all required certification to ensure sea worthiness. In addition they will employ best practice measures to minimise any possible impacts on the marine environment and in case of an accidental event the ship's Oil Pollution Plan will be implemented and on board oil pollution control measures will be implemented to minimise any impacts on the environment. The quantities of oil/fuel involved in accidental spillages are likely to be very small and the impact on water quality would be minor. The likelihood of a spillage would be unlikely.

There is the potential for contamination from the use of anti-fouling compounds and the erosion of sacrificial anodes. As the quantities and toxicities associated with these are generally expected to be extremely small and therefore the potential effect will be of negligible significance (Aecom, 2010). There are no sensitive habitats in the vicinity of where these compounds may be used and as a result any impacts will be negligible.

As the test site is located outside of the industrial dock area, outside any of the main shipping routes, there is no historical munitions or spoil disposals at the site, the rivers that discharge into the area are not from industrialised areas and there is a rich diversity of benthic fauna at the site, it is extremely unlikely that the sediments in the test site are contaminated. As a result the remobilisation of contaminated sediments during the installation phase is extremely unlikely.

Likelihood = Unlikely;
Consequence = Negligible;
Impact = Low

6.6.2. Impact Assessment Tables

Table 6-9 shows the impact matrix for the various activities associated with the test site. All impacts are considered Low.

Table 6-9: Risk matrix for the Galway Bay Marine & Renewable Energy Test Site.

Likelihood	Highly Likely	5		Loss Habitat & Species Disturbance to Sediment New Substrata				
	Probable	4						
	Possible	3		Noise				
	Unlikely	2		EMF Accident/Contamination	Collision Risk			
	Remote	1	Energy Removal	Barrier to Movement				
			0	1	2	3	4	5
			None	Negligible	Minor	Moderate	Major	Severe
				Consequence				

6.7. Mitigation

6.7.1. Proposed Measures

A number of mitigation / best practice measures are recommended to ensure minimal impact of the Galway Bay Marine and Renewable Energy Test Site.

- Site specific geophysical and geotechnical surveys to establish a baseline and identify suitable locations for infrastructure
- Carry out pre installation baseline seabed surveys (sediment and faunal) for comparison with post installation surveys to document any changes. Control sites must be included.
- Use installation methods that minimise disturbance of sediments
- Deploy all objects on to the seabed as slowly and controlled as possible to minimise sediment disturbance on the seabed
- Carry out work in appropriate tidal conditions to minimise effect
- Carry out potentially hazardous operations under appropriate weather/tide conditions
- Avoid sensitive time periods for local receptors
- Risk assessment for contingency planning
- Use low toxicity and biodegradable materials
- Use minimum quantities
- Design infrastructure for minimum maintenance
- Design devices to minimise risk of leakage of pollutants
- Risk assessment for contingency planning
- Implementation of Shipboard Oil Pollution Emergency Plan (SOPEP)
- Presence of a trained experienced Marine Mammal Observer (MMO) to implement the NPWS best practice guidelines when all work is taking place and to implement appropriate buffer zones in good sea-state.
- If bow thrusters are required on installation vessels they should be covered to prevent collision with marine mammals
- Target work to take place when porpoise presence is at its lowest e.g. during the spring or early summer
- Only carry out observations (and therefore work) during daylight hours (this will also minimise risk of bird and mammal collision with vessels)
- Carryout SAM at the site during and after installation works to assess if avoidance behaviour is recorded and if so for how long it lasts.
- Design devices for minimal impact of collision risk
- Plan operations efficiently to minimise the number of trips that the service vessel must make.
- Leave any long-term devices, which have become established as functional artificial reefs and are beneficial to the area in place.

6.7.2. Mitigated Impact Assessment Table

Table 6-10 shows the mitigated impact matrix for the various activities associated with the Galway Bay Marine and Renewable Energy Test Site. Again all impacts are considered Low and the likelihood of impact on mammals has decreased to remote.

Table 6-10: Risk matrix for the Galway Bay Marine & Renewable Energy Test Site.

Likelihood	Highly Likely	5		Loss Habitat & Species Disturbance to Sediment New Substrata				
	Probable	4						
	Possible	3						
	Unlikely	2		EMF Accident/Contamination	Collision Risk			
	Remote	1	Energy Removal	Barrier to Movement Noise				
			0	1	2	3	4	5
			None	Negligible	Minor	Moderate	Major	Severe
				Consequence				

6.8. Conclusion

Given the scale of the site and the intermittent nature of deployments the impacts on all receptors are of low concern.

- The impacts from the loss of habitats/species, sediment disturbance and addition of new substrata/structures on the benthos, fisheries, protected habitats/species, mammals and birds are all negligible.
- Impacts on mammals, birds, fish and protected species caused by barriers to movement are negligible.
- The impacts from vessel noise on mammals, birds and fish are negligible.
- The collision risk posed to birds, mammals, fish and protected species is minor.
- No impact is expected on any receptor from energy extraction.
- Impacts associated with EMF on mammals and fish are negligible as are impacts from accidental events or contamination.

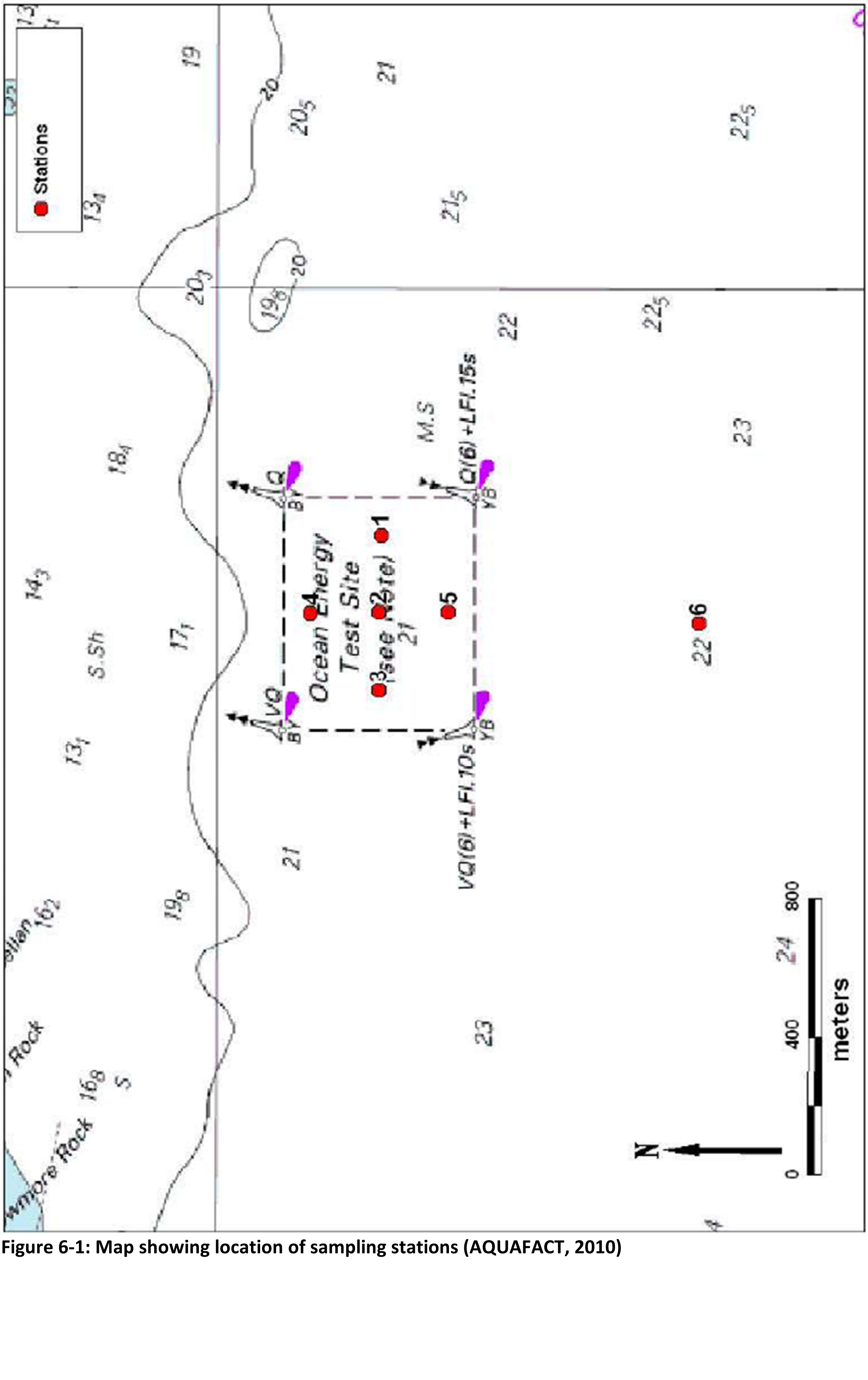

Figure 6-1: Map showing location of sampling stations (AQUAFACT, 2010)

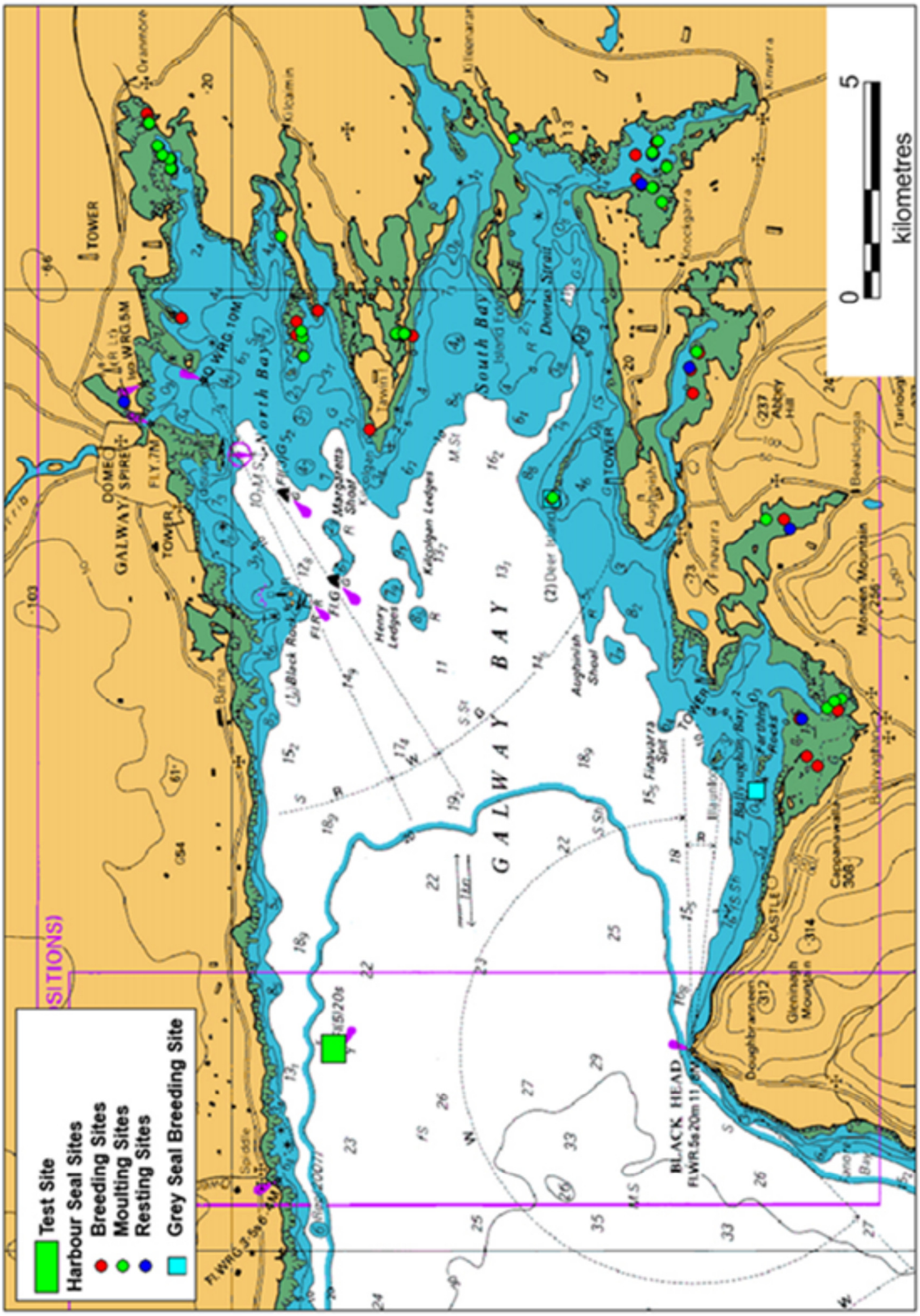

Figure 6-2: Important harbour seal and grey seal sites in Galway Bay (AquaFact 2015)

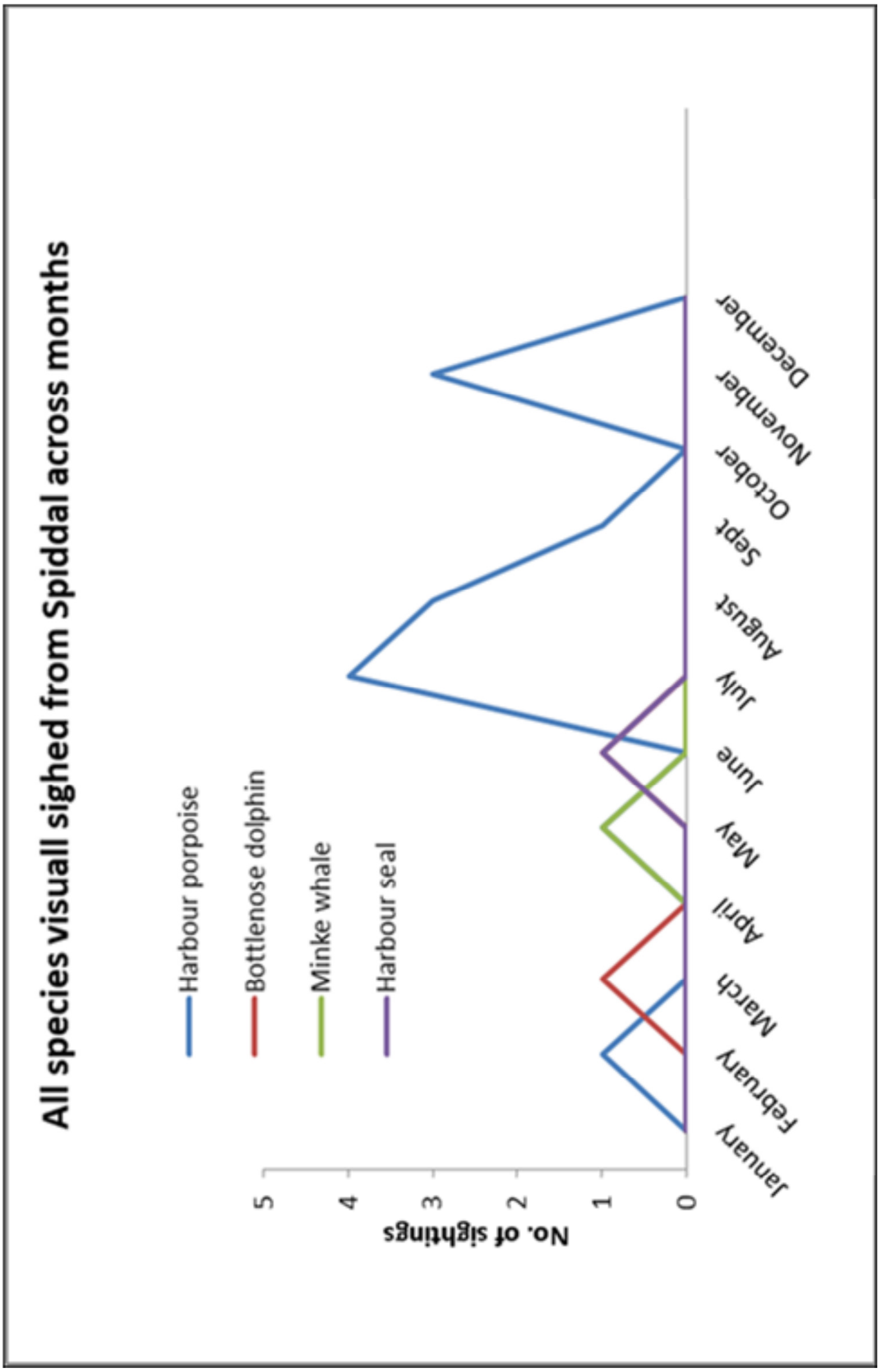

Figure 6-3: Visual sighting data as recorded from Spiddal Pier, March 2005 to February 2007(O'Brien, 2013)

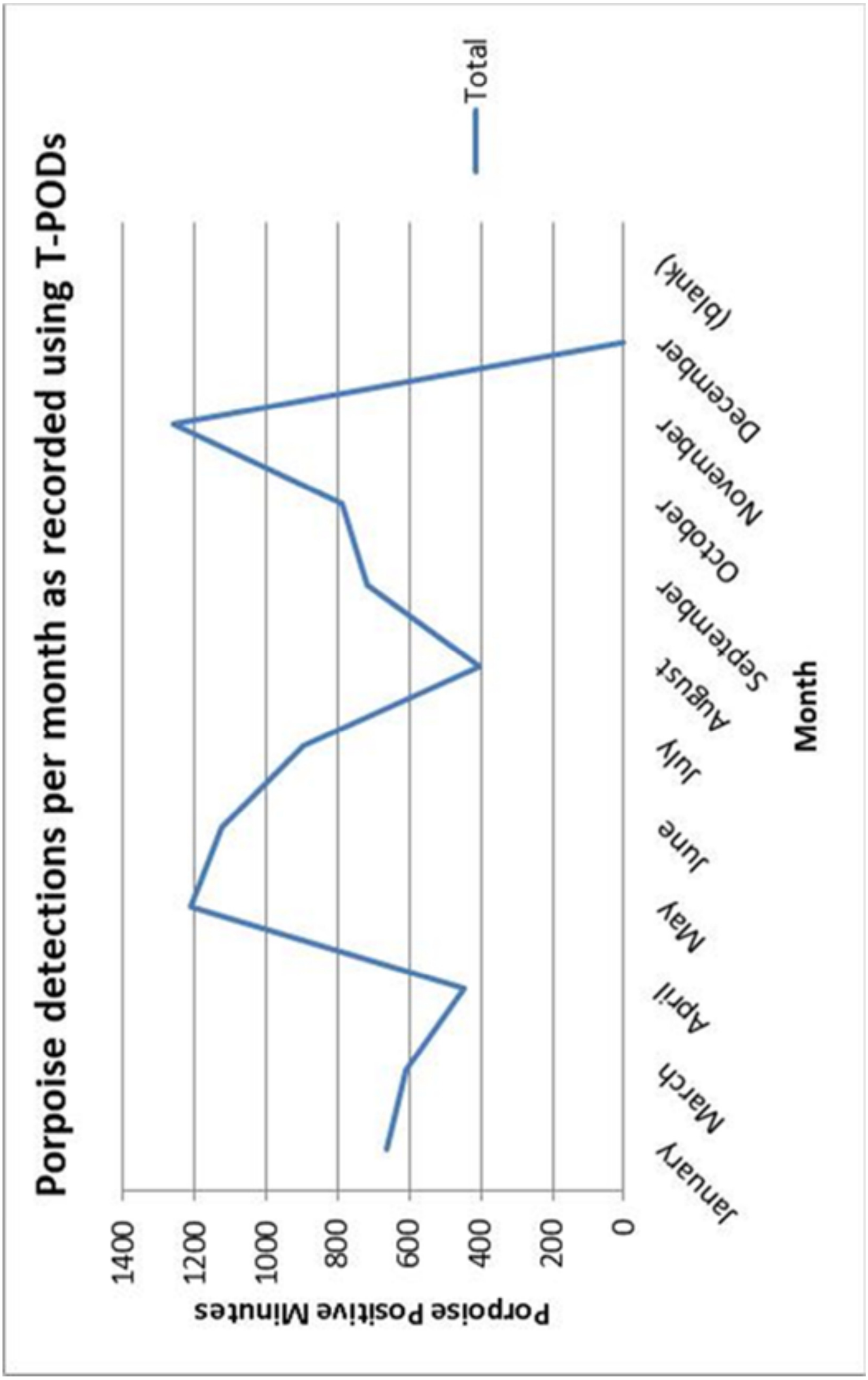

Figure 6-4: Harbour porpoise detections per month (O'Brien, 2013).

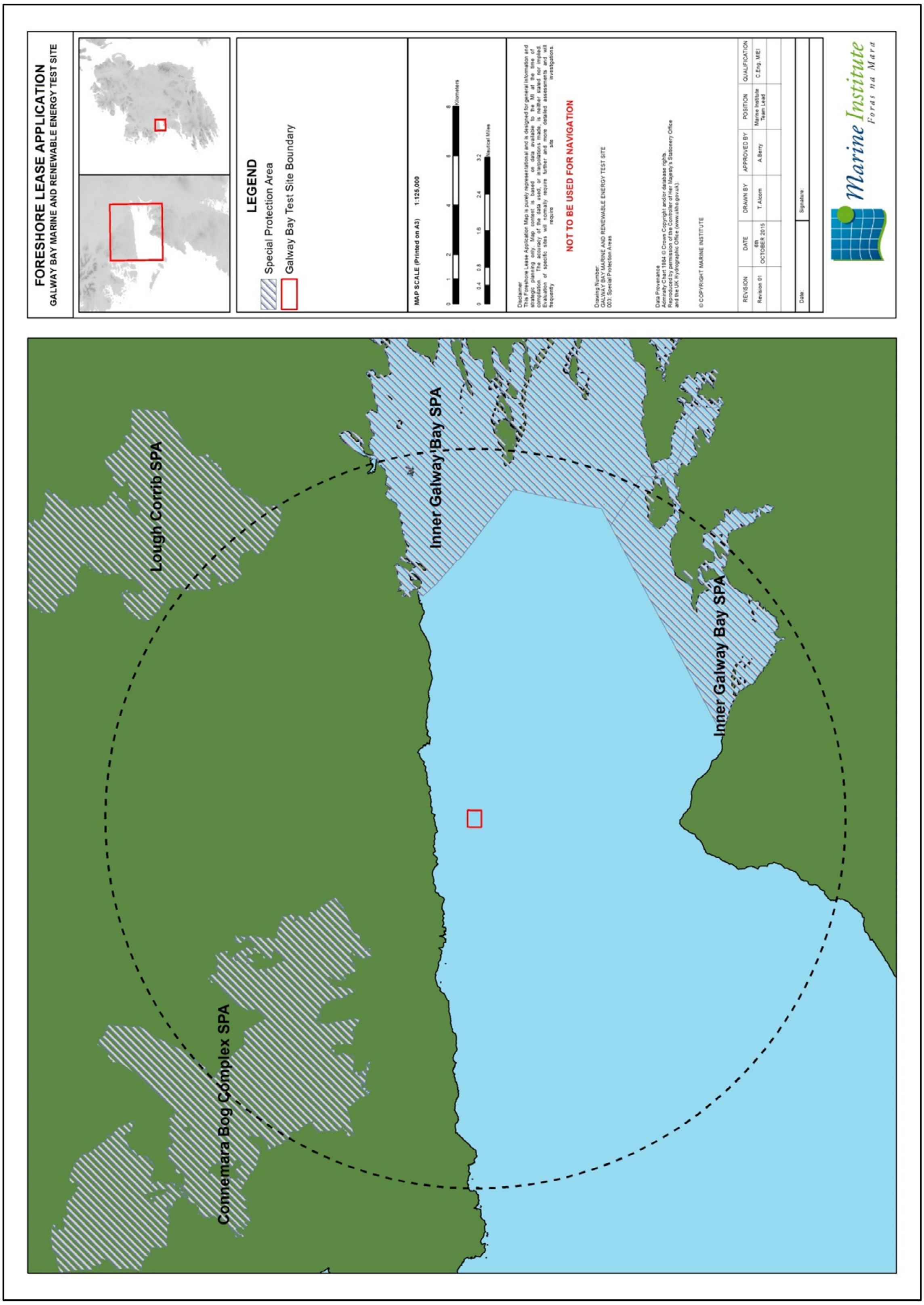

Figure 6-5: Special Protection Areas within 15km (dashed line) of Galway Bay Marine and renewable Energy Test Site.

7. Water

7.1. Introduction

This chapter considers the potential impacts of a development on the quality of surface water. The information used in this chapter comes from publicly available sources, from the results of sediment samples taken in the marine environment and from the benthic sampling and analysis undertaken as part of the ecological assessment in the marine environment (Chapter 6). The following documents and sources were consulted:

- Water Quality in Ireland 2010-2012, EPA.
- Western River Basin District Transitional and Coastal Waters Action Programme (http://www.wfdireland.ie/docs/)
- Final River Basin Management Plan for the Western River Basin District in Ireland (2009-2015)
- Result of sediment sampling and sediment analysis (Aquafact, 2010)
- EPA water quality database

7.2. Receiving environment

The Galway Bay Marine and Renewable Energy Test Site is located within the WFD designated coastal water body of *Outer Galway Bay*. This coastal water body, as defined by the EPA, is 136.73km^2 in size. The test site area, at 0.375km^2, comprises a very small fraction of this total area.

The surface water ecological status (2010-2012) is classified as good (European Communities Water Framework Directive (Directive 2000/60/EC of the European Parliament and of the Council, establishing a framework for Community action in the field of water policy).

The Water Framework Directive (WFD) rationalises and updates existing water legislation by setting common EU-wide objectives for water quality. It provides for a new, strengthened system for the protection and improvement of water quality and dependent ecosystems. In brief, the legislation provides for the protection of the status of all waters (surface water and groundwater).

Galway County Council is the coordinating local authority for the Western River Basin District. The *Western River Basin District – River Basin Management Plan 2009–2015* (published 2009) has been adopted for the river basin district. It establishes four core environmental objectives to be achieved generally by 2015, as follows:

- Prevent deterioration: maintain the status of waters classified as High or Good
- Restore all waters to at least Good status
- Reduce chemical pollution
- Achieve water-related protected areas objectives.

In addition, the Surface Waters Environmental Objectives Regulations (S.I. No. 272/2009) and the Groundwater Environmental Objectives Regulations (S.I. No. 9/2010) set out the measures needed to achieve the environmental objectives established in river basin management plans for surface water and groundwater. The regulations place a legal obligation on public authorities to aim to achieve those objectives in the context of their statutory functions.

7.2.1. Existing water quality status

Water quality status is assigned by assessing biological, hydromorphological and physico-chemical quality elements. The EPA is responsible for assigning the status to water bodies in Ireland. The EPA assigned the status of Good Ecological Status to Outer Galway Bay in 2012.

7.2.2. Seabed contaminants

There are no licensed marine waste disposal sites at sea within the project area.

7.3. Impact of the development

The main potential for impact on surface water quality arises during the installation, operation, and decommissioning phases of demonstrator projects.

7.3.1. Worst Case Scenario

The impacts of the Galway Bay Marine and Renewable Energy Test Site project have been assessed under the worst case scenario deployment of items at the test site in Table 7-1.

Table 7-1: Water worst case scenario

Permanent	Recurring	Devices
4 x cardinal marks	Data buoy	1 x OWC
Subsea observatory	Acoustic Array	1 x Point Absorber
Waverider	ADCP	1 x Attenuator
SeaStation	Cabling	
9 x gravity bases		

7.3.2. Installation phase

- Sedimentation: There may be temporary mobilisation of sediment on the seabed;

- Accidental spillage of oil and fuels on vessels: any such spillages would have a direct impact on fish, fish food and fish habitats, and other aquatic species.

7.3.3. Operational phase

During this phase, devices will be brought to and anchored in the test areas, and routine maintenance operations will be carried out. These activities will involve vessel movement in the area. The impacts that may potentially arise include:

- Contamination of marine waters resulting from oil spillage from work vessels or devices;
- Contamination from anti-foulants used on the devices;
- Leakage of hydraulic fluids from devices during deployment: any such leakages would involve small volumes and the fluids would be rapidly dispersed in the open ocean environment;
- Short-term disturbance of the sea bed from device anchoring activities when devices are taken off station and reinstated, resulting in increased concentration of suspended solids. Any such suspended solids will rapidly disperse, and impact will be minimal.

7.3.4. Decommissioning phase

- Sediment mobilisation: The impact would be temporary, of short duration and of low significance.

7.4. Mitigation

7.4.1. Installation phase

To minimise potential impact in the marine environment:

- Use installation methods that minimise disturbance of sediments;
- Carry out work in appropriate weather / tidal conditions;
- Implementation of Shipboard Oil Pollution Emergency Plan (SOPEP);
- All hydrocarbons on board vessels should be managed appropriately to prevent their potential release to surface or ground water.

7.4.2. Operational phase

Mitigation of potential impacts during the operational phase are those for the installation phase, and also;

- Design devices to minimise risk of leakage of pollutants;
- Only oils with low environmental impact should be used;
- Use minimum quantities of antifoulants on devices.

7.4.3. Decommissioning phase

Mitigation as set out above in Section 7.4.1 will be required during the decommissioning phase.

7.5. Conclusion

The maximum footprint on the seabed of the combinations of worst case scenario infrastructure and devices is 337 m^2. This represents less than 1% of the total area of seabed within the test site, thus the impact on mobilisation of suspended sediment is very low.

The test site is not anticipated to present any significant risks to water quality during installation, operation or decommissioning. In the marine environment, the main threat to water quality is oil pollution arising from accidental leakage from the vessels used in construction and deployment and from devices in operation.

Vessels engaged in installation and operational activities will be required to have appropriately trained staff to implement an oil pollution emergency response plan and to have appropriate emergency response equipment in line with the accredited HSEQ Management System. This will minimise the impact of any oil spill that might occur.

Devices should be designed so that on-board oil leaks are contained within the hull, and only oils with low environmental impact should be used.

Overall, any impact on water quality from the project will be short-term and of low significance, and the development does not present any significant risks to water quality.

8. Seabed and Geology

8.1. Introduction

This section of the Environmental Report describes the physical seabed characteristics and the geology of Galway Bay and the environs of the proposed development at the Marine and Renewable Energy Test Site (MaRETS). It provides a description of the sediment type and composition. This chapter draws on the following data sources:

- Bedrock and structural geology available through the Department of Communications, Energy & Natural Resources and the Geological Survey of Ireland (GSI), via http://www.gsi.ie/Mapping.htm.
- Geological Survey of Ireland. Sheet 14, Geology of Galway Bay
- Aquafact report
- MSc by Cathal Clarke NUI Galway
- INFOMAR Surveys

8.2. Receiving environment

Galway Bay is a westward facing bay on the west coast of Ireland. The total area of the bay is 1445km^2. It is bound by the Burren, a karst region, to the south and Connemara to the north. The three Aran Islands guard the entrance to the Bay. The Inner Bay is relatively shallow, with depths of <30m. The Outer Bay is up to 60m in depth to the N of the Aran Islands.

The receiving environment at the test site comprises 0.375km^2 in area, 2.4km to the southeast of Spiddal Pier in water depths of 20-25m. The seabed of the test site is relatively flat and featureless. In the near vicinity of the test site, the marine geomorphology comprises rock reefs to the North, along the Connemara coastline. From 10m depth the seabed is generally sandy extending southwards

8.2.1. Sediment Types in Galway Bay

The bottom sediment of Galway Bay is mainly sand. The mud composition is highest along the north shore and falls gradually towards the south, which reflects the influence of the River Corrib and the prevailing conditions. The majority of the Inner Bay is composed of muddy fine sands which are exposed to the prevailing south-westerly wind and subject to significant resuspension. Silty sand/sand occurs over the majority of the inner bay and along the N shore of the outer bay and to the SW of the Aran Islands.

There is a predominance of gravel (shell or stone) on the South part of the inner bay. There are Maerl Beds in the North and South of the Bay, at the mouth of Casla Bay and NE of Inis Meain and Inis Oir.

The rock outcrops along most of the coastline. It is interspersed with gravel and mixed substrates. The predominant rocky outcrops in the inner Bay are Henry Ledges and the Margaretta Shoal. The rocky outcrops in outer Galway Bay are the Curan Banks, Inverin, Killa and Craigmore Patches.

8.2.2. Shallow Geology at the Marine and Renewable Energy Test Site

The shallow geology within the test site consists of bedrock unconformably overlain by unconsolidated sediment (Clarke, 2014). The unconsolidated sediment layer is interpreted to consist of muddy fine sand to coarse sand and possibly shelly gravel. The bedrock unit is interpreted to be granite or in deeper water a compacted unsorted sediment unit. The depth of sediment to bedrock can be seen in Figure 8-1. The bedrock is deepest beneath the seabed in the south of the area where it reaches a depth of 19m.

In 2014, MaRETS was surveyed by INFOMAR. An interpretation of multibeam and sub bottom profiling data was used to assess bathymetry (Figure 8-2), seabed texture, seabed features and shallow geology in Galway Bay. Multibeam backscatter data (Figure 8-3) indicates that the seabed texture has low reflectivity/smooth and is featureless

A sub-bottom profiler was deployed at the test site during the 2014 survey. Survey tracks were run at 50m line spacing on east-west and west-east headings, with crosslines on north-south and south-north headings at 70m line spacing. Data were interpreted using Coda Geosurvey and output to ascii files. Depths to the main reflectors; (Bedrock and Horizon 1) were plotted and colour coded based on depth. Three different geological units were interpreted. Unit 1 is bedrock. The bedrock sporadically outcrops in the very north of the area and is up to 22 metres beneath the seabed in the southern part of the site.

The sub-bottom profile data indicates the presence of glacial till and near-surface or exposed bedrock. Glacial till is a catch-all term for the poorly sorted soil deposited by some glacial processes, although it is frequently encountered as boulder clay – that is, poorly sorted gravel, cobbles and boulders in a clay matrix. The glacial till of the study area is derived from the underlying metamorphic rocks, which consist primarily of gneiss. It is the result of glacial action during the last Ice Age, which ended approximately 10,000 years ago.

Figure 8-4 is an interpretation of a single track with geological units and reflectors annotated. The bedrock is close to the seabed in the north but at depth in the south. The survey line is 1 km in length from south to north. As an indication of vertical scale, Horizon 1 is approximately 10 metres beneath the seabed.

8.2.3. Seabed Substrate at the test site

As part of the investigation by Aquafact in 2010, six sediment samples were taken for biological and physical analysis (Figure 8-5). The results from the traditional granulometric analysis can be seen in

Table 8-1. Figure 8-6 shows this data in graphical form. The sediment sampled during the survey was classified slightly gravelly muddy sand, muddy sand, sand and slightly gravelly sand according to Folk (1954), (Figure 8-7)

The majority of stations were classified as muddy sand (Stations S2, S3 and S4). These stations were located in the northwestern part of the test site. Sand was present at station S5 in the southern part of the test site and slightly gravelly muddy sand was present at station S1 in the eastern part of the test site. The control site, S10 was classified as slightly gravelly sand.

Station S1 contained the highest percentage of gravel (1.7%), very coarse sand (1.7%), coarse sand (1.9%), medium sand (2.2%) and silt-clay (13.1%). Station S6 contained the highest percentage of fine sand and station S4 contained the highest percentage of very fine sand (74.5%).

Table 8-1: Granulometric analysis of bed sediment samples

Station	Gravel* (%)	Very Coarse Sand* (%)	Coarse Sand*(%)	Medium Sand*(%)	Fine Sand* (%)	Very Fine Sand*(%)	Silt-Clay* (%)	Folk*
S1	1.7	1.7	1.9	2.2	13.9	65.4	13.1	Slightly Gravelly Muddy Sand
S2	0.3	0.7	1.2	1.6	11.8	73.9	10.6	Muddy Sand
S3	0.7	1	1.5	1.8	12.6	71.4	11	Muddy Sand
S4	0.2	0.7	1.3	1.7	11	74.5	10.7	Muddy Sand
S5	0.5	0.9	1.4	1.8	14.4	72	8.8	Sand
S6	1.1	0.9	1.3	1.9	24.4	63.7	6.7	Slightly Gravelly Sand

8.3. Impact of the development

8.3.1. Worst Case Scenario

The impacts of the Galway Bay Marine and Renewable Energy Test Site project have been assessed under the following worst case scenario deployment of items at the test site in Table 8-2.

Table 8-2: Cultural Heritage worst case scenario

Permanent	Recurring	Devices
4 x cardinal marks	Data buoy	1 x OWC
Subsea observatory	Acoustic Array	1 x Point Absorber
Waverider	ADCP	1 x Attenuator
SeaStation	Cabling	
9 x gravity bases		

8.3.2. Impact Assessment

The impacts of the development on the seabed and geology are the same for installation, operational and decommissioning phases of the project.

All prototypes on test at the site will be anchored to the seabed using gravity anchors, or embedment anchors. The placement of anchoring systems may give rise to some small-scale sediment displacement. Scour protection using rock deposition may also be required to prevent erosion around anchoring systems. This is not anticipated to have any impact on the nature and distribution of marine sediments.

The maximum footprint on the seabed of the combinations of worst case scenario infrastructure and devices is 337 m^2. This represents less than 1% of the total area of seabed within the test site.

Given the type of works, the nature of the project and the environmental setting, it is not anticipated that the marine aspect of the proposed development will have any discernible impact on sediments and geology.

8.4. Mitigation

No impacts are anticipated with regard to sediment and geology offshore. Therefore no specific mitigation measures are anticipated beyond using installation methods that minimise disturbance of sediments.

8.5. Conclusion

The proposed development does not present any significant risks to sediment or geology during construction or subsequent operation.

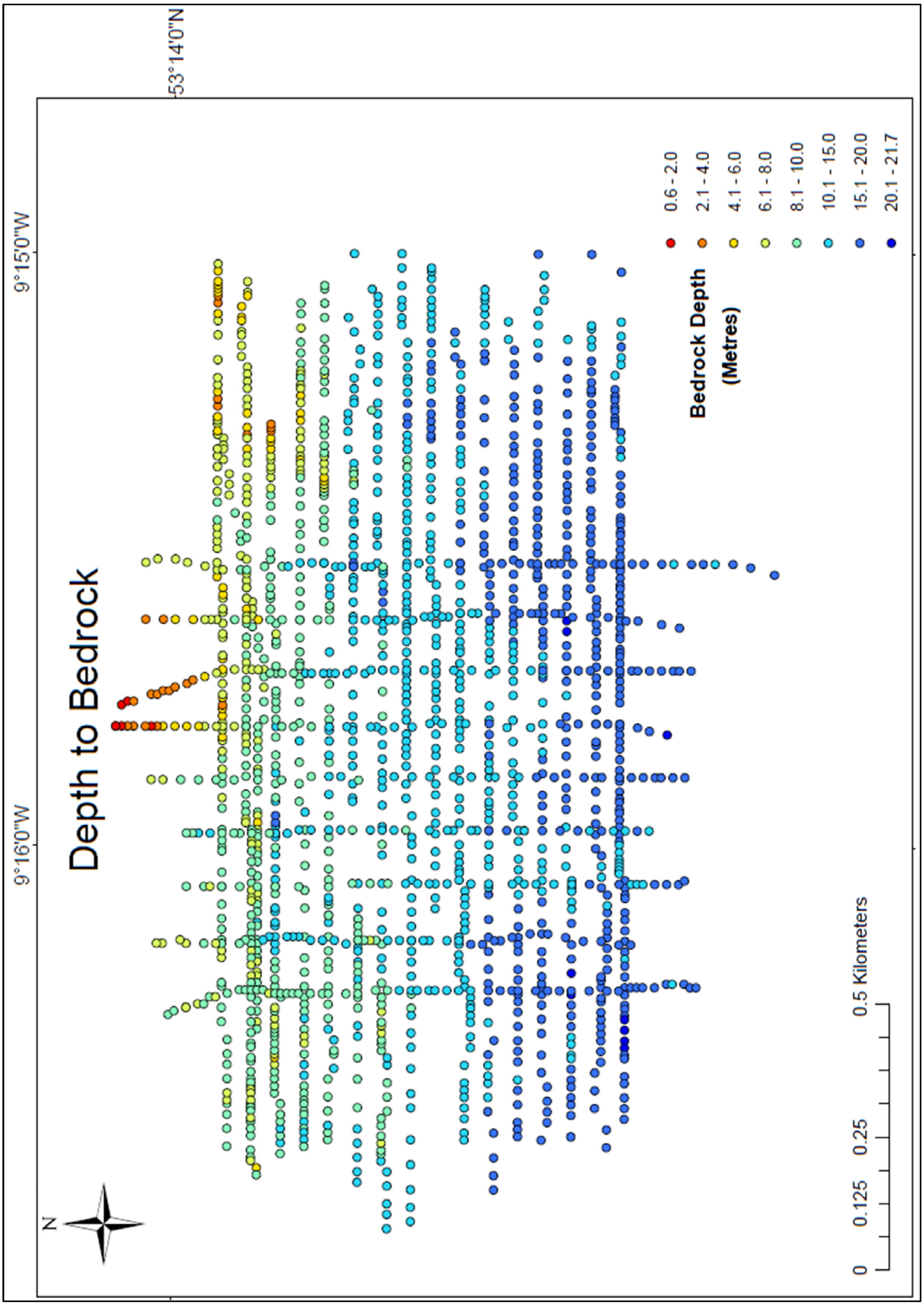

Figure 8-1: Depth to bedrock at Galway Bay Marine and Renewable Energy Test Site

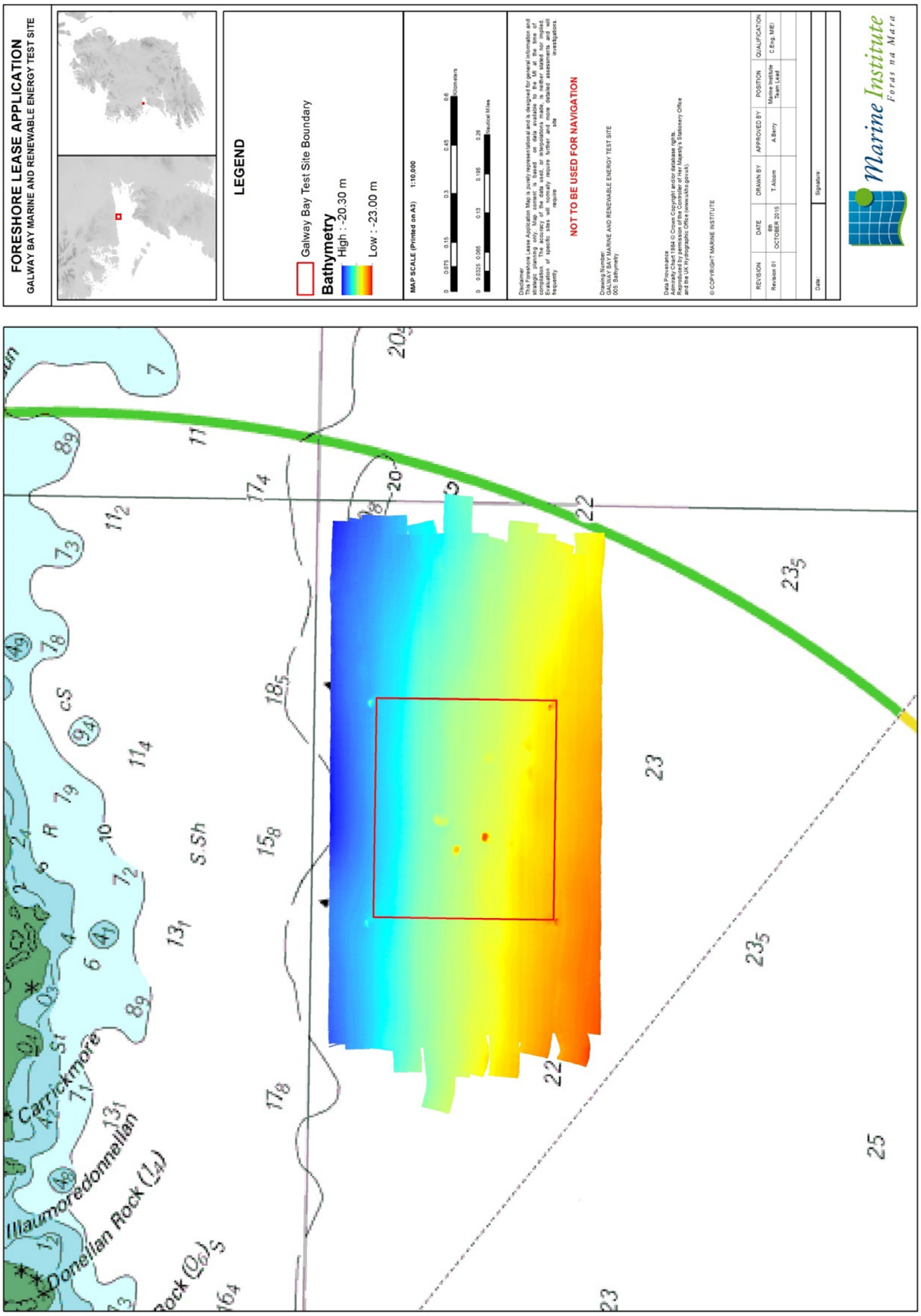

Figure 8-2: 2014 Bathymetry at Galway Bay Marine and Renewable Energy Test Site

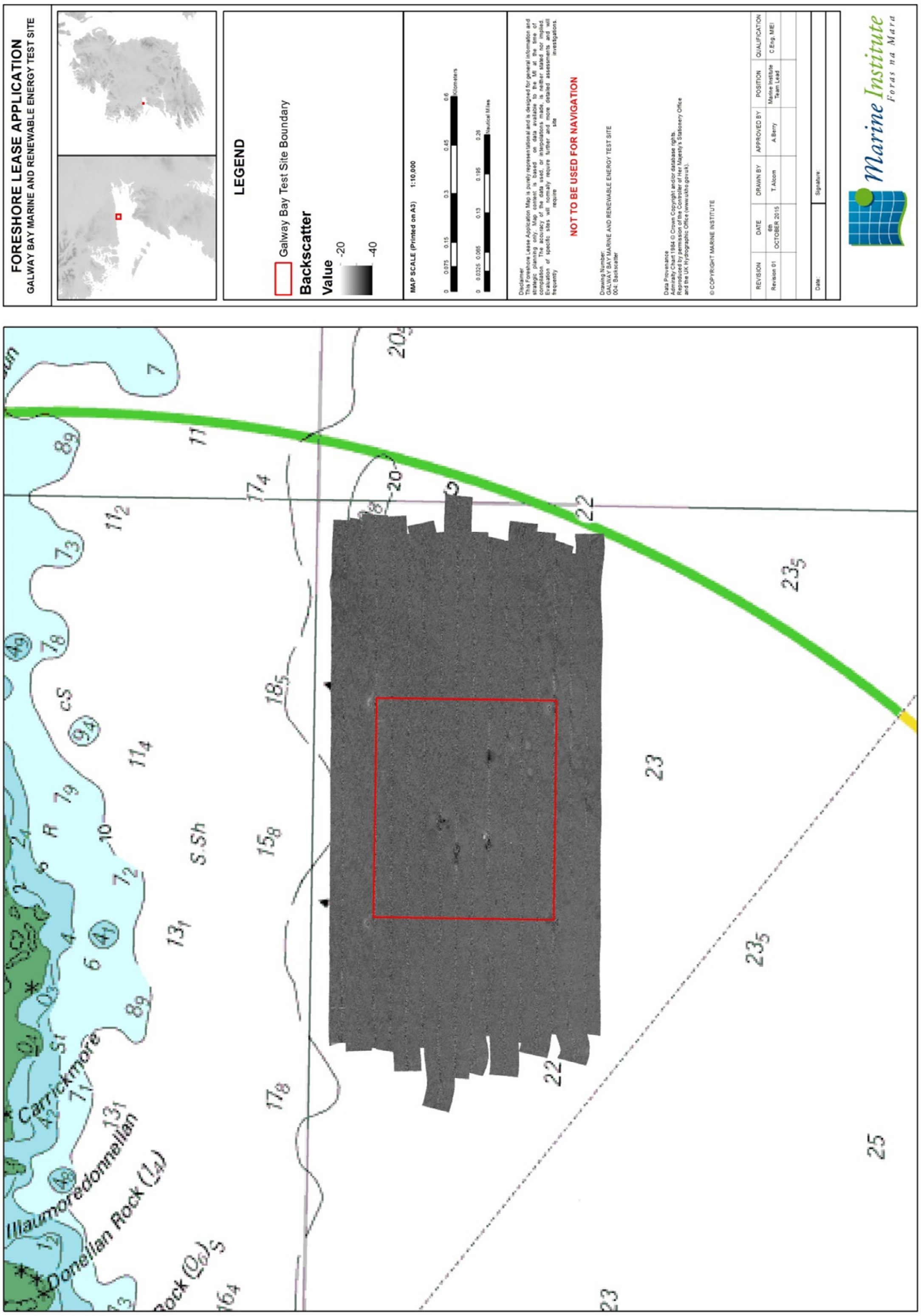

Figure 8-3: Backscatter mosaic of the wave energy test site

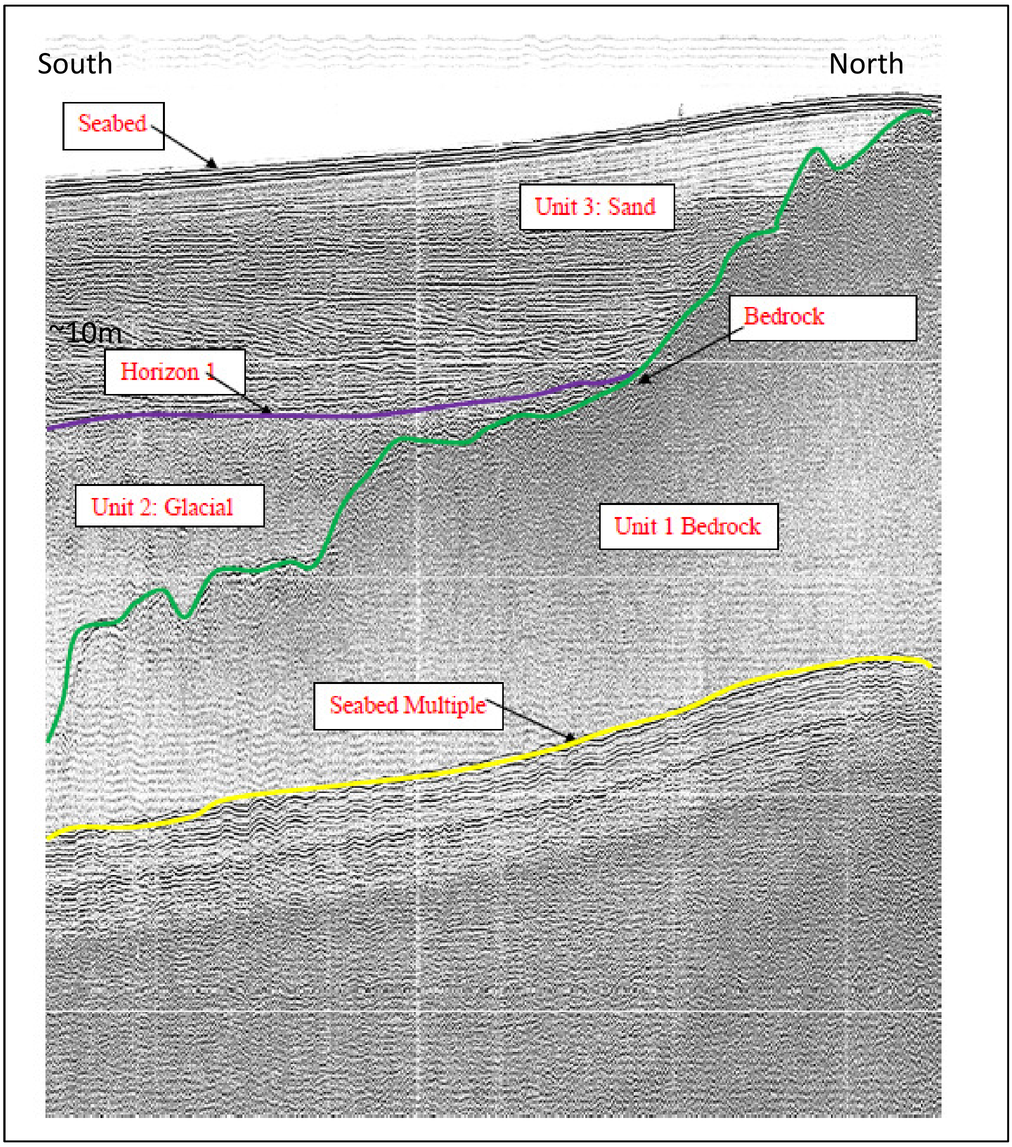

Figure 8-4: South-North sub bottom Profile of the Marine and Renewable Test Site

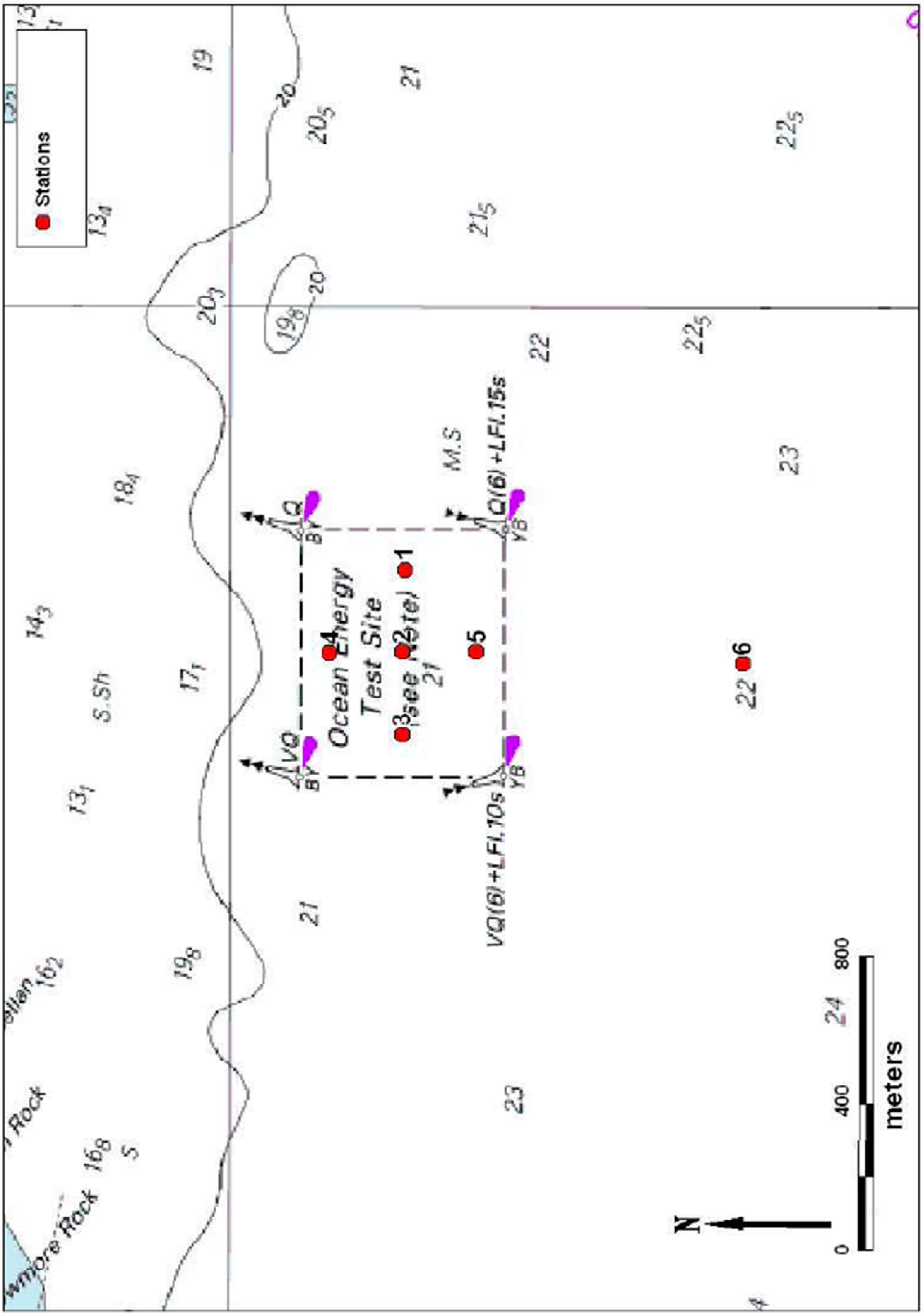

Figure 8-5: Map showing location of sampling stations (AQUAFACT, 2010)

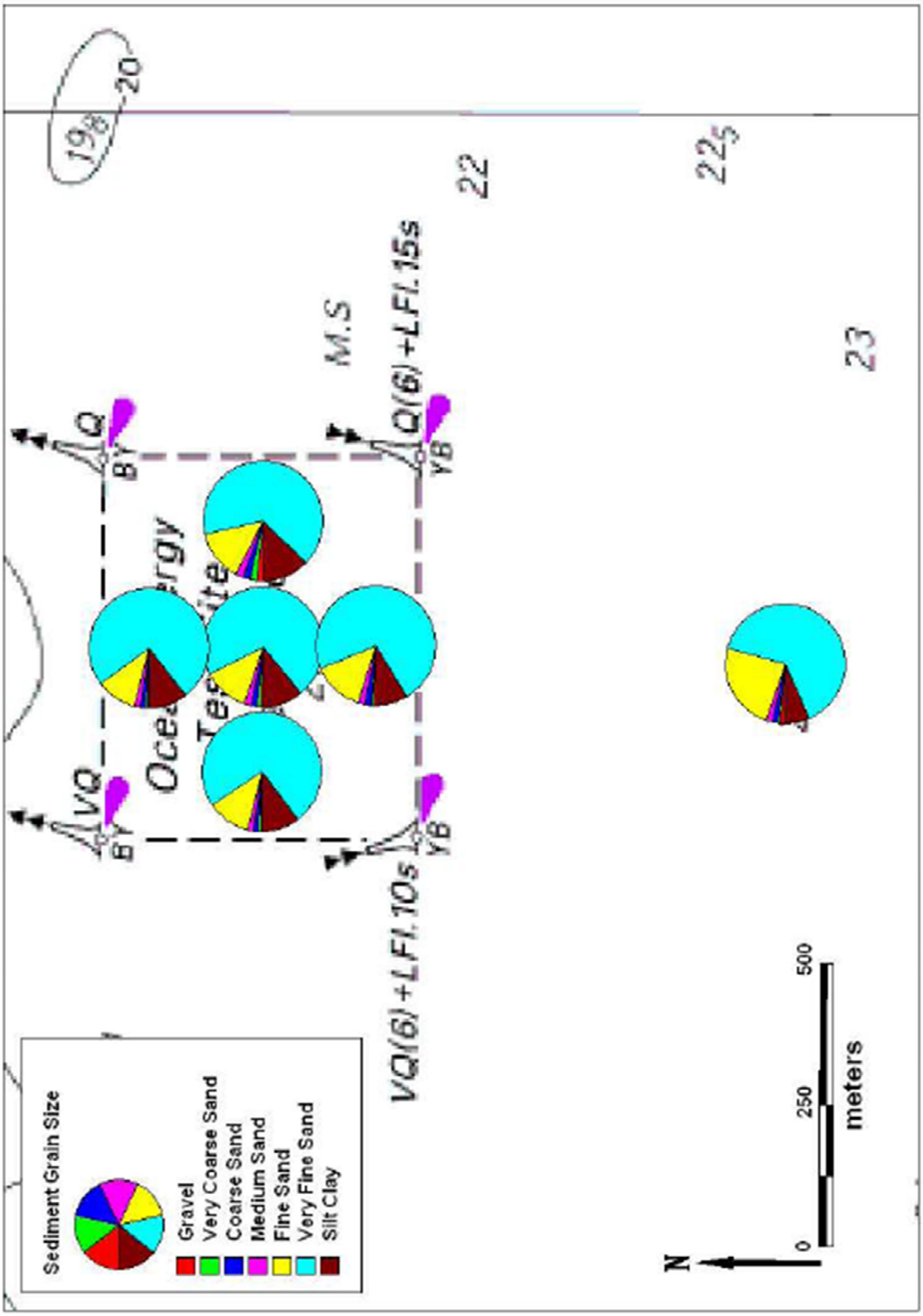

Figure 8-6: Sediment Grain Size and distribution at Marine and Renewable Test Site

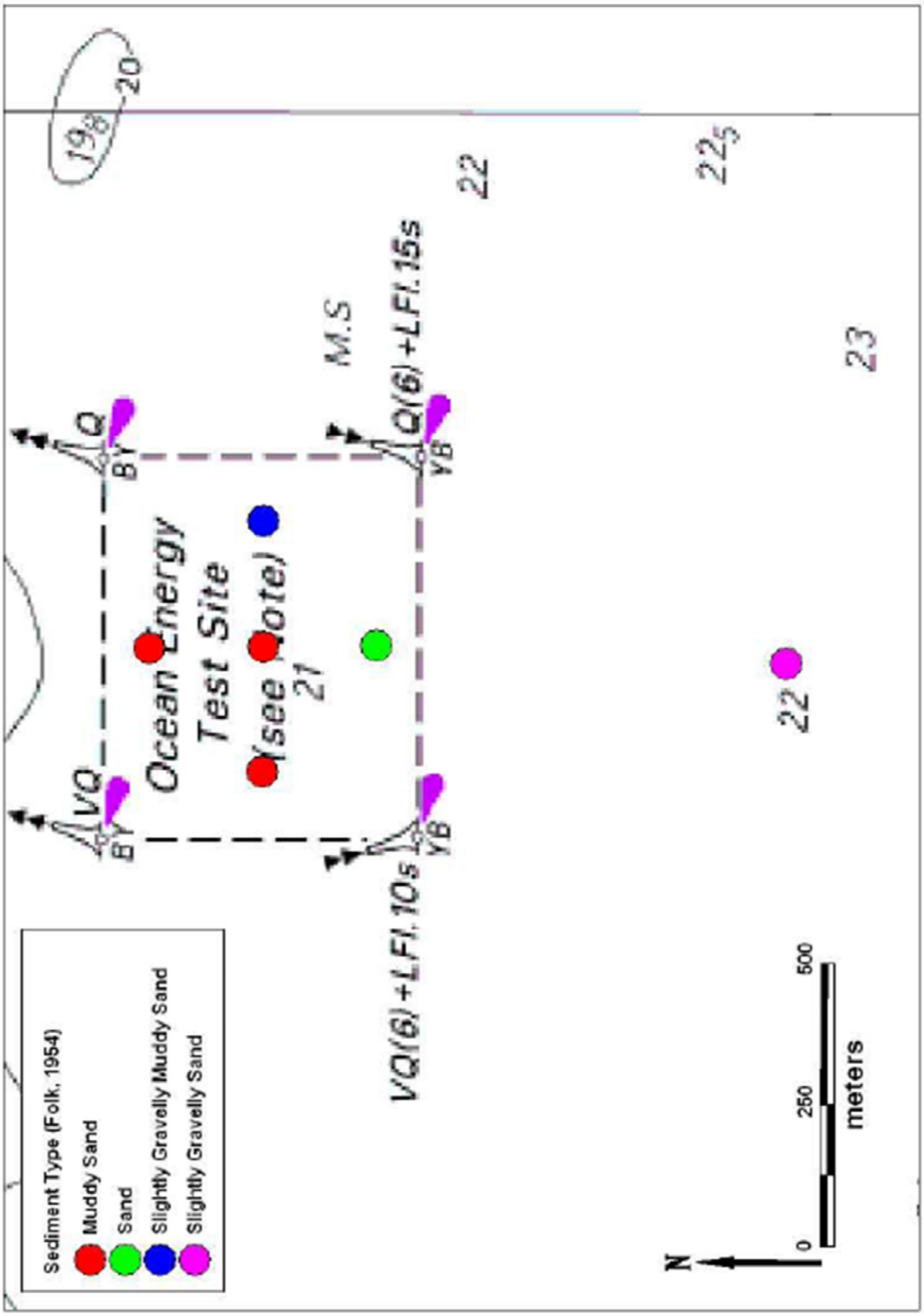

Figure 8-7: ***Sediment Grain Size according to Folk Classification***

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9. Air Quality

9.1. Introduction

This chapter provides a qualitative assessment of potential impacts of the development on air quality during the installation, operation and decommissioning phases.

The installation relates to the offshore marking of the test site, operation relates to ocean energy devices and prototype deployment, mooring and recovery operations. Vessel emissions associated with these activities are not anticipated to contribute to emissions above normal background levels in Galway Bay due to the short duration of operations, and their impacts are predicted to be negligible.

9.2. Receiving environment

The Environmental Protection Agency (EPA) is an independent public body charged with the statutory protection of the environment in Ireland. In conjunction with individual local authorities, it undertakes ambient air quality monitoring at specific locations throughout the country in both urban and rural environments. It prepares an annual air quality report based on data from thirty three monitoring stations.

Air quality data is provided by the Mace Head Coastal Research Station (53° 19'N, 9° 54'W) operated by NUI Galway, near Carna on the west coast. This station is an important Global Atmosphere Watch (GAW) measurement site and is designated as a clean marine background station for atmospheric aerosol research. It contributes to the World Data Centre on Greenhouse Gases.

The EPA's most recent report, Air Quality in Ireland 2014 – Key Indicators of Ambient Air Quality (published in 2015), indicates that, overall, air quality in Ireland continues to be good and remains the best in Europe. Measured values of sulphur dioxide (SO2), nitrogen dioxide (NO2), carbon monoxide (CO), ozone (O3), particulate matter (PM10 and PM2.5), heavy metals, benzene and polycyclic aromatic hydrocarbons (PAH) were all below limit and target values set out in the Ambient Air Quality and Cleaner Air for Europe (CAFE) Directive (transposed into Irish law by the Air Quality Standards Regulations 2011 – SI 180 of 2011), and the 4th Daughter Directive.

Since air quality targets are being met across the country, particularly in urban settings such as Galway City, it is assumed that air quality is also satisfactory in the Spiddal region, a less densely populated, coastal area.

The receiving environment will be the offshore area where the test site is located. The nearest potential receptors are likely to be the existing residential and business premises in Spiddal, some 2.4km from the test site and the recreational users of the area.

9.3. Impact of the development

9.3.1. Worst Case Scenario

The impacts of the Galway Bay Marine and Renewable Energy Test Site project have been assessed under the following worst case scenario deployment of items at the test site in Table 9-1.

Table 9-1: Air Quality worst case scenario

Permanent	Recurring	Devices
4 x cardinal marks	Data buoy	1 x OWC
Subsea observatory	Acoustic Array	1 x Point Absorber
Waverider	ADCP	1 x Floating Wind Turbine
SeaStation	Cabling	
9 x gravity bases		

9.3.2. Impact Assessment

Potential impacts and mitigation measures have been identified using background data from other marine energy test sites, such as EMEC in Scotland, and with reference to the environmental assessment for the Atlantic Marine Energy Test Site (AMETS) in Belmullet, Co. Mayo (SEAI, 2011).

The only impacts associated with the installation of the test site are those for the deployment of the cardinal marks at the test site. This operation is expected to take at most one day with emissions from the required vessel negligible in a local context over the course of the day.

Offshore activities by their nature are weather-dependent, and the estimates for the duration of installation and vessel operation on-site are based on acceptable weather conditions. Should inclement weather conditions result in more prolonged vessel activity, the predicted emissions will increase accordingly, but will still be negligible in terms of potential impact on receptors in the area.

The operational phase of the test site will involve the recurring deployment and testing of devices and their subsequent recovery at least annually. A maximum of three devices can be accommodated in the test site at any one time. Their deployment and recovery would involve vessel movement (devices towed to and from the test area) and mooring operations (emplacement of anchoring systems and connection to the SeaStation if required). Devices will be deployed using local tugs, work boats, or national research vessels with integrated dynamic GPS, enabling them to stay on station without mooring hardware.

Mooring operations may require multiple trips to the test area from the port where equipment will be stored, as it is unlikely that the vessel used would have sufficient capacity to carry all the equipment in one trip. Mooring operations are likely to take several days to accurately install the mooring systems for a device. Devices will be towed to the site and connected to the installed mooring system. This operation will be completed within two days for each.

Based on the analysis undertaken for the fullscale test site in AMETS, even if the maximum number of devices is deployed at the site at any one time, the overall impact would be negligible.

Decommissioning of the devices and test area will involve removal of the device mooring system and cardinal marker buoys. This will require local work boats or tugs as previously described. It is estimated that this each operation will take approximately three days to complete. Estimated emissions during the decommissioning stage are less than those for the installation and operational phases, and only a negligible impact is anticipated.

9.4. Mitigation

In accordance with the accredited HSEQ Management System for test site operations, all vessels will be required to meet relevant emissions standards. No specific mitigation measures are proposed and it is not anticipated that offshore operations will result in a significant or prolonged incremental increase in emissions in the project area. As there will be negligible impacts on receptors in the area onshore, no specific mitigation measures are proposed.

9.5. Conclusion

Emissions from offshore vessels constitute a small fraction of one percent of national air emissions. Emissions associated with this project will be of short duration. Considering the low levels of air pollutants in the receiving environment and the rapid dispersion in the area, the impact on air quality from emissions associated with installation, operation and decommissioning of the test site is predicted to be negligible.

Overall, the impacts on air quality will be negligible, both in the national context and in the immediate receptor area.

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10. Cultural Heritage

10.1. Introduction

Cultural heritage in respect of the project is assumed to include all humanly created features on the affected landscape, including portable artefacts, which might reflect the prehistoric, historic, architectural, engineering and/or social history of the area. Archaeological activity underwater and in the coastal zone has expanded significantly in recent years, with a consequent rirsing awareness of the need to protect cultural resources in the marine environment from damage by human and natural action.

All archaeological sites and monuments are protected under the National Monuments Act 1930 and subsequent Amendment Acts, 1954, 1987, 1994, 2004, the Heritage Act, 1995 and 'The Valetta Convention'. The European Convention on the Protection of Archaeological Heritage (revised), European Treaty Series No. 143, dated 16 January 1992 (commonly referred to as 'The Valetta Convention') entered into force for Ireland on 19 September 1997.

The archaeological assessment of the proposed upgrade to the Galway Bay Marine and Renewable Energy Test Site has been prepared in conjunction with Geomara Ltd., and is based on the detailed report in Appendix 7.

Previously, Moore Marine was commissioned by the Marine Institute to carry out an underwater archaeological and cultural heritage impact assessment of three route options for a proposed cable to travel from the north shore of Galway Bay between Spiddal and Furbogh to the Wave Energy Test Site, c. 1.3km south from the shore.

That report informed Chapter 8 of the Galway Bay Cable Project Environmental Report. Side-scan sonar and magnetometer surveys revealed no potential shipwrecks or RMP sites along the subtidal cable route. The sub-bottom profiler data indicated the presence of an unconsolidated sediment filled palaeo-valley which extends from the Boluisce River estuary just to the east of Spiddal New Pier.

10.2. Methodology

The assessment comprises a desktop assessment of background historical and archaeological data relating to the site and assessment of third party acquired marine geophysical data. It provides an overview of the site data and the proposed test site operations. It also outlines the potential impact of the proposed development on the receiving environment and suggests measures to mitigate any impact.

This assessment takes into account the following legislative procedures and guidelines:

- The Continental Shelf Act
- The National Monuments Act (1930-2004),
- The Foreshore Act (1933),

- Merchant Shipping Act (1995);
- Valetta Convention;
- ICOMOS;
- UNESCO

The assessments consulted the following sources:

- Local and National Libraries;
- The National Monuments and Site Register;
- The National Museum – topographical files;
- The Geological Survey of Ireland – aerial photographs;
- Examination of historic maps and related sources;
- The Architectural Archive of Ireland;
- The National Archives of Ireland;
- Historic Annals;
- Lewis' Topographical Dictionary;
- Genealogical Societies and Local Historical Societies;
- The Ports and Harbour Archive;
- The National Shipwreck Inventory.

A variety of sources were consulted to provide information on potential impacts and the relationship of the test site within the wider maritime context to include all known maritime and terrestrial cultural heritage assets. Together these provided an overview of the proposed test site and its surroundings which could then be used to determine areas of archaeological potential.

Two elements of the previous assessments were worth highlighting. The shipwreck inventory noted four vessels being lost near Spiddal. No evidence of any of these vessels or their remains was noted along the cable route or the new subject site.

A paleo valley was noted just to the east of Spiddal new pier. This highlights the possibility of subsea floor archaeological features associated with relative sea level rise. No evidence of any palaeo-landscape was noted at the proposed site.

For the current assessment, geophysical surveys were carried out at the test site in 2015 (Figure 10-1). The area was surveyed through INFOMAR the national seabed mapping programme. Datasets collected in 2015 for the area of interest include; magnetometer and side scan sonar. Previous geophysical and bathymetric data acquired in 2014 (multibeam and sub bottom profiler) were also provided for the current assessment.

The processed data from 2014 and the unprocessed data from 2015 were analysed using combinations of the following software; Sonar Wiz 6, Hypack 2015, Microsoft Excel, PDS2000 and ARC GIS.

The following equipment was deployed during the surveys.

Table 10-1: Equipment deployed during the surveys

Instrument	Model	Frequency
Multibeam Echo sounder	EM2040	200,300 and 400 kHz
Side Scan Sonar	Edgetech 4200	100 and 500 kHz
Sub Bottom Profiler	Sonar equipment Services Pinger	3.5 – 9 kHz
Magnetometer	Seaspy	

10.3. Receiving environment

The side scan acoustic returns across survey were uniform across the survey area indicating a sandy seafloor. Eleven anomalies were highlighted during the processing (Figure 10-2). All eleven anomalies are also visible on the bathymetric data. Four mooring buoy anchor scars with associated rope or chains were noted and formed a square area (Contacts 1, 2, 11 and 9). These were the locations of the four cardinal marks delimiting the wave energy test site. Three large anchor scars at the centre of the test energy site can ranging from 15 – 40m can be clearly identified (Contacts 3, 4 and 5). Another two anomalies due to their location are likely to be associated with the two southern marker buoys (Contacts 10 and 8). Two further unidentified anomalies were also noted (Contacts 6 and 7), and are most likely anchor scars associated with the OE Buoy wave energy converter.

The ambient magnetic field in the vicinity of Galway Bay is in the region of 49,000nT (nanotesla). The magnetometer data collected from the Galway Bay Test Site shows no significant variation from the ambient value. The data ranges from a low of 49,192nT to a high of 49,333Nt. This amounts to a localised variation of 141nT across the area of survey. The post processed magnetometer data sets showed no magnetic anomalies in the survey area to reflect the presence of archaeological remains or debris.

The seafloor slopes very gently towards the centre of Galway Bay from north to south (Figure 10-3). The sea floor ranges from 20 m along the northern edge of the survey area to 23 m along the southern edge. A number of localised hollows area clearly visible and correspond precisely with anomalies recorded on the Side Scan sonar data. The features relate to anchor scars from the four cardinal marker buoys and anchor marks from previous deployments within the wave energy test site.

The backscatter mosaic like the Side Scan sonar data reveal a very uniform seafloor with little variation across the entire survey area (Figure 10-4). The four cardinal marker buoy anchor scars are visible along with the other anchor scars associated with deployments at the wave energy test site.

The bedrock surface mirrors the bathymetry in that it increases from north to south across the wave energy site (Figure 10-5). The bedrock however dips more sharply than the seafloor with the depth to bedrock ranging from 0.5m – 8m along the northern side of the area and 15m – 20m along the southern edge of the area. A second horizon was also noted between the seafloor and the bedrock which has been interpreted as corresponding to a change from sand below the seafloor to glacial till above the bedrock.

The sea floor and bedrock reflectors were visible (Figure 10-6 and Figure 10-7). It is also possible to discern the sand/ glacial till interface noted previously in some of the profiles. No other features were noted on any of the sub bottom profiles. Nothing of any archaeological significance was noted.

10.4. Impact of the development

10.4.1. Worst Case Scenario

The impacts of the Galway Bay Marine and Renewable Energy Test Site project have been assessed under the following worst case scenario deployment of items at the test site in Table 10-2.

Table 10-2: Cultural Heritage worst case scenario

Permanent	Recurring	Devices
4 x cardinal marks	Data buoy	1 x OWC
Subsea observatory	Acoustic Array	1 x Point Absorber
Waverider	ADCP	1 x Floating Wind Turbine
SeaStation	Cabling	
9 x gravity bases		

10.4.2. Impact Assessment

Based on the results of the assessment study, it would appear that the proposed development will have a specific but limited direct impact on the seafloor.

The desk based archaeological assessment indicated the possibility of encountering evidence for wreck sites and paleo environmental features associated with relative sea level rise. The bathymetric and geophysical surveys did not reveal any features associated with these two possibilities.

Following review of the survey data, no archaeological features were identified within the test site. It is suggested that the current proposed development will not have any impact on any known archaeological features.

The project envisages the permanent deployment of four cardinal markers at the corners of the test site. These will be moored to the sea bed by a single point chain mooring affixed to a 2 tonne clump weight. The predicted impact of these on the sea floor will be limited to anchor scarring similar to that noted and highlighted in the bathymetry and side scan data from the previously deployed cardinal marker buoys.
A cable end equipment frame will be permanently installed on the seafloor in the south west corner of the test site and will be anchored under its own weight. The predicted impact on the seafloor will be of a similar magnitude to the anchor scarring previously noted.

A Wave Rider data buoy will be moored on the west side of the test area by a single point mooring affixed to a 0.5 tonne clump weight. It is envisaged that the resultant seafloor impact footprint will be less than that resulting from the 2 tonne cardinal marker clump weights.

A SeaStation platform will be moored by four two point chain moorings affixed to a 2 tonne high hold anchor such as a Danforth. These anchors are designed to dig deeper into the sea floor the more strain or force that is exerted on them.

It is proposed to install a prefabricated modular frame capable of containing concrete weights of up to 9 tonnes. This will be deployed as a gravity base for mooring various test devices. A series of interlocking frames may also be deployed. The 9 tonne weights associated with the gravity base will have an impact on the seafloor.

The side scan and bathymetry survey data both revealed the effects of anchoring operations on the sea floor. These were exclusively manifested as anchor scars clearly visible on the sea floor.

The hold anchor associated with the sea station may have more impact on the sea floor and it is unclear what impact the proposed gravity base composed of an interlocking modular frame and concrete weights will have on the seafloor. Also at this stage it is unclear what other mooring systems will be used to deploy other recurring short term infrastructure.

The maximum footprint on the seabed from the combinations of worst case scenario infrastructure and devices is 337 m^2. This represents less than 1% of the total area of seabed within the test site.

10.5. Mitigation

It is suggested that any future proposed anchoring or mooring systems for short term infrastructure associated with the deployment of devices at the wave energy test site should be reviewed and assessed for archaeological impacts. This would be especially important where any subsurface anchoring systems such as suction anchors were proposed.

It is also advised that review surveys should be undertaken annually to monitor the impact of the proposed anchoring methodologies and to assess the impact of the proposed gravity base.

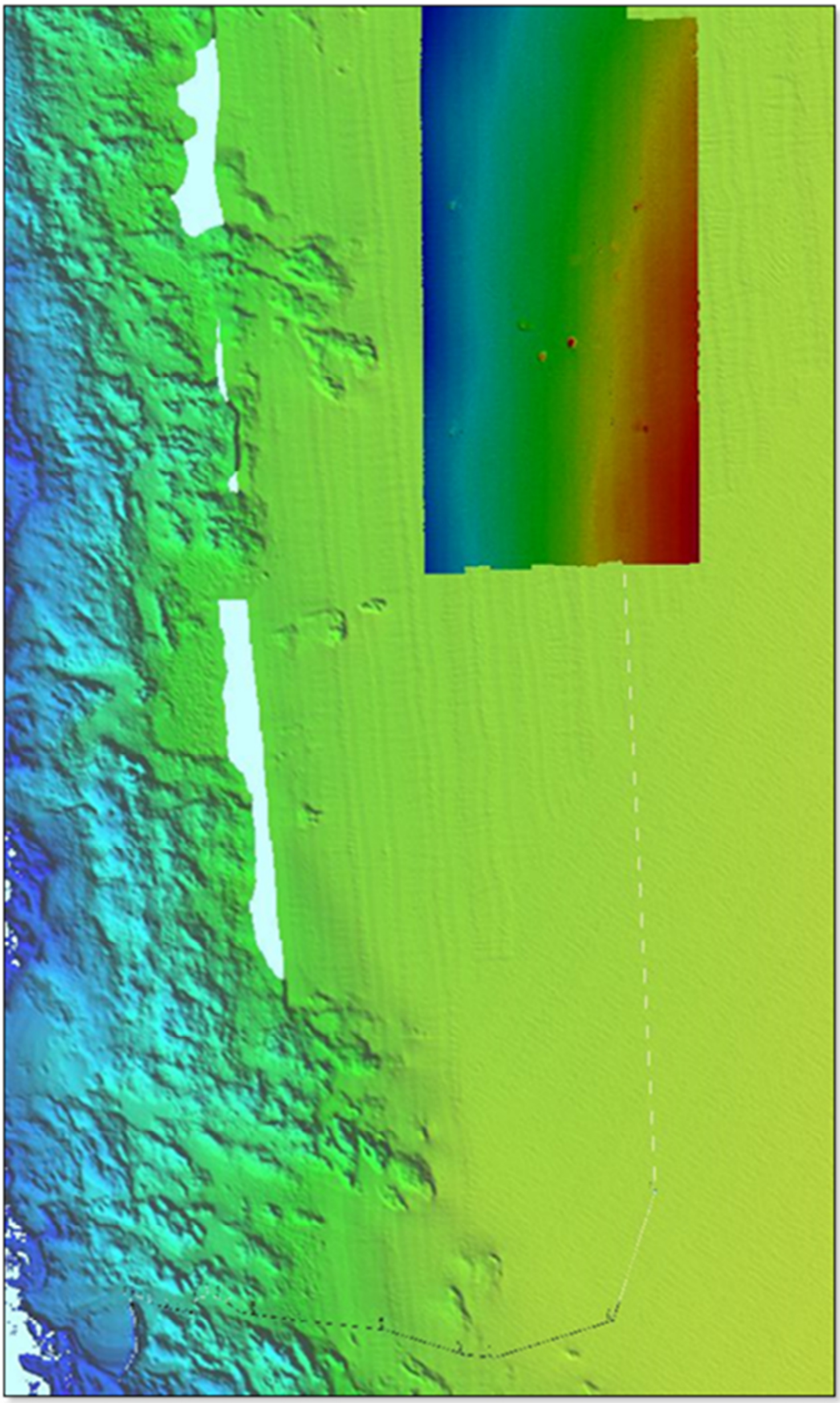

Figure 10-1: Location of the bathymetry data superimposed on a larger scale bathymetry data set for Galway Bay. The associated cable route and landing at Spiddal pier is also visible

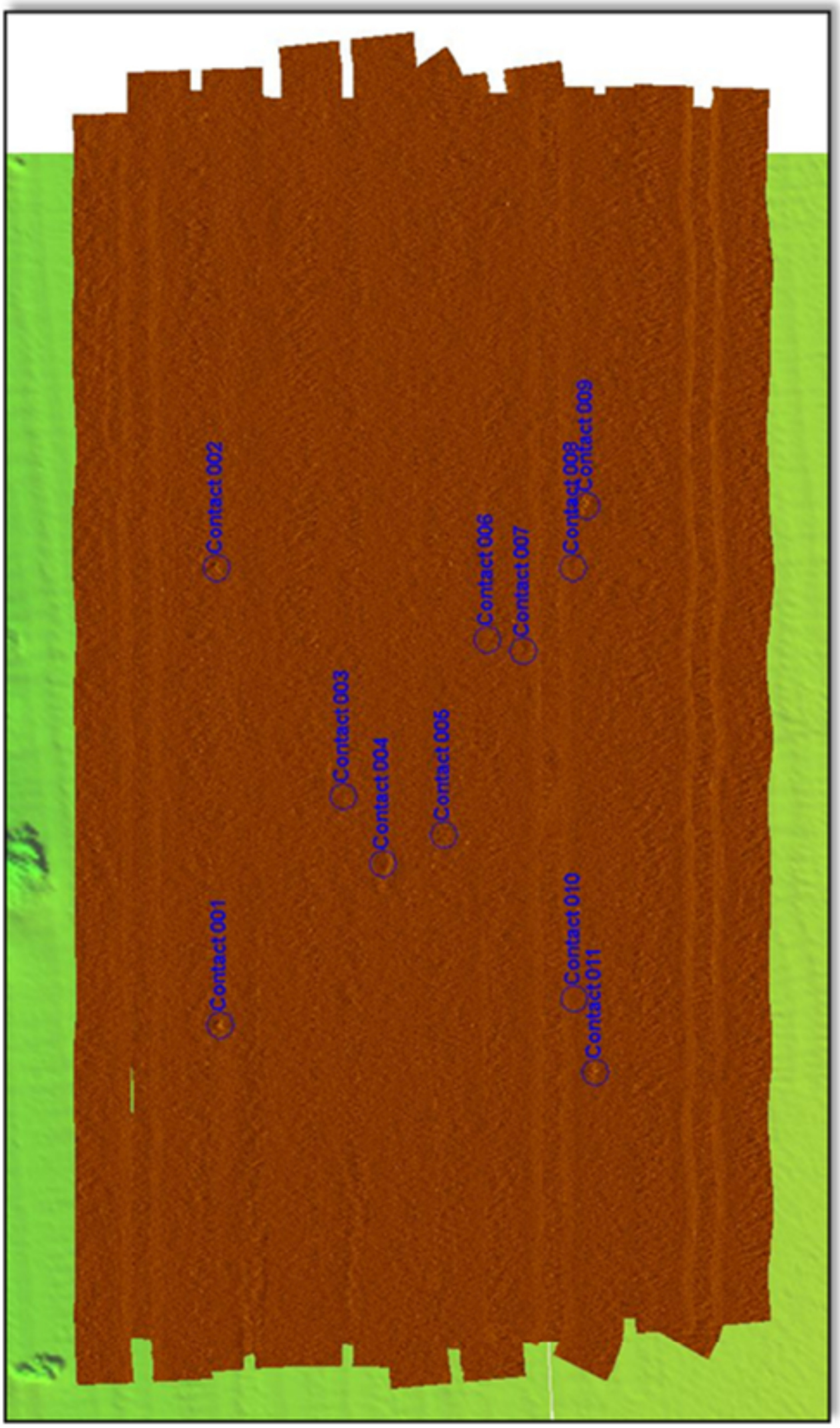

Figure 10-2: Sidescan survey mosaic overlain on bathymetry data. Shows contacts 1-11

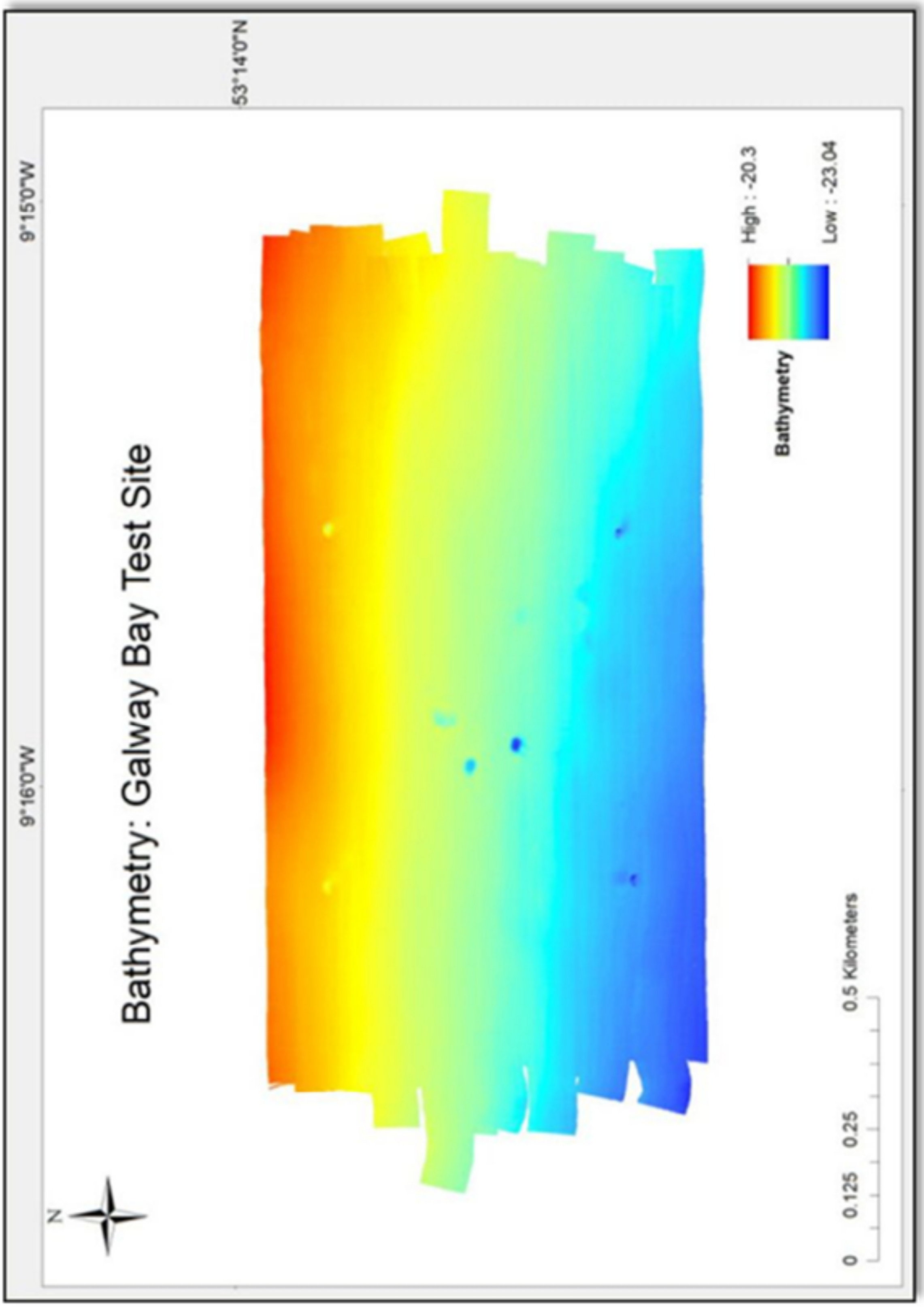

Figure 10-3: Multibeam bathymetry grid of the wave energy test site

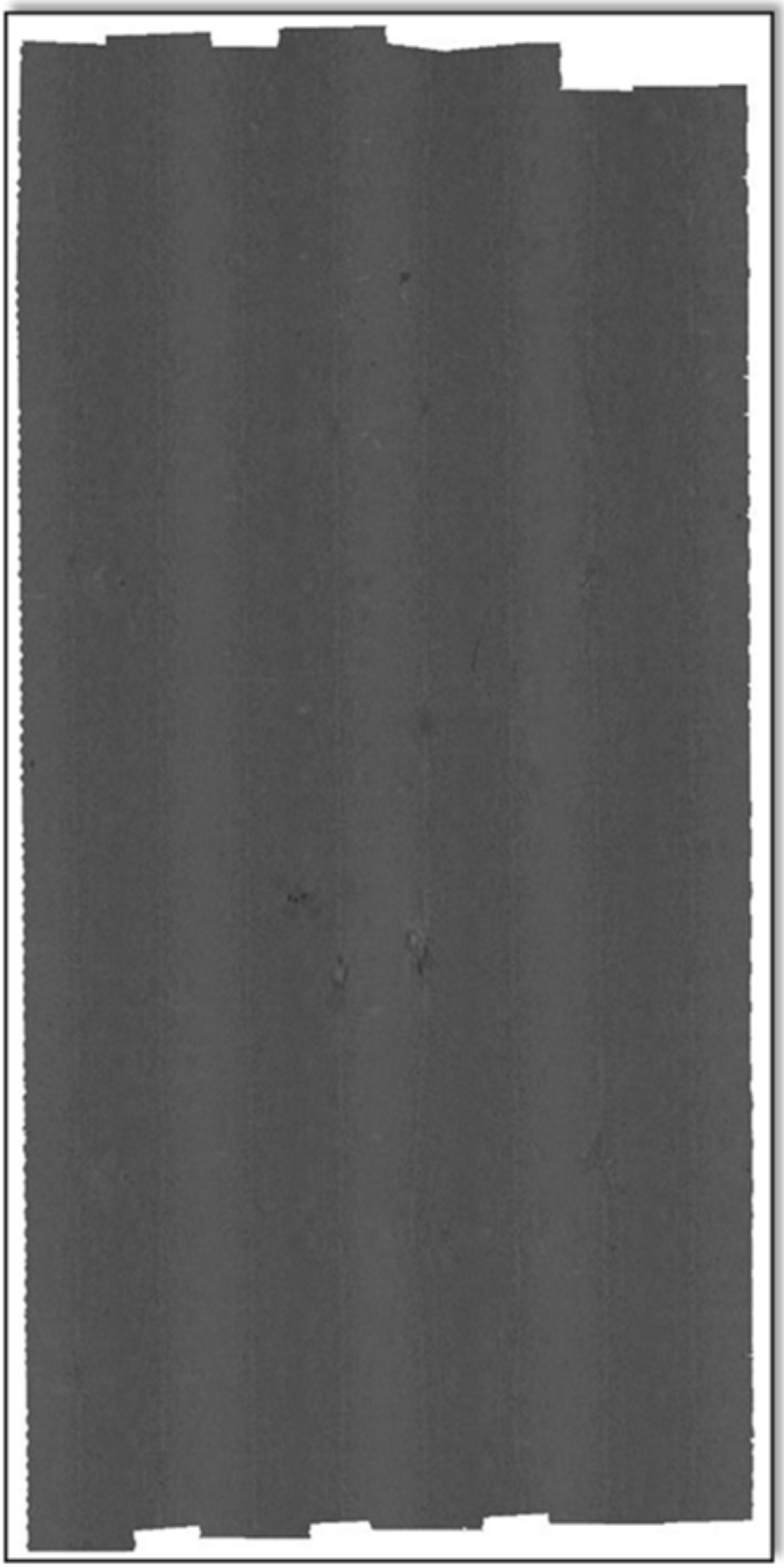

Figure 10-4: Backscatter mosaic of the wave energy test site

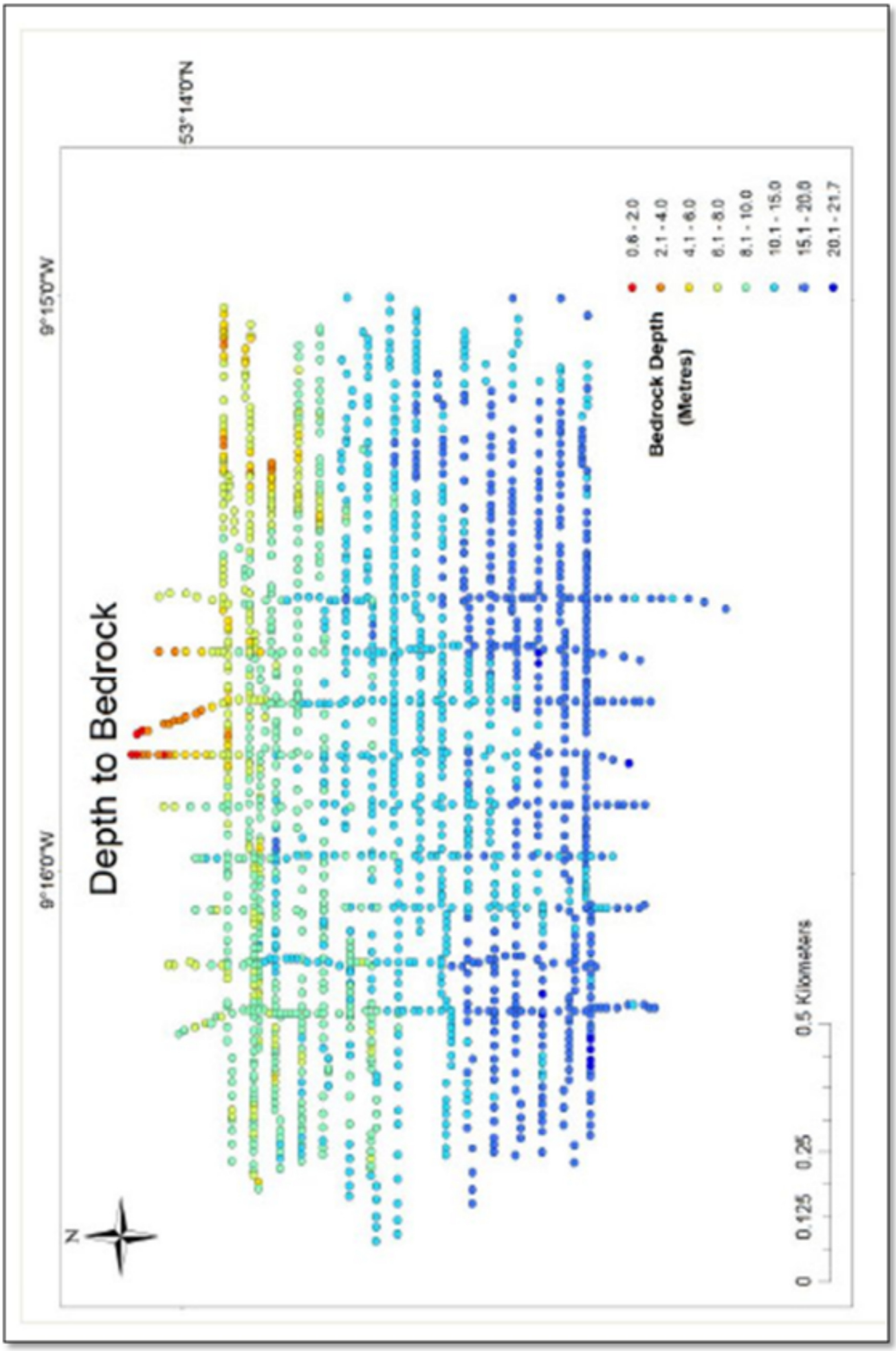

Figure 10-5: Sub bottom profile data used to generate a depth to bedrock surface

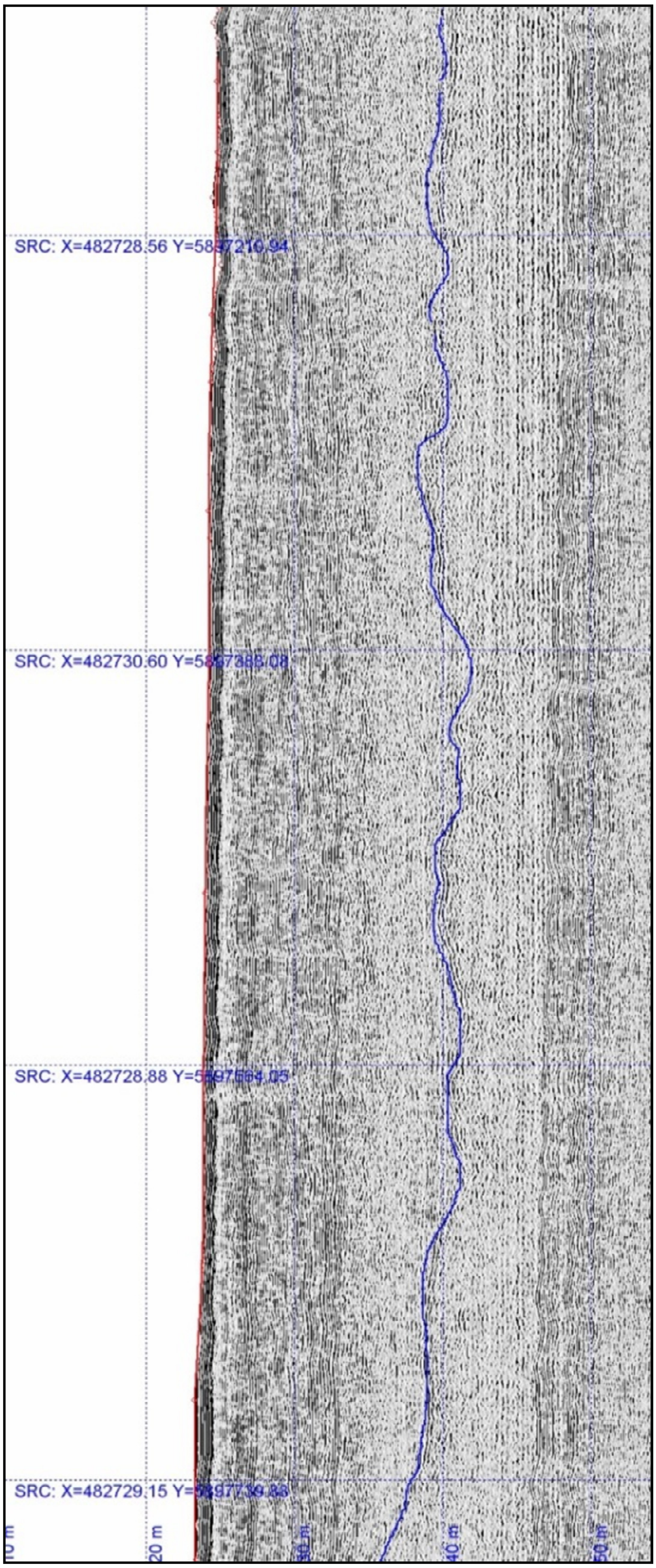

Figure 10-6: Section of SBP line 260414.182700_176 showing the seafloor and bedrock reflectors

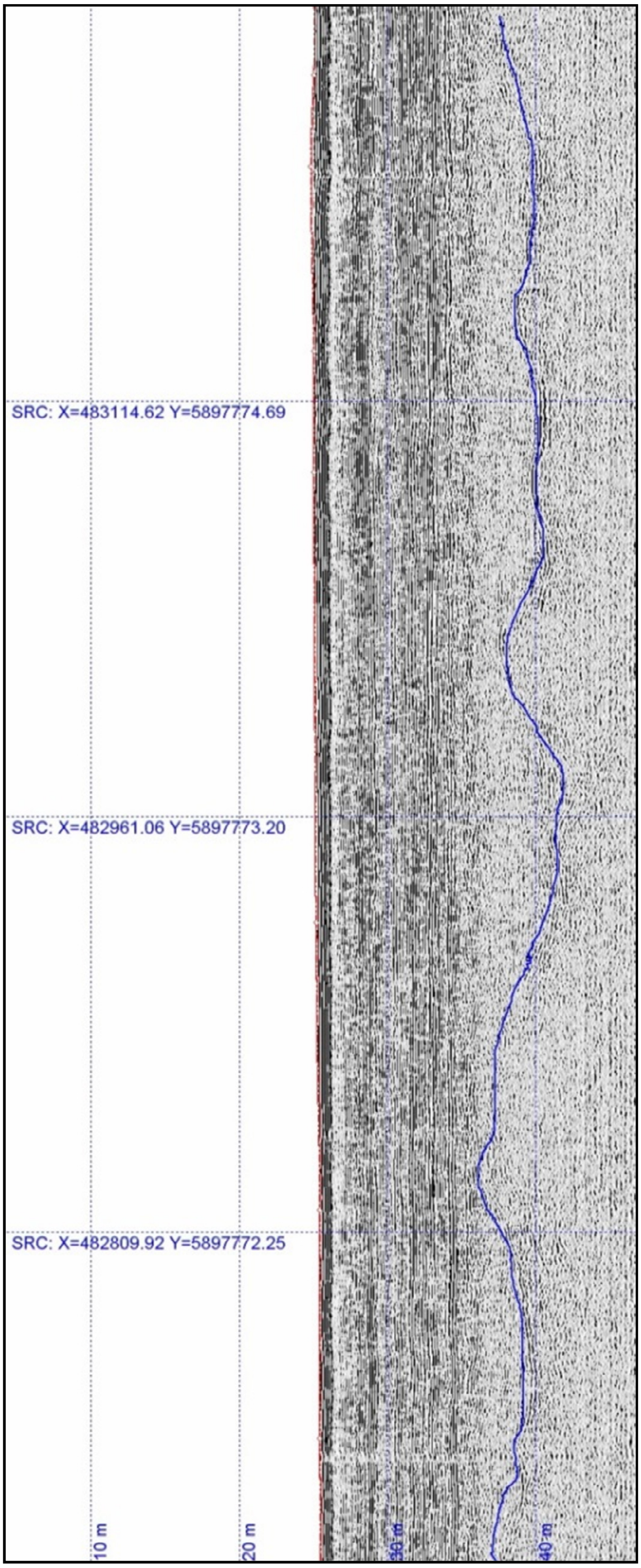

Figure 10-7: Section of SBP line 260414.155744_158 showing the seafloor and bedrock reflectors

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11. Visual Impact Assessment

11.1. Introduction

This section of the Environmental Report describes the seascape context of the proposed Galway Bay Marine and Renewable Energy Test Site and assesses the likely impacts of the scheme on the receiving environment in terms of both seascape character and visual amenity.

Like landscape assessment, seascape assessment relates to changes in the physical environment, brought about by a proposed development, which may alter its character. This requires a detailed analysis of the individual elements and characteristics of a landscape or seascape that go together to make up the overall character of that area. By understanding the aspects that contribute to this character it is possible to make judgements in relation to its quality (integrity) and to identify key sensitivities. This, in turn, provides a measure of the ability of the landscape or seascape in question to accommodate the type and scale of change associated with the proposed development, without causing unacceptable adverse changes to its character.

Visual Impact Assessment (VIA) relates to changes in the composition of views as a result of changes to the landscape, how these are perceived and the effects on visual amenity. Such impacts are population based rather than resource based as in the case of landscape / seascape impacts. The VIA was carried out by Macro Works Ltd., and the associated report is available in the Appendix 8, with photomontages in Appendix 9.

11.2. Methodology

This seascape and visual impact assessment is based on:

- Landscape Institute and the Institute of Environmental Management and Assessment publication entitled Guidelines for Landscape and Visual Impact Assessment (GLVIA-2013).
- Natural England publication 'An approach to Seascape Character Assessment' (2012)
- Environmental Protection Agency (EPA) publication 'Guidelines on the Information to be contained in Environmental Impact Statements (2002) and the accompanying Advice Notes on Current Practice in the Preparation of Environmental Impact Statements (2003)

In relation to Seascape Assessment, GLVIA-2013 states that it is important to take account of the particular characteristics of the marine and coastal environment, including those associated with the natural environment, cultural and social characteristics, and perceptual and aesthetic qualities. These will include:

- Coastal features;
- Views to and from the sea;
- Particular qualities of the open sea;

- The importance of dynamic changes due to weather and tides;
- Change in seascapes due to coastal processes;
- Cultural associations;
- Contributions of coastal features to orientation and navigation at sea.

The proposed Galway Bay Marine and Renewable Energy Test Site is 1.3km offshore and most of the components will not be more than a few metres above the waterline. Whilst some of the components of the proposed development may be discernible from distances up to 10km in optimal viewing conditions, they are likely to be barely discernible. Thus, they would be very unlikely to give rise to any significant visual impacts at such distances. For this reason, a more focussed 5km radius study area has been applied in this instance.

Production of this Landscape and Visual Impact Assessment involved;

- A desktop study to establish an appropriate study area, relevant landscape and visual designations in the Galway County Development Plan (2015-2021) as well as other sensitive visual receptors. This stage culminates in the selection of a set of potential viewpoints from which to study the effects of the proposal;
- Fieldwork to establish the landscape character of the receiving environment and to confirm and refine the set of viewpoints to be used for the visual assessment stage;
- Assessment of the significance of the landscape impact of the proposal as a function of seascape sensitivity weighed against the magnitude of the seascape impact;
- Assessment of the significance of the visual impact of the proposal as a function of visual receptor sensitivity weighed against the magnitude of the visual impact;

11.3. Receiving environment

11.3.1. Seascape baseline

The seascape baseline represents the existing seascape context and is the scenario against which any changes to the landscape brought about by the proposal will be assessed.

11.3.1.1. Coastline characteristics

The northern coastline of Galway Bay runs in a fairly consistent east-west direction with only occasional shallow sandy/pebbly coves between longer sections of rocky shoreline. Galway Bay is a large inlet (c. 10km wide and 30km long) and given the relative absence of significant coves along its northern shoreline as well as the proximity to the Atlantic Ocean, it is a rugged and exposed coastline.

The tidal zone consists of rock outcrops and tidal pools but there is not a dramatic change to the setting between high and low tides as might occur in an estuarine environment. The proposed site is currently identified by 4 no. buoys at each corner, which are discernible in clear viewing conditions, but are unlikely to draw the attention of casual observers. It should also be noted in terms of baseline conditions that the ocean energy test site has been in operation since 2006 with various temporary deployments of test equipment.

Above the high water mark the terrain rises at a moderate rate forming undulating hillocks and coastal spurs with a windswept land cover of scrubby grassland and small clumps of hardy coastal tree species. Occasional small conifer plantations also occur beyond the shoreline. Further upslope is a zone of marginal grazing land interspersed with a more naturalistic land cover of costal scrub. Within 1-2km of the shoreline, hummocky moorland land cover takes over on the higher slopes above Galway Bay.

11.3.1.2. Centres of Population and Houses

The northern coast of Galway Bay is lined with a series of coastal villages including Barna, Furbogh and Spiddal, which line the R336 regional road (the coast road). Between these settlements is a consistent string of residential development lining the coast road and the narrow boreens that run both upslope and downslope from it. It should be noted that this is a Gaeltacht area and the dense yet dispersed coastal settlement pattern is somewhat synonymous with the west coast Gaeltacht areas from Donegal to Cork.

11.3.1.3. Transport Routes

The principal transport route in this area is the R336 coastal road which loops from Galway City along the northern coast of Galway Bay and then veers inland through Connemara to join the N59 at Maam Cross. Otherwise transport routes within the study area consist of a tight network of boreens emanating from the coast road.

11.3.1.4. Public Amenities and Facilities

The northern coast of Galway Bay is a popular tourist area hosting numerous hotels, B&Bs, restaurants and pubs. There is also a craft village in Spiddal. The R336 coast road forms part of the recently inaugurated and highly popular 'Wild Atlantic Way' tourist driving route and also provides access to the Aran Islands via a Ferry service at Rossaveel and an aerodrome at Inverin.

Piers are provided at Barna and Spiddal forming a nucleus for these coastal settlements where fishing is a vital part of both the historic and current way of life. Galway Bay is also used by day tour operators and water based recreationalists such as divers, sailors, windsurfers and fishermen.

11.3.1.5. Galway County Development Plan (2015 – 2021)

A Landscape Character Assessment has been prepared for County Galway, which divides the county into a range of landscape character areas (LCAs). The proposed marine test facility is located just offshore of LCA 9 – 'Inverin to Galway City Coastline'. This LCA is shown on the associated maps to have a 'High' landscape value rating (the second highest of four possible ratings). It is also shown to have a 'Class 3 - High' landscape sensitivity rating (the median of five possible classes). Relevant landscape objectives in the Galway County Development Plan include;

<u>Objective LCM 1 – Landscape Sensitivity Classification</u>
The Planning Authority shall have regard to the landscape sensitivity classification of sites in the consideration of any significant development proposals and, where necessary, require a Landscape/ Visual Impact Assessment to accompany such proposals. This shall be balanced against the need to develop key strategic infrastructure to meet the strategic aims of the plan, and having regard to the zoning objectives of serviced development land within the Galway Metropolitan Areas.

<u>Objective LCM 2 – Landscape Sensitivity Ratings</u>
Consideration of landscape sensitivity ratings shall be an important factor in determining development uses in areas of the County. In areas of high landscape sensitivity, the design and the choice of location of proposed development in the landscape will also be critical considerations.

11.3.2. Visual baseline

11.3.2.1. Views of recognised scenic value

Views of recognised scenic value are primarily indicated within County Development Plans in the context of scenic views/routes designations, but they might also be indicated on touring maps, guide books, road side rest stops or on post cards that represent the area. In this instance there are a number of pull-in areas and promenades along the R336 coast road that are considered to be recognised coastal viewing locations that are not necessarily represented by designations contained in the Galway County Development Plan.

11.3.2.2. Galway County Development Plan (2015 – 2021)

There are a series of designated focal points and views indicated on map FPV1 in the Galway County Development Plan that are potentially relevant to this proposal. These are set out below and indicated on the following map excerpt (Figure 11-4);

- View 71 – 'View of the headland Illaunafaumona' (east of Barna)
- View 72 - 'View of the sea from north of Barna'
- View 73 – 'View of Lough Inch from surrounding 3rd class roads'
- View 74 – 'View of north Clare Coast'
- View 77 – 'View of Catholic Church and High Tower in An Spideal'

Of the above designated views, the most pertinent are considered to be View no. 72 and View no. 74 as they both relate to views of the sea. However, it should be noted that elevated views from local roads around Barna and Spiddal were investigated during fieldwork and clear views of the proposal site were difficult to obtain due to the moderate incline and degree of screening from vegetation and buildings.

The only planning objective relating to focal points and views is set out below;

<u>Objective FPV 1 – Development Management</u>
Preserve the focal points and views as listed in Map FPV1 from development that in the view of the Planning Authority would negatively impact on said focal points and views. This shall be balanced against the need to develop key infrastructure to meet the strategic aims of the plan, and have regard to the zoning objectives of serviced development land within the Galway Metropolitan Area.

11.3.2.3. Identification of Viewshed Reference Points

Viewshed Reference Points (VRP's) are the locations used to study the visual impacts of the proposal in detail. It is not warranted to include each and every location that provides a view of this development as this would result in an unwieldy report and make it extremely difficult to draw out the key impacts arising from the project. Instead, the selected viewpoints are intended to reflect a range of different receptor types, distances and angles. The visual impact of a proposed development is assessed using up to 6 categories of receptor type as listed below:

- Key Views - from features of national or international importance;
- Designated Scenic Routes and Views;
- Local Community views;
- Centres of Population;
- Major Routes; and
- Amenity and heritage features;

The Viewshed Reference Points selected in this instance are set out in Table 11-1 below and shown on Figure 1 of Appendix 9.

Table 11-1: Outline Description of Selected Viewshed Reference Points (VRPs)

VRP No.	Location	Direction of view
VP1	Amenity area at the base of Spiddal Pier	SE
VP2	Promenade along R336 coast road at Spiddal	SE
VP3	Coastal walking track at Spiddal East	S
VP4	R336 coast road at Doorath	S
VP5	Promenade along R336 coast road at Furbogh	SW

11.4. Impact of the development

11.4.1. Seascape Impact

11.4.1.1. Assessment Criteria

When assessing the potential impacts on the seascape resulting from a proposed development, the following criteria are considered:

- Seascape character, value and sensitivity
- Magnitude of likely impacts; and
- Significance of landscape effects

The sensitivity of the seascape to change is the degree to which a particular receptor (Landscape / Seascape Character Area (LCA) or feature) can accommodate changes or new features without unacceptable detrimental effects to its essential characteristics. Landscape Value and Sensitivity is classified using the following criteria;

Table 11-2: Seascape Value and Sensitivity

Sensitivity	Description
Very High	Areas where the seascape character exhibits a very low capacity for change in the form of development. Examples of which are high value seascapes, protected at an international or national level (World Heritage Site/Marine Park), where the principal management objectives are likely to be protection of the existing character.
High	Areas where the seascape character exhibits a low capacity for change in the form of development. Examples of which are high value seascapes, protected at a national or regional level (Area of Outstanding Natural Beauty), where the principal management objectives are likely to be considered conservation of the existing character.
Medium	Areas where the seascape character exhibits some capacity and scope for development. Examples of which are seascapes, which have a designation of protection at a county level or at non-designated local level where there is evidence of local value and use.
Low	Areas where the seascape character exhibits a higher capacity for change from development. Typically this would include lower value, non-designated seascapes that may also have some elements or features of recognisable quality, where seascape management objectives relate to enhancement rather than protection.
Negligible	Areas of seascape character that include dereliction and industrial uses where there would be a reasonable capacity to embrace change or the capacity to include the development proposals. Management objectives in such areas could be focused on change, creation of seascape improvements and/or restoration to realise a higher value.

The magnitude of a predicted seascape impact is a product of the scale, extent or degree of change that is likely to be experienced as a result of the proposed development. The magnitude takes into account whether there is a direct physical impact resulting from the loss of seascape components and/or a change that extends beyond the proposal site boundary that may have an effect on the seascape character of the area.

Table 11-3: Magnitude of Seascape Impacts

Magnitude of Impact	Description
Very High	Change that would be large in extent and scale with the loss of critically important seascape elements and features, that may also involve the introduction of new uncharacteristic elements or features that contribute to an overall change of the seascape in terms of character, value and quality.
High	Change that would be more limited in extent and scale with the loss of important seascape elements and features, that may also involve the introduction of new uncharacteristic elements or features that contribute to an overall change of the seascape in terms of character, value and quality.
Mediium	Changes that are modest in extent and scale involving the loss of seascape characteristics or elements that may also involve the introduction of new uncharacteristic elements or features that would lead to changes in seascape character, and quality.
Low	Changes affecting small areas of seascape character and quality, together with the loss of some less characteristic seascape elements or the addition of new features or elements.
Negligible	Changes affecting small or very restricted areas of seascape character. This may include the limited loss of some elements or the addition of some new features or elements that are characteristic of the existing seascape or are hardly perceivable.

The significance of a seascape impact is based on a balance between the sensitivity of the seascape receptor and the magnitude of the impact. The significance of seascape impacts is arrived at using the following matrix in Table 11-4;

Table 11-4: Seascape Impact Significance Matrix

	Sensitivity of Receptor				
Scale/Magnitude	Very High	High	Medium	Low	Negligible
Very High	Profound	Profound-substantial	Substantial	Moderate	Minor
High	Profound-substantial	Substantial	Substantial-moderate	Moderate-slight	Slight-imperceptible
Medium	Substantial	Substantial-moderate	Moderate	Slight	Imperceptible
Low	Moderate	Moderate-slight	Slight	Slight-imperceptible	Imperceptible
Negligible	Slight	Slight-imperceptible	Imperceptible	Imperceptible	Imperceptible

Note: those categories indicated in orange are considered to be equivalent to 'Significant' impacts in EIA terms

11.4.1.2. Seascape Value and Sensitivity

This is something of an iconic coastal area that combines rugged scenic values with cultural and heritage values. It is a popular destination for both tourists and the residents of Galway with the piers amenity areas hotels, pubs and restaurants all strongly associated with the coastal environment and views out to sea. The coast road forms part of the 'Wild Atlantic Way' tourist driving route and this area epitomises the crossover of nature and culture that route users are seeking.

Aside from the attraction to tourists and visitors this is also a working coastline where marine based industries such as fishing are part of the heritage as well as the current way of life. Being a Gaeltacht area there are also a range of small industries and craft related businesses that add to the productive character of the area. Many of these also have associated retail outlets.

Compared to much of Irelands west coast, this is a relatively densely populated section of coastline. The various villages along the coast road form slightly denser nodes of development rather than distinctive settlements, due to the dispersal of detached dwellings along the entire northern coast of Galway Bay.

Being within the enclosure of Galway Bay and the Aran Islands at the mouth of the Bay, there is some sense of protection from the full force of the Atlantic Ocean even if this is only perceptual. It is not considered to be as rugged, exposed and isolated as many west facing sections of the Atlantic coastline. There is also a lesser sense of the naturalistic due to the density of population and degree of built development.

The rugged scenery of this section of coastline, particularly seaward of the high-water mark, is balanced in seascape sensitivity terms by the relative density of built development and variety of anthropogenic land uses above the high-water mark. Although this coastal strip, identified as LCA 9 – 'Inverin to Galway City Coastline' in the Galway County Development Plan, is designated as a 'high' sensitivity landscape therein, two higher categories (Unique and Special) were not applied. This is presumably on the basis of the same balance of factors described above. Using a slightly more universal categorisation system outlined in Table 11-2 above it is considered that the landscape / seascape sensitivity of this section of coastline is Medium.

11.4.1.3. Magnitude of Seascape Effects

There will be no physical effects on the landscape or coastal features as a result of the proposed development so the appraisal of impacts is limited, in this instance, to those affecting seascape character only.

In clear viewing conditions the proposed marine energy test facility will be a noticeable concentration of variant, but apparently associated, structures covering a small geometric section of Galway Bay. The structures may appear slightly ambiguous compared to vessels and structures that might be more familiar in the marine environment this far offshore. As an iconic renewable energy form, the floating turbine structure, in particular, is likely to hint at the purpose of the structures and provide some legibility to the view of the facility. It is also important to note that this marine energy test site has been in operation for nearly 10 years and the occasional placement of wave energy devices will not be an unfamiliar occurrence for the local population.

Along a rugged section of coastline there is potential that the view of a geometric array of offshore structures could generate a sense of developing and taming of the naturalistic seascape. However, in this instance the section of coastline in question is not synonymous with the wild Atlantic and has been influenced by cultural activities for hundreds of years. The existing test site is contained within a large bay that accommodates the daily activities of a relatively high coastal population who are already familiar with similar activities taking place at the site. For this reason, it is not considered that the proposed structures will conflict with the seascape values associated with the northern portion of Galway Bay. Furthermore, two of the most distinctive features; being the floating turbine and long, hinged wave device will only be temporary features at the site (2-3 months and 12-18 months per installation respectively)

On the basis of the reasons outlined above, it is considered that the magnitude of seascape impact is 'Low'.

11.4.1.4. Significance of Seascape Impact

When the magnitude judgement of Medium-low is coupled with the earlier sensitivity judgement of 'Medium', the overall significance of seascape impact is deemed to be **Slight**.

11.4.2. Visual Impact

As with the seascape impact, the visual impact of the proposed marine energy test facility will be assessed as a function of sensitivity versus magnitude. In this instance the sensitivity of the visual receptor (viewer), weighed against the magnitude of the visual effect.

11.4.2.1. Sensitivity of Visual Receptors

Unlike landscape / seascape sensitivity, the sensitivity of visual receptors has an anthropocentric basis. It considers factors such as the perceived quality and values associated with the view, the landscape context of the viewer, the likely activity they are engaged in and whether this heightens their awareness of the surrounding landscape. A list of the factors considered by the assessor in estimating the level of sensitivity for a particular visual receptor is outlined below and used in Table 11-5 to establish visual receptor sensitivity at each VRP:

- **Recognised scenic value of the view** (County Development Plan designations, guidebooks, touring maps, postcards etc.). These represent a consensus in terms of which scenic views and routes within an area are strongly valued by the population because in the case of County Developments Plans, at least, a public consultation process is required;

- **Views from within highly sensitive landscape areas**. Again, highly sensitive landscape designations are usually part of a county's Landscape Character Assessment, which is then incorporated with the County Development Plan and is therefore subject to the public consultation process. Viewers within such areas are likely to be highly attuned to the landscape around them;

- **Primary views from dwellings**. A proposed development might be seen from anywhere within a particular residential property with varying degrees of sensitivity. Therefore, this category is reserved for those instances in which the design of dwellings or housing estates; has been influenced by the desire to take in a particular view. This might involve the use of a slope or the specific orientation of a house and/or its internal social rooms and exterior spaces;

- **Intensity of use, popularity**. This relates to the number of viewers likely to experience a view on a regular basis and whether this is significant at county or regional scale;

- **Connection with the landscape**. This considers whether or not receptors are likely to be highly attuned to views of the landscape i.e. commuters hurriedly driving on busy national route versus hill walkers directly engaged with the landscape enjoying changing sequential views over it;

- **Provision of elevated panoramic views**. This relates to the extent of the view on offer and the tendency for receptors to become more attuned to the surrounding landscape at locations that afford broad vistas.

- **Sense of remoteness and/or tranquillity.** Receptors taking in a remote and tranquil scene, which is likely to be fairly static, are likely to be more receptive to changes in the view than those taking in the view of a busy street scene, for example;

- **Degree of perceived naturalness**. Where a view is valued for the sense of naturalness of the surrounding landscape it is likely to be highly sensitive to visual intrusion by distinctly manmade features;

- **Presence of striking or noteworthy features.** A view might be strongly valued because it contains a distinctive and memorable landscape feature such as a promontory headland, lough or castle;

- **Historical, cultural and / or spiritual significance.** Such attributes may be evident or sensed by receptors at certain viewing locations, which may attract visitors for the purposes of contemplation or reflection heightening the sense of their surroundings;

- **Rarity or uniqueness of the view**. This might include the noteworthy representativeness of a certain landscape type and considers whether the receptor could take in similar views anywhere in the broader region or the country;

- **Integrity of the landscape character**. This looks at the condition and intactness of the landscape in view and whether the landscape pattern is a regular one of few strongly related components or an irregular one containing a variety of disparate components;

- **Sense of place**. This considers whether there is special sense of wholeness and harmony at the viewing location;

- **Sense of awe**. This considers whether the view inspires an overwhelming sense of scale or the power of nature.

Those locations which are deemed to satisfy many of the above criteria are likely to be in the higher order of magnitude in terms of sensitivity and vice versa. No relative importance is inferred by the order of listing in the Table 11-5 below. Overall sensitivity may be a result of a number of these factors or, alternatively, a strong association with one or two in particular.

Table 11-5: Analysis of Visual Receptor Sensitivity at Viewshed Reference Points

Strong association	Moderate association	Mild association	Negligible association

Assessment Criteria	**VP1**	**VP2**	**VP3**	**VP4**	**VP5**
Recognised scenic value of the view	Moderate	Moderate	Moderate	Moderate	Strong
Views from within highly sensitive landscape areas	Strong	Strong	Strong	Strong	Strong
Primary views from residences	Mild	Moderate	Mild	Moderate	Moderate
Intensity of use, popularity (number of viewers)	Mild	Moderate	Mild	Moderate	Moderate
Viewer connection with the landscape / seascape	Strong	Strong	Strong	Moderate	Strong
Provision of vast, elevated panoramic views	Moderate	Moderate	Moderate	Moderate	Moderate
Sense of remoteness / tranquillity at the viewing location	Mild	Negligible	Moderate	Negligible	Negligible
Degree of perceived naturalness	Mild	Mild	Moderate	Mild	Mild
Presence of striking or noteworthy features	Moderate	Moderate	Moderate	Mild	Moderate
Sense of Historical, cultural and / or spiritual significance	Mild	Mild	Mild	Mild	Mild
Rarity or uniqueness of the view	Moderate	Moderate	Moderate	Moderate	Moderate
Integrity of the landscape character within the view	Moderate	Moderate	Moderate	Mild	Moderate
Sense of place at the viewing location	Moderate	Moderate	Moderate	Mild	Moderate
Sense of awe	Negligible	Negligible	Negligible	Negligible	Negligible
Overall sensitivity assessment	H	H	H	HM	H

N = negligible; **L** = low sensitivity; **M** = medium sensitivity; **H** = high sensitivity; **VH** = very high sensitivity

11.4.2.2. Visual Impact Magnitude

The magnitude of visual effects is determined on the basis of two factors; the visual presence (relative visual dominance) of the proposal and its effect on visual amenity.

Given that the proposed Galway Bay Marine and Renewable Energy Test Site does not represent significant bulk, visual impacts will result almost entirely from visual 'intrusion' rather than visual 'obstruction' (the blocking of a view). The magnitude of visual impacts is classified in the following table;

Table 11-6: Magnitude of Visual Impact

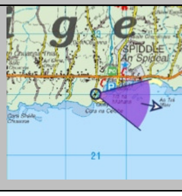
Criteria	Description
Very High	The proposal intrudes into a large proportion or critical part of the available vista and is without question the most noticeable element. A high degree of visual clutter or disharmony is also generated, strongly reducing the visual amenity of the scene
High	The proposal intrudes into a significant proportion or important part of the available vista and is one of the most noticeable elements. A considerable degree of visual clutter or disharmony is also likely to be generated, appreciably reducing the visual amenity of the scene
Medium	The proposal represents a moderate intrusion into the available vista, is a readily noticeable element and/or it may generate a degree of visual clutter or disharmony, thereby reducing the visual amenity of the scene. Alternatively, it may represent a balance of higher and lower order estimates in relation to visual presence and visual amenity
Low	The proposal intrudes to a minor extent into the available vista and may not be noticed by a casual observer and/or the proposal would not have a marked effect on the visual amenity of the scene
Negligible	The proposal would be barely discernible within the available vista and/or it would not detract from, and may even enhance, the visual amenity of the scene

11.4.2.3. Visual Impact Significance

As stated above, the significance of visual impacts is a function of visual receptor sensitivity and visual impact magnitude. This relationship is expressed in the same significance matrix and applies the same EPA definitions of significance as used earlier in respect of seascape impacts (Table 11-3).

11.4.2.4. Estimation of Visual Impacts at VRPs

To be read in conjunction with the viewpoint map and photomontages contained in Appendix 9.

Viewshed Reference Point			Location
VP1	**Amenity area at the base of Spiddal Pier**		
Representative of:	• A coastal settlement • An amenity area		
Receptor Sensitivity	High		
Existing View	This is a relatively enclosed coastal view from just above the beach at Spiddal Pier. To the left is a small, grassed area containing a beach hut, beyond which can be seen a rocky coastline characterised by small promontory outcrops and sandy inlets. Above the high-water line is a scattering of residential dwellings set amongst scrubby coastal vegetation on gently rising slopes. To the right is a stout stone pier that truncates the view at a short distance to the southwest. However, the view across the bay to the southeast is extensive between the pier and rocky shoreline. Whilst the inland portion of Burren headland can be seen beyond the pier, the only other containment of the view is the Slieve Aughty mountains in the far distance to the southeast.		
Visual Impact of the marine energy structures	The proposed marine energy test facility will be seen as a linear cluster of structures lining the horizon between the waters of Galway Bay and the base of the Slieve Aughty range beyond. The most noticeable features will be the wind turbine due to its height, the twin-float wave machine due to its length and the SeaStation due to its bulk. The remaining structures are likely be perceived as large buoys. All of the structures are seen at a relatively small scale from this distance and in the context of the overall coastal vista they are considered to have a minimal visual presence. In aesthetic terms, the various structures will add a minor degree of visual clutter to the seaward view, but without intruding on or detracting from the view of any seascape features beyond, or indeed, in the foreground. Visitors may experience a minor degree of confusion as to the purpose of this collection of variant structures. However, local residents are likely to be more familiar with such structures being temporarily introduced at the facility over the past 10 years. On the basis of the reasons outlined above, the magnitude of visual impact is deemed to be Low-negligible and only in a scenario where all proposed structures are in place at the same time.		
Summary	Based on the assessment criteria and matrices outlined at section 1.4 the significance of visual impact is summarised below.		
	Visual Receptor Sensitivity	Visual Impact Magnitude	Significance of Visual Impact
	High	Low-negligible	**Slight**

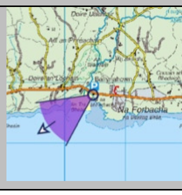
<table>
<tr><th colspan="3">Viewshed Reference Point</th><th>Location</th></tr>
<tr><td>VP2</td><td colspan="2">Promenade along R336 coast road at Spiddal</td><td></td></tr>
<tr><td colspan="2">Representative of:</td><td colspan="2">A coastal settlement
A major route
The ‘Wild Atlantic Way’ tourist driving route</td></tr>
<tr><td colspan="2">Receptor Sensitivity</td><td colspan="2">High</td></tr>
<tr><td colspan="2">Existing View</td><td colspan="2">This is a broad panoramic vista cross Galway Bay from the coastal promenade walkway along the R336 at Spiddal. On the inland side of the road is a craft village that is a popular visitor attraction. The shoreline consists of rounded boulders with rock outcrops and patches of sand. Although the coast is oriented in a fairly consistent east – west direction, there are small inlets and tidal pools providing some sense of enclosure. Across the bay in the far distance is Black Head and the other domed forms of the Burren limestone region, which defines the southern side of Galway Bay.</td></tr>
<tr><td colspan="2">Visual Impact of the marine energy structures</td><td colspan="2">The proposed marine energy test facility will be seen as a horizontal array of floating structures with a backdrop of terrain on the opposite side of the bay. The structures are all seen at a small scale from this distance and are not likely to be visible at all in anything but clear viewing conditions. The most distinctive features are the wind turbine, the SeaStation and the long wave machine. Nonetheless, the marine energy test facility is still likely to have minimal visual presence in this complex coastal scene.

Aesthetically, the array of variant structures may appear slightly anomalous within the waters of the bay, particularly for visitors who might be unfamiliar with the existence of the test facility. However given the low degree of visual presence of the structures and the anthropogenic context of this seascape setting, they will not noticeably detract from visual amenity at this location.

Overall, it is considered that the magnitude of visual impact is Low-negligible.</td></tr>
<tr><td colspan="2">Summary</td><td colspan="2">Based on the assessment criteria and matrices outlined at section 1.4 the significance of visual impact is summarised below.</td></tr>
<tr><td colspan="2"></td><td>Visual Receptor Sensitivity</td><td>Visual Impact Magnitude</td><td>Significance of Visual Impact</td></tr>
<tr><td colspan="2"></td><td>High</td><td>Low-negligible</td><td>Slight</td></tr>
</table>

<table>
<tr><th colspan="3">Viewshed Reference Point</th><th>Location</th></tr>
<tr><td>VP3</td><td colspan="2">Coastal walking track at Spiddal East</td><td></td></tr>
<tr><td colspan="2">Representative of:</td><td colspan="2">A local amenity walkway
Coastal community views</td></tr>
<tr><td colspan="2">Receptor Sensitivity</td><td colspan="2">High</td></tr>
<tr><td colspan="2">Existing View</td><td colspan="2">This view is from a small coastal loop walk, which runs between dry stonewalls and scrubby coastal vegetation. It encompasses the hummocky terrain that is typically found in coastal zone between the shoreline and the coast road. This is a slightly elevated view over Galway Bay with the Burren headland forming a distinctive backdrop in the distance. This is the nearest section of shoreline to the proposed marine energy test facility.</td></tr>
<tr><td colspan="2">Visual Impact of the marine energy structures</td><td colspan="2">The proposed structures of the marine energy test facility will be visible from here in a linear cluster just below the waterline that defines the far side of Galway Bay (due to the effects of perspective). They will be seen as relatively small scale features from here, but they are directly aligned with the path at this point making them more likely to be noticed by walkers approaching the shore. In terms of visual presence, the proposed facility is considered to be sub-dominant within this visual context.
From this closest land-based viewpoint there is a slightly greater sense of the varying designs of this cluster of marine structures and this may lead to some visual confusion for those unfamiliar with the test facility (10 years). However, this is likely to be more on the basis of interest rather than a sense that they are out of place in this coastal setting. Mainly because this is a modified and richly varied coastal setting, not a pristinely naturalistic one. The three dimensional layout of the facility is apparent from here due to the slightly elevated nature of the view. This marginally reduces the sense of visual clutter that occurs in relation to shoreline views (such as VP1 and VP2 above).
On the basis of the reasons outlined above the magnitude of visual impact is deemed to be Low.</td></tr>
<tr><td colspan="2">Summary</td><td colspan="2">Based on the assessment criteria and matrices outlined at section 1.4 the significance of visual impact is summarised below.</td></tr>
<tr><td colspan="2"></td><td>Visual Receptor Sensitivity</td><td>Visual Impact Magnitude</td><td>Significance of Visual Impact</td></tr>
<tr><td colspan="2"></td><td>High</td><td>Low</td><td>Moderate-slight</td></tr>
</table>

<table>
<tr><th colspan="3">Viewshed Reference Point</th><th>Location</th></tr>
<tr><td>VP4</td><td colspan="2">R336 coast road at Doorath</td><td></td></tr>
<tr><td colspan="2">Representative of:</td><td colspan="2">A major route
Coastal community views
The ‘Wild Atlantic Way’ tourist driving route</td></tr>
<tr><td colspan="2">Receptor Sensitivity</td><td colspan="2">High-medium</td></tr>
<tr><td colspan="2">Existing View</td><td colspan="2">This is a slightly elevated, panoramic vista across Galway Bay to the south from the R336 coast road. It takes in a foreground of marginal grazing and reverting scrubland on shallow slopes that lead down to the shore in the near middle distance. Only a small section of the rocky shoreline can be seen jutting out into the bay. Across the broad expanse of water can be seen the humpbacked form of the Burren Peninsula in the distance. The low forms of the Aran Islands can also be seen at the mouth of Galway Bay to the southwest</td></tr>
<tr><td colspan="2">Visual Impact of the marine energy structures</td><td colspan="2">The proposed structures of the marine energy test facility will be appear in the heart of the bay despite being much nearer to its northern coastline. They will be seen in a relatively narrow horizontal array and the variant forms of the structures may draw attention, particularly the floating wind turbine. The proposed facility is judged to have a sub-dominant visual presence in this coastal scene.
There will be a minor degree of visual clutter generated within the seaward aspect of this view. However, this is tempered slightly by the perception of the three dimensional layout of the structures due to the slightly elevated nature of the view (actual separation distances between structures can be appreciated). Visitors may experience some visual confusion associated with the cluster of differing forms within a defined section of the bay. However, the facility has already been in place for nearly 10 years and it is not considered that the current proposal detracts from any sensitive qualities associated with this seascape context.
Overall, the magnitude of visual impact is considered to be Low.</td></tr>
<tr><td colspan="2">Summary</td><td colspan="2">Based on the assessment criteria and matrices outlined at section 1.4 the significance of visual impact is summarised below.</td></tr>
<tr><td colspan="2"></td><td>Visual Receptor Sensitivity</td><td>Visual Impact Magnitude</td><td>Significance of Visual Impact</td></tr>
<tr><td colspan="2"></td><td>High medium</td><td>Low</td><td>Slight</td></tr>
</table>

Viewshed Reference Point			**Location**
VP5	**Promenade along R336 coast road at Furbogh**		
Representative of:	• A designated scenic view • A coastal settlement • A major route • The ‘Wild Atlantic Way’ tourist driving route		
Receptor Sensitivity	High		
Existing View	This is a view from one of nearest sections of the R336 coast road to the sea at the dispersed coastal settlement of Furbogh. It takes in a foreground of a promenade footpath above a sandy inlet, which is defined at it western end by a cluster of residences and commercial buildings set against the immediate backdrop of a small coastal promontory headland. A lower promontory of rocky outcrops and tidal pools defines the eastern end of the beach. Black Head on the opposite side of Galway Bay is a distinctive background feature in the distance.		
Visual Impact of the marine energy structures	The proposed structures of the marine energy test facility will be barely discernible from here towards the mouth of Galway Bay (southwest) due to the viewing distance and the lack of contrast against the sky. In clear viewing conditions the floating wind turbine will be the structure most likely to be noticed. In the context of the dynamic and complex coastal setting in the foreground, the proposed marine energy test facility is considered to have a minimal visual presence. For the same reason it is not likely to noticeably detract from the visual amenity experienced at this location. On the basis of the reasons outlined above, the magnitude of visual impact is judged to be negligible.		
Summary	Based on the assessment criteria and matrices outlined at section 1.4 the significance of visual impact is summarised below.		
	Visual Receptor Sensitivity	Visual Impact Magnitude	**Significance of Visual Impact**
	High	Negligible	**Slight-imperceptible**

11.5. Mitigation

One of the main issues associated with the view of Galway Bay Marine and Renewable Energy Test Site is that the array of different structures might appear slightly anomalous to visitors who are unaware of the sites' purpose. Concern has also been expressed by local residents regarding the duration of the installations and whether this is just the precursor to a permanent commercial site.

By way of mitigation, therefore, the Marine Institute intends to provide an interpretive installation on the shoreline (most likely at Spiddal), which provides information about the various marine renewable technologies and the purpose of the site for testing such devices. It is believed that there would be genuine interest in the test facility and any visual ambiguity is likely to be removed for those armed with information about the site.

11.6. Conclusion

11.6.1. Seascape Impacts

Seascape impacts are considered in the same way as landscape impacts would be for a normal LVIA. In this instance there will be no physical impacts on the coastal environment so the focus of the appraisal is impacts on the character of the seascape of north Galway Bay.

In this regard, it is considered that the section of coastline in question is not synonymous with the wild Atlantic to the degree that much of Irelands west coast is. Instead, this is a settled section of coastline hosting an array of coastal industries and relatively dense yet dispersed population. This coastline therefore has an anthropogenic character and the continuing use of the Galway Bay Marine and Renewable Energy Test Site is not considered to significantly conflict with the seascape values associated with the northern portion of Galway Bay.

The overall significance of seascape impact is judged to be **Slight** and this only applies to a worst case scenario where all of the structures are briefly in place at the same time. The temporary nature of most of the structures (wave energy converters 12-18 months and floating turbine 2-3 months per installation) is a strong ameliorating factor in this instance.

11.6.2. Visual Impacts

The sensitivity of visual receptors (people and groups of people at particular locations) is generally considered to be high in this coastal area, which hosts the Wild Atlantic Way tourist driving route. Local residences are also generally oriented to take in the richly diverse coastal vistas on offer.

In terms of visual impacts, the proposed structures will generally be seen as small-scale features from shore-based viewing locations due to the viewing distances involved (generally greater than 2km) and none are of significant bulk. They will be most noticeable due to the concentration of variable floating structures in one portion of the bay. The three structures that will tend to stand out the most are the; floating turbine, due to its height and movement; the SeaStation, due to its bulk, and the twin-float wave machine, due to its length. The highest level of visual presence (relative noticeability within the view) is deemed to be ‘sub-dominant’ and this occurs at VP3 – the closest of the viewpoints (1.3km). Visual presence at the other locations is considered to range between sub-dominant and minimal.

In terms of aesthetics, it is considered that the cluster of variant structures may appear slightly anomalous, particularly when they first brought to site or for visitors who are unaware of their purpose. Local residents, on the other hand, are likely to be more familiar with the occasional placement of such structures at this facility, which has been operational for nearly 10 years.

The proposed structures may also contribute a minor degree of visual clutter to the seaward view, particularly in low angle views from the shore where the three dimensional layout of the structures is less apparent. Nonetheless, this is a living and working section of coastline that hosts an array of structures and land uses and it is not considered that the marine energy test facility conflicts with the character and values associated with the coastal vistas in this area.

Important ameliorating factors in this instance are the temporary nature of the installations for most of the energy devices and the fact that it will be uncommon for all of the structures to be in place at any one time.

11.6.3. Overall Significance of Impact

Owing to the balance between the relatively high sensitivity of this seascape area versus the relatively low degree of impact arising from the proposed marine energy test facility, the highest overall significance of impact is deemed to be **Moderate-Slight** (VP3).

Given the pattern of impacts at the various viewpoints, this degree of impact is only likely to occur at viewing distances of less than 2km and only for the brief worst-case-scenario periods when all structures are in place at once. Beyond approximately 2km impact levels fall away quickly to slight and imperceptible. There will be no residual seascape or visual impacts once the various structures are eventually removed from the site.

Overall, it is not considered that the proposed Galway Bay Marine and Renewable Energy Test Site will give rise to any significant impacts in EIA terms.

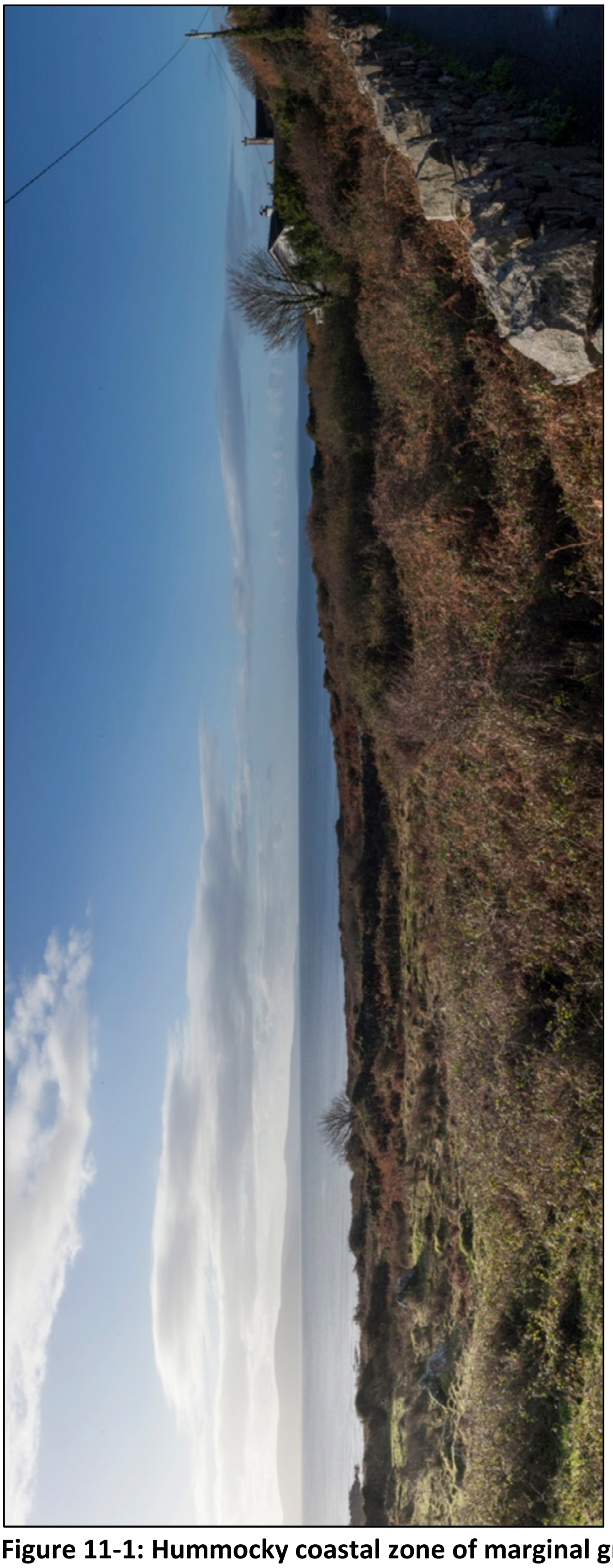


Figure 11-1: Hummocky coastal zone of marginal grazing and windswept scrub interspersed with frequent dwellings

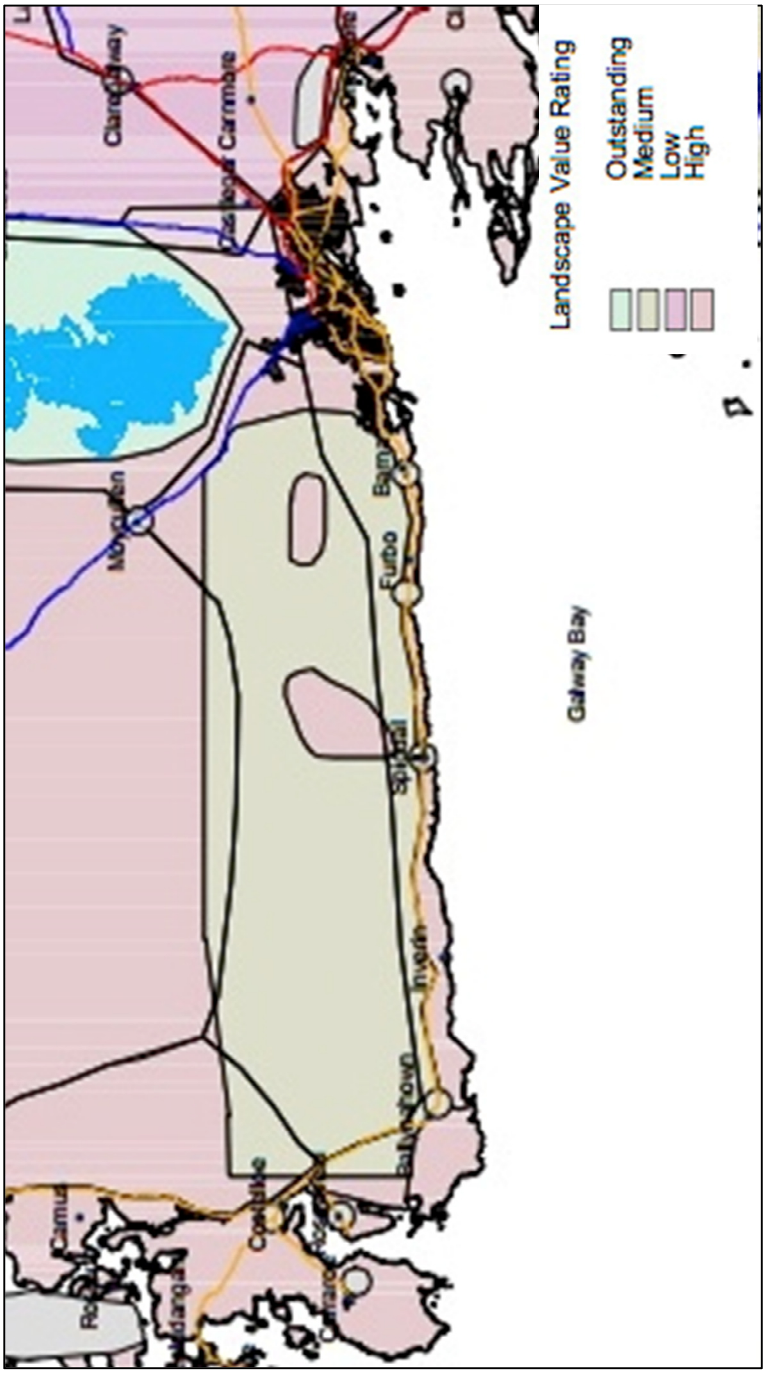


Figure 11-2: Excerpt from Landscape Character Assessment map (Landscape Value – Figure 2)

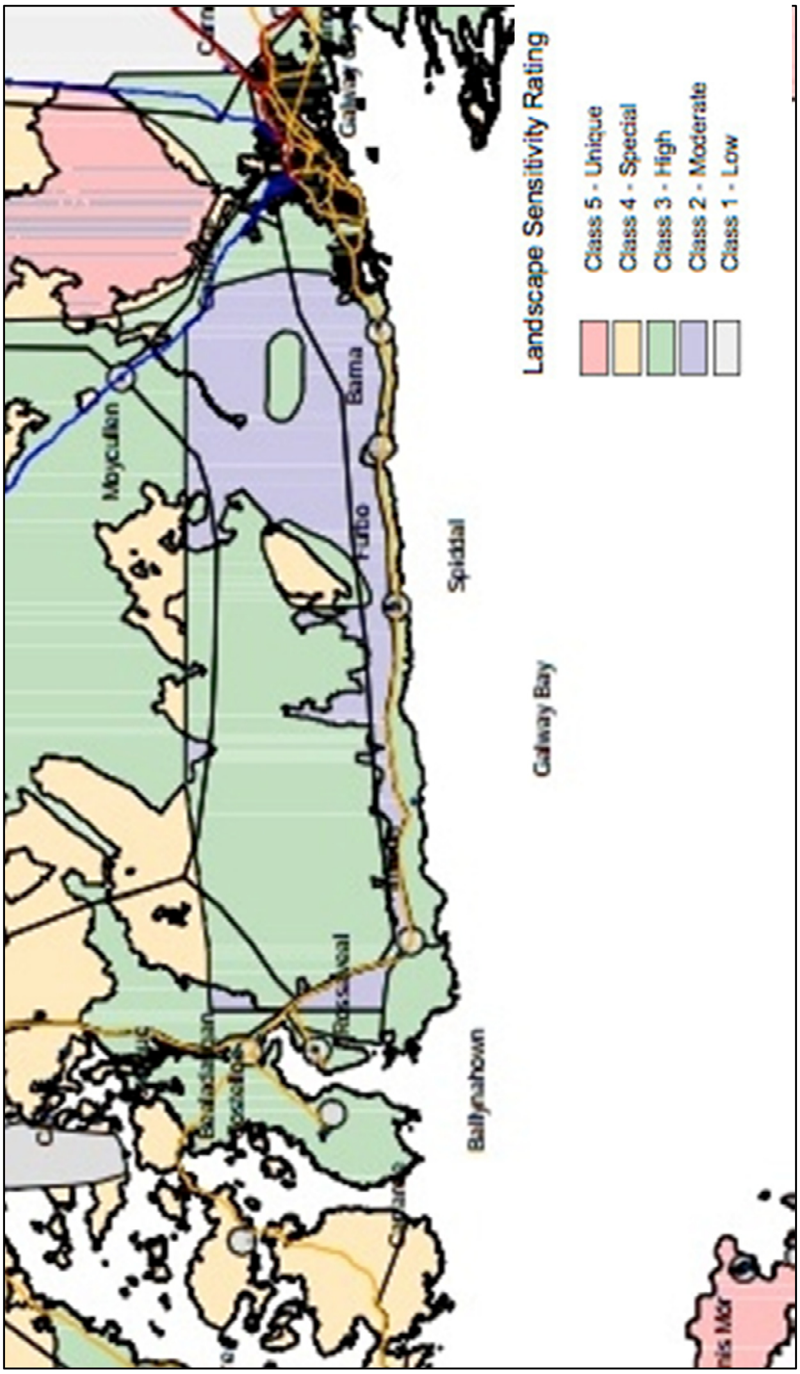


Figure 11-3: Excerpt from Landscape Character Assessment map (Landscape Sensitivity – Figure 3)

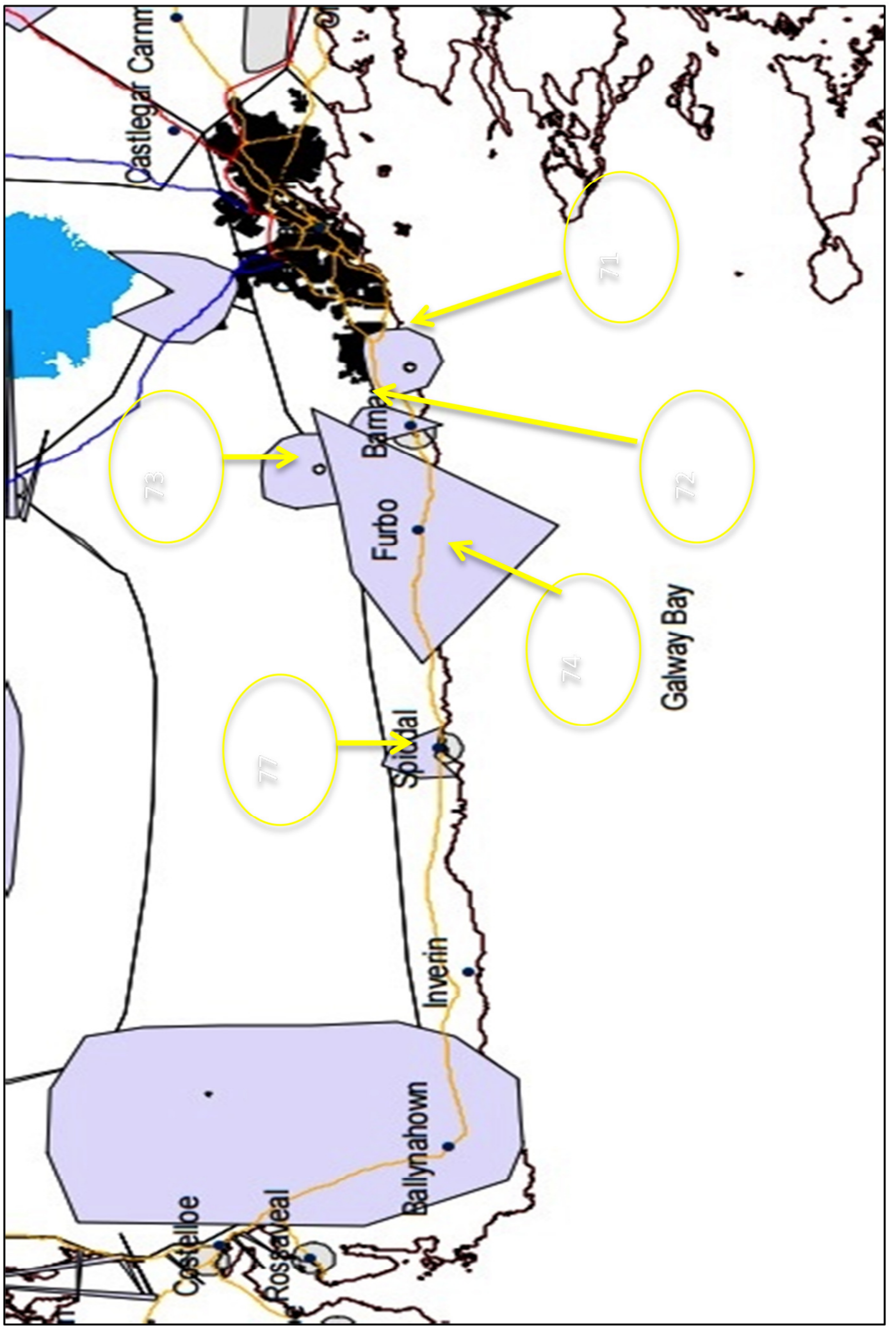


Figure 11-4: Excerpt from Galway County Development Plan Map FPV1 showing designated focal points and views in the vicinity of the proposal site (numbering added)

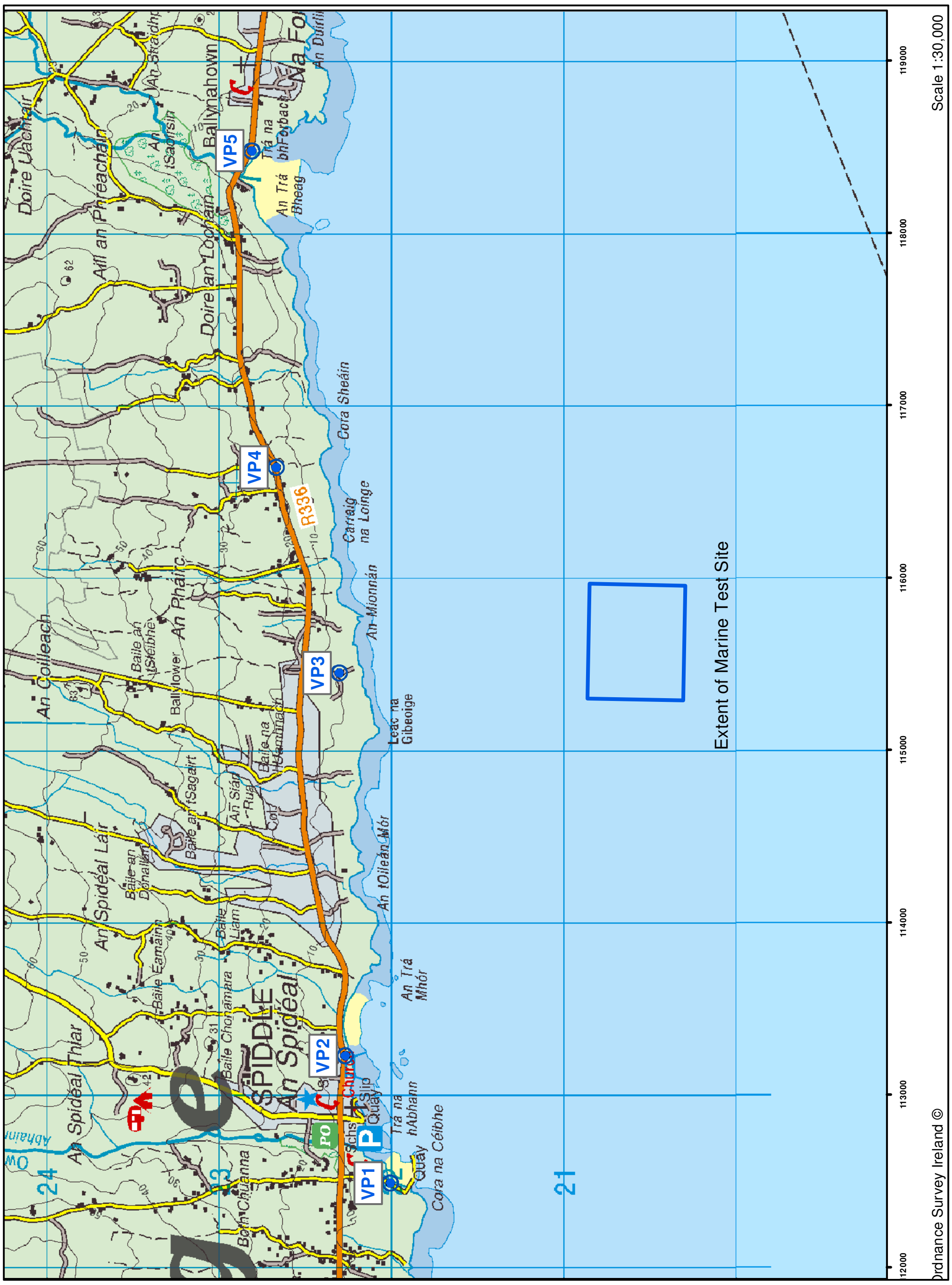


Figure 11-5: Viewpoint map indicating the locations chosen for photomontages

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12. Material Assets

12.1. Introduction

This chapter deals with the potential impact of the proposed development on fishing, tourism and amenity. The test site area has been in existence for the past ten years and has been demarcated during that time by four cardinal marks. The test site is marked on all navigation charts as an "ocean energy test site" and is known to commercial fishermen, commercial and recreational vessels. There are no plans to extend the area of the test site.

The information in this section is primarily provided by the Central Statistics Office, Failte Ireland, Bord Iascaigh Mhara, Marine Institute, Sea Fisheries Protection Agency, Naval Service and Coastguard.

12.2. Worst Case Scenario

The impacts of the Galway Bay Marine and Renewable Energy Test Site project have been assessed under the following worst case scenario deployment of items at the test site in Table 12-1.

Table 12-1: Material Assets worst case scenario

Permanent	Recurring	Devices
4 x cardinal marks	Data buoy	1 x OWC
Subsea observatory	Acoustic Array	1 x Attenuator
Waverider	ADCP	1 x Floating Wind Turbine
SeaStation	Cabling	
9 x gravity bases		

12.3. Commercial Fishing & Aquaculture

12.3.1. Receiving environment

Inner Galway Bay has valuable crustacean fisheries with annual landings exceeding 100 tonnes (Tully *et al*., 2010). Most of the fishing activities (mainly potting) takes place along the northeast shore of Galway Bay with over 45% of catches comprising of shrimp (*Palaemon serratus*). The distribution of various fishing and aquaculture activities in Galway Bay is shown in Figure 13-8.

There is high seasonal fishing effort in the coastal waters off Furbo and Spiddal which comprises several boats (6 - 10m in length) fishing for lobsters, shrimps and velvet crabs. Pots are set along rocky areas and over stretches of sand in water depths of up to 22m usually in strings of 20-30 pots. Each vessel operates between 200 and 500 pots. Vessels are based at Spiddal and Barna and most of the fishermen are members of the Galway Bay Inshore Fishermen's Association (GBIFA).

Shrimp fishing takes place mainly in late Autumn, Winter and Spring and is particularly active from August to January. There is a closed season for shrimp fishing over a three month period between May and August. Lobster and velvet crab fishing is usually carried out in the Summer months from June to October with no closed season for catching these species.

Line fishing for mackerel and pollock takes place in the Summer months from small inshore boats and from the shore at various locations between Furbo and Spiddal. Some inshore boats also use trammel nets (bottom anchored net) to catch wrasse, pollack and edible crab over rocky reefs.

Some limited bottom trawling for Dublin Bay prawn (*Nephrops norvegicus*) and demersal fish species such as plaice, haddock and cod is carried out by a few small trawlers (10 to 15m) just to the west of test site. Further to the west in deeper waters off Inverin and in the central parts of Outer Galway Bay larger trawlers operate occasionally.

Only one area is designated for aquaculture along the north shore of Galway Bay and it is located approximately 12km west of the test site off Spiddal. This site has been designated for shellfish and was a mussel growing site operating mainly long-line systems but has ceased operations.

The Owenboluisce River drains several lakes in a catchment stretching over 12km to the north of Spiddal. It is approximately 5km long and flows through Spiddal Demesne and into Galway Bay at Spiddal Pier. The river contains Atlantic Salmon (*Salmo salar*), Trout (*Salmo trutta*), Lamprey and occasional Arctic Char (*Salvelinus alpinus*). Atlantic Salmon (in their freshwater environment) and Lampreys are Annex II protected species under the Habitats Directive. Small runs of Salmon grilse and Sea Trout occur in the Summer months with fish moving into the estuary and up the river during May to July. The river and its environs are important components of the areas biodiversity and link with a designated ecological site to the north of the Spiddal Demesne and the coastal area to the south of the village.

12.3.2. Impacts of the development

The site has been in existence for ten years, and other than the upgrade of the four cardinal marks delineating the site, there will be no impacts associated with the installation phase of the test site infrastructure.

The operational phase of the project will last 35 years, during which devices will be deployed, tested and recovered from the test areas. This will involve movements of vessels such workboats and support vessels and the devices themselves, some of which may be towed into position.

There may be some very short-term disruption to fishing activity during device deployment and recovery operations; however, due to the small amount of ocean energy devices that will tested at any one time the impact on fishing will be negligible.

During inclement weather, fishermen’s gear may drift and become entangled with the mooring systems of the test area marker buoys or with the device mooring arrangements, leading to gear damage and subsequent cost and loss of income. If this occurred, the impact would be of short duration and of medium significance, due to the immediate economic loss to the fishing community.

Similarly, during severe weather, devices under test might break loose from their moorings and damage deployed fishing gear, resulting in cost and loss of income to the fishermen. If this occurred, the impact would be of short duration and of medium significance, due to the immediate economic loss to the fishing community.

If the existing subsea telecommunications and power cable suffers damage, repairs will be made in *situ*. A section of cable will be lifted by a repair vessel which will be on station until repair is completed (approximately two weeks). This could cause temporary disruption of fishing activity. The impact would be of short duration and of low significance.

During decommissioning of devices there may be a short-term presence of large slow moving craft in the area. This could disrupt fishing activities due to increased vessel traffic in the area. The effect of this is likely to be insignificant due to the short-term nature of the disruption.

The test area, with its effective exclusion on fishing activity, may result in the development of nursery areas which could enhance fish and shellfish stock. Mooring systems may also create artificial reef structures which could also lead to enhanced fish and shellfish stock in the area. Such nursery areas may lead to increased catch in future, enhancing fishermen’s income on a sustainable basis.

12.3.3. Mitigation

To avoid impacts on the fishing industry in the area the following mitigation measure should be undertaken:

- Advance notice of all marine operations and device deployment, maintenance and recovery will be notified to all marine stakeholders. To the greatest extent possible, operations will be timed to minimise disruption of fishing activity. However, good weather conditions are required for all deployment operations associated with the test site, and these are likely to coincide with fishing activities to some extent.
- A specific communication forum will be established to facilitate consultation with and information dissemination to all stakeholders.

- All operations at the test site will be governed by the accredited HSEQ Management System that sets out the rules for the test site users and for their interaction with other stakeholders. The operational plan includes an emergency response plan. This will facilitate rapid response to emergency situations, such as devices breaking their moorings and coming adrift or becoming entangled with fishing gear. The implementation of the operational plan will minimise the potential for impact on the fishing community.

12.3.4. Conclusion

The project is unlikely to have any significant negative impacts on commercial fishing and aquaculture as the vessel exclusion zone does not impede access to a significant part of the fishery and may even result in gains to fishing income due to the nursery that it creates. During the installation and during device deployment and recovery operations, the impacts on the fishing industry in the area will be of short duration and of low significance overall. Impacts can be reduced through careful planning of all activities associated with the test site in line with the accredited HSEQ Management Plan, and through continuing engagement with key stakeholders in Spiddal.

12.4. Tourism & Leisure

12.4.1. Receiving environment

Tourism is vitally important to Ireland's national economy and is regarded as one of the greatest wealth creators and employers at national level. Although there was a significant decline in tourism due to the global economic downturn the number of overseas visits to Ireland has risen in the last two study years. The majority of visitors hail from only three countries; Great Britain, the USA and Canada meaning overseas visitor numbers are vulnerable to fluctuations in exchange rates.

Table 12-2: Overseas Trips to Ireland (Thousand) by Area of Residence and Year

Year	2008	2009	2010	2011	2012	2013	2014
Great Britain	3872.4	3257	2738.5	2878.1	2774.2	2928.9	3163.9
Other Europe	2610.3	2382.3	2045.2	2283.2	2347.4	2463	2638.1
USA and Canada	1004.6	980.4	935.6	987.1	1016.9	1158.1	1328.6
Other Areas	351.7	307.9	317.8	356.7	378.6	435.9	473.8
Total	7839	6927.6	6037.1	6505.1	6517.1	6985.9	7604.4

Source: CSO Country of Residence Survey

In 2014, overseas visitor expenditure excluding travel fares amounted to €3.5 billion. Combined domestic and overseas visitors expenditure was estimated to be €6.5 billion, a significant portion of Irish GDP. Tourism can generate economic growth in areas that lack other employment opportunities, the 2010 Failte Ireland Tourism Employment Survey estimated that almost 180,000 people were employed in the tourism and hospitality sector that year. Marine tourism accounts for 10% of the overall value of the tourism sector according to Failte Ireland. The Socio-Economic Marine Research Unit's report on Ireland's Ocean Economy provided an estimated figure of 5,952 jobs in marine based tourism and marine activities for the year 2014 (SEMRU, 2015).

Spiddal has swimming beaches that are popular with both local and tourist visitors in summer months and have important amenity value. Ceibh an Spideil is located inside the New Pier, Trá na mBan is located east of the village. Following water quality assessments over the period 2011-2014 Ceibh an Spideil was rated as having "Good" water quality and Trá na mBan was deemed to have "Sufficient" water quality. In recent years both beaches have been awarded "Excellent" water quality ratings on a seasonal basis.

Other activities include shore angling, boating and canoeing and sailing that, take place especially in the Spiddal area where there are good services and two piers. A number of sea angling charter boats operate out of Spiddal and good catches of mackerel, pollock, wrasse, ray and tope shark are regularly taken in season. Other activities include diving, leisure boating, bay cruises and local heritage trips along the coastal area.

The shoreline along the coast off Spiddal is very exposed and open directly to the prevailing south west and west winds. Although there are no designated vessel mooring, yacht anchorage facilities or sites in the area, local yachts sometimes anchor for short periods off Spiddal pier during summer months.

Local and tourist ferries operating in Galway Bay are based out of Galway Harbour, Ros a' Mhíl and Doolin and their routes are well to the south and west of the test site. Shipping to and from Galway Port navigates up to 10km to the south of Spiddal through the central part of the Bay. Vessels reach the open ocean through the deep water channel in the North Sound between Inishmore and the Connemara mainland or south west between Inisheer and the Clare coast.

12.4.2. Impact of the development

The test site is already in operation, with all necessary components such as marker buoys designating the limits of the test area and the data transmission cable being put in place during previous projects therefore there will be no impacts from installation on tourism activity in the area.

During the operational phase, one of the issues associated with the Galway Bay Marine and Renewable Energy Test Site is that the array of different structures might appear slightly anomalous to visitors who are unaware of the sites' purpose. The overall impact is judged to be slight and this only applies to a worst case scenario where three above-surface devices are briefly in place at the same time.

Due to its uniqueness however, the test site may result in an increase in visits to the area. It could provide a first-hand opportunity to view marine renewable resources in operation in a near-shore environment.

The impact of the test site on recreation activities is likely to be negligible because operations will not affect water quality in the area. The site is not in the path of shipping ensuring that no additional costs are incurred to passenger or freight services that operate out of ports in Galway Bay and Rossaveel. During decommissioning there may be some short-term disruption to the amenity value of the area.

12.4.3. Mitigation

By way of mitigation, the Marine Institute intends to provide an interpretive installation on the shoreline (most likely at Spiddal), which provides information about the various marine renewable technologies and the purpose of the site for testing such devices. It is believed that there will be genuine interest in the Galway Bay Marine and Renewable Energy Test Site and any visual ambiguity is likely be removed for those armed with information about the site.

12.4.4. Conclusion

The impacts of the proposed project on tourism in the area are adjudged to be negligible; ferry services and water quality are not likely to be affected by operations at the test area. The marine renewable energy technologies that are being tested may instead serve to raise the profile of the area.

13. Navigation

13.1. Introduction

The Marine Institute are proposing to upgrade the existing ¼ scale wave energy test site located off the coast of Spiddal, Co. Galway. The existing wave energy test site has been in existence for ten years. The site is demarcated by four cardinal marks, one at each corner of the test site. The test site is marked on all navigation charts as an "ocean energy test site" (Figure 13-1).

The proposed Galway Bay Marine and Renewable Energy Test Site will be at the exact same location, and of the same dimensions, as the existing test site. Nonetheless, ocean energy converters and other marine technologies will be placed in the test site. Deep sea shipping, fishing vessels and pleasure craft routinely operate in the environs of Galway Bay, and in this context there is a potential for interaction with the test site.

13.2. Description of the Project

The Galway Bay Marine and Renewable Energy Test Site is located at the existing ¼ scale ocean energy test site on the north side of Galway Bay (Figure 13-2). The test-site is located 2.4 km southeast of the village of Spiddal which is located 19 km west of Galway City. The coordinates of the test site are provided in Table 13-1.

The area of the Galway Bay Marine and Renewable Energy Test Site will be the same as the existing site, at 37 hectares and located in water depths of 21-24 metres. Its east-west extent is approximately 670 m and its north-south extent approximately 560 m.

The test site area is demarcated by four cardinal marks, one at each corner. A fibre optic telecommunications and power cable was installed from the test site to shore in April 2015 under Foreshore Licence No. 2014/02786.

The upgrade will allow for the deployment and testing of a wide range of prototype marine renewable energy devices, innovative marine technologies and novel sensors. The facility will also provide access to a subsea observatory allowing researchers and scientists to conduct research in the marine environment.

Table 13-1: Coordinates of Galway Bay Marine and Renewable Energy Test Site

Location	Longitude	Latitude
1 North West	53^{o} 13.90' N	9^{o} 16.15' W
2 North East	53^{o} 13.90' N	9^{o} 15.55' W
3 South West	53^{o} 13.60' N	9^{o} 16.15' W
4 South East	53^{o} 13.60' N	9^{o} 15.55' W

It is proposed that the upgraded test site will operate for up to 35 years, with devices on site intermittently throughout the year. The site will be structured into three berths for testing of ocean energy prototypes. The fourth berth will be for the Cabled Observatory and related projects.

The upgrade of the site will involve deploying a range of supporting infrastructure to the site, including:

- An acoustic array for monitoring underwater sound;
- A ‘Sea Station’ to provide power to, and dissipate power from, ocean energy devices;
- Buoys for testing of marine technologies and scientific sensors;
- A Waverider buoy for wave measurements;
- Interlocking modular gravity foundations;
- A variety of scientific sensors and instruments;
- Cables to connect the instruments, sensors, and ocean energy devices;
- Upgraded cardinal marks to allow for safe navigation.

Upgrading the site will enable a maximum of three devices of the following types to be deployed at the test site for a period of testing no greater than 18 months in any one instance:

- Surface ocean energy converters;
- Sub-surface ocean energy converters;
- Seabed ocean energy converters;
- Prototype floating wind turbines;
- Novel marine technologies and scientific sensors.

13.3. Existing Environment

13.3.1. Introduction

This section presents general information on the existing environment in the area with respect to shipping and navigation.

13.3.2. Port & Harbours

The closest ports to the test site include the commercial port of Galway to the east and the fisheries harbour at Rossaveal to the west as shown in Figure 13-3. Rossaveel is also used by non-fishing vessels working from the port, and passenger ferries to the Aran Islands.

There are also a large number of smaller harbours, piers and slipways dotted along the coast in the area. A number of these are used by smaller fishing vessels, leisure craft and small ferries serving islands. The locations of these berthing facilities are presented in Figure 13-4.

13.3.3. Routing Measures

Two traffic separation schemes for ship navigation are in place in Galway Bay, located on the southern side of Galway Bay, presented in Figure 13-5. All vessels entering and leaving Galway port are obliged to follow these schemes.

13.3.4. Aids to Navigation & other navigation aids

There are a number of AtoN, lighthouses, marker buoys and other navigation lights in the vicinity of test site in Galway Bay shown in Figure 13-6.

13.3.5. Wrecks

The shipwreck inventory noted four vessels being lost near Spiddal. No evidence of any of these vessels or their remains was noted in the vicinity of the test site location. Admiralty charts for the area close to the test site location also have no record of the presence of wrecks.

13.3.6. Oil & Gas Infrastructure

There is no oil and gas infrastructure in the surrounding area close to the location of the test site.

13.3.7. Dredging Activity

There is no dredging activity in the surrounding area close to the location of the test site.

13.3.8. Exercise Areas

There are no military exercise areas in the surrounding area close to the location of the test site.

13.3.9. Bathymetry

The receiving environment at the test site comprises 0.375km^2 in area, 2.4km to the southeast of Spiddal Pier in water depths of 20-25m (Figure 13-7). The seabed of the test site is relatively flat and featureless. In the near vicinity of the test site, the marine geomorphology comprises rock reefs to the North, along the Connemara coastline. From 10m depth the seabed is generally sandy extending southwards.

13.3.10.Fishing Grounds

Most of the fishing activities (mainly potting) takes place along the northeast shore of Galway Bay. The distribution of various fishing and aquaculture activities in Galway Bay is shown in Figure 13-8.

There is high seasonal fishing effort in the coastal waters off Furbo and Spiddal which comprises several boats (6 - 10m in length). Pots are set along rocky areas and over stretches of sand in water depths of up to 22m usually in strings of 20-30 pots. Each vessel operates between 200 and 500 pots. Vessels are based at Spiddal and Barna and most of the fishermen are members of the Galway Bay Inshore Fishermen's Association (GBIFA).

Shrimp fishing takes place mainly in late Autumn, Winter and Spring and is particularly active from August to January. There is a closed season for shrimp fishing over a three month period between May and August. Lobster and velvet crab fishing is usually carried out in the Summer months from June to October with no closed season for catching these species.

Line fishing for mackerel and pollack takes place in the Summer months from small inshore boats and from the shore at various locations between Furbo and Spiddal. Some inshore boats also use trammel nets (bottom anchored net) to catch wrasse, pollack and edible crab over rocky reefs.

Some limited bottom trawling for Dublin Bay prawn (Nephrops norvegicus) and demersal fish species such as plaice, haddock and cod is carried out by a few small trawlers (10 to 15m) just to the west of test site. Further to the west in deeper waters off Inverin and in the central parts of Outer Galway Bay larger trawlers operate occasionally.

13.4. Maritime Traffic

The assessment of maritime traffic includes all the vessel types found in the area. It takes into account seasonal variation in traffic patterns and fishing operations.

Traffic beyond the 10 nautical mile, 10 NM, horizon from an offshore installation is normally considered not to have any effect nor to be affected by the same installation. In view of this, the traffic analysis is therefore usually limited to the area within a 10 NM radius from the site.

For the Galway Bay Marine and Renewable Energy Test Site area a smaller limit was chosen for the assessment. All maritime traffic that may potentially interact with the test site area is constrained between the north and south shores of Galway Bay, a distance of approximately 5NM.

The Area of Interest where the traffic assessment was carried out covers a minimum of 5 NM from any point on the boundary of the test site as shown in Figure 13-9.

13.4.1. Automatic Identification System (AIS)

AIS enables vessels and Coast Guard shore stations to transmit and receive information regarding identity, position, course and speed of vessels. AIS transmissions and information is broadcast over VHF radio and is freely available to those with AIS monitoring equipment. AIS is compulsorily carried by commercial vessels of more than 300 gross tonnes but can be used by small craft as an additional safety feature.

AIS is a very accurate method of detecting a vessels location and the track they are travelling. There was no restriction to the range from the Galway Bay Marine and Renewable Energy Test Site in which AIS data could be recorded thus vessel tracks recorded by AIS are available for the entire Area of Interest around the test site and beyond. AIS data was provided by the Coastguard.

The AIS data was analysed for the months of January 2013, July 2014, January 2014 and July 2014. Figure 13-10 and Figure 13-11 show all AIS vessel positions identified during the winter months of January 2013 and January 2014 respectively, both months colour-coded based on vessel type. Figure 13-12 and Figure 13-13 show all AIS vessel positions identified during the summer months of July 2013 and July 2014 respectively, both months colour-coded based on vessel type.

It is clear from the January 2013 and January 2014 AIS data in Figure 13-10 and Figure 13-11 that the majority of traffic through Galway Bay consists of tanker and cargo traffic transiting to and from the Port of Galway along with fishing vessels. Notable in Figure 13-10 is the presence of research vessel activity in the vicinity of the test site during scheduled test site maintenance operations.

The summer months of July 2013 and July 2014 (Figure 13-12 and Figure 13-13) show a greater diversity of vessel activity in Galway Bay, including increased sailing vessel activity.

In winter and summer only one vessel of any type interacted with the test site area. This was the Marine Institute research vessel RV Celtic Voyager undertaking authorised scheduled maintenance operations at the test site. All vessels in Galway Bay observed the cardinal marks demarcating the test site area.

13.4.2. Vessel Monitoring System (VMS)

The Vessel Monitoring System (VMS) is a system which processes information passed by Irish registered fishing vessels using onboard satellite communications regarding their position, effort and catch. All fishing vessels over 12 metres have a VMS system.
These systems are used primarily in the Fishery Monitoring Centre (FMC), onboard Naval Service ships and onboard Air Corps Maritime Patrol Aircraft on fishery protection duties.

The Vessel Monitoring System in use by the Fisheries Monitoring Centre was originally installed in 2000 and it provides a visual display of all fishing vessels. There are approximately 400 vessels active in Irish waters each day.

VMS data were provided by the Irish Naval Service and processed by the Marine Institute according to methods outlined in Gerritsen and Lordan (2014). VMS data was aggregated on a grid of 0.010 degrees longitude x 0.005 degrees latitude over the period 2006-2014 to give an annualised average representation of fishing activity in Galway Bay over the past ten years.

As part of the assessment, fishing activity (Figure 13-14) and streaming time (Figure 13-15) was determined in Galway Bay. Both sets of data show that there is no interaction of fishing vessel activity within the demarcated limits of the test site area.

13.5. Risk Assessment

The assessment of maritime traffic near the site indicates that the shipping activity within Galway Bay was relatively high, but that all vessels transiting through Galway Bay have observed the cardinal marking scheme denoting the safe navigation routes around the test site area.

The UK's Department of Trade and Industry (DTI) guidance in relation to navigation risk assessment for offshore windfarms states that the scope and depth of any risk assessment, together with the tools and techniques necessary to carry this out, should be proportionate to the scale of the development and the magnitude of the risks.

As a result, the Galway Bay Marine and Renewable Energy Test Site development is a 'low risk, small scale development ... a development in an area where the potential risks are low, and/or a small scale development' for the following reasons:

- the location of the test site on the northern shore of Galway Bay outside commercial shipping routes;
- the existence of the test site for the past ten years;
- knowledge of the site location within the local fishing community;
- the cardinal marking scheme demarcating safe passage routes around the test site;
- the inclusion of the test site on all Admiralty Charts for navigation purposes/

The risks associated with the operation of the test site when ocean energy convertors are on site are:

- The risk of a vessel under control making contact with a device on site;
- The risk of a vessel not under command or drifting making contact with a device on site;

- The risk of a vessel towing fishing equipment snagging the subsea cable causing the vessel to founder or capsize;
- The risk of mooring failure of a device causing it to leave the test site area and enter open waters;
- The risk of accidents caused by transfer to/from servicing vessel to a device on site requiring SAR response;
- The risk of a service vessel requiring SAR and /or emergency response;
- The risk of a person in the water requiring rescue.

13.6. Site management

13.6.1. Introduction

The Galway Bay Marine and Renewable Energy Test Site will be operated in accordance with the accredited HSEQ Management System (Appendix 10). The system is accredited to ISO 9001 (Quality), ISO 14001 (Environment), and OHSAS 18001 (Occupational Health & Safety).

The HSEQ Management System is based on the BSi Occupational Health and Safety, the ISO International Standards Quality and Environmental Management Systems taking into account recommended Offshore Wind and Marine Energy Health and Safety Guidelines, International and National maritime safety and environmental regulations, codes and guidelines.

The HSEQ Management System comprises of the following parts:

- Tier 1 Manual Describes the HSEQ Management System, in three Parts A, B & C.
  - Section A: Policies, Administration and Risk Management.
  - Section B: HSEQ Project Management.
  - Section C: Offshore & Shore Based Hazards and Activities.
- Tier 2 Manual Detailed Company Procedures.
- Tier 3 Registers Risk Assessments, Method Statements.
- Tier 4 Register Forms.

13.6.2. Site Management

On-going site management arrangements take into account the need to address issues such as:

- Tracking personnel between vessels and onshore areas;
- Shift work, and potentially lone working;
- Housekeeping, including the need to maintain clear access routes, and waste disposal at the shore interface;

- Storage and movement of materials, possibly including use of temporary storage areas;
- Maintenance and security of data nodal sites where cables come ashore;
- Maintenance and security of long range RF data link equipment and broadband connections;
- Response to severe weather, including storms and winter conditions;
- Emergency response, either relating to an incident in the port, on the offshore site, or an external emergency event.

Ports and shore-based contractors will have their own safety management systems; bridging documents are needed in order to manage the interface with the OREI operator's systems, in normal operation and emergency situations. Common arrangements will be put in place for the management of visitors and contractors who are not normally on the site, such as specialist repair technicians.

Harbour Authorities marine coordination functions play a key role in managing the use of the port. This includes planning all vessel movements, in conjunction with any construction contractors / port facility operations when planning logistics support, which possibly involves Vessel Traffic Systems control (VTS) or Harbour Masters and pilots who control vessel movements where harbour authorities operate such systems. Harbour Masters have a statutory obligation to direct traffic within their port limits and so have the right to pass instructions to vessels.

With responsibility for the management of marine energy test site, there is a legal obligation to ensure that planned changes to the site are notified to authorities responsible for navigation marks including lights that warn shipping.

Given the wide range of requirements and associated mitigation actions, early dialogue with port authorities, existing users, onshore contractors and workforce representatives is beneficial to establishing safe and efficient port operations.

13.6.3. Risk & Hazards

SmartBay subscribes to the principals and practice of Risk Management. The objectives of the HSEQ Management System are to ensure safety ashore and at sea, prevention of human injury or loss of life, and avoidance of damage to the environment and to property.

The HSEQ Management System procedures are based on Safe Systems of Work which include:

- Hazard Operability (HAZOP);
- Hazard Identification;
- Risk Assessment;

- Risk management controls including Permits to Work;
- Method Statements;
- Accident / Dangerous Occurrence Reporting;
- Accident / Dangerous Occurrence Investigation and corrective actions;
- Audits, Inspections and Review;
- Continuous Improvement through Monitoring, Analysis and Preventive Action;
- Ownership by all personnel through participation and consultation;
- Compliance with all regulations, codes and industry guidelines;

The purpose of Risk Management is to reduce, eliminate or transfer the risk by identifying hazards, assessing the consequences, likelihood and determination of controls that reduce eliminate or reduce the risks to acceptable levels for business activities to be carried out safety and without harming the environment.

Risk Assessments (RA) are conducted for the purposes of reducing risk to its employees and other interested parties. Risk Assessments are conducted in accordance with detailed procedures. Relevant Risk Assessments are reviewed prior to each activity where risks to human health and safety or damage to the environment are identified. Competency to complete RA is based on expertise that currently exists at all levels, which has been passed on through a mentoring process; they may be completed by any competent member of the staff and approved or authorized by the manager. Further training in this area may be necessary as the safety systems continue to evolve.

Hazard Operability studies of test sites are conducted and updated, and the processes related to projects for the purposes of identifying hazards associated with the overall management and maintenance of the marine sites and their operation. An analysis of the findings provides information useful in the Hazard Identification process (HAZID).

An essential element of any OH&S Risk Assessment is Hazard Identification or “HAZID” process, identifying hazards which could cause harm. Hazards associated with each step of a work process are identified and transposed into the relevant Risk Assessment. Each hazard is assessed for its consequence, severity, likelihood and existing controls. It is important that other activities do not conflict with the intended work thereby creating additional hazards. Such potential conflicts are also risk assessed and if the additional hazards cannot be eliminated or controlled then alternative means of conducting the work should be found.

Method Statements are developed for work activities during the Project Planning process and for any activity where Hazards have been identified. The Method Statement is documented and is supported by the HAZID, Risk Assessments and Permits to Work where required. The Method Statement forms the basis for the “Tool Box Talk” which is conducted between the persons actively involved, supervisors and any contractors and any other persons who may be engaged in activities that could conflict with the work described in the Method Statement.

Potential emergency scenarios are analysed as part of the organization's risk management processes. A review of the analysis of potential hazards or circumstances that could lead to an emergency may provide opportunities to prevent an incident or at least mitigate the consequences through both improved preparedness and response actions.

When assessing the controls to eliminate or reduce risk where the consequences might lead to an emergency the findings are applied to both the Method Statement and the emergency contingency plans respectively thus the safe systems of work encourage should become effective in mitigating risk as part of the HSEQ lifecycle

13.6.4. Vessels

Before any operation involving vessels takes place it is compulsory to carry out a pre-cruise inspection to the vessel.There are a number of objectives to achieve during this inspection, including:

- Vessel documentation;
- Safety tour;
- Induction, emergency briefing including life saving appliances and fire alarms systems;
- In smaller vessels, i.e. below 15 metres length, check out the VHF, fire extinguishers, EPIRB and SART, where assistance in an emergency might be necessary;
- Inspection of vessel equipment that may be required for the task and conditions of use;
- Inspect working conditions;
- Tool-Box briefing with the boat crew, to cover the intended tasks;
- Discuss passage plan with the Master/Skipper;

Vessels that are not fully compliant and up-to-date with their regulatory certifications and applicable maritime standards will not be used

Updated documentation is requested on an annual basis for passenger boats used as workboats and any other class of boat up to 24 metres. Workboat certification is maintained on a spreadsheet supported by scanned/photographed documentation including at least the following (if relevant):

- Passenger Safety "Licence" Certification under Merchant Shipping (Passenger Boat) Regulations1 displayed onboard with an expiry date not exceeding 2 years. It is a criminal offence to operate a passenger boat without a licence. Passenger boats must be inspected by an authorized person on behalf of the Irish DTTAS Marine Survey Office;

- Load Line Certificate, which includes freeboard and intact stability survey requirements;
- Insurance Certificate in respect of injury, loss or damage to passenger or property on the vessel, or to a person or property not on the vessel, caused by or arising out of the operation of the vessel;
- Master's Certificate of Competency;
- Workboat condition and equipment inspections, pre hire.

Periodic Second Party Audits of charter boats are conducted to verify compliance.
For vessels in excess of 24 metres, carrying 12 or less passengers the following certification is requested and held on record with periodic checks for continued verification:

- International Load Line Certificate;
- Cargo Ship Safety Certificate;
- Cargo Ship Safety Construction Certificate;
- Cargo Ship Safety Equipment Certificate;
- Certificate of entry to P&I Third Party Insurance Certificate;
- Details of equipment likely to be used for SmartBay work such as deck cranes.

Larger vessels which are subject to the ISM Code, i.e. > 500 gross register tonnage (GRT) or less for which there is a valid Safety Management Certificate (SMC) under a voluntary system are not audited. However copies of relevant certification are obtained, and a safety tour of inspection conducted and the findings recorded if deemed necessary. Vessel certification is verified on an annual basis.

13.6.5. Infrastructure

All aspects of design, operation, maintenance and performance in terms of the effects that infrastructure has in the provision of safe, clean and effective resource are considered.

Infrastructure consists of *(inter alia):*

- Buildings and associated utilities;
- Equipment including hardware and software;
- Workshops, tools and plant;
- Buoys, cables and other offshore equipment;
- Transport including marine craft;
- Information and communication technology;
- Instrumentation;

- Hired in equipment such as surveying / measuring devices;
- Sub-sea cable and observatory.

Note: Hired in craft such as RIBs or workboats supplied with a skipper / crew are a resource and should be fit for purposes in every respect.

13.6.6. Safe working conditions

Procedures for safe working on the test site using shore based workboats have been developed. These procedures take in account, at least the following:

- Weather conditions and weather forecasts covering the period from prior to departure by boat, during the passage and on site and for the return passage back to a safe berth plus one day;
- Tidal conditions including heights of tides, tidal stream rates;
- Sea conditions taking in account that predicted wave and swell conditions are serious affected by "wind over tide" which increases wave height and reduces the pitch of the waves making them steeper and more likely to break. When the tide runs opposite to the wind the sea state is affected by the equivalent of 1 notch on the Beaufort Scale or additional 2-3 metres/second. These conditions can result in lower boat speeds with smaller vessels throttling back from e.g. normal cruising speed to 5 knots to avoid damage and less discomfort for crew.

13.6.7. Emergency Preparedness and Response

In accordance with statutory maritime regulations an "Emergency Response Plan" in accordance with the Offshore Renewable Energy Installations (OREI) guidelines has been developed.

Adequate plans and procedures to be taken in the case of an emergency or serious imminent danger including medical emergencies and actions to assist others in distress are prepared and updated as required.

In developing, maintaining and improving Emergency Response Plans account is taken of the following explicit duties in addition to general duties:

- Establishing procedures in the event of serious and imminent danger to persons during emergency response – taking into account the balance of risk in saving life;
- Nominating sufficient number of competent persons to implement those procedures;
- Restricting employee access to danger area;
- Informing persons exposed to serious and imminent danger as to nature of the hazard and steps taken/to be taken to protect them from it;

- Enable persons to stop work and immediately proceed to a place of safety in the event of their being exposed to serious, imminent and unavoidable danger;
- Prevent persons from resuming work in any situation where there is still a serious and imminent danger following an emergency incident;
- Implement dynamic Risk Assessment when considering emergency actions. Reviewing or assessing residual risk following any Emergency situation;
- Ensuring any necessary contacts with external emergency services are arranged, particularly as regards first-aid, emergency medical care and rescue work;

The Emergency Response Plan is required to address specific regulatory requirements and/or the findings of Risk Assessments preformed, include, but are not limited to:

- Confined Spaces (including Entry to Enclosed Spaces);
- Construction, installation, maintenance activities;
- Electrical repair installation, repair, maintenance and decommissioning;
- Diving;
- Fire;
- Hazardous substances;
- Lifting operations;
- Marine personnel transfer;
- Vessels;
- Working at height;
- Man Over Board (Unintentionally);

The Emergency Response Plan shall be maintained in an up to date form including the internal and external emergency response contact details (landline, mobile telephone, email address and alternative numbers). External contact details include:

- Gardaí / Fire & Rescue / Coast Guard;
- Local affiliated rescue services;
- Marine Rescue Coordination Centre (MRCC);
- Harbour Masters;
- Salvage / Towing / workboat contractors;
- Diving companies;
- Oil / Chemical spillage emergency responders.

13.7. Impact of the development

During the operational phase of the test site the presence of vessels on site and the additional vessel movements to and from the main ports of Rossaveel and Galway will pose an additional navigational risk. Marine Notices will be issued advising of deployments and recovery operations for all ocean energy devices. All vessels employed in relation to the development will comply with all statutory regulations and will be of sufficient size to cope with the works and the adverse weather conditions.

13.7.1. Worst Case Scenario

The impacts of the Galway Bay Marine and Renewable Energy Test Site project have been assessed under the following worst case scenario deployment of items at the test site in Table 13-2

Table 13-2: Navigation worst case scenario

Permanent	Recurring	Devices
4 x cardinal marks	Data buoy	1 x OWC
Subsea observatory	Acoustic Array	1 x Attenuator
Waverider	ADCP	1 x Floating Wind Turbine
SeaStation	Cabling	
9 x gravity bases		

13.7.2. Impacts on fishing vessels

Based on data collected, and discussions with the local fishing communities, the impact on vessels avoiding the test site is minimal as there is sufficient sea-room to the north and south of site area to transit to and from fishing grounds. The local boats have become familiar with the navigational rules governing the test site cardinal marks since its establishment ten years ago. No fishing activity (predominantly potting) has been carried out within the test site.

13.7.3. Impacts on commercial vessels

Commercial shipping routes in and out of Galway Bay are located to the south of the test site and therefore the impact on commercial vessels is negligible. The marking of the test site on Admiralty charts minimises the risk of collisions.

13.7.4. Impacts on recreational vessels

Based on information from local sailing clubs, the test site has had, and will continue to have, negligible impact on the recreational vessel activity in the area. The marking of the test site on Admiralty charts minimises the risk of collisions.

During the operational phase of the test site the presence of vessels and the likely additional vessel movements to and from the main ports of Rossaveel and Galway will pose an additional navigational risk. Marine Notices will be issued advising of deployments and recovery operations for devices on site.

13.8. Mitigation

13.8.1. General

- Control measures for frequent users of the area around the test site are defined and managed. This includes measures such as defining and agreeing a procedure with fishermen a procedure for retrieving any fishing gear that enters the site.
- Position monitoring of devices and buoys to ensure stationary position.
- A separate device-specific risk assessment outlining the hazards associated with the devices will be prepared by the device developer before devices are installed. The device-specific risk assessments will conform to the guidelines of the SmartBay HSEQ Management System.

13.8.2. Operational phase

- Notices to be issued in advance of installation or decommissioning of any device.
- All vessels employed in relation to the development will comply with all statutory regulations. They will be of sufficient size to undertake the works and ambient weather conditions in accordance with the HSEQ management System
- The installation and decommissioning of devices will be planned and managed to ensure the safety of those involved and of other maritime users in this area in accordance with the HSEQ management System
- A reliable inspection, maintenance and casualty response regime conditions in accordance with the HSEQ Management System will be implemented. This will ensure that the required reliability targets for navigation aids (as specified by IALA standards) are met
- The RNLI and other emergency services will be notified of the layout and workings of the site and are involved in emergency exercises for the site. Search & Rescue should also be included in each device-specific risk assessment.
- Personal protective equipment will be compulsory for all personal on site to ensure safety, in accordance with the HSEQ Management System

13.9. Conclusions

Information on local ports and harbours, standard sailing routes, existing Aids to Navigation, existing navigation aids, known navigation hazards, industry activity, sea conditions, bathymetry, fishing grounds and fishing activity was gathered relating to navigation in the area to support the assessment. On assessment of the existing environment, no significant impact on navigation was identified.

To minimise risks to vessels navigating in the area and the devices to be deployed at the test site, it would appear appropriate that the test site area be re-designated as an Area to be Avoided (ATBA) on all navigation charts. An Area to be Avoided (ATBA) is a routeing measure comprising an area within defined limits in which either navigation is particularly hazardous or it is exceptionally important to avoid casualties and which should be avoided by all ships or certain classes of ships.

To avoid confusion from multiple navigation lights & warning/hazard lights within the confines of the test site area, priority will be given to the primary conspicuity of the cardinal mark lights. It is planned that the only marking lights denoting the presence of the test site will be those of the statutorily sanctioned cardinal marks. No devices deployed on site will carry marking lights, other than any floating wind turbine which must comply with aviation lighting as specified by Irish Aviation Authority.

Details of individual devices are unknown at this stage. However the marking and lighting of each device installed in the site will be in accordance with the IALA standards and agreed with CIL, the Marine Survey Office, and Galway Harbour Master.

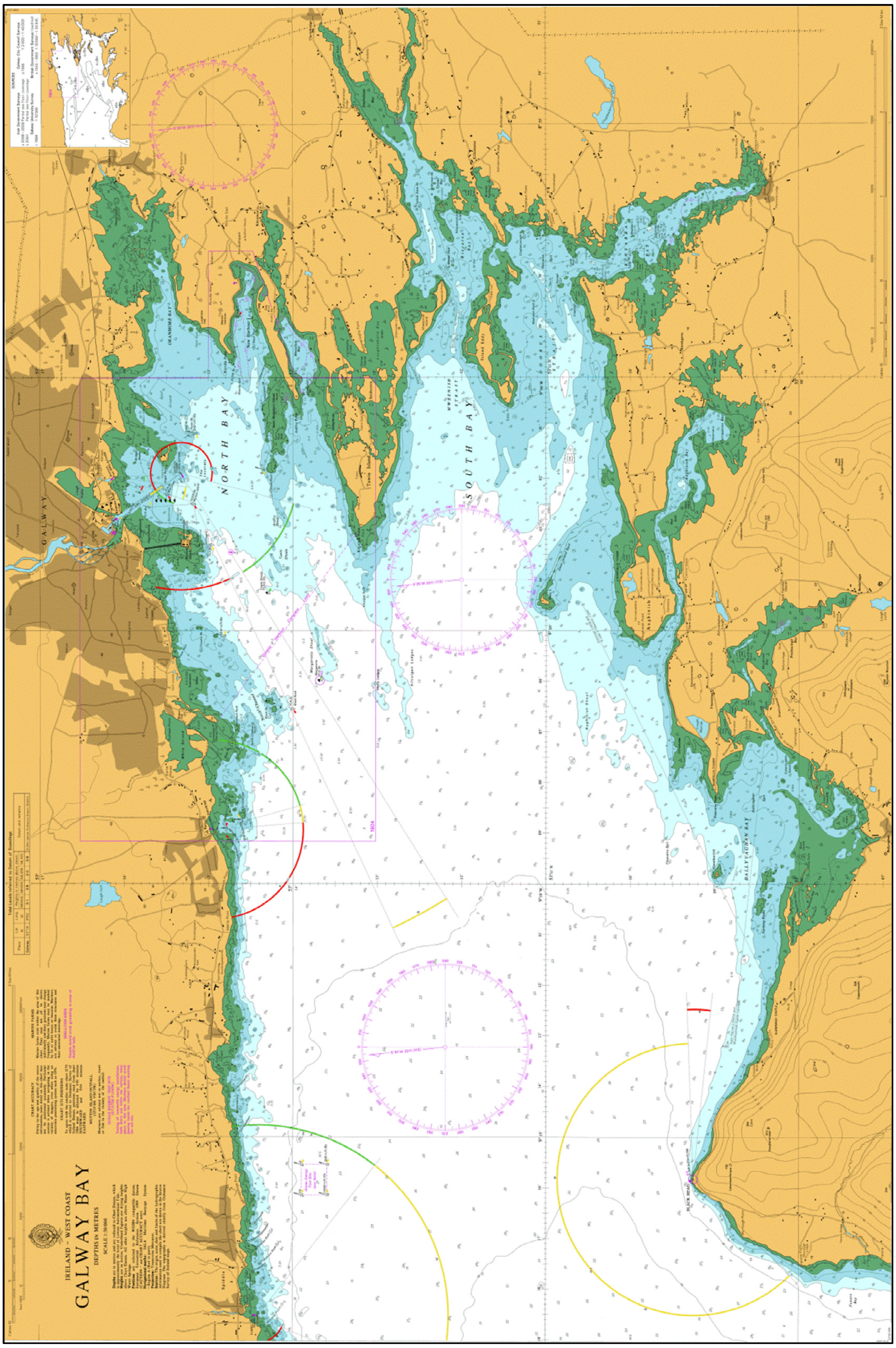

Figure 13-1: UK Hydrographic Office Admiralty Chart 1984

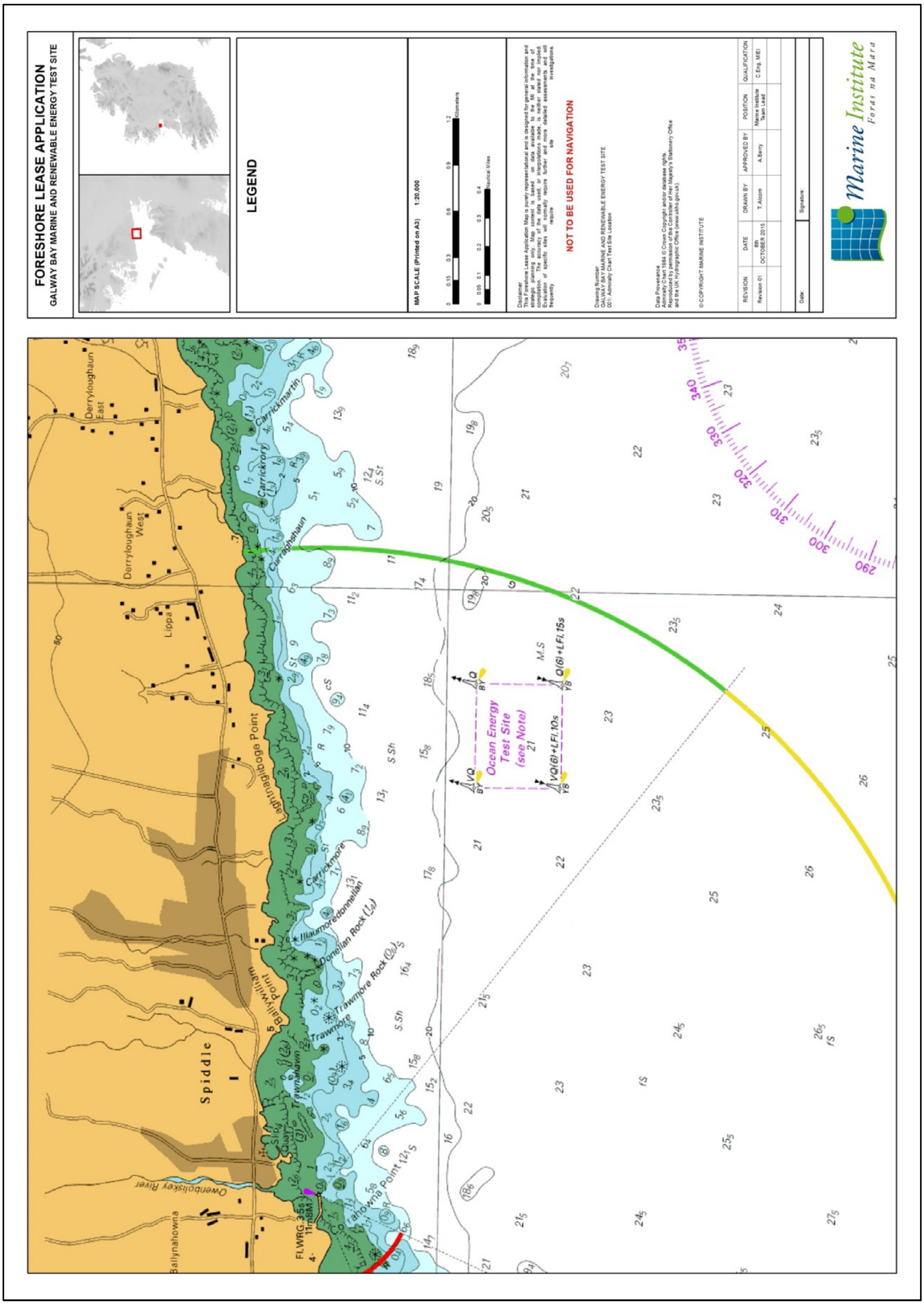

Figure 13-2: Location of existing ocean energy test site, and location of proposed Galway Bay Marine and Renewable Energy Test Site.

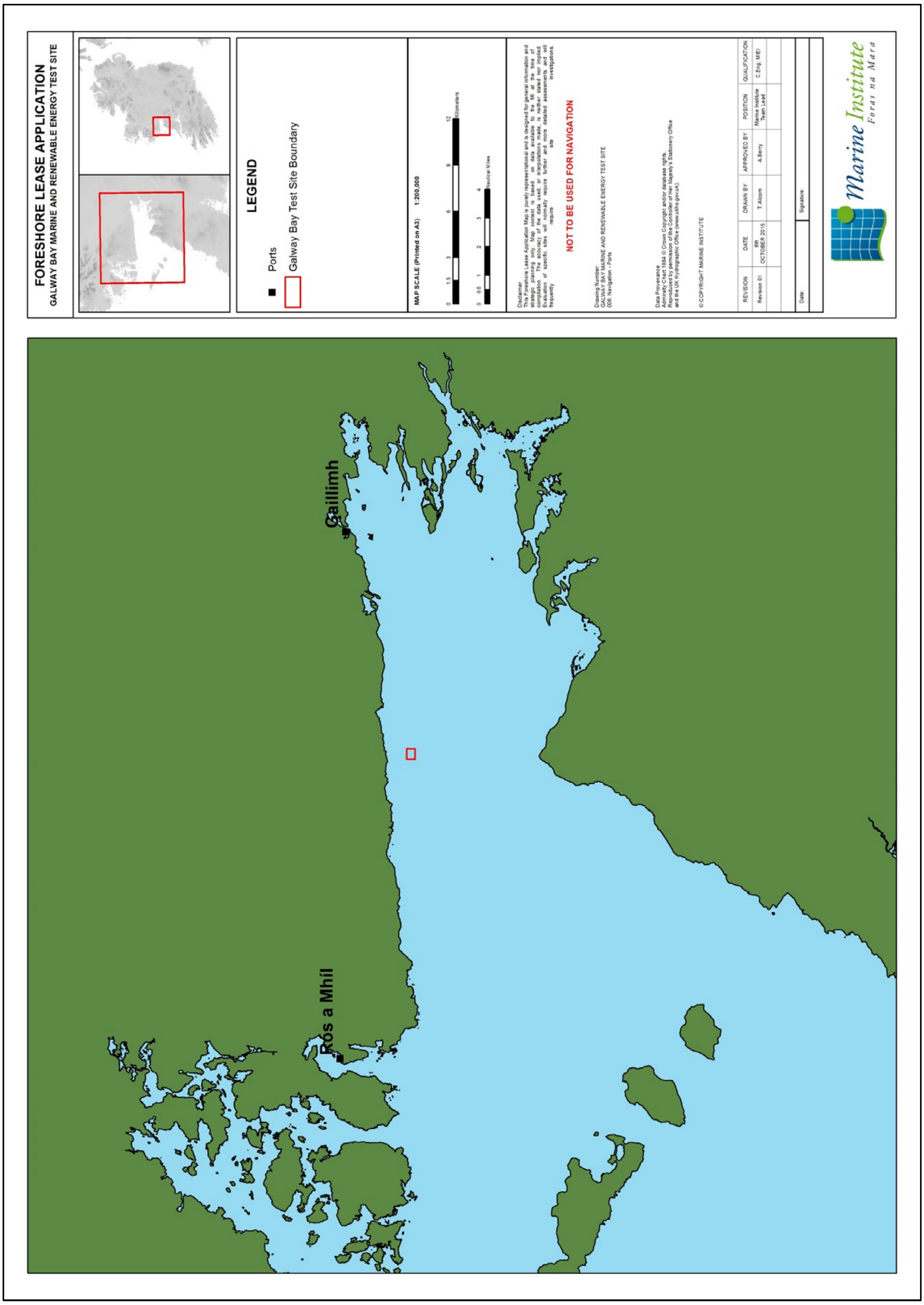

Figure 13-3: Location of commercial ports and fisheries harbours in the vicinity of the test site.

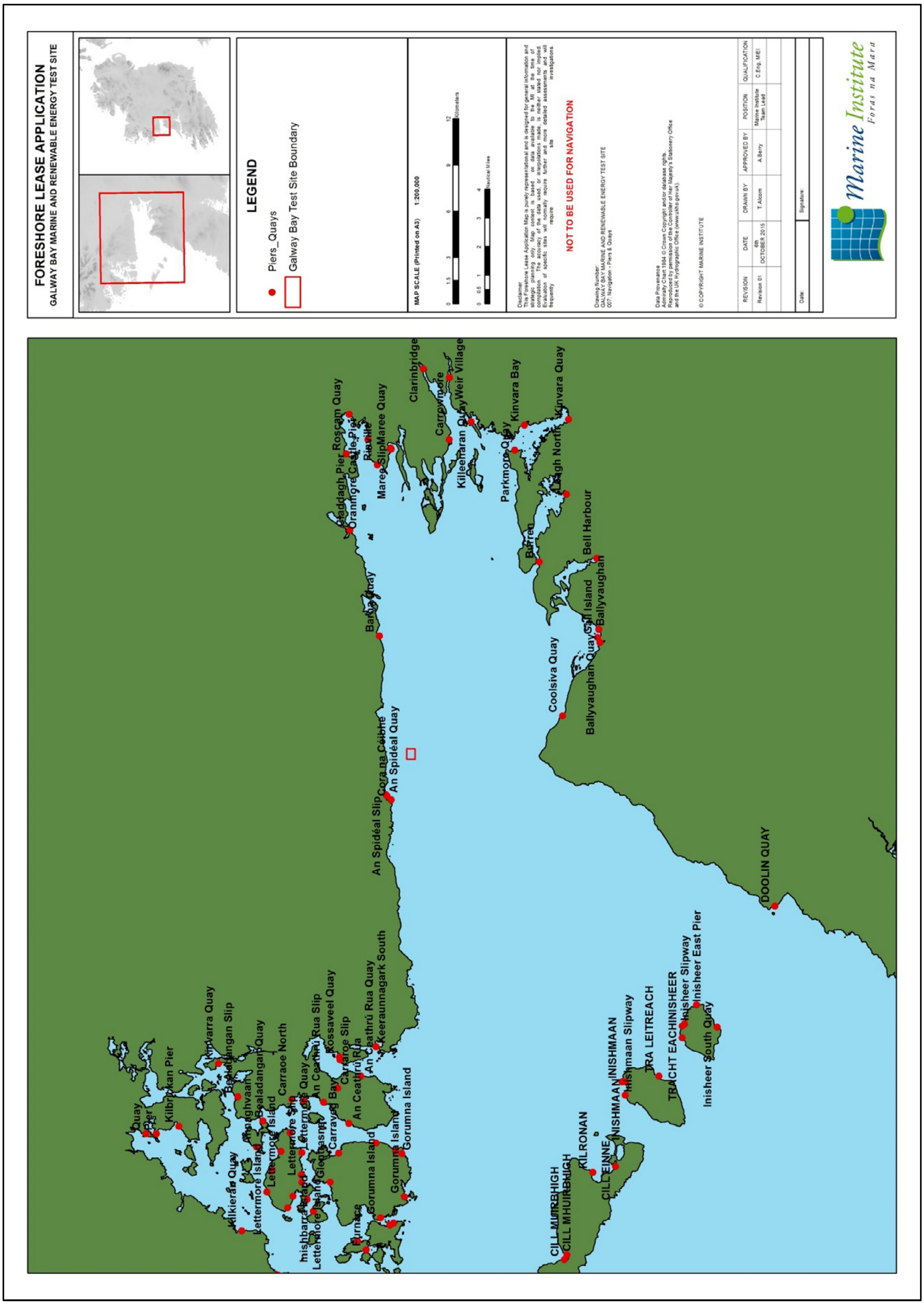

Figure 13-4: Location of small harbours, piers and slipways in the vicinity of the test site.

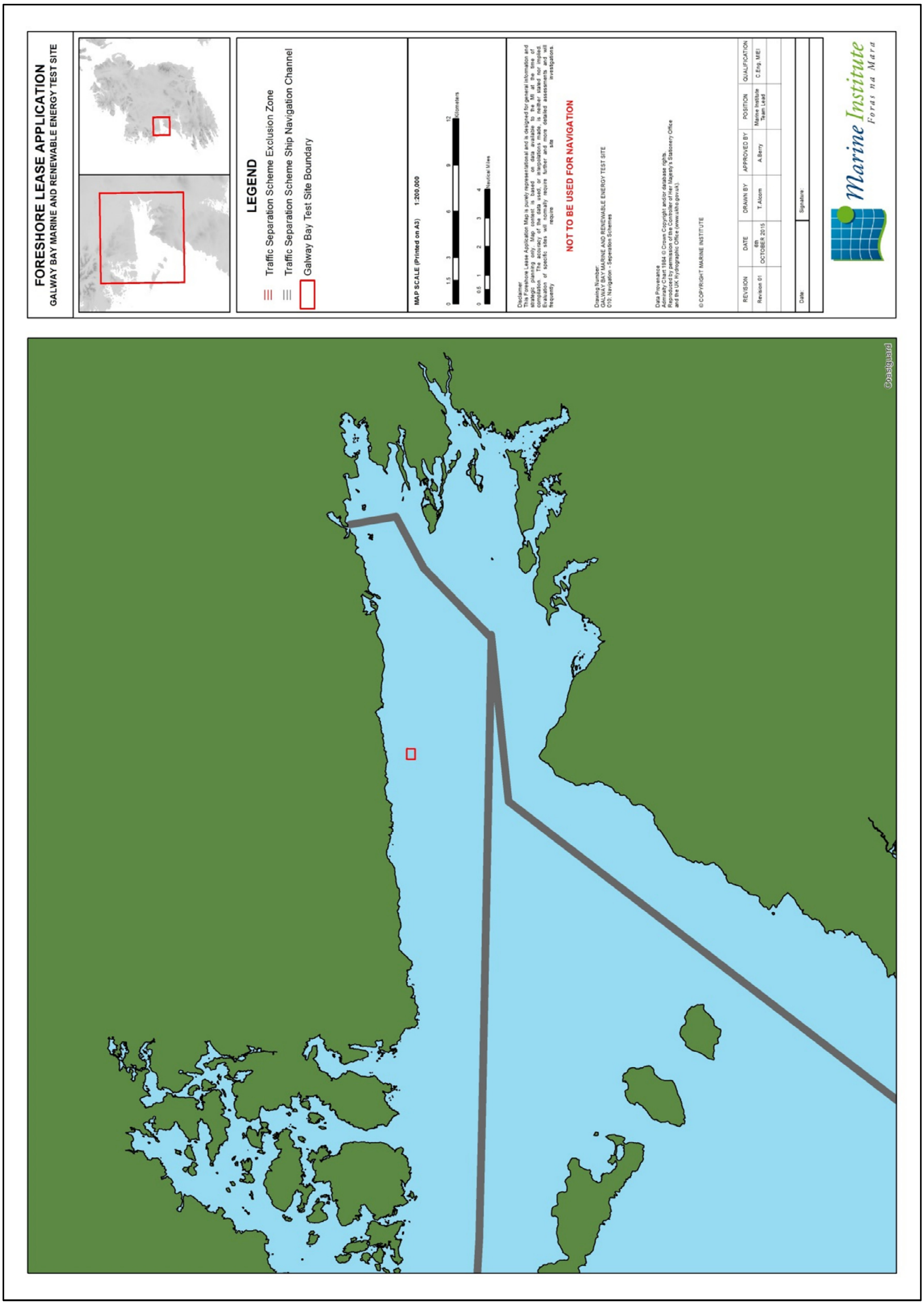

Figure 13-5: Maritime traffic separation scheme in the vicinity of the test site.

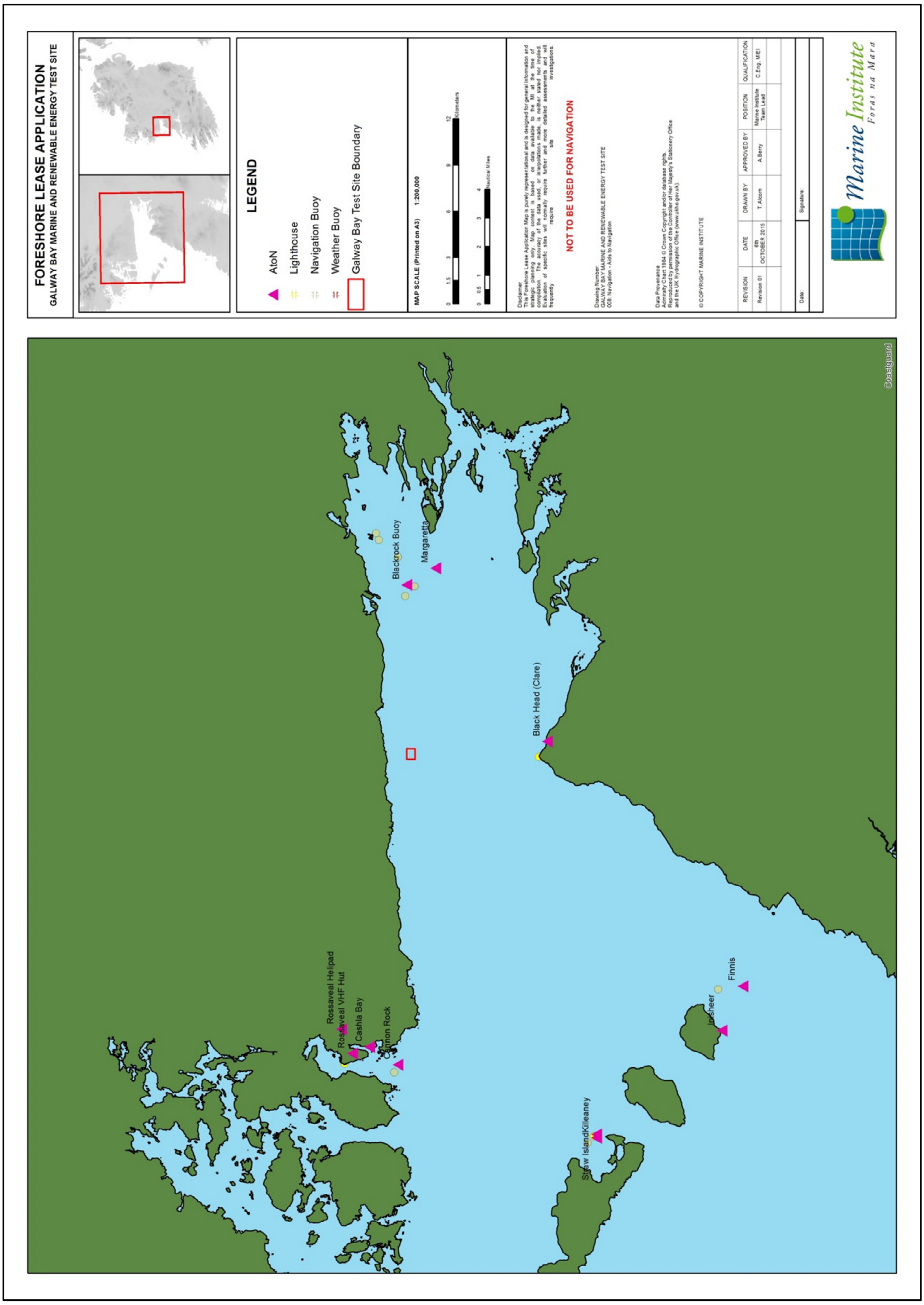

Figure 13-6: Aids to Navigation and other Navigation Aids in the vicinity of the test site.

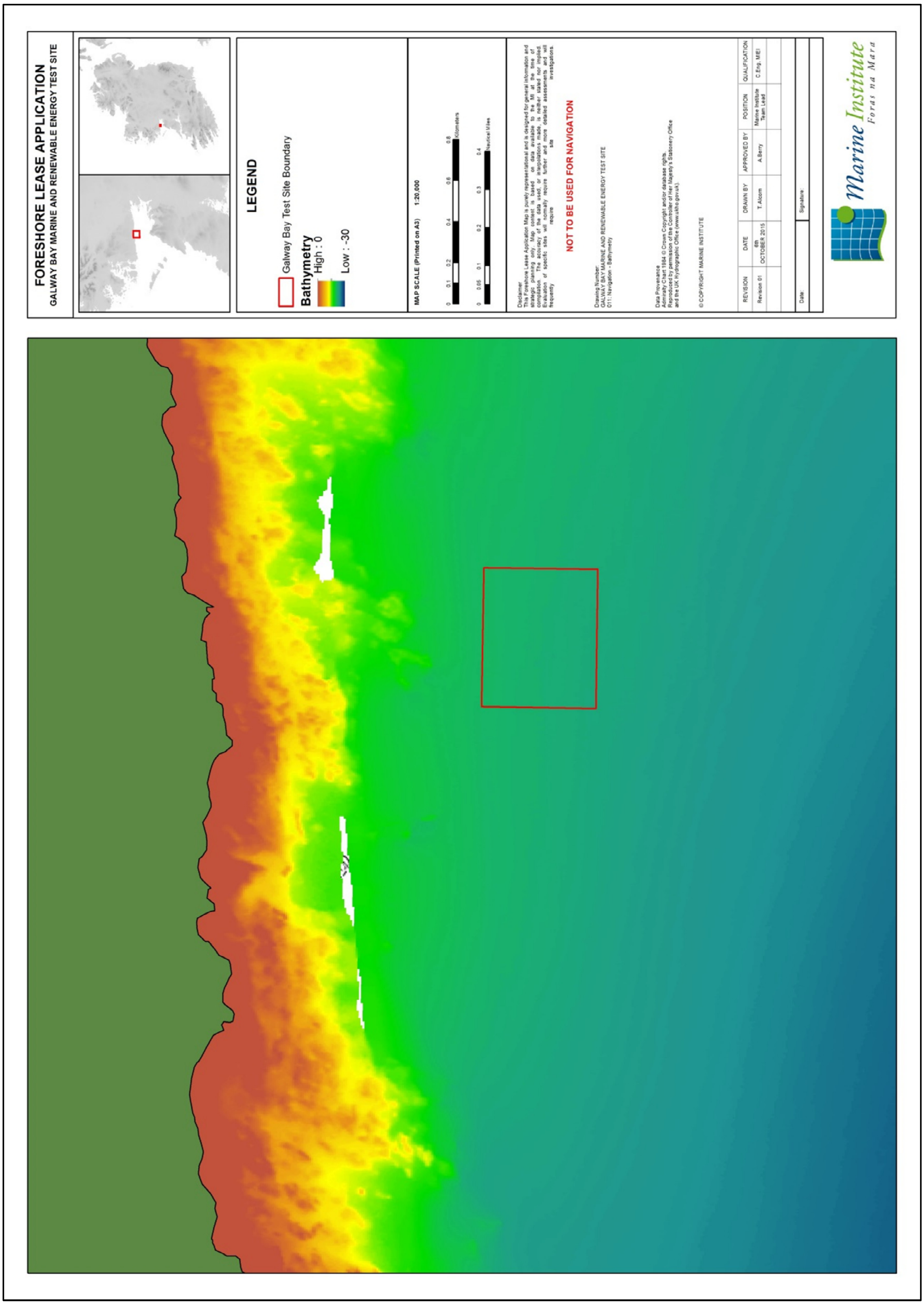

Figure 13-7: Seabed bathymetry in the vicinity of the test site.

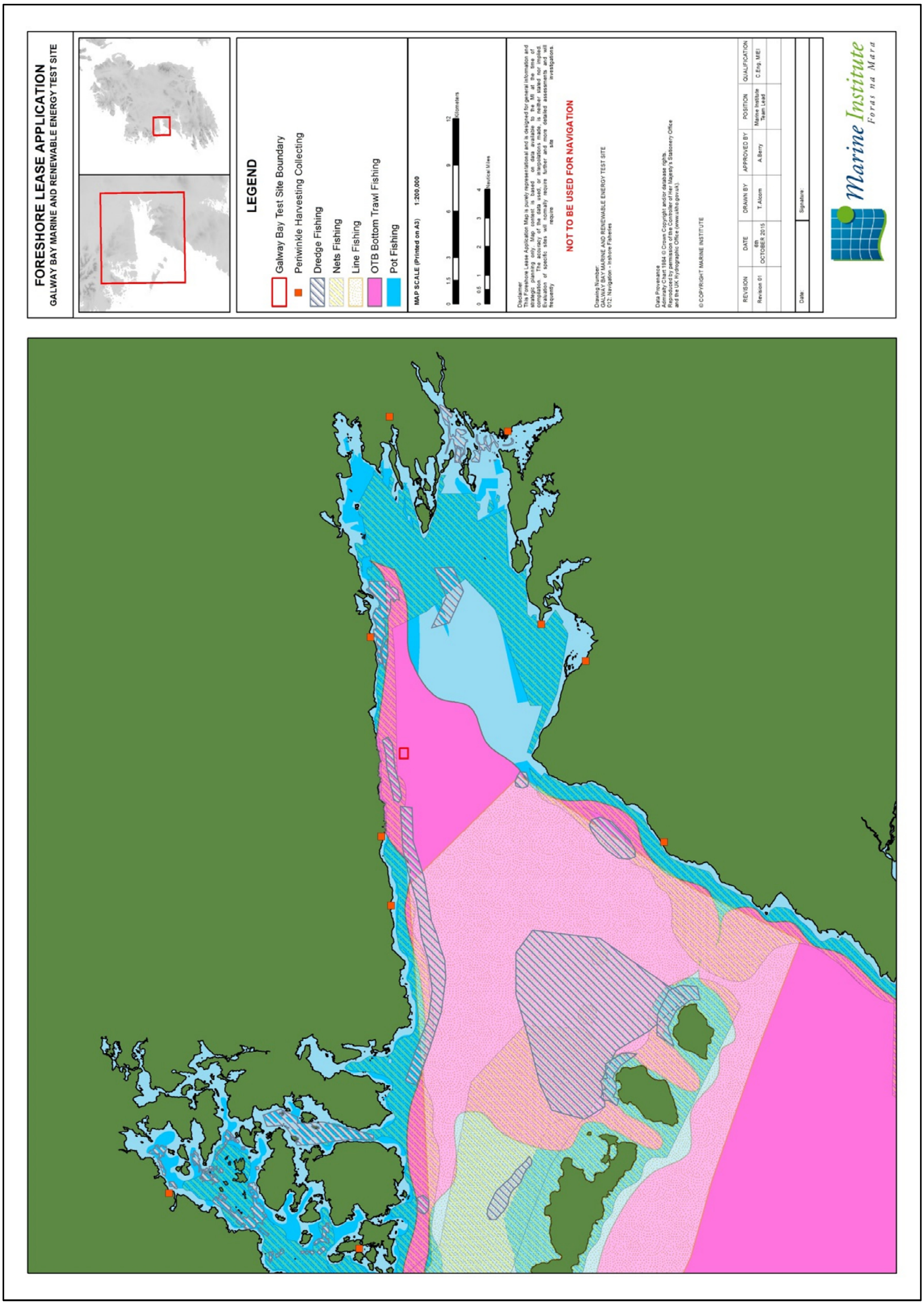

Figure 13-8: Inshore fishing grounds in the vicinity of the test site location.

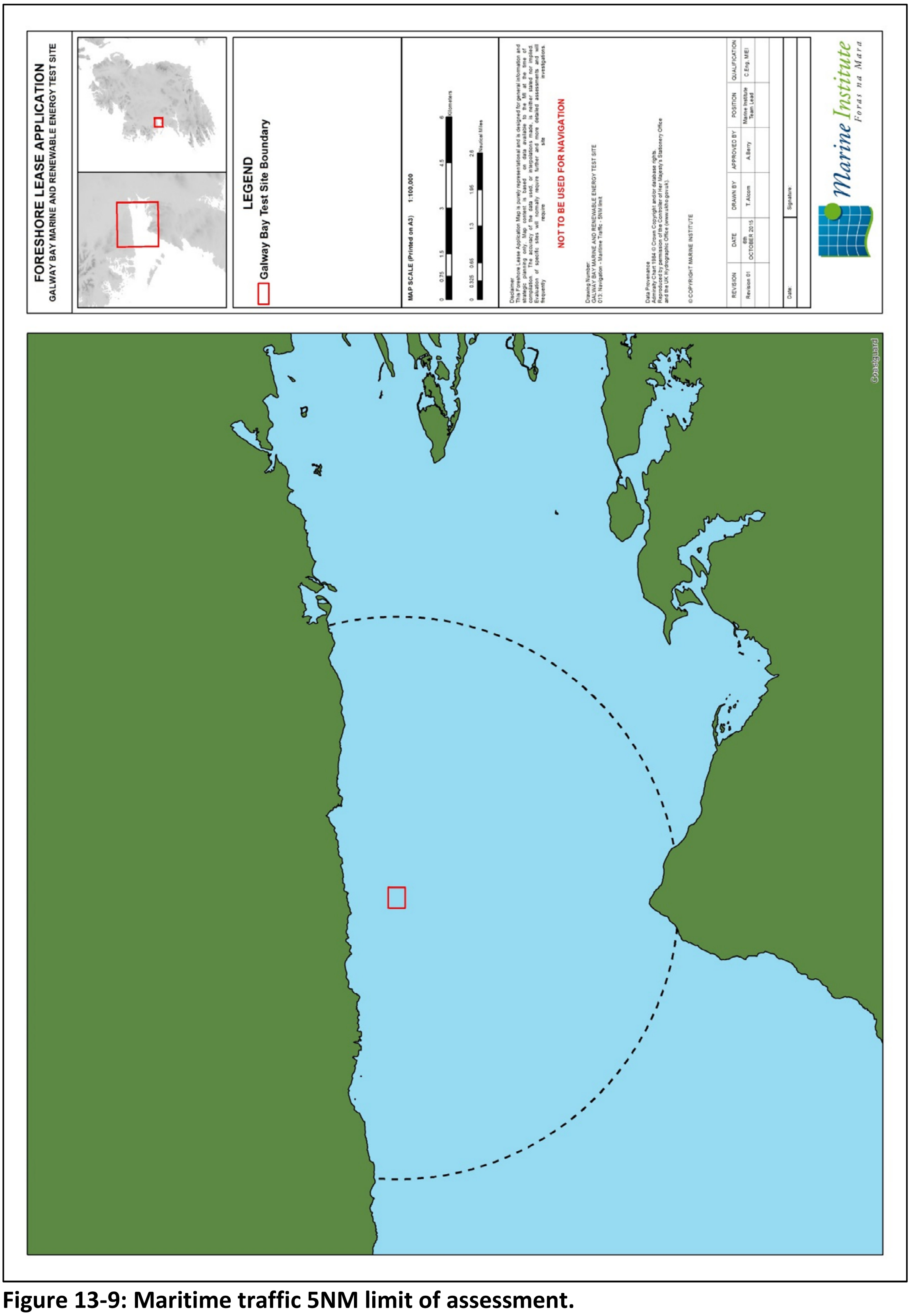

Figure 13-9: Maritime traffic 5NM limit of assessment.

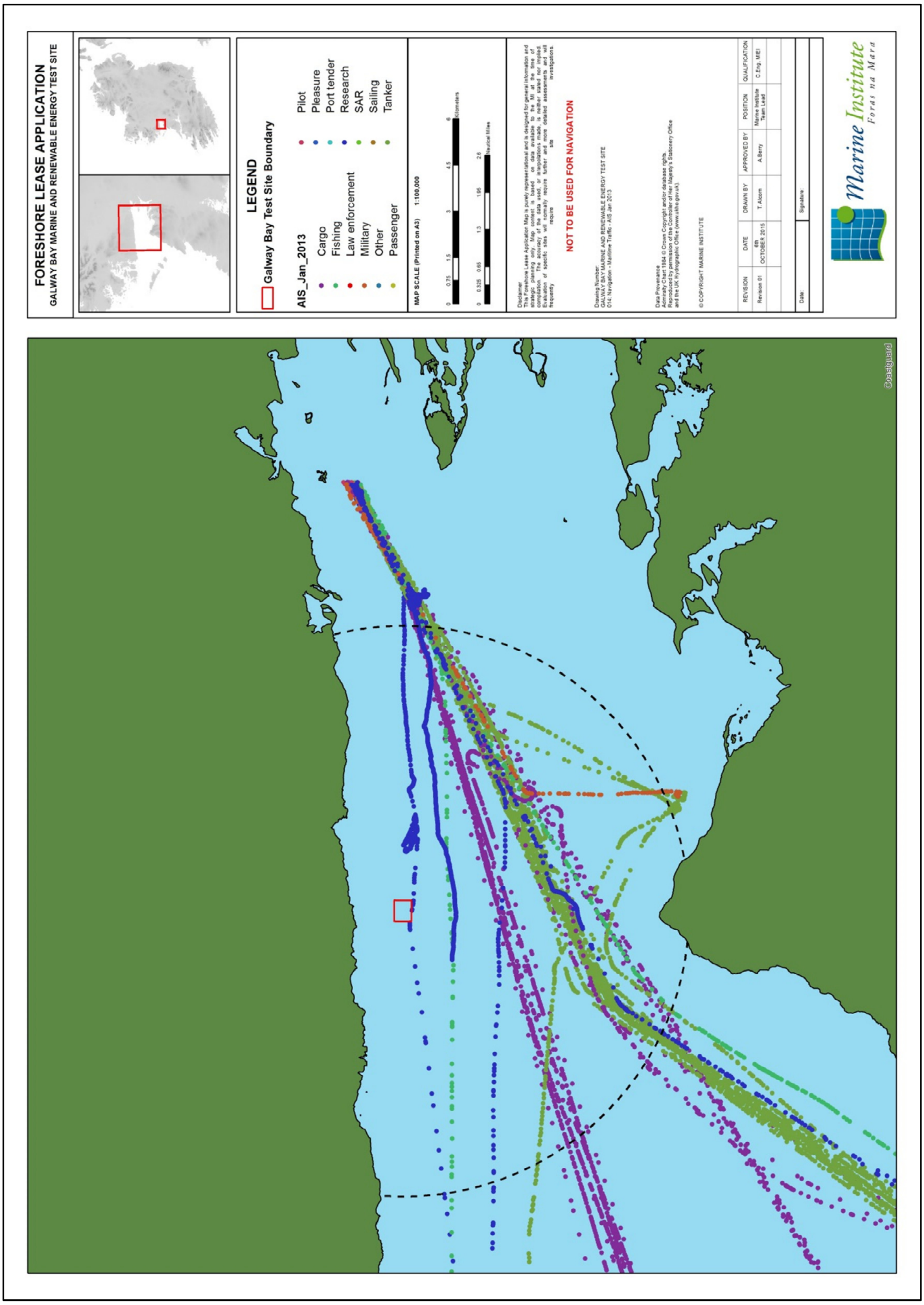

Figure 13-10: AIS records from January 2013 in vicinity of test site.

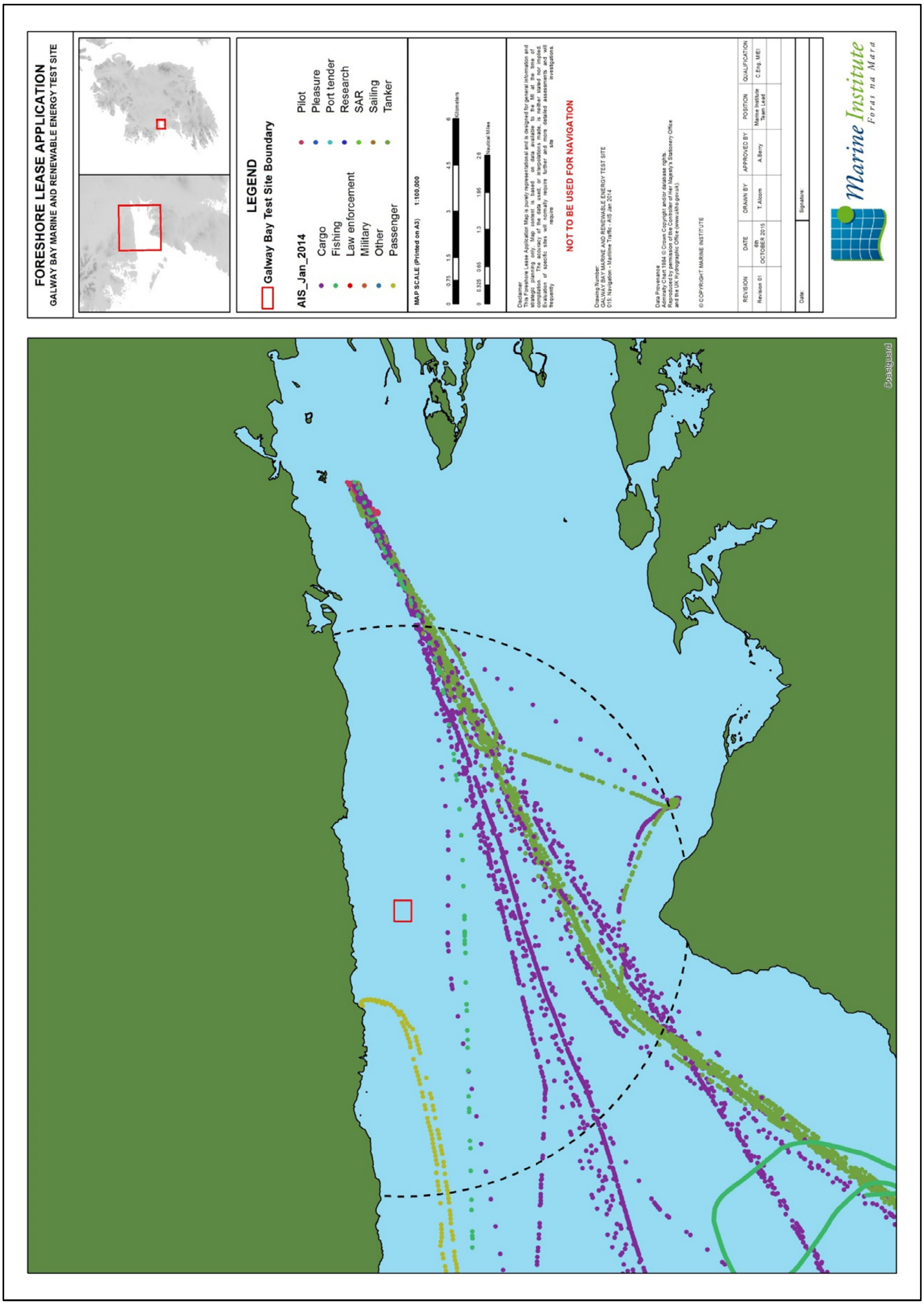

Figure 13-11: AIS records from January 2014 in vicinity of test site.

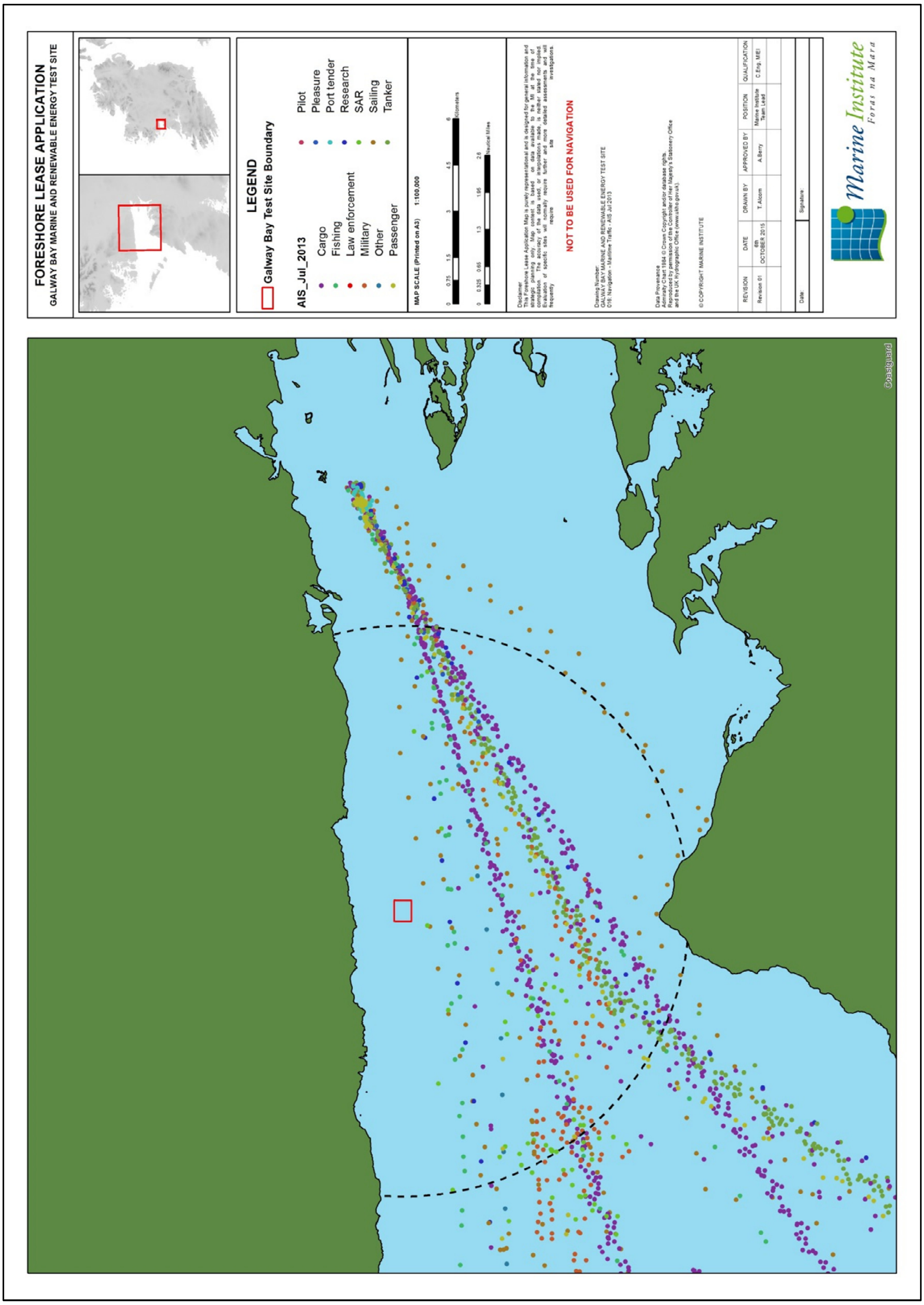

Figure 13-12: AIS records from July 2013 in vicinity of test site.

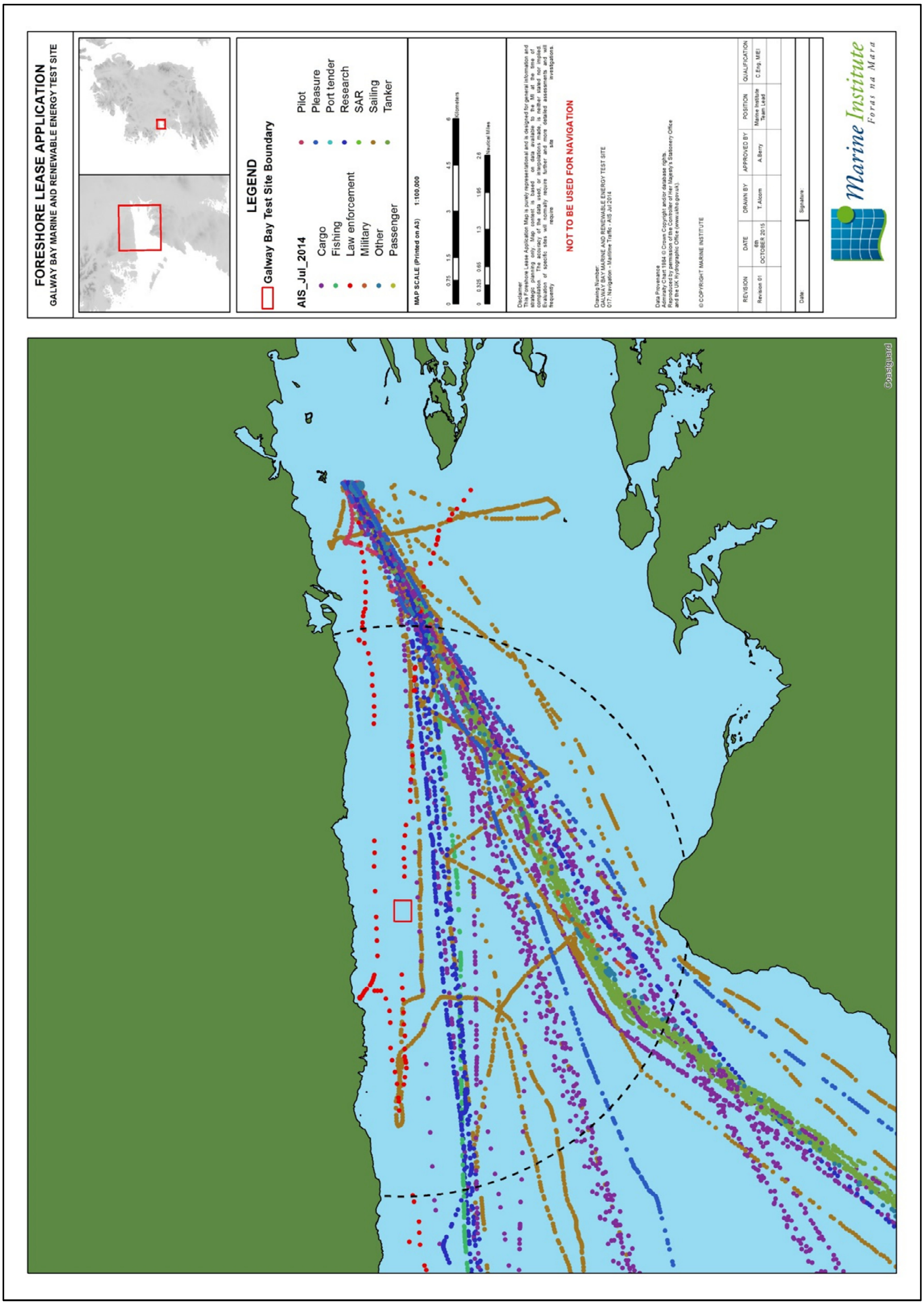

Figure 13-13: AIS records from July 2014 in vicinity of test site.

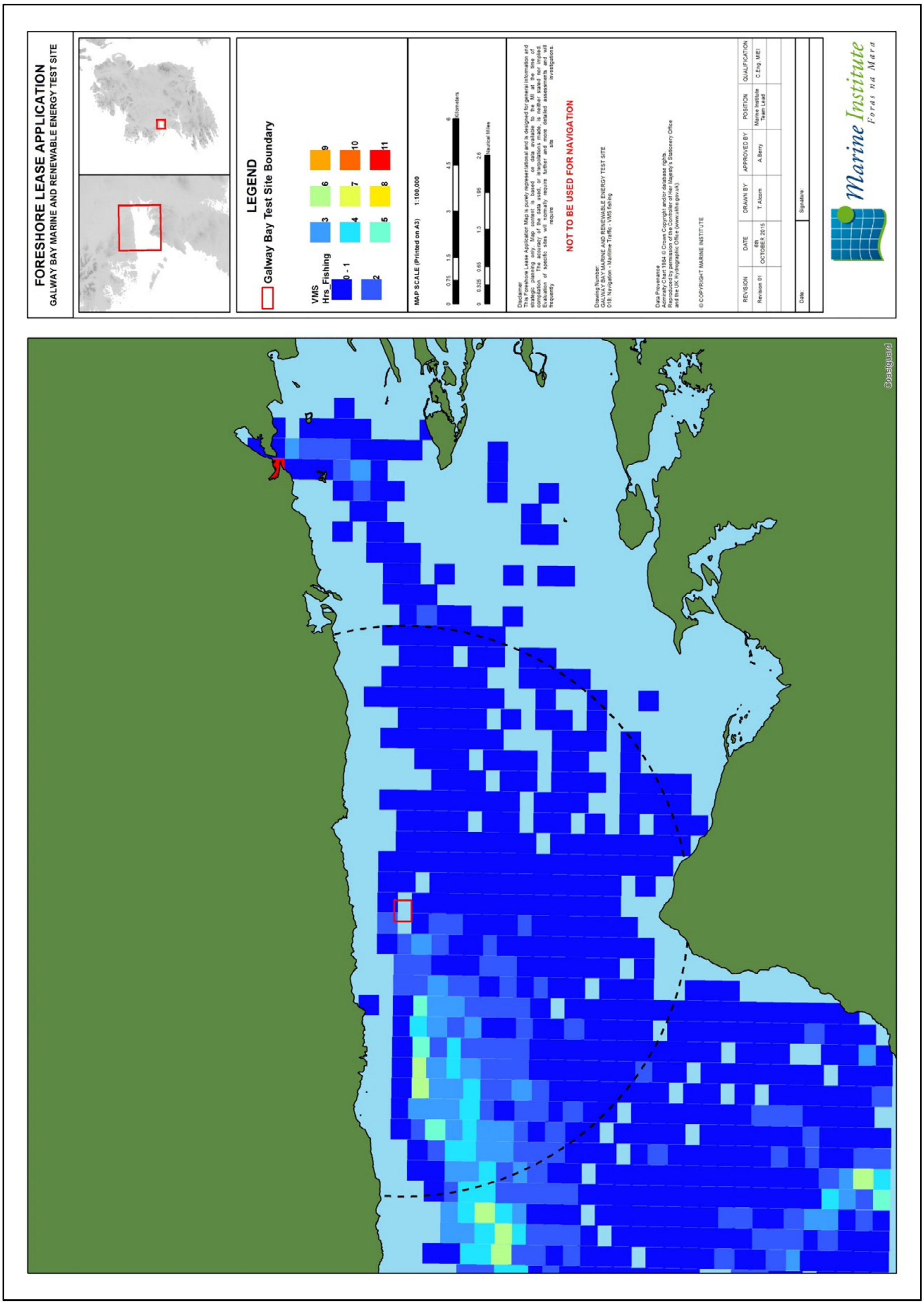

Figure 13-14: VMS records of fishing activity in vicinity of test site. (annualised average 2006-2014)

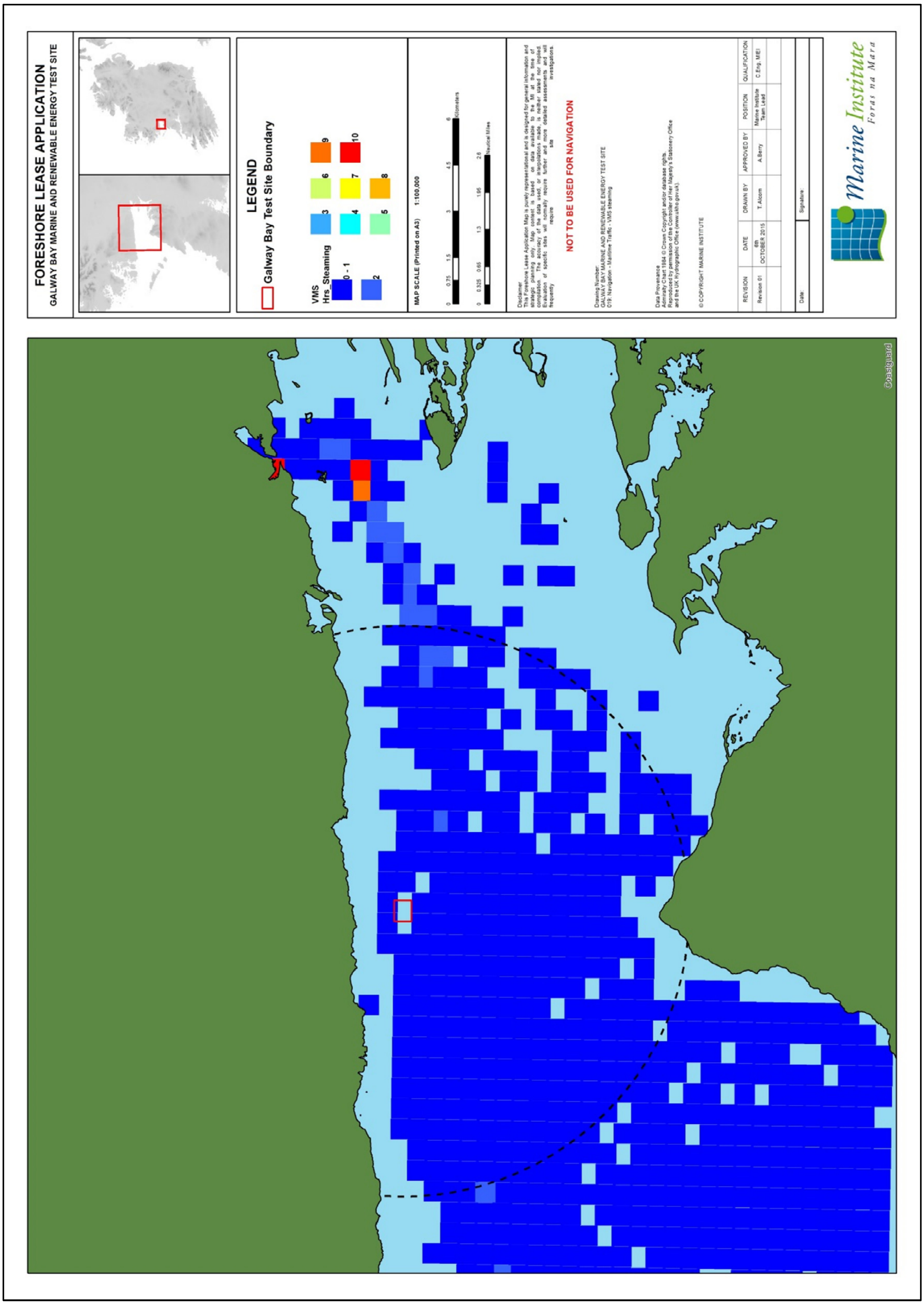

Figure 13-15: VMS records of fishing vessels underway in vicinity of test site. (annualised average 2006-2014)

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14. Coastal Processes

14.1. Introduction

The hydrodynamics of Galway Bay are regulated by variations in tidal height during the lunar cycle with strongest currents (*c*. 30 cm/s) occurring at spring tides and weakest (*c*. 20 cm/s) flows occurring at neap tides.

The tide rises from the south and flows northwards and when the tidal stream meets the Connemara coastline, it is deflected westwards and leaves Galway Bay via the North Sound. These directions are reversed on ebb tides.

Tidal current directions at the test site are therefore westwards on flooding tides and southwards on ebbing tides. Oceanic waters enter the Outer Bay mainly through the South Sound (between the Clare coast and Inisheer) and have been observed to follow an anti-clockwise circulation pattern before exiting through the North Sound.

The Boluisce River flows into the sea at Spiddal, closest to MaRETS, and when in spate gives rise to depressed salinities, particularly at the surface close to its mouth. There are a number of freshwater sources at the eastern end of Galway Bay: the River Corrib drains approximately 70% of the catchment area around Galway Bay with an average flow of 99 m^3 s-1 (OPW, 2012), the Clarin and Corraun rivers contribute 11% of the total fresh water flow into Galway Bay while smaller rivers and diffuse sources contribute the remainder.

14.2. Existing environment

14.2.1. Temperature & Salinity

Sea surface temperatures in Galway Bay typically range from approximately 8˚C in January to 18.0˚C in August with bottom sea temperatures varying from 5˚C in February to 16.5˚C in August. In mid Galway Bay, data collected from a moored buoy by the Marine Institute showed an annual surface temperature ranging from 10˚C to 16˚C. Annual surface and bottom salinities in Galway Bay range from 15.0 to 35.0 ppt depending on the location within the bay.

14.2.2. Tides & Currents

The mean bottom current speed recorded at the ocean energy test site (over 3 full spring and neap tidal cycles) in 2007 was 9cm/s with a maximum speed of 34cm/s (see Figure 14-1). Current speed throughout the water column averaged 10cm/s with a maximum estimated at 33cm/s. This data is based on an ADCP (Acoustic Doppler Current Profiler) deployed at the site in 2007.

Further data for the Spiddal test site area based on circulation models provided by the Oceanographic Services section in the Marine Institute (Lyons & Berry, OSIS Oceanographic Services, *pers. comm.*) for surface and bottom currents over spring and neap tides are given in Figure 14-2 and Figure 14-3. A summary of data for surface and bottom currents over a spring tide for 17th June 2011 are given in Table 14-1 below.

Table 14-1: Surface and bottom current speeds on a spring tide at the Ocean Energy test site (Marine Institute, Oceanographic Services, Lyons & Berry, *pers. comm.*)

Date	Tide	Time	Surface Currents Speed (cm/s)	Bottom Currents Speed (cm/s)	Direction
17/06/11	Spring Flood	15h00	19.35 – 27.14	8.80 – 10.95	East-North East
17/06/11	Spring Ebb	09h00	30.20 – 37.30	3.97 – 7.35	West – South West

The mean spring and neap tidal ranges at the Galway port tide gauge are 4.9 and 1.79 metres, respectively. The peak tidal velocities are in the order of 60 cm/s but average 25cm/s over a typical tidal cycle.

14.2.1. Wave climate

The north shore of Galway Bay is exposed to the prevailing west and south west winds. Wave data has been collected by the Marine Institute at the ocean energy test site since 2006 using a wave rider buoy. The wave climate summary statistics are in Table 14-2 based on 10 years of data. The mean significant wave height is 0.8m and the max is 4.94m. The highest wave encountered in December 2006 was 8.63m (HMax).

Table 14-2: Summary wave statistics at the Galway Bay Marine and Renewable Energy Test Site (2006-2015)

Parameter	Min	Mean	Max
Hs (m)	0.07	0.80	4.94
Hmax (m)	0.020	1.24	8.63
Tz (s)	1.47	3.99	8.70
Tp (s)	1.31	7.28	22.0
Dirp (degrees)	0	230.81	359.9

A common way of visualising the wave resource is the probability plot of Hs against Tz. This is illustrated for the Galway Bay Marine and Renewable Energy Test Site in Figure 14-4. The numbers in the boxes indicate the % of the total that fall within that box. Waves with a Hs between 0.5m and 1m and a Tz between 3 and 5 seconds occur 19% of the time. Figure 14-5 shows the % occurrence of the significant wave height. 45% of waves are within the 0.5m and 1m range. The Wave instrumentation deployed at the test site also provides directional data about the waves. The prevailing wave direction is in a NW direction (Figure 14-6).

The Hydraulics and Maritime Research Centre carried out a resource characterisation of the Galway Bay ¼ Scale Wave Energy Test Site in 2011 (Appendix 11). Device developers who will deploy devices at the Galway Bay Marine and Renewable Energy Test Site will wish to extrapolate test results to gain an understanding of how their device will operate at full scale. The Galway Bay and AMETS experience a similar range of sea states. It can be seen that the extreme sea states measured at both sites are analogous, indicating that developers who deploy devices in Galway Bay are likely to discover how their device will respond in the equivalent of the storm conditions experienced off the west coast of Ireland.

14.3. Impact of the development

The impacts of the operational phase of the test site are confined to the physical presence of the devices, equipment, infrastructure and cables within the site, either on the seabed, in the water column or at the surface. The operation of the devices and associated equipment may impact on hydrodynamics and sediment processes.

14.3.1. Worst Case Scenario

The impacts of the Galway Bay Marine and Renewable Energy Test Site project have been assessed under the following worst case scenario deployment of items at the test site in Table 14-3.

Table 14-3: Coastal Process worst case scenario

Permanent	Recurring	Devices
4 x cardinal marks	Data buoy	3 x OWC
Subsea observatory	Acoustic Array	
Waverider	ADCP	
SeaStation	Cabling	
9 x gravity bases		

14.3.2. Physical Presence

The placement of any infrastructure on the seabed will disturb and remobilise sediments in the immediate footprint of the object. This will result in a short-term (minutes), localised increase in suspended sediment levels and turbidity. Small localised sediment plumes are generated frequently in the marine environment by a variety of activities. It is not possible to quantify the volumes of sediment that would be mobilised during the placement of infrastructure on the seabed; however, they will be so low as to have no effect. It is worth noting that naturally high background levels of 65,000mg/l have been recorded in Galway Bay under storm conditions (Galway Harbour Company, 2014a) and these volumes are orders of magnitude greater than what would be generated by the proposed activities.

Sediment disturbance during the operational phase could include scour around the gravity bases, however given the relatively low velocities in the area any impact from this is likely to be minimal. Movement of the catenary mooring lines and any other cables which will continuously or periodically rest of the seafloor have the potential to disturb and remobilise sediments. It is estimated that up to 5m either side of the lines/cables could be affected. The sediments disturbed by this activity will be orders of magnitude lower than that generated during storm events. Any short term temporary impacts from this will have a negligible impact on the environment.

The maximum footprint on the seabed of the combinations of worst case scenario infrastructure and devices is 337 m^2. This represents less than 1% of the total area of seabed within the test site.

In summary, disturbance to sediment and the resultant increases in suspended sediments and turbidity and the subsequent deposition of sediments will be of such a scale that impacts will be negligible.

The likelihood of these disturbances occurring are highly likely however the consequences are negligible (i.e. not detected against natural background variability). Monitoring at the commercial scale SeaGen turbine in Strangford Lough reported that the changes observed appeared to be gradual and in line with natural variation (Keenan *et al.,* 2011).

Likelihood = Highly Likely;
Consequence = Negligible;
Impact = Low

14.3.3. Energy Extraction

Sediment transport pathways and coastal processes could be impacted by localised hydrodynamic changes associated with wave or tidal energy removal by the operating device. This can have impacts in the immediate vicinity of devices or foundations and sediment accretion or erosion (scour) of the sediment could occur. The effects of energy extraction on sediment processes could result in changes to suspended sediment levels and turbidity and occur up to 50m from the operating device and operating devices could potentially have significant adverse effects on coastal processes particularly in areas with high levels of erosion, accretion and long-shore drift (Scottish Executive, 2007).

The maximum footprint on the water surface of the combinations of worst case scenario infrastructure and devices is 1436 m^2. This represents less than 1% of the total area of water surface within the test site.

Studies carried out to date on single devices or very small arrays (e.g. Keenan *et. al.,* 2011; Smith, & Adonizio, 2011) have shown that due to the small footprint of these devices, entering into large bodies of swiftly moving water, there is little possibility of measurable changes to the physical environment (Copping *et al.,* 2013a).

In addition, as waves travel through the water rather than the water itself moving, wave energy extraction will be low and somewhat recoverable as there is a large area of fetch after any device before it comes to the shore, which will see the biggest impact of energy extraction. As a result, given the scale of the proposed test site and the fact that the devices are scaled and not full size, the likelihood of any impact occurring is remote and there would be no change to the physical environment.

Likelihood = Remote;
Consequence = None;
Impact = Low

14.4. Conclusion

The installation and operation of the test site will only have a low impact, of negligible consequence, on coastal processes in Galway Bay.

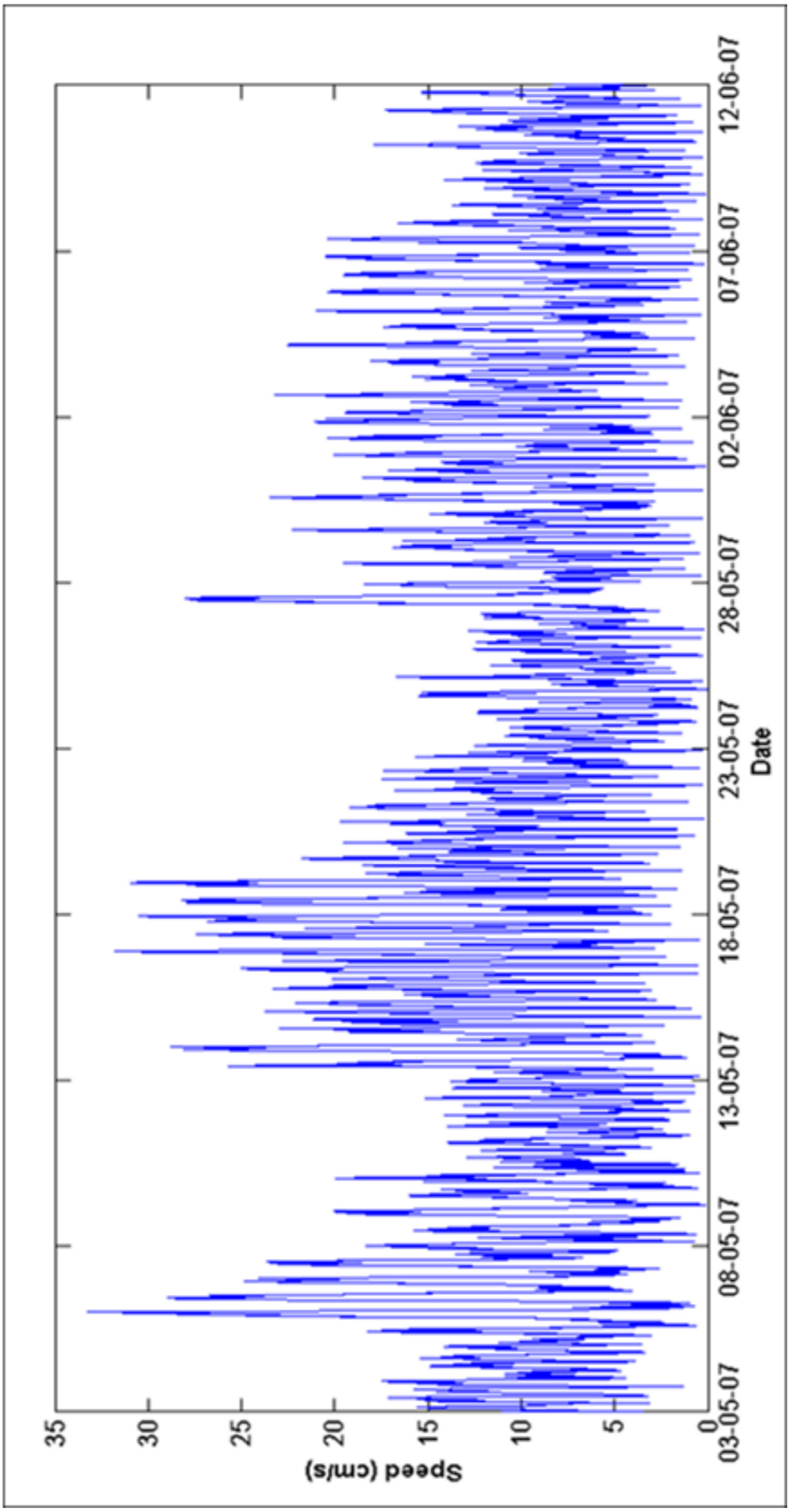

Figure 14-1: ADCP data collected at ocean energy test site, Galway Bay (Source: Marine Institute)

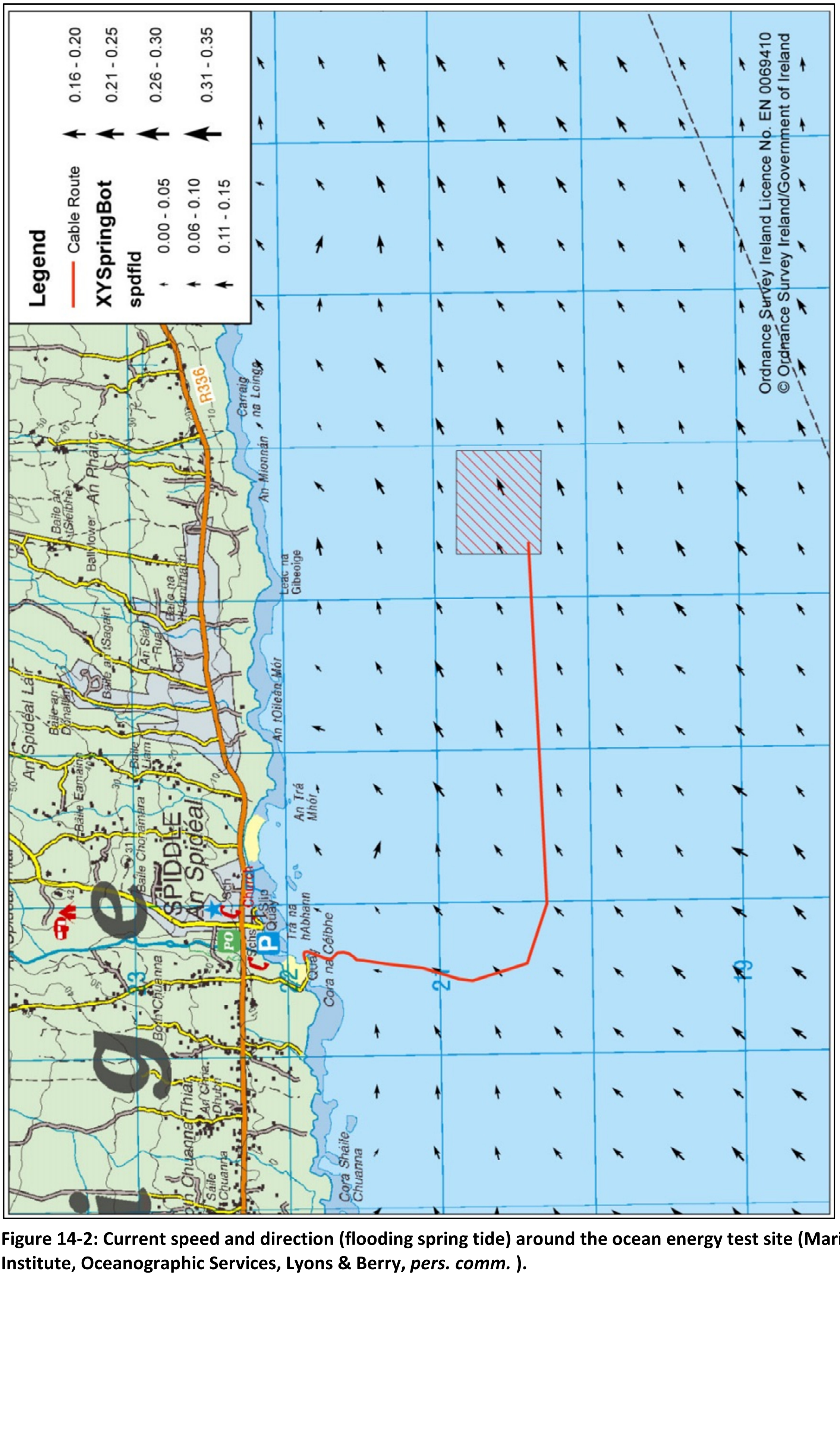

Figure 14-2: Current speed and direction (flooding spring tide) around the ocean energy test site (Marine Institute, Oceanographic Services, Lyons & Berry, *pers. comm.*).

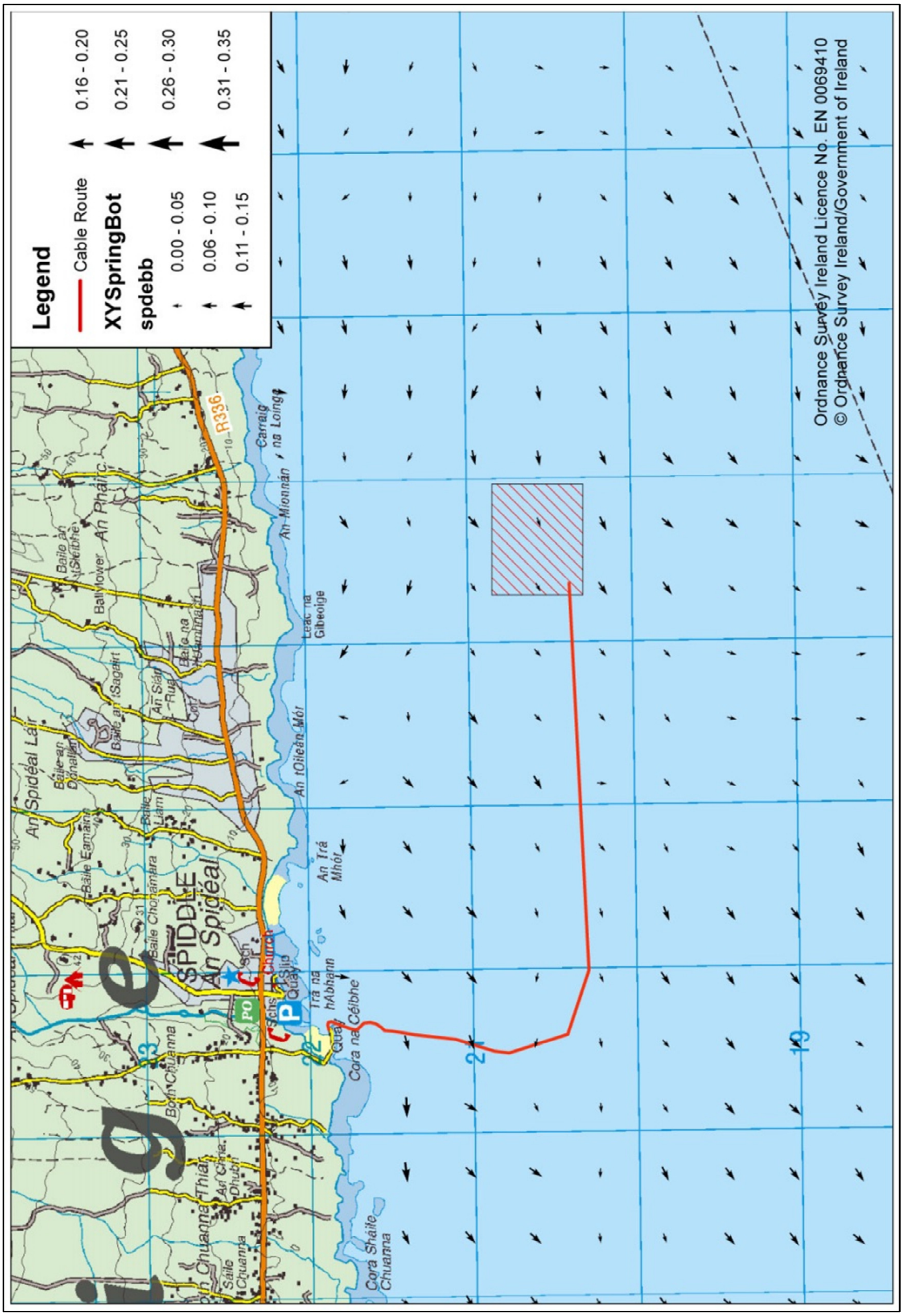

Figure 14-3: Current speed and direction (ebbing spring tide) around the ocean Energy test site. (Marine Institute, Oceanographic Services, Lyons & Berry, *pers. comm.*)

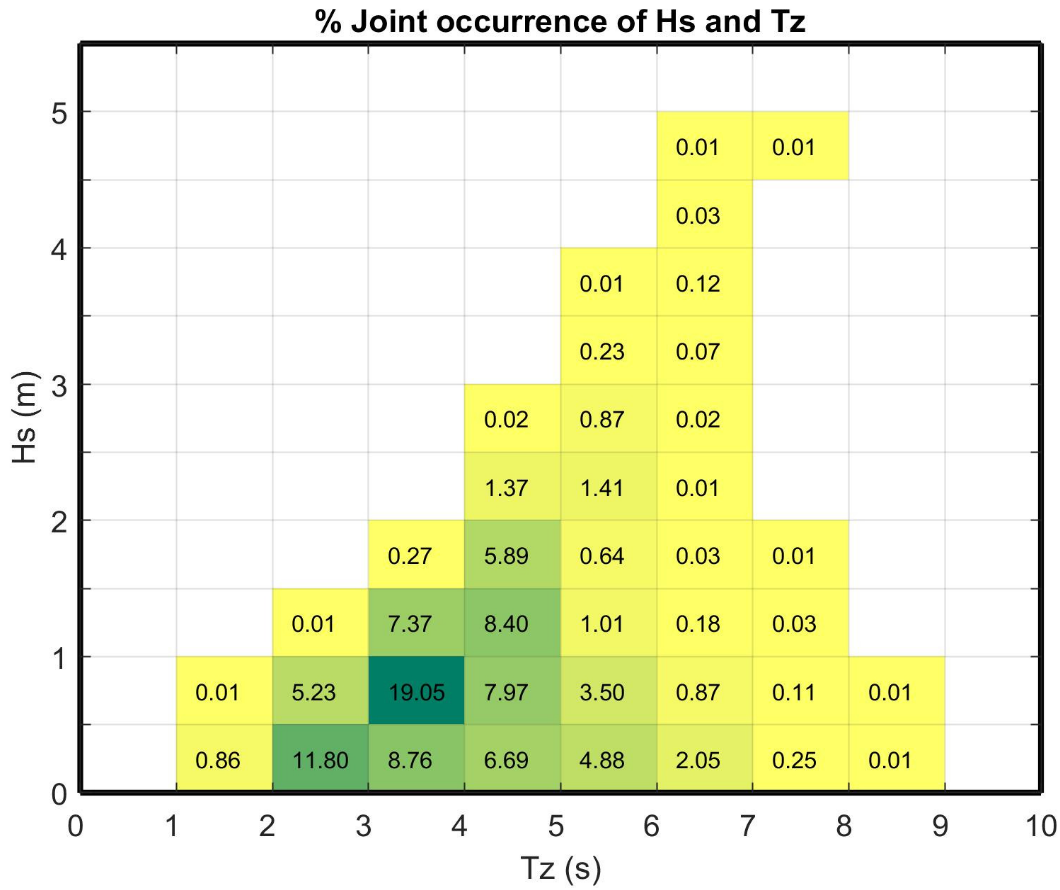

Figure 14-4: Percentage Joint occurrence of Hs and Tz at the Galway Bay Marine and Renewable Energy Test Site

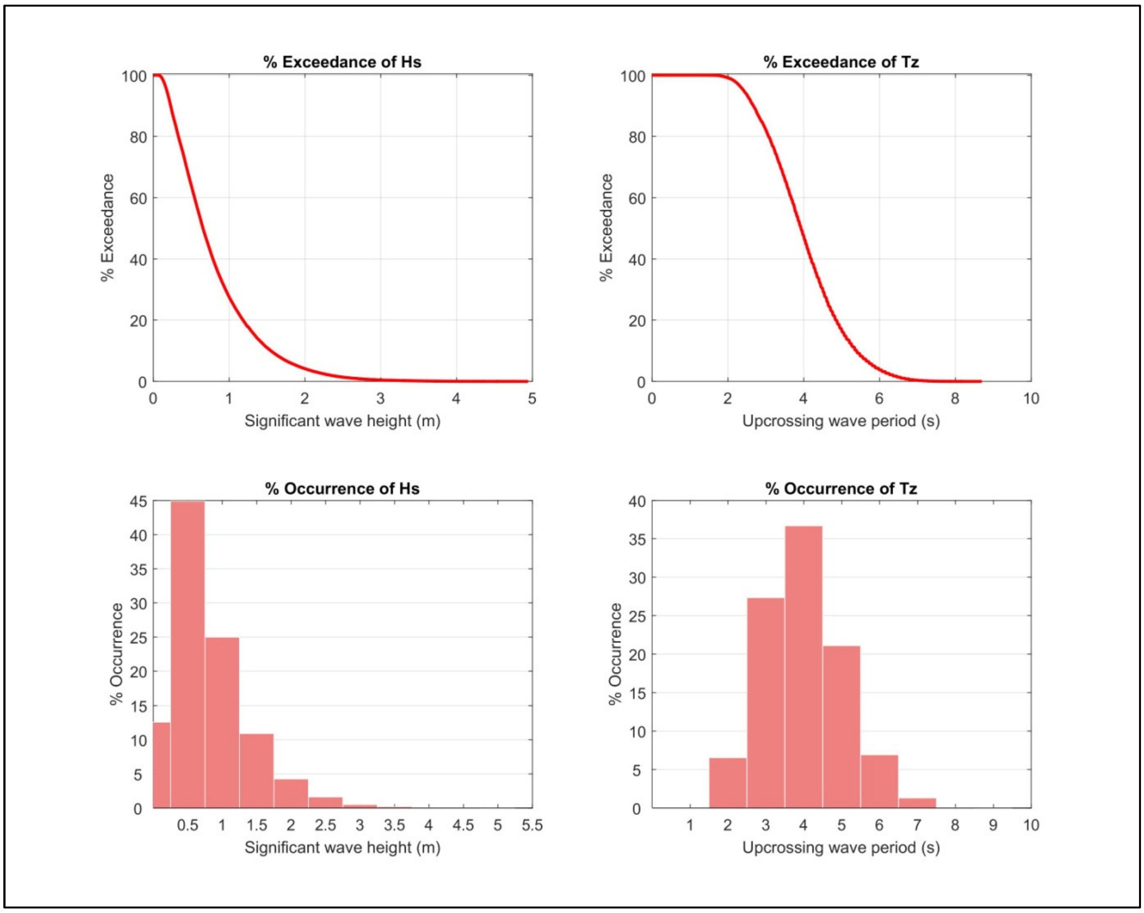

Figure 14-5: Exceedance and occurrence of Hs and Tz at the Galway Bay Marine and Renewable Energy Test Site

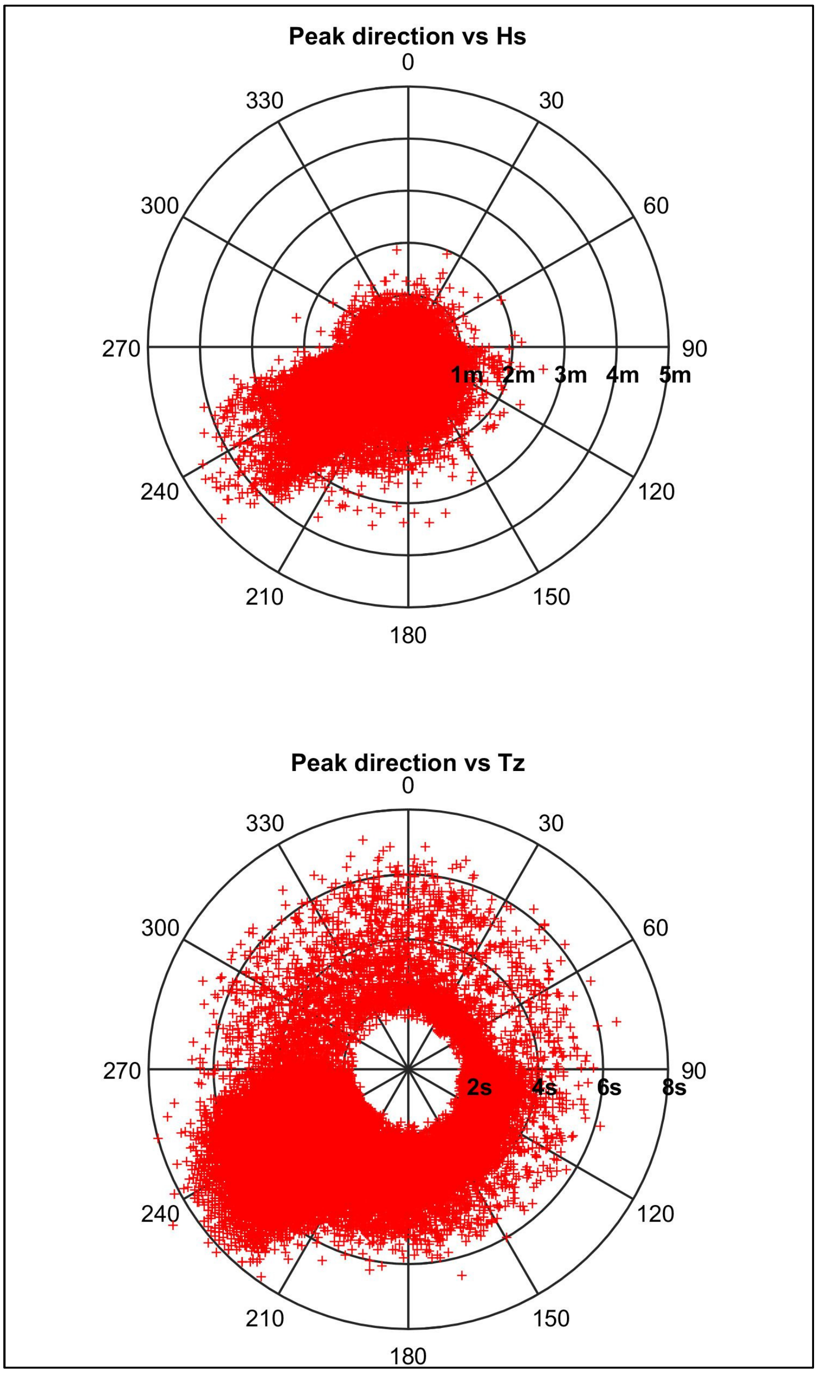

Figure 14-6: Polar plot of (top) peak direction versus Hs and (bottom) peak direction versus Tz

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15. Indirect and Cumulative Impacts and Interactions Between

15.1. Introduction

This chapter addresses the cumulative impacts, indirect impacts and main interactions between different aspects of the environment likely to be significantly affected by the Galway Bay Marine and Renewable Energy Test Site. In the Environmental Report the impacts identified relate to the following: (i) human activity, (ii) flora and fauna, (iii) water, (iv) seabed and geology, (v) air quality, (vi) cultural heritage, (vii) visual impact, (viii) material assets and (ix) coastal processes. This section is not intended to be a summary of all of the impacts as these have been addressed in detail within their relevant chapters. It focuses on the potential for interaction between environmental impacts.

15.2. Approach and methodology

In any development with the potential to impact on the environment, there is also the potential for interaction between those impacts. The indirect impacts, main interactions and the cumulative impacts are identified and evaluated. Where necessary, mitigation measures are proposed. This chapter has been prepared with reference to the EPA Guidelines for the preparation of Environmental Impact Statements, (EPA, 2003).

According to the Environmental Impact and Mitigation Desk Study for the Galway Bay Marine and Renewable Energy Test Site prepared by Aquafact (Appendix 1), any impact that is classed as None-Moderate is considered to be non-cumulative as the frequency of disturbance is less than the recovery time.

15.3. Indirect impacts

Indirect impacts are described in the EPA Guidelines as being ‘impacts which are caused by the interaction of effects, or by associated or off-site developments’. For the Galway Bay Marine and Renewable Energy Test Site, indirect impacts are those not directly caused by the project but are associated with the development or arise from mitigation measures.

The main indirect impacts associated with the Galway Bay Marine and Renewable Energy Test Site are the following:

- The Galway Bay Cable Project was installed in 2015 and is fully operational. The Cable End Equipment and subsea observatory is co-located with the proposed development. The proposed development will need approval to ensure the safe operation of the infrastructure.
- The use of the test site by developers will lead to temporary economic benefits related to accommodation requirements, transportation and provision of services all of which will give rise to additional income to the area and temporary increased employment.

- The placement of subsea infrastructure could result in an increase in abundance of species in the area. This could result in increased catches and increased economic benefit to the fishing industry in nearby areas.
- There is no access to the site for fishing activity, leading to a potential increase in ecological diversity. This will provide a natural ecosystem and an opportunity to undertake benthic, fishery and ecological process research.
- A wealth of survey data has been collected for the area. This provides a unique dataset to the fishing community and wider stakeholder groups. It potentially could be used to enhance overall coastal zone management in Galway Bay.
- Real-time wave and metocean data is being provided from the test site area. This online data is useful information to fishermen, surfers and other recreational users of the marine environment in the area, providing knowledge of suitable conditions for their specific activities.

15.4. Interaction of impacts

Figure 15-1 provides a matrix of the interactions of the environmental impacts. It considers the installation and operational phases having taken the proposed mitigation measures into account. The level of the interaction is evaluated and colour-coded based on the mitigated level of impact.

The level of environmental impact for all interactions is considered to be *none, negligible or minor* for both the installation and operational phases of the project. No environmental interaction will lead to a high level of potential impact. Any impact that is classed as *None-Moderate* is considered non- cumulative as the frequency of disturbance is less than the recovery time.

The matrix demonstrates that human activity has the potential to interact with most environmental impacts as non-compliance with specified requirements or standards could cause disturbance. Similarly with seabed and geology the potential for interactions arises with many of the environmental impacts, for example with the management of suspended sediments. The potential for interactions with the environmental impact of water quality arises for example with accidental spills could lead to secondary effects on aquatic communities. The potential for interactions arises with material assets in that a change in food sources could affect the invertebrates, fish, birds, mammals and to a lesser extent, fishing.

All environmental factors are interrelated to some extent, where an interaction is considered to be likely it is discussed in detail below. The mitigation measures in relation to primary impacts are outlined in the relevant chapters of this document. These are not repeated and only mitigation that is additional to the primary impacts is described.

15.4.1. Ecology

According to the Environmental Impact and Mitigation Desk Study for the Galway Bay Marine and Renewable Energy Test Site prepared by Aquafact (Appendix 1), the installation of prototypes and foundations to support the devices and the actual installation of the devices, sensors and equipment could create a small amount of disturbance. Indirect impacts include **smothering and increased suspended sediment and turbidity**. The smothering of sensitive benthic species, fish spawning habitat and shellfish habitat can occur due to the subsequent settlement of the resuspended sediments. Increased suspended sediment and turbidity levels can impact on sensitive filter feeding organisms such as king and queen scallop, cockles and mussels. Fine particles can travel great distances from the disturbed area due to tidal currents and depending on the quantities of remobilised sediments this impact could be widespread. Increased turbidity could affect the foraging and predator/prey interactions of birds due to reduced visibility. In addition, herring, sprat, grey and common seals are sensitive to reduced visibility. No measures above those required to mitigate the primary impact are required.

15.4.2. Accidental Events

There is the potential of accidental pollution events from service and support vessels required during the installation works. These vessels will have fuel tanks and hydraulic systems for cranes and winches. These pollution events could include the release of fuel and lubricating oil, cleaning fluids, paints, specialised chemicals and litter. Any potential spillages could impact water quality and contaminate seabed sediments.

To mitigate for accidental pollution events, vessels operating in the site will have appropriate risk management procedures

15.4.3. Traffic and transport

The technology prototypes on test on site will present a sense of uniqueness to the area. Their presence may prove to be a novel visitor attraction and lead to an increase in marine tourism in the area. This impact could be for the project duration but would be intermittent depending on when and for how long devices are deployed at sea.

There are ample car parking facilities at the known vantage points along the Furbo and Spiddal beach fronts to accommodate the very small number of tourist visiting the area specifically to view the marine energy devices. No further mitigation is required.

15.4.4. Fishing Industry

The test site has been in operation for 10 years heretofore. The closed site may have beneficial impacts for certain fish and shellfish. It could lead to an increased fish stock resource in the area leading to enhanced or better quality catches in the future, there is no direct evidence that this is the case, however. Monitoring of catches and controlled studies would be required to establish this impact. No mitigation is required in relation to the impact on fishing.

15.4.5. Navigation

The Galway Bay Marine and Renewable Energy Test Site will give rise to a small amount of extra marine traffic during installation of devices. Chapter 13 indicated that the increased marine traffic will not give rise to any significant impacts on navigation in the area.

15.4.6. Noise

Increased vessel traffic and operation of devices has the potential to lead to an increase in the level of noise in the coastal zone. Such impacts will be low, intermittent in nature and will be confined to distinct periods.

To mitigate the potential impacts from noise, monitoring will take place in advance of any device deployed at the tests site to establish background reference noise levels. During the operation of devices at the site, noise monitoring will be undertaken at the same stations to determine the levels of any increase in noise attributable to the operation of the device(s). Should increased noise levels be evident during the operation of the devices, appropriate noise mitigation measures will be put in place.

15.5. Cumulative Impacts

Cumulative impacts are those that result from incremental changes caused by other (past, present or reasonably foreseeable actions) together with changes directly arising from the project.

15.5.1. Other Projects

Cumulative impacts may arise resulting from a combination of other projects in the general area or from the project components itself. There are a number of projects in planning which may occur during the lifetime of the Galway Bay Marine and Renewable Energy Test Site, these include:

- **Galway Port Development:** Galway Harbour Company are proposing to redevelop the Port of Galway. Phase 1 is the construction of 2 deep water Cruise liner berths, a new channel and a 200 berth marina.
- **WestWave Project:** WestWave is a proposed project to develop a small pre-commercial wave energy farm (about 5MW) on the west coast of Ireland. The project is in development by ESB with Government funding support at a site near Killard in County Clare.
- **Atlantic Marine Energy Test Site (AMETS):** AMETS is being developed by Sustainable Energy Authority of Ireland (SEAI) for testing of full scale wave energy converters in an open ocean environment. It is located to the west of Belmullet in County Mayo. The test site will provide a grid connected national test facility, for WECs at the final stages of pre-commercial development.

The above projects are in the development phase and will require either planning permission or a foreshore lease/licence from the statutory authorities if they are to proceed; for that reason no assessment of potential cumulative impacts can be made at this time.

15.6. Conclusion

The interaction between impacts, indirect or cumulative are primarily concerned with ecology, accidental events, vessel traffic, noise and fishing. The indirect and cumulative impacts are largely low and are considered non-cumulative.

Environmental Impact	Environmental Interactions								
	Human Activity	Seabed & Geology	Water (Physical/ Chemical]	Flora & Fauna	Noise	Air	Visual	Cultural Heritage	Material Assets
Human Activity				I/O	I/O		I/O		O
Seabed & Geology	O		I/O	I/O				I/O	I/O
Water (Physical/Chemical]		O		O					
Flora & Fauna		I/O							O
Noise	I/O			I/O					I/O
Air			I/O	O			I/O		
Visual	O							I/O	
Cultural Heritage	O								
Material Assets	O	I/O	O	O	O	O	O	O	

I= Installation Phase Impact
O=Operational Phase Impact

Level of Potential Impact:

None	Negligble	Minor	Moderate	Major	Severe

Figure 15-1: Potential Interactions of Impacts at the Galway Bay Marine and Renewable Energy Test Site

16. Summary of Impacts and Mitigations

The tables in this chapter summarise the impacts relating to the following:

- Chapter 5: Human Activity
- Chapter 6: Flora and Fauna
- Chapter 7: Water
- Chapter 8: Seabed and Geology
- Chapter 9: Air Quality
- Chapter 10: Cultural Heritage
- Chapter 11: Visual Impact Assessment
- Chapter 12: Material Assets
- Chapter 13: Navigation
- Chapter 14: Coastal Processes

16.1. Human Activity - Impacts and Mitigations

Ref.	Receptor	Predicted impacts	Mitigation	Conclusion
5.2.2	Population	As the proposed development contains no land based infrastructure there will be no impact on the local population composition	No mitigation required.	The Marine Renewable Energy Test Site will not have any direct impact on the population in the immediate area.
5.3.2	Employment and socio –economic benefits	<u>Operation & Decommissioning</u> Potential for short-term employment of small vessels during operations and decommissioning. Marine contractors will be needed to assist operations. Regular monitoring and maintenance will bring device development teams to the area.	Local employment opportunities will be identified and local business will be encouraged to avail of any opportunities.	Through the provision of some local employment it will help sustain the existing population and help prevent decline in the population of the area. There will be an increase in visits to the area which will promote economic activity in the local hotel and catering industries.
5.4.1	Traffic volumes	<u>Operation</u> Traffic to Spiddal Pier will be very low in volume with an estimated two to four vehicles per week using these facilities when devices are on test site. <u>Decommissioning</u> Likely to be a minor increase in use of the pier at Spiddal for short periods.	The local access road to the new pier in Spiddal should be maintained in good condition	The increase in traffic is minimal and will have no significant impacts.

16.2. Flora and Fauna - Impacts and Mitigations

Ref	Receptor	Predicted impacts	Likelihood	Consequence	Impact	Mitigation
6.6.1.1	Seabed	Loss of habitat and species	Highly likely	Negligible	Low	• Baseline geophysical/geotechnical surveys • Baseline sediment and faunal surveys for comparison with post installation surveys • Use installation methods that minimise disturbance of sediments • Use appropriate deployment methods • Carry out work in appropriate weather / tidal conditions • Avoid sensitive time periods for local receptors • Risk assessment for contingency planning • Use low toxicity and biodegradable materials • Use minimum quantities • Design infrastructure for minimum maintenance • Design devices to minimise risk of leakage of pollutants • Implementation of Shipboard Oil Pollution Emergency Plan (SOPEP) • Presence of Marine Mammal Observer (MMO) to implement the NPWS guidelines. • If bow thrusters are required on installation vessels they should be covered to prevent collision with marine mammals • Target work to take place when porpoise
6.6.1.2		Disturbance to seabed				
6.6.1.3		Addition of new substrata / structures				
6.6.1.4	Marine Mammals	Collision risk	Unlikely	Minor	Low	
6.6.1.4	Birds					
6.6.1.4	Fish					
6.6.1.5	Marine Mammals	Barrier to movement	Remote	Negligible	Low	
6.6.1.5	Birds					
6.6.1.5	Fish					
6.6.1.6	Marine Mammals	Installation noise	Possible	Negligible	Low	
6.6.1.6	Fish					

Ref	Receptor	Predicted impacts	Likelihood	Consequence	Impact	Mitigation
6.6.1.7	Marine Mammals	Operational noise	Possible	Negligible	Low	presence is at its lowest • Only carry out observations (and therefore work) during daylight hours • Carryout SAM at the site during and after installation works to assess if avoidance behaviour is recorded and if so for how long it lasts. • Design devices for minimal impact of collision risk • Plan operations efficiently to minimise the number of trips that the service vessel must make. • Leave any long-term devices, which have become established as functional artificial reefs and are beneficial to the area in place.
6.6.1.7	Fish					
6.6.1.8	Fauna	Electromagnetic field	Unlikely	Negligible	Low	
6.6.1.8	Marine Mammals					
6.6.1.8	Fish					
6.6.1.9	All	Accidental events / contamination	Unlikely	Negligible	Low	

16.3. Water - Impacts and Mitigations

Ref.	Receptor	Predicted impacts	Mitigation	Conclusion
7.3.2	Seabed	Mobilisation of sediment	• Use installation methods that minimise disturbance of sediments • Carry out work in appropriate weather / tidal conditions • Implementation of Shipboard Oil Pollution Emergency Plan (SOPEP) • All hydrocarbons on board vessels should be managed appropriately to prevent their potential release to surface or ground water. • Design devices to minimise risk of leakage of pollutants • Only oils with low environmental impact should be used. • Use minimum quantities of antifoulants on WECs	No significant risk to water. Main threat is from accidental leakage. Overall the impact is of low significance, temporary and of short duration.
7.3.2	Seabed	Accidental events / contamination		
7.3.2	Water quality			
7.3.3	Seabed	Mobilisation of sediment		
7.3.3	Seabed	Accidental events / contamination		
7.3.3	Water quality			
7.3.3	Seabed	Mobilisation of sediment		

16.4. Seabed and Geology - Impacts and Mitigations

Ref.	Receptor	Predicted impacts	Mitigation	Conclusion
8.3	Seabed	Mobilisation of sediment	• Use installation methods that minimise disturbance of sediments	No significant risk to sediment or geology

16.5. Air Quality - Impacts and Mitigations

Ref.	Receptor	Predicted impacts	Mitigation	Conclusion
9.3	Air Quality	Negligible impact	None	Impact on air quality will be negligible

16.6. Cultural Heritage - Impacts and Mitigations

Ref.	Receptor	Predicted impacts	Mitigation	Conclusion
10.4	Archaeological features	No impact	Anchoring or mooring systems for short term infrastructure be reviewed and assessed for archaeological impacts	The proposed development will not have any impact on any known archaeological features. The proposed development will have a specific, but limited, direct impact on the seafloor.
10.4	Seabed	Anchor scarring	Annual surveys to monitor the impact of anchoring methods and to assess the impact of the gravity base	

16.7. Visual Impact - Impacts and Mitigations

The summary of visual impact and mitigations should be read in conjunction with the view point map and photomontages in Appendix 10a.

<table>
<tr><th>Ref.</th><th>Receptor</th><th>Predicted impacts</th><th>Mitigation</th><th>Conclusion</th></tr>
<tr><td>11.4.1.4</td><td>Seascape</td><td>Seascape Sensitivity: Medium
Impact Magnitude: Medium - Low
Impact Significance: Slight</td><td rowspan="6">Provide interpretive installation on the shoreline at Spiddal which provides information about the various marine renewable technologies and the purpose of the site for testing such devices.</td><td>Overall significance is **Slight**. Only applies to worst case scenario with all devices briefly in place at the same time. Temporary nature of devices is strong ameliorating factor.</td></tr>
<tr><td>11.4.2.4</td><td>VRP 1</td><td>Viewpoint Sensitivity: High
Impact Magnitude: Low - Negligible
Impact Significance: Slight</td><td rowspan="5">Given the pattern of impacts at the various viewpoints, the degree of impact is only likely to occur at viewing distances of less than 2km and only for the brief worst-case-scenario periods when all structures are in place at once.

Beyond approximately 2km impact levels fall away quickly to slight and imperceptible.

There will be no residual seascape or visual impacts once the various structures are eventually removed from the site.</td></tr>
<tr><td>11.4.2.4</td><td>VRP 2</td><td>Viewshed Sensitivity: High
Impact Magnitude: Low - Negligible
Impact Significance: Slight</td></tr>
<tr><td>11.4.2.4</td><td>VRP 3</td><td>Viewshed Sensitivity: High
Impact Magnitude: Low
Impact Significance: Moderate - Slight</td></tr>
<tr><td>11.4.2.4</td><td>VRP 4</td><td>Viewshed Sensitivity: High - Medium
Impact Magnitude: Low
Impact Significance: Slight</td></tr>
<tr><td>11.4.2.4</td><td>VRP 5</td><td>Viewshed Sensitivity: High
Impact Magnitude: Negligible
Impact Significance: Slight - Imperceptible</td></tr>
</table>

16.8. Material Assets - Impacts and Mitigations

Ref.	Receptor	Predicted impacts	Mitigation	Conclusion
12.3.2	Commercial Fishing	Intermittent short-term disruption to fishing activity during WEC deployment and recovery operations – Negligible impact	Advance notice of operations notified to marine stakeholders. Operations timed to minimise disruption of fishing activity	During the installation and during WEC deployment and recovery operations, the impacts on the fishing industry in the area will be of short duration and of low significance overall. Impacts can be reduced through careful planning of all activities associated with the test site in line with the accredited HSEQ Management Plan, and through continuing engagement with key stakeholders in Spiddal.
12.3.2	Commercial Fishing	Intermittent short-term disruption to fishing activity in the event of telecommunications cable repair - Negligible impact		
12.3.2	Commercial Fishing	Loss of fishing gear drifting into test site in inclement weather – Medium impact	Test site operations governed by SmartBay HSEQ Management Plan incl. emergency response plan facilitating rapid response to WECs breaking their moorings and coming adrift or becoming entangled with fishing gear	
12.3.2	Commercial Fishing	Loss of fishing gear due to damage by WECs breaking moorings		
12.3.2	Commercial Fishing	Test site creates nursery area for fish & shellfish stocks – Low impact	None	May result in gains to fishing income.
12.4.2	Tourism & Leisure	Visual Impact adjudged to be slight	Provide interpretive installation on the shoreline at Spiddal which provides information about the various marine renewable technologies and the purpose of the site for testing such devices.	The marine renewable energy devices may serve to raise the profile of the area. Ferry services and water quality are not likely to be affected by operations at the test area.
12.4.2	Tourism & Leisure	Negligible impact on bathing water quality	None	
12.4.2	Tourism & Leisure	No impact on ferry routes or leisure sailing	None	

16.9. Navigation - Impacts and Mitigations

<table>
<tr><th>Ref.</th><th>Receptor</th><th>Predicted impacts</th><th>Mitigation</th><th>Conclusion</th></tr>
<tr><td>13.7.2</td><td>Fishing Vessels</td><td>Sufficient sea-room to the north and south of test site area to transit to and from fishing grounds – negligible impact.</td><td rowspan="3">Test site be designated as an Area to be Avoided (ATBA) on all charts

Marine Notices to be issued in advance of installation or decommissioning of any device.

All test site vessels will comply with statutory regulations.

All test site vessels will be of sufficient size to cope with works and weather conditions

24/7 monitoring of WECs and buoys to ensure position stationary.

Reliable inspection, maintenance and casualty response regime conditions in accordance with SmartBay HSEQ Management System will be implemented

Emergency services & RNLI informed of site layout and workings.</td><td rowspan="3">Information on local ports and harbours, standard sailing routes, existing Aids to Navigation, existing navigation aids, known navigation hazards, industry activity, sea conditions, bathymetry, fishing grounds and fishing activity was gathered relating to navigation in the area to support the assessment.

On assessment of the existing environment there will be a negligible impact on navigation.</td></tr>
<tr><td>13.7.3</td><td>Commercial Shipping</td><td>Commercial shipping routes are some distance to the south of the test site therefore negligible impacts predicted</td></tr>
<tr><td>13.7.3</td><td>Recreational vessels</td><td>Increased test site vessel activity to/from Spiddal Pier, Rossaveel & Galway Ports may pose additional navigational risk to leisure craft.</td></tr>
</table>

16.10. Coastal Processes - Impacts and Mitigations

Ref.	Receptor	Predicted impacts	Mitigation	Conclusion
14.3.2	Bed Sediments	Physical presence will disturb and remobilise sediments in the immediate footprint of the object, including scouring predicted to have a low impact	None	Given the area of the proposed test site and the fact that devices are scaled and not full size the installation, the operation of the test site will only have a low impact, of negligible consequence, on coastal processes in Galway Bay.
14.3.3	Sediment Transport	Could be impacted by localised hydrodynamic changes associated with wave or tidal energy removal by the operating device but the likelihood is remote with no consequences arising	None	
14.3.3	Wave regime	The impact of wave energy extraction will be low and somewhat recoverable but the likelihood is remote with no consequences arising	None	

17. HSEQ Management System

17.1. Introduction

This chapter describes the operating framework that will be in place during both the development and the operation of the Galway Bay Marine and Renewable Energy Test Site.

SmartBay Ireland, is the organisation established by the Marine Institute to manage the promotion and development of the Galway Bay Marine and Renewable Energy Test Site. SmartBay have developed a HSEQ Management System (Appendix 10) accredited to ISO 9001 (Quality), ISO14001 (Environment), and OSHS 18001 (Occupational Health and Safety) international standards (Appendix 10a).

The HSEQ Management System is based on the BSi Occupational Health and Safety, the ISO International Standards Quality and Environmental Management Systems taking into account recommended Offshore Wind and Marine Energy Health and Safety Guidelines, International and National maritime safety and environmental regulations, codes and guidelines.

The marine operations at the Galway Bay Marine and Renewable Energy Test Site will be undertaken by P&O Maritime who have vast experience in marine operations. All marine operations will be undertaken in accordance with the accredited HSEQ Management System developed.

Environmental monitoring will also be a major responsibility. Critical to successful environmental monitoring will be the design and implementation an Environmental Management System (EMS) to ensure that environmental conditions (as characterised during the baseline studies), will be monitored on an on-going basis, so that any negative impacts can be addressed at the earliest possible stage. Close consultation with the relevant statutory and non-statutory bodies will ensure an appropriate EMS is put in place.

The HSEQ Management System comprises of the following parts:

- Tier 1 Manual Describes the HSEQ Management System, in three Parts A, B & C.
    - Section A: Policies, Administration and Risk Management.
    - Section B: HSEQ Project Management.
    - Section C: Offshore & Shore Based Hazards and Activities.
- Tier 2 Manual Detailed Company Procedures.
- Tier 3 Registers Risk Assessments, Method Statements.
- Tier 4 Register Forms.

17.2. Management System

The HSEQ Management system incorporates the Safety Management System and applies to all parts of the organisation including the Galway Bay Marine and Renewable Energy Test Site, to all personnel and where relevant to all contractors.

SmartBay Ireland manages and operates a national facility for testing novel equipment and sensors in a licenced test site within Galway Bay. Facilities at the test site include a subsea cabled observatory, floating data buoys, WiFi communications, cardinal marks delineating the site and a future floating sea station is planned.

The Health, Safety, Environment and Quality Management Systems (SMS), incorporating the Safety Statement applies to all parts of the organization, to all personnel and where relevant to all contractors to whom activities or support has been outsourced

It is the responsibility of the "Designated Person" to ensure that the Safety Management System is properly documented, controlled, made readily accessible and that obsolete documents are removed promptly.

Procedures are "process" based, carefully drafted and reviewed by management. Procedures are documented, approved by management, and issued by the Designated Person with a revision number and date.

Method Statements are "risk based", are devised to cover all physical activities associated with the business where workers may be exposed to danger or hazards. It is very important that Method Statements are well documented and controlled. Method Statements rely on careful critical analysis of the activity processes, their interactions and developed on the basis of Risk Assessment, regulatory requirements and codes of best practice and industry guidelines.

Method Statements are subject to strict document control and must be associated with up to date Risk Assessments and depending on the activity may require a Permit to Work.

All Method Statement are registered and must be readily available for consultation at all times.

17.3. Risk Management

The objectives of the HSEQ Management System are to ensure safety ashore and at sea, prevention of human injury or loss of life, and avoidance of damage to the environment and to property.

The HSEQ Management System procedures are based on Safe Systems of Work which include:

- Hazard Operability (HAZOP).
- Hazard Identification.

- Risk Assessment.
- Risk management controls including Permits to Work.
- Method Statements.
- Accident / Dangerous Occurrence Reporting.
- Accident / Dangerous Occurrence Investigation and corrective actions.
- Audits, Inspections and Review.
- Continuous Improvement through Monitoring, Analysis and Preventive Action.
- Ownership by all personnel through participation and consultation.
- Compliance with all regulations, codes and industry guidelines.

The purpose of Risk Management is to reduce, eliminate or transfer the risk by identifying hazards, assessing the consequences, likelihood and determination of controls that reduce eliminate or reduce the risks to acceptable levels for business activities to be carried out safety and without harming the environment.

17.4. Site management

On-going site management arrangements take into account the need to address issues such as:

- Tracking personnel between vessels and onshore areas.
- Shift work, and potentially lone working.
- Housekeeping, including the need to maintain clear access routes, and waste disposal at the shore interface.
- Storage and movement of materials, possibly including use of temporary storage areas.
- Maintenance and security of data nodal sites where cables come ashore.
- Maintenance and security of long range RF data link equipment and broadband connections.
- Response to severe weather, including storms and winter conditions and:
- Emergency response, either relating to an incident in the port, on the offshore site, or an external emergency event.

Ports and shore-based contractors will have their own safety management systems; bridging documents are needed in order to manage the interface with the HSEQ Management System and the OREI operator's systems, in normal operation and emergency situations. Common arrangements will be put in place for the management of visitors and contractors who are not normally on the site, such as specialist repair technicians.

Harbour Authorities marine coordination functions play a key role in managing the use of the port. This includes planning all vessel movements, in conjunction with any construction contractors / port facility operations when planning logistics support, which possibly involves Vessel Traffic Systems control (VTS) or Harbour Masters and pilots who control vessel movements where harbour authorities operate such systems. Harbour Masters have a statutory obligation to direct traffic within their port limits and so have the right to pass instructions to vessels.

Marine energy test sites must be clearly marked by navigation marks and identified on navigation charts. GIS (Geographic Information Systems) is used to assist in the identification of site margins and for planning, recording deployment of devices and cables, for monitoring positions of moored units and for vectoring MetOcean data. GIS systems assist with maps / vector layering, visualization, geocoding, geographical analysis, imagery and database management.

There is a legal obligation to ensure that planned changes to the site are notified to authorities responsible for navigation marks including lights that warn shipping as other vessel movements may take priority due to their draft and the tidal opportunities and harbour operational requirements.

Given the wide range of requirements and associated mitigation actions, early dialogue with port authorities, existing users, onshore contractors and workforce representatives is beneficial to establishing safe and efficient port operations.

The General Manager is responsible for ensuring that any issues relating to Navigation Marks (site IALA cardinal marks) are reported to the Commissioners of Lights and any changes that may require temporary Notices to Mariners to the relevant hydrographic service and the Marine Institute (MI).

17.5. Site Design, Specification, Management and Testing

SmartBay design and manage the layout of test sites and work with clients to establish the most suitable location within the overall site for the positioning of wave energy test devices.

17.5.1. Site Specific Data Requirements

Factors taken into consideration include *(inter alia):*

- MetOcean information including wave and tidal stream data.
- Proximity of umbilical power and data cables.
- Positions of other buoys and devices on site.
- Holding ground most suitable for effective mooring.

17.5.2. Device Safety in Design Considerations

Whilst clients may have specific requirements for the provision of a SeaStation, test sensor platform, buoys, or some sub-sea bottom based or mid depth device, all of which should be provided with safe access for engineers during mobilization, operations, maintenance and decommissioning.

- Systems are designed or modified after design reviews to ensure safe access.
- Safe mooring systems.

- Prevention of interference with effectiveness of neighbouring devices.
- Located within the area marked by the cardinal buoy system.
- Buoys and devices fitted with navigation marks / lights and radar reflectors and GPS automatic position reporting and alarm systems.

Mooring failures usually require complex subsea operations including the use of divers, necessary to recover buoys, devices and their mooring equipment including sinkers / clumps and anchors, which should be carefully avoided as it puts humans at additional risk and has cost and data interruption aspects.

17.5.3. Responsibility for safe design of wave energy devices

The Designated Person has overall responsibility for ensuring that Hazard Operability (HAZOP) studies are completed on a consultative basis and records maintained of technical and safety reviews.

17.5.4. Method statement risk management information

Method statements shall take into account the findings from *(inter alia):*
As applicable –

- HAZOPS.
- Project planning for commissioning / decommissioning, operations and maintenance.
- HAZID.
- Risk Assessments.
- Safety design factors intended to reduce the risk and facilitate enhanced controls that mitigate the consequences to moderate the residual risk eg. decking, guard rails and strong points for life lines and facility for a person in the water to climb on to the device, and mooring rings for workboats.

17.5.5. Design Records

Design records are maintained including provision for obsolete documents archived to assist in any research or for reference purposes.

17.6. Design for Marine Hazards

17.6.1. Identification

Marine Hazards are identified during the project planning stage and during device, mooring and cable network design. The HSEQ Management System provides guidance for the development of safe systems of work including procedures, Method Statements, Risk Assessments and Permits to Work underpinned by Hazard Operability (HAZOP) studies and Hazard Identification (HAZID) which will be subjected to Risk Assessment processes to determine the controls required to reduce or eliminate the risks. Examples of where in the design processes the identification of where marine hazards may be inherent or encountered include:

Design of the device itself:

- Design specifications taking into account access for installation and maintenance.
- Design of battery and sensor PODs, access to POD, tower and antennas.
- Solar and wind-turbine power generation systems.
- Deployment – lifting, launching, towing, transport at sea, and recovery.
- Mooring – type of, methods, fittings, cables and clumps or anchors.
- Connecting of cables.
- Electrical systems.
- Stability, ballast and buoyancy arrangements, watertight integrity.
- Fire protection.

MetOcean and meteorological considerations:

- Tide – tidal stream rates – potential for buoys to drag or break free, requiring marine operations to recover or reposition buoys including repositioning of anchors and clumps and restoration of cable connections.
- Wind over tide, rip tides, counter currents and under tow.
- Tidal range – heights of tides – especially at spring tides.
- Heavy ocean (sea) swell that cause the buoy or device to roll heavily or “heave” which makes boarding or working onboard difficult or unsafe and so access is restricted to calmer conditions.
- Wind – wind affects the sea state, see also “wind over tide” schedule maintenance when wind is with the tide reducing breaking wave tops and spray and moderating buoy / device movement.
- Sea floor conditions, visibility, swell effect, topography, under sea hazards.

Buoys or devices may break away and need to be recovered in weather and sea conditions that render boarding dangerous, in which case emergency towing hawsers need to be attached without boarding or even without using a workboat / daughter vessel. This can be achieved by the use of buoyed pennants permanently deployed that can be grappled by a larger vessel offering a safe platform for workers.

17.6.2. Personnel Transfer

The HSEQ Management System safe systems of work require all personnel marine transfer arrangements to be risk assessed and included in relevant Method Statements. Procedures have been established for personnel transfer i.e.:

- From quay side to work boat.
- From safe berth to site.

- Transfer of persons from work boat to device, buoy, platform or other vessel.
- Competent use of safety gear including lanyards, life lines, harnesses, fall arresters, dry-suits, life-jackets and Personal Locator Beacons.
- Transfer back to work boat and returning safely to the shore.
- Safety gear accounted for, checked out and re-stowed.

When personnel are working from a large vessel using daughter boats they will adhere to the procedures and comply with instructions provided by the Master of the ship. Personnel transfer is not completed until the personnel are safely back on shore together with all equipment. Method Statements and Risk Assessments shall be developed or at least shared with the boat skipper.

Where larger vessels in excess of 24 metres are used for transfer of personnel, Method Statements shall be developed together with the Master of the vessel. Larger vessels are required to have Safety Management Systems with which test site activities should interact. In most cases where technicians are transferred from larger vessels the transfer is completed using a RIB or other daughter craft launched from the larger vessel.

17.6.3. Tests on site

System and instrumentation tests are conducted and third party tests are facilitated by lease operators or their contractors. Tests on site require visits to the shore base station or to the device offshore in the test area. In some cases underwater tests are necessary. The HSEQ Management System covers the following interventions:

- Planning work activities.
- Risk assessments.
- Safe Systems of Work including Method Statements and Permits to Work.
- Access to sites and personnel transfer vessels.
- Boarding devices from workboats.
- Personnel transfer and access between boats and devices and with other boats/ships.
- Underwater or subsea activities.
- Transfer of tools and spares.
- Working safely.
- Electrical safety including electrical testing.
- Emergency procedures (see Emergency Response Plans).

Procedure for “Tests on Site” have been developed and accompanying safety check list to assist with planning tests on site.

17.7. Installation, Commissioning and Decommissioning

SmartBay works with the client to determine the requirements of the particular project. The summary requirements for the project are detailed in the contract which is prepared prior to being agreed at the time of engagement. The contract includes a schedule for the main "delivery" stages of the work and agreed prior to engagement.

17.7.1. Planning, Communication, Coordination

SmartBay takes the lead in planning for installation, commissioning and decommissioning of test equipment on test sites under management for the lessor and follows the requirements described in the HSEQ Management System where reference is made to the HSEQ Management Systems "Contents" at the front of the HSEQ document. Planning requirements include close liaison with the client (lessee) to establish *(inter alia):*

- Establishing appropriate and effective communications with all stakeholders, including the client (lessee), site license holder (lessor), internally and with authorities and contractors.
- A thorough understanding of agreed specifications and requirements.
- Time schedules for installation, commissioning, operations and de-commissioning.
- Identification of all safety and environmental hazards, risks and controls.
- Identification of legal requirements.
- Identification and implementation of plans for compliance with legal and Approved Codes of Practice (ACOP).
- Implementation of relevant "Construction, Design and Management" regulations (CDM).
- Notifications.
- Resources necessary to meet project requirements including competences and training.
- Reporting.
- Documentation and records.

17.7.2. Notification

All legal notification requirements are complied with including those recommended in codes of practice. Notifications include *(inter alia):*

- CDM notifications (where appropriate).
- Accident and incident reporting.
- Marine notices (including: Notices to Mariners, lighthouse authorities)
- Insurance information disclosure (to ensure cover and avoid withdrawal by insurers) required by the terms of the project contract.
- Archaeological and heritage aspects including discovery of wreck and human remains.

Note: Approved Codes of Practice including those standards, codes and guidelines recognized by authorities and by International Conventions e.g. SOLAS, MARPOL, Maritime Security, International Maritime Labour Convention.

17.7.3. Documentary control and record keeping

Reference is made to the requirements of the HSEQ for document control and record keeping. Project planners utilize the arrangements in place for the electronic control of documents including means for access, updating, sharing, data handling, protection and IT security. Individual project requirements specify documentation requirements, additional controls and requirements for sharing and dissemination.

17.7.4. Hazard Identification and Risk Assessment (HIRA)

There is a legal requirement to identify hazards and conduct Risk Assessments to determine the necessary controls to reduce the consequences, minimize or eliminate the risk of accidents and injuries to humans and for the protection of the environment. See Sections: A.6.4.2 HAZOP; A.6.4.3 HAZID; B.4.2 HIRA (Site).

17.7.5. Method statement

The safe systems of work detailed in the HSEQ Management System require risk based "Method Statements" for the safe operational control of work activities associated with the all projects. Method statements are also required from contractors and any other organizations or individuals working on or visiting the sites. Method Statements shall be documented and shared and amended to maintain currency and effectiveness and are subject to document control and record requirements.

17.7.6. MetOcean considerations

Weather working limits may be a complex combination of wind, wave and tidal velocities. It is likely that different working limits will be set for different project activities for example crane operations, towing or diving operations, and also for different vessels. Good, site specific forecasts are important to assist the scheduling of weather dependant operations safely and efficiently. Contingency planning in the event of deteriorating conditions requiring the suspension of operations should be considered as part of a Risk Assessment prior to commencement of works.

17.7.7. Project Handbook

The purpose of a Project Handbook is to ensure that quality, health, safety and environmental requirements are fully catalogued and communicated to personnel. A "Project Handbook" is created during project planning to provide a document detailing the main points in the contract and detailing references to at least the following *(inter alia):*

- "Operational Log" is kept on the project and is held in the "Developer Folder" on the common drive.

- Introduction.
- HSEQ statement (to include obligation to meeting HSEQ management system requirements).
- CDM statement (to confirm CDM status i.e. notifiable works).
- Detailed description of project.
- Flow chart of events and organizational aspects.
- Time scale.
- Team members, roles and responsibilities.
- Contractor list and relevant tasks.
- Organogram.
- Resources.
- Details of relevant Approved Codes of Practice.
- HAZOP.
- HAZID (indicating whether or not a Permit to Work is required).
- Method statements.
- Risk assessments.
- Environmental aspects.
- Principal legislation.

The Project Handbook should contain the following live documents in support of the HSEQ aspects related to the project *(inter alia):*

- Appendices (supporting documents):
- Method statements.
- Risk assessments (referenced to the Project Number).
- Drawing identification lists.
- Technical specifications of equipment and components.
- Client contact details.
- Contractor contact details.
- Contact details for relevant authorities.
- Emergency contact numbers.
- Emergency plans specific to project and reference to HSEQ management system emergency preparedness, actions and response.
- Any other relevant project information.

The Project Handbook shall be maintained in electronic form, uncontrolled if printed, and devoid of financial and commercial aspects apart from “Quality” requirements.

17.7.8. Simultaneous Marine Operations (SIMOP)

Where two or more potentially clashing operations occur simultaneously at the same time or same place there is the risk of conflicts which can override individual controls. SmartBay recognize the hazards that can arise out of Simultaneous Marine Operations of SIMOPs. It is very important when project planning to investigate the possibility of a clash of activities. Individual jobs might be quite safe when the risks are identified and properly managed but when SIMOPS are identified great vigilance is required to ensure that the hazards arising out of conflicts are risk assessed and additional controls applied that all parties take into account.

The project planners identify the scope of the work and the scheduling. This why it is important that permits are required by all contractors and own personnel before commencing work on the test site and any activity within 500 metres of the subsea cables and equipment including mooring clumps or sinkers. This means that the potential for SIMOPS risks need to be assessed and signed off before any Permit to Work on the site can be issued.

This is used to review all activities on the planned dates and localities to determine whether or not SIMPOS can be identified. The following issues are considered *(inter alia):*

- Schedule clashes e.g. activities in the same area or time.
- Physical clashes e.g. anchor patterns, loss of position.
- Failure impacts e.g. buoy break away, damage to under water nodal equipment.
- Marine surface operations.
- Diving safety.
- Interference between surface operations e.g. towing and deployment.
- Contracts and third part interfaces e.g. liabilities, risk / insurance.
- Environmental impacts e.g. currents, weather limitations and sea state.
- Territorial clashes e.g. third party activities i.e. hydrographic surveys, fishery research.
- Any other combined / simultaneous activity in the area of operation which could compromise project success criteria.

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18. Conclusion

Marine renewable energy is an emerging industry which has considerable potential for economic growth and job creation. This can happen through the development, manufacture, deployment and operation of wave, tidal and offshore wind technologies and the creation of an indigenous supply chain in Ireland. Ireland can capitalise on its natural advantages in the area of marine renewable energy by following the recommendations in the Government's Offshore Renewable Energy Development Plan (OREDP). This plan will help establish Ireland as a leader in ocean energy technologies in developing facilities that will enable the commercialisation of ocean energy products and services.

As part of the OREDP, an upgrade of the ¼ scale wave energy test site in Spiddal, Co. Galway is proposed to improve the service offered to end-users. The upgraded test site will be known as the Galway Bay Marine and Renewable Energy Test Site and will provide developers and researchers with a cabled and leased area in which to test and demonstrate their prototype ocean energy converters and related technologies. The upgraded site will enable periodic deployments of up to three individual devices for test and evaluation purposes for a maximum period of 18 months in any one instance. The Galway Bay Marine and Renewable Energy Test Site is an integral part of the OREDP. The site will be operational for thirty five years.

Ireland is in a unique position with regard to developing this new ocean energy renewable industry. The technology to harness the wave resource is still at development and testing stages and no commercial full scale device is in operation as of yet. On the critical path for proving technology is the requirement for testing and demonstration in a benign ocean environment, such as that found in Galway Bay. The Galway Bay Marine and Renewable Energy Test Site will delivery this requirement and will also support the delivery of the Government and EU policy and implementation of the OREDP and Action Plan for Jobs. The Irish ocean energy industry has the potential to support 17,000 – 52,000 jobs at a net present value of around €4-10 billion by 2050.

The main benefit from this project will be to enable ocean energy converter technology developers to test and modify their equipment in an open ocean national test site facility, thereby attracting developers to the site and encouraging the growth of an indigenous ocean energy industry in Ireland.

Proving ocean energy converter technology in a benign environment like Galway Bay is critical to the future development of the industry as a whole. It will give confidence to investors to proceed to full scale commercial development, in support activities at the full scale Atlantic Marine energy Test Site in Belmullet, Co Mayo.

The equipment deployed at the test site will have undergone rigorous assessment and certification processes and will have complied with procedures laid down in the Galway Bay Test and Demonstration Site manual.
The environmental impacts from the project have been examined and the best available mitigation measures have been proposed and will be adopted in an integrated manner.

As a consequence, there will be no significant adverse impacts on the environment arising from the development.

An accredited Health, Safety, Environmental and Quality Management System has been developed for the Galway Bay Marine and Renewable Energy Test Site operations to allow the broadest variety of activity to take place in a safe and controlled manner.

References

ABPmer. 2002. Potential effects of offshore wind developments on coastal processes. ETSU W/35/00596/00/REP.

AECOM Ltd. 2010. Strategic Environmental Assessment (SEA) of the Offshore Renewable Energy Development Plan (OREPD) in the Republic of Ireland.

AQUAFACT. 2010. Marine Environmental Appraisal of an Ocean Energy Test Site in Inner Galway Bay Produced by AQUAFACT International Services Ltd on behalf of Hydraulics & Maritime Research Centre.

Aristharkhov V.M., Arkhipova G.V. & G.K. Pashkova. 1988. Changes in common mussel biochemical parameters at combined action of hypoxia, temperature and magnetic field Ser. Biologisceskaja 2: 238–45

Bailey, H., Senior, B., Simmons, D., Rusin, J. Picken, G., & P.M. Thompson. 2010. Assessing underwater noise levels during pile-driving at an offshore windfarm and its potential effects on marine mammals. Marine Pollution Bulletin 60(6): 888-897.

Bald, J., del Campo, A., Franco, J., Galparsoro, I., González, M., Liria, P., Muxika, I., Rubio, A., Solaun, O., Uriarte, A., Comesaña, M., Cacabelos, A., Fernández, R., Méndez, G., Prada, D., Zubiate, L., 2010. Protocol to develop an environmental impact study of wave energy converters. Revista de Investigación Marina, 17(5): 62-138

Barlow, J. 1988. Harbour porpoises, Phocoena phocoena, abundance estimates for Caifornia, Oregon and Washington; 1. Ship surveys. Fisheries Bulletin 86: 417-432.

Bergström, L., Kautsky, L., Malm, T., Rosenberg, R., Wahlberg, M., Åstrand Capetillo, N. & D. Wilhelmsson. 2014. Effects of offshore wind farms on marine wildlife—a generalized impact assessment. Environ. Res. Lett. 9: 12pp/

Berrow, S.D., Hickey, R., O'Brien, J., O'Connor, I & D. McGrath. 2008. Harbour porpoise survey 2008. Report to the National Parks and Wildlife Service. Irish Whale and Dolphin Group. 31pp.

Bio/consult. 2000. Visit to measuring tower on Horns Rev. Technical note to ESLAM. (in Danish).

BirdLife International. 2003. Windfarms and Birds: An analysis of the effects of windfarms on birds, and guidance on environmental assessment criteria and site selection issues. Report written by BirdLife International (R.H.W. Langston & J.D. Pullan, RSPB, UK.) on behalf of the Bern Convention on the Conservation of European Wildlife and Natural Habitats Standing Committee.

Birklund, J. 2005. Surveys of Hard Bottom Communities on Foundations in Nysted Offshore Wind Farm and Schönheiders Pulle in 2004. DHI Water & Environment

Bochert, R. & M.L. Zettler. 2004. Long-term exposure of several marine benthic animals to static magnetic fields. Bioelectromagnetics 25: 498–502

Brasseur, S. M. J. M. & P. J. H. Reijnders, 1994. Invloed van diverse verstoringsbronnen op het gedrag en habitatgebruik van gewone zeehonden: consequenties voor de inrichting van bet gebied. - IBN-Rapp. 113, 62 pp.

Bryden, I.G. 2006. Marine Renewable Energy: Predicting the Influence of Energy Extraction. Unpublished Report to Metoc plc. June 2006.

Clarke, C. 2014. An Interpretation of the Single Channel High Frequency Seismic Reflection Datasets of Galway Bay, Ireland. MSc thesis NUI Galway

Clausen, K.T., Wahlberg, M., Beedholm, K., Eedholm, S., Deruitier, S., & P. Teglberg Madsen. 2010. Click Communication in Harbour Porpoises Phocoena Phocoena. Bioacoustics-the International Journal of Animal Sound and Its Recording 20(1): 1- 28.

Coates, D., Van Hoey, G., Colson, L., Vincx, M., & J. Vanaverbeke. 2015. Rapid macrobenthic recovery after dredging activities in an offshore wind farm in the Belgian part of the North Sea. *Hydrobiologia* 756(1): 3-18.

Connell, S.D. & T.M. Glasby. 1999. Do urban structures influence local abundance and diversity of subtidal epibiota? A case study from Sydney Harbour, Australia. Marine Environmental Research 47: 373-387.

Copping, A., Hanna, L., Whiting, J., Geerlofs, S., Grear, M., Blake, K., Coddey, A., Massaua, M., Brown-Saracino, J. & H. Battey. 2013a. Environmental effects of marine energy development around the world for the OES Annex IV, [Online], Available www.ocean-energy-systems.org

Cronin, M., Duck, C., Ó Cadhla, O., Nairn, R., Strong, D. & C. O' Keeffe. 2004. Harbour seal population assessment in the Republic of Ireland: August 2003. Irish Wildlife Manuals, No. 11. National Parks & Wildlife Service, Department of Environment, Heritage and Local Government, Dublin, Ireland.

Czech-Damal, N.U., Liebschner, A., Miersch, L., Klauer, G., Hanke, F.D., Marshall, C., Dehnhardt, G. & W. Hanke. 2012. Electroreception in the Guiana dolphin (Sotalia guianensis). Proc. R. Soc. B 279: 663–8

Daunt, F., Wanless, S., Peters, G., Benvenuti, S., Sharples, J., Gremillet, D. & Scott, B. (2006). Impacts of oceanography on the foraging dynamics of seabirds in the North Sea. In: Top predators in marine ecosystems: their role in monitoring and management. (eds I.L. Boyd, S. Wanless & K. Camphuysen). Cambridge University Press, Cambridge, pp177-190.

Dineen, D., Howley M. and Holland M. (2015). Renewable Energy in Ireland 2013. Sustainable Energy Authority of Ireland

Flaherty, C. 1981. Apparent effects of boat raffic on harbour porpoises (Phocoena phocoena). In: Abstracts of the 4th Biennial Conference on the Biology of Maine Mammals. San Francisco, CA. Dec. 1981. p.35.

Folk R.L., 1954. The distinction between grain size and mineral composition in sedimentary-rock nomenclature The Journal of Geology, Vol. 62, No. 4 (Jul., 1954), pp. 344-359

Galway Harbour Company. 2014b. Galway Harbour Extension. Environmental Impact Statement Chapter 10 Noise and Appendix 10. Report prepared by Tobins Consulting Engineers.

Gerritsen, H.D. and Lordan, C. 2014. Atlas of Commercial Fisheries Around Ireland, Marine Institute, Ireland. ISBN 978-1-902895-56-7

Gill, A.B., Bartlett, M. & F. Thomsen. 2012. Potential interactions between diadromous fishes of UK conservation importance and the electromagnetic fields and subsea noise from marine renewable energy developments. J. Fish Biol. 81: 664–95.

Grossman, G.D., Jones, G.P. & W.J. Seaman. 1997. Do artificial reefs increase regional fish production? A review of existing data. Fisheries 22: 17-23.

Haikonen, K., Sundberg, J. & M. Leijon. 2013a. Characteristics of the Operational Noise from Full Scale Wave Energy Converters in the Lysekil Project: Estimation of Potential Environmental Impacts. Energies, 6(5): 2562-2582. IV

Haikonen, K., Sundberg, J. & M. Leijon, M. 2013b. Hydroacoustic measurements of the noise radiated from wave energy converters in the Lysekil project and project WESA. 1st international conference and exhibition on Underwater Acoustics, UA2013, Corfu, Greece, 23rd - 28th June 2013.

Haikonen, K. 2014. Underwater radiated noise from Point Absorbing Wave Energy Converters. Noise Characteristics and Possible Environmental Effects. Digital Comprehensive Summaries of Uppsala Dissertations from the Faculty of Science and Technology 1200. 62 pp. Uppsala: Acta Universitatis Upsaliensis. ISBN 978-91-554-9097-3.

Hall, S.J., Basford, D.J. & M.R. Robertson. 1990. The impact of hydraulic dredging for razor clams *Ensis* spp. on an infaunal community. *Netherlands Journal of Sea Research* 27: 119-125.

Hastings, M.C. & A.N. Popper. 2005. Effects of sound on fish. California Department of Transportation Contract No. 43A0139.

Hoffmann, E., Astrup, J., Larsen, F., Munch-Petersen, S. & J. Strottrup. 2000. The effects of marine windfarms on the distribution of fish, shellfish and marine mammals in the Horns Rev area. Baggrundsrapport nr. 24. Report to ELSAMPROJEKT A/S. Danish Institute for Fisheries Research

Jennings, S. & M.J. Kaiser. 1998. The effects of fishing on marine ecosystems. Advances in Marine Biology 34: 201-352.

Johnson, C.S. 1967. Sound detection thresholds in marine mammals. In: Travolga, W.N. (ed.) Marine bio-acoustics. Pergamon, Oxford. pp. 247-260.

Karlsen, A.G. & Aristharkhov, V.M. 1985. The effect of constant magnetic field on the rate of morphogenesis in a hydroid Clava multicornis (forskal). Zurnal Obscej Biologii 5: 686–90.

Kastelein, R.A., Bunskoek, P., Hagedoorn, M. & W.W.L. Au. 2002. Audiogram of a harbor porpoise (Phocoena phocoena) measured with narrow-band frequency modulated signals. J. Acoust. Soc. Am. 112: 334-344.

Keenan, G., Sparling, C., Williams, H. & F. Fortune. 2011. SeaGen Environmental Monitoring Programme Final Report. Report prepared for Marine Current Turbines Reference 9S8562/R/303719/Edin.

Leonard, S.B. 2000. Horns Rev offshore wind park, EIA of sea bottom and marine biology. Report to I/S ESLAM, Denmark.

Ljungblad, D.K., Scoggins, P.D. & W.G. Gilmartin. 1982. Auditory thresholds of a captive eastern Pacific bottlenose dolphin, Tursiops spp. Hournal of the Acoustical Society of America 72: 1726-1729.

Marine Institute, 2013. The Galway Bay Cable Project Environmental Report. Marine Institute, SEAI and SmartBay Ireland.

Nelson, P.A., 2003. Marine fish assemblages associated with fish aggregating devices (FADs): effects of fish removal. FAD size, fouling communities, and prior recruits. Fish. Bull. 101:835-850

NPWS. 2004. Site Synopsis Lough Corrib SPA. 13.8.2004. http://www.npws.ie/sites/default/files/protected-sites/synopsis/SY004042.pdf

NPWS. 2005. Site Synopsis Inner Galway Bay SPA (004031). 22.2.2005. http://www.npws.ie/sites/default/files/protected-sites/synopsis/SY004031.pdf

NPWS. 2010. Site Synopsis Connemara Bog Complex SPA (004181). 30.11.2010. http://www.npws.ie/sites/default/files/protected-sites/synopsis/SY004181.pdf

NPWS. 2012. Harbour Seal Pilot Monitoring Project January 2012. National Parks and Wildlife Service, Department of Arts, Heritage and the Gaeltacht. Unpublished Report.

O'Brien, J. 2009. The inshore distribution and abundance of small cetaceans on the west coast of Ireland: Site assessment for SAC designation and an evaluation of monitoring techniques. Galway-Mayo Institute of Technology, Unpublished Ph.D Thesis, pp 1-226.

O'Brien, J., Beck, S., Wall, D., Pierini, A. & S. Hansen. 2012. Marine mammals and megafauna in Irish waters, behaviour, distribution and habitat use. Work Package 2: Developing acoustic monitoring techniques. PReCAST Final Report – Marine Research Sub-programme 2007-2013, pp 1-205.

O'Brien, J. 2013. Cetacean presence at the ocean energy test site Spiddal: as determined through land-based visual monitoring and static acoustic monitoring using PODs. Report prepared for the Marine Institute. GMIT. March 2013.

Ó Cadhla, O., Strong, D., O'Keeffe, C., Coleman, M., Cronin, M., Duck, C., Murray, T., Dower, P., Nairn, R., Murphy, P., Smiddy, P., Saich, C., Lyons, D. & Hiby, A.R. 2005. An assessment of the breeding population of grey seals in the Republic of Ireland, 2005. Irish Wildlife Manuals No. 34. National Parks & Wildlife Service, Department of the Environment, Heritage and Local Government, Dublin, Ireland.

Ó Cadhla, O. & Strong, D. 2007. Grey seal moult population survey in the Republic of Ireland, 2007. Unpublished report.

O'Connor, B and D. Mc Grath. 1981. Benthic Macrofaunal Studies in the Galway Bay area: Volume 1: The Macrofaunal Assemblages of Galway Bay: PhD Thesis, University College Galway.

Ocean Renewable Power Company. 2013. Environmental Monitoring Report March 3, 2014

O'Connor, B., Bowmer, C.T. and Grehan, A., 1983. Long-term assessment of the population dynamics of *Amphiura filiformis (Echinodermata: Ophiuridea*) in Galway Bay, west coast of Ireland. Marine Biology 75, 279-286. Office of Public Works, Ireland 2007. www.opw.ie

O'Donoghue, P. 2011. Galway Bay Cable Project Bird Screening Report. Prepared by Atkins Consulting Ltd. on behalf of the Marine Institute, August 2011, 22pp.

O'Leary, E., O'Leary, D. & T. Hubbard. 2001. Artificial Reefs Feasibility Study. Marine Institute.

Olsson, T & A. Larsson. 2009. Impact of electromagnetic fields (EMF) from sub-sea power cables on marine organisms – the current state of knowledge: Vattenfall Research and Development AB. Project PR.38.3.14, 33 pp 14 Appendices.

OPW. 2012. http://www.opw.ie/en/FloodRiskManagement/HydrometricData/.

O'Reilly, R., Kennedy, R., Patterson, A. and Keegan B.F., 2006. Ground truthing sediment profile imagery with traditional benthic survey data along an established disturbance gradient. Journal of Marine Systems, 62, pp. 189-203.

Parker, D.L. 1993. The presence of ship avoidance during line transect survey of harbour porpoises in the Gulf of Maine. In: Abstracts of the 10th Biennial Conference on the Biology of Marine Mammals. Galveston, TX, Nov. 93. p. 84.

Pickering, H & D. Whitmarsh. 1997. Artificial reefs and fisheries expolitation: a review of the 'attraction versus production' debate, the influence of design and its significance for policy. Fisheries Research, 31: 39-59.

Richardson, W.J., Greene, C.R., Malme, C.I. & H.H. Thompson. 1995. Marine Mammals and Noise. Academic Press, San Diego.

Rilov, G. & Y. Benayahu. 1998. Vertical artificial structures as an alternative habitat for coral reef fishes in disturbed environments. Marine Environmental Research 45: 431-451

Rilov, G. & Y. Benayahu. 2000. Fish assemblages on natural versus vertical artificial reefs: the rehabilitation perspective. Marine Biology 136(5): 931-942.

Scottish Executive. 2007. Scottish Marine Renewables Strategic Environmental Assessment. Report prepared by Faber Maunsell and Metoc plc

SEAI. 2011. Atlantic Marine Energy Test Site Environmental Impact Statement.

SEMRU, 2015. Ireland's Ocean Economy: reference Year 2012. NUI Galway

SMRU, 2001. Background information on marine mammals relevant to SEA2. Technical Report TR_006. Technical report produced for Strategic Environmental Assessment – SEA2.

SQW, 2011. Economic Study for Ocean Energy Development in Ireland. SEAI

Taylor, B.L. & P.K. Dawson. 1984. Seasonal changes in density and behaviour of harbour porpoises (Phocoena phocoena) affecting census methodology in Glacier Bay National Park, Alaska. Reports of the International Whaling Committee 34: 479-483.

Thomsen, F., Lüdemann, K., Kafemann, R. & W. Piper. 2006. Effects of offshore wind farm noise on marine mammals and fish, biola, Hamburg, Germany on behalf of COWRIE Ltd.

Tougaard, J. 2015. Underwater Noise from a Wave Energy Converter Is Unlikely to Affect Marine Mammals. Plos One 10(7): 1-7.

Tully, O., Tyndall, P. & S. Breathnach, 2010. The Crustacean Fisheries of Inner Galway Bay: report to the Galway bay Inshore Fishermen's Association (GBIFA) 32pp.

Vella, G., Rushforth, I., Mason, E., Hough, A., England, R., Styles, P., Holt, T & P. Thorne. 2001. Assessment of the effects of noise and vibrations from offshore wind farms on marine wildlife. ETSU W/13/00566/REP. DTI/Pub URN 01/1341.

Westerberg, H. & M. Begout-Anras. 2000. Orientation of silver eel (Anguilla anguilla) in a disturbed geomagnetic field Advances in Fish Telemetry: Proc. 3rd Conf. on Fish Telemetry Centre for Environment, Fisheries and Aquaculture Science (Lowestoft) ed A Moore and I Russel pp. 149–58

Westerberg, H. & I. Lagenfelt. 2008. Sub-sea power cables and the migration behaviour of the European eel Fish. Manag. Ecol. 15: 369–75.

Wickens, J. & G. Barker. 1996. Quantifying complexity in rock reefs. In: Jensen, A.C. (ed) European artificial reef research. Proceedings of the 1st EARRN conference, Ancona, Italy. Pub. Southampton Oceanography Centre. 423-430p.

Winkleman, J.E. 1992. The impact of the Sep wind park near Oosterbierum (Fr.), the Netherlands, on birds, 2: nocturnal collision risks. DLO-Instituut voor Bos-en Natuuronderzoek. RIN-rapport 92/3. 4 volumes. (In Dutch with English summary).

Appendices

Appendix 1

Appendix 2

Appendix 3

Appendix 4

Appendix 5

Appendix 6

Appendix 7

Appendix 8

Appendix 9

Appendix 10

Appendix 10a

Appendix 11