Appendix 3:
Ecological Assessment for the Proposed Atlantic Marine Energy Test Site

Ecological Assessment

For

The Proposed Atlantic Marine Energy Test Site

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Executive Summary

Baseline ecological assessments and the consideration of potential impacts of the development of the proposed Atlantic Marine Energy Test Site (AMETS) off Annagh Head, Co. Mayo were conducted throughout 2010 to fulfil the requirement of Appropriate Assessment of designated sites within the Natura 2000 network as required under Article 6(3) and 6(4) of the EU Habitats Directive. As such this report provides an Appropriate Assessment of designated habitats within the development area.

Baseline ecological assessments were also conducted in the wider area of the AMETS to provide the information required for the preparation of a subsequent Environmental Impact Statement.

Ecological assessments included surveys of:

- the use of the site by marine mammals
- the use of the site by birds
- subtidal benthos
- subtidal reefs
- intertidal habitats and species
- terrestrial habitats and species

The proposed site (test areas, cable route, cable land fall and substation location) was selected following on an initial screening assessment of possible environmental constraints within the wider area.

The proposed AMETS is designed to provide a grid-connected national test facility, at which full-scale pre-commercial wave energy converters could be deployed during their final stages of pre-commercial development. The test site is an integral component of Irelands Ocean Energy Strategy and will facilitate testing and validation of various Wave Energy Converters (WEC) in an open ocean environment. The site, located off Annagh Head, Co. Mayo, has one of Europe's best wave climates. In this location WECs can be tested in a full-scale open ocean environment. Their performance can be assessed in terms of their ability to generate electricity over their full envelope of proposed operation. In addition their survivability in such open ocean conditions can be tested. The test site will provide a facility, not only for testing WECs, but also for gaining experience on how to develop wave farms for electricity

generation and how electricity generated from WECs can be integrated and connected to the existing electricity network.

Wave energy production is an emerging technology and as such, data relating to environmental impacts that may arise from its development are limited. This study gathered baseline ecological data on a range of environmental factors (habitats and species) in and around the AMETS and assessed the potential impacts that the proposed development might have on them. The baseline assessment is currently being further developed by on-going surveys at the site to provide a more robust dataset to better inform knowledge of the ecology of the site and any likely impacts of the development of the AMETS on them.

A summary of each of the habitats surveyed and the potential impacts of the AMETS on them is presented below.

Subtidal habitats

Bathymetric and seabed typology data for the AMETS area indicated the majority of the area under consideration was comprised of a mosaic of soft sediments and geogenic reefs (infralittoral and circalittoral). Two separate surveys, one focusing on geogenic reefs and a second focusing on soft sediments were conducted.

Reef surveys conducted by a combination of dropdown video and dive surveys indicated that the most common reef morphotype present consisted of flat and sloping bedrock with numerous crevices and gullies. The biotopes recorded for this morphotype were consistent with deep, exposed circalittoral communities. Smaller areas of cobble were identified along some sections of the cable route; these were all relatively species poor, most likely due to the effect of wave action causing mobility of the cobble and a subsequent lack of encrusting species.

The shallower inshore, infralittoral reefs were characterised by vertical rock walls and pinnacles with numerous crevices, gullies and overhangs. The only biotope recorded in this area was *Laminaria hyperborea* on moderately exposed vertical rock.

A programme of grab sampling of soft sediments conducted at the AMETS indicated that sediment distribution along the proposed cable route and in the proposed test areas was quite consistent, with most stations being classified as infralittoral or circalittoral fine sands. The ecological status of the stations sample was generally High or Good. There was a tendency for lower diversity in shallower water to lead to a lower classification of habitat quality. It is likely that the lower diversity found in the shallower areas is due to greater physical disturbance from wave action rather than any anthropogenic influences.

The effects of buried electrical cable laying on the macrobenthos is poorly known but some studies that describe the environmental impact of submarine HVDC transmission lines have found that one year after the cable had been laid no mechanical disturbances on a dynamic sandy bottom were visible and no significant changes in zoobenthos species composition, abundance or biomass was evident. Given that the proposed site for this development is also a dynamic sandy bottom, this would indicate that a recovery time in the order of one year is likely for this development.

Intertidal habitats

Replicate core samples were taken at a number of stations at Belderra strand, the location of the proposed cable landfall. Analysis of these cores showed extremely low species diversity and biomass. Both factors are likely due to the particularly harsh environment at this site, where even the most robust species were lacking. The only biotope complex recorded in the intertidal area was “Amphipods and Scolelepis spp. in littoral medium-fine sand” which is characteristic of highly mobile exposed sites and is common at many exposed locations on the west coast of Ireland. The only other biotope recorded was the typical strandline biotope complex “Talitrids on the upper shore and strand-line.

It is unlikely that any impact of landing the cable at this exposed sandy beach would be noticeable by the following season.

Marine mammals

Marine mammal surveys were conducted by a combination of monthly land based watches, seasonal line transects through the AMETS, towed hydrophone surveys and analysis of data recorded by CPODS deployed at the site and a number of control stations.

The marine mammal community at the AMETS is described from a combination of visual and acoustic surveys as well as published, unpublished and historic data. There was great consistency between datasets with common and bottlenose dolphins the most frequently reported species, harbor porpoise recorded during the current survey and a range of species recorded regularly but infrequently. These studies and reports show that there is a rich marine mammal community in, and adjacent to, the AMETS.

Cetaceans were recorded throughout the year with common dolphin and harbour porpoise widespread and abundant and bottlenose dolphins abundant during summer and autumn. Some species such as minke whale were only present in the summer. Seven cetacean species, two seal species and two other marine megafauna species were recorded within the site and another three adjacent to it. In addition to the high species diversity and relative abundance, the presence of known individual dolphins as recognised through photo-identification is significant.

Although spatially restricted the site is important for the diversity of species recorded, including the year round presence of common dolphin and harbour porpoise and the regular occurrence of bottlenose dolphins.

Terrestrial habitats

Habitat mapping of the terrestrial area in the vicinity of the cable landfall and substation location were conducted according to Fossitt (2000). Each habitat mapped was surveyed by conducting a detailed walkover of the habitat to record vascular plant species and their abundance together with any evidence of fauna of conservation importance. All survey work was carried out in July 2010. Within the most prominent habitats, likely to be impacted by the cable route or sub-station location, data was gathered from three 1 x 1 m^2 relevés.

Belderra Strand and the surrounding area is an exposed, low lying mosaic of improved agricultural grassland and dry calcareous grassland with smaller areas of marram dune, dune slack and machair. Within all of these habitats the vegetation recorded was typical of the habitat and no rare or threatened species were recorded.

With the exception of Belderra Strand and a small area consisting of a car park behind Belderra Strand and all remaining areas of the site that will encompass the cable land fall, temporary construction area, cable bay and substation location are outside any designated area (SAC, NHA or SPA). However, a number of habitats within the study area (dune Slacks, marram dunes and machair) are listed under Annex I of the EU habitats Directive.

Evidence of mammals of conservation importance was looked for during site surveys. The Irish hare (*Lepus timidus hibernicus*) was recorded at the site but no evidence of other EU Habitats Directive Annex II species was noted.

Avifauna

Birds were surveyed by a combination of monthly land based watches from vantage points and monthly offshore seabirds at sea surveys using the European Seabird at Sea (ESAS) standard method. Terrestrial habitats at Belderra Strand, Emlybeg and Annagh Beach were surveyed using line transect methods. A one-day Winter survey was conducted in February 2010 and a breeding bird survey was conducted in Spring and summer 2009. Breeding Storm Petrels on Inishglora Island were surveyed by targeting suitable nesting habitat on Inishglora Island using the standard tape playback method to establish monitoring plots for future survey.

Important species and species groups that use the shore habitats of the Bay are wintering waders, Common Sandpiper and Ringed Plover. Use of shore habitats by flocks of roosting Gulls and by waders during the summer months is also of note. Coverage of shore habitats and their use by birds was considered good. Counts of birds at Belderra Strand were consistently low. This may be due in part to disturbance, which was regularly recorded at this site.

The inner Bay is used year round by a range of birds, including wintering waterfowl, and foraging seabirds. The shallow waters of the inner Bay support a greater abundance and diversity of birds. Of note is the use of the Bay by the Annex I species Great Northern Diver and the occurrence of Eider Duck, which are part of a recently established, local breeding population. Long tailed Duck regularly occur in nationally important numbers within the Bay. Large rafts of Manx Shearwater were also recorded in the bay. The Annex I species, Arctic, Little and Sandwich Tern were recorded foraging in the Bay during the breeding season. Gulls, Shag and Auks species also used the Bay and breed locally.

Winter and summer surveys of terrestrial habitats found that they were used by a range of species typical of coastal dune and grassland habitats, none of which appear on the RED List of Birds Of Conservation Concern were recorded. The presence of breeding waders, Ringed Plover and Common Sandpiper was of note.

The results of the seabird at sea survey which covers the period of Spring migration, the breeding season, and the start of autumn migration indicated that species that breed at nearby colonies were present during the breeding season, such as Auks, Terns, Gulls, Fulmar and Storm Petrel. Passage migrants were present during the autumn, such as Great Skua and Great and Sooty Shearwater. There are no nearby breeding sites for Gannet and Manx Shearwater, however the study site lies within the foraging range of Irish and Scottish breeding colonies of these species. Large rafts of Manx Shearwater are of note, and may be linked to the late arrival of non-breeding birds in Irish waters. While the occurrence of many species can be linked to the breeding season, both breeding and immature non-breeding birds are likely to have been present in the survey area. Fledged young and adults birds were also present

Species and species groups of particular interest within the survey area are those that may be breeding in nearby SPA's, i.e. Gulls, Auks, Terns and Storm Petrel, and those that were common and/or occurring in high densities within the site, i.e. Gannet, Manx Shearwater and Great Shearwater.

Conservation objectives

Introduction

Prior to the collection of the baseline ecological information from the AMETS presented in this report, very little ecological information on the site was available. The vast majority of the site is outside any current designations and therefore the detailed ecological data required to set conservation objectives was not available. However, a number of Annex I habitats and Annex

II species under the EU Habitats Directive and both species listed in Article (4) 1 and 2 of the Birds Directive together with species considered to be of national conservation importance (Amber or Red listed bird species) do occur within the site. Without more detailed baseline assessments of these habitats and particularly of the species, it is difficult to assess their conservation status and to set defined conservation objectives to ensure that they remain at Favorable Conservation Status (FCS).

It is intended that further surveys of the site to add to the already existing baseline dataset will provide the information required to set conservation objectives. The required measurements to allow conservation status to be assessed and measured will result from the data gathered through continued survey of the site pre-construction.

In the interim the project team has devised a set of broad conservation objectives based on the data obtained from the first year of survey and intended as the minimum baseline for the site with the intention of refining these objectives as more detailed information on the site is gathered in the future. As part of the programme of monitoring for the site reference values and targets for future monitoring will be developed to allow FCS to be measured and thus provide a mechanism to ensure the conservation status of the site is maintained into the future. It is hoped such a process will help to provide guidance for the development of future wave energy test sites in temperate waters.

The Habitats Directive aims to achieve and maintain FCS for all habitats listed on Annex I, and all species listed on Annex II of the Directive. It also aims to contribute towards maintaining biodiversity of natural habitats and of wild flora and fauna in the European territory of the Member States. In this respect the Habitats Directive affords protection to habitats and species within designated areas (known as Natura 2000 sites).

More recently the European Communities (Environmental Liability Regulations) 2008, attempts to extend this protection to all Annex I habitats and Annex II species, regardless of whether or not they are within Natura 2000 sites. This Directive provides for any damage or imminent threat of damage where an operator of an occupational activity acts or fails to act where he or she knows or ought to have known that his or her act or failure to act causes or would cause damage or imminent threat of damage to protected habitats or species, i.e. the species listed in Article (4) 1 and 2 of the Birds Directive and Annex I, II and IV of the Habitats Directive.

FCS of a habitat is defined in Article 1(e) of the Habitats Directive as when:

1. Its natural range and areas it covers within that range are stable or increasing, and

2. The specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future, and

3. The conservation status of its typical species is favourable as defined in Article 1(i).

FCS for a species is defined in Article 1(i) of the Habitats Directive when:

1. Population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats, and

2. The natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future, and

3. There is, and will probably continue to be, a sufficiently large habitat to maintain its population on a long-term basis.

It is important to note that the assessment of conservation status not only includes the elements of ‘diagnosis’ based on current condition, which can be calculated from the points listed above for the assessment of FCS for habitats and species, but that there is also an important element of ‘prognosis’ (foreseeable future) based on known threats. Such foreseeable future influences could be specific or general threats, positive or negative middle to long-term impacts, e.g. by trends in certain policies, *etc.* The prognosis element forms an integral part of the assessment result.

The notes and guidelines for reporting under Article 17 (European Commission, 2006) state that three classes of conservation Status are to be used: ‘Good’ (green) where a species or habitat is at Favourable Conservation Status as defined in the Directive and the habitat or species can be expected to prosper without any change to existing management or policies. Two classes of ‘Unfavourable’ are used: one ‘unfavourable-Bad’ (red) where the situation is very poor and the second ‘Unfavourable-inadequate’ (amber) for situations where a change in management or policy is required but the danger of extinction is not so high.

Each of the above four classes (range, area/population, structure and function/suitable habitat and future prospects) are defined in the Habitats Committee document in the form of evaluation matrices. Combining the result for the 4 parameters makes the overall assessment. The method is described in more detail in a guidance note prepared by the European Topic Centre for Biodiversity (ETC/BD). The ETC/BD is an international consortium working with the European Environment Agency to assist the European Environment Agency in its task of reporting on Europe's environment by addressing state and trends of biodiversity in Europe among other tasks.

In practice defining FCS is complex. The Commission, working with the European Topic Centre and selected Member States have participated in workshops to provide further clarity. This has resulted in a Commission paper approved by the EC Habitats Committee in March 2005 entitled ‘Assessment, monitoring and reporting of conservation status - preparing the 2001-2007 report under Article 17 of the Habitats Directive’ (European Commission, 2006).

In an attempt to further clarify methods for assessing FCS the document states:

"In addition to the information on trends, the assessment of conservation status will need to be done in relationship to favourable reference values which should be defined for each species and habitat type depending on its specific situation. Favourable reference values, e.g. for range, area covered, population size, should be established on technical basis based on the best available conservation knowledge in a transparent way. 'Best expert judgement' may be used to define it in absence of other data. Establishing favourable reference values must be distinguished from establishing concrete targets: setting targets would mean the translation of such reference values into operational, practical and feasible short-, middle- & long-term targets/milestones. This obviously would not only involve technical questions but be related to resources and other factors".

Many recent projects funded by the NPWS have examined the issue of (a) Assessing the conservation status and (b) defining favourable conservation Status for selected habitats and/or species by setting reference values against which targets can be set to allow favourable conservation status to be assessed and monitored. The setting of reference values for targets against scientifically derived reference values involved extensive field studies to obtain baseline information on the habitats and species concerned. Unfortunately this slow and detailed process will take many years to complete for all Annex I habitats and Annex II species. The process has however provided much of the baseline information currently required to address the issue of assessing conservation status and allowing conservation objectives to be set.

Preliminary Conservation objectives for habitats and species at the AMETS

Reefs (Annex I habitat: EU Habitat Code 1170)

- Prevent a loss in surface area of subtidal reef within the site of no more than 5% loss in total.

- Ensure individual operations or activities, in combination with other operations or activities, does not cause a change in the integrity of the principal community types.

- To maintain the structure, function and biodiversity of subtidal reefs within the site.

Bottlenose Dolphin, Harbour Porpoise, Common seal and Grey seal (Annex II species)

- Maintain the population structure of this species such that reproduction, mortality and age structure are not deviating from normal and that the population does not decrease to a level below the favourable reference population.

- Ensure that the habitat remains of suitable quality to support the long-term survival of this species.
- Ensure individual operations or activities, in combination with other operations or activities, do not cause a change in range, distribution or population structure which would result in unfavourable conditions for the future conservation interests of this species.

Humpback whale, Killer whale, Minke whale, Rissos' dolphin, Common dolphin, Striped dolphin and white sided dolphin (Annex IV species).

- Maintain the population structure of this species such that reproduction, mortality and age structure are not deviating from normal and that the population does not decrease to a level below the favourable reference population.
- Ensure that the habitat remains of suitable quality to support the long-term survival of this species.
- Ensure individual operations or activities, in combination with other operations or activities, do not cause a change in range, distribution or population structure which would result in unfavourable conditions for the future conservation interests of this species.

Red throated Diver, Great Northern Diver, Storm Petrel, Barnacle Goose, Little tern, Arctic tern, Common tern, Sandwich tern (Annex I of the Birds Directive).

- Maintain the population structure of this species such that reproduction, mortality and age structure are not deviating from normal and that the population does not decrease to a level below the favourable reference population.
- Ensure that the habitat remains of suitable quality to support the long-term survival of this species.
- Ensure individual operations or activities, in combination with other operations or activities, do not cause a change in range, distribution or population structure which would result in unfavourable conditions for the future conservation interests of this species.

Birds of international and/or national conservation importance (wintering Brent Goose, Long tailed Duck, Ringed Plover, Sanderling, Dunlin, Curlew).

- Maintain the population structure of this species such that reproduction, mortality and age structure are not deviating from normal and that the population does not decrease to a level below the favourable reference population.

- Ensure that the habitat remains of suitable quality to support the long-term survival of this species.

- Ensure individual operations or activities, in combination with other operations or activities, do not cause a change in range, distribution or population structure which would result in unfavourable conditions for the future conservation interests of this species

Red and Amber listed species (Manx Shearwater, Sooty Shearwater, Gannet, Shag, Brent Goose, Eider, Oystercatcher, Ringed Plover, Redshank, Greenshank, Common Sandpiper, Great Skua, Black-headed Gull, Common Gull, Herring Gull, Lesser Black-backed Gull, Great Black-backed Gull, Kittiwake, Puffin, Black Guillemot, Guillemot, Razorbill, Skylark, Sand Martin).

- Maintain the population structure of this species such that reproduction, mortality and age structure are not deviating from normal and that the population does not decrease to a level below the favourable reference population.

- Ensure that the habitat remains of suitable quality to support the long-term survival of this species.

- Ensure individual operations or activities, in combination with other operations or activities, do not cause a change in range, distribution or population structure which would result in unfavourable conditions for the future conservation interests of this species

1. MARINE FLORA AND FAUNA - SUBTIDAL HABITATS

1.1 INTRODUCTION

Data provided on the bathymetry and seabed typology present within the proposed area of the Atlantic Marine Energy Test Site for the environmental scoping report, together with an examination of the admiralty Marine charts allowed an overview to be made of the subtidal habitats likely to be present in the area. This assessment indicated that the majority of the area under consideration was comprised of a mosaic of soft sediments (sands of varying grain size) and geogenic reefs (infralittoral and circalittoral).

Soft sediments were examined under a programme of benthic grab sampling detailed under Section 3 of this report while reef habitats are considered in this section of the report.

Geogenic reefs are a widespread but important feature of conservation interest in Ireland and are included under the Annex I habitat "Reefs (Habitat code 1170)" of the EU Habitats Directive. (European Commission, 1992). They may be composed of bedrock, boulders or cobble and form a variety of subtidal topographic features such as hydrothermal vent habitats, sea mounts, vertical rock walls, horizontal ledges, overhangs, pinnacles, gullies, ridges, sloping or flat bed rock, broken rock and boulder and cobble fields.

Reef habitats are of conservation importance for a number of reasons. In temperate areas, infralittoral reefs generally support kelp communities and these form an important habitat for a wide variety of species of other plants and animals. Such habitats are one of the most biologically diverse habitats on the planet (Birkett *et al* 1998). They are also extremely productive habitats, exporting biomass to the wider marine environment.

Circalittoral reef communities are less productive than the shallower kelp dominated infralittoral communities. However, they still support diverse assemblages of encrusting and erect species. Knowledge of these biotopes is poor due to the depths in which they occur and the resultant technical difficulties associated with their survey (Hartnoll, 1999).

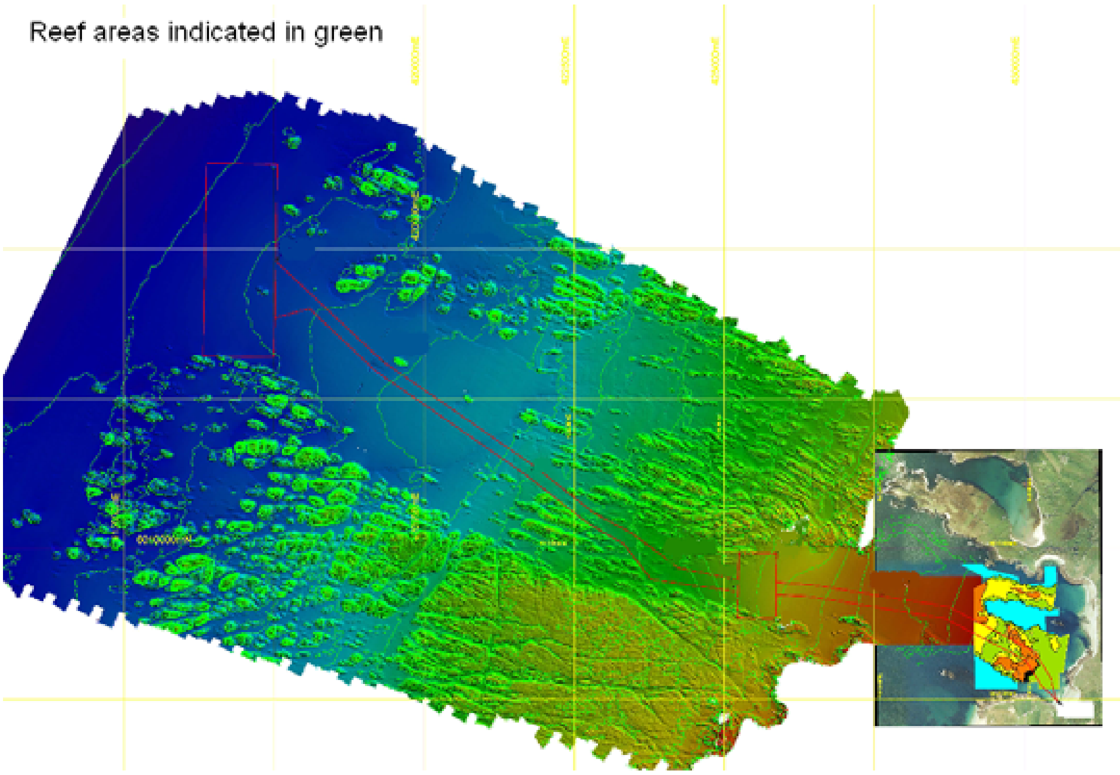
Due to the importance of reefs as a habitat of conservation interest, a detailed survey of the reef habitats within the area of the Atlantic Marine Energy Test Site was conducted during summer 2010. Techniques included the use of a scientific dive team to examine the shallower infralittoral areas of the site and remote drop down video imagery to record deep circalittoral biotope communities.

1.2 METHODOLOGY

1.2.1 Preliminary survey of subtidal habitats

Seabed bathymetry was mapped principally by the Marine Institute (R.V. Celtic Voyager) in 2008 with supplementary shallow water surveys conducted by IMAR Survey in September - October 2009. Geotechnical investigation (vibrocoring) was undertaken by the Marine Institute and Coastline Limited. Seabed topographical data was collected during geophysical studies of the area. Post-processing of acoustic data provided a series of georeferenced images showing bottom type (sedimentary/bedrock/reef), bathymetry (1 m isobath resolution) and pinnacle heights (Figure 1.1). This information allowed an overview of the subtidal habitats present within the wider survey areas, including near-shore subtidal areas to the west of Annagh Bay, as far as Annagh Head in the north and Cross Point in the south. Within these areas, the data provided also indicated the location and height (metres above the seabed) of the most prominent rock pinnacles. This facilitated interpretation of the three dimensional structure of subtidal habitats within the areas surveyed.

Figure 1.1. Bathymetric map of the survey area showing the distribution of prominent reefs in green. (Marine Institute and IMAR Survey).



In general terms, the near-shore limit of survey coverage within Annagh Bay as well as the area between Belderra Strand and Cross Point corresponds with a water depth of between 5 and 8 m (OD) as shown by isobaths from the survey data. The near-shore survey limit of the area west of Annagh Beach as far as Annagh Head corresponds with a depth range between 16 m and 22 m.

Examination of the relief imagery from the 2009 Celtic Voyager survey of the cable route corridor and berth areas indicated obvious areas of reef habitat. The total area of these reef habitats within the cable route corridor and berth areas was estimated using GIS software. A seabed classification raster supplied by ESBI that categorised the seabed into sand, gravely sand, glacial till and rock outcrop was also used to assist in the process of identifying reef habitat.

As this site is of an exposed nature, with sand of vary thicknesses lying over bedrock, the amount of exposed reef habitat could vary annually or even seasonally. In addition, areas of flat bedrock may not be visible on the multibeam relief imagery. The use of the seabed classification raster assisted in highlighting areas of bedrock that were not visible from the multibeam. Flat cobble field areas not shown on the multibeam may be under represented in this approach, as there is no size classification in the generic term “glacial till” and it has not been determined if these areas are gravels, cobbles or boulders. Based on analysis of this data and taking into account the assumptions made relating to the possible under representation of reef habitat Table 1.1 shows the area of reef habitat within the cable route corridor and berth areas.

Table 1.1 Estimated area of reef identified within the cable route corridor and berth areas.

Area	Area (km^2)	Reef Habitat extent (km^2)	Reef habitat extent (percent)
Cable route to inner berth.	1.02	0.000	0.000
Inner berth.	1.50	0.389	25.964
Cable route from inner berth to outer berth.	2.22	0.113	5.096
Outer berth.	3.64	0.017	0.468
Total	8.37	0.519	6.199

As this data indicated the location and extent of subtidal reef within a large proportion of the survey area it was subsequently used as the target for more detailed studies of the ecology of the reef habitats present. In areas not surveyed by remote methods, e.g. multibeam, concentrated surveys by drop down video and/or diver surveys were conducted to complete any gaps in coverage.

1.1.2.2 Dropdown video survey

The test site encompassing the two test areas, the cable route and a buffer zone either side of the cable route at the Atlantic Marine Energy Test Site were surveyed by drop down video during July 2010. The average spacing of dropdown video stations along the cable route between the lower shore and the inshore Area was 780 m and 1,500 m in the outer cable route section. A number of additional drops were made in both the inshore and offshore test areas to capture seabed imagery within these areas.

More detailed surveys of the inner bay area were conducted by continuous line transects across the width of the bay. The inner bay transects were conducted by allowing the video camera to fly slightly above the seabed so that a continuous image across the entire width of the bay could be captured. The locations of each individual video station are presented in Table 1.2 and Figures 1.2 - 1.4.

All video imagery was recorded using an Inspecam® Z underwater drop down camera system based on a 3CCD Sony DRV 950 digital video camera in a Gates Aluminium housing rated to 130 m. A 150 m multi-core umbilical allowed the system (camera and lights) to be controlled from the surface. The digital video footage was relayed to the surface via the umbilical and viewed live and recorded on a Sony mini digital VCR (GV-D1000E). The video recorder is housed in a custom built viewing box that provides the remote control facilities over the camera, lights and the surface video recorder. The system has a GPS and text overlay facility allowing the position and station location to be overlaid on each video clip. However, as the GPS signal received by the camera unit is not differential a THALES mobile mapper® with differential GPS capability was used to record each drop location.

Table 1.2 Positions of all drop down video stations

Station Number	Latitude (Decimal degrees)	Longitude (Decimal degrees)	Station Number	Latitude (Decimal degrees)	Longitude (Decimal degrees)
1	54.225237	10.103000	24.22	54.218763	10.080590
2	54.228458	10.103000	24.23	54.217938	10.081138
3	54.220442	10.103033	24.24	54.217230	10.081203
4	54.219547	10.089672	24.25	54.216830	10.081362
5	54.222478	10.089195	24.26	54.216010	10.081653
6	54.226138	10.088472	24.27	54.215602	10.081862
7	54.223643	10.077533	24.28	54.215155	10.081855
8	54.219225	10.078743	24.29	54.214668	10.081647

Station Number	Latitude (Decimal degrees)	Longitude (Decimal degrees)	Station Number	Latitude (Decimal degrees)	Longitude (Decimal degrees)
9	54.215550	10.080133	24.30	54.214467	10.081327
10	54.230236	10.118778	24.31	54.214052	10.081232
11	54.225568	10.117666	24.31	54.213872	10.081203
12	54.222678	10.118333	24.33	54.213678	10.081037
13	54.223988	10.129778	24.34	54.213587	10.081060
14	54.226875	10.128444	24.35	54.213282	10.081372
15	54.230837	10.127610	24.36	54.212960	10.081648
16	54.232009	10.138640	24.37	54.212637	10.081945
17	54.231882	10.142222	24.38	54.212385	10.081778
18	54.237833	10.143000	24.39	54.211610	10.081498
19	54.232765	10.146521	24.40	54.211547	10.081462
20	54.227220	10.147000	25.1	54.228170	10.070418
21	54.227003	10.142000	25.2	54.227780	10.070195
22	54.227235	10.137000	25.3	54.227648	10.070240
23	54.230032	10.081788	25.4	54.226845	10.070103
24.1	54.229167	10.081638	25.5	54.226458	10.070257
24.2	54.228855	10.081408	25.6	54.225827	10.070453
24.3	54.228772	10.081340	25.7	54.225290	10.070578
24.4	54.228517	10.081090	25.8	54.224968	10.070657
24.5	54.228227	10.081007	25.9	54.224398	10.070795
24.6	54.227397	10.080448	25.10	54.223860	10.071002
24.7	54.226185	10.080095	25.11	54.223297	10.071227
24.8	54.225647	10.080083	25.12	54.222795	10.071322
24.9	54.224443	10.079307	25.13	54.222418	10.071407
24.10	54.224192	10.079165	25.14	54.222005	10.071572
24.11	54.223813	10.079250	25.15	54.221638	10.071322
24.12	54.223447	10.079323	25.16	54.220365	10.070437

Station Number	Latitude (Decimal degrees)	Longitude (Decimal degrees)	Station Number	Latitude (Decimal degrees)	Longitude (Decimal degrees)
24.13	54.223245	10.079327	25.17	54.219633	10.069952
24.14	54.222870	10.079693	25.18	54.219175	10.069668
24.15	54.222795	10.079780	25.19	54.218647	10.069448
24.16	54.222570	10.080025	27	54.263958	10.277778
24.17	54.222115	10.080268	28	54.270700	10.274115
24.18	54.221720	10.080338	28	54.270910	10.274275
25.20	54.218025	10.069298	28	54.270725	10.273663
25.21	54.217465	10.069173	28	54.270430	10.273281
25.22	54.216708	10.068868	29	54.279987	10.270788
25.23	54.215877	10.068640	29	54.280190	10.270850
25.24	54.215105	10.069107	29	54.280390	10.270713
25.25	54.214707	10.069340	29	54.280587	10.270543
25.26	54.214223	10.069753	29	54.281135	10.270250
25.27	54.213808	10.070313	29	54.281218	10.270145
25.28	54.213525	10.070710	29	54.281352	10.270055
25.29	54.213150	10.070710	29	54.281443	10.270030
25.30	54.212827	10.070590	29	54.281488	10.269987
25.31	54.212635	10.070550	30	54.284885	10.281888
25.32	54.212502	10.070533	30	54.285143	10.281777
25.33	54.212302	10.070505	30	54.285385	10.281533
25.34	54.211913	10.070465	30	54.285765	10.281092
25.35	54.211870	10.070462	30	54.285875	10.280963
26.1	54.216552	10.062463	30	54.286088	10.280795
26.2	54.216278	10.062557	30	54.286287	10.280683
26.3	54.215323	10.063560	31	54.272940	10.254210
26.4	54.214967	10.063728	32	54.264997	10.251343
26.5	54.214617	10.063772	33	54.260900	10.250490
26.6	54.213975	10.063863	33	54.260947	10.250628

Station Number	Latitude (Decimal degrees)	Longitude (Decimal degrees)	Station Number	Latitude (Decimal degrees)	Longitude (Decimal degrees)
26.7	54.213760	10.063917	34	54.253120	10.231203
26.8	54.213452	10.063922	34	54.253043	10.231368
26.9	54.212933	10.064190	35	54.255538	10.229902
26.10	54.212488	10.064528	36	54.259122	10.226820
26.11	54.211970	10.064870	36	54.259137	10.227047
26.12	54.211667	10.065320	37	54.249953	10.209697
26.13	54.211420	10.065805	38	54.249387	10.213815
26.14	54.211178	10.066208	39	54.247135	10.216295
26.15	54.210950	10.066697	40	54.244883	10.195212
26.16	54.210808	10.067192	41	54.242657	10.196597
26.17	54.210747	10.067572	42	54.239593	10.198510
27	54.262100	10.278465	43	54.235472	10.180632
27	54.262313	10.278482	43	54.235927	10.180002
27	54.262440	10.278420	44	54.237725	10.179847
27	54.262518	10.278445	44	54.238075	10.179365
27	54.262618	10.278447	45	54.233178	10.182437
27	54.262755	10.278378	46	54.228263	10.160547
27	54.262967	10.278338	47	54.225548	10.160235
27	54.263192	10.278130	48	54.231697	10.159653
27	54.263193	10.278127	49	54.232172	10.142107
27	54.263422	10.278067	50	54.223330	10.146710
27	54.263807	10.277868	51	54.224015	10.140518
24.19	54.221017	10.080357	52	54.222717	10.142208
24.20	54.220217	10.080470	53	54.219648	10.140540
24.21	54.219958	10.080493	54	54.223358	10.137510

Figure 1.2. Location of all drop down video stations

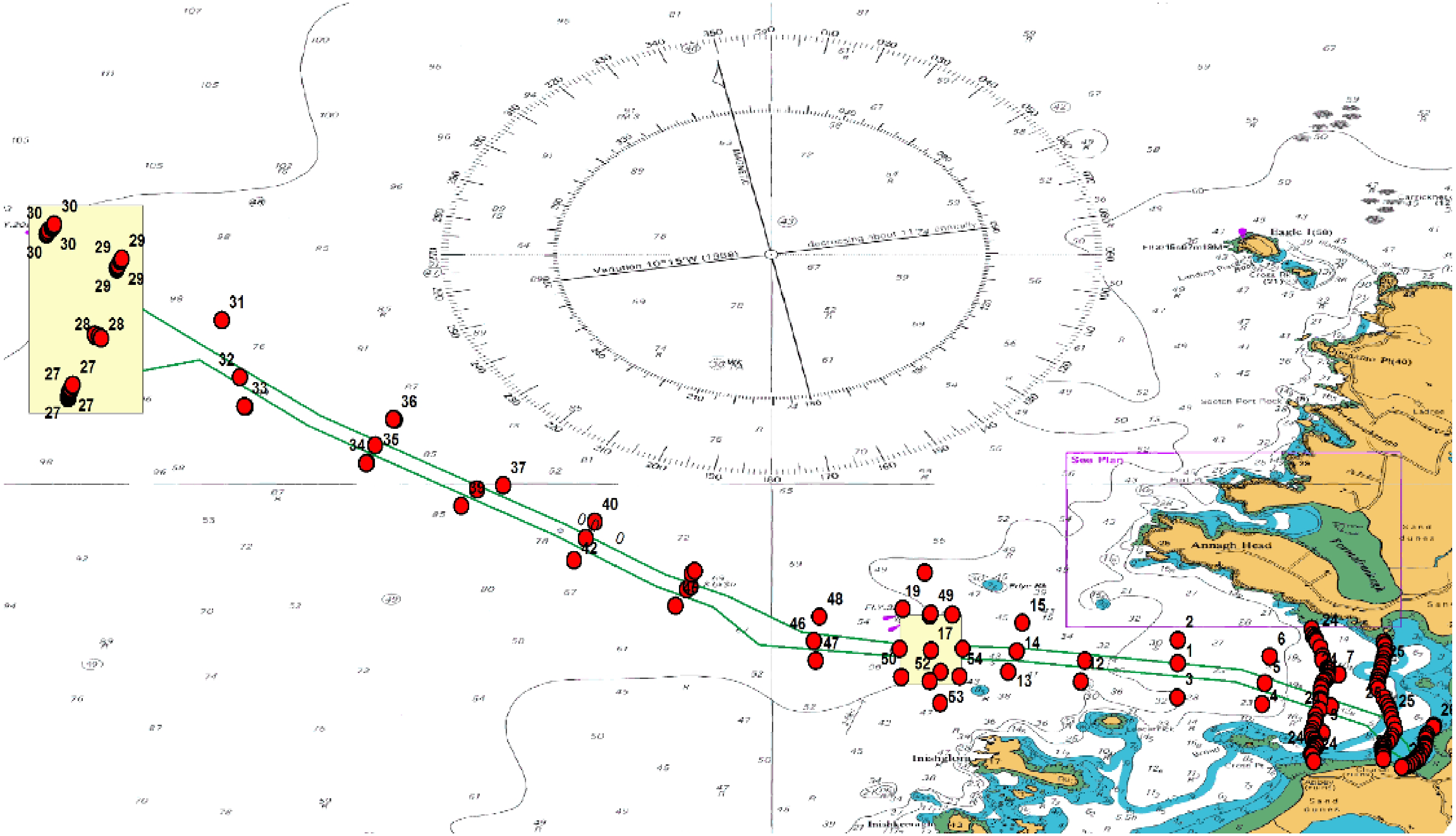


Figure 1.3. Locations of drop down video stations at the offshore area and outer cable route section.

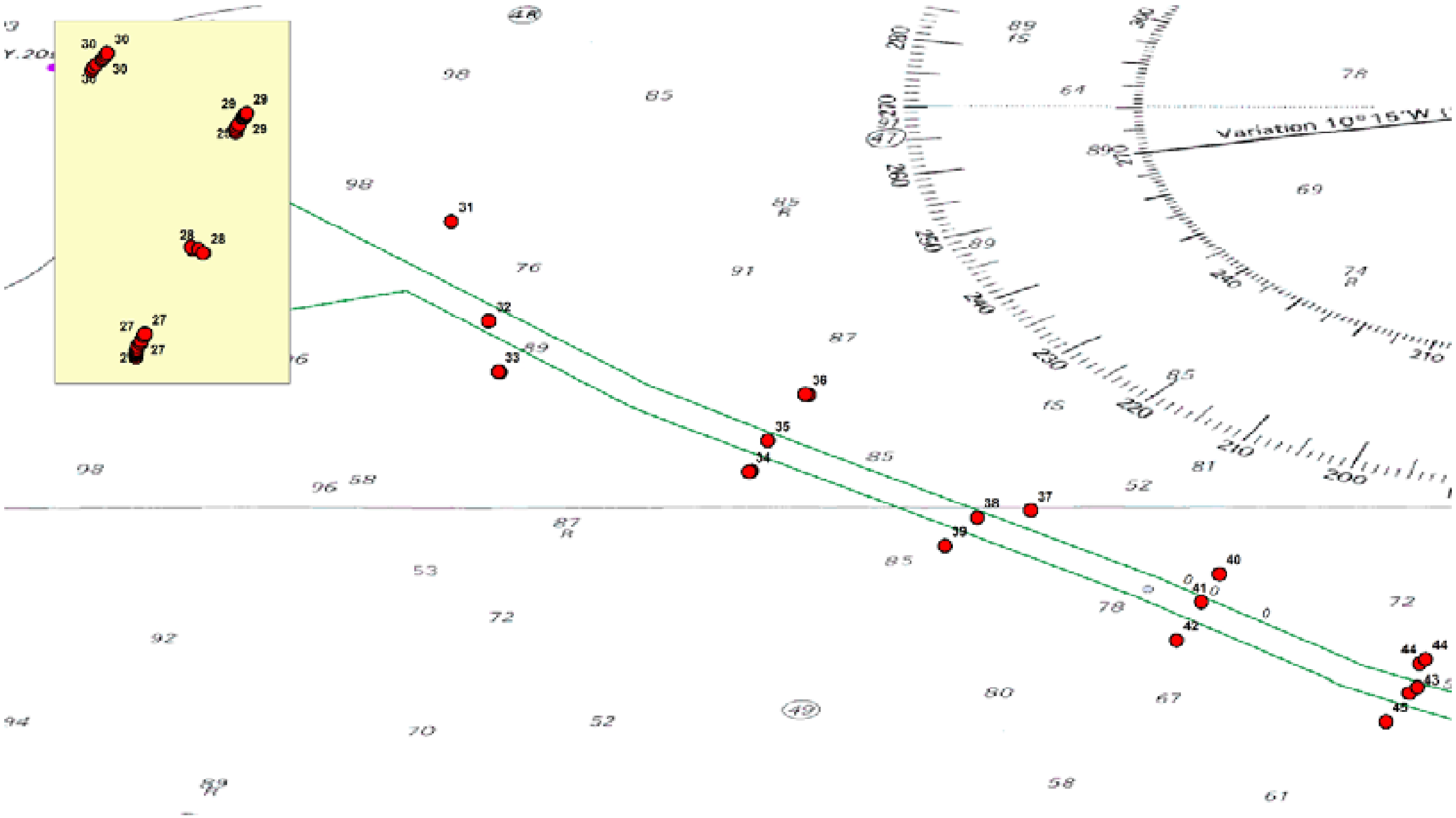
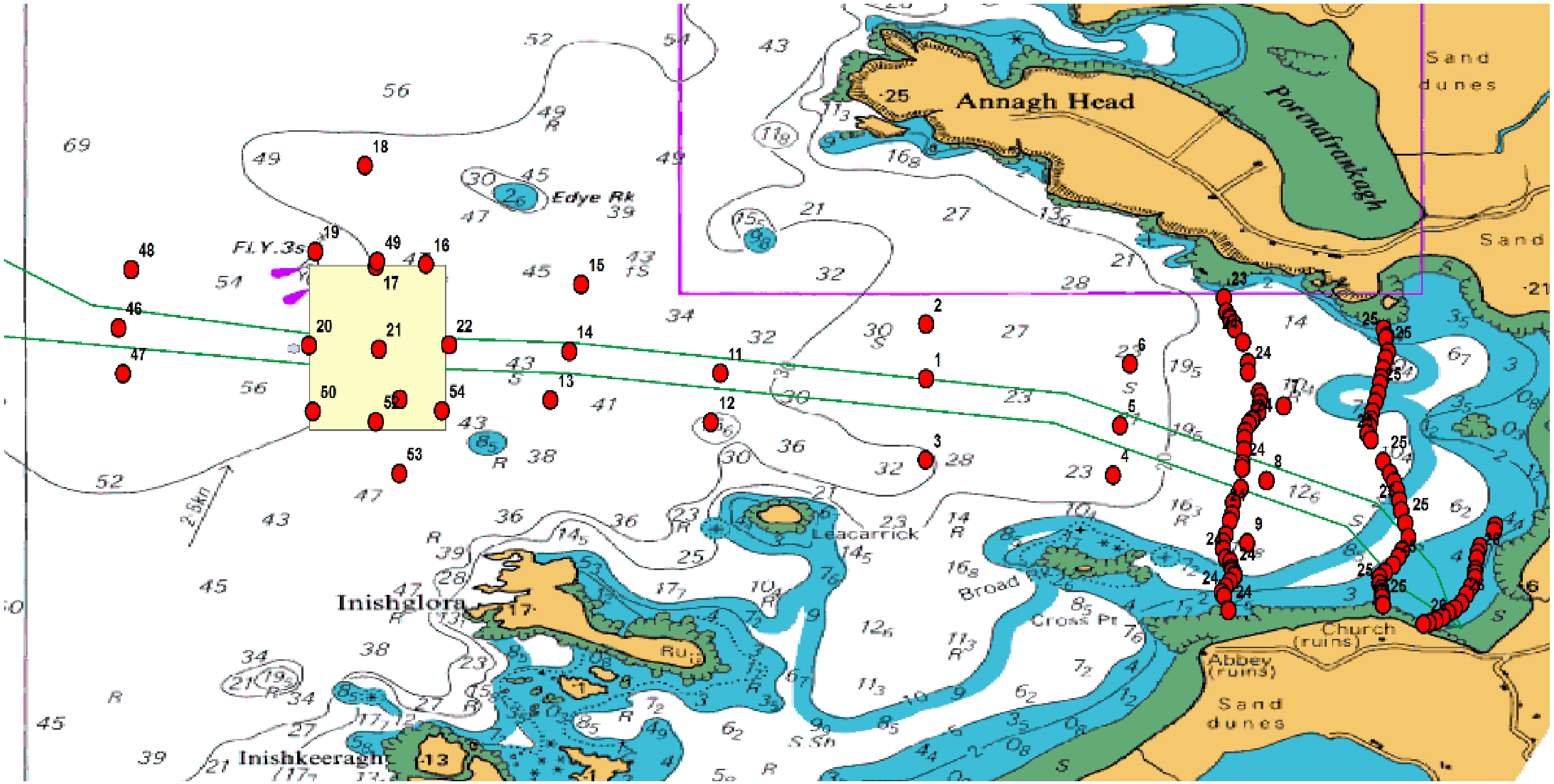


Figure 1.4. Location of drop down video stations at the inner area, inner cable route section and inner bay area.



Data analysis of drop down video surveys

All video footage was post processed to assess the habitats and biotopes present at each camera drop location according to the Marine Habitat Classification for Britain and Ireland Connor *et al* (2004). All species observed were recorded and an estimation of their abundance on a DAFOR (Dominant, Abundant, Frequent, Occasional, Rare) scale was assigned.

1.1.3 Diving survey

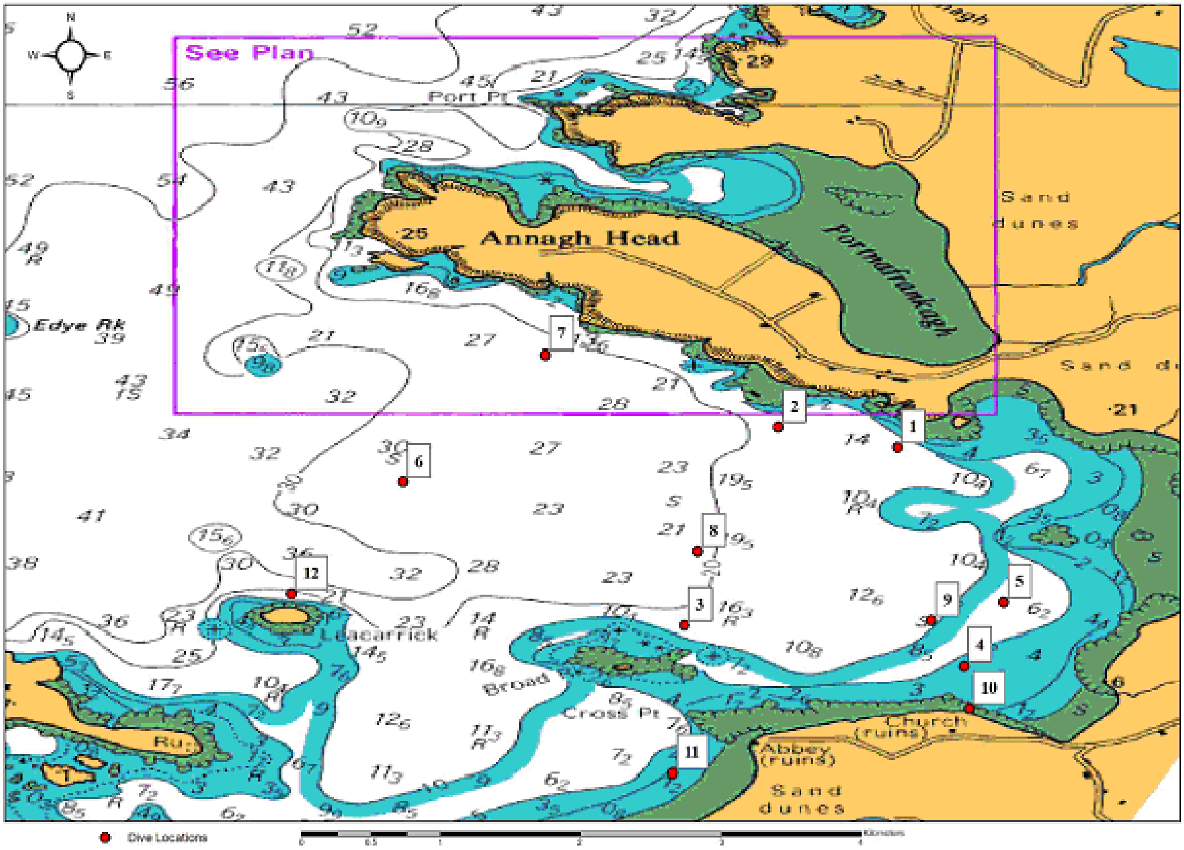
The limitations of drop down video for biotope identification are widely known (Davies *et al,* 2001). For example, certain species such as encrusting sponges, bryozoans and hydroids are very difficult to identify from video footage and this can lead to the misidentification of species and biotopes. As scuba diving to fully ground truth habitats is precluded in water depths of greater than 40 m, ground truthing of the offshore area of the site was not possible. However, a scientific dive team extensively surveyed the inshore area of the site during July and October 2010. Dive surveys were conducted using standard MNCR phase 2 survey techniques (Davis *et al* 2002) for the *In situ* survey of subtidal (epibiota) biotopes and species. The locations of all dive sites are shown in Figure 1.5. Dive stations were selected to represent the range of reef habitats present based on exposure, depth and reef morphotype. Two additional stations (Station numbers 4, west of Belderra Strand and 11, south of Cross Point) were included in the dive survey to examine the seabed in an area where long tailed duck were recorded to determine if any particular seabed feature or species may be present to account for the reason that long tailed duck appear to be faithful to this area.

Diver video and diver stills imagery of the habitats and species were recorded in situ on every dive to assist with future monitoring of the site.

Data analysis of dive surveys

Data from dive surveys was analysed according to the Marine Habitat Classification for Britain and Ireland (version 04.05) Connor *et al* (2004). All species observed were recorded and an estimation of their abundance on a DAFOR (Dominant, Abundant, Frequent, Occasional, Rare) scale was assigned. Biotopes were subsequently assigned to each site surveyed.

Figure 1.5. Location of all dive stations



1.3 RESULTS

1.3.1 Drop down video survey

Table 1.3 shows the reef morphotype, depth, biotope code and biotope description for each of the drop down video locations. The results of the survey in the off shore areas of the site indicated that the most common reef morphotype consisted of bedrock with ridges, gullies and crevices with additional areas of cobble field. The most common biotope recorded was “echinoderms and crustose communities” wi,th some areas more consistent with the biotope “mixed faunal turf communities”. In general species biomass was low in these areas, but species diversity was moderate. A number of these areas appeared to have an extensive cover of encrusting sponges and bryozoans, which are not possible to identify from video imagery, but indicate the likelihood of diverse sponge and bryozoan communities in the circalittoral reef habitats. While many of the reefs surveyed in this area are extremely deep (70-108 m bcd) they were still characteristic of high-energy sites indicating that the extreme exposure of the site is having an effect on the circalittoral reef area. The species recorded from the deep circalittoral zone (Table 1.4) are all characteristic of deep, high-energy sites. No rare species or species of conservation importance were recorded, although it should be noted that the identification of some encrusting sponges and bryozoans is not possible from video imagery. A brief description of the habitat at each drop down video location is provided in Table 1.5.

Both drop down video and diver surveys were conducted to examine the shallower infralittoral reefs of the inshore area. The results of the drop down video survey (Tables 1.3 & 1.4) were similar to those of the dive surveys, the dive survey adding additional information to the species list and confirming the biotope ascribed to each survey. Drop down video analysis of the infralittoral reef areas indicated that the most common reef morphotype was Irregular bedrock with crevices, gullies and some vertical faces. The most common biotope was consistent with "*Laminaria hyperborea* and red seaweeds on exposed vertical rock". This biotope, which is common on reefs on the west coast of Ireland, is typical of exposed to moderately exposed areas of tide and current. No rare species or species of conservation importance were recorded.

Table 1.3. Biotope descriptions derived from drop down video analysis.

Station No.	**Depth**	**Sediment type/rock morophotype**	**Biotope Code**	Biotope description
1	33	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
2	33	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
3	34	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
4	25	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
5	26	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
6	26	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
7	14	Irregular bedrock with crevices, gullies and some vertical faces	IR.HIR.KFaR.LhypRVt	*Laminaria hyperborea* and red seaweeds on exposed vertical rock
8	18	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
9	17	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
10	37	Rippled sand	SS.SSA.OSa	Offshore circalittoral sand
11	40	Rippled sand	SS.SSA.OSa	Offshore circalittoral sand
12	20	Irregular bedrock with crevices, gullies, vertical faces and overhangs	CR.HCR.XFa	Mixed faunal turf communities
13	43	Rippled sand	SS.SSA.OSa	Offshore circalittoral sand
14	42	Rippled sand	SS.SSA.OSa	Offshore circalittoral sand
15	43	Rippled sand	SS.SSA.OSa	Offshore circalittoral sand
16	47	Rippled sand	SS.SSA.OSa	Offshore circalittoral sand
17	52	Ridged bedrock with crevices and sand filled	CR.MCR.EcCr	Echinoderms and crustose communities

Station No.	Depth	Sediment type/rock morophotype	Biotope Code	Biotope description
		gullies		
18	60	Ridged bedrock with crevices and sand filled gullies	CR.MCR.EcCr	Echinoderms and crustose communities
19	51	Ridged bedrock with crevices and sand filled gullies	CR.MCR.EcCr	Echinoderms and crustose communities
20	56	Rippled sand	SS.SSA.OSa	Offshore circalittoral sand
21	54	Rippled sand	SS.SSA.OSa	Offshore circalittoral sand
22	49	Rippled sand	SS.SSA.OSa	Offshore circalittoral sand
23	15	Irregular bedrock with crevices, gullies and some vertical faces	IR.HIR.KFaR.LhypRVt	*Laminaria hyperborea* and red seaweeds on exposed vertical rock
24.1	14	Irregular bedrock with crevices, gullies and some vertical faces	IR.HIR.KFaR.LhypRVt	*Laminaria hyperborea* and red seaweeds on exposed vertical rock
24.2	14	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
24.3	12	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
24.4	12	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
24.5	11	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
24.6	12	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
24.7	12	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
24.8	9	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
24.9	7	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
24.10	6	Irregular bedrock with crevices, gullies and some vertical faces	IR.HIR.KFaR.LhypRVt	*Laminaria hyperborea* and red seaweeds on exposed vertical rock

Station No.	**Depth**	**Sediment type/rock morophotype**	**Biotope Code**	Biotope description
24.11	14.2	Irregular bedrock with crevices, gullies and some vertical faces	IR.HIR.KFaR.LhypRVt	*Laminaria hyperborea* and red seaweeds on exposed vertical rock
24.12	14.5	Irregular bedrock with crevices, gullies and some vertical faces	IR.HIR.KFaR.LhypRVt	*Laminaria hyperborea* and red seaweeds on exposed vertical rock
24.13	15	Irregular bedrock with crevices, gullies and some vertical faces	IR.HIR.KFaR.LhypRVt	*Laminaria hyperborea* and red seaweeds on exposed vertical rock
24.14	17	Irregular bedrock with crevices, gullies and some vertical faces	IR.HIR.KFaR.LhypRVt	*Laminaria hyperborea* and red seaweeds on exposed vertical rock
24.15	19	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
24.16	19	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
24.17	19	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
24.18	18	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
24.19	14	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
24.20	14	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
24.21	14	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
24.22	13	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
24.23	14	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
24.24	15	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
24.25	14	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
24.26	14	Irregular bedrock with crevices, gullies and some vertical faces	IR.HIR.KFaR.LhypRVt	*Laminaria hyperborea* and red seaweeds on exposed vertical rock

Station No.	Depth	Sediment type/rock morophotype	Biotope Code	Biotope description
24.27	13	Irregular bedrock with crevices, gullies and some vertical faces	IR.HIR.KFaR.LhypRVt	*Laminaria hyperborea* and red seaweeds on exposed vertical rock
24.28	12	Irregular bedrock with crevices, gullies and some vertical faces	IR.HIR.KFaR.LhypRVt	*Laminaria hyperborea* and red seaweeds on exposed vertical rock
24.29	12	Irregular bedrock with crevices, gullies and some vertical faces	IR.HIR.KFaR.LhypRVt	*Laminaria hyperborea* and red seaweeds on exposed vertical rock
24.30	12	Irregular bedrock with crevices, gullies and some vertical faces	IR.HIR.KFaR.LhypRVt	*Laminaria hyperborea* and red seaweeds on exposed vertical rock
24.31	11	Irregular bedrock with crevices, gullies and some vertical faces	IR.HIR.KFaR.LhypRVt	*Laminaria hyperborea* and red seaweeds on exposed vertical rock
24.32	11	Irregular bedrock with crevices, gullies and some vertical faces	IR.HIR.KFaR.LhypRVt	*Laminaria hyperborea* and red seaweeds on exposed vertical rock
24.33	10	Irregular bedrock with crevices, gullies and some vertical faces	IR.HIR.KFaR.LhypRVt	*Laminaria hyperborea* and red seaweeds on exposed vertical rock
24.34	9	Irregular bedrock with crevices, gullies and some vertical faces	IR.HIR.KFaR.LhypRVt	*Laminaria hyperborea* and red seaweeds on exposed vertical rock
24.35	9	Irregular bedrock with crevices, gullies and some vertical faces	IR.HIR.KFaR.LhypRVt	*Laminaria hyperborea* and red seaweeds on exposed vertical rock
24.36	8	Irregular bedrock with crevices, gullies and some vertical faces	IR.HIR.KFaR.LhypRVt	*Laminaria hyperborea* and red seaweeds on exposed vertical rock
24.37	8	Irregular bedrock with crevices, gullies and some vertical faces	IR.HIR.KFaR.LhypRVt	*Laminaria hyperborea* and red seaweeds on exposed vertical rock
24.38	9	Irregular bedrock with crevices, gullies and	IR.HIR.KFaR.LhypRVt	*Laminaria hyperborea* and red seaweeds on

Station No.	Depth	Sediment type/rock morophotype	Biotope Code	Biotope description
		some vertical faces		exposed vertical rock
24.39	7	Irregular bedrock with crevices, gullies and some vertical faces	IR.HIR.KFaR.LhypRVt	*Laminaria hyperborea* and red seaweeds on exposed vertical rock
24.40	7	Irregular bedrock with crevices, gullies and some vertical faces	IR.HIR.KFaR.LhypRVt	*Laminaria hyperborea* and red seaweeds on exposed vertical rock
25.1	4	Irregular bedrock with crevices, gullies and some vertical faces	IR.HIR.KFaR.LhypRVt	*Laminaria hyperborea* and red seaweeds on exposed vertical rock
25.2	5	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
25.3	6	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
25.4	6	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
25.5	6	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
25.6	7	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
25.7	6	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
25.8	6	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
25.9	7	Irregular bedrock with crevices, gullies and some vertical faces	IR.HIR.KFaR.LhypRVt	*Laminaria hyperborea* and red seaweeds on exposed vertical rock
25.10	7	Irregular bedrock with crevices, gullies and some vertical faces	IR.HIR.KFaR.LhypRVt	*Laminaria hyperborea* and red seaweeds on exposed vertical rock
25.11	8	Irregular bedrock with crevices, gullies and some vertical faces	IR.HIR.KFaR.LhypRVt	*Laminaria hyperborea* and red seaweeds on exposed vertical rock
25.12	9	Irregular bedrock with crevices, gullies and some vertical faces	IR.HIR.KFaR.LhypRVt	*Laminaria hyperborea* and red seaweeds on exposed vertical rock

Station No.	Depth	Sediment type/rock morophotype	Biotope Code	Biotope description
25.13	7	Irregular bedrock with crevices, gullies and some vertical faces	IR.HIR.KFaR.LhypRVt	*Laminaria hyperborea* and red seaweeds on exposed vertical rock
25.14	10	Irregular bedrock with crevices, gullies and some vertical faces	IR.HIR.KFaR.LhypRVt	*Laminaria hyperborea* and red seaweeds on exposed vertical rock
25.15	10	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
25.16	9	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
25.17	10	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
25.18	10	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
25.19	10	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
25.20	9	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
25.21	9	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
25.22	8	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
25.23	9	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
25.24	7	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
25.25	7	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
25.26	5	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
25.27	4	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
25.28	4	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
25.29	3	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
25.30	3	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna

Station No.	Depth	Sediment type/rock morophotype	Biotope Code	Biotope description
25.31	3	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
25.32	3	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
25.33	3	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
25.34	3	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
25.35	3	Irregular bedrock with crevices, gullies and some vertical faces	IR.HIR.KFaR.LhypRVt	*Laminaria hyperborea* and red seaweeds on exposed vertical rock
26.1	4	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna.
26.2	5	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna.
26.3	5	Irregular bedrock with crevices, gullies and some vertical faces	IR.HIR.KFaR.LhypRVt	*Laminaria hyperborea* and red seaweeds on exposed vertical rock
26.4	4	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna.
26.5	4	Irregular bedrock with crevices, gullies and some vertical faces	IR.HIR.KFaR.LhypRVt	*Laminaria hyperborea* and red seaweeds on exposed vertical rock
26.6	4	Irregular bedrock with crevices, gullies and some vertical faces	IR.HIR.KFaR.LhypRVt	*Laminaria hyperborea* and red seaweeds on exposed vertical rock
26.7	5	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
26.8	5	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
26.9	5	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
26.10	5	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
26.11	5	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
26.12	5	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna

Station No.	Depth	Sediment type/rock morophotype	Biotope Code	Biotope description
26.13	4	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
26.14	5	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
26.15	4	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
26.16	5	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
26.17	5	Rippled sand	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna
27	106	Rippled sand	SS.SSA.OSa	Offshore circalittoral sand
28	104	Rippled sand	SS.SSA.OSa	Offshore circalittoral sand
29	104	Rippled sand	SS.SSA.OSa	Offshore circalittoral sand
30	108	Rippled sand and broken shell	SS.SSA.OSa	Offshore circalittoral sand
31	90	Rippled sand	SS.SSA.OSa	Offshore circalittoral sand
32	92	Rippled sand	SS.SSA.OSa	Offshore circalittoral sand
33	92	Rippled sand	SS.SSA.OSa	Offshore circalittoral sand
34	88	Rippled sand	SS.SSA.OSa	Offshore circalittoral sand
35	88	Rippled sand	SS.SSA.OSa	Offshore circalittoral sand
36	89	Rippled sand	SS.SSA.OSa	Offshore circalittoral sand
37	88	Rippled sand, small amount of broken shell	SS.SSA.OSa	Offshore circalittoral sand
38	88	Rippled sand, small amount of broken shell	SS.SSA.OSa	Offshore circalittoral sand
39	88	Rippled sand, small amount of broken shell	SS.SSA.OSa	Offshore circalittoral sand
40	80	Bedrock with many flat upper surfaces, crevices and ridges	CR.HCR.XFa	Mixed faunal turf communities

Station No.	Depth	Sediment type/rock morophotype	Biotope Code	Biotope description
41	80	Rippled sand	SS.SSA.OSa	Offshore circalittoral sand
42	80	Bedrock with many flat upper surfaces, crevices and ridges	CR.HCR.XFa	Mixed faunal turf communities
43	76	Cobble and boulder bed	CR.MCR.EcCr	Echinoderms and crustose communities
44	74	Cobble bed and area of bedrock with ridges	CR.MCR.EcCr.	Echinoderms and crustose communities
45	77	Bedrock with many flat upper surfaces and ridges	CR.MCR.EcCr.	Echinoderms and crustose communities
46	70	Dunned sand	SS.SSA.OSa	Offshore circalittoral sand
47	66	Cobble bed	CR.MCR.EcCr.	Echinoderms and crustose communities
48	65	Dunned sand	SS.SSA.OSa	Offshore circalittoral sand
49	55	Rippled sand	SS.SSA.OSa	Offshore circalittoral sand
50	50	Cobble and boulder bed	CR.MCR.EcCr.	Echinoderms and crustose communities
51	50	Rippled sand	SS.SSA.OSa	Offshore circalittoral sand
52	50	Rippled sand	SS.SSA.OSa	Offshore circalittoral sand
53	48	Bedrock	CR.MCR.EcCr.	Echinoderms and crustose communities
54	48	Rippled sand	SS.SSA.OSa	Offshore circalittoral sand

Plate 1.1. Exposed Infralittoral kelp habitat. Annagh Head, North, proposed Atlantic Marine Energy Test Site, Co. Mayo. July 2010.

Plate 1.2. Circalittoral reef habitat. Broad Rock, proposed Atlantic Marine Energy Test Site, Co. Mayo. July 2010.

Plate 1.3. Typical Ascidian encrusted infralittoral reef habitat. Annagh Head north, proposed Atlantic Marine Energy Test Site, Co. Mayo. July 2010.

Plate 1.4. Edible crab (Cancer pagurus). Leacarrick, proposed Atlantic Marine Energy Test Site, Co. Mayo. July 2010.

Table 1.4. Species recorded from drop down video analysis with associated DAFOR scale.

DAFOR Codes: D = Dominant, A = Abundant, F = Frequent, O = Occasional, R = Rare, P = Present (Present is included when only 1 incident of a species was recorded or a species group, such as sponges, which could not be identified to a higher taxonomic level were recorded).

Species	**Station**														
	7	**12**	**17**	**18**	**19**	**40**	**42**	**43**	**44**	**45**	**47**	**48**	**49**	**50**	**53**
Alcyonium digitatum		D								R				R	
Antedon bifida							F								
Asterias rubens	O	R	R							R		R			
Axinella infundibuliformis			O			F				O				F	F
Axinella dissimilis															
Balanus balanus			F	F	F			O							
Calliostoma zizyphinum							R								
Carophyllia smithii		O	O	O	O					F		O		O	
Corynactis viridis		F					D								
Cliona celata		A	O	F	O		F	R	R					O	O
Echinus esculentus	O		O	F	F			O	F	F	F			F	F
Haliclona cinerea				F											
Haliclona viscosa											O				
Holothuria forskali		O		F			O					O		F	F
Luidia ciliaris			O	R			R			R				R	

Species	Station														
	7	**12**	**17**	**18**	**19**	**40**	**42**	**43**	**44**	**45**	**47**	**48**	**49**	**50**	**53**
Marthasterias glacialis					O		R								O
Membranipora membranacea	F														
Nemertesia antennina		O	F	O	F	O		O		O					
Ophiocomina nigra			A												
Pachymatisma johnstonia		O		O										F	
Pentapora fascialis			O	O								O			
Polymastia boletiformis		O	F	O		O	O								
Pomatoceros sp.		F	F	F		F		F	F	A					
Porania pulvillus			R					O	O			R			
Porella compressa			F	F	O	O		O		O		O		R	
Stichastrella rosea				R											
Suberites carnosus														R	
Encrusting sponges		F	P	P		P						P		P	
Bryozoan turf		F	P	P		P		P	P			P			
Bugula sp.	F														

Species	Station														
Algae	**7**	**12**	**17**	**18**	**19**	**40**	**42**	**43**	**44**	**45**	**47**	**48**	**49**	**50**	**53**
Callophyllis laciniata															
Cryptopleura ramosa															
Delesseria sanguinea	F	F													
Dictyota dichotoma		O													
Laminaria hypoborea	F	O													
Plocamium cartilagineum															
Phycodrys rubens															
Encrusting coralline algae	F	F													

Table 1.5. Habitat description for each of the drop down video stations

Station number	Habitat description
7	Typical exposed infralittoral *L.hypoborea* kelp forest with heavily epiphytised stipes on bedrock with an under story of encrusting coralline algae and foliose red algae. The faunal community is not particularly species rich.
12	This station represented the biotope complex CR.HCR.XFa it is best represented by the sub biotope CR.HCR.XFa.CvirCri although *Carophyllia smithii* occurred in low numbers. The shallower regions of this station included a fringe of infralittoral reef characterised by *L. hypoborea* park.
17	This station consists of ridges of silted bedrock with sand filled gullies between. The biotope complex is consistent with CR.MCR.EcCr and the sub biotope could be considered to best represent CR.MCR.EcCr.CarSp.Bri.
18	This station consists of ridges of silted bedrock with sand filled gullies between. The biotope complex is most consistent with CR.MCR.EcCr CR.MCR.EcCr.
19	This station consists of ridges of silted bedrock with sand filled gullies between. The biotope complex is consistent with CR.MCR.EcCr. Although it is much less species rich than sites 17 and 18 with a rather grazed appearance.
40	This station consists of bedrock with a many flat upper surfaces and some ridges covered in a thin layer of silt. The biotope complex is most consistent with CR.HCR.XFa. and possibly with the sub biotope CR.HCR.XFa.ByErSp. However, many of the characterising species of this sub biotope are absent. While the area is rather species poor with a somewhat grazed appearance there was a notable lack of grazers present at the time of survey.
42	Dense cover of *Corynactis viridis with Antedon bifida* frequent in parts. Most resembling CR.HCR.XFa and sub biotope CR.HCR.XFa.CvirCri.
43	Rather species poor cobble and boulder bed with a fine covering of silt dominated by *Pomatocerus* sp with occasional *Echinus esculentus* and *Porella compressa.* Most resembles CR.MCR.EcCr although echinoderms were few with only *Echinus esculentus* recorded occasionally.
44	Very species poor cobble bed and area of bedrock with ridges. Most resembles CR.MCR.EcCr.
45	Area of bedrock with ridges and a thin covering of silt. Rather grazed in appearance with encrusting bryozoans and *Carophyllia*

Station number	Habitat description
	smithii, Echinus esculentus and *Porella compressa*. Most resembles CR.MCR.EcCr.
48	Cobble bed. Rather grazed in appearance with *Echinus esculentus and Holothuria forskali*. Most resembles CR.MCR.EcCr.
50	Cobble and boulder bed covered by a layer of silt with erect and encrusting sponges, *Echinus esculentus and Holothuria forskali*. Most resembles CR.MCR.EcCr.
53	Bedrock with many upper surfaces, crevices and gullies. Most resembles CR.MCR.EcCr.

1.3.2 Dive survey

In addition to the ground truthing of reef by diver surveys, a number of spot dives were conducted in the vicinity of the proposed cable route in areas indicated as sand for ground truthing purposes and the results of these spot dives are included in Table 1.6. An additional two dives (dives number 4 and 11) were conducted to examine the seabed in the region that the bird surveys had indicated long tailed duck appeared to be faithful.

Table 1.6 shows the reef morphotype, depth, biotope code and biotope description for each of the dive survey locations. The results of the survey indicated that the most common reef morphotype consisted of bedrock with ridges, gullies and crevices often forming pinnacles, with additional areas of cobble field. The most common infralittoral biotope recorded was "*Laminaria hyperborea* and red seaweeds on exposed vertical rock".

In general, the under story of red algae was poorly developed in most areas surveyed and large areas of encrusting coralline algae, bryozoans and ascidians (*Botryllus schlosseri*) were present at most sites, red algae being more confined to the kelp stipes. Most sites showed evidence of sand scouring and often crevices and gullies within the reef were sand filled. Sponge cover was generally moderately high at most sites. No rare species or species of conservation importance were recorded. All species recorded and their abundance are provided in Table 1.7, a brief description of the habitat at each dive station is provided in Table 1.8.

At stations number 4 and 11, dives conducted to detect any evidence of a food source for long tailed duck was inconclusive. Station number 4 was an area of mobile sand with no signs of any epifauna or burrowing macrofauna. While station number 11 was also characterised by mobile sand, although small areas of boulder with a number of crustacean species were present, the site was not significantly different from other areas of similar substrate within the inshore area.

Table 1.6. Biotope descriptions for each of the dive stations.

Dive No.	Max depth (Metres bcd)	Zone	Reef morphotype	Biotope code	Biotope description
1	16.4	1	Rounded and smooth bedrock with some more angular areas with crevices and gullies.	IR.MIR.KR.LhypVt	*Laminaria hyperborea* on moderately exposed vertical rock.
2	18.5	1	Bedrock forming pinnacles with kelp free vertical faces.	IR.MIR.KR.LhypVt	*Laminaria hyperborea* on moderately exposed vertical rock.
3	15	1	Bedrock, smooth rounded.	IR.MIR.KR.LhypVt	*Laminaria hyperborea* on moderately exposed vertical rock.
4	5	1	Rippled sand.	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna.
5	7	1	Rippled sand.	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna.
6	34	1	Rippled sand.	SS.SSA.OSa	Offshore circalittoral sand.
7	17	1	Bedrock forming pinnacles with gullies and crevices.	IR.HIR.KSed	Sediment-affected or disturbed kelp and seaweed communities.
	22	2	Bedrock forming pinnacles with gullies and crevices.	IR.MIR.KR.LhypVt	*Laminaria hyperborea* on moderately exposed vertical rock.
	30	3	Bedrock and boulders with cobble.	CR.MCR.EcCr	Echinoderms and crustose communities.
8	20	1	Rippled sand.	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna.
9	6	1	Rippled sand.	SS.SSA.IFiSa.IMoSa	Infralittoral mobile clean sand with sparse fauna.
10	3	1	Boulder and cobble.	IR.MIR.KR.Ldig	*Laminaria digitata* on moderately exposed sublittoral

Dive No.	Max depth (Metres bcd)	Zone	Reef morphotype	Biotope code	Biotope description
					fringe rock.
11	5	1	Occasional boulders on rippled sand.	IR.HIR.KSed	Sediment-affected or disturbed kelp and seaweed communities.
12	15	1	Bedrock, smooth and rounded but with many vertical faces and gullies.	IR.MIR.KR.LhypVt	*Laminaria hyperborea* on moderately exposed vertical rock.
	22	2	Bedrock, smooth and rounded but with many vertical faces and gullies.	IR.MIR.KR.LhypVt	*Laminaria hyperborea* on moderately exposed vertical rock.
	28	3	Bedrock, smooth and rounded but with many vertical faces and gullies.	CR.MCR.EcCr	Echinoderms and crustose communities.

Table 1.7. Species recorded at dive stations.

DAFOR Codes: D = Dominant, A = Abundant, F = Frequent, O = Occasional, R = Rare, P = Present (Present is included when only 1 incident of a species was recorded or a species group, such as sponges, which could not be identified to a higher taxonomic level were recorded).

Species	Station number (DAFOR)															
	1	2	3	4	5	6	7.1	7.2	7.3	8	9	10	11	12.1	12.2	12.3
Actinothoe sphyrodeta	-	F	F	-	-	-	-	F	-	-	-	-	-	-	-	-
Anemonia viridis	O	-	O	-	-	-	-	R	-	-	-	-	-	-	-	-
Alcyonium digitatum	-	F	-	-	-	-	-	-	R	-	-	-	-	-	O	F
Asterias rubens	F	O	O	-	-	-	F	-	-	-	-	-	-	O	-	O
Botryllus leachii	F	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Botryllus schlosseri	A	F	-	-	-	-	O	O	-	-	-	-	-	-	-	-
Calliostoma zizyphinum	-	O	-	-	-	-	-	O	-	-	-	-	-	O	-	-
Cancer pagurus	-	O	-	-	-	-	O	-	-	-	-	-	R	F	O	R
Carophyllia smithii	-	F	O	-	-	-	-	-	-	-	-	-	-	-	-	O
Cliona celata	-	O	O	-	-	-	-	-	-	-	-	-	-	-	O	F
Crenilabrus melops	-	-	-	-	-	-	O	-	-	-	-	-	-	-	-	-
Crisiidae indet.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	F	F
Crossaster papposus	-	-	-	-	-	-	-	-	R	-	-	-	-	-	R	-
Dysidea fragilis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	O	O

Species	Station number (DAFOR)															
	1	**2**	**3**	**4**	**5**	**6**	**7.1**	**7.2**	**7.3**	**8**	**9**	**10**	**11**	**12.1**	**12.2**	**12.3**
Echinus esculentus	F	-	O	-	-	-	-	O	F	-	-	-		O	O	F
Eledone cirrhosa	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-
Galathea dispersa	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gibbula cineraria	-	-	O	-	-	-	-	O	-	-	-	-	-	-	-	-
Haliclona cinerea	-	F	F	-	-	-	-	-	-	-	-	-	-	-	-	-
Helcion pellucidum	-	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Henricia oculata	-	-	R	-	-	-	-	-	-	-	-	-	-	-	R	-
Holothuria forskali	-	F	O	-	-	-	-	O	F	-	-	-	-	-	O	O
Homarus gammarus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R
Labrus bergylta	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Luidia ciliaris	-	O	O	-	-	-	O	-	-	-	-	-	-	-	-	O
Marthasterias glacialis	-	O	-	-	-	-	-	R	-	-	-	-	-	-	-	-
Membranipora membranacea	-	F	F	-	-	-	F	-	-	-	-	-	-	-	-	-
Necora puber	-	O	O	-	-	-	O	R	-	-	-	-	O	-	-	-
Obelia geniculata	-	-	F	-	-	-	O	-	-	-	-	-	-	-	-	-
Pachymatisma johnstonia	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-	F
Pagurus bernhardus	-	-	-	-	-	-	-	-	-	-	-	-	F	-	-	-

Species	Station number (DAFOR)															
	1	**2**	**3**	**4**	**5**	**6**	**7.1**	**7.2**	**7.3**	**8**	**9**	**10**	**11**	**12.1**	**12.2**	**12.3**
Pollachius pollachius	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pomatoceros sp.	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-
Scomber scombrus	-	-	-	-	-	-	P	-	-	-	-		-	-	-	-
Taurulus bubalis	-	R	-	-	-	-	-	-	-	-	-		-	-	-	-
Urtica felina	F	-	-	-	-	-	-	-	-	-	-	F	-	-	-	-
Bryozoa indet. (crusts)	-	-	O	-	-	-	-	-	-	-	-	O	-	-	F	O
Encrusting sponges	-	F	F	-	-	-	-	-	-	-	-	-	-	-	O	F
Marine algae																
Callophyllis laciniata	-	-	-	-	-	-	-	-	-	-	-	-	-	O	O	-
Chondrus crispus	F	-	-	-	-	-	O	-	-	-	-	-	O	-	-	-
Dictyota dichotoma	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dilsea carnosa	-	-	-	-	-	-	-	-	-	-	-	-	-	O	-	-
Himanthalia elongata	-	-	-	-	-	-	-	-	-	-	-	F	-	-	-	-
Laminaria digitata	-	-	-	-	-	-	-	-	-	-	-	F	-	-	-	-
Laminaria hypoborea	F	F	A	-	-	-	D	A	-	-	-	-	O	F	O	-
Palmaria palmata	O	O	-	-	-	-	O	O	-	-	-	-	-	-	-	-
Phycodrys rubens	-	-	-	-	-	-	O	O	-	-	-	-	-	-	O	-

Species	Station number (DAFOR)															
	1	2	3	4	5	6	7.1	7.2	7.3	8	9	10	11	12.1	12.2	12.3
Ulva lactuca	-	-	-	-	-	-			-	-	-	-	A	-	-	-
Encrusting Coralline algae	P	P	P	-	-	-	F	A	O	-	-	O	-	F	F	O

Table 1.8. Habitat descriptions for each dive station.

Dive station	Habitat description
1	Reef formed of bedrock running in parallel ridges running down to medium grained sand at a depth of 16. 2 m bcd. *L. hypoborea* with epiphytised stipes occurred to the maximum depth of the reef. Only one single zone and one biotope present. Very tide swept and sand scoured and red algae confined to kelp stipes. Quite species poor.
2	Very species rich bedrock forming pinnacles with kelp free faces, however kelp (*L.hypoborea*) extends to bottom of reef at 18.5 m bcd where the reef ends in rippled sand.
3	Reef formed of smooth rounded bedrock with multiple aspects, undercuts and overhangs.
4	Rippled sand, no epifauna
5	Rippled sand, no epifauna
6	Rippled sand, no epifauna
7	Reef comprised of three distinct biotopes
8	Rippled sand, no epifauna
9	Rippled sand, no epifauna
10	Infralittoral fringe boulders and cobble
11	Rippled sand with occasional boulders
12	Reef comprising 3 distinct biotopes formed on bedrock with a fringe of cobble and boulder at the maximum depth of the reef. Numerous vertical faces, crevices and gullies.

1.4 DISCUSSION

Data provided on the bathymetry and sediment type of the study area allowed an overview of the subtidal habitats present along the proposed cable route corridor, test areas and a buffer zone extending approximately 200 m either side of the cable route corridor, together with a more extensive area within Annagh Bay. Within this area, the data provided indicated the location and height (metres above the seabed) of the most prominent rock pinnacles together with other sediment habitats such as sand, gravels and cobble. This facilitated interpretation of the three dimensional structure of subtidal habitats within the areas surveyed, which correspond to the EU Habitats Directive Annex I habitat “Reef” and other sediment types. The data indicated that the area of habitat corresponding to the definition of Reefs as defined by the interpretation manual of the EU Habitats Directive (European Commission, 1992) comprises an area of approximately 0.519 km^2, the remainder of the area comprising soft sediment habitats (see Section 3 for details of soft sediment habitats).

The classification of biotopes within deep circalittoral habitats is problematic, largely due to the lack of suitable habitat and species data available to accurately define the characterising species. It is not possible to ground truth very deep circalittoral habitats by diving unless technical mixed gas diving practices are employed and such surveys are not within the scope of most scientific surveys teams. Many species cannot be reliably identified by drop down video as close examination under a microscope is often required and samples need to be collected for this purpose.

The character of the fauna of deep circalittoral communities varies enormously and is affected mainly by wave action, tidal stream strength, salinity, turbidity, the degree of scouring and rock topography. It is typical for the communities to comprise a more diverse range of species than might be found in shallower infralittoral habitats. These factors coupled with a lack of detailed species data and other factors makes circalittoral rock a difficult area to satisfactorily classify (Connor *et al* 2004).

Notwithstanding these difficulties, drop down video is one of the only methods of survey available for deeper circalittoral communities. The technique does allow the identification of conspicuous species and an estimation of abundance and diversity to be made.

The present survey indicated that the most common reef morphotype present consisted of flat and sloping bedrock with numerous crevices and gullies. The biotopes recorded for this morphotype were consistent with deep, exposed circalittoral communities, which would be relatively common in their extent and distribution off the west coast of Ireland. The most interesting aspect of these biotopes appears to be the associated sponge communities. Although it was not possible to identify many of the encrusting sponge species by drop down video.

Smaller areas of cobble were also identified along some sections of the cable route; these were all relatively species poor, which is most likely due to the effect of wave action causing mobility of the cobble and a subsequent lack of encrusting species.

The shallower inshore, infralittoral reefs were characterised by vertical rock walls and pinnacles with numerous crevices, gullies and overhangs. The only biotope recorded was *Laminaria hyperborea* on moderately exposed vertical rock. This biotope is very common in infralittoral areas off the west coast of Ireland.

The optimum substrate for the laying and burial of the subsea cable and suction anchoring of WECs is soft sediment. Therefore, areas of reef were avoided as far as practically possible when designing the cable route corridor and the route has been selected to run along areas of soft sediment. In a section of the cable route (4km), there was no alternative to laying the cable over an area of cobble.

Dives conducted in the shallow circalittoral inshore areas consisted of smooth and rounded bedrock with numerous gullies and crevices and the biotope community “Echinoderms and crustose communities” a community that is relatively common off the west coast of Ireland.

Almost all of the reefs examined by both drop down video or dive surveys showed evidence of sand scour and had a covering of sediment. This indicates the highly exposed location of the study site and the ability of the existing reef communities to withstand disturbance due to wave action and sediment deposition on a regular basis.

The non-reef areas surveyed by drop down video or dives were classified as either “Infralittoral mobile clean sand with sparse fauna” or “offshore circalittoral sands”. Grab sampling of these sections (Section 2) provides a more detailed analysis of the sediments and biotopes of these areas.

1.5 IMPACT OF THE DEVELOPMENT

The biotopes present within the site, at both the infralittoral and circalittoral reef areas, are all characteristic of exposed communities already subject to extreme wave action. They all showed evidence of being subjected to the effects of sand scouring and sediment movement during the survey and any sedimentation caused during the cable laying process is unlikely to have any more effect on these communities than a natural storm event would have.

The impact of the development on the reef biotopes of both the inshore and offshore areas is considered to be low.

The impact of the placement of rock armour over sections of the cable route and within the mid-shore box has the potential to cause habitat loss and fragmentation and damage to or loss of certain species. It may also cause an alteration to the existing environment by the creation of new habitats. The area of impact of rock armour placement has been estimated to be approximately 45,000 m². The impact of placing rock armour over this area is likely to be negligible in the context of the overall area of the site, as it would comprise of less than 0.04% of the total reef area. Colonisation of the rock armour by local species may occur depending on the type of rock armour used.

1.5.1 General effects

The general effects of the development on the reef habitats are likely to be an increase in sediment displacement during the cable burial process, disturbance and change in habitat through the occlusion of areas of cobble beds by cable protection along the cable route and within sections of the two test area locations. If rock armour is used for the purpose of cable burial along sections of the cable route this will have an impact on reef habitats (particularly cobble beds) if placed over these habitats. The addition of rock armour will cause habitat loss and fragmentation and damage to species. This impact will be permanent, as the rock armour will still exist long after the lifetime of the AMETS.

Rock armour will both alter existing reef habitats if placed directly over them and provide artificial reef habitats in areas where reef does not currently exist. The positive effects of artificial reefs are not fully known, but the creation of artificial reef is likely to alter the species composition of existing reef habitats and cause species not previously associated with the area to colonise the new artificial reef areas. A review of the reef effect caused by wind turbine footings and other artificial substrates by Petersen and Malm (2006), and the 66 references therein, raises some concern about the reef effect of introduced artificial substrates. It is not clear that the increased diversity effect is always positive. Artificial reefs tend to have more non-native species than natural reefs and may provide a stepping-stone for the establishment of invasive species. Many of these studies that Petersen and Malm (2006) reviewed are from shallow water in coastal developments where the association with invasive species may be as a result of interaction with the proximity to ports and shipping traffic, and to other sources of anthropogenic disturbance. This is not the case, however, with the AMETS as there are no large coastal developments or ports in the vicinity of the site.

A recent review of the potential for wave energy devices to provide artificial habitats and protect areas from fishing, commissioned by Vattenfall AB and conducted by the IUCN (2010) also concludes that the knowledge base for optimising both artificial reef programmes and fish aggregation device deployment, and for managing the risks of both remains weak. This report highlights that in the case of large artificial reef projects, biological surveys are often conducted before artificial reef deployment, to avoid direct damage on vulnerable habitats and species, but that well-designed post-deployment surveys are less common. The ecological surveys of the natural reef habitats of the Atlantic Marine Energy Test Site have provided valuable base line pre-deployment data and the continued monitoring of these habitats post-deployment of both construction material and Wave Energy Test Devices would greatly contribute to knowledge of artificial reef effects in temperate waters. The monitoring of the artificial reefs should be included in the project management plan for the operational phase of the AMETS.

Most artificial reefs take five years to develop a stable community, but this is often not the same as that occupying neighbouring hard substrates. The community that develops depends on the nature of the introduced substrate and the proximity of natural hard substrates and their associated natural biological communities available to colonise new reef structures. In the case of the AMETS, the close proximity of natural reef habitats provides available natural communities which may colonise artificial reef habitats provided the substrate provided is suitable. Boulders similar to the local bedrock provide the most heterogeneous environment that allows for the development a diverse epifaunal community with positive effects on diversity. Concrete blocks treated to prevent salt-water intrusion provide the least suitable surface for the development of a rich reef community, particularly on the smooth vertical surfaces. These surfaces tend to favour invasive species, particularly in the years immediately following deployment.

1.5.2 Construction phase - potential impacts

There are two main potential impacts of the development on the subtidal reefs within the area, the placing of rock armour and the burial of cables.

It is proposed that rock armour will be placed over the cable for 4 km of the cable route that passes over cobble beds and cannot be trenched. Rock armour will also be placed over the cable from the outer box as it passes through the inner box to prevent devices in this area anchoring over the cable. This will likely consist of 1-2 layers of graded boulders that are chemically inert being placed over the cable. The placement of rock armour will cause habitat loss and fragmentation to the areas of reef, mainly coble beds, over which it is placed and alteration of the existing biotope complex.

The burial of cables by water jetting or cable plough will increase sedimentation in the water column. This can impact the species and biotopes within the adjacent reef habitats where deposition could occur. The predicted impacts of this are considered insignificant as the species and biotopes within the existing reef habitats are all characteristic of exposed sites subject to sand scour and sediment deposition caused by the frequent high winds and swell associated with the event. The impact on species within the soft sediment is discussed elsewhere.

Other potential impacts of the development during the construction phase, such as oil spillage from vessels associated with the cable laying and deployment of WECs is considered in the project risk assessment.

1.5.3 Operational phase - potential impacts

Physical disturbance during the operational phase is considered negligible.

The wave energy devices currently described for deployment at the site have a requirement for mooring on sandy substrates and the mooring of the devices will therefore not impact on reef habitats.

Scour protection of the WEC anchoring system will probably be undertaken using rock armouring, which will lead to potential artificial reef development, as with the laying of rock armour for cable protection the laying of rock armour, the placement of rock armour will cause habitat loss and fragmentation to the areas over which it is placed and alteration of the existing biotope complex. The likely impact of this is considered insignificant as it represents less than 0.04% of the total site area.

Any incident of accidental leakage of the hydraulic fluids used in some of the devices may cause a negative impact on reef communities. However, it is unlikely to have a significant impact on deeper reef communities due to the available area for dispersion, the high-energy environment and the depth of the reef.

It is highly unlikely that any antifoulants used on wave energy devices would cause a negative impact on local reef communities. All wave energy devices will be deployed in deeper areas and not in the vicinity of the inshore infralittoral reefs. The Pelarmis device for example does not use antifoulants, allowing any species that accumulate to drop to the seabed. The impact of high biomass volumes falling onto the seabed in the vicinity of reefs might cause an impact on reef communities in close proximity to the WECs over time due to nutrient enrichment and alteration of the habitat. However, the likely impact of increased biomass in the vicinity of WECs is considered to be low, as the exposed nature and depth of the site would prevent the accumulation of biomass beneath individual WECs.

1.6 MITIGATION OF IMPACTS

1.6.1 Construction phase

The use of rock armour should ensure that consideration be given to using local inert rock of the same type as currently present in the sublittoral area of the site. This will help to mitigate the alterations in reef structure and function that would result as a consequence of using rock of a different type, both in terms of its composition and morphotype.

All vessels used in the cable laying process should have an Oil Pollution Emergency Response Plan and should carry emergency response equipment

1.6.2 Operational phase

Any disturbance of reef habitats during the operational phase is likely to be insignificant.

1.7 MONITORING

Monitoring of both the shallow infralittoral and deep circalittoral reefs within the Atlantic Marine Energy Test Site is strongly recommended and should be included in the Environmental Monitoring Plan for the Site

It is recommended that additional (pre-construction) base line information on the biotope complexes and structure and function of the deep circalittoral reefs is collected. This will greatly contribute to knowledge of these biotope complexes and assist in detecting and measuring change.

Monitoring of the reef habitats, post construction will allow an assessment of any changes in biotope complexes or alteration in habitat as a result of either the placement of rock armour or sediment deposition. It may also help to identify any introductions of non-native species. It is recommended that post-construction monitoring takes place at the same locations as the baseline information was gathered and at areas where rock armour is placed.

As full-scale wave energy development is still in the early stages, the monitoring of any artificial reefs created will contribute greatly to knowledge in this area and help to inform future methods of construction and monitoring of wave energy test sites. It will allow recording of the type of biotope complexes that may occur due to the creation of artificial reef, the type and diversity of species that occur and the colonisation of artificial reefs by native species that have not been recorded so far at the site.

Table 1.9. Potential impacts during construction phase

Species and Habitats	Potential impacts
All epifauna	Cable laying may cause damage to or loss of species on areas of cobble over which the cable passes. The trenching process on areas of soft sediment may cause smothering of nearby epifauna in reef habitats. The placement of rock armour over sections of cobble to bury the cable will cause species loss and damage.
Reefs	Cable laying will cause habitat loss and fragmentation within areas of cobble over which it passes. The placement of rock armour over sections of cobble to bury the cable will cause habitat loss and fragmentation and alter the existing habitat by the placement of inert rock, which differs from the natural hard substrate in the area. Placement of rock armour will create an artificial reef effect at the location it is placed.

Where likely impacts have been identified in terms of a species or a habitat, the significance of this impact has been assessed, following a standard assessment process detailed below.

Table 1.10a. Assessment of significance – Construction phase

Potential impact:	**Species loss and damage on reef habitats**
Significance criteria	
Character and perceived value of affected environment	No Annex 1 habitats, Annex II species or rare or unusual species have been recorded, but deep water sponge communities, which are poorly studied, occur in the deeper circalittoral reefs on the site. The entire site is a highly exposed environment and the reef habitats and species within them are characteristic of this environment, which is frequent along the west coast of Ireland.

Confidence in the accuracy of predictions of change	Cabling activity will disturb sediments, which may cause a temporary smothering effect on the marine epifauna in nearby reef habitats. It is likely they will recover due to the dynamic environment. The placement of rock armouring over sections of cobble beds will cause habitat loss and species loss and damage. This will be a localised effect over a small area of the likely reef habitat within the site (Approximately 0.04 % of habitat loss). The placement of rock armouring over sections of cobble beds will cause alteration of the habitat and the creation of new habitat. This may have either a positive or negative effect on the site depending on how this new habitat is colonised.
Magnitude, spatial extent and duration of anticipated change	The loss of the existing natural reef habitat where rock armouring is placed will be permanent. The area affected will comprise approximately 45,000 m^2. The creation of new, artificial reef habitat will be permanent. The area affected will comprise approximately45,000m^2.
Resilience of environment to cope with change	This is a dynamic environment, subject to constant wave action. Smothering effects due to sediment deposition from the cabling process will be of a very short duration (days) and habitats and species would recover over a very short period. The creation of new artificial reefs will occupy a very small area of the site (0.04%) and would be unlikely to effect existing reef structures.
Scope for mitigation, sustainability and reversibility	Damage to reef habitats should be minimised by careful consideration to the placement of rock armour. Consideration should be given to the type of rock armour used. If possible rock similar to the local bedrock should be used.
SIGNIFICANCE OF IMPACT	**LOW**

Table 1.10b. Assessment of significance – Construction phase

Potential impact:	**Introduction and potential for colonisation by invasive species**
Significance criteria	
Character and perceived value of affected environment	No Annex 1 habitats, Annex II species or rare or unusual species have been recorded, but deep water sponge communities, which are poorly studied, occur in the deeper circalittoral reefs on the site. The entire site is a highly exposed environment and the reef habitats and species within them are characteristic of this environment, which is frequent along the west coast of Ireland.
Confidence in the accuracy of predictions of change	Rock armour may provide the opportunity for invasive species (both native local species and species not currently local to the area) to colonise new artificial reef structures, particularly if this consists of larger less mobile boulders and such species could spread to surrounding natural reefs.
Magnitude, spatial extent and duration of anticipated change	The creation of new, artificial reef habitat will comprise approximately 45,000 m^2 over existing cobble beds. These cobble beds are currently species poor due to the dynamic nature of the environment and it is unlikely colonisation of additional rock armouring would occur.
Resilience of environment to cope with change	This is a dynamic environment, subject to constant wave action. The placing of rock armour over existing cobble beds is unlikely to have a significant affect on what is already a species poor habitat. The creation of new artificial reefs will occupy a very small area of the site (0.04%) and would be unlikely to effect existing reef structures.
Scope for mitigation, sustainability and reversibility	Consideration should be given to the type of rock armour used. If possible rock armour should be similar to the local bedrock and should not contain large immobile boulders.
SIGNIFICANCE OF IMPACT	**LOW**

Table 1.11. Potential impacts during operational phase.

Species and habitats	Potential impacts
All epifauna	Accidental leakage of the hydraulic fluids. Contamination from antifoulants. Increased biomass from WECs falling onto reef species
Reefs	Accidental leakage of the hydraulic fluids. Contamination from antifoulants. Increased biomass from WECs falling onto reef habitats

Where likely impacts have been identified in terms of a species or a habitat, the significance of this impact has been assessed, following a standard assessment process detailed below.

Table 1.12. Assessment of significance during operational phase.

Potential impact:	Species loss and damage to reef habitats
Significance criteria	
Character and perceived value of affected environment	No Annex 1 species or species of conservation importance have been recorded, but deep water sponge communities, which are poorly studied, occur in the deeper circalittoral reefs on the site. The entire site is a highly exposed environment and the reef habitats and species within them are characteristic of this environment, which is frequent along the west coast of Ireland.
Confidence in the accuracy of predictions of change	The use of hydraulic fluids in WECs is minimal. Antifoulants are not commonly used on WECs The WECs to be deployed will be anchored into soft sediments and not into reef habitats.

Magnitude, spatial extent and duration of anticipated change	Any accidental spillage of hydraulic fluid or vessel oil is likely to be minimal and unlikely to effect reef habitats or species at the depths they occur (50 or greater). The exposed nature of the site is likely to cause rapid dispersion of any accidental spillage. Increased biomass falling onto the seafloor would only be very localised around a WEC and on soft sediments.
Resilience of environment to cope with change	It is highly unlikely that any antifoulants that might be used on wave energy devices would cause a negative impact on local reef communities due to the depth of the reefs in the vicinity of the test areas and the exposed nature of the site. All wave energy devices will be deployed in deeper areas and not in the vicinity of the inshore infralittoral reefs. Any biomass will rapidly disperse due to the exposed nature of the site and
Scope for mitigation, sustainability and reversibility	Regular maintenance and the creation of the Oil Pollution Emergency Response Plan for the site would address the issue of oil spillage from either WECs or vessels working at the site. This is a dynamic environment and would recover quickly from the input of increased biomass.
SIGNIFICANCE OF IMPACT	**LOW**

Table 1.13: Mitigation of impacts during construction phase

Potential Impact	**Scope for mitigation, sustainability and reversibility**
Species loss and damage on reef habitats	Damage to reef habitats should be minimised by careful consideration to the placement of rock armour. Consideration should be given to the type of rock armour used. If possible rock similar to the local bedrock should be used.
Introduction and potential for colonisation by invasive species	Consideration should be given to the type of rock armour used. If possible rock armour should be similar to the local bedrock and should not contain large immobile boulders.

Table 1.1.14: Mitigation of impacts during operational phase

Impact	Scope for mitigation, sustainability and reversibility
Accidental leakage of the hydraulic fluids.	Regular maintenance of WECs and the creation of the Oil Pollution Emergency Response Plan for the site
Contamination from antifoulants.	Minimise or avoid use
Increased biomass from WECs falling onto reef habitats	Monitor seabed in area below WECs to assess impact

2 MARINE FLORA & FAUNA - SUBTIDAL BENTHOS

This section deals with the results of subtidal benthic sampling along the cable route and within the proposed WEC test areas.

2.1 INTRODUCTION

Marine environmental monitoring programs are generally designed to detect any ecologically significant change in habitat quality associated with a discrete or chronic source of impact, or with remedial action taken after a disturbance event. Dauer *et al.* (1993) list the reasons that benthic macrofaunal communities have often been the foci of these programs as:

- benthic macrofauna are generally sedentary and are forced to tolerate local conditions.
- the lifespan of many species (ranging from a few months to a few years) allows community structure to integrate and reflect sources of stress over time.
- many species reside at the sediment-water interface where many pollutants concentrate.
- macrobenthic communities are taxonomically diverse, consisting of species that exhibit different tolerances to stress (Gray, 1980; Boesch & Rosenberg, 1981; Hartley, 1982; Phillips & Segar, 1986).

Though individual study areas and monitoring programs may negate one or more of these generalisations to some degree, the description of macrobenthic community structure remains an integral component of many environmental impact assessment schemes (Bilyard, 1987; Weston, 1990).

The European Water Framework Directive (WFD; 2000/60/EC) has established a framework for the protection and improvement of all European surface and ground waters including transitional and coastal waters. The final objective is to achieve at least 'good water status' for all water bodies, by 2015. Each Member State is required to assess the Ecological Status (ES) of water bodies. Status will be assigned through the assessment of biological, hydromorphological and physico-chemical quality elements. Data obtained from monitoring are compared to reference (undisturbed) conditions to derive an Ecological Quality Ratio (EQR). These ratios are expressed as a decimal value between zero and one, with 'high' status represented by values close to one and 'bad' status by values close to zero. The EQR scales are divided into five ecological status classes (high, good, moderate, poor, and bad) by assigning a numerical value to each of the class boundaries.

In coastal and transitional waters soft bottom benthic macrofauna is one of the important and frequently used elements in determining habitat quality (Pearson and Rosenberg 1978, Borja *et al*. 2000, Dauer *et al*. 1993).

Biological quality elements that must be included in the ES assessment of a water body include ‘the level of diversity and abundance of invertebrate taxa’ and the proportion of ‘disturbance–sensitive taxa’ (Borja *et al*. 2007). Several methodologies have been proposed by member states for the status assessment of the benthic component. In the UK and Ireland the EQR developed is the Infaunal Quality Index (IQI).

The need for conservation and management of biological resources and associated habitats has led to the development of standardised biotopes for the classification of benthic habitats in Britain and Ireland (Connor *et al*. 2004). These biotope classifications can be useful in assessing the suitability of a site for development if the nature of temporal and spatial variability of the biotope is known.

Here, a proposed site for a wave energy test site and cable route to classify the benthic biotopes of the area were surveyed. The sediments were characterised in terms of grain size and organic content and the distribution of sediment types throughout the study area was assessed with multivariate statistics. The macrofaunal communities of the study area were sampled, delineated and characterised as communities. These communities were classified in terms of standard biotopes. The ecological status of the sampling stations was assessed using IQI. Multivariate analyses were used to model the variability in macrofaunal community structure and assess the suitability of the site for development. Possible effects of the proposed development were assessed and mitigation measures recommended where appropriate.

2.2 METHODOLOGY

2.2.1 Field sampling

Twenty-five stations were sampled at the proposed test sites and along the proposed cable route (Table 2.1 and Figure 2.1). Sampling occurred in July and November 2010 from the *mv Tarrea Queen* and *mv Dulra na Mara*. Station position was recorded using a differential GPS. At each station, four 0.1 m^2 Day grab samples were taken. One grab was used for particle size distribution and organic content (LOI) analysis. Three were preserved for macrofaunal identification.

All samples were labelled inside and outside so that each sample could be identified. Sediment samples were frozen (<-18°C) in screw top containers, labelled inside and outside, as soon as possible after acquisition. A digital image of each sample was taken on deck to include the sample code, date and scale identifier. Available ancillary in situ environmental observations were recorded for each sampling location including:

Co-ordinates (Lat/Long & national grid)	Depth
Ship Anchored (Y/N)	Sediment type
Time	Sampler type
Weather & Sea state	Sieve size
Exposure	Sample photograph (Y/N and identifier code)

All data were entered into a Microsoft Excel database on an onboard laptop as the samples were processed. This was backed up on four solid-state external storage devices.

On board, the faunal grab samples were photographed and rapidly visually assessed for bottom type. The penetration depth, texture and grain size of the sediments were visually determined and noted. The samples were emptied into a hopper and the grab rinsed thoroughly to avoid loss of the sample. The samples were sieved on a 1 mm sieve using a Wilson autosiever.

All material retained on the sieve was flushed into a prelabelled 15l bucket, with water from below. The samples were fixed in buffered 4% w/v buffered formaldehyde solution as quickly as possible. The samples were completely covered by the fixative solution.

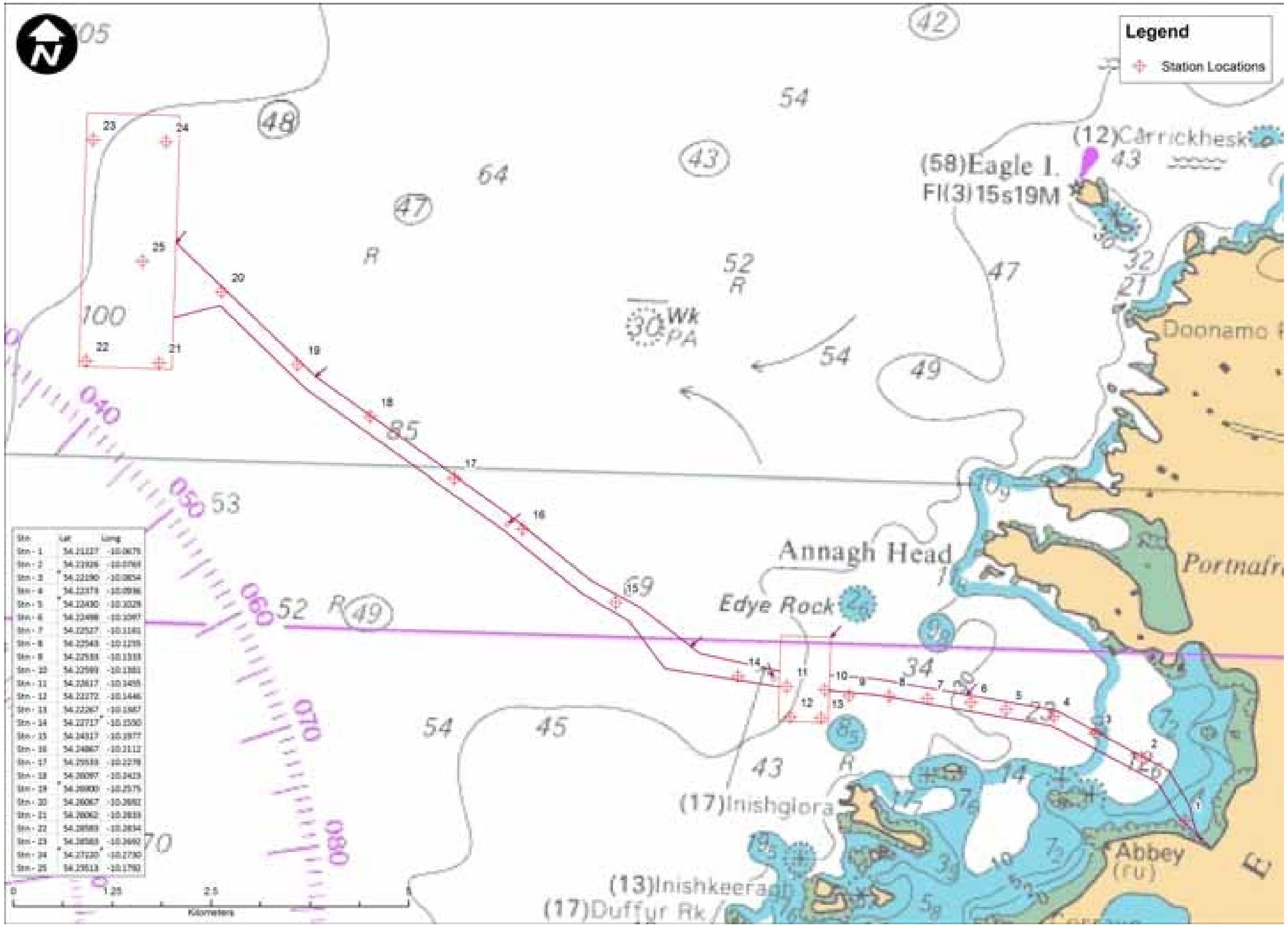
Station 15 (NP08-15) consisted of coarse sediments, gravel and cobbles, and it was not possible to get quantitative grab samples at this station. The Day grab retrieved no material on most attempts because cobbles stuck in the jaws of the sampler allowed any sediment to wash out while being hauled. On the single occasion that sediments were retrieved, the grab was partially open. This sample was photographed and fixed for macrofaunal analyses. No fauna was found in this sample. A qualitative biotope was assigned to this station based on depth and approximate bottom type.

Table 2.1. Positions of all benthic grab sampling stations.

Station Number	Latitude	Longitude
NP08-1	54.21227	-10.0675
NP08-2	54.21926	-10.0763
NP08-3	54.2219	-10.0854
NP08-4	54.22373	-10.0936
NP08-5	54.2243	-10.1029
NP08-6	54.22498	-10.1097
NP08-7	54.22527	-10.1181
NP08-8	54.22543	-10.1255
NP08-9	54.22533	-10.1333
NP08-10	54.22593	-10.1381
NP08-11	54.22617	-10.1455
NP08-12	54.22272	-10.1446
NP08-13	54.22267	-10.1387
NP08-14	54.22717	-10.155
NP08-16	54.24317	-10.1977

Station Number	Latitude	Longitude
NP08-17	54.24867	-10.2112
NP08-18	54.25533	-10.2278
NP08-19	54.26097	-10.2423
NP08-20	54.269	-10.2575
NP08-21	54.26067	-10.2692
NP08-22	54.26062	-10.2833
NP08-23	54.28583	-10.2834
NP08-24	54.28583	-10.2692
NP08-25	54.2722	-10.273
NP08-15	54.23513	-10.1792

Figure 2.1. Benthic sampling stations at proposed wave energy test sites west of Annagh Head, Co. Mayo and associated cable route.



2.2.2 Sediments

2.2.2.1 Organic Content (Loss on Ignition)

The method of Dean (1974) was used. Approximately 5g of homogenised sediment were dried to a constant weight at 100^{o}C. The dried sediment was ground down to a fine powder in a mortar and pestle. 1g of the fine dried sediment was heated in a muffle furnace at 450^{o}C for a period of 6 hours. The organic content of the sediment was determined by calculating the loss of mass of the sediment after ignition as a percentage of the initial dry weight of the sediment.

2.2.2.2 Grain Size Analysis

The grain size analysis technique specified in Marine Institute tenders for subtidal biotope mapping in coastal cSACs was used to determine grain size distributions as summarised below.

25g of the homogenised sediment were digested in a 1L beaker using 30% hydrogen peroxide and manual agitation over a four-day period. The sample was washed on a 63µm sieve using distilled water and returned to the beaker. The sample was dispersed using a sodium hexametaphosphate solution and mechanical agitation. The sediment was washed on a 63µm sieve with distilled water to remove the silt/clay fraction and dried to a constant weight at 100ºC.

The sediment was passed through a series of Wentworth sieves ranging from 4 mm to 63 µm in whole phi intervals, i.e. the mesh of each sieve is one half the size of the sieve preceding it. Sizes used were 4 mm, 2 mm, 1 mm, 500 µm, 250 µm, 125 µm, and 63 µm. The stack of sieves was mechanically agitated on a Resch mechanical shaker for 10 minutes. The fraction retained in each sieve was recorded. The <63µm fraction of the sediment sample was calculated from the material retained in the base pan and the difference between the sum of the sediment retained on the sieves and the initial weight of the sample.

A cumulative frequency plot of the particle size distributions was constructed from a table of particle size distributions in Gradistat V. 7 (Blott and Pye, 2001). Mass percentiles were calculated from the cumulative frequency plots and used to calculate the following summary statistics developed by Folk (1974). The range and implications of these statistics is presented in Table 2.2.

1) Graphic Mean (Mz)

$$\mathrm{Mz} = \frac{(ø16 \ + \ ø50 \ + ø84)}{3}$$

where ø = -$\log_2$ of particle diameter (mm) of the respective percentiles.

Mz is a measure of the average particle size of the sediment, given in ø units. Negative values correspond to coarse sand and gravel, while positive values correspond to medium to very fine sands, clay and silt.

2) Inclusive graphic standard deviation or Sorting (δ_i)

$$\delta_i = \frac{ø84 - ø16}{4} + \frac{ø95 - ø5}{6.6}$$

δ_i defines the degree of scatter of particle sizes about Mz. A theoretical perfectly homogeneous sediment would have a δ_i of 0. Values <1 imply a homogeneous, well-sorted sediment, while those >1 imply a poorly sorted sediment.

3) Inclusive graphic skewness (Sk_i)

$$Sk_i = \frac{(ø16 + ø84 - 2(ø50))}{2(ø84 - ø16)} + \frac{(ø5 + ø95 - 2(ø50))}{2(ø95 - ø5)}$$

Sk_i characterises the asymmetry of the cumulative frequency curve. A range of values is obtained from -1.0, strongly coarse skewed, to 1.0, strongly fine skewed.

4) Kurtosis

$$K_G = \left(\frac{\phi 90 - \phi 10}{2.44(\phi 75 - \phi 25)} \right)$$

Kurtosis assesses the peakedness of the curve in terms of departure from the normal distribution. If the distribution is excessively peaked it is termed leptokurtic; if it is squashed or flattened, it is termed platykurtic.

Table 2.2. The range of values and implications of the sediment particle cumulative frequency parameters and the classification of sediment particle size ranges into size classes (after Buchannan, 1984).

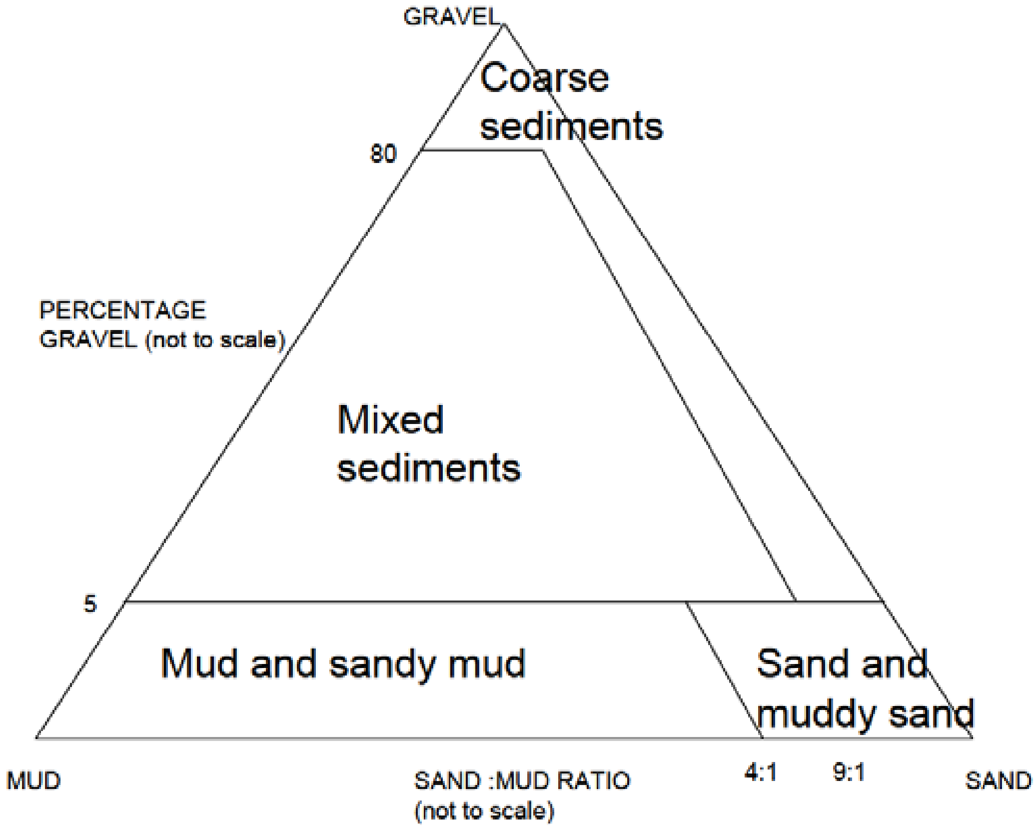
Parameter	Range of Values	Implications
Graphic mean (Mz)	<-1.0ø	Gravel
	-1.0 to 0.0ø	Coarse sand
	0.0 to 3.5ø	Sand
	>3.5ø	Silt/clay
Sorting (δ_i)	<0.35	Very well sorted
	0.35 to 0.5	Well sorted
	0.5 to 1.0	Moderately sorted
	1.0 to 2.0	Poorly sorted

Parameter	Range of Values	Implications
	2.0 to 4.0	Very poorly sorted
Skewness (Sk_i)	-1.0 to –0.3	Very coarse skewed
	-0.3 to –0.1	Coarse skewed
	-0.1 to 0.1	Nearly symmetrical
	0.1 to 0.3	Fine skewed
	0.3 to 1	Very fine skewed
Kurtosis (K_G)	<0.67	Very platykurtic
	0.67-0.90	platykurtic
	0.90-1.11	mesokurtic
	1.11-1.50	leptokurtic
	>1.50	Very leptokurtic

Range of particle size	Classification	Range of particle size	Classification
<63µm	Silt/clay	710-1000 µm	Medium coarse sand
63-125µm	Very fine sand	1000-1400 µm	Coarse sand
125-250µm	Fine sand	1,400-2,000µm	Very coarse sand
250-500µm	Medium fine sand	2,000-4,000µm	Fine Gravel
500-710µm	Medium sand	>4000µm	Gravel

Sediment grain size samples were classified using the simplified Folk classification of the EUNIS seabed sediment classification for biotope analysis (Long 2006). This classification uses the percentages of mud, sand and gravel to group the stations into four possible categories. Samples with <5% gravel are mud and sandy mud (MU) or sand and muddy sand (SA). The boundary between MU and SA is a 4:1 ratio of sand to mud (Figure 2.2). Coarse sediments (CS) correspond to the normal Folk categories slightly gravely sand, gravely sand, sandy gravel and gravel. All other sediments are designated as mixed sediments (Mx).

Figure 2.2. Simplified classification of the Folk triangle used for EUNIS sediment classification (after Long, 2006).



Principal components analysis (PCA; Pearson, 1901, Joliffe, 2002) was used to determine the distribution of sediment types in the area. PCA is a standard parametric ordination technique that plots station distributions in (usually) two dimensions based on linear combinations of variables into principal components of variation (PC). Stations that are plotted close together on the ordination plot tend to be of similar composition. The reliability of the PCA plot depends of the amount of variation explained by PC. Here, a correlation based PCA on normalised sediment data was used. Input variables were grain size distributions and organic content.

The power of the sediment data to explain the macrofaunal distribution was investigated using distance based linear regression (DistLim) and distance based redundancy analysis (dbRDA).

2.2.3 Macrofauna

Samples were analysed using standard analytical procedures as outlined below. These procedures meet the requirements of the National Marine Biological Analytical Quality Control Scheme (NMBAQC).

The samples were stained overnight with Eosin-briebrich scarlet to facilitate visual extraction of small individuals The sample contents were split into two fractions, >2 mm and 1-2 mm, and fixed in 70% alcohol. Sieves were thoroughly washed between samples to avoid cross contamination. The fractions were clearly labelled including a permanent internal label in each container.

The >2 mm fraction was placed in an illuminated shallow white tray and sorted first by eye to remove large specimens, and the remainder sorted using a Nikon stereo microscope at 6-10 times magnification. The 1-2 mm fractions were placed into Petri dishes, approximately one half teaspoon at a time and sorted using a Nikon binocular microscope at x 25 magnification.

The fauna were split into five “taxa” in the first instance: molluscs, echinoderms, crustaceans, polychaetes and a miscellaneous grouping consisting of all other taxa, and maintained in stabilised 70% industrial methylated spirit (IMS). These groupings were subsequently identified to species level where practical using a Nikon binocular microscope, a Nikon compound microscope and the best available taxonomic keys. Species nomenclature was classified in accordance with the Unicomarine species list in compliance with NMBAQC guidelines.

After identification and enumeration, specimens were separated and stored to species where possible. All containers were clearly labelled on the outside stating the site, date, replicate number, and the name of the person that analysed the sample. A permanent internal label bearing the same information was also included with all containers. Specimens were stored in stabilised Industrial Methylated Spirits (IMS) in containers with adequate seals to comply with the Control of Substances Hazardous to Health (COSHH) regulations that were labelled accordingly.

Residual detritus was kept in a separate container for each sample, labelled inside and outside. Sample residue was preserved in 10% formalin in containers with adequate seals to comply with COSHH regulations that were labelled accordingly.

Multivariate analyses were carried out using Primer 6.1.7 (Clarke and Warwick, 2001; Clarke and Gorley 2006). The following diversity indices were calculated for the mean faunal data from each station using formulae given in Pielou (1977):

- Shannon-Wiener diversity index (H').
- Simpson’s evenness index (1-λ’)
- Margalef’s species richness index (D).
- Number of species (S)

A mulitmetric index was calculated to determine benthic habitat quality *sensu* the Water Framework Directive (WFD; 2000/60/EC). The UK and Irish Infaunal Quality Index (IQI) version 4 was calculated using a proprietary tool in Microsoft Excel developed by the UK Environment Agency. This includes truncation of the species lists, and spelling and synonym standardisation. IQI was calculated by Equation1.

$$IQI = \frac{\left(\left(0.38\times\left(\frac{(1-AMBI/7)}{(1-AMBI/7)_{\max}}\right)\right)+\left(0.08\times\left(\frac{(1-\lambda')}{(1-\lambda')_{\max}}\right)\right)+\left(0.54\times\left(\frac{S^{0.1}}{S^{0.1}_{\max}}\right)\right)-0.4\right)}{0.6} \quad (1.3.1)$$

Where: AMBI is the AZTI Marine Benthic Index (Borja *et al*., 2000)

1-λ' is Simpson's Evenness Index

$S^{0.1}$ is Log_{10} (number of species)

max parameters are the expected maximum reference values for the habitat

The multimetric boundaries for Water Framework Directive classification of EUNIS A5.2 and A5.3 marine sublittoral sands and muds were used in this study as shown in Table 2.3.

Table 2.3. Classification boundaries for Infaunal Quality Index (IQI).

Classification boundary	IQI	Classification boundary	IQI
Good-High	0.75	Poor-Moderate	0.44
Moderate-Good	0.64	Bad-Poor	0.24

A modified data analysis procedure was used to classify the stations according to the JNCC Biotope scheme. This is explained in detail in Figure 2.3. The faunal data matrix was averaged by station and square root transformed but not standardised. A Bray-Curtis similarity matrix was constructed. The similarity matrix was used to classify the stations into groups of similar elements in a dendrogram by higher agglomerative clustering (HAC) using group average linkage. The Similarity Profile (SimProf) test was used to determine significant difference between the clusters. This technique is a permutation test of the null hypothesis that a specified set of samples, which are not grouped *a priori*, do not differ in multivariate structure. The classification structure output by SimProf was used as the factor in a Similarity Percentages (SIMPER) analysis that determined the characterising species of each group of stations. The characterising species were compared to the JNCC comparative tables (Connor *et al*. 2004) to determine the level 5 biotope classification. The levels higher than 5, i.e. levels 2, 3 and 4, were assigned to match the level 5 biotope and field descriptions. Where the significant cluster produced by SimProf had only one element, i.e. that station was a singleton, Simper analysis was performed on the species abundance data for the replicates from that station and the level 5 biotope was assigned as above.

The power of the measured environmental data to explain the multivariate faunal distribution pattern was determined using distance based linear models (DISTLIM) and distance based redundancy analysis (dbRDA) in the Permanova+ add in for

Primer 6.1.7 (Clarke and Gorley 2006, Anderson *et al*., 2008). DISTLM is a data analysis that performs linear regression using interpoint similarities in the similarity matrix as the response variable. Parsimonious model selection (the ability to determine the optimal subset of predictor variables providing the best explanatory power) is available using standard model fitting techniques such the Akaike Information Criterion (AIC; Akaike 1974) and R^2. The output of the DISTLIM procedure was visualised using dbRDA. In this case, the ordination technique plots fitted values of between sample Bray-Curtis similarity from the prediction of the linear model. A vector overlay of the predictor variables shows visually the influence of each predictor variable.

Square root transformed data are used to calculate Bray Curtis similarity. The Bray Curtis similarity matrix is subjected to higher agglomerative clustering using group average linkage and statistically significant groups are identified in the dendrogram using a similarity profile test. These groups are analysed for characterising species using Simper analyses. The simper outputs were used to determine the level 5 biotope by comparison to the core macrofaunal records in conjunction with the core environmental records. Levels 2, 3 and 4 are usually determined by the mean environmental parameters, for example, grain size of the group. This is a “bottom up approach”.

2.3 RESULTS

2.3.1 Sediments

Table 2.4 shows summary results of the grain size distribution at the stations sampled. Organic content (%LOI) was low at all stations (0.3 to 1.1%). Most stations were largely composed of fine sand, but stations 14, 21 and 22 had significant amounts of medium and coarse sand. Table 2.5 shows the descriptive statistics from these analyses. Most stations were well sorted with unimodal distributions and modes in the fine sand size class (188 µm). Station 21 was the only bimodal station with modes in the gravel and medium sand size classes. It was classified as very coarse sand under the Folk (1954) classification. Stations 14 and 22 were classified as medium sand.

Most stations were classified as sand and muddy sand (SA) under the EUNIS scheme, with only stations 21 and 15 (qualitatively) being classified as coarse sediments (CS).

Figure 2.3. Modified EUNIS / JNCC biotope classification scheme used in this survey.

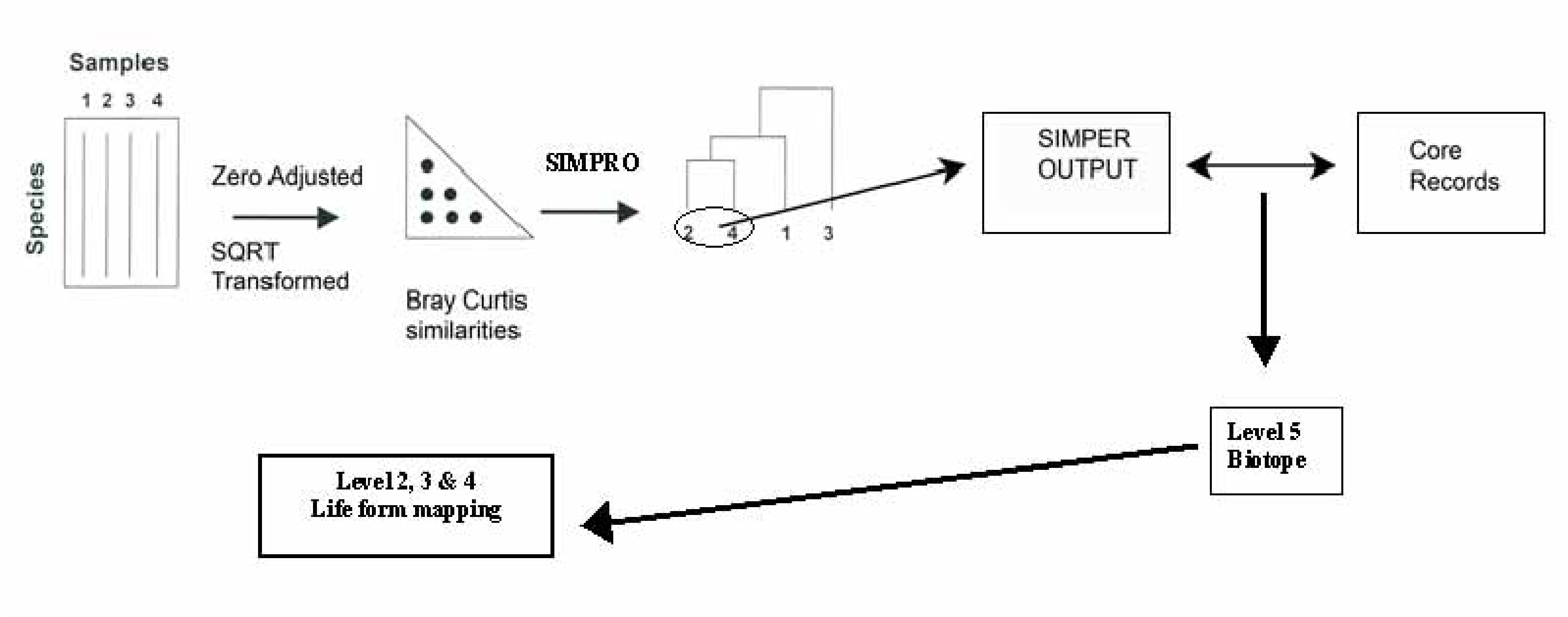


Plate 2.1. Deep circalittoral sandy sediment habitat. Cable route corridor, proposed Atlantic Marine Energy Test Site, Co. Mayo.

Principal components analysis (PCA) of the sediment data (Figure 2.4.) showed that most of the stations overlap in terms of grain size and organic content. The ordination accounts for 69.3% of the total variation in the environmental dataset, and is a good representation of overall pattern. Principal component 1 (PC1) accounts for most of the variation in the plot. On this axis, stations to the right of the origin have higher than average coarse sediment fractions (coarse sand and gravel). Station 21 separates strongly from the other stations. Stations 14 and 22 also separate from the other stations on this axis, but PC2 is also important in differentiating between stations 14 and 22 and the other stations. On PC2, stations above the origin have higher than average medium sand content and depth. There is spatial pattern apparent in the PCA plot. Stations 1 to 5 form a diffuse group in the lower right quadrant of the plot. The symbols overlain on the PCA plot indicate the biotopes assigned to the stations based on the macrofaunal data (Table 2.6). There is some degree of separation of the biotopes on the PCA plot, but the circalittoral fine sand biotopes do not separate clearly.

The symbols indicate the EUNIS biotope assigned to each station, see Table 2.7 for biotope codes. LOI is organic content measured as Loss on Ignition, Gr is gravel >4mm, FGr is Fine Gravel 2-4mm, VCS is very coarse sand 1-2mm, CS is coarse sand 0.5-1mm, MS is medium sand 250-500 µm, FS is fine sand 125-250 µm, VFS is very fine sand 63-125 µm, SC is silt clay <63 µm.

Table 2.4. Summary particle size analysis results.

	%LOI	%Gr	%FGr	%VCS	%CS	%MS	%FS	%VFS	%SC	Depth (m)	Folk	EUNIS SED
NP08-1	1.1	0.0	0.0	0.6	3.1	34.1	59.8	0.9	1.4	5	Fine Sand	SA
NP08-2	1.0	0.0	0.0	0.4	1.0	13.7	80.4	2.9	1.5	12	Fine Sand	SA
NP08-3	0.7	0.0	0.0	0.2	0.5	8.0	86.0	4.1	1.2	21	Fine Sand	SA
NP08-4	0.9	0.0	0.4	1.4	2.5	5.0	72.9	14.6	3.2	27	Fine Sand	SA
NP08-5	0.7	0.2	0.7	1.4	1.1	4.0	81.1	9.3	2.2	32	Fine Sand	SA
NP08-6	0.6	0.0	0.1	0.7	0.7	5.5	87.7	4.4	0.9	34	Fine Sand	SA
NP08-7	0.6	0.0	0.1	0.4	0.9	6.0	84.8	6.9	0.9	38	Fine Sand	SA
NP08-8	0.4	0.0	0.2	0.4	0.6	4.6	85.9	7.6	0.7	38	Fine Sand	SA
NP08-9	0.5	0.0	0.2	0.3	0.5	3.6	83.2	10.4	1.8	52	Fine Sand	SA
NP08-10	0.4	0.0	0.6	0.3	0.6	5.1	80.2	12.3	1.0	56	Fine Sand	SA
NP08-11	0.3	1.0	0.1	0.1	0.3	3.9	86.1	7.5	1.0	52	Fine Sand	SA
NP08-12	0.6	0.0	0.1	0.2	0.5	5.1	85.8	7.4	1.0	54	Fine Sand	SA
NP08-13	0.3	0.0	0.1	0.0	0.4	4.9	88.8	4.8	0.9	52	Fine Sand	SA
NP08-14	0.8	0.0	0.0	0.3	6.4	50.2	40.9	0.7	1.5	51	Medium Sand	SA
NP08-15	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	77	Cobbles and Gravel	CS
NP08-16	0.2	0.0	0.0	0.1	0.2	10.0	84.1	4.6	1.0	83	Fine Sand	SA
NP08-17	0.3	0.0	0.1	0.1	0.2	5.6	84.9	7.5	1.5	86	Fine Sand	SA

	%LOI	%Gr	%FGr	%VCS	%CS	%MS	%FS	%VFS	%SC	Depth (m)	Folk	EUNIS SED
NP08-18	0.3	0.6	0.2	0.1	0.3	5.8	84.9	6.9	1.0	90	Fine Sand	SA
NP08-19	0.3	0.0	0.0	0.2	0.3	5.0	89.0	4.2	1.3	95	Fine Sand	SA
NP08-20	0.3	0.0	0.1	0.1	0.4	6.1	89.9	2.6	0.8	100	Fine Sand	SA
NP08-21	1.4	10.6	31.8	25.1	6.0	16.5	7.7	0.4	1.8	102	Very Coarse Sand	CS
NP08-22	0.3	0.0	0.2	1.0	3.1	57.5	36.5	0.9	0.8	103	Medium Sand	SA
NP08-23	0.6	0.0	0.0	0.1	0.5	7.1	87.0	3.7	1.6	105	Fine Sand	SA
NP08-24	0.4	0.0	0.1	0.2	0.4	4.2	90.1	3.6	1.5	100	Fine Sand	SA
NP08-25	0.3	0.0	0.1	0.1	0.3	4.2	92.2	1.7	1.5	100	Fine Sand	SA

LOI is organic content measured as Loss on Ignition, Gr is gravel >4mm, FGr is Fine Gravel 2-4mm, VCS is very coarse sand 1-2mm, CS is coarse sand 0.5-1mm, MS is medium sand 250-500 µm, FS is fine sand 125-250 µm, VFS is very fine sand 63-125 µm, SC is silt clay <63 µm. Folk is mean sediment type *sensu* Folk (1954). EUNIS SED is the simplified sediment classification scheme for biotope classification *sensu* Long (2006).

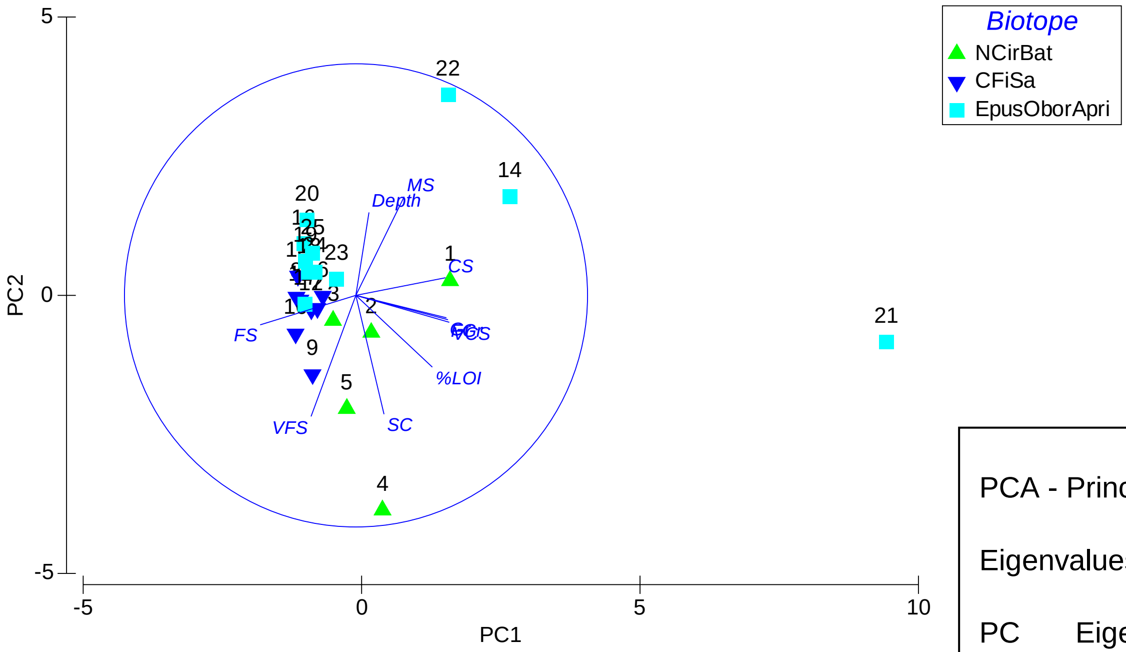
Table 2.5. Sediment descriptive statistics results for proposed wave energy test site west of Annagh Head, Co. Mayo

		FOLK AND WARD METHOD (Ø)				FOLK AND WARD METHOD (Description)				
	Modality	Mz	SORTING	SKEWNESS	KURTOSIS	SORTING:	SKEWNESS:	KURTOSIS:	MODE 1 (µm):	MODE 2 (µm):
NP08-1	Unimodal	2.11	0.64	-0.21	0.79	Moderately Well Sorted	Coarse Skewed	Platykurtic	188	
NP08-2	Unimodal	2.43	0.4	-0.18	1.14	Well Sorted	Coarse Skewed	Leptokurtic	188	
NP08-3	Unimodal	2.48	0.43	-0.12	1.08	Well Sorted	Coarse Skewed	Mesokurtic	188	
NP08-4	Unimodal	2.59	0.67	0.03	1.63	Moderately Well Sorted	Symmetrical	Very Leptokurtic	188	
NP08-5	Unimodal	2.53	0.56	0.01	1.53	Moderately Well Sorted	Symmetrical	Very Leptokurtic	188	
NP08-6	Unimodal	2.50	0.40	-0.10	1.00	Well Sorted	Symmetrical	Mesokurtic	188	
NP08-7	Unimodal	2.50	0.50	0.00	1.20	Well Sorted	Symmetrical	Leptokurtic	188	
NP08-8	Unimodal	2.50	0.40	0.10	1.10	Well Sorted	Symmetrical	Leptokurtic	188	
NP08-9	Unimodal	2.50	0.50	0.20	1.10	Well Sorted	Fine Skewed	Leptokurtic	188	

		FOLK AND WARD METHOD (Ø)				FOLK AND WARD METHOD (Description)				
	Modality	**Mz**	**SORTING**	**SKEWNESS**	**KURTOSIS**	**SORTING:**	**SKEWNESS:**	**KURTOSIS:**	**MODE 1 (µm):**	**MODE 2 (µm):**
NP08-10	Unimodal	2.50	0.50	0.10	1.30	Moderately Well Sorted	Symmetrical	Leptokurtic	188	
NP08-11	Unimodal	2.52	0.44	0.10	1.11	Well Sorted	Fine Skewed	Mesokurtic	188	
NP08-12	Unimodal	2.52	0.44	0.08	1.14	Well Sorted	Symmetrical	Leptokurtic	188	
NP08-13	Unimodal	2.50	0.38	0.03	0.90	Well Sorted	Symmetrical	Mesokurtic	188	
NP08-14	Unimodal	1.90	0.70	0.03	0.83	Moderately Sorted	Symmetrical	Platykurtic	375	
NP08-16	Unimodal	2.47	0.45	-0.10	1.15	Well Sorted	Coarse Skewed	Leptokurtic	188	
NP08-17	Unimodal	2.52	0.46	0.09	1.20	Well Sorted	Symmetrical	Leptokurtic	188	
NP08-18	Unimodal	2.50	0.47	0.01	1.25	Well Sorted	Symmetrical	Leptokurtic	188	
NP08-19	Unimodal	2.50	0.37	0.00	0.88	Well Sorted	Symmetrical	Platykurtic	188	
NP08-20	Unimodal	2.48	0.38	-0.10	0.92	Well Sorted	Coarse Skewed	Mesokurtic	188	

		FOLK AND WARD METHOD (Ø)				FOLK AND WARD METHOD (Description)				
	Modality	**Mz**	**SORTING**	**SKEWNESS**	**KURTOSIS**	**SORTING:**	**SKEWNESS:**	**KURTOSIS:**	**MODE 1 (µm):**	**MODE 2 (µm):**
NP08-21	Bimodal	-0.30	1.41	0.61	0.56	Poorly Sorted	Very Fine Skewed	Very Platykurtic	3000	375
NP08-22	Unimodal	1.87	0.64	0.17	0.78	Moderately Well Sorted	Fine Skewed	Platykurtic	375	
NP08-23	Unimodal	2.49	0.42	-0.10	1.04	Well Sorted	Symmetrical	Mesokurtic	188	
NP08-24	Unimodal	2.50	0.34	0.01	0.75	Very Well Sorted	Symmetrical	Platykurtic	188	
NP08-25	Unimodal	2.49	0.33	0.00	0.74	Very Well Sorted	Symmetrical	Platykurtic	188	

Figure 2.4. Principal components analysis (PCA) plot of environmental variables sampled along proposed cable route.



PCA - Principal Component Analysis

Eigenvalues

PC	Eigenvalues	%Variation	Cum.%Variation
1	5.05	50.5	50.5
2	1.89	18.9	69.3

Eigenvectors: (Coefficients in the linear combinations of variables making up PC's)

2.3.2 Macrofauna

Summary returns for the macrofauna identified for the entire survey are listed in Table 2.6. There were 5268 individuals distributed amongst 172 species and 72 grab samples. The most common species was the pea urchin *Echinocyamus pusillus* a small flattened animal <15 mm in length that inhabits mobile sands and gravels in fully saline water. *Echinocardium cordatum*, the sea potato, is a larger urchin distributed in sands and muddy sands in circalittoral, infralittoral and littoral sediments. *Minuspio multibranchiata* and *Cirriformia tentaculata* are both small polychaete worms that deposit feed on the surface layer of sands and muddy sands in circalittoral and infralittoral sediments. Nemertean worms, *Spiophanes bombyx and Nephtys cirrosa* are common species in circalittoral and infralittoral sands. The distribution of species and individuals among major taxonomic groups is typical of infralittoral and circalittoral sands.

Table 2.6. Summary of macrofauna identified in survey of proposed wave energy test site and cable route west of Annagh Head, Co. Mayo.

Group	S	%S	N	%N
ANNELIDA	73	42.44	2426	46.05
CHELICERATA	1	0.58	1	0.02
CHORDATA	1	0.58	6	0.11
CNIDARIA	2	1.16	140	2.66
CRUSTACEA	43	25	721	13.69
ECHINODERMATA	10	5.81	1005	19.08
MOLLUSCA	33	19.19	620	11.77
NEMATODA	1	0.58	68	1.29
NEMERTEA	1	0.58	191	3.63
PHORONIDA	1	0.58	34	0.65
PLATYHELMINTHES	1	0.58	1	0.02
SIPUNCULA	1	0.58	1	0.02

Table 2.6a. Taxa details

Top 4 taxa by number of individuals		Top 4 taxa by number of samples	
Echinocyamus pusillus	529	NEMERTEA	50
Minuspio multibranchiata	294	Spiophanes bombyx	48
Echinocardium cordatum	259	Nephtys cirrosa	42
Cirriformia tentaculata	207	Minuspio multibranchiata	40

Table 2.7 lists the diversity indices calculated for the mean faunal per station. All of the diversity indices showed a consistent increase with depth and distance seaward from the shore except for Simpson's index. The outer stations were highly diverse in terms of Shannon diversity, while the inner stations showed only moderate diversity. This pattern is reflected in number of species, species richness and number of individuals. Simpson's index was high at all stations except for stations 3 and 4 where 1-λ' was low relative to the other stations, indicating a potential dominance of the abundance by one or a few species. Examination of the species abundance matrix revealed that both stations were numerically dominated by the deposit feeding cirratulid polychaete *Cirriformia tentaculata*. This animal is an opportunistic worm generally associated with physical disturbance or organic enrichment.

Table 2.7. Diversity indices, Simprof grouping and biotope assigned to each station from macrofaunal grab sampling.

Station	S	N	d	H'(loge)	1-λ'	Simprof group	EUNIS Sed	Biotope
NP08-1	12	15.3	4.0	2.1	0.90	a	SA	NCirBat
NP08-2	13	32.7	3.4	2.0	0.84	a	SA	NCirBat
NP08-3	16	37.0	4.2	1.4	0.52	a	SA	NCirBat
NP08-4	23	62.3	5.3	1.9	0.69	a	SA	NCirBat
NP08-5	19	27.7	5.4	2.3	0.87	a	SA	NCirBat
NP08-6	24	23.7	7.3	2.8	0.95	f	SA	CFiSa
NP08-7	20	16.0	6.9	2.8	0.99	f	SA	CFiSa
NP08-8	29	31.3	8.1	3.1	0.98	g	SA	CFiSa
NP08-9	26	24.7	7.8	3.0	0.97	g	SA	CFiSa
NP08-10	29	29.7	8.3	3.1	0.98	g	SA	CFiSa
NP08-11	35	33.7	9.7	3.3	0.98	g	SA	CFiSa
NP08-12	32	37.0	8.6	3.2	0.97	g	SA	CFiSa
NP08-13	36	44.7	9.2	3.3	0.98	g	SA	CFiSa
NP08-14	37	100.0	7.8	2.4	0.86	h	SA	EpusOborApri
NP08-15	n/a	n/a	n/a	n/a	n/a	n/a	CS	CCS
NP08-16	48	55.3	11.7	3.4	0.97	c	SA	EpusOborApri
NP08-17	44	90.0	9.6	3.1	0.93	e	SA	EpusOborApri
NP08-18	33	93.0	7.1	3.0	0.94	e	SA	EpusOborApri
NP08-19	40	84.0	8.8	3.2	0.95	e	SA	EpusOborApri
NP08-20	41	87.7	8.9	3.2	0.96	e	SA	EpusOborApri
NP08-21	67	234.3	12.1	3.1	0.93	h	CS	EpusOborApri

Station	S	N	d	H'(loge)	1-λ'	Simprof group	EUNIS Sed	Biotope
NP08-22	39	80.7	8.7	2.6	0.84	d	SA	EpusOborApri
NP08-23	74	169.0	14.2	3.5	0.96	b	SA	EpusOborApri
NP08-24	60	135.0	12.0	3.5	0.96	b	SA	EpusOborApri
NP08-25	73	211.3	13.4	3.5	0.96	b	SA	EpusOborApri

S is number of species, N is number of individuals, d is Margalef species richness, H'(loge) is Shannon diversity, 1-λ' is Simpson's evenness index. Data used were the average of three Day grab samples per station.

Biotope codes: CfiSa: Circalittoral fine sand. CFiSa.EpusOborApri: *Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand. NcirBat: *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand. CCS: Circalittoral coarse sediment.

Table 2.7 lists the diversity indices used to calculate the Infaunal quality index (IQI). As shown in Equation 1.3.1, IQI uses a modification of the AZTI marine Biotic Index (AMBI; Borja *et al*. 2000) in its calculation. AMBI itself is calculated based on the percentage distribution of ecological groups in the faunal abundance matrix. Each species is assigned to one of five groups based on sensitivity to disturbance. Group I is stress intolerant, Group V is the most stress tolerant, Groups II to IV represent intermediate tolerances. None of the stations in this survey showed a significant percentage of Group V species, the highest values being 2.3% at station 1. Most stations were dominated (>90%) by Groups I, II and III. Stations 3, 4 and 5 had significant amounts of Group IV species (69%, 55% and 39% respectively). At all three stations this is wholly accounted for by *Cirriformia tentaculata.*

The IQI tool uses a reduced data set to calculate the IQI index because of the deletion and aggregation of certain taxa. Consequently the values of S, N and 1-λ' in Tables 2.7 & 2.8 are different, though the same trends in diversity are apparent in both datasets. IQI ecological status was High at all stations seaward of station 5. At stations 1, 2 and 5 the status was Good; while at stations 3 and 4 the status was Moderate. The IQI tool has not been sufficiently tested in areas of natural disturbance. This appears to be the reason for the trend of a decreasing IQI in sampling stations closer inshore where the natural impact of exposure on subtidal sediments increases with decreasing depth. As there is no known anthropogenic impact in this area and no inflow of fresh water it is concluded that the lower IQI values are a result of natural impacts (disturbance due to wave exposure) rather than any anthropogenic impact.

Plate 2.2. Brittle star (*Ophiura ophiura*). Atlantic Marine Energy Test Site, Co. Mayo.

Figure 2.5 shows the dendrogram output from the higher agglomerative cluster analysis of the Bray Curtis similarity matrix based on mean faunal data per station. A similarity profile (Simprof) test was done to discriminate clusters that had significant multivariate structure. Colour coding on the dendrogram shows these groupings. Samples joined by red lines form a significant cluster, while samples and groups joined by black lines do not form a significant cluster. These groupings were used as a factor in a Simper analysis to determine the species that characterise each group. Where a group had only one station, Simper analysis was carried out using the replicate samples from that station. Table 2.9 shows the species characterising each group. This output was compared to the biological tables of core records (Connor *et al*., 2004) to determine a biotope.

Table 2.8.Classification of ecological status of macrofaunal stations sensu the Water Framework Directive using the Infaunal Quality Index (IQI).

Station	I %	II%	III%	IV%	V%	AMBI	S	N	1-λ'	V.4 IQI	V.4 Status	Biotope
NP08-1	34.1	22.7	40.9	0.0	2.3	1.7	10	14.7	0.89	0.70	GOOD	NCirBat
NP08-2	24.2	13.7	60.0	0.0	0.0	2.0	11	31.7	0.82	0.66	GOOD	NCirBat
NP08-3	13.5	13.5	2.7	69.4	0.9	3.5	16	37.0	0.52	0.52	MODERATE	NCirBat
NP08-4	16.7	11.8	1.6	54.8	0.0	3.2	22	62.0	0.69	0.59	MODERATE	NCirBat
NP08-5	20.5	30.8	1.3	38.5	1.3	2.5	16	26.0	0.85	0.65	GOOD	NCirBat
NP08-6	56.9	29.2	10.8	0.0	0.0	0.8	23	21.7	0.94	0.86	HIGH	CFiSa
NP08-7	47.8	32.6	2.2	2.2	0.0	0.8	19	15.3	0.99	0.85	HIGH	CFiSa
NP08-8	57.0	23.7	12.9	1.1	0.0	0.8	28	31.0	0.98	0.87	HIGH	CFiSa
NP08-9	59.7	18.1	15.3	1.4	0.0	0.8	25	24.0	0.97	0.86	HIGH	CFiSa
NP08-10	47.2	19.1	21.3	3.4	1.1	1.2	29	29.7	0.98	0.84	HIGH	CFiSa
NP08-11	37.6	23.8	18.8	5.0	0.0	1.3	35	33.7	0.98	0.84	HIGH	CFiSa
NP08-12	45.9	20.7	23.4	2.7	0.0	1.2	32	37.0	0.97	0.85	HIGH	CFiSa
NP08-13	54.5	18.7	16.4	3.7	0.0	1.0	36	44.7	0.98	0.88	HIGH	CFiSa
NP08-14	78.5	17.5	3.0	0.3	0.0	0.4	34	99.0	0.86	0.92	HIGH	EpusOborApri
NP08-15	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	CCS
NP08-16	43.9	22.0	25.6	0.6	0.0	1.2	46	54.7	0.97	0.88	HIGH	EpusOborApri
NP08-17	60.2	11.9	19.0	6.3	0.0	1.1	43	89.7	0.93	0.88	HIGH	EpusOborApri

Station	I %	II%	III%	IV%	V%	AMBI	S	N	1-λ'	V.4 IQI	V.4 Status	Biotope
NP08-18	52.6	12.5	17.6	8.5	0.0	1.2	32	90.7	0.94	0.84	HIGH	EpusOborApri
NP08-19	51.2	15.4	20.3	4.1	0.0	1.1	39	82.0	0.95	0.87	HIGH	EpusOborApri
NP08-20	44.5	20.1	21.3	9.4	0.0	1.4	40	84.7	0.95	0.84	HIGH	EpusOborApri
NP08-21	54.9	24.8	9.0	3.4	0.7	0.9	61	193.7	0.91	0.92	HIGH	EpusOborApri
NP08-22	54.7	11.0	23.7	4.7	0.0	1.2	37	78.7	0.83	0.85	HIGH	EpusOborApri
NP08-23	37.2	35.8	18.2	4.4	0.0	1.3	71	166.7	0.96	0.90	HIGH	EpusOborApri
NP08-24	32.4	29.0	22.5	7.7	0.5	1.6	59	134.7	0.96	0.86	HIGH	EpusOborApri
NP08-25	42.9	28.2	19.0	4.8	0.0	1.3	72	210.3	0.95	0.91	HIGH	EpusOborApri

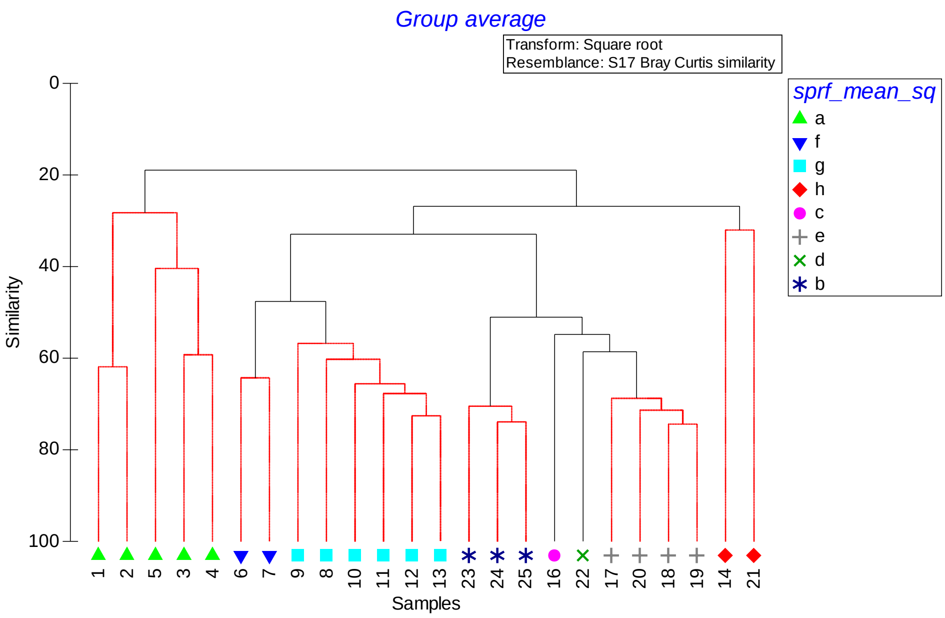
I% to V% are percentage distributions of AMBI groups, AMBI is the biotic coefficient. S, N and 1-λ' are number of species, number of individuals and Simpson's index but differ from the values in Table 2.6 because IQI is calculated based on a reduced species list following aggregation and deletion of some taxa. V.4 IQI is the calculated ecological quality ratio. V.4 status is the ecological quality assigned to the station using the boundaries listed in Table 2.3. Biotope is the biotope assigned. For biotope codes see Table 2.7.

The biotope assigned to each group is listed in Table 2.9 and shown in Figure 2.6. Stations 1 to 5 were assigned to (SS.SSA.IFiSa.NcirBat) *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand. Stations 6 to 13 were assigned to (SS.SSA.CFiSa) Circalittoral fine sand. Stations 14 and 16 to 25 were assigned to (SS.SSA.CFiSa.EpusOborApri) *Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand. Station 15 was qualitatively assigned to (SS.SCS.CCS) Circalittoral coarse sediment based on qualitative grain size analysis and does not feature in the dendrogram. The biotope descriptions for each of these biotopes is presented in Appendix 1.3.1

The ability of the measured environmental variables to explain the multivariate distribution of the macrofauna was determined using distance based linear modelling (DistLim) and distance based redundancy analysis (dbRDA). Model selection using the Akaike Information Criterion (AIC; Akaike 1974) found that the optimal model that explained the most variance in inter-station Bray Curtis similarity using the fewest possible explanatory variables included depth, % coarse sand, % fine sand, % very fine sand and % silt/clay. Figure 2.7 shows the dbRDA plot for the model output. The model explains 58.2% of total variation, but the two-dimensional plot represents only 44.2% of total variation. The biotopes were assigned to the stations were superimposed on the ordination plot and showed clear separation between the biotopes based on the predictor variables. The vector overlay shows that NcirBat is associated with % silt/clay and shallow depth, CFiSa is associated with % very fine sand and EpuOborApri is associated deeper water.

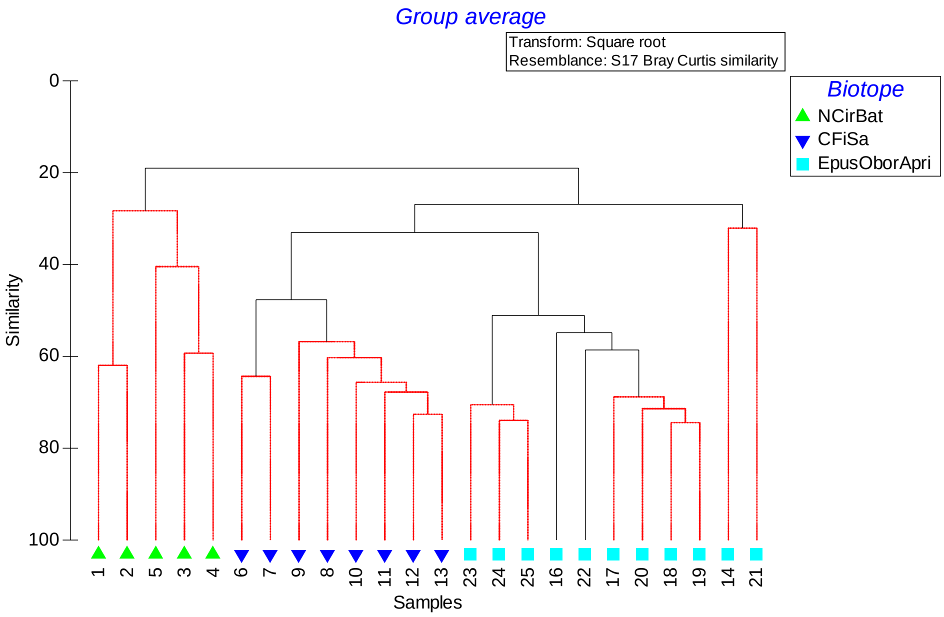
Figure 2.8 shows the spatial distribution of grain size distribution as classified by Folk (1974) and the EUNIS scheme (Long, 2006), the distribution of IQI ecological status and the biotopes assigned to the stations.

Figure 2.5. Dendrogram of cluster analysis of Bray Curtis similarity derived square root transformed mean abundances from macrofaunal samples.



The symbols indicate significant clusters as determined by a similarity profile test.

Figure 2.6 Dendrogram of cluster analysis of Bray Curtis similarity derived square root transformed mean abundances from macrofaunal samples



The symbols indicate biotopes assigned to each cluster following Simper analysis and comparison to the core JNCC records of Connor *et al*. (2004). For biotope codes see Table 2.6.

Figure 2.7 Distance based redundancy analysis dbRDA plot showing the predicted interpoint Bray Curtis similarities from the optimal distance based linear model as determined using the AIC.

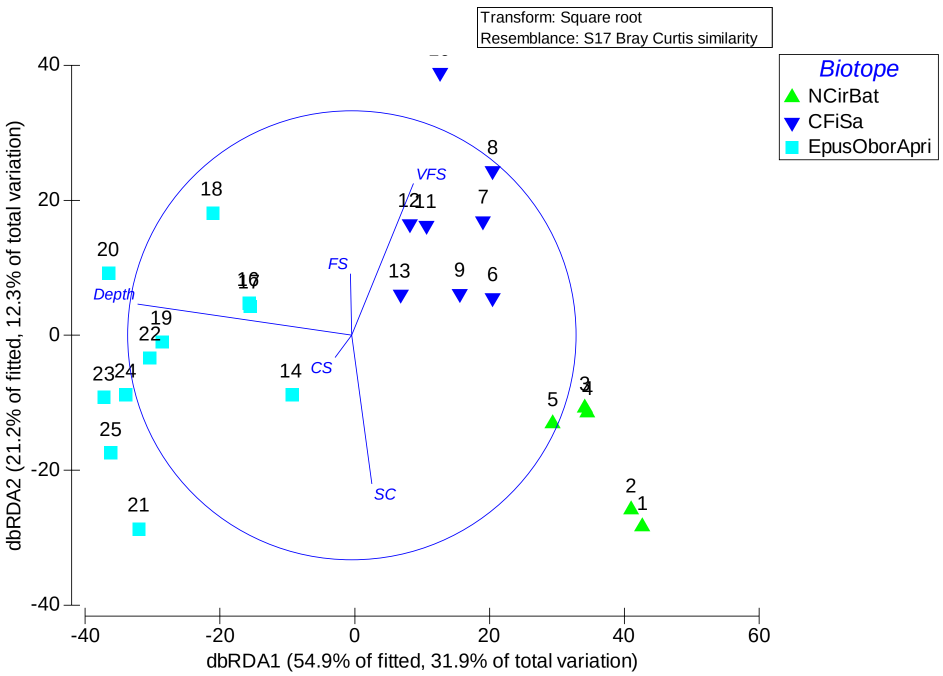
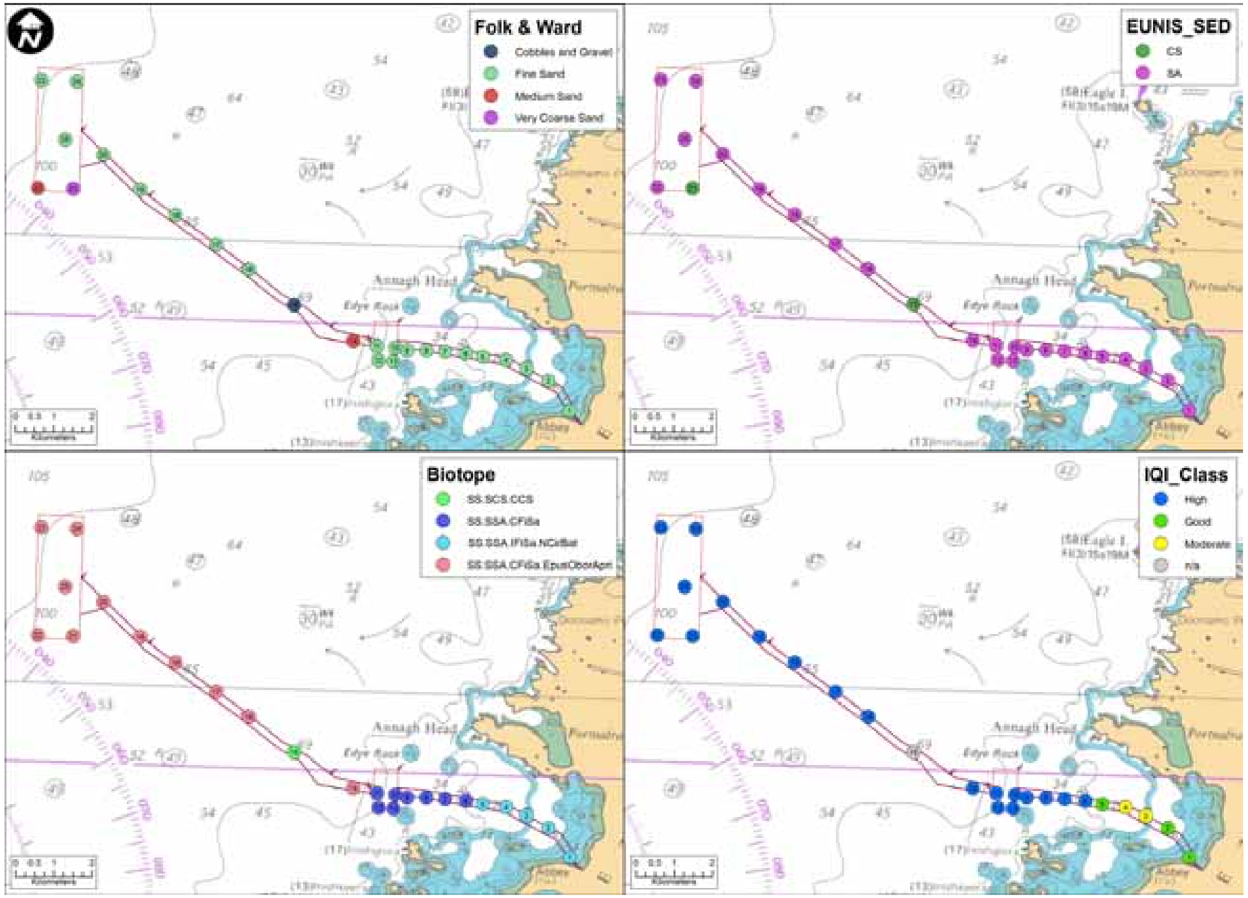


Figure 2.8. Spatial distribution of grain size as classified by Folk and Ward method and EUNIS sediment scheme, biotopes assigned to macrofaunal samples sensu Connor *et al*. (2004) and ecological quality *sensu* the Water Framework Directive as determined using the Infaunal Quality Index (IQI).



R^2 for the model is 0.582, but the two dimensional plot shows only 44.2% of total variation. Vectors for the predictor variables are overlain. The superimposed symbols represent biotopes assigned by Simper analysis, for biotope codes see Table 2.6.

Biotope codes: SS.SSA.CFiSa Circalittoral fine sand SS.SSA.CFiSa.

EpusOborApri Echinocyamus pusillus, Ophelia borealis and Abra *prismatica* in circalittoral fine sand SS.SSA.IFiSa.NcirBat *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral Sand SS.SCS.CCS Circalittoral coarse sediment

Table 2.9a. Species characterising stations 1 to 5 as determined by SIMPER analyses.

Group a: Stations 1 to 5. SS.SSA.IFiSa.NCirBat Average similarity: 37.17					
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Nephtys cirrosa	1.43	6.54	2.51	17.60	17.60
Cirriformia tentaculata	2.79	5.17	0.60	13.91	31.51
Spiophanes bombyx	1.51	4.06	0.90	10.92	42.43
Bathyporeia elegans	1.14	3.95	1.13	10.62	53.05
Iphinoe trispinosa	0.80	2.60	1.07	6.98	60.03
Echinocardium cordatum	0.56	1.81	1.14	4.87	64.90
Pontocrates altamarinus	0.56	1.50	0.62	4.04	68.94
Scolelepis squamata	0.60	1.45	0.55	3.89	72.83
Bathyporeia guilliamsoniana	0.59	1.39	0.61	3.75	76.58
NEMERTEA	0.68	1.34	0.61	3.61	80.18
Capitella	0.35	1.07	0.62	2.87	83.05
Perioculodes longimanus	0.60	1.00	0.60	2.68	85.73
Donax vittatus	0.68	0.94	0.32	2.54	88.27
Ammodytes	0.39	0.92	0.61	2.49	90.76

Table 2.9b. Species characterising stations 6 to 7 as determined by SIMPER analyses.

Group f: Stations 6 to 7. SS.SSA.CFiSa Average similarity: 64.34					
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Travisia forbesii	1.86	7.36	-	11.43	11.43

Group f: Stations 6 to 7. SS.SSA.CFiSa Average similarity: 64.34					
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Nephtys cirrosa	1.22	6.01	-	9.34	20.77
Hippomedon denticulatus	1.28	6.01	-	9.34	30.10
Diastylis bradyi	1.28	6.01	-	9.34	39.44
Sigalion mathildae	1.00	5.20	-	8.08	47.52
Owenia fusiformis	0.82	4.25	-	6.60	54.12
Bathyporeia elegans	0.82	4.25	-	6.60	60.73
Siphonoecetes kroyeranus	0.99	4.25	-	6.60	67.33
NEMERTEA	0.87	3.00	-	4.67	71.99
Glycera tridactyla	0.58	3.00	-	4.67	76.66
Spiophanes bombyx	0.93	3.00	-	4.67	81.33
Magelona johnstoni	0.79	3.00	-	4.67	86.00
Synchelidium maculatum	0.93	3.00	-	4.67	90.66

Table 2.9c. Species characterising stations 8 to 13 as determined by SIMPER analyses.

Group g: Stations 8 to 13. SS.SSA.CFiSa Average similarity: 62.00					
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Travisia forbesii	1.37	3.90	3.30	6.29	6.29
Hippomedon denticulatus	1.46	3.89	3.58	6.27	12.56
Eurydice pulchra	1.21	3.48	4.06	5.62	18.18
Scolelepis squamata	1.21	3.27	2.83	5.28	23.46
Pseudocuma longicornis	1.16	3.23	6.56	5.21	28.67
Diastylis bradyi	1.15	3.13	2.52	5.05	33.72
Echinocardium cordatum	1.39	3.02	1.33	4.87	38.58
Bathyporeia elegans	1.11	2.99	3.80	4.82	43.40
Minuspio multibranchiata	1.21	2.77	1.34	4.48	47.88
Ampelisca brevicornis	1.00	2.77	3.87	4.47	52.35
NEMERTEA	1.01	2.69	4.43	4.35	56.69
Spiophanes bombyx	0.98	2.67	3.43	4.31	61.00

Group g: Stations 8 to 13. SS.SSA.CFiSa Average similarity: 62.00					
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Magelona johnstoni	0.85	2.33	4.21	3.75	64.75
Sthenelais limicola	0.88	2.12	1.35	3.42	68.17
Chaetozone setosa	0.78	2.12	6.95	3.42	71.59
Owenia fusiformis	0.92	2.04	1.33	3.28	74.87
Scoloplos armiger	0.91	1.93	1.26	3.11	77.98
Ophiura ophiura	0.88	1.89	1.27	3.05	81.04
Nephtys cirrosa	0.88	1.68	1.18	2.71	83.74
Chamelea gallina	0.48	1.24	1.36	1.99	85.73
Dosinia lupinus	0.69	1.09	0.78	1.76	87.50
Echinocyamus pusillus	0.64	0.89	0.78	1.43	88.93
Aricidea cerrutii	0.59	0.86	0.76	1.38	90.31

Table 2.9d. Species characterising stations 14 to 21 as determined by SIMPER analyses.

Group h: Stations 14 and 21. SS.SSA.CFiSa.EpusOborApri Average similarity: 32.05					
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Echinocyamus pusillus	5.28	6.61	-	20.64	20.64
Glycera lapidum	3.36	2.76	-	8.62	29.26
Polygordius appendiculatus	3.90	2.76	-	8.62	37.88
Owenia fusiformis	1.35	1.86	-	5.81	43.69
Aricidea cerrutii	1.62	1.67	-	5.20	48.89
Minuspio multibranchiata	2.21	1.67	-	5.20	54.09
NEMERTEA	1.45	1.18	-	3.68	57.77
Pisione remota	2.43	1.18	-	3.68	61.45
Goniada maculata	0.82	1.18	-	3.68	65.12
Eurydice pulchra	2.97	1.18	-	3.68	68.80
Malmgreniella ljungmani	0.70	0.83	-	2.60	71.40
Syllis armillaris	1.00	0.83	-	2.60	74.00
Lumbrineris gracilis	0.87	0.83	-	2.60	76.60

Group h: Stations 14 and 21. SS.SSA.CFiSa.EpusOborApri Average similarity: 32.05					
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Polycirrus norvegicus	0.58	0.83	-	2.60	79.20
Copepoda	1.70	0.83	-	2.60	81.80
Perioculodes longimanus	0.58	0.83	-	2.60	84.40
Ampelisca brevicornis	0.70	0.83	-	2.60	87.00
Bathyporeia elegans	0.58	0.83	-	2.60	89.60
Mactra stultorum	0.70	0.83	-	2.60	92.20

Table 2.9e. Species characterising station as determined by SIMPER analyses.

Group c: Station 16 only. SS.SSA.CFiSa.EpusOborApri Average similarity: 40.15. These results are based on within station replicates.					
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Minuspio multibranchiata	2.03	4.88	4.51	12.15	12.15
Echinocyamus pusillus	2.51	4.88	4.51	12.15	24.30
NEMERTEA	1.61	4.13	10.77	10.29	34.59
Magelona filiformis	1.58	3.61	3.20	8.99	43.58
Sthenelais limicola	1.28	3.31	5.21	8.25	51.83
Ampelisca brevicornis	1.38	3.30	6.37	8.21	60.04
Lumbrineris gracilis	1.33	2.92	10.77	7.28	67.32
Abra nitida	1.48	1.81	0.58	4.52	71.83
Scoloplos armiger	1.24	1.57	0.58	3.91	75.74
Owenia fusiformis	1.14	1.28	0.58	3.19	78.93
Spio martinensis	0.67	1.08	0.58	2.68	81.62
Edwardsia	0.67	0.94	0.58	2.34	83.95
Hyalinoceia bilineata	0.91	0.94	0.58	2.34	86.29
Pagurus bernhardus	0.67	0.94	0.58	2.34	88.63
Thracia phaseolina	0.80	0.94	0.58	2.34	90.97

Table 2.9f. Species characterising stations 17 to 20 as determined by SIMPER analyses.

Group e: Stations 17 to 20. SS.SSA.CFiSa.EpusOborApri Average similarity: 70.59					
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Echinocyamus pusillus	3.45	5.90	8.19	8.35	8.35
Minuspio multibranchiata	2.76	5.14	22.51	7.29	15.64
Magelona filiformis	2.92	4.61	6.55	6.53	22.17
Thracia phaseolina	2.15	3.67	9.15	5.20	27.37
NEMERTEA	2.21	3.55	3.91	5.03	32.40
Dosinia lupinus	2.00	3.47	7.10	4.91	37.32
Sthenelais limicola	1.57	2.88	18.17	4.07	41.39
Travisia forbesii	1.70	2.75	8.32	3.89	45.28
Abra nitida	1.54	2.66	5.67	3.77	49.05
Magelona alleni	1.81	2.55	2.32	3.61	52.65
Spiophanes bombyx	1.32	2.18	3.44	3.09	55.74
Phoronis	1.21	2.11	11.51	2.98	58.72
Bathyporeia elegans	1.15	2.10	12.92	2.98	61.70
Prionospio fallax	1.23	2.02	3.86	2.86	64.56
Scoloplos armiger	1.29	1.99	2.07	2.82	67.38
Gastrosaccus normanii	1.31	1.99	2.07	2.82	70.20
Lumbrineris gracilis	1.21	1.93	5.02	2.73	72.94
Owenia fusiformis	1.34	1.84	2.19	2.61	75.54
Chaetozone setosa	1.42	1.83	3.14	2.59	78.13
Aricidea cerrutii	1.12	1.40	0.91	1.98	80.11
Scolelepis squamata	0.83	1.27	3.70	1.79	81.91
Ampelisca brevicornis	0.79	1.27	3.70	1.79	83.70
Aricidea minuta	1.13	1.26	0.90	1.78	85.48
Edwardsia	0.95	1.20	6.95	1.71	87.18
Nephtys cirrosa	1.01	1.14	0.91	1.61	88.79
Spio martinensis	0.58	1.13	57.57	1.60	90.39

Table 2.9g. Species characterising station 22 as determined by SIMPER analyses.

Group d : Station 22 only. SS.SSA.CFiSa.EpusOborApri Average similarity: 40.99. These results are based on within station replicates.					
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Echinocyamus pusillus	5.19	11.65	17.51	28.41	28.41
Minuspio multibranchiata	3.49	7.31	18.17	17.83	46.24
Lumbrineris gracilis	1.14	3.12	3.81	7.61	53.85
Ampelisca brevicornis	1.14	3.12	3.81	7.61	61.45
Aricidea minuta	1.56	1.63	0.58	3.99	65.44
Travisia forbesii	1.39	1.27	0.58	3.09	68.53
Abra nitida	1.15	1.27	0.58	3.09	71.61
Euspira pallida	0.67	1.25	0.58	3.04	74.66
Aphelochaeta	0.67	1.14	0.58	2.78	77.44
Aricidea cerrutii	1.14	1.03	0.58	2.52	79.96
Prionospio fallax	0.94	1.03	0.58	2.52	82.48
Owenia fusiformis	1.14	1.03	0.58	2.52	85.00
Gastrosaccus normanii	1.05	1.03	0.58	2.52	87.52
NEMERTEA	1.44	0.73	0.58	1.78	89.31
Sthenelais limicola	0.91	0.73	0.58	1.78	91.09

Table 2.9h. Species characterising stations 23 to 25 at the proposed AMETS Co. Mayo as determined by SIMPER analyses.

Group b: Stations 23 to 25. SS.SSA.CFiSa.EpusOborApri Average similarity: 71.65					
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Edwardsia	3.66	3.99	27.83	5.57	5.57
Abra nitida	3.12	3.35	11.26	4.68	10.25
Minuspio multibranchiata	2.93	2.89	26.93	4.04	14.29
Ophiura ophiura	3.17	2.89	5.77	4.03	18.32
Echinocyamus pusillus	3.08	2.85	5.78	3.98	22.30
Thracia phaseolina	2.81	2.76	4.49	3.86	26.16
Lumbrineris gracilis	2.54	2.57	9.72	3.59	29.75

Group b: Stations 23 to 25. SS.SSA.CFiSa.EpusOborApri Average similarity: 71.65					
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
NEMERTEA	2.48	2.47	4.23	3.45	33.20
Spiophanes bombyx	2.41	2.43	5.39	3.39	36.59
Echinocardium cordatum	3.59	2.23	1.01	3.11	39.70
Aricidea minuta	2.13	2.21	29.33	3.08	42.78
Sthenelais limicola	2.05	1.98	22.26	2.76	45.54
Chaetozone setosa	1.88	1.95	6.28	2.72	48.26
Magelona filiformis	1.81	1.83	14.36	2.56	50.82
Scoloplos armiger	1.96	1.82	20.07	2.54	53.36
Aricidea cerrutii	1.87	1.76	12.44	2.45	55.81
Harpinia antennaria	1.60	1.72	14.36	2.40	58.21
Philine scabra	1.93	1.67	5.77	2.33	60.54
Amphipholis squamata	1.49	1.38	2.72	1.92	62.46
Glycera tridactyla	1.32	1.34	32.98	1.88	64.33
Phaxas pellucidus	1.57	1.26	2.09	1.76	66.10
Prionospio fallax	1.30	1.18	9.02	1.65	67.75
Scaphander lignarius	1.48	1.16	3.13	1.63	69.37
Phoronis	1.29	1.14	2.87	1.59	70.97
Acanthocardia echinata	1.18	1.12	14.36	1.57	72.53
Dosinia lupinus	1.21	1.12	14.36	1.57	74.10
Asterina	1.05	1.12	14.36	1.57	75.67
Orchomenella nana	0.99	0.99	7.11	1.38	77.05
Pseudocuma longicornis	0.99	0.99	7.11	1.38	78.42
Nephtys cirrosa	0.93	0.92	14.36	1.28	79.70
Bathyporeia elegans	0.93	0.92	14.36	1.28	80.99
Aphelochaeta	1.13	0.92	1.95	1.28	82.27
Phyllodoce longipes	0.96	0.82	2.47	1.14	83.41
Copepoda	0.96	0.80	3.70	1.11	84.52
Spio martinensis	0.74	0.74	4.49	1.03	85.55
Podarkeopsis capensis	0.74	0.73	6.93	1.02	86.57

Group b: Stations 23 to 25. SS.SSA.CFiSa.EpusOborApri Average similarity: 71.65					
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Magelona alleni	0.80	0.73	6.93	1.02	87.59
Abra prismatica	1.19	0.65	0.58	0.91	88.50
Anaitides rosea	0.66	0.65	14.36	0.91	89.41
Scolelepis squamata	0.89	0.65	14.36	0.91	90.31

2.4 DISCUSSION

Sediment distribution along the proposed cable route and in the proposed Test Areas is quite consistent, with most stations being classified as infralittoral or circalittoral fine sands. These habitats are characterised by frequent disturbance due to wave action and currents and the macrofaunal communities tend to be robust to disturbance events (Hall, 1994; Eleftheriou and Robertson, 1992; Newell *et al.,* 1998). At depths greater than the reach of wind-wave disturbance macrofaunal communities on sandy bottoms tend to be well developed in terms of diversity and community structure. At shallow depths where wave disturbance reaches the seafloor coastal sandy communities are often characterised by low diversity, opportunistic species and early successional stages (McCall, 1977; Rhoads *et al.* 1978).

The ecological status of the stations sample was generally High or Good. There was a tendency for lower diversity in shallower water to lead to a lower classification of habitat quality, particularly at stations 3 and 4. Connor *et al.* (2004) state that CFiSa is generally more stable than the shallower infralittoral biotopes and consequently supports a more diverse fauna. In the case of this survey it appears that the shallower stations are subjected to more physical disturbance from wave action and tidal currents. This is the likely cause of the lower diversity at the NcirBat stations. There is clear spatial pattern in the distribution of sediments between the NcirBat stations and the CFiSa stations. This pattern can be explained using the measured environmental variables. Depth is an important parameter in the DISTLIM and dbRDA analyses. The lower IQI status assigned to the NcirBat stations is attributable to lower diversity and the abundance of an opportunistic polychaete *Cirrifomia tentaculata* at stations 3, 4 and 5. The generally low baseline numbers of species and individuals in the shallower stations amplifies the effect of the settlement of *C. tentaculata*, in terms of the distribution of AMBI groups at these stations. Diversity and IQI status increase with increasing water depth.

The data obtained from this survey conformed well to established biotopes in as far as possible. NcirBat is a relatively common biotope and is well described from the British Isles. Other than the apparent settlement of *C. tentaculata*, the data in this survey are a good match to the core records. The CFiSa biotopes (EpusOborApri is a subset of CFiSa) are not well described in the core records and are described only from the North Sea. As can be seen from Appendix 5, there are no indicative quantitative abundances to compare Simper outputs for determining these biotopes. The stations classified here, as CFiSa are a good general match for the biotope description. Those classified as EpusOborApri were classified so because of the very high densities of *Echinocyamus pusillus.* There is no temporal variability information available concerning CFiSa in Connor *et al.* (2004). Consequently, published accounts of the variability and response to disturbance of circalittoral and infralittoral sand biotopes are used to inform the assessment in this study.

While there are several published accounts concerning the environmental impacts of fibre optic cable laying on the seafloor (Kogan *et al.* 2006; Coffen-Smout and Herbert, 2000), there is very little published describing the effects of buried electrical cable laying on the macrobenthos. Andrulewicz *et al.* (2003) describe the environmental effects of the installation and functioning of the submarine SwePol Link HVDC transmission line in the Polish Marine Area of the Baltic Sea. They found that one year after the cable had been laid no mechanical disturbances on the dynamic sandy bottom were visible. Studies of the bottom macrofauna indicated that there had been no significant changes in zoobenthos species composition, abundance or biomass, which could have been clearly related to cable installation. Changes in the components of the magnetic field, although significant in the vicinity of the cable itself, did not exceed natural variability at a distance of 20 m. Given that the proposed site for this development is also a dynamic sandy bottom, this would indicate that a recovery time in the order of one year is likely for this development.

2.5 IMPACT OF THE DEVELOPMENT

Possible impacts on the benthic habitats are broadly associated with physical disturbance, the creation of artificial reef structures and possible electromagnetic and thermal radiation from cables. All of these are specific to the habitat in question (Hiddink *et al*., 2007) and to the nature of the disturbance event (Kaiser *et al.,* 2006). Sandy habitats similar to those present at the site are generally less sensitive to physical disturbance by trawling gear than muddy habitats. Very few studies describe the direct effects of cable laying in sediments, possibly because the scale of the disturbance footprint is generally considered to be minor. Petersen and Malm (2006) suggest that where an offshore renewable energy development occupies <1% of the spatial extent of a habitat, the area of habitat removal involved in construction and operation can be considered negligible. This is very likely to be the case in this development. Combined with the sandy nature of the biotopes, the dispersive nature of the high-energy water movement, and general tolerance of the associated fauna to sediment resuspension, it is likely that the impacts of the development will lie within the natural variability of the area.

2.5.1 General effects

General effects will include construction disturbance associated with cable laying, mooring deployment and device deployment. The main concern with construction effects is physical disturbance. The operational phase of the development provides a lesser potential for physical disturbance effects. There is potential for physical disturbance during device deployment and in mooring servicing. The mooring chains move with the tide and may disturb the bottom. Other potential effects during operation include the use of antifoulants and the possibility of spills of hydraulic fluids from damaged devices.

Artificial reef (which may be formed by the placement of rock armour over sections of the cable route) can affect the benthos by changing hydrodynamic effects causing increased bottom scour and/or deposition. The fish and scavenging macrofauna such as decapod crustacean and large gastropods attracted to artificial reefs can cause significant change in macrobenthic community structure because of predation on benthic fauna. In the case of this development, the rock armour is likely to develop a rich faunal community, particularly because of the proximity of natural reef habitats in the area. The gravity anchors, suction anchors or embedment anchors which may be used to anchor the WETS may have a less positive effect on diversity depending on their composition but these may also require scour protection. The effects of the rock armour along sections of the cable route are considered in more detail in Section 1 of this report.

The main concern of Electromagnetic Fields (EMF) in marine systems relates to their potential effect on organisms that are either magnetoreceptive, e.g. marine mammals, or electroreceptive, e.g. Chondrichthyes. The flow of electric current within an electrical sub-sea cable creates electric and magnetic fields. Subsea electricity cables are designed to use either direct current (DC) or alternating current (AC), both of which emit EMF. The two constituent fields of the EMF are defined as the E (Electric) field and the B (Magnetic) field. Industry standard AC cables will effectively shield against direct electric field emissions but do not completely shield the magnetic component. This magnetic field may induce an electric field outside the cable termed the induced electric field (iE field) adjacent to the cable due to magnetic properties.

The electromagnetic field emissions from the marine cable are very small from a human perspective but they come within the range of bioelectrical emissions utilised by certain electrosensitive species. Hence, there is some potential to interact with aquatic animals that are sensitive to electric (E-field) and magnetic (B-field) fields. This mainly affects fish, particularly the elasmobranchs, and marine mammals that use the Earth’s magnetic field to navigate. Sub-sea cables produce electromagnetic fields in the order of 0.6-7 μT at a distance of approximately 0.5m from the cable. The nature and strength of the field depends on voltage and current and the design of the transmission system. A 95mm^2, 10 kV cable is proposed for the AMETS, giving an associated electromagnetic field of 3.2 μT. The electromagnetic field decreases with distance from the cable, and at a distance of approximately 1m is likely to be <1 μT (Olsson, 2009).

There is currently no literature that documents electro reception in marine invertebrates, although Bullock *et al* (1999) suggests a lack of research in this area may have contributed to this fact. Evidence suggests that lobsters are capable of using magnetic fields for navigation (Boles and Lohman, 2003). While the possible effects of EMF from buried cables servicing windfarms has been the subject of research in recent years, the available data is not sufficient to make reasonable statements on the possible effects of electromagnetic fields on benthic organisms. However, in regard to benthic marine invertebrates, such effects are likely to only occur in close vicinity to the cables (Meißner and Sordyl 2006).

The Ospar Commission assessment of the environmental impacts of cables (Merck and Wasserthal, 2009) concluded that due to the lack of field studies on operational submarine cables the effects of artificially increased temperature on benthos are difficult to assess.

Published negative effects of increased temperature include decreased recruitment of fish juveniles to the benthos (Drinkwater, 2004) and increased mortality in intertidal snails (Newell, 1979). A permanent increase of the seabed temperature will lead to changes in physiology, reproduction or mortality of certain benthic species and possibly to subsequent alteration of benthic communities due to emigration or immigration (Merck and Wasserthal 2009; Hiscock *et al*., 2004). The temperature increase of the upper layer of the seabed inhabited by the majority of benthos depends, amongst other factors, on the burial depth of the cable. To reduce temperature rise an appropriate burial depth should be applied.

Other than direct effects on the marine biota, temperature rise of the sediment due to heat emission from the cable may also alter the physico-chemical conditions in the sediment and increase bacterial activity (Meißner and Sordyl, 2006). Knowledge of warming effects on bacterial and other microbial activity and, thus on biogeochemical processes is currently insufficient. Processes set off in deeper sediment layers by increased temperatures such as the release of methane or hydrogen sulphide are likely to affect the entire seabed above the cable due to contact with pore water. Alteration of sediment chemistry is likely to cause secondary impacts on benthic fauna and flora (Pearson and Rosenberg, 1978). The nature of these processes will be determined by grain size and organic content of the sediments.

2.5.2 Construction phase

The industry standard methods of cable burial are water jetting and ploughing. Water jetting tends to resuspend more sediment than ploughing but this is dependent on the substrate. Ploughing devices usually fill in the trench behind them as they lay the cable. Trenches created by water jetting can take up to one month to fill in by tidal sediment movement. Cable burial by any method will lead to some amount of habitat loss, potential increased sedimentation on reefs and adjacent sedimentary habitats, and possible release of pollutants and/or toxic compounds associated with reduced sediments dredged up from below the oxidized layer of surficial sediments (Shields *et al*. 2009).

Protection such as rock armour will be placed over the cable for 4km the cable route that passes over cobbles and cannot be trenched. Rock armour will also be placed over the cable from the outer box as it passes through the inner box to prevent devices in this area anchoring over the cable. While full details are yet unavailable, this will lilely consist of 1-2 layers of graded boulders that are chemically inert being placed over the cable.

Various WECs have different depth and mooring requirements. Some such as Wavebob and Pelarmis require soft sediment bottoms and deeper water (>50 m) to operate effectively. The typical anchoring systems likely to be used for WECs are described in Chapter 4 of the EIS. The discussion below focuses on the two devices most likely to be deployed at the AMETS site.

Moorings are likely to be created for a maximum of five Wavebob devices and five Pelarmis devices in the outer box and two WEC devices in the inner box. Wavebob devices will be anchored using suction anchors of 4.5m in diameter that are buried 7m into the seafloor and protrude 1.5m into the water column. The protruding section of the suction mooring will provide a substrate for an artificial reef. A single cable runs from this mooring to the Wavebob device.

Mooring deployment will lead to habitat removal for the actual footprint of the mooring and is likely to have temporary negative effects on macrofaunal community structure in a radius of tens of metres from each mooring. The Pelamis moorings will be gravity/embedment anchors that will simply be dropped to the bottom. The mooring chains attached to the Pelarmis devices will sweep the seafloor and may cause disturbance effects to the macrofaunal communities. There will be a small amount of habitat loss under the footprint of the anchors, while the anchors themselves will provide a substrate for the development of an artificial reef.

Disturbance by boat traffic is unlikely to be an issue. The innermost area may experience some bottom disturbance from boat activity, but these habitats are frequently effected by wave disturbance and are robust to this type of effect.

Possible hazards from construction work include fuel and lubricant spills from construction equipment. These risks should be assessed on site and standard operating procedures to minimise these risks adopted.

2.5.3 Operational phase

Physical disturbance during the operational phase is likely to be minor compared to the construction phase. The mooring chains will sweep the bottom, causing disturbance in a radius around the mooring in the order of 100 m. There may be minor shifting of the gravity/embedment anchors during servicing and replacement of the Pelarmis devices. Gravity anchors will be replaced on a regular cycle. This has not been specified at this point. This level of disturbance is likely to lie within the natural variability of the area.

The use of antifoulants on wave energy devices may cause a negative impact on local communities. This is unlikely to have a significant impact on the benthos in deep water. The Pelarmis device does not use antifoulants, while the antifoulant use of the Wavebob device has not been specified at this point.

Electromagnetic radiation is likely to have no significant effect on the benthic macrofauna based on the available literature. Thermal radiation from the cable is reported as being very low. The fine sandy sediment should allow any heat created by the cables to dissipate efficiently. The cable will be buried to a depth of 1m where possible, which will reduce any warming of the surficial sediments. The low organic content of the sediments is unlikely to provide a food source for increased bacterial activity to cause out-gassing from the reduced sediments at depth.

The overall impact although negative will not be significant.

2.6 MITIGATION OF IMPACTS

2.6.1 Construction phase

The proposed site meets the criteria for good site selection well. The AMETS has a community that is robust to physical disturbance and the habitats likely to be affected are large enough in spatial extent so that the construction activities effect a small (<1%) portion of the soft sediment habitats. This will prevent habitat fragmentation and encourage the rapid recolonisation of the impacted area both by horizontal migration and larval settlement.

On-site mitigation of construction activities should include the use of the smallest possible footprint for the laying of cables and burial of mooring structures. This will lead to the smallest amount of resuspended sediment settling on reefs and adjacent sedimentary habitats in the area, and minimize direct habitat loss. It is also advisable to perform as much of the construction work as possible in a single phase of work so that the disturbance effects of construction do not become chronic. This will allow the area as a whole to recover as quickly as possible.

Ploughing would provide the preferred method of cable laying as this technique fills in the trench behind it as it lays the cable. This technique would shorten the recovery time of the habitat by providing suitable substrate for recolonisation by macrofauna.

2.6.2 Operational phase

Physical disturbance to the seabed caused by servicing the wave energy devices are likely to be insignificant.

Antifoulant use should be minimized to prevent the excessive accumulation of tributyl tin and similar compounds in the sediments of the area, particular the infra littoral and littoral sediments.

Temperature increases associated with heat loss from the buried cables should be minimised by specifying a cable that radiates very little heat. The cable should be buried to a depth of 1m where possible to minimize warming of the surficial sediments.

2.7 MONITORING

There are very few studies directly applicable to this development, and the biotopes in the area are only loosely defined. However, given the overall assessment that the communities of the proposed development area are likely to be robust to the disturbance involved in construction and operation, no benthic monitoring is likely to be needed for this development

Table 2.10. Potential impacts during construction phase

Species and Habitats	Potential impacts
All infauna	Cable trenching may cause damage to or loss of species in areas trenched. The trenching process may increase sedimentation on adjacent sedimentary habitats, and possible release of pollutants and/or toxic compounds associated with reduced sediments dredged up from below the oxidized layer of surficial sediments. The placement of rock armour over areas of soft sediments to prevent anchor scour may cause species loss and damage. Fuel and lubricant spills from vessels and WECs during construction may cause species loss
Soft sediment habitats	Rock armouring will cause habitat loss on areas of soft sediment over which it is placed Mooring deployment will lead to habitat removal for the actual footprint of the mooring and is likely to have temporary negative effects on macrofaunal community structure in this area. The mooring chains attached to the WECs will sweep the seafloor and may cause disturbance effects to the macrofaunal communities in the area of the anchor sweep. Disturbance by boat traffic during construction is unlikely to be an issue throughout most of the proposed site where depth is greater than 20 m. The innermost area may experience some bottom disturbance from boat activity during cable trenching. Fuel and lubricant spills from vessels and WECs during construction may cause habitat damage

Where likely impacts have been identified in terms of a species or a habitat, the significance of this impact has been assessed, following a standard assessment process detailed below.

Table 2.11. Assessment of significance – Construction phase

Potential impact:	**Species loss and damage to soft sediment habitats**
Significance criteria	
Character and perceived value of affected environment	No Annex I habitat, Annex II species or rare or unusual species have been recorded. The entire site is a highly exposed environment and the soft sediment habitats and species within them are characteristic of this environment, which is common along the west coast of Ireland.
Confidence in the accuracy of predictions of change	Cabling activity will cause increased sedimentation, which may cause a temporary disturbance of species. The placement of rock armouring to prevent scouring of the anchoring system will cause small-scale local habitat loss.
Magnitude, spatial extent and duration of anticipated change	The loss of the existing soft sediment habitats will be negligible. Disturbance to species due to cable trenching are likely to be of very short duration, i.e. within one season.
Resilience of environment to cope with change	The existing infaunal community is robust to physical disturbance and the habitats likely to be affected are large enough in spatial extent so that the construction activities effect a small (<1%) portion of the habitat
Scope for mitigation, sustainability and reversibility	An Oil Pollution Emergency Response Plan will deal with the risks associated with accidental spillage of fuel or lubricants. The smallest digging footprint possible should be used for the trenching of cables and burial of mooring structures
SIGNIFICANCE OF IMPACT	**LOW**

Table 2.12. Potential impacts during operational phase.

Species and habitats	Potential impacts
All infauna	Contamination from antifoulants. Temperature rise in vicinity of cables.
Soft sediment habitats	Contamination from antifoulants.

Where likely impacts have been identified in terms of a species or a habitat, the significance of this impact has been assessed, following a standard assessment process detailed below.

Table 2.13. Assessment of significance during operational phase.

Potential impact:	Species loss and damage to soft sediment habitats
Significance criteria	
Character and perceived value of affected environment	No Annex I habitat, Annex II species or rare or unusual species have been recorded. The entire site is a highly exposed environment and the soft sediment habitats and species within them are characteristic of this environment, which is common along the west coast of Ireland.
Confidence in the accuracy of predictions of change	The site is highly exposed and the depths of the test areas are 50 m or greater. The soft sediments communities are robust and dynamic.
Magnitude, spatial extent and duration of anticipated change	It is highly unlikely that any antifoulants that might be used on wave energy devices would cause a negative impact on local sediment habitats or communities due to the depth of the seabed in the vicinity of the test areas and the exposed nature of the site. Cable burial to a depth of at least 1 m and the use of cable with good insulation properties would ensure negligible heat loss to the surrounding sediment.
Resilience of environment to cope with change	The depth of the test and exposed nature of the site would indicate that any area affected would be insignificant and the affect short lived.
Scope for mitigation, sustainability and reversibility	Limit the use of antifoulants where possible. Bury cables to a depth of 1 m and use a cable with heat shielding properties
SIGNIFICANCE OF IMPACT	**LOW**

Table 2.14: Mitigation of impacts during construction phase

Potential Impact	Scope for mitigation, sustainability and reversibility
Species loss and damage on soft sediment habitats	Damage and habitat loss to soft sediment should be minimised by reducing the area of trenching to a minimum and by using the minimum amount of rock armour around WEC moorings. A comprehensive Oil Pollution Emergency Response Plan should be put in place to deal with accidental Fuel and lubricant spills from vessels and WECs. Shallow draft vessels should be used for trenching operations in shallow waters.

Table 2.15: Mitigation of impacts during operational phase

Impact	Scope for mitigation, sustainability and reversibility
Accidental leakage of the hydraulic fluids.	Regular maintenance of WECs and the creation of the Oil Pollution Emergency Response Plan for the site
Contamination from antifoulants.	Minimise or avoid use of antifoulants.
Temperature rise in vicinity of cables	Temperature increases associated with heat loss from the buried cables should be minimised by specifying a cable that radiates very little heat. The cable should be buried to a depth of 1m where possible to minimize warming of the surficial sediments.

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3 MARINE FLORA & FAUNA - INTERTIDAL HABITATS

3.1 INTRODUCTION

Belderra strand, the proposed location of the cable landfall, is an extremely exposed small embayment with a high proportion of fine and medium sands backed by a shingle and gravel bank caused by the repeated wave exposure at this site. The beach is approximately 425m long with rocky outcrops at either end and accessed by a public road. A small car parking area is situated at the southern end of the beach and surfers and walkers frequent the area throughout the year. Belderra strand, together with the backing sand dune and dune slack area and car park, are within Mullet/Blacksod Bay Complex cSAC (site code 000470).

Intertidal habitats can support diverse communities of invertebrates and algal and plant communities which provide an important source of food for numerous bird species and act as a nursery for numerous deeper water species. The physical structure of intertidal areas can range from mobile, course sand beaches on wave-exposed coasts to more stable, fine sediment mudflats in more sheltered locations.

Although many intertidal areas have complex interactions between physical, chemical, geological and biological factors, the main determining factors affecting beach systems is their exposure to wave, current and wind action (Eagle, 1973, Sward, 1983). Other factors, such as the runoff from freshwater systems, sea-level rise and predator changes will also affect the composition and complexity of intertidal biotopes.

Temporal variation is common in exposed intertidal areas where onshore winds from winter storms increases wave action and erode material from beaches causing changes to the physical structure of the beach, replacing finer sands with courser sediments (Swart, 1983). As the grain size characteristics of the sediment are one of the main determining factors that influence the type and abundance of species present within the intertidal area, seasonal variation in biotope complexes often occurs.

Such high-energy sites are characterised by low diversity, lack of sedentary infauna such as bivalve molluscs and a dominance of more mobile species such as haustoriid amphipods and isopods (Elliot *et al*., 1998). These species have a short life span and are characterised by their ability to withstand sediment disturbance.

A survey of the intertidal area of Belderra Strand, in the vicinity of the proposed cable landfall, was conducted in July 2010. The purpose of the survey was to record and characterise the intertidal biotopes present by a programme of coring and walkovers of the intertidal area.

3.2 METHODOLOGY

Intertidal core samples were collected from two transects at Belderra Strand in July 2010. Figure 3.1 shows the position of the coring stations in relation to the proposed cable landfall and Table 3.1 gives the positions of each sampling station.

Figure 3.1. Coring stations at each of two transects at Belderra Strand shown relative to the position of the cable landfall.

Table 3.1. Location of stations of intertidal core sampling at Belderra Strand.

Transect	Station	Latitude (Decimal degrees)	Longitude (Decimal degrees)
1	Low shore	54.210140	10.064591
	Mid shore	54.209607	10.063546
	Upper shore	54.209201	10.062842
	Strandline	54.209036	10.062636
2	Low shore	54.210991	10.062811
	Mid shore	54.210633	10.062104
	Upper shore	54.210236	10.061233
	Strandline	54.210101	10.061030

The position of the two transects was selected to best obtain a description of the biotopes present in the vicinity of the cable landfall and most likely to be disturbed by its installation, while also obtaining an overview of the general biotope composition of the beach. One transect was placed directly in line with the proposed cable landfall and the second was placed further north along the beach, avoiding the area in the vicinity of a small culvert covering a stream that enters the beach through the backing dune slack area.

A cylindrical coring device, measuring 10 cm in diameter, was used for all cores. Sampling was carried out to a depth of 25 cm. During the coring operation a sediment sample was also collected from the surface at each station. These were retained for later particle size distribution analysis.

The collected cores were sieved in seawater over a 1 mm stainless steel mesh and the retained residue preserved in 10% buffered formaldehyde solution. The samples were then transported to the Aquatic Environments laboratory for subsequent infaunal analysis.

During analysis the formaldehyde was removed by pouring off over a 0.5 mm mesh. The waste formaldehyde solution was retained and stored in an outside, well ventilated, locked sample store room in airtight, 'Hazard' marked containers prior to appropriate disposal.

Portions of the retained sample were then gently washed on a 0.5 mm sieve using copious amounts of running fresh water to remove all traces of fixative. During this process excess silt and sand are also removed and the process continued until the water running through the sieve was clear and the sample odour and silt free.

The rinsed portions were then washed into a series of white trays marked out with a black grid, in amounts that formed a thin covering on the bottom of each tray. The portions were then covered with freshwater so that the water surface was unbroken by the contents of the tray.

The fauna and other target items, such as fruit pips, e.g. Tomato or *Rubus sp.*, were then removed from the trays with fine forceps, taking care not to damage the specimens. This was carried out by eye and when all organisms were removed the residue was checked with the aid of a low power microscope, to ensure faunal extraction was complete.

Table 3.2. Belderra Strand sampling regime.

Transect 1	No. Replicates	Samples containing biota	Notes	Samples from 1m x 1m dig over
Low Shore	5	4	1 sample had no infauna	0
Mid Shore	5	4	1 sample had no infauna	1
Upper shore	5	1	4 samples had no infauna	0
Strand line	1	1		N/A

Transect 2	No. Replicates	Samples containing biota	Notes	Samples from 1m x 1m dig over
Low Shore	5	5		0
Mid Shore	5	3	2 samples had no infauna	1
Upper shore	5	5		0
Strand line	1	1		N/A

The Aquatic Environments Taxonomist then identified the extracted organisms to the lowest possible taxonomic level. The members of each taxon collected were also counted. The number of samples containing biota and the sampling regime is shown in Table 3.2. Total counts were recorded for all animals with heads.

The sediment scrapes were analysed for their particle size distribution, by Hebog Environmental, using a standard dry sieving technique.

3.3 RESULTS

The results of the infaunal analysis of cores are presented in Table 3.3 and the results of the grain size and organic content analysis are presented in Table 3.4.

The results of the grain size and organic content analysis indicated that both transects ran across a beach of mixed sandy sediments, dominated by fine sand with a variable proportion of medium sand mixed in. The sediments contain very little organic matter and consequently very few species of invertebrate.

Transect 1 contained only two species in the lower and middle shore, with no fauna found in the upper shore. The fauna was dominated numerically by the opportunistic, robust, spionid polychaete worm, *Scolelepis squamata*, a species that is typical of exposed sandy shores and one predatory *Nephtys cirrosa* (cat worm) specimen was also encountered, a species also typical of sandy environments.

Transect 2 was very similar to Transect 1 in that the same two species were encountered in the lower and middle shore, with only slight differences in numbers separating them. The upper shore of Transect 2 did however contain several small crustacean species, the isopod *Eurydice pulchra* and the amphipod *Bathyporeia pilosa*, both highly typical of energetic sandy beaches.

Table 3.3. Taxa recorded in the Belderra Strand beach cores.

	T1 lower shore					**T1 Mid shore**					**T1 Upper shore**				
Species Stations	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Scolelepis squamata	3	7	6	11		3	1	2	1		-				
1 m² dig over															
Nephtys cirrosa	1														
Strandline															
Talitrus saltator	23														
	T2 lower shore					T2 Mid shore					T2 Upper shore				
Species Stations	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Scolelepis squamata	1	1	2	2	10	1	1								
Nephtys cirrosa								1							
Eurydice pulchra											2	1	2	3	3
Bathyporeia pilosa												1		1	
1 m² dig over															
Nephtys cirrosa						2									
Strandline															
Talitrus saltator	19														

Table 3.4.Sediment characteristics for the Belderra Strand beach cores.

			Site					
Sediment type	**Size**	**Phi**	**T1 LS**	**T1 MS**	**T1 US**	**T2 LS**	**T2 MS**	**T2 US**
Medium pebble (gravel)	> 8 mm	< -3	0	0	0	0	0	0
Small pebble (gravel)	4-8 mm	-2 to -3	0	0	0	0	0	0
Granule	2-4 mm	-1 to -2	0	0	0	0	0	0
Sand - very coarse	1-2000 µm	0 to -1	0.12	0.11	0	0.08	0.01	0
Sand - coarse	500-1000 µm	1 to 0	3.33	1.74	0.10	0.99	0.02	0.01
Sand - medium	250-500 µm	2 to 1	30.68	45.74	26.01	42.63	14.87	4.38
Sand - fine	125-250 µm	3 to 2	62.95	40.31	70.63	56.17	85.06	95.36
Sand - very fine	63-125 µm	4 to 3	2.91	12.10	3.26	0.11	0.03	0.25
Silt & Clay	< 63 µm	>4	0.01	0.01	0.00	0.01	0.00	0.01
% Organic Matter (LOI)			1.75	1.63	1.42	1.80	0.97	0.99

The lack of variation along each transect in either grain size or infauna indicates that only one biotope complex is present between the lower and upper shores and this was most consistent with “Amphipods and Scolelepis spp. in littoral medium-fine sand” (LS.LSa.MoSa.AmSco), although some of the characterising species for this biotope were not present. While the species composition of the area had many similarities with the biotope complex “Barren littoral coarse sand” the grain size analysis indicated that the sands in this area are dominated by fine sand with variable amounts of medium sand. The presence of a large percentage of fine sand may be attributed to a period of relatively calm summer weather preceding the sampling and winter events could change the sand composition to some degree. The lack of variation between the two transects indicated that this biotope is constant between the lower and upper shore across the beach.

The common biotope “Talitrids on the upper shore and strand-line” was recorded at the strandline, which was characterised by a typical strandline of decaying seaweed and sandhoppers.

No rare or unusual species were encountered during the analysis.

Walkovers of the beach showed it to appear to be a relatively homogenous site. Other than a small stream, entering the beach via a culvert from the backing area of dune slack, no other conspicuous features were noted. A number of digs across the width and length of the beach showed that no anoxic layer was present at the time of survey.

Plate 3.1. Intertidal and rock shore habitats at Belderra Strand. Co. Mayo.

Plate 3.2. Strandline at Belderra Strand.

Plate 3.3. Strandline at Belderra Strand.

3.4 DISCUSSION

The biodiversity of intertidal sedimentary biotope complexes is influenced by habitat stability and sediment type. In particular, the complexity of the substratum will determine the number of available niches and hence the diversity of the community (Elliot *et al* 1998). Transitional communities, subject to a high degree of natural variability, often define high-energy intertidal areas.

The effect of disturbance on such intertidal biotopes varies depending on the nature of the biotope and may range from short to longer-term changes in diversity and species richness. For example, salinity changes may cause large-scale localised changes in community structure, while severe storm events may cause shorter-term changes in the characteristics of the biotopes present.

The paucity of species in all cores taken at Belderra Strand was notable. Both species diversity and biomass was so low that it precluded any statistical analysis of the results.

Low species diversity and biomass can be expected in such exposed sandy shores and the extremely low diversity of species and biomass at Belderra Strand indicates the particularly harsh environment at this site, where even the most robust species were lacking. The lack of organic matter in the sand, a factor of the exposure regime and lack of any silt input into this area has contributed to the lack in species diversity and biomass.

The biotope complex “Amphipods and Scolelepis spp. in littoral medium-fine sand” is characteristic of highly mobile exposed sites and is common at many exposed locations on the west coast of Ireland. Although winter storms may reduce the number of or temporarily remove macroinvertebrates from exposed sandy beaches, with the sediment becoming re-colonised during the summer months, this beach was sampled during the month of July 2010 and still remained species poor.

The only other biotope recorded was the typical strandline biotope complex “Talitrids on the upper shore and strand-line “. This biotope frequently varies in its position between Spring and neap tides, and because of changing weather. Following storms, it may extend into the fore dunes at the back of Belderra Strand and during Spring tides it may occur higher on the shore. Generally, during neaps the greatest numbers of talitrids may be found at or just below Mean High Water Neap (MHWN) level. The amount of debris washed up on strandlines, and hence the extent of this biotope, may also vary significantly depending on factors such as recent storms or high tides.

3.5 IMPACT OF THE DEVELOPMENT

The site is characterised by a high-energy, mobile biotope that occurs in this area due to the constant disturbance of the beach by severe weather events. Any alteration to this habitat as a result of cable trenching would be extremely unlikely to be detected even within the following season.

The impact of any development on the intertidal areas of Belderra Strand is likely to be of short duration and not significant.

3.5.1 General effects

The general effects will be disturbance to the habitat during the time of trenching and routing of the cable caused by both trenching activities and construction machinery on the intertidal areas.

3.5.2 Construction phase

All four sub-sea cables will be ducted though the beach area in separate preinstalled conduits. The conduits will be installed by open trenching.

The trenching through sand would typically involve a trench approximately 2 m deep from the low water mark, directly across the beach and off the intertidal area at the side of the existing car park behind Belderra Strand. It is expected that the entire operation would take no more than 2-3 days and a working corridor of 40 m along the cable route in the intertidal area would be required for access and construction.

The proposed route, leaving the beach on the northern side of the car park, would mean an avoidance of the sand dune area (See Section 5 for further detail).

The obvious impact of this activity is disturbance of the habitat, although the effects of such disturbance are unlikely to be detectable within a very short time frame as the intertidal area is already frequently disturbed by severe weather conditions.

The operation of trenching machinery on the beach may cause compaction of sediments in the localised area of the cable route and associated 40 m working area. The effects of such compaction are unlikely to be evident by the following season.

The potential impact would be of short duration and not significant. The habitat would be expected to restore by the following season.

Horizontal Directional Drilling was also considered as a possible option for cable landing. The use of directional drilling to bring the cable duct onshore could take considerably longer (months) and would involve the use of bentonite in the drilling process. While this method of construction would have little direct impact on the near surface sediments of the beach, the use of bentonite could have negative environmental effects if breakout occurred. The presence of a heavy duty HDD Rig would also cause prolonged disturbance to birds in the area.

3.5.3 Operational phase

Once the cable is in place there will be not further impact caused by the placement of the cable beneath the sand.

3.6 MITIGATION OF IMPACTS

3.6.1 Construction phase

To avoid any undue disturbance to the beach an on-site ecologist should oversee the process of trenching and cable routing through the intertidal area and off the beach.

Trenching of the beach and the laying of cables should be conducted in as short a time frame as possible. The trench should be backed filled with the removed sand as soon as possible after the cable is landed onshore and routed through the trench.

Machine drivers should be instructed to remain within the 40 m corridor and avoid moving the machine unnecessarily around the intertidal area while working. The machine should be removed from the beach at the end of each working day to avoid over compaction of the sand.

Care should be taken that no oils or hydraulic fluids are allowed to leak from any machinery entering the beach during construction and that the risk management report considers actions to be taken in the event of any accidental spillage or leaking of oils from machinery.

Any accidental spillage of oils or hydraulic fluids should be cleaned up and contaminated material removed from the beach area and disposed off in accordance with legal practice.

3.6.2 Operational phase

No mitigation is required.

3.7 MONITORING

No monitoring of this area is required, as the results of the baseline analysis have indicated that it already very species poor and no alteration of this situation is likely to occur.

Table 3.5. Potential impacts during construction phase

Species and Habitats	Potential impacts
Intertidal species	Cable trenching may cause disturbance and damage to or loss of species in areas trenched. Driving of machinery on the intertidal area may cause compaction of the sand and subsequent species damage. Accidental oil spillage from trenching machine may cause species damage.
Intertidal habitats	Cable trenching will cause habitat disturbance Driving of machinery on the intertidal area may cause compaction of the sand and subsequent damage to the habitat. Accidental oil spillage from trenching machine may cause species damage.

Where likely impacts have been identified in terms of a species or a habitat, the significance of this impact has been assessed, following a standard assessment process detailed below.

Table 3.6. Assessment of significance – Construction phase

Potential impact:	**Species and habitat loss and damage in intertidal habitats**
Significance criteria	
Character and perceived value of affected environment	Belderra strand and its intertidal area forms part of Mullet/Blacksod Bay Complex cSAC (site code 000470). No Annex II species or rare or unusual species have been recorded in the intertidal area. The entire intertidal area is a highly exposed environment and the soft sediment habitats and species within the intertidal area are characteristic of this environment. The intertidal area is extremely species poor and species biomass and diversity is extremely low.
Confidence in the accuracy of	Cabling activity will cause temporary loss and disturbance of species.

predictions of change	Cabling activity will cause temporary disturbance to the habitat by both trenching and the driving of machinery on the intertidal area that may cause compaction of the sand.
Magnitude, spatial extent and duration of anticipated change	A trench approximately 2 m deep from the low water mark, directly across the intertidal area will be dug. A working corridor of 40 m will be required for the trenching operation. The duration of works will be approximately 2-3 days
Resilience of environment to cope with change	The existing environment is so dynamic that no effect of the trenching operation is likely to be evident by the following season. The intertidal area is extremely species poor. Therefore the impact of trenching is likely to be too small to measure.
Scope for mitigation, sustainability and reversibility	An Oil Pollution Emergency Response Plan will deal with the risks associated with accidental spillage of fuel or lubricants. A working corridor of 40 m should be maintained. An ecologist should be on-site during trenching operations.
Significance of impact	**LOW**

Table 3.7. Potential impacts during operational phase.

Species and habitats	Potential impacts
Intertidal species	None identified
Intertidal habitats	None identified

Table 3.8. Mitigation of impacts during construction phase

Potential Impact	Scope for mitigation, sustainability and reversibility
Species and habitat loss and damage in intertidal areas	Damage and habitat loss in the intertidal should be minimised by keeping the working area to a 40 m corridor and the total trench width to 2 m. The use of machines driving across the intertidal area should be reduced as far as practical. Machines should not be parked on the beach when not in use. A comprehensive Oil Pollution Emergency Response Plan should be put in place to deal with accidental Fuel and oil spills from machinery. Machinery accessing the beach should be checked for oil leaks before accessing the intertidal area. An ecologist should be onsite for all trenching operations.

Table 3.9. Mitigation of impacts during construction phase

Potential Impact	Scope for mitigation, sustainability and reversibility
None identified	Not applicable

4 MARINE FLORA & FAUNA - MARINE MAMMALS

4.1 INTRODUCTION

Following a review of Irish Whale and Dolphin Group database, related literature and extensive fieldwork at the Atlantic Marine Energy Test Site, the marine mammal community in the area can be described. Common dolphin and harbour porpoise occur throughout the year with a peak in common dolphins in the autumn and winter. Densities of this species are similar to those reported elsewhere on the west coast of Ireland. Bottlenose dolphins use the site during summer and autumn and photo-identification suggests both the inshore coastal and the offshore population use the site which is a unique finding. Minke whale are frequent during summer and autumn but other species such as Risso's, white-sided and white-beaked dolphins and killer whales, although not recorded during the surveys conducted for this report, are known from the literature to be infrequent visitors.

Extensive static acoustic monitoring data using C-PODs, which have demonstrated a peak in detections of dolphin and porpoise at the outer Area, compared to control sites have been obtained. These and additional data can be used as baseline reference values to monitor any changes in use at the site.

The Atlantic Marine Energy Test Site and adjacent waters are important for a range of species and full consideration has been given to the potential impacts that the development of this site for testing wave energy devices might have on these species.

4.1.1 Cetaceans

The waters off northwest Mayo have a long association with marine mammals, especially cetaceans, as it was the site of two whaling stations that operated at the beginning of the 20th century. These stations, situated in Elly Bay on the Mullet Peninsular and on South Inishkea, were based as close to the edge of the continental shelf as possible in order to intercept migrating whales (Fairley, 1981). During a 15-year period between 1908 and 1923, an estimated 894 whales were processed at the two stations. Most (67%) were fin whales but blue, sei and sperm whales were also captured. The small number of humpback and right whales captured is attributed to their populations having already been severely depleted due to over-hunting. This shows that historically large baleen whales migrated annually along the shelf edge around 60 nautical miles (nmls) from the proposed Atlantic Marine Energy Test Site.

Early broad-scale surveys of the UK and Ireland, reported cetaceans as part of seabird surveys but there were very few sightings off northwest Mayo. Pollock *et al*. (1997) reported minke whales in the autumn and white-beaked dolphin in the winter, with the only significant sightings being of common dolphin, which occurred all year round. Reid *et al*. (2003) reported the same data but surprisingly reported no harbour porpoise sightings off northwest Mayo. The first attempt to create an atlas of cetaceans in Irish waters occurred from 1999 to 2001 as part of the Petroleum Infrastructure Programme funded surveys. O'Cadhla *et al*. (2004) only reported common dolphins off northwest Mayo in the winter during surveys on ships of opportunity. During a dedicated survey in July-August 2000 there were also sightings of northern bottlenose whale.

Gordon *et al*. (1999) carried out the first contemporary dedicated cetacean survey of the area. Using a 46ft research yacht designed for acoustic surveys, 20 days of survey effort were carried out during June and July 1993. Most of the survey effort was conducted offshore, along the shelf edge, but effort was also carried out along the Mullet peninsular and through the area of the proposed Atlantic Marine Energy Test Site. There were no sightings within the proposed Atlantic Marine Energy Test Site but two sightings of minke whale off Erris Head to the north of the site were made and sightings of common and white-sided dolphin on the 200 m contour directly west of the site were also made. Acoustic detections were similar with no detections within the proposed Atlantic Marine Energy Test Site and only dolphin detections off Achill Head to the south and on the 200 m contour to the west of the site (Gordon *et al*. 1999).

Since 2001 there has been intensive surveys and monitoring of Broadhaven Bay to the north of the study site as part of the development of the Corrib gas field (Coleman *et al* 2009, Visser *et al*, 2009 and Englund *et al*, 2006). These studies have shown that Broadhaven Bay provides habitats for a variety of marine mammal species including all four species on Annex II of the EU Habitats Directive. Indeed, it is one of the most diverse sites for marine mammals in Ireland, though this may in part be a consequence of the intensive studies. O'Cadhla *et al*. (2003) reported 223 sightings of marine mammals over a 14 month period with the greatest concentration of sightings off Erris Head. Seven cetacean species were reported, five dolphin species (common, bottlenose, Risso's white-sided and white-beaked dolphin), harbour porpoise and minke whale. Sightings generally peaked in July and August. Bottlenose dolphin and harbour porpoise were by far the most frequently reported species, both occurring throughout the year. Risso's dolphin were only recorded during July and August, white-sided and white-beaked dolphin only in August and common dolphin in August and November. Minke whales were mainly reported in May and October. Acoustic monitoring using TPODs in the inner bay detected harbour porpoise and dolphins, presumed to be bottlenose dolphins. Harbour porpoise were detected throughout the six-month monitoring period (May to October). Dolphin detections were less frequent, occurring in four months with most encounters (97%) in September and October. In addition to these surveys, photo-identification of bottlenose dolphins was carried out which showed that at least one relatively large group of bottlenose dolphins occurred in Broadhaven Bay. Since this initial study ongoing monitoring in 2005, 2008 and in 2009 has revealed similar patterns but increased the number of cetacean species recorded in the Bay to nine with killer whale reported in 2005 and 2008 and sei whale added in 2009 (Englund *et al*. 2006; Coleman *et al*. 2009; Visser *et al*. 2010).

Table 4.1. Species recorded within the 200 m contour off northwest Mayo during previous sighting surveys.

Species	Pollock *et al.* (1997)	Gordon *et al.* (1999)	Reid et al. (2003)	O'Cadhla *et al.* (2004)	Oudejens (2008)
White-sided dolphin		√		√	√
Bottlenose dolphin					√
Common dolphin	√	√	√	√	√
Harbour porpoise					√
Killer whale					√
Minke whale	√	√	√		√
Bottlenose whale				√	
White-beaked dolphin	√		√		√

By far the most intensive and relevant study carried out in the study area was that of Oudejans (2008). More than 89 hours of land-based and 79 hours of boat-based surveys were carried out between May and October 2008, with most, but not all, in the area of interest. A total of 145 sightings of seven cetacean species were recorded as well as sunfish and basking sharks. Bottlenose dolphins were by far the most frequently recorded species with 33 sightings, occurring on 27 of the 69 days of fieldwork. Mother-calf pairs were recorded on 11 occasions and neonates on three occasions with six recorded in total. Photo-identification of this species showed that six dolphins were observed on multiple days but were recorded as part of small groups of 3-4 individuals. This high re-sighting rate suggests these dolphins remained in the study area throughout the period of May to September.

4.1.2 Seals

4.1.2.1 Grey seal

Northwest Mayo is also important for seals, especially grey seals, with the Inishkea Islands being an important breeding site for this species in Ireland (Kiely and Myers, 1998). The National Parks and Wildlife Service have being carrying out grey seal surveys of the Inishkea Islands since at least 1978.Together with the Blasket Islands Co Kerry, the Inishkea Islands are the best-monitored sites in Ireland (Lyons, 2004). O'Cadhla and Strong (2002) estimated a population of 1,351-1,737 grey seals at the Inishkea Islands in 2002 from a total Irish population of 5,509-7,083 grey seals of all ages, making it the most important site for this species in Ireland.

Table 4.2. Grey seal pup production on the Inishkea Islands.

Year	Number of pups	Reference	Comment
1964-65	10	Lockley (1966)	Poorly covered
1980	197	Summers (1980)	
1983	135-155	Summers (1983)	Thought to be due to culling
1984	242		
1986	294	Lyons (2004)	
1995	154	Kiely and Myers (1998)	
1998	234	BIM (2001)	
1999	228	BIM (2001)	
2002	292	O'Cadhla and Strong (2002)	
2003		Cronin *et al*. (2007a)	Feasibility study for aerial surveys

There are at least 22-30 sites among the 10 islands making up the Inishkea group used for seal pupping (Kiely and Myers, 1998; Lyons, 2004). The first pups are born on the Inishkea Islands in the second week of September and finish in early December with a pupping peak in mid-October (Kiely and Myers, 1998). The best available data suggests a three-fold increase in pup production between 1995 and 2003 (O'Cadhla *et al*. 2007) prompting Cronin *et al*. (2007a) to test the feasibility of carrying out aerial surveys of these islands in the future.

As part of a study of dispersal of grey seals from pupping sites on the Inishkea Islands a total of 95 pups were tagged during the 1998 and 1999 breeding seasons (BIM 2002). Of these, 14 seals were re-sighted. Two animals were observed within the Inishkea Island group 4 and 11 days after tagging. One of these animals had traveled 6 km. A third animal was re-sighted at the Inishkea Islands three months after tagging had ceased. One individual was spotted at Slyne Head, Co Galway 28 days after being tagged 90 km from the Inishkea Islands. There were two international re-sightings: one 68 days after tagging at Seine Island, Brittany in North West France, a distance of 840 km and one sighted on the Isle of Tiree, Scotland, 60 days after tagging and 360 km from the Inishkea Islands. One bycaught seal was landed near Dursey Island, Co. Cork 131 days after it had been tagged, at a distance of 285 km from the Inishkea Islands. This shows that seals from the Inishkea Islands disperse widely though site-fidelity to their breeding areas is strong.

The diet of grey seals in the Inishkeas has also been studied (BIM, 2002). Two hundred and ninety seven faecal samples were collected between 1997 and 1999 from known grey seal haul out sites within the Inishkea Island group and 138 grey seal stomachs and intestines were collected around the Mullet and north Mayo between 1997 and 1999. Of the eight species positively identified, whiting was the most abundant prey species found in the stomachs in 1997 and 1998 coming a close second to Trisopterus sp. in 1999. From scat samples Trisopterus sp. otoliths were the most abundant in 1997, and was the third most abundant in 1998 and the second most abundant in 1999. Scad was the most abundant in 1998 with whiting a close second and sandeels were the most abundant in 1999.

4.1.2.2 Common or harbour seals

No common or harbour seals are known to pup in the area but they do occur in Blacksod Bay on the east side of the Mullet peninsula and may visit the area of the Atlantic Marine Energy Test Site. An aerial survey carried out in 2003 estimated around 116 seals occurred with another 84 recorded on Achill Island to the south of the site (Cronin *et al*. 2007b). Cronin *et al*. (2007b) suggested a minimum population of around 2,905 harbour seals occurred in the Republic of Ireland. The harbour seal population in Ireland is thought to be stable.

4.2 METHODOLOGY

4.2.1 Review of IWDG cetacean records at, and the vicinity of site.

The IWDG manage a sighting database, which stores data collected by an All-Ireland cetacean sighting schemes. These data are stored on a database, which can be accessed on-line through www.iwdg.ie. The database is updated regularly and at the time of preparing this report (October 2010) there were details of 15,752 sightings from all around the Irish coast.

The IWDG co-ordinates two sighting schemes; a casual sighting scheme, which collect sightings made opportunistically while carrying out another activity, e.g. sailing, fishing, walking, and an effort related scheme, where the effort spent watching for cetaceans or travelling at sea is also recorded.

Casual sightings help provide broad information on status and distribution for rare species that would otherwise be recorded too infrequently for adequate interpretation from systematic observations. They help identify areas of population concentration, which can then be targeted for more systematic survey or monitoring and they boost sample sizes for analyses of biological, e.g. calving times, or ecological information where data on effort is not necessary. Sightings are recorded in a standardized format. The form prompts the observer for information on size, blow, fin and head shape, behaviour and high-low-best estimate of numbers present. It also provides space to report environmental data, the most important of which is sea-state. Effort related sightings provide better data on the seasonal distribution and relative abundance of cetaceans in a given area. Even when observers record no cetaceans, this scheme still provides useful data as the watching effort has been quantified.

Sightings of cetaceans may be made by a wide range of people, engaged in a wide range of activities. Standardised reporting forms have been produced and distributed widely.

Information packs are supplied to anyone interested in contributing to this scheme, including tips on how to watch for cetaceans and how to identify cetaceans at sea. An identification poster has been produced and workshops and training weekends organised. Sightings data may be submitted to the IWDG through a number of channels including: submitting a sighting form through the IWDG website (www.iwdg.ie) via the on-line sighting form or directly by phoning in records on the IWDG phone line.

In order to ensure the quality of the data maintained on the database, it is essential to have a system of validating records and data control. Each sighting record is assessed to determine whether the basic information on the sightings form is complete e.g. date, location and contact information of the observer. All records are then assessed by IWDG using their experience in "field identification" of cetaceans and knowledge of the observer to determine whether the species reported is accurate based on the description of each sighting. Increasingly, records are being submitted with photographs or video to verify the record. If the record is submitted verbally the observer is asked to describe what was seen by prompting for information without giving hints as to what the characteristic should look like e.g. bushy blow. Other factors such as weather conditions especially sea-state, observer experience and confidence level are also factors used in assessing records.

If insufficient information is provided to verify the sighting record then the species identification is downgraded to a level which the information provides warrants. For example; a dolphin sighting may be reported as a common dolphin (Code 2254) but the observer has not provided sufficient information to distinguish from a striped dolphin (Code 2255). This sighting would be coded as a common/striped dolphin (Code 2034). If the information is insufficient for this category then it will be downgraded further to patterned dolphin (2032), or perhaps further again to dolphin species (2200), until the code reflects the level of information provided.

4.2.2 Site survey

In order to gain a better understanding of the community of marine mammals that occur along the proposed cable route, and in adjacent waters, a marine mammal survey was carried out. This survey used a combination of visual and acoustic techniques and both land based and at sea survey methods.

Land-based monitoring

Monthly watches were carried between October 2009 and September 2010 from Annagh Head overlooking the northern end of the proposed route. Each watch was of 100 minute duration and was only carried out whenever possible in favourable conditions. For land-watches favourable conditions occur when sea-state is two or less, i.e. no white caps present, and visibility ≥15 km as per the IWDG Inshore Cetacean Monitoring Programme protocol (see Berrow *et al*. 2010). With good optics a land-based observer should be able to detect large mammals up to 20 km offshore and smaller marine megafauna around 5-10 km offshore. Optics used in this survey included 7x50 Steiner binoculars and a Kowa telescope with x 20 eyepiece. Machiel Oudejans carried out all watches.

All marine mammals, including cetaceans and seals and other marine megafauna e.g. basking sharks and sunfish were recorded. Recording bearing and distance to each sighting determined the location of animals observed.

Line transect surveys

Visual surveys require calm seas and a good vessel with a platform at least 2-3m above sea level. Track-lines were pre-determined and changed on each survey to provide full coverage of the site. Lines were chosen to cross depth gradients and provide as close to equal coverage probability as possible following the recommendations of Dawson *et al*. (2008) who suggested systematic line spacing resulted in better precision than randomised line spacing. The track-line were used as the sample, to reduce variability (see below) and thus a zigzag survey route through the area was preferred. On occasion, however, a seabird survey team was joined, using parallel track-lines, with both surveys being carried out simultaneously. The track-lines surveyed each day totalled approximately 50 nmls in length, which at 10 knots vessel speed took around 5 hours to complete once the start of the first track line was reached.

A single platform line-transect as described by Berrow *et al*. (2009) was used in an attempt to derive density and abundance estimates. A minimum of three people (two primary observers and one logger) was required for each visual survey.

The survey vessel travelled at a speed of approximately 10 knots, which was 2-3 times the typical average speed of the target animal (harbour porpoise and dolphins) as recommended by Dawson *et al*. (2008). Two primary observers were positioned on top of the wheelhouse, which provided an eye-height above sea level of around 3m. Each primary observer watched with naked eye from dead ahead to 90º to port or starboard depending on which side of the vessel they were stationed. All sightings were recorded together with bearing and distance from the observer. Although all sightings were recorded, Buckland *et al*. (2001) showed that outliers do not contribute much to the density estimate and they make it difficult to fit the detection function and thus the data can be truncated. Calves were defined as porpoises or dolphins ≤ half the length of the accompanying animal (adult) and in very close proximity and juveniles half to two-thirds of adult length.

During each transect the position of the survey vessel was tracked continuously through a GPS receiver connected directly to a laptop, while survey effort, including environmental conditions (sea-state, wind strength and direction, glare etc.) were recorded directly onto LOGGER software (©IFAW) every 15 minutes. When a sighting was made, the position of the vessel was recorded immediately and the angle of the sighting from the track of the vessel and the perpendicular distance of the sighting from the vessel recorded. These data are communicated to a LOGGER recorder in the wheelhouse via VHF radio. The angle was recorded to the nearest degree via an angle board attached to the vessel immediately in front of each observer.

All effort data and sightings/detections were digitally mapped in both National Grid reference (ITN) and Latitude and Longitude (WGS84).

Abundance estimate

If enough sightings are made then a density estimate can be calculated using distance sampling. The software programme DISTANCE (Version 5, University of St Andrews, Scotland) was used for calculating the detection function, which is the probability of detecting an object a certain distance from the track-line. The detection function is used to calculate the density of animals on the track-line of the vessel. In these surveys it is assumed that all animals on the track-line are observed i.e. that g (0) = 1. The DISTANCE software allows the user to select a number of models in order to identify the most appropriate for the data. It also allows truncation of outliers when estimating variance in group size and testing for evasive movement prior to detection.

Estimates of abundance in sea-state 2 or less were calculated for each survey day providing there were sufficient sightings for a species to generate an estimate. Buckland *et al*. (2001) suggested that 40-60 sightings are required for a robust estimate. For the model, it is assumed that there are no major changes in distribution within each site between sample days or any immigration or emigration into or out of the site over the survey period.

The data was fitted to a number of models. The data for common dolphins in March 2010 was grouped into equal distance intervals of 0-100, 100-200 up to 800-1000 and truncated at 1000 m and for seals 0-50, 60-100 up to 500 m for dolphins. Cluster size was analysed using size-bias regression method with log(n) of cluster size against estimated g(x) and the variance estimated empirically.

A Chi-squared test is associated with each detection function. If significant will indicate whether the detection function is a good fit and whether the estimate is robust. The proportion of the variability accounted for by the encounter rate, detection probability and group size is also calculated with each detection function. Variability associated with the encounter rate reflects the number of sightings on each track-line and the detection probability reflects how far the sightings were from the track-line and group size the range of group sizes recorded at each site. For common dolphin this was 10.5 for detection probability and 89.5 for cluster size showing most variability was associated with the wide range in group size recorded in March (2-200 individuals). For seals the opposite was recorded with 94.5 for detection probability and 5.5 for cluster size, reflecting that most sightings were of single individuals.

Photo-identification

During this survey high quality digital cameras with f2.8 70-200 mm lens (including x2 converters) were used to photograph all bottlenose dolphins encountered. Each group was followed until images of all individuals present in the group were obtained or dolphins showed signs of disturbance by the presence of the vessel. Other species such as common dolphin and minke whale were also photographed opportunistically but these species do not lend themselves to individual recognition.

Images of bottlenose dolphins were examined for photographic quality and the severity of marks and lesions on individual dolphins (see Ingram, 2000 for detailed methodology). Images were compared to those in the Inshore Bottlenose Dolphin Photo-id Catalogue lodged with the National Biodiversity Data Centre (see O'Brien *et al*. 2009b) and www.iwdg.ie/photo-id .

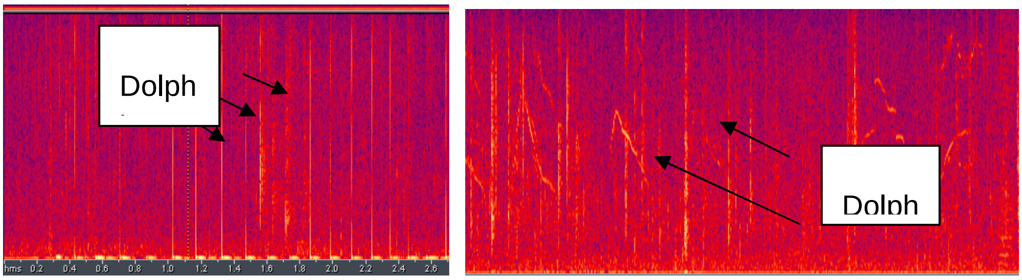
Passive Acoustic Monitoring

A towed hydrophone array was used during three dedicated acoustic surveys. This array consisted of a 200 m cable with two hydrophone elements (HP-30) situated 25 cm apart in a fluid filled tube towards the end of the cable. The hydrophone connected to a MAGREC HP-27 buffer box that runs through a laptop computer, which is connected to a National Instrument DAQ-6255 USB soundcard. This allowed for the detection of sounds outside the capability of the computers soundcard, i.e. harbour porpoise high frequency echolocation clicks. Detection software used during all surveys included PAMGUARD (freely available at www.pamguard.org) and IFAW´s, Logger and Rainbowclick (freely available at www.ifaw.org). The acoustic survey track line was recorded via an external GPS receiver linked to the Logger software. PAMGUARD is a fusion of the IFAW suite and Ishmael and therefore has applications such as click detectors, tonal whistle detectors, capability to calculate bearings on maps, record a track log, spectrogram viewer, detection energy display, and has built in filters. The collection of acoustic data during visual surveys added an extra dimension to the monitoring dataset. Acoustic monitoring allowed for the detection of cetaceans, which are beyond the visual observers view and therefore increased the capacity of the survey.

Data analysis of towed hydrophone data

The use of biosonar by porpoises and dolphins has been extensively studied (Au, 1993), and has shown that porpoise and dolphin sonar characteristics differ greatly from each other, therefore making it possible to differentiate between these species. They can vary in click duration, inter-click interval, frequency, source level, and range. Harbour porpoises echolocation signals are characterised as being narrow-band, high frequency between 110 kHz and 150 kHz, with a detection range (for a single fish of ingestible size) of up to 30 m. Variations in inter-click intervals (ICIs) can be used to identify different acoustic behaviours such as feeding, approach behaviour and communication. Boat sonar and echosounders are the only known sounds in the sea that are similar to harbour porpoise sonar, as other sounds are more broadband, have longer durations and occur at lower frequencies. Dolphins also have a highly developed sonar system for discriminating objects with bottlenose dolphin echolocation clicks characterised as broadband, between 200 Hz and 150 kHz, with a peak energy at 30-60 kHz with a source level of 40-80 dB re 1 μbar @ 1 m (Figure 4.1). Dolphins also have the ability to produce frequency-modulated sounds called whistles, which are usually below 20 kHz (Figure 4.1). All towed hydrophone acoustic data detected was post processed in the laboratory following survey. Data analyses included the visual inspection of all sound files on spectrograms using IFAW's whistle detector and porpoise detector. All characteristics associated with detections including, inter-click interval of click trains, as well as frequency, shape and outline of whistles will be taken into account when identifying detections to species level.

Figure 4.1. Spectrogram of dolphin clicks and whistles.



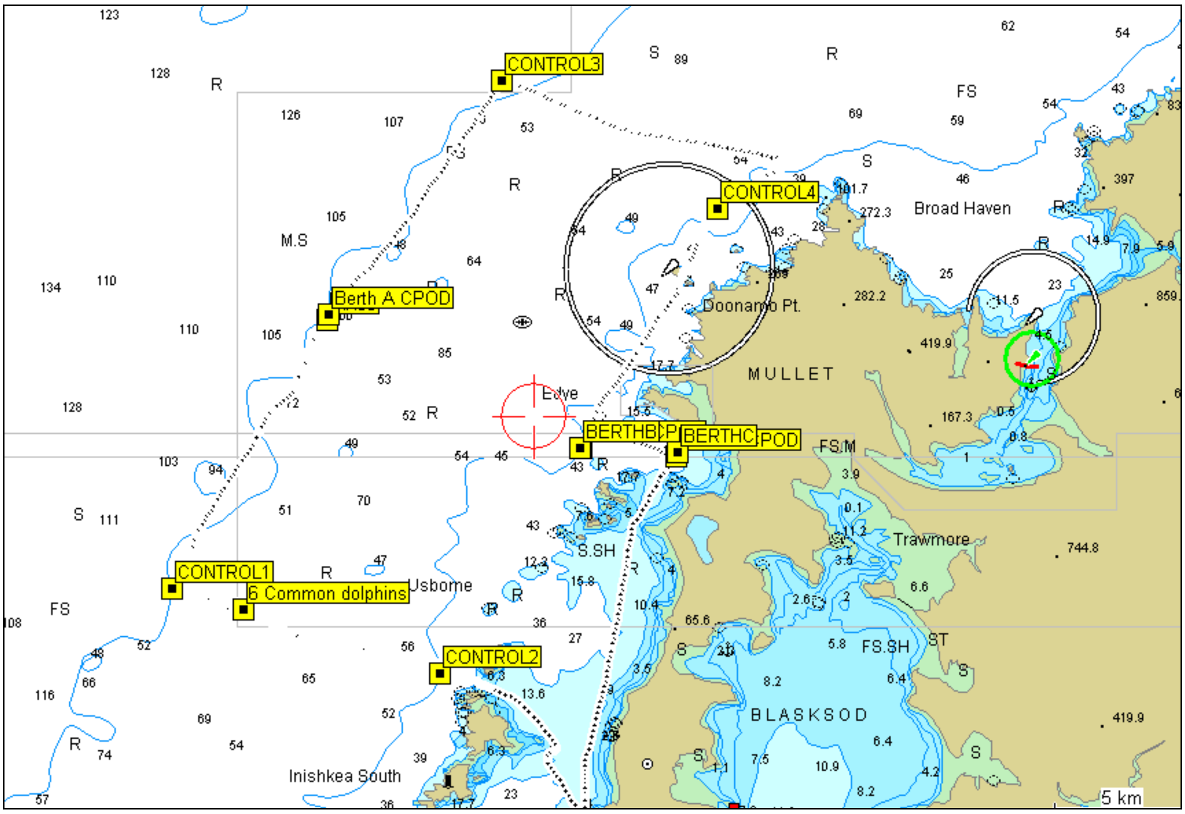
<u>Static Acoustic Monitoring (SAM)</u>

Static acoustic monitoring (SAM) can be achieved with the use of devices called C-PODs. C-PODs are self contained click detectors that log the echolocation clicks of porpoises and dolphins. Once deployed at sea, the C-POD operates in a passive mode and is constantly listening for tonal clicks within a frequency range of 20-160 kHz. When a tonal click is detected, the C-POD records the time of occurrence, centre frequency, intensity, duration, bandwidth and frequency of the click. Internally, the C-POD is equipped with a Secure Digital (SD) flash card, and all data are stored on this card. Dedicated software, CPOD.exe, provided by the manufacturer, is used to process the data from the SD card when connected to a PC via a card-reader. This allows for the extraction of data files under pre-determined parameters as set by the user. Additionally, the C-POD also records temperature over its deployment duration. It must be noted that the C-POD does not record actual sound files, only information about the tonal clicks it detects. SAM can be carried out independent of weather conditions once deployed and thus ensures high quality data for prolonged periods (months) is collected but only at a small spatial scale (typically around 800 m radius for dolphins and 250 m for porpoise).

Philpott *et al*. (2007) estimated a detection range of up to 1,250 m for bottlenose dolphins in the Shannon Estuary by using Version 3 T-PODs (the C-PODs predecessor), but the majority of detections occurred within 500 m. Tougaard *et al*. (2006) estimated T-POD detection distances of 200 m and Villadsgaard *et al*. (2007) estimated 300- 500 m for the harbour porpoise. As C-PODs are only available since September 2008, there is no published material yet available on the detection range of these devices. Trials were carried out in 2009 in the Shannon Estuary to estimate a detection distance of C-PODs for dolphins. Preliminary results suggest a detection range of between 500 m and 800 m for bottlenose dolphins (O'Brien *et al*. in prep). Trials carried out in Cardigan Bay suggest a detection distance of over 500 m for bottlenose dolphins (Peter Evans pers. comms). Further theoretical testing of C-PODs in control tanks has been carried out by Line Kyhn and colleagues at the National Environmental Research Institute, Denmark and they suggest C-PODs should have a detection distance of about 250 m for harbour porpoises in the field, while field trials carried out by O'Brien *et al*. (in prep) reported similar detection distances.

C-PODs were deployed at two locations, inshore at a former proposed Test area (Test Area C) which was subsequently discontinued as a test area and offshore at Test Area A (100 m water depth) on 15 October 2009, and these sites were monitored for the duration. An additional 5 sites were monitored with C-PODs between July and October 2010, one at the main site at Test Area B (50 m water depth) and 4 control sites; 2 offshore and 2 inshore (Figure 4.2). For the purposes of this report the area was divided into three regions, inshore, mid-shore and offshore.

Figure 4.2. Distribution of CPOD deployments including Areas A-C and four control sites.



Moorings

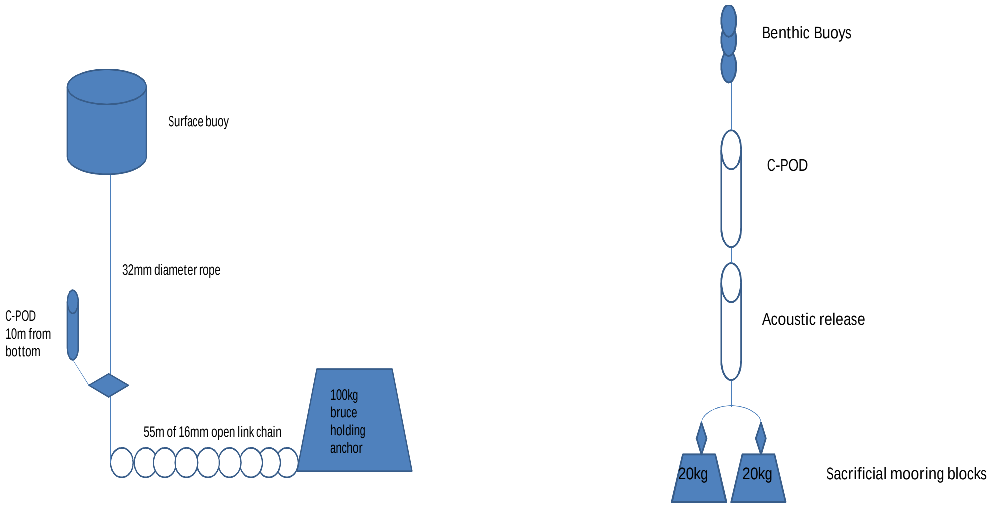
All C-PODs were deployed on acoustic release systems except for one, at the inshore site, where it was considered that shifting sands and wave action would move a bottom deployed release system, so a robust mooring array was deployed instead. The mooring consisted of a 100kg Bruce holding anchor with 55m of 16 mm open link chain attached. A surface rope of 32 mm diameter (25 m length) was attached as a riser to a yellow mooring buoy. One C-POD was attached to the rope around 5m from the end of the chain, which positioned the C-POD approximately 10 m off the bottom (Figure 4.3a). A number of salmon floats were attached to the C-POD in order to keep it upright even in strong tidal conditions. The acoustic release systems used incorporated two release types, Sonardyne's 7986 lightweight release transponder (www.sonardyne.com) and the Marine Electronics transponder model (www.marine-electronics.com). Both device types are designed for use in inshore waters to depths of 500 m. The use of these devices eliminates the need for surface markers and hence reduces the drag on the mooring systems in rough sea conditions. Furthermore, as no mooring lines or surface markers are visible it also eliminates interference with the gear, but deployments have to be selective and outside the area of trawling or other fishing activities. The battery life of the two devices varied, where Sonardyne's device offered the best option in excess of 18 months, in comparison with the Marine Electronics release that needs to be serviced every 3 months. Both devices operate on the principal of receiving an acoustic message at a specific frequency that triggers a motor to release the system from the bottom weights. The attachment of benthos buoys to the C-POD array provides enough buoyancy to lift the devices to the surface upon release where they can be retrieved to a vessel (Figure 4.3).

C-POD calibration

Calibration of equipment is important in order to compare results between units. Chelonia Ltd, the manufacturers of C-PODs calibrate all units to a standard prior to dispatch. These calibrations are carried out in the lab under controlled conditions and thus Chelonia highly recommend that further calibrations are carried out in the field prior to their employment in monitoring programmes instead of further tank tests (Nick Tregenza pers. comms). Field calibrations aim to assess differences in sensitivity between units (O'Brien, 2009), and facilitate comparisons between datasets collected in different areas using multiple loggers (Dähne *et al*. 2006). This is especially important where projects employ several units aimed at comparing detections across a number of sites. If units of differing sensitivities are used, then these data do not truly reflect the activity at a site. For example, a low detection rate may be attributed to a less sensitive POD, with a lower detection threshold, which in turn leads to a lower detection range, while the opposite holds for a very sensitive unit. It is fundamental that differences between units are determined prior to their deployment as part of any project, to allow for the generation of correction factors, which can be applied to the resulting data. Field trials are carried out in high-density areas in order to determine the detection function (O'Brien *et al*. in prep). The field calibration of new units should be carried out in conjunction with a reference C-POD, where a single unit is used solely for calibrations and is deemed a reference. This allows for the incidence where new units are acquired over the course of a project to be calibrated with the reference.

Figure 4.3. Mooring designs used to deploy C-PODs during the Atlantic Marine Energy Test Site survey.

a. Surface mooring b. Bottom set on acoustic release



Nine individual units were used for SAM during the present project. A number of reference units have recently been tested for calibrating new units, to assess their performance in the field before they are incorporated in any long-term monitoring programmes. On this occasion, three separate trials were carried out to calibrate equipment prior to their deployments. A correction factor was calculated and applied to the resulting data to eliminate biasing the results due to confounding sensitivities between units. The data were extracted using C-POD dedicated software. The correction factor was calculated according to Berrow *et.al*. (2009) using the following equation, where the mean DPM/hr^{-1} from the reference C-POD was divided by the least sensitive pod:

$$CF = \frac{X_{reference}}{X_{least\ sensitive}}$$

C-POD data analyses

C-POD.exe, the dedicated software V1.054 (latest version, May 2010) provided by the manufacturer was used to process all C-POD data files (cp.1files processed to output cp.3 files). Only dolphin and porpoise click trains in the train filters "High" and "Mod" were used for analyses. These options included a combination of clicks classed as being of high probability cetacean origin and clicks classed of lower probability cetacean origin. Both dolphin and porpoise detections were extracted as detection positive minutes per day and per hour. Although some dolphin clicks could be detected in the porpoise channels, the setting of the click bandwidth used should have greatly reduced this incidence. Therefore it was assumed that all detections in porpoise channels were of porpoise origin, while those in the dolphin channels were of dolphins. The term ppm represents the number of minutes in a day or an hour that harbour porpoises are acoustically detected, while dpm represents the number of minutes dolphins are detected, and DPM represents the number of detection positive minutes inclusive of both dolphins and porpoises.

4.3 RESULTS

4.3.1 Review of IWDG cetacean records at, and the vicinity of site.

The sighting databases was interrogated for cetacean sighting records within the co-ordinates 54.38º and 54.05º N and 10.71º to 10.09º W which takes in the area west of Annagh Head, north to Erris Head and south to Blacksod.

The IWDG have records of 52 sightings of 1,577 individuals in the area of interest collected between 22 May 1984 and 17 October 2010. Of these, 46 sightings were identified to species level, which included 562 individuals of at least ten species. Of the six records not identified to species level, three were dolphins or possibly porpoise and two were of whales, the remainder being of a cetacean species.

The most frequently recorded species was the bottlenose dolphin (25.0%), followed by common dolphin (17.3%), Risso's dolphin (11.5%), killer whale (9.6%) and harbour porpoise and minke whales (both 7.7%), with the remaining percentage including those individuals not identified to species level. In addition there were two records of Atlantic white-sided dolphin and one record each of striped dolphin, humpback whale and sei whale.

The monthly distribution of sighting records is shown in Table 4.3. Most records are from the summer (April to September) but records have occurred throughout the year.

The following species reviews provide detail on cetacean sightings in the area following analysis of the IWDG database.

4.3.1.1 Dolphins

Bottlenose dolphin

The 13 records of this species in the area span 15 years with the first record reported on 8 April 1995. Bottlenose dolphins have been reported throughout the year though most were in September. Records were received from throughout the area including offshore. Group size was small with half the records of eight or less individuals and half between 12-20 individuals.

Common dolphin

The common dolphin was the second most abundant cetacean species recorded in the area of interest (Figure 4.4b). They were recorded throughout the year and throughout the area although all offshore. Group size was typically small between 4 and 12 individuals with an exceptionally large group of 300 individuals reported in October 2010.

Table 4.3. Number of sightings and individuals (in brackets) recorded in the area of interest between 54.36º and 54.05º N and 10.71º to 10.08º W (in order of most abundant) taken from the IWDG database.

Species	J	F	M	A	M	J	J	A	S	O	N	D
Bottlenose dolphin *		1 (20)		2 (18)	2 (17)		1 (12)		4 (49)		2 (16)	
Common dolphin			2 (11)	3 (26)			2 (10)			1 (300)	1 (11)	
Risso’s dolphin								2 (5)	4 (20)			
Killer whale				1 (5)	1 (2)			2 (5)		1 (2)		
Harbour porpoise *							4 (7)					
Minke whale					2 (2)			2 (2)				
White-sided dolphin							1 (4)		1 (7)			
Humpback whale					1 (1)							
Striped dolphin							1 (2)					

* species included on Annex II of the EU Habitats Directive

Figure 4.4. Geographical distribution of main species sighted in the area.

a. Bottlenose dolphin (n=13)

b. Common dolphin (n=9)

c. Risso's dolphin (n=6)

d. Killer whale (n= 4)

e. Harbour porpoise (n=6)

f. Minke whale (n=5)

Risso's dolphin

There were six records of Risso's dolphins, most recorded off Annagh Head and all in the late summer (August and September). This species has been frequently observed in Broadhaven Bay to the north and west of the study area.

Atlantic white-sided dolphin

The two records of white-sided dolphin occurred in 2001 and 2003. Both groups were relatively small

Striped dolphin

The only record of this species was a group of 2-4 individuals around 5km west of Inishkea Islands on 27 July 2001.

Despite there being a paucity of records of cetaceans from this area the species diversity is high with inshore (harbour porpoise) and offshore (Risso's dolphin, Atlantic white-sided dolphin). Bottlenose dolphins were the most frequently reported species and have occurred throughout the site and over at least 15 years.

Both bottlenose dolphin and harbour porpoise are included on Annex II of the EU Habitats Directive and therefore entitled to full protection and protection of their habitat. All cetacean species are included on Annex IV of the EU Habitats Directive, which entitles them to strict protection.

4.3.1.2 Harbour porpoise

There were four records of harbour porpoise all in July. Three records were of two individuals and one single individual. No calves were reported.

4.3.1.3 Whale

Killer whale

Of the five sightings of killer whales reported to the IWDG, three were between May and August 2009, when between two and three individuals were reported in the area. Images taken of the sighting of two individuals on 10 August 2009 showed these were Nos. 05 and 09 from the North Atlantic Killer Whale Photo-id Catalogue (see www.northatlantickillerwhales.com) who are members of the of the well known Scottish West Coast Community of killer whales (Andrew Foote pers. comm.). One of the individuals observed on 4 May 2009 is thought to be "John Coe" who has been recorded in Ireland on two occasions (North Donegal and Galway Bay) and is known from the Shetland Islands in the 1980s. This individual is also a member of the Scottish West Coast Community of killer whales.

Minke whale

The four records of minke whales were all of single individuals and occurred inshore although well spread out over the area of interest.

Humpback whale

The only record of this species was of a single animal observed on 22 May 1984 breaching off the Inishkea Islands.

4.3.2 Site survey

4.3.2.1 Land-based monitoring

A total of 13 land-based watches were carried out from October 2009 to October 2010. All but one watch was carried out in sea-state ≤2. Sightings were recorded on seven occasions (54%) of watches. A total of 16 sightings were made (Table 4.4).

The sixteen sightings are presented in Table 4.5. Eight were identified to species level with an additional four sightings identified to a probable species (common dolphin and grey seal). Most sightings were of common dolphin (44%) with harbor porpoise and grey seal accounting for two sightings each (12%). There was one sighting of a small group of bottlenose dolphins. The group sizes of common dolphins ranged from around 15-20 to approximately 300 individuals.

Table 4.4. Number of sightings recorded during land-based effort watches from Annagh Head.

Date	Sea-state	Visibility	Sightings
8 October 2009	2	16-20 km	1
10 November 2009	3	>15 km	2
23 January 2010	2	11-15 km	0
6 February 2010	2	6-10 km	0
13 February 2010	1-2	16-20 km	3
10 March 2010	2	11-15 km	0
16 April 2010	2	16-20 km	0
12 May 2010	2-3	16-20 km	0
24 June 2010	2	16-20 km	0
9 July 2010	2	16-20 km	3
26 August 2010	2	16-20 km	1
6 September 2010	2	16-20 km	3
13 October 2010	2	11-15 km	3

Date	Sea-state	Visibility	Sightings
Total			16

Most common dolphins observed were foraging, fast travel or both often with gannets in association. Gannets frequently associate with common dolphins in Ireland as both feed on pelagic fish species such as mackerel. Gannets search out feeding common dolphins that herd fish towards the surface and thus bring them into range of surface feeding seabirds. Both sightings of single harbor porpoise were thought to be of foraging individuals.

Table 4.5. Species recorded during land-based effort watches from Annagh Head.

Species	**Date**	**Group Size**	Behaviour
Common dolphin	8 October 2009	250-300	Travelling southwest with thousands of gannets. Juveniles present
	10 November 2009	25	Probably feeding
	10 November 2009	200-250	Fast travelling and breaching
	9 July 2010	25-30	Fast travelling. Juveniles present
(probably)	26 August 2010	15-20	Foraging
	6 September 2010	14-16	Travelling/Foraging + juveniles
(possibly)	13 October 2010	25-50	Foraging
Bottlenose dolphin	9 July 2010	3	Milling
Harbour porpoise	13 February 2010	1	Foraging
	13 February 2010	1	Foraging
Grey seal (prob)	6 September 2010	2	Swimming/Bottling
	13 October 2010	2	Swimming
Unidentified seal	13 February 2010	1	Milling
	9 July 2010	1	Spyhopping

4.3.2.2 Line transect surveys

Six line transect surveys of the site were carried out. The track lines are shown in Figure 4.5. Three of these surveys were carried out simultaneously with bird surveys of the study area and three were dedicated cetacean surveys. All but one of these surveys was carried out in sea-state ≤2 (Table 4.6.). Sightings of both cetaceans and seals were recorded on each survey with additional megafauna species (basking shark and sunfish) on two.

Table 4.6. Details of line transect surveys carried out of the Wave Energy Test Site.

Date	Method	Sea-state	Sightings
15/10/2009	Dedicated cetacean survey	0-1	6 (cetaceans); 8 (seals)
16/10/2009	Opportunistic with bird survey	3-4	4 (cetaceans); 14 (seals)
5/3/2010	Simultaneous with bird survey	1	14 (cetaceans); 5 (seals); 1 (basking shark)
16/6/2010	Dedicated cetacean survey	2	1 (cetacean); 8 (seals)
12/7/2010	Simultaneous with bird survey	0	6 (cetaceans); 21 (seals); 1 (basking shark)
23/11/2010	Dedicated cetacean survey	1	9 (cetaceans); 20 (seals)

Note: Opportunistic surveys are those where marine mammals were recorded by qualified marine mammal observers while conducting surveys for seabirds at sea rather than the dedicated marine mammal surveys following the transects lines prescribed for the marine mammal survey.

Common dolphin was the most frequently recorded cetacean species with 17 sightings followed by harbour porpoise (15 sightings) and minke whale and bottlenose dolphin (2 sightings). Two unidentified dolphin sightings were also recorded and were most likely common dolphin. Common dolphin was also the most abundant species with up to 200 recorded on 5 March 2010. The second largest group of cetaceans recorded were bottlenose dolphins, when a group of 50 were recorded on 15 October 2010 (Table 4.7). Two seal species were recorded, grey and common seal. Grey seal was the most frequently recorded and the most abundant (Table 4.8).

Table 4.7. Sightings during line transect surveys at the Wave Energy Test Site.

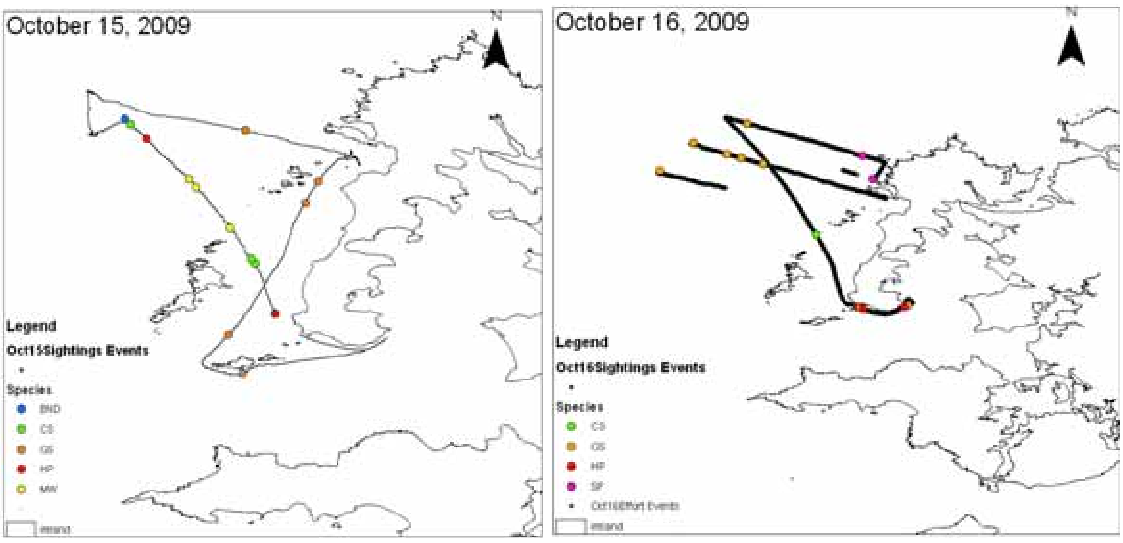
Species	Date	Number of sightings	Group Size
Common dolphin	5/3/2010	12	3-200
	16/6/2010	1	10
	23/11/2010	4	1-16
Bottlenose dolphin	15/10/2009	1	50
	12/7/2010	1	8
Harbour porpoise	15/10/2009	2	1-2
	16/10/2010	4	1-3
	5/3/2010	1	3
	12/7/2010	5	1-3
	23/11/2010	3	2

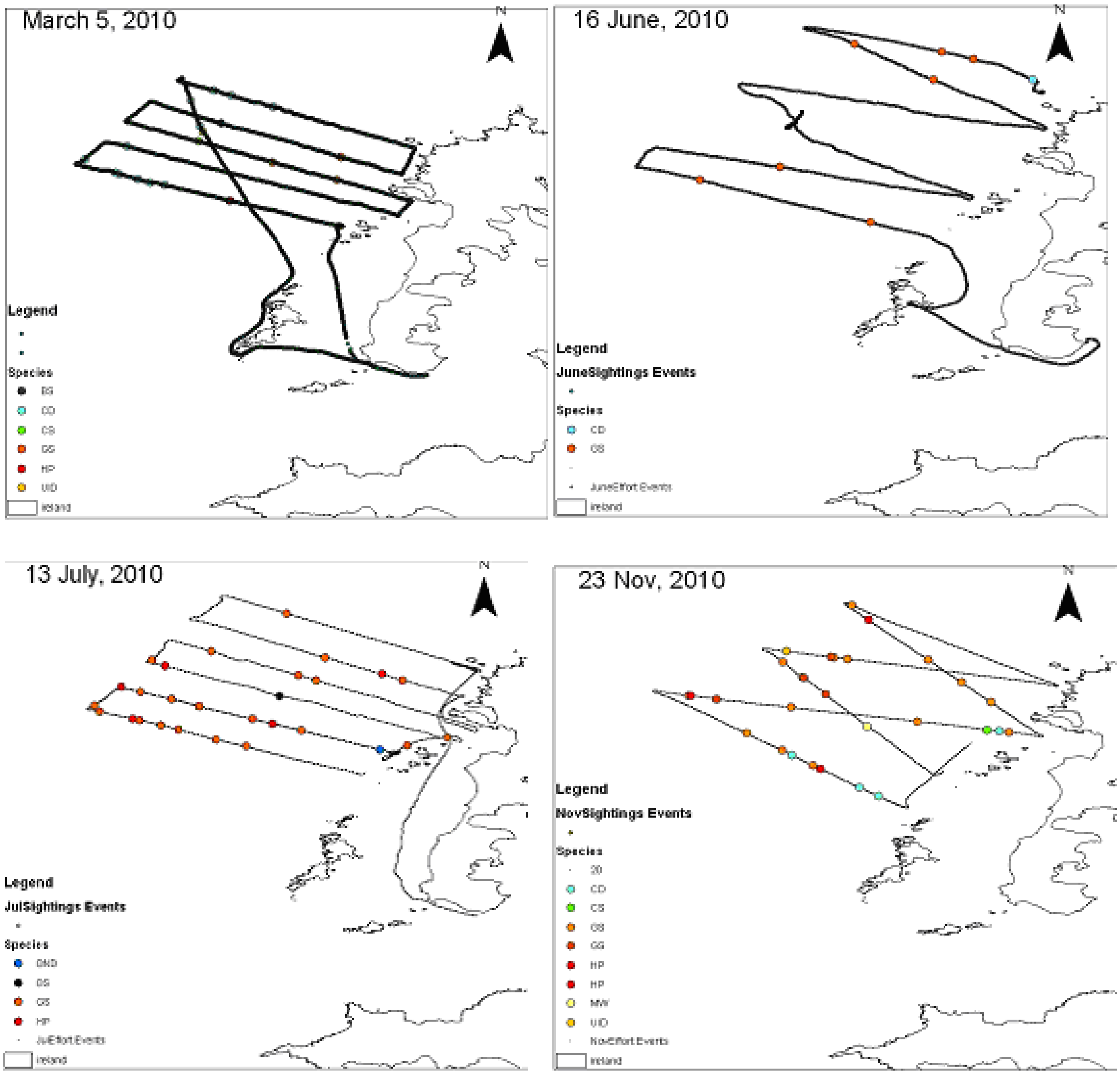
Species	Date	Number of sightings	Group Size
Minke whale	15/10/2009	3	1
	23/11/2010	1	1
Unidentified dolphins	5/3/2010	1	1
	23/11/2010	1	2
Total		41	

Table 4.8. Seals recorded on line transect surveys of the Wave Energy Test Site.

Species	Date	Number of sightings	Group Size
Grey seal	15/10/2010	5	1
	16/10/2010	11	1-2
	5/3/2010	4	1
	16/6/2010	8	1-4
	12/7/2010	21	1-2
	23/11/2010	19	1
Common seal	15/10/2009	3	1-2
	16/10/2009	3	1
	5/3/2010	1	2
	23/11/2010	1	1
Total		76	

Figure 4.5. Track lines and visual sightings during line transect surveys.





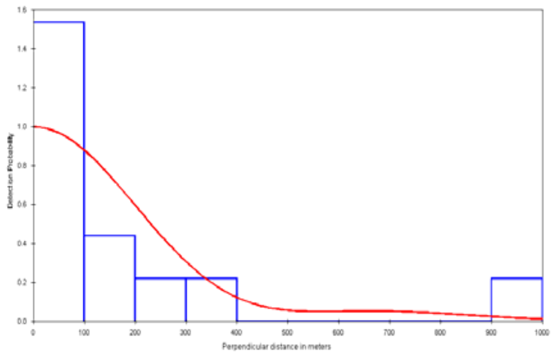
Key to species. CD: Common dolphin, BDN: Bottlenose dolphin, GS: Grey seal, CS: Common seal, HP; Harbour porpoise, MW: Minke whale, SF: Sun fish, UID, Unidentified dolphin

Abundance estimates

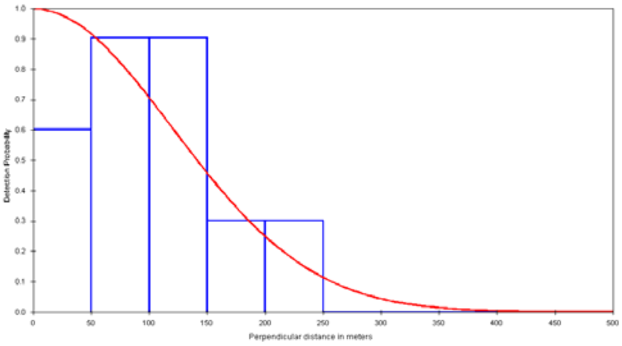
Abundance estimates using distance sampling were calculated for two species on three different survey days (Table 4.9). There were 12 sightings of common dolphins on 5 March 2010 and 11 - 21 grey seal sightings on separate surveys days between October 2009 and 23 November 2010. The length of track-line surveyed during each survey day ranged from 77 km to 222 km. it was calculated that an area of 300 km^2 (15 km x 15 km) was surveyed on each day. The detection function for common dolphins on 5 March 2010 was significant (P<0.05, df=7) and the detection function suggests movement towards the vessel as the distribution is peaked around 0-100 m. The high coefficient of variation (CV) of 0.60 suggests the estimate was poor and should be treated with caution.

Figure 4.6. Examples of detection functions for common dolphin and grey seal.

a. Common dolphin (March)



b. Grey seal (July)



Density and thus abundance estimates for grey seal increased from July (0.51 seals km^2 = 153 seals) to 0.56 seals / km^2 (171 seals) in October and to a maximum of 0.88 seals/km^2 (257 seals) in November. The CVs ranged from 0.16 to 0.21 and thus the estimates were quite robust. This increase in abundance at the Wave Energy Test Site is to be expected as November is at the start of the pupping season on Inishkea.

Table 4.9. Density and abundance estimates for common dolphin and grey seal at the Atlantic Marine Energy Test Site.

Species	Date	No. Sightings	Density	Abundance (95% Confidence Interval)
Common dolphin	5/3/2010	12	3.40	1022 (309-3383)
Grey seal	16/10/2009	11	0.56	171 (106-276)
Grey seal	12/7/2010	21	0.51	153 (109-215)
Grey seal	23/11/2010	19	0.85	257 (177-373)

Other marine megafauna sightings.

Other marine megafauna recorded during the boat based line transect surveys included basking shark and sunfish (see Table 4.10).

Table 4.10. Other marine megafauna recorded during line transect surveys.

Species	Date	Number of Sightings	Behaviour
Basking shark	5/3/2010	1	Single animal feeding
Basking shark	12/7/2010	1	Single animal feeding
Sunfish	16/10/2010	2	

4.3.2.3 Photo-identification

On 15 October 2009 a group of approximately 40 bottlenose dolphin were encountered. Images of 20 dolphins suitable for photo-identification were obtained and 12 individual dolphins from distinctive markings on their dorsal fin were identified. These images were compared to images contained in the Irish Coastal Bottlenose Dolphin Catalogue (O'Brien *et al*. 2009) and surprisingly none were matches.

On 16 June 2010 a second group of bottlenose dolphins was observed on passage to Blacksod at the end of the transect line. This group numbering around 12 individuals was photographed and images of 11 individual dolphins were recorded. These images were compared to images in the Irish Coastal Bottlenose Dolphin Catalogue and with images of individual dolphins on the IWDG website (www.iwdg.ie/sighings/photo-id). Two of these dolphins had been recorded before, one in Donegal Bay on 8 August 2008 and one off Mace Head, Co Galway on 24 May 2010. This suggests this group was part of the inshore population which have been recorded of all Irish coasts including Donegal, Antrim, Dublin, Cork and Galway (O'Brien *et al*. 2009).

4.3.2.4 Passive Acoustic Monitoring

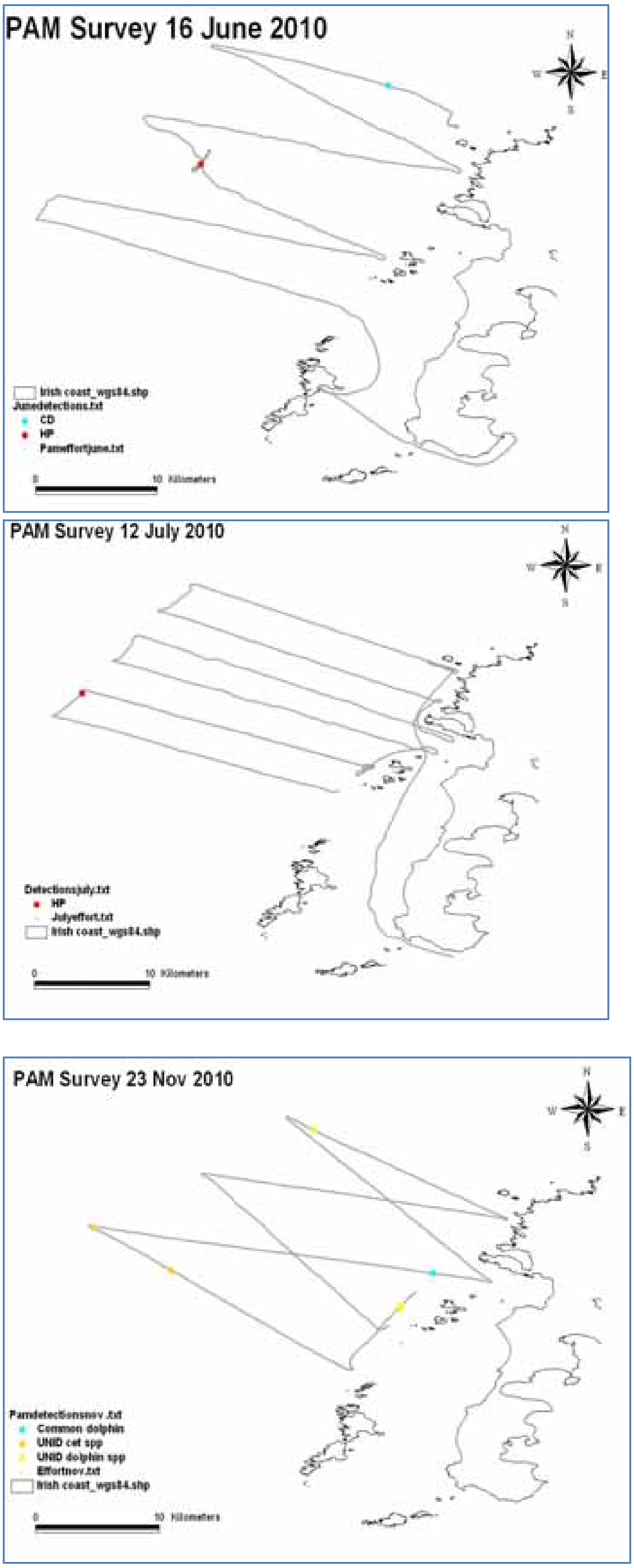
Passive Acoustic Monitoring complimented visual surveys by ensuring cetaceans are not generally missed by the visual survey team. PAM can be especially useful for the elusive harbour porpoise, as if they are missed visually, then they may be picked up acoustically, if in range of the hydrophone (Table 4.11). Hydrophones may also detect cetaceans that are beyond the visual observers view and therefore increase the capacity of the survey.

Table 4.11. Towed hydrophone surveys carried out of the Wave Energy Test Site,

Date	Detections with visual observation	Detections without visual observation	Comments
16/6/2010	1	1	Harbour porpoise clicks detected with no sighting
12/7/2010	1	0	Harbour porpoise
23/112010	2	4	Unidentified dolphin species

Three acoustic surveys simultaneous to visual observations were carried out using a towed hydrophone array (Table 4.11). A total of 317 km were surveyed acoustically over the three surveys, yielding a total of nine acoustic events of two species (Figure 4.7) and five detections of dolphin species. Of the 9 acoustic detections, four were simultanous to visual while five were recorded acoustically alone. The distribution of acoustic detections were random, with too few sightings to identify areas with high concentrations from this technique alone.

Figure. 4 7. Acoustic detections on track-lines during passive acoustic monitoring survey of the Wave Energy Test Site.



C-POD Calibration.

Three separate calibration trials were carried out in the Shannon Estuary over the duration of this study. This was due to the acquisition of new equipment over the duration, when funding became available. Firstly, two units were calibrated in the Shannon Estuary prior to their deployment at the Atlantic Marine Energy Test Site in October 2009. This calibration trial was carried out for 13 days. Results from this trial showed that the application of a correction factor was not necessary for these two units as their total Detection Positive Minutes per day (DPM) and mean DPM/hr^{-1} were so similar, showing there was little variation in sensitivities between units (Table 4.12). Mean DPM/hr^{-1} ranged between 0.14 and 0.18, while DPM/day range between 41 and 52 over the duration. A second trial on C795 was also carried out in October 2009, against C173. Again results were found to be very similar and hence removed the necessity to apply a correction factor to the resulting data (Table 4.13).

Table 4.12. Results of calibration trials for C-PODs C-547 and 549.

C-POD No.	Total deployment Days	Total DPM	Mean No. of DPM/hr^{-1}
547	13	41	0.14
549	13	45	0.15
173*	13	52	0.18

(*Reference unit)

Table 4.13. Results of calibration trials for CPODs used during survey.

C-POD No.	Total deployment days	Total DPM	Mean No. of DPM/hr^{-1}	Correction Factor (CF)
795	53	398	0.32	N/A
173*	53	380	0.30	N/A

(*Reference unit)

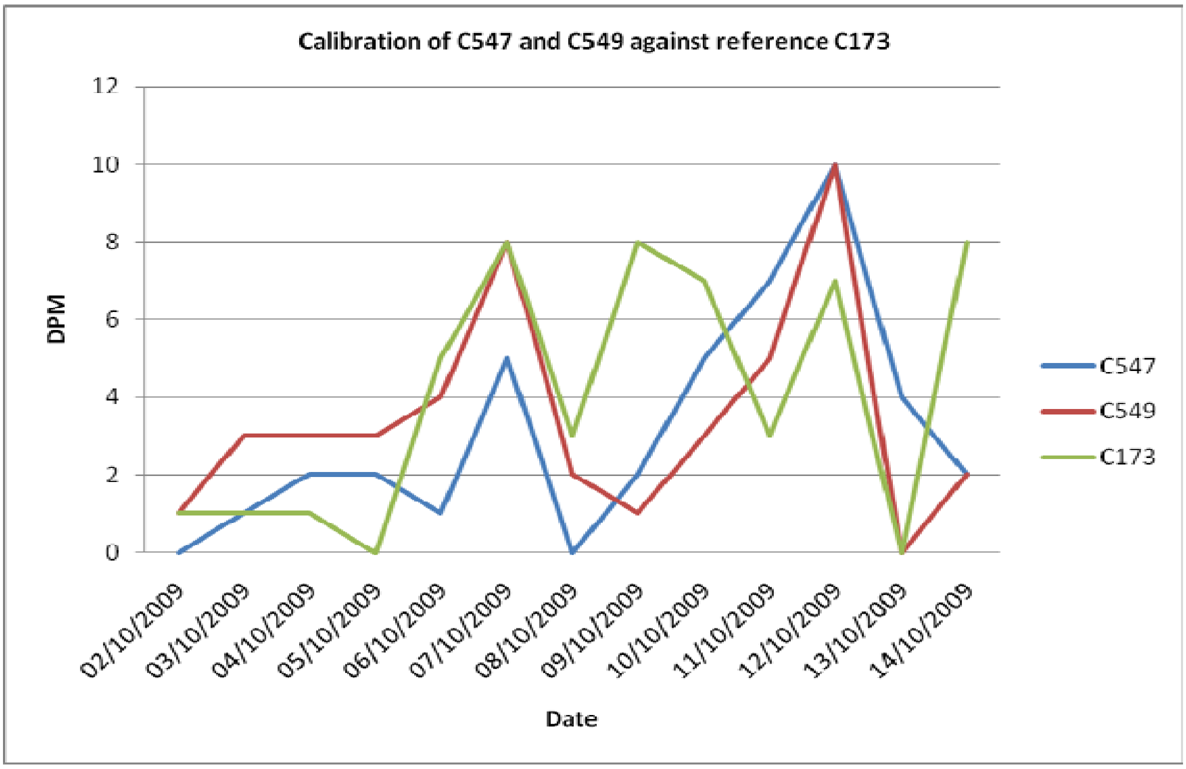
Table 4.14. Results of calibration trials for CPODs used during survey.

C-POD No.	Total deployment days	Total DPM	Mean No. of DPM/hr^{-1}	Correction Factor (CF)	Mean No. of DPM/hr^{-1} (x CF)	Total DPM
947	27	386	0.60	1.9	1.19	754
949	27	510	0.80	1.4	1.12	710
950	27	405	0.62	1.8	1.13	722
951	27	166	0.30	3.8	0.98	619

C-POD No.	Total deployment days	Total DPM	Mean No. of DPM/hr^{-1}	Correction Factor (CF)	Mean No. of DPM/hr^{-1} (x CF)	Total DPM
952	27	740	1.14	0	0	740
172*	27	108	0.20	5.7	0.98	616

(*Reference unit)

Figure 4.8. Calibration results DPM per day from Shannon Estuary trials.



The third trial was carried out in March-April 2010, upon the delivery of new equipment following a successful tender for provision of acoustic monitoring equipment. Seven units were calibrated against a reference (C-172). Unlike the previous trial, some discrepancies between sensitivities were detected between the reference and all other PODs, hence a correction factor was generated and applied. All units were calibrated against the most sensitive unit and the data transformed accordingly (Table 4.15). Upon the application of the correction factor, results showed there to be less variation between units, with the mean DPM/hr^{-1} ranging between 0.98 and 1.2, where the range before the correction factor was applied was much greater (0.2-1.14 DPM/hr^{-1}) (Table 4.14).

Table 4.15. Results of calibration trials for CPODs used during survey.

C-POD No.	Total deployment days	Total DPM	Mean No. of DPM/hr^{-1}	Correction Factor (CF)
795	53	398	0.32	N/A
173*	53	380	0.30	N/A

(*Reference unit)

Static Acoustic Monitoring

The survey area was divided into three regions, offshore, mid-shore and inshore (Figure 4.2). Initially SAM was only carried out at two sites, the inshore site (formerly test area C) and the offshore site (Test Area A). Deployment techniques varied between the two sites, with a mooring and surface marker used at C, while acoustic release system was employed at A. Over the duration, a total of three deployments took place at former test area C and three deployments at test area A (Table 4.16). Control sites for areas A and B were monitored concurrently from July to October 2010. Offshore control sites were stationed along the same depth contour at a distance of 10 km to the north and south of each test area, which was much greater than the detection distance of the equipment.

A total of 159 days were monitored offshore at area A, while 179 days were monitored inshore at area C. The mid-shore site, area B was only monitored for duration of 78 days. Four control sites, (two inshore and two offshore) were also monitored simultaneous to areas A and B between July and October 2010 (78 days). This simultaneous deployment at six sites, facilitated a comparison of results from the three key sites, with four control sites and was the most intensive static acoustic monitoring project to be carried out in Irish waters.

Results from the three main sites (Areas A, B & C) show that the offshore site (area A) was where most detections were logged (total 2282 DPM from 158 days monitored, X = 19.0 DPM/day), followed by the mid sites (area B, 1459 from 77 days monitored, X = 18.9 DPM/day), and the inshore site (Area C, 1042 DPM from 179 days, X = 4.0 DPM/day). Most dolphin positive minutes were recorded at the offshore site, Area A (2026 dpm, X = 25.6 dpm /day), and the midshore site Area B (1134 dpm, X = 14.7 dpm/day), in comparison with the inshore site area C (185 dpm, X = 1.7 dpm /day). Most Harbour porpoise detections were recorded at Area A (X = 12.1 ppm/day) and C (X = 6.3 ppm/day), with a mean of 4.2 ppm / day at Area B.

Table 4.16. Summary of results from acoustic monitoring using CPODS.

Site	POD No.	CF	Location	Deployment No.	No. of monitoring days	% of days with detections	Detection Positive Minutes (DPM)	Porpoise Positive Minutes (ppm)	Dolphin Positive Minutes (dpm)	Mean DPM/day
Area A	547	NA	Offshore	1	81	98	1190	256	934	14.5
	549	NA		2	NR	-	-	-	-	-
	950	1.8		3	77	95	1692	689	1092	23.2
Area B	795	NA	Mid	1	77	92	1459	325	1134	18.9
Area C	549	NA	Inshore	1	40	24	32	10	22	0.8
	795	NR		2	139	54	1010	847	163	7.2
	173	5.7		3	NR	-	-	-	-	-
Control 1	952	0	Offshore	1	77	73	257	67	190	3.3
Control 2	947	1.9	Inshore	1	77	56	521	42	479	6.7
Control 3	949	1.4	Offshore	1	77	62	209	70	139	2.7
Control 4	951	3.8	Inshore	1	77	66	445	365	80	5.7

N/A = Not applicable, N/R Not retrieved

Table 4.17. Summary of detection minutes per day recorded at Area A, B & C.

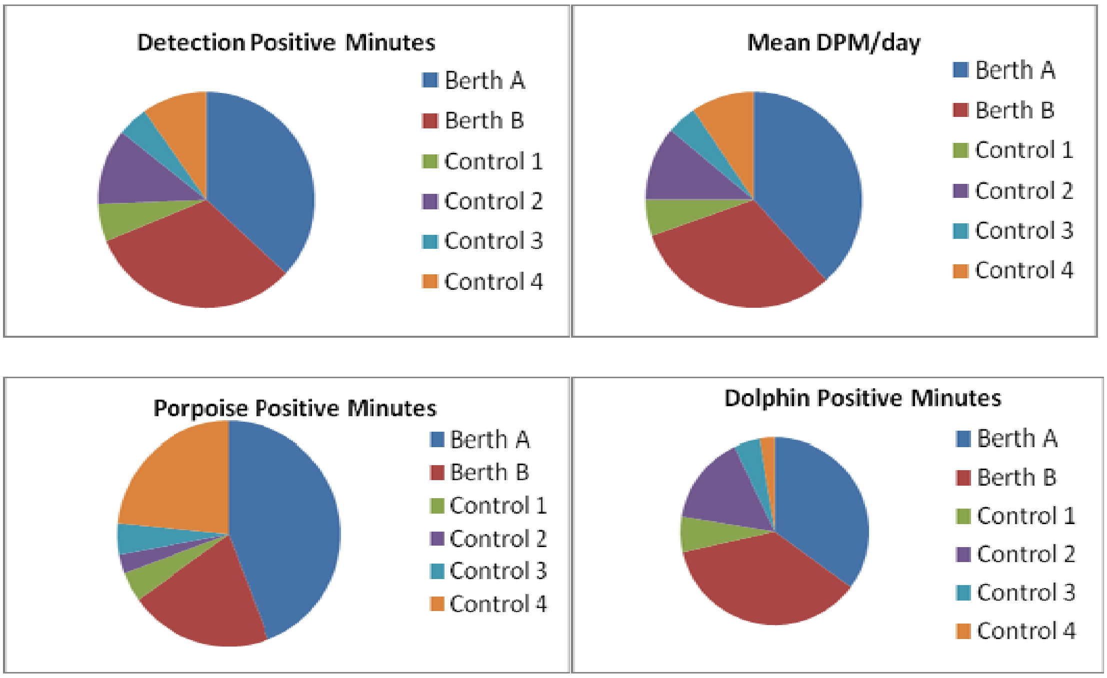
	PPM/day	DPM/day	Total Detection Positive Minutes per day
Area A	12.1	25.6	37.7
Area B	4.2	14.7	18.9
Area C	6.3	1.7	8.0

Results from the control sites showed that the inshore locations had more total DPM logged than the offshore sites, with most porpoise and dolphin detections logged on the inshore PODs (Table 4.18). However, when this data is compared to the three main sites (Areas A, B and C), the mean DPM's per day from are far greater than those of the control sites (Figure 4.9).

Table 4.18. Summary of detections per day recorded at control sites.

	Location	PPM/day	DPM/day	Total Detection Positive Minutes per day
Control 1	Offshore	0.9	2.5	3.3
Control 2	Inshore	0.5	6.2	6.7
Control 3	Offshore	0.9	1.8	2.7
Control 4	Inshore	4.7	1.0	5.8

Figure 4.9. Comparison of data between Areas A & B and 4 control sites.



Seasonal Variation

A summary of the monthly variability in acoustic detections during this survey is presented in Figure 4.10 and Table 4.19, where the mean DPM/day is presented. The failure of an acoustic release at Area A in April, and the loss of a unit at Area C in October, when the mooring was recovered intact but the unit missing resulted in some gaps in the dataset.

No clear seasonal trends can be detected due to gaps in the dataset though there is a suggestion dolphin detections were greater in the autumn and winter. This is thought to be due to common dolphins, which were frequently observed at the site. Detections at Area C were greater during the summer which was thought to be due to harbour porpoise activity and detections at Area B were similar to Area A though there was only a limited dataset.

Figure. 4.10. Monthly variation in detection positive minutes.

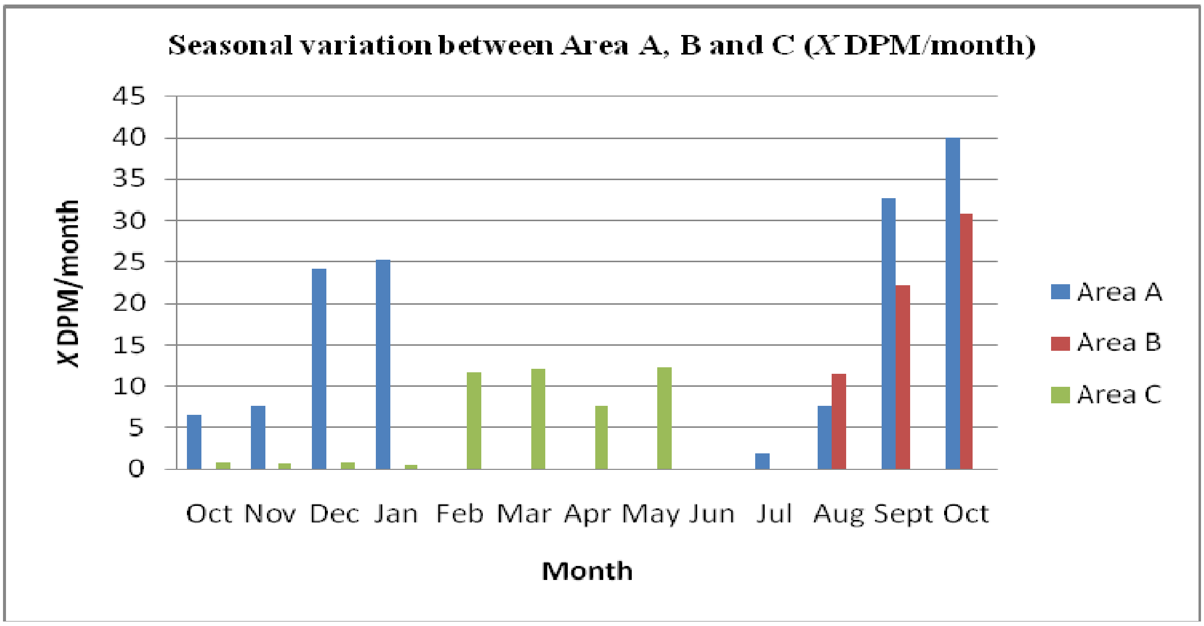


Table 4.19. Monthly variability in Detection Positive Minutes per month.

Location	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Jun	Jul	Aug	Sep	Oct
Area A	6.4	7.6	24.2	25.3	-	-	-	-	1.8	7.7	32.7	40
Area B	-	-	-	-	-	-	-	-	-	11.5	22.2	30.9
Area C	0.9	0.7	0.9	0.5	11.6	12.1	7.6	12.3	-	-	-	-

4.3.2.5 Off-effort sightings

A number of casual sightings recorded with no associated effort were collected during the survey (Table 4.20). The project team recorded some of these sightings during the dedicated bird surveys. Two species, killer whale and white-beaked dolphins were not recorded during the dedicated cetacean surveys. One sighting of 15-20 bottlenose dolphins on 16 June 2010 enabled images suitable for photo-identification to be collected (see photo-identification section).

Table 4.20. Cetaceans recorded at Wave Energy Test Site while engaged in other activities.

Species	Date	Group Size	Behaviour
Harbour porpoise	12 July 2010		Observed during bird survey
Common dolphin	4 January 2010	10	In Broadhaven Bay
	4 January 2010	40	At Area A
	11 May 2010	c.45	Observed during bird survey
	29 July 2010		
	12 October 2010	c.80	Observed during bird survey
	14 October 2010	c.100	
Bottlenose dolphin	21 May 2010	8-12	Belderra (Jackie Hunt)
	16 June 2010	15-20	Photographed for id purposes
White-beaked dolphin	15 June 2010	6-8	Observed during bird survey
	12 October 2010	c.35	Observed during bird survey
Killer whale	16 August 2010	1	Observed during bird survey
Minke whale	11 May 2010	1	Observed during bird survey
	12 October 2010	3	Observed during bird survey
Basking sharks	11 May 2010	2	Observed during bird survey
	21 May 2010	2	Annagh Head (Jackie Hunt)
Sunfish	12 July 2010	1	Observed during bird survey
	16 August 2010	1	Observed during bird survey
	12 October 2010	1	Observed during bird survey

4.4 DISCUSSION

All survey methodology has its limitations and constraints and a combination of methods will provide the best record of marine mammal occurrence and abundance. Visual surveys are constrained by weather conditions but have the advantage of allowing species identification and the calculation of abundance. Visual surveys also enable photo-identification of individual animals if encountered, for example bottlenose dolphin or killer whale. Acoustic surveys allow monitoring throughout the day and night and in all sea conditions (SAM) or much greater detection distance for some species than is possible for visual surveys (PAM).

Table 4.21. Summary of marine mammal occurrence at and adjacent to the Wave Energy Test Site.

Species	Spring	Summer	Autumn	Winter	Comments
Harbour porpoise					Regular
Common dolphin					Regular/abundant
Bottlenose dolphin					Seasonally resident
Risso's dolphin					Vagrant
White-sided dolphin					Rare
White-beaked dolphin					Rare
Striped dolphin					Rare
Killer whale					Infrequent visitor
Minke whale					Common/Seasonal
Humpback whale					Rare
Grey seal					Resident/abundant
Common seal					Resident/abundant
Basking shark					Seasonally frequent
Sunfish					Infrequent visitor

4.4.1 Mammal Community

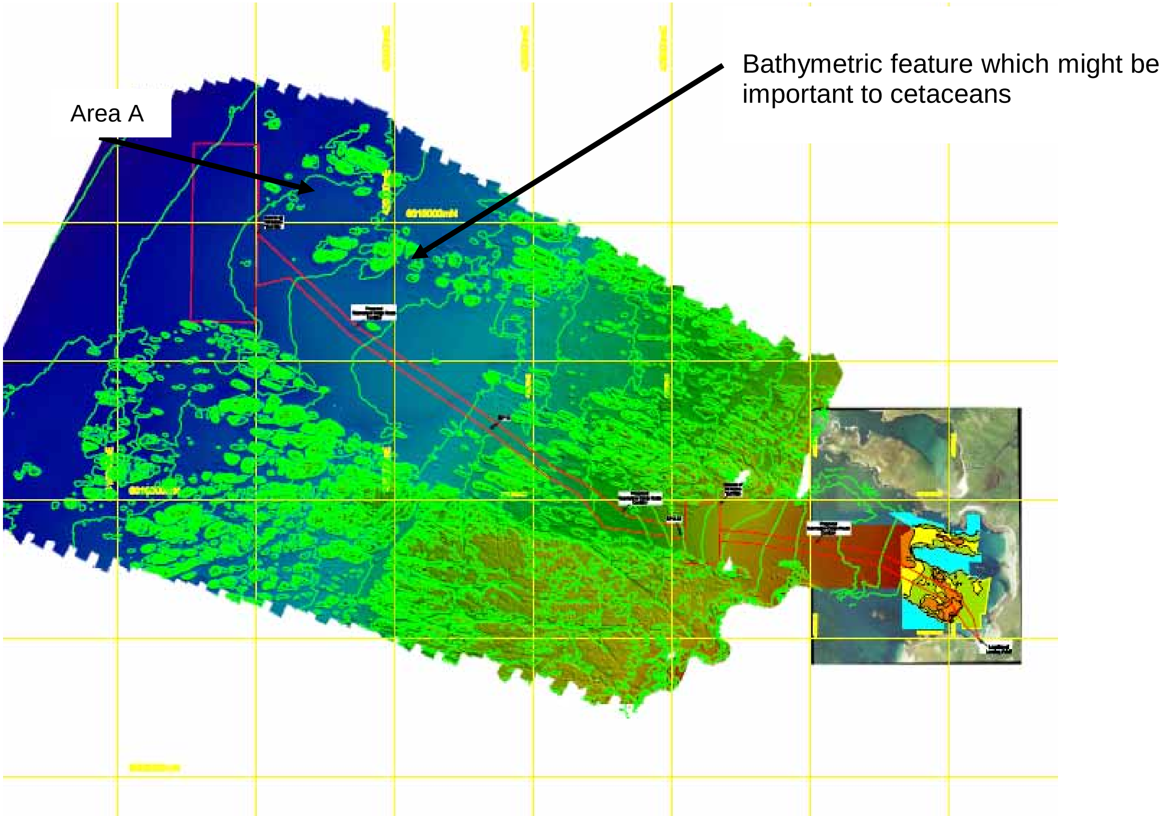
The marine mammal community occurring at the Wave Energy Test Site can be described from a combination of visual and acoustic surveys as well as published, unpublished and historic data. There was great consistency between datasets with common and bottlenose dolphins the most frequently reported species, harbor porpoise recorded during the current survey and a range of species recorded regularly but infrequently. These studies and reports show that there is a rich marine mammal community in, and adjacent to, the Atlantic Marine Energy Test Site.

4.4.2 Seasonal and Geographical effects

Cetaceans were recorded throughout the year with common dolphin and harbour porpoise widespread and abundant and bottlenose dolphins abundant during summer and autumn. Some species such as minke whale were only present in the summer. Results from SAM did not show consistent seasonal trends in the presence of dolphins and porpoises, as although there was a peak in dolphin detections (thought to be due to common dolphins) in the autumn and winter this was not the case with porpoises.

Interestingly, the greatest detections using SAM were at Area C for both dolphins and porpoise. Detections at both offshore control sites (Control 1 and 3) were an order of magnitude less for both dolphins and porpoise. The proportion of days with detections was also greater at Area A and Area B than for any of the control sites. This may be due to some bathymetric feature such as a break in the reef system, which was used to select the site for the deployment of a wave energy device, and was also used as a feature by dolphins. This aspect requires further investigation as the potential for disturbance by wave devices on dolphins increases if this relationship is found to be consistent.

Figure 4.11. Location of bathymetric feature which may be important to cetaceans.



4.4.3 Importance of the site

The Atlantic Marine Energy Test Site is a relatively small area when considering mobile marine species such as marine mammals. Nevertheless, seven cetacean species, two seal species and two other marine megafauna species have been recorded within the site and another three adjacent to it. Most sites in Ireland are poorly studied and greater levels of survey generally result in more species being recorded. Thus, high species diversity such as reported here is likely to be quite typical for inshore waters off the west coast of Ireland, especially at sites near the shelf edge For example, Broadhaven Bay at the northern end of the Mullet peninsular has been shown to have a rich marine mammal fauna including nine cetacean and two seal species as a consequence of intensive monitoring carried as part of the Corrib Gas Project (Visser *et al*. 2010).

The abundance of common dolphin was very similar to that reported in the autumn by Ryan *et al.* (2010) for the west (3.83 individuals / km^2) and southwest coasts (3.02

individuals / km^2) suggesting that although the Atlantic Marine Energy Test Site is a good site for common dolphins densities are similar to other sites.

In addition to the high species diversity and relative abundance, the presence of known individual dolphins as recognised through photo-identification is significant. During the survey some dolphins were matched to the Irish Coastal Bottlenose Dolphin Catalogue (O'Brien *et al.*2009) showing they are part of a highly mobile population that may occur off all Irish coasts. Dolphins that could not be matched to the coastal catalogue were also recorded and they are thought to be offshore in origin. The probability that 12 well-marked dolphins would not be matched if they belonged to the coastal population is very low given that dolphins are regularly matched to this catalogue. The study site is only 70 km from the edge of the continental shelf, which is relatively close and it is quite likely that offshore dolphins make incursions into the coastal waters of the Mullet peninsular. Recently, Mirimin *et al*. (in press) using mitro-chondrial and micro-satellite genetic analysis has suggested there are three putative bottlenose dolphin populations in Ireland; the Shannon Estuary population, a Mayo-Connemara population (our coastal population) and an offshore population. It seems that two of these three populations may occur within the site. As no site in Ireland has been shown to be used by both bottlenose dolphin populations this requires further investigation, however, if it were to occur it is likely to be off northwest Mayo, as the edge of the continental shelf is closer to this area than any other inshore site in Ireland.

Thus although spatially restricted the site is important for the diversity of species recorded, including the year round presence of common dolphin and harbour porpoise and the regular occurrence of bottlenose dolphins.

4.5 IMPACT OF THE DEVELOPMENT

The impact of marine renewable energy devices on marine mammals is not known. Without full size devices deployed at sea with which to monitor for any effects, at presen predicting impacts is speculative. For this reason, a recent (June, 2010) special request advice document on environmental interactions of wave and tidal energy generation devices (Marine wet renewables) (OSPAR 2010) stated that It is important that the results of thorough monitoring of early deployments of wave and tidal stream devices are published and used to guide the management of subsequent developments.

There has been considerable interest recently on the potential effects and impacts with a number of useful and extensive reviews, e.g. Inger *et al* 2009; Boehlert and Gill, 2010. However, with a lack of working devices deployed in the marine environment with which to test this hypothesis, inevitably there is much speculation with very little empirical data to inform these debates.

Inger *et al*. (2009) provided a review of the impacts, both positive and negative, on biodiversity and suggested the main negative effects include some loss of habitat from physical displacement, collisions, where marine renewable energy devices have moving or rotating parts, disturbance of feeding and perhaps migratory behaviour through interference by electromagnetic fields generated along active power cables and possibly the most relevant to marine mammals, the impact of noise generated by working devices and during construction.

While research into the effects of noise on marine mammals is steadily increasing the evidence base to make any concrete predictions is still lacking. Inger *et al* (2009) in their comprehensive review of the impacts of various anthropogenic impacts of Marine Renewable Energy Installations (MREI) on biodiversity state that most research has been carried out on wind farms, yet the effects of noise from other MREI are likely to be highly variable. They also make the observation that an assumption is made that minimisation of noise from MREI is desirable; however, the evidence base to make this assumption is currently not available. They therefore suggest that, when sufficient evidence becomes available, a systematic review be undertaken which will provide an unbiased, quantitative assessment of the overall noise impacts of MREI.

Walker *et al* (1992) found evidence that fin whales possess a magnetic sense and that they use it to travel in areas of low geomagnetic field gradient and possibly low magnetic intensity during migration. Kirschvink *et al*. (1986) tested the hypothesis that cetaceans use weak anomalies in the geomagnetic field as cues for orientation, navigation and/or piloting. Their results suggested that cetaceans have a magnetic sensory system comparable to that in other migratory and homing animals, and predict that the magnetic topography and in particular the marine magnetic lineations may play an important role in guiding long-distance migration. The ‘map’ sense of migratory animals may therefore be largely based on a simple strategy of following paths of local magnetic minima and avoiding magnetic gradients. However, the research base on this topic is still poor, making it difficult to draw any conclusive opinions.

Based on a literature review of the effects of EMF from sub sea power cables on marine organisms (Olsson, 2010) there is currently no information to suggest that any strictly marine species of mammal is electro-receptive.

A lot has also been written about the potential benefits that marine renewable energy devices may bring to marine biodiversity (Inger *et al*. 2009; Wilson *et al*. 2010). The hard substrates created, especially with respect to offshore wind farms, may act as artificial reefs but all devices may potentially act as fish aggregating devices (FADS). The latter may positively impact on marine mammals especially if fish biomass is increased rather than concentrated around FADS, without depleting surrounding areas. In addition the exclusion zone created around devices, or more realistically an aggregation of devices or farms, may act as no-take zones or pseudo-marine protected areas. A recent review of the potential for wave energy devices to provide artificial habitats and protect areas from fishing, commissioned by Vattenfall AB and conducted by the IUCN (2010) also concludes that the knowledge base for assessing the benefits of fish aggregation devices, and for managing the risks of both remains weak. This report concluded that responses to different types of artificial reefs, FADs, and sizes of Marine Protected Areas are species specific, and the available data only allow for qualitative estimates based on scientifically founded speculations. This is due to the lack of empirical data available to explore these issues.

A major and relevant development in Ireland is the construction of SeaGen in Northern Ireland. There has been major environmental monitoring of this development, the world's first commercial-scale tidal turbine, which suggests no changes to benthic communities but that noise production during operation could result in avoidance behaviour (SeaGen, 2010). Most studies of environmental impact to date have involved the construction and operation of offshore wind farms. Wilson *et al*. (2010) reviewed recent environmental impact studies of offshore wind farm construction and concluded that although not benign the impacts were minor and can be mitigated through good siting practices. This conclusion is also relevant to the production of wave energy.

4.5.1 General effects

The general effects of the deployment of wave energy devices and arrays are speculatively considered by some to be entanglement (Boehlert *et al*., 2007), collision and disturbance of feeding and perhaps migratory behaviour through interference by electromagnetic fields (Inger *et al,* 2009). However, all such potential effects are purely speculative without the necessary baseline research by which to test these hypotheses.

4.5.2 Construction phase

The construction phase is generally regarded as potentially the most disruptive period in the development and operation of a wave energy farm in the absence of any research data on the effect of the deployment of wave energy devices and arrays on marine mammals. Increased boat traffic during construction may lead to disturbance of marine mammals. The deposition of rock armour may create a disturbance to marine mammals and degradation of preferred habitats Of the species recorded in the vicinity of the AMETS, Porpoise are likely to be the most sensitive to disturbance, actively avoiding vessels and more sensitive to high frequency sounds than dolphins. The effects of disturbance by vessels and noise on other marine mammals are likely to be similar.

4.5.3 Operational phase

There is a low risk that the presence of wave energy devices and associated moorings may create a physical barrier to the movement of marine mammals. Increased ambient noise associated with wave energy devices is a possibility.

4.6 MITIGATION OF IMPACTS

4.6.1 Construction phase

Marine Mammal Observers (MMO) should be used during deposition of rock armour to ensure there is a minimum distance between marine mammals and the vessel when working. This distance should be agreed with NPWS and take into account noise source level and attenuation. Ideally this would be measured and modeled before a minimum distance is determined.

4.6.2 Operational phase

Once operational, the greatest impact to marine mammals is likely to be from noise production from wave energy devices and service vessels. It is difficult to determine the extent of any impact without information on the sound sources and frequencies generated. Attempts should be made to minimise noise production during operation of the wave site.

Collission with mooring systems would also be a potential risk. The use of acoustic deterrents has been considered but discounted on the advice of NPWS.

4.6 MONITORING

Ongoing visual and acoustic monitoring is continuing at present in order to build a more robust baseline dataset to enable any changes to the marine mammal community in the future to be detected. A number of issues have arisen from the current survey, which are addressed below.

Acoustic monitoring provides high quality data particularly if enough devices are deployed over a good spatial scale. C-PODs have proven to be effective at monitoring small odontocetes (harbour porpoise and dolphins) at the site and have recorded differences between sites and controls.

Acoustic detections at Area A were high compared to control site. This may be due to some bathymetric feature, selected for wave energy testing and by dolphins. This requires further investigation as the potential for disturbance by wave devices on dolphin's increases if this relationship is found to be consistent.

Power analyses of both the acoustic data and visual surveys will be conducted to decide on the optimum number and frequency of surveys required to calculate the minimum sample size necessary to detect change. While it is envisaged that the data gathered thus far from the acoustic surveys will provide a more robust power analysis it is anticipated that data from the visual surveys should also be sufficient at this stage to provide a significant level of confidence in assessing the optimum number and frequency of surveys. A power analysis has not been carried out to date, as the data acquired from the first year of survey is insufficient but could be with another years data.

The continued monitoring of the site will add significantly to the already existing baseline data and provide the data required to allow evidence based conservation objectives to be set for marine mammals using the AMETS.

Table 4.22. Potential impacts during construction phase

Species and Habitats	Potential impacts
Species	Increased boat traffic during construction may disturb marine mammals currently in the area. The deposition of rock armour may create a disturbance to marine mammals.
Habitats	The deposition of rock armour may cause alteration or degradation of preferred habitats.

Where likely impacts have been identified in terms of a species or a habitat, the significance of this impact has been assessed, following a standard assessment process detailed below.

Table 4.23. Assessment of significance – Construction phase

Potential impact:	**Species disturbance and habitat alteration or damage**
Significance criteria	
Character and perceived value of affected environment	There is a rich marine mammal community in, and adjacent to, the AMETS. Cetaceans are present throughout the year with common dolphin and harbour porpoise widespread and abundant and bottlenose dolphins abundant during summer and autumn. Some species such as minke whale are only present in the summer. Although spatially restricted the site is important for the diversity of species present.
Confidence in the accuracy of predictions of change	Marine mammals are known to be sensitive to disturbance. While research into the effects of noise on marine mammals is steadily increasing the evidence base to make any concrete predictions is still lacking.
Magnitude, spatial extent and duration of anticipated change	Marine mammals are highly mobile species and the spatial extent of the AMETS is small relative to the available habitat.
Resilience of environment to	The scale of the development in the context of the overall available habitat would mean any changes to the

cope with change	environment would be insignificant.
Scope for mitigation, sustainability and reversibility	Ensure a Marine Mammal Observer is onboard vessels during the construction phase of the development
SIGNIFICANCE OF IMPACT	**LOW**

Table 4.24 Potential impacts during operational phase.

Species	Potential impacts
Marine mammals	Unknown. Research data is lacking to inform the likely impacts of WECs on marine mammals.

Where likely impacts have been identified in terms of a species or a habitat, the significance of this impact has been assessed, following a standard assessment process detailed below.

Table 4.25. Assessment of significance during operational phase.

Potential impact:	**Species disturbance**
Significance criteria	
Character and perceived value of affected environment	There is a rich marine mammal community in, and adjacent to, the AMETS. Cetaceans are present throughout the year with common dolphin and harbour porpoise widespread and abundant and bottlenose dolphins abundant during summer and autumn. Some species such as minke whale are only present in the summer. Although spatially restricted the site is important for the diversity of species present.
Confidence in the accuracy of predictions of change	Unknown. Research data is lacking to inform the likely impacts of WECs on marine mammals
Magnitude, spatial extent and duration of anticipated change	Marine mammals are highly mobile species and the spatial extent of the AMETS is small relative to the available habitat.

Resilience of environment to cope with change	Spatial scale of the development in relation to the available habitat and the dynamic environment would indicate little impact.
Scope for mitigation, sustainability and reversibility	Monitoring of marine mammal activity is essential during the operational phase to provide the evidence base required to assess the impacts of WECs on marine mammals.
SIGNIFICANCE OF IMPACT	**Unknown**

Table 4.26: Mitigation of impacts during construction phase

Potential Impact	Scope for mitigation, sustainability and reversibility
Species disturbance and alteration or damage to habitats	Ensure a marine mammal observer is onboard vessels during the construction phase to ensure no marine mammals are in close proximity to construction works and that works are suspended until marine mammals have moved away from the area of construction.

Table 4.27: Mitigation of impacts during operational phase

Impact	Scope for mitigation, sustainability and reversibility
Species disturbance	Unknown. Monitoring of the site post deployment or information gained from post deployment monitoring at other similar test sites (if this occurs in advance of operations commencing at the AMETS) would be required to provide the evidence base required.

5. TERRESTRIAL FLORA & FAUNA

5.1 INTRODUCTION

A preliminary study in advance of this ecological assessment was undertaken to examine a number of proposed cable landfall options in relation to their ecology and extended the scope of work to examine the wider environment in the vicinity of the AMETS. The objective of the extended survey was to investigate the ecology and conservation interests of the wider countryside to assess the potential for alternative cable landfall options. The details of the extended survey are provided in the Environmental Scoping report for the AMETS (2010).

This study examined the terrestrial ecology (flora and fauna) of the proposed landfall option at Belderra Strand, the associated preferred substation location and a buffer zone surrounding these two areas (Figure 5.1). The intertidal area of the Belderra Strand is fully considered in Section 2 of this report.

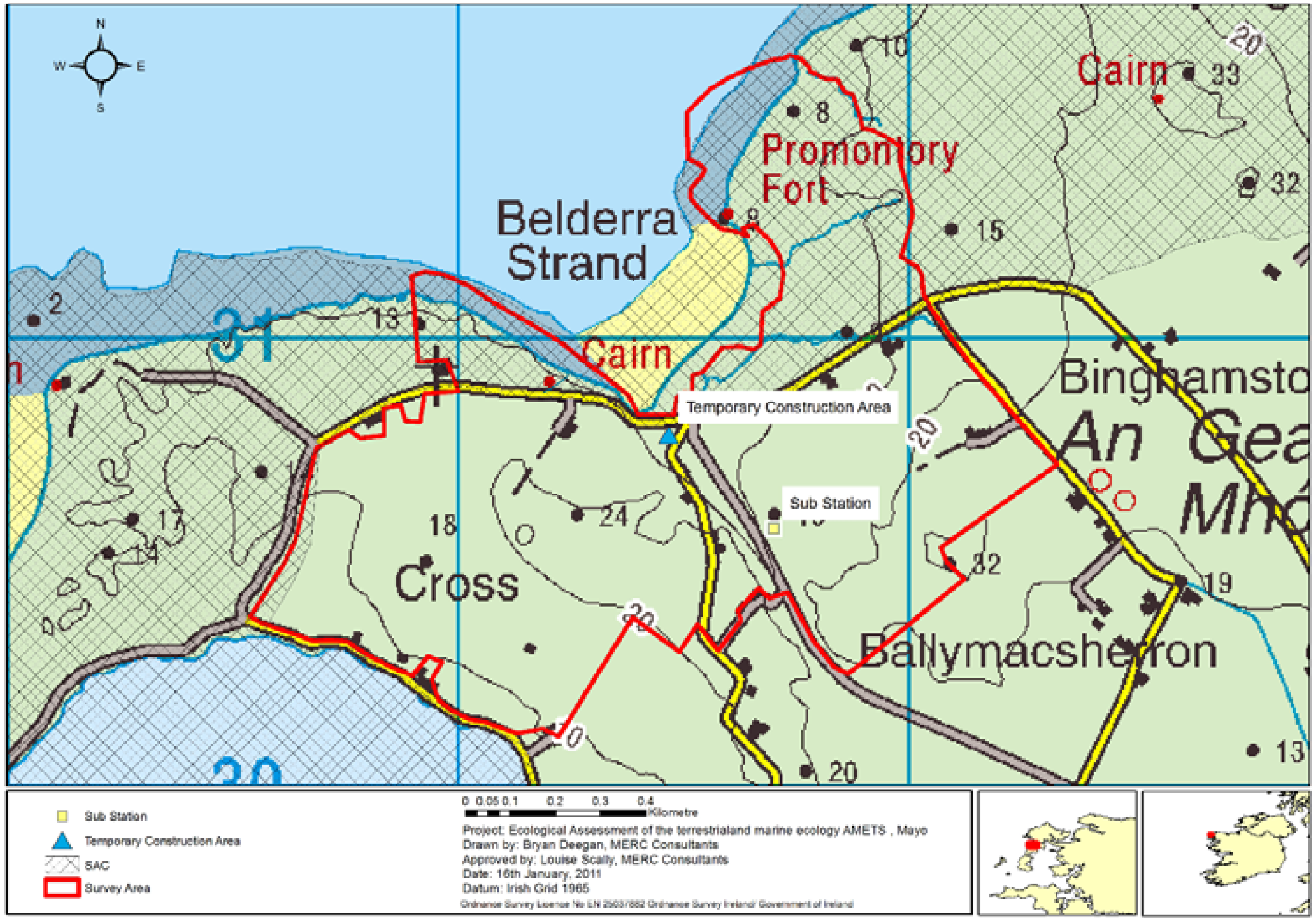
Belderra Strand is located at the south-eastern end of the bay in the townland of Cross. It is a gently sloping sandy beach backed by a low sand dune system which is heavily grazed, a small paved parking area is situated at the extreme southwestern end of the beach.

The proposed land fall option at Belderra Strand would land the cables at the south-western end of the beach where they could be trenched through the beach and through or adjacent to the car park area to a proposed substation on the land side of the coast road. The proposed substation location is elevated and would require excavation of rock to embed the substation in the landscape. The distance through the SAC, i.e. the intertidal area, is approximately 0.28 km.

It is proposed that a small triangular area behind the car park at Belderra Strand (Figure 5.1) is used for the temporary parking of machinery associated with the cable landing operations and the subsequent positioning of a cable bay.

The site of the proposed substation (Figure 5.1) does not lie within any designated areas (SAC, SPA or NHA). Belderra strand lies within the Mullet/Blacksod Bay Complex cSAC (Site code 000470) and this area is considered elsewhere in this report.

Figure 5.1. Location of substation, temporary construction area/cable bay.



5.2 METHODOLOGY

A habitat map of the area was constructed by reference to the aerial imagery and 1:50,000 OS maps for the area and a detailed walk over of the study site. Habitat maps were constructed by drawing habitat boundaries on copies of the ortho imagery for the site and polygons were subsequently drawn in ARC GIS®. All habitats identified were classified according to Fossitt (2000). Some habitats, e.g. coastal grassland that did fit within the Fossitt habitat classification system were classed within a broad Fossitt classification but described in more detail.

In some cases boundaries between habitats were transitional, e.g. between machair and dry calcareous grassland and between embryonic and marram dunes, and in these cases the boundary was drawn to best fit the current situation at the time of survey.

Each habitat mapped was then surveyed by conducting a detailed walkover of the habitat to record vascular plant species present and their abundance on a DAFOR scale. All survey work was carried out in July 2010. Species identification was based on Webb *et al*., (1996) and Hubbard (1992). The vernacular names of plants are used within the text of this report, with a list of all species and their scientific names presented in the associated species tables.

Within the most prominent habitats, likely to be impacted by the cable route or sub-station location, data was gathered from three 1 x 1 m^2 relevés. In the case of the sand dune system, relevé data was not gathered as this habitat was almost entirely dominated by a monoculture of marram grass. DOMIN scores were assigned based on Table 5.1.

Table 5.1: DOMIN scale.

DOMIN scale			
Single individual, cover <1%	+	26-33%	6
2-3 individuals; cover < 1%	1	34-50%	7
Several individuals; cover <1%	2	51-75%	8
1-4%	3	76-90%	9
5-10%	4	91-100%	10
11-25%	5		

Any evidence of mammals of conservation importance (otter sprint etc) was also looked for during the walk over surveys and literature searches were conducted to assess species distribution maps to ascertain their likely existence within the survey area.

5.3 RESULTS

5.3.1 Habitats

Much of the area immediately behind Belderra Strand consists of a thin band of low-lying Marram dune (CD2), which leads into an area of dune slack (CD5). A small pocket of machair, at the western end of the dune slack that was identified in the original scoping report, has since been altered by the positioning of a drainage ditch through the area and this area is now degraded and more consistent with the area of dune slack.

On the far side of the road, behind the beach, the main habitat is a mosaic of semi improved agricultural grassland, much of which had been cut for silage at the time of the site visit. Smaller areas more consistent with dry calcareous grassland (GS1), largely as a consequence of sand blown influence, occur immediately behind the area of dune slack. Figure 5.2 shows a map of the location of the habitats surveyed, a description of each of the habitats is provided below and a detailed species list for each area is provided in Table 5.4.

Dry calcareous grassland (GS1). Areas 1, 2 & 9

This habitat occurs extensively throughout the site, and comprises most of the coastal grassland surrounding Belderra Strand. Although the geology of the underlying bedrock is gneiss, the soils are influenced by wind blown calcareous sands. Area 1 (Figure 5.2) comprised a fenced field to the south of Belderra Strand with a tightly grazed sward of grasses and broad-leaved herbs. A small ditch cuts through this field and onto the beach below. Cattle were grazing this area at the time of survey. Area 2, behind the road at the back of Belderra Strand, also consisted of dry calcareous grassland, although much of this area is currently being improved. A number of dry rocky knolls occur in this area with drier heath type vegetation. Area 2, to the north of Belderra Strand also consists of dry calcareous grassland leading into an area of machair (area 4) to the west.

Improved agricultural grassland (GA1). Areas 5 & 6

Improved agricultural grassland forms the dominant habitat of the surrounding area (Areas 5 and 6). Much of which had been cut for silage at the time of survey or was about to be cut, while some areas were being used for cattle grazing. Drainage ditches were frequent around the boundaries of many of the fields in these two areas and embankments planted with conifer species and New Zealand flax were common.

Dune Slack (CD5). Area 7

Dune slack occurs in the area behind the marram dunes to the back of Belderra Strand (Area 7). The area is low lying and characterised by a mosaic of damp hollows and drier hummocks. A drainage ditch has recently been cut through this area.

Plate 5.1. Low dunes behind Belderra Strand, Co. Mayo.

Marram dunes (CD2). Area 8

A thin band of gently sloping embryonic/marram dune occurs immediately behind Belderra Strand. While the seaward boundary of the dunes appear more in keeping with the classification of an embryonic dune system the gradation between the fore dunes and the more stable backing dunes is difficult to define. The beach is constantly subjected to storm events and the boundary of this dune complex appears to frequently shift. The dunes are not well developed and cattle were grazing among the dunes at the time of surveys.

Drainage ditches (FW4). Throughout the site

A number of drainage ditches occur throughout the area and typically comprise a vegetation of fool's watercress, *Juncus* spp and yellow flag. The invasive species, giant rhubarb (*Gunnera tinctoria*), was recorded from two of the drainage ditches in the survey area but was not recorded elsewhere.

Marsh (GM1). Area 10

An area of marsh occurs between the two roads behind the car park at Belderra Strand. The area is dominated by reeds and is boarded by drainage ditches on both sides. This area has frequent drainage channels and its character has altered since the time of an initial site visit in 2009.

Machair (CD6). Area 4

An area of machair occurs on the northern side of Belderra Strand directly behind a rocky shoreline before merging into dry calcareous grassland. The machair hosts a range of typical species including red fescue, sedges, plantain, daisy, common bird's foot trefoil and lady's bedstraw. Cattle grazing, necessary for the maintenance of machair, occurs throughout this area and the adjacent dry calcareous grassland.

Exposed rocky shores. Areas 11 & 12

Exposed rock shores occur on both the northern and southern edges of Belderra Strand. The habitat is typical of exposed rocky shores with thrift frequent at the transition from coastal grassland to rock, an upper lichen zone beneath which occurs a fucoid zone with abundant *Mytilus edulis.* Rock pools are occasional throughout.

5.3.2 Vegetation

Table 5.2. Dune Slack relevé data (Area 7).

Species	DOMIN		
	Relevé 1	Relevé 2	Relevé 3
Agrostis stolonifera	-	5	-
Festuca rubra	3	1	-
Holcus lanatus	8	4	-
Hydrocotyle vulgaris	3	-	4
Hypochoeris radicata	3	1	-
Iris pseudacorus	-	-	7
Juncus effusus	4	-	2
Potentilla anserina	6	-	5
Prunella vulgaris	3	1	1
Ranunculus acris	4	3	-
Trifolium repens	4	2	-

Figure 5.2. Boundaries of the mapped habitats within the study site

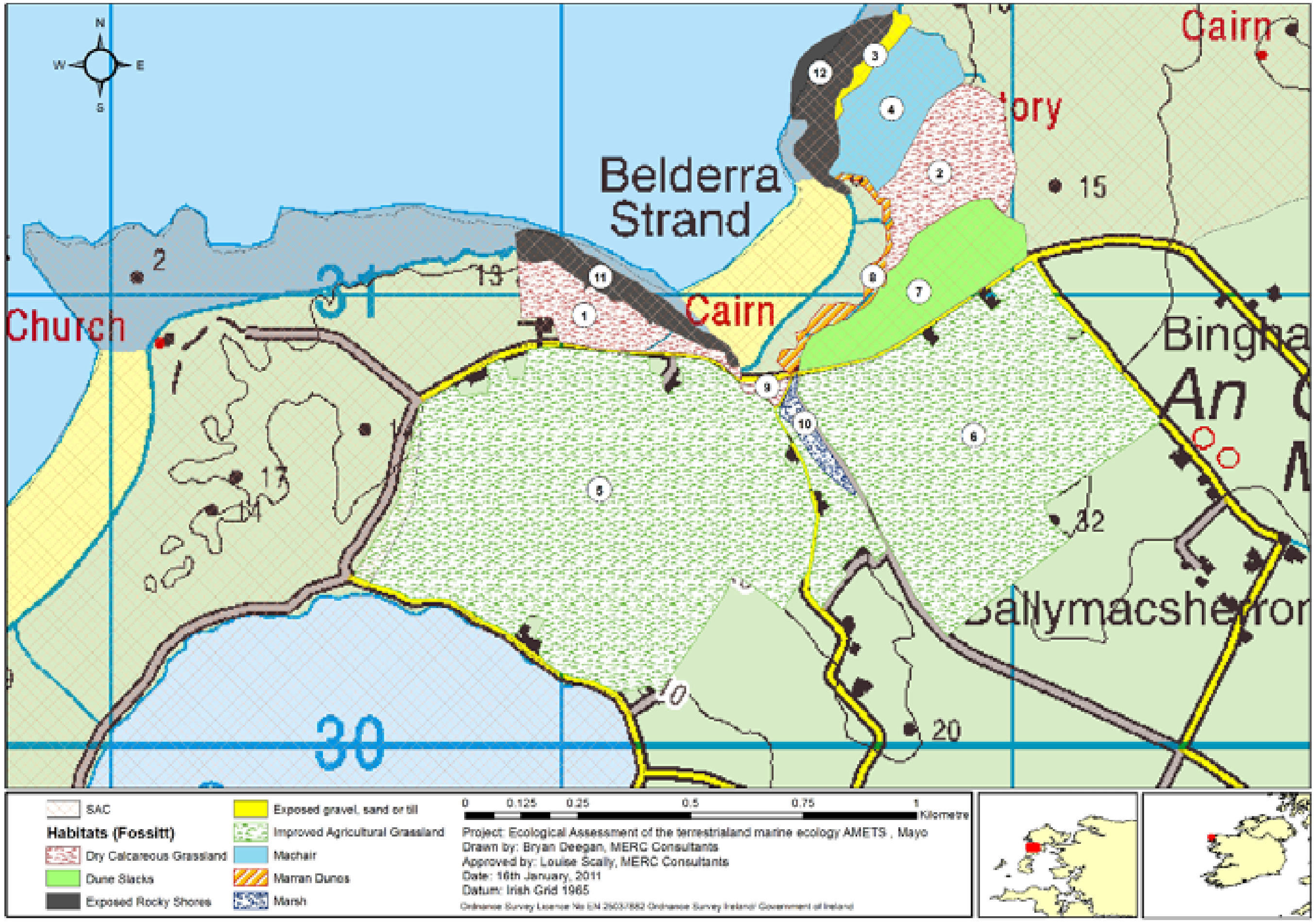


Table 5.3. Dry calcareous grassland relevé data (Areas 1, 2, and 9).

Species	DOMIN		
	Relevé 1	Relevé 2	Relevé 3
Achillea millefolium	-	-	+
Cirsium arvense	3	5	-
Dactylis glomerata	8	7	9
Festuca rubra	-	4	-
Lolium sp.	3	-	-
Ranunculus acris	5	-	3
Trifolium repens	-	-	-
Thymus praecox	-	-	1

Plate 5.2. Self heal (Prunella vulgaris). Dune slack area, Belderra Strand, Co. Mayo.

Plate 5.3. Sea holly (Eryngium maritimum). Belderra Strand, Co. Mayo.

Plate 5.4. Area of impact behind Belderra strand, where recreational vehicles access the sand dune and dune slack areas.

Table 5.4. Species and their abundance within each area mapped. Refer to figure 5.2 for details of mapped areas.

Species	**Area**									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Agrostis stolonifera	F	F	O		F	F	F		F	
Achillea millefolium	R	O	O		R	O			O	
Ammophila arenaria								D	R	
Anthyllis vulneraria	O		O						R	
Armeria maritima		O								
Bellis perennis	F		R	O		R	F			
Beta vulgaris								O		
Carex spp.				O						
Cirsium arvense					O	O				O**
Cirsium palustre	O	P	R				O		O	
Cynosurus cristatus		P	F		F	F				

Dactylis glomerata					F	F				
Erica cinerea						R				
Eryngium maritimum							O	F		
Festuca arundinacea										F
Festuca rubra	D	A	A	D	F	F	F		F	
Galium verum				F						
Gunnera tinctoria										O**
Holcus lanatus	F	O	O		O	F	F			
Hydrocotyle vulgaris	O*						O			
Hypochoeris radicata	F	F					F		F	F
Iris pseudacorus	O*				O*		A			A**
Juncus effusus							F			A
Lolium sp.		O			A	A				
Lotus corniculatus	O	O	O	F	O	R	O		O	
Lythrum salicaria										F**
Senecio jacobaea	O	O			O	F				
Phragmites australis										D
Plantago coronopus			R		O				O	
Plantago lanceolata	O	O	R	F	F	F	O			
Plantago maritima							R			
Polygonum hydropiper							O			
Polygonum persicaria							F			
Potentilla anserina	A*				F	F	F			
Primula vulgaris	O		R						O	
Prunella vulgaris			O				F			

Ranunculus acris							O			
Ranunculus ficaria							F			
Ranunculus repens					O	O				O**
Rubus fructicosus					O	O				F**
Rumex Acetosa						F				
Sedum acre						R				
Taraxacum sp						R	R			
Thymus praecox	O	O			R	O				
Trifolium repens	A	O	F	F	F	F	O		F	
Trifolium pratense	F	F	F		F	O	F			
Tripleurospermum maritimum								F		
Urtica dioica		F			O		F			

* In ditch running through the area

**In ditch along margin of marsh

Note: Areas 11 and 12 are exposed rocky shores with frequent *Armeria maritima* above a fucoid and mussel (*Mytilus edulis*) dominated lower zone.

5.3.3 Fauna

The only non-domestic mammal recorded at the survey site was the Irish hare (*Lepus timidus hibernicus*), which was recorded on four occasions over a three day period in July 2010 in the dune slack area to the back of Belderra Strand.

Distribution maps for mammals (bats, otter, Irish hare) within the study site indicated that both the Irish hare and otters are present within the area.

5.4 DISCUSSION

Belderra Strand and the surrounding area is an exposed, low lying mosaic of improved agricultural grassland and dry calcareous grassland with smaller areas of marram dune, dune slack and machair. Within all of these habitats the vegetation recorded was typical of the habitat and no rare or threatened species were recorded.

With the exception of the intertidal area at Belderra Strand all remaining areas of the site that will encompass the cable land fall, temporary construction area, cable bay and substation location are outside any designated area (SAC, NHA or SPA). However, a number of habitats within the study area (dune Slacks, marram dunes and machair) are listed under Annex 1 of the EU habitats Directive

Machair is a highly specialised and complex sand dune system that occurs nowhere else in the world outside of the north-western coasts of Ireland and Scotland. Machair in Ireland is a priority habitat under Annex I of the EU Habitats Directive (Habitat code 21A0). In addition to being a globally restricted habitat, machair is also important for breeding birds and provides a valuable grazing resource. The reported overall conservation status of machair habitat in Ireland is Bad (NPWS, 2008).

Dune slacks are wet depressions that typically occur between or behind sand dune systems. They are characterised by more diverse vegetation communities than the sand dune areas, as they are more nutrient rich. Typically the water table in this habitat is close to the surface, supporting communities that favour wetter soils. Humid dune slack is listed under Annex I of the EU Habitats Directive (Habitat code 2190). The conservation status of humid dune slack in Ireland is currently reported as Bad (NPWS, 2008).

Marram dune, or white dunes are also listed under Annex 1 of the EU Habitats Directive (Habitat Code 2120). They are generally situated further inland than the fore dunes. The area of marram dune at Belderra Strand appears to be midway between what would typically be considered marram dune and an embryonic dune system. The conservation status of marram dunes in Ireland is currently reported as Bad (NPWS, 2008), while that of Embryonic dune is reported as Poor.

There is currently no National classification system for Irish plant communities. While previous attempts have been made to classify the vegetation in certain habitats e.g. grasslands O'Sullivan (1982), the vegetation of most habitats in Ireland is poorly classified. Fossitt (2000) was the first attempt to classify habitats in Ireland and provides a useful guide for assigning broad habitat categories. However, it is largely based on landscape features, physical characteristics and soils and while a number of Irish phytosociological classifications were used in the production of the Fossitt classification, it largely relied on the British National vegetation classification system (Rodwell, 1991-2000). For this reason it is often difficult to assign habitats based on Irish plant communities and no attempt to conduct extensive vegetation analysis of the plant communities associated with the habitats mapped was made..

However, the relevé data gathered within the principle habitats recorded indicated that the dune slack community best fits the *Potentilla anserina – Carex nigra* dune slack community (SD17) of The British National Vegetation Classification, while the Dry calcareous grassland communities do not appear well placed in any of the NVC system rankings.

The Irish hare (*Lepus timidus hibernicus*) is considered to be a sub-species of *Lepus timidus* (L.) and is endemic to Ireland. It is found in many different habitats including unimproved, semi-improved and improved grassland, upland habitats and in coastal habitats including sand-dunes. According to the status of Hares is Ireland (Reid *et al*. 2007); the population of Irish hares in the Republic of Ireland was approximately 233,000 in early 2006 and 535,000 in early 2007. The distribution of this species is widespread in Ireland including the area of Mullet peninsula. It is therefore unsurprising that the Irish hare was noted within the survey site on several occasions.

While the otter (*Lutra lutra*) or evidence of the presence of otters was not noted during the survey, it is likely that they occur within the study site. Otters are widespread in Irish coastal habitats and the current population is estimated to be in the region of 10-20,000 adults. However, they have suffered a decline in recent years and their conservation status is considered to be Poor (NPWS, 2008). Otters (Species code 1355) are currently listed under Annex II of the EU Habitats Directive.

A number of bat species are included in Annex I of the EU Habitats Directive. However, current distribution maps for these species indicated that they have not been recorded on the Mullet peninsula or within or close to the cable landfall and sub-station locations. Indeed, the habitat surrounding the study site is not considered particularly suitable for bat species, being an exposed coastal area with a paucity of habitats favoured by bats for foraging and roosting.

5.5 IMPACT OF THE DEVELOPMENT

With the exception of the intertidal area at Belderra Strand all remaining areas of the site that will encompass the cable landfall, temporary construction area, cable joint transmission bay and substation location are outside any designated area (SAC, SPA or NHA). However, a number of habitats within the study area (dune slacks, marram dunes and machair) are listed under Annex 1 of the EU habitats Directive and their conservation status should not be negatively impacted by any aspect of the proposed development.

The general impacts of the development will include disturbance and temporary loss of habitat to a small triangular area (Area 9, Figure 5.2) for the storage and parking of machinery during the cable landing operation and the positioning of an underground cable joint transmission bay. There will be an additional area of habitat loss (approximately 300^2 m) for the construction of a sub-station in the south-west corner of Area 6 (Figure 5.2).

5.5.1 General effects

The general affects of the cable laying operation and the construction of the substation area on the terrestrial ecology of the area include habitat loss and some habitat disturbance within the intertidal area. The effects of the cable laying operation on the intertidal area are considered in Section 2.

5.5.2 Construction phase

During the cable laying operation it will be necessary to use the triangular area (Area 9, Figure 5.2) for the parking of machinery associated with the cable laying operation. It is also proposed that this area is used to site a cable joint bay. This will result in the loss of some dry calcareous grassland habitat.

The substation is located in Area 6 (Figure 5.2), which is a fenced field with a semi-improved agricultural grassland habitat. The substation will be situated in a depression to the back of this field, behind a low hill. The footprint of the substation building and associated hard-standing area for vehicles is approximately 10000 m^2. It is proposed that soil (approximately 1,400 m^2) excavated during substation construction be used to create embankments around the substation building to provide visual screeing. The main impact of the construction of the substation will be the loss of improved agricultural grassland habitat. As the substation lease would be for 20 years, the potential for restoration of this area to the original habitat (semi-improved agricultural grassland) exists.

5.5.3 Operational phase

There are no impacts on the ecology of the site associated with the operational phase of the development. All access to the substation will be via existing roads in the area and the level of human activity associated with the substation location will be very low.

5.6 MITIGATION OF IMPACTS

All access to and egress from the substation should be via existing roads and the proposed new road across the field. Prior to entry to the site, all vehicle drivers should be instructed not to impinge on unfenced areas of calcareous grassland, dune slack or any other habitat for either the parking or turning of vehicles. Vehicles, machinery and construction materials should only be parked or housed in the designated area at Belderra car park and Area 9 (Figure 5.2) or within the site compound for the substation location which should be fenced in advance of any construction operations and these areas should be clearly marked.

Soil excavated in construction of the substation should be re-used to create any embankments being designed to screen the substation. No other soil from any other area should be brought onto the site to minimise the likel-hood of introducing species not native to the site and/or invasive species.

Any landscaping of the screening embankments surrounding the substation should only include the use of species native to the calcareous grassland of the area.

5.7 MONITORING

No monitoring of the terrestrial habitats is required.

Table 5.5. Potential impacts during construction phase

Species and Habitats	Potential impacts
Species	Disturbance to fauna, loss of vascular plant species.
Habitats	Habitat alteration and habitat loss.

Where likely impacts have been identified in terms of a species or a habitat, the significance of this impact has been assessed, following a standard assessment process detailed below.

Table 5.6 Assessment of significance – Construction phase

Potential impact: Species disturbance and habitat alteration or loss	
Significance criteria	
Character and perceived value of affected environment	Belderra strand lies in an area of largely semi-improved agricultural grassland. The beach is backed by a band of low-lying Marram dune, leading into an area of dune slack. Smaller areas of dry calcareous grassland occur immediately behind the area of dune slack. On the far side of the road, behind the beach, the main habitat is a mosaic of semi-improved agricultural grassland. With the exception of the intertidal area (discussed in Section 3 of this report), no EU Habitats Directive Annex I habitats will be impacted during cable trenching or substation construction. The Irish hare (Annex II of the EU Habitats Directive occurs within the area.
Confidence in the accuracy of predictions of change	An area of semi-improved agricultural grassland and its associated flora will be lost during substation construction (10000 m^2). An area of approximately 1,000 m^2 of calcareous grassland and its associated flora will be temporarily lost during construction A trench approximately 0.4 km long and x m wide would be dug from the car park area behind Belderra strand to the substation location. The trench will follow the existing road. Disturbance to the Irish hare is likely.
Magnitude, spatial extent and	Construction of the substation will be completed over a six month period.

duration of anticipated change	The area of impact is very small relative to the amount of semi-improved agricultural grassland in this area of the Mullet peninsula. The area of the substation location would cause the loss of 10,000 m^2 of semi-improved agricultural grassland. The area could be reinstated as agricultural grassland after the lease for the AMETS ends (20 years). An area of approximately 10,000 m^2 of calcareous grassland will be temporarily lost during construction but will be reinstated within one year.
Resilience of environment to cope with change	No change to the adjacent habitats would occur. The existing habitat could be reinstated after the life of the AMETS. The area is subject to recreational use by surfers and other recreational users and agricultural workers (silage cutting, grazing) and as such is subject to moderate disturbance. The Irish hare is a mobile species and unlikely to be unduly affected by construction activity.
Scope for mitigation, sustainability and reversibility	With the exception of the construction area behind Belderra Strand car park, no machinery and materials should be parked or placed on any of the adjacent habitat, which should be clearly marked by temporary fencing prior to construction works.
SIGNIFICANCE OF IMPACT	**LOW**

Table 5.7. Potential impacts during operational phase.

Species and habitats	Potential impacts
Species	No impact on species would occur during the operational phase.
Habitats	No impact on habitats would occur during the operational phase.

Table 5.8: Mitigation of impacts during construction phase

Potential Impact	Scope for mitigation, sustainability and reversibility
Species loss and disturbance	Store excavated material from temporary construction area for habitat restoration following construction. Store excavated material from the location of the substation construction area for the creation of screening berms following construction. Planting of screening berms should be by natural recolonisation and the planting of local native species only. Do not bring other soil onto the site to reduce the possible introduction of alien invasive species. Consult with an ecologist in relation to the construction of screening berms. Ensure all machinery keeps to the existing roadway and is not parked on adjacent habitats, other than the temporary construction areas. Ensure all plant is kept in the temporary construction areas and is not placed on adjacent habitats.
Habitats loss	Reinstate 10,000 m^2 of calcareous grassland temporarily lost during construction within one year. Reinstate the area of semi-agricultural grassland after the life of the AMETS.

Mitigation of impacts – Operational phase

Table 5.9: Mitigation of impacts during operational phase

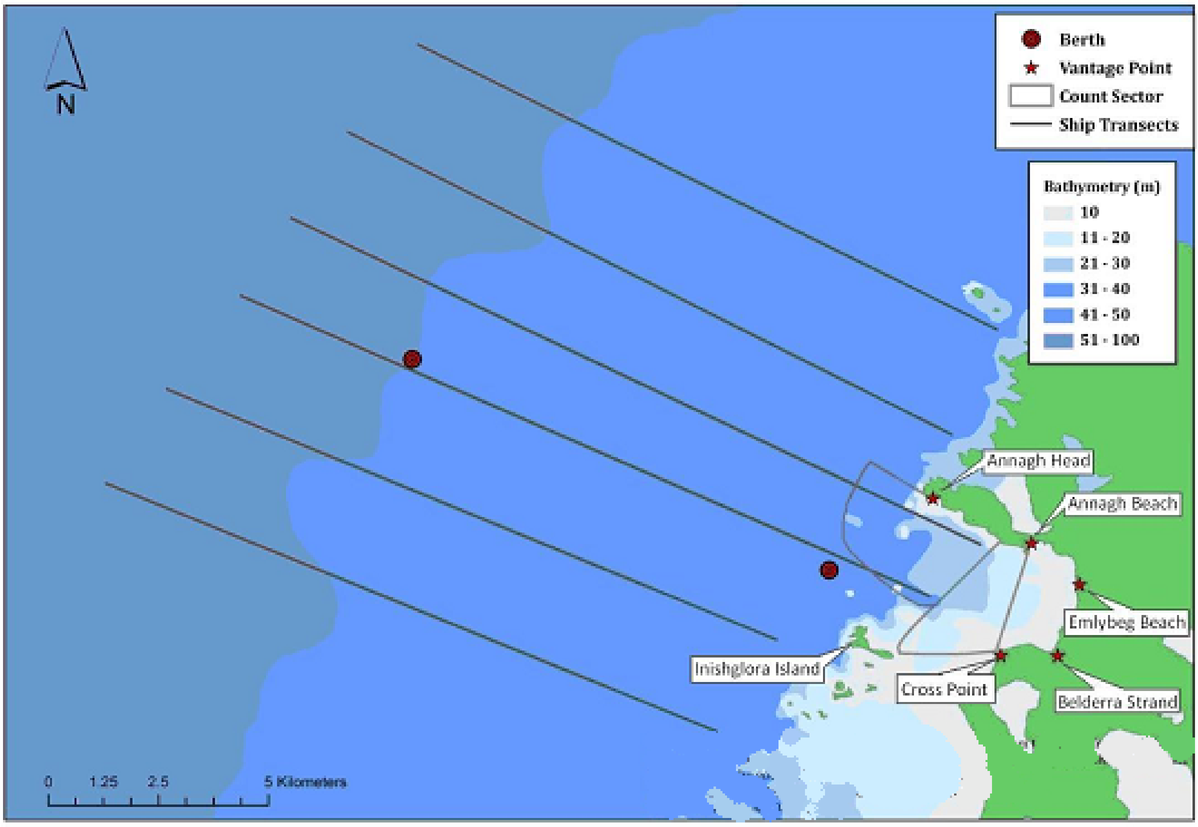
Impact	Scope for mitigation, sustainability and reversibility
No impact anticipated	Not applicable.

6. AVIFAUNA

6.1 INTRODUCTION

The “study site” is located on the west of the Mullet Peninsula in north Co. Mayo (Figure 6.1). This area was selected to ensure coverage of the greater area of the proposed Atlantic Marine Energy Test Site (AMETS). Its selection was, in part, informed by background data from the preliminary ecological assessment (Tonn Energy Ltd, 2009). The study site includes an area referred to as the “Bay” and an area of open sea. The “Bay” extends from Annagh Head across to Inishglora Island, inland to Cross Point and along the shore back to Annagh Head. The Bay includes all coastal, intertidal and open water habitats within these points. From the Bay the study site extends 15 km west, to include an area of “open sea” approximately 12 km x 15 km in size. The “Bay” is surveyed from the land and the “open sea” area is surveyed by boat. The study site also includes Inishglora Island and terrestrial habitats at Annagh Beach, Emlybeg and Belderra Strand.

Figure 6.1. The study site showing the Bay and open sea areas.



This product has been derived in part from material obtained from the UK Hydrographic Office with the permission of the Controller of Her Majesty’s Stationery Office and UK Hydrographic Office (www.ukho.gov.uk). “NOT TO BE USED FOR NAVIGATION”

6.1.1 The Bay area

The Bay comprises shallow waters around its edge to 10 m depth increasing to 20 m depth towards the middle of the Bay and then to 30 m at its mouth. The Bay supports reef and island features and rocky, sandy and shingle shores.

The Mullet peninsula and its nearby islands are protected by a number of Special Protection Areas for Birds (SPAs). Six SPAs, lie within 5 km of the study site, two lie within 15km of study site and a further two lie 20-30 km from the study site. These SPAs are nationally and internationally important for a range of breeding and wintering birds (Tables 6.1 & 6.2).

The Mullet Peninsula is included in the Irish Wetland Bird Survey (I-WeBS) wintering waterbird monitoring scheme. Within this scheme the Mullet Peninsula is known as The Mullet, Broadhaven and Blacksod Bays I-WeBs count site (Crowe, 2005). Results from the I-WeBS (Crowe, 2005 and Boland *et al.* 2009) show that a number of species occur within this site in numbers of national and, or, international importance (Table 6.3). Results in Crowe (2005) are based on five years of I-WeBS survey data (1994/95 – 2000/01), while Boland *et al.* (2009) presents more recent data for the season 2007/08.

Belderra Strand is a sub-site of The Mullet, Broadhaven and Blacksod Bays I-WeBS count site and lies within the study site. Specific data for part of the study site is therefore available from the I-WeBS scheme and is shown in Table 6.4.

Long tailed Duck and Great Northern Diver are difficult to survey from land and accurate national population estimates are not available for these species (Crowe *et al.* 2008). However, Crowe suggests that national totals for these species are likely to be less than 2000, giving a 1% threshold of 20 for national importance. Using this threshold Belderra Strand is of national importance for Long tailed Duck (Table 6.4). Belderra Strand, while a subsite of the Mullet, Broadhaven and Blacksod Bays I-WeBS count site is not part of the Blacksod/Broadhaven Bay SPA.

Further relevant data on the Bay, is available for Great Northern Diver (Suddaby, in press). Counts of Great Northern Diver in Blacksod Bay, from 2002 – 2010, together with Broadhaven Bay from 2005, recorded a mean of 97.5 birds. Over this period three counts included the west coast of the Mullet Peninsula and during one of these counts, (March 2010) 254 Great Northern Diver were recorded. These data highlight the international importance of the waters around the Mullet Peninsula for Great Northern Diver, both as a wintering area and as a major moulting area in Spring (Suddaby, in press).

Data on summer use of the study site is limited. Annagh Islet, a small island at Annagh Head, is a breeding site for Arctic Tern and the nearshore waters of the Bay are known to be used by rafts of Manx Shearwater (Dave Suddaby pers. comm.).

Some data for birds using habitats directly adjacent to the study site is available. Termoncarragh Lake SPA, which is adjacent to Annagh Beach, was surveyed as part of a national machair survey in 2009 (Suddaby *et al.* 2010). Lapwing and Snipe were recorded breeding here. The dunes surrounding the study site are used by post juvenile flocks of foraging Chough (Dave Suddaby pers. comm.). Data from the most recent breeding seabird survey (Seabird 2000; Mitchell *et al.*, 2004) shows Inishglora and Inishkeeragh Islands to support a Storm Petrel breeding population of 3,423 Apparently Occupied Sites (AOS).

Other species of note are small numbers of wintering female Eider, which occur at Belderra Strand (Dave Suddaby, pers. comm.) and wintering Purple Sandpiper. Eider were first observed to breed off the Mullet Peninsula in 1996 and this area represents one of the most southerly points of their breeding distribution (Murray & Cabot, 1997). There are now 25 pairs of Eider breeding on Inishglora, Inishkeeragh and Inishkea Island North (Dave Suddaby pers. comm.). Purple Sandpiper have been recorded within the study site. This species has a limited distribution in Ireland, with the Mullet Peninsula being one of the top five sites (Crowe, 2005)

6.1.2 The Open Sea area

The open sea part of the study site is marine in nature with water depths mainly between 50 m and 100 m. At its eastern extent the open sea study area overlaps with the Bay and with the coastal waters of the Mullet Peninsula. At its western extent the open sea area reaches into waters > 100 m deep. Further west of this (approximately 60 km), is the edge of the continental shelf at the 200 m isobath. The north-west Mayo coast is closer than any other part of Ireland to the edge of the continental shelf. There is little specific information on seabird distribution within the open sea area of study site. However, Annagh Head is a known sea watching location, for observing migratory seabirds and two reports on the seabirds of Irelands offshore waters provide relevant information on the open sea study area (Pollock, *et al.* 1997; Mackey *et al.* 2004).

Up to 1994 relatively few surveys of seabirds at sea had been conducted west of Ireland. Between August 1994 and September 1997 intensive at-sea surveys were carried out in waters around Ireland (Pollock *et al.* 1997). The aim of this study was to identify and describe year round dispersion patterns of seabirds in Irish waters. Pollock describes the link between seabird distribution and numerous dynamic physical and biological processes that operate in the marine environment e.g. oceanic circulatory patterns and prey distribution. Survey coverage included coastal and inshore waters off the Mullet Peninsula.

Following the 1994 – 1997 surveys, further sea birds at sea surveys were completed in Irish waters between July 1999 and September 2001 (Mackey *et al.* 2004). The primary study area for these surveys was the off shore waters to the west and south west of Ireland. The study area was termed Ireland’s Atlantic Margin. Survey coverage for this study also included coastal and inshore waters off the Mullet Peninsula.

Table 6.1. SPA's close to the study site, with summarised details of their interest for wintering birds.

' * ' Indicates Annex I status. Source: NPWS site synopses.

SPA (name and site code)	Species for which site is designated SPA		
	International Important	Nationally important species	Other species of note
SPA's adjacent to or within 5 km of the study site			
Inishglora and Inishkeeragh (4048)	Barnacle Geese*		
Termoncarragh Lake and Annagh Machair (4093)	Barnacle Geese*	Whooper Swan* Greenland White-fronted Geese* Ringed Plover	
Cross Lough (4055)	Barnacle Geese*		Whooper Swan*
Blacksod / Broadhaven Bay (4037)	Barncale Geese*, Light bellied Brent Goose*, Great Northern Diver*	Common Scoter, Red Breasted Merganser, Bar-tailed Godwit*, Ringed Plover, Sanderling, Dunlin , Curlew	
SPA's < 15 km from the study site			
Inishkea Islands (4004)	Barnacle Geese*	Ringed Plover, Sanderling , Purple Sandpiper, Turnstone	
Duvillaun Islands (4111)	Barnacle Geese*		
SPA's 20-30 km from the study site			
Illaunmaster (4074)			Barnacle Geese*

Table 6.2. SPA's close to the study site, with summarised details of their interest for breeding birds.

' * ' Indicates Annex I status. Source: NPWS site synopses.

SPA (name and site code)	Species for which site is designated SPA		
	Internationally Important	Nationally Important	Other species of note
SPA's adjacent to or within 5 km of the study site			
Inishglora and Inishkeeragh (4048)	Storm Petrel*, Arctic Tern*	Cormorant, Shag, Lesser Black backed Gull, Herring Gull	
Termoncarragh Lake and Annagh Machair (4093)	Corncrake*	Lapwing, Dunlin*,	Chough*
Blacksod/Broadhaven Bay (4037)		Sandwich Tern*	
Inishkea Islands (4004)		Arctic* and Little Tern*, Shag, Common Gull, Lesser Black backed Gull, Herring Gull, Great Black-backed Gull	Corncrake*, Dunlin* , Common Tern*
SPA's adjacent <15 km of the study site			
Duvillaun Islands (4111)		Storm Petrel*, Herring Gull, Fulmar, Great Black backed Gull	
SPA's 20-30 km from the study site			
Illaunmaster (4074)		Storm Petrel*, Puffin	
Stags of Broadhaven (4072)		Leach's Petrel*, Storm Petrel*, Puffin	

Table 6.3. Species of international and national importance occurring within The Mullet, Broadhaven and Blacksod Bays I-WeBs count site (Crowe, 2005 and Boland et al. 2009)

Crowe, (2005)		**Boland *et al.* (2009)**	
Internationally important	Nationally important	Internationally important	Nationally important
Great Northern Diver Barnacle Goose	Red-throated Diver Common Scoter Red Breasted Merganser Ringed Plover Sanderling Dunlin Bar-tailed Godwit Turnstone	Barnacle Goose Light Bellied Brent Goose Great Northern Diver Ringed Plover	Whooper Swan Red Breasted Merganser Sanderling Dunlin Bar-tailed Godwit Curlew Greenshank Turnstone

Table 6.4. I-WeBs data for subsite Belderra Strand (Source: BirdWatch Ireland).

’ * ‘ Indicates estimated national threshold (see Crowe *et al*. 2008).

Species/year	1% National	1% International	2003/04	2004/05	2005/06	2006/07	2007/08	Peak	Mean
Mute Swan	110	110		2		2		2	1
Wigeon	820	15000						7	1
Long tailed duck	20*	20000	12	21	18	29	26	29	21
Eider	30	12830			2	6		6	2
Common Scoter	230	16000				2		2	0
Red breasted Merganser	35	1700		2				2	0
Red-throated Diver	20	3000	1		1	2	3	3	1
Great Northern Diver	20*	50	8	10	9	10	12	12	10
Cormorant	140	1200	3	1		1	1	3	1
Shag				13		31	24	31	14
Grey Heron	30	2700				1	3	3	1
Oystercatcher	680	10200	51	39	19	47	17	51	35
Ringed Plover	150	730		7	13			13	4
Golden Plover	1700	9300		42	1			42	9
Sanderling	65	1200		34	3	3		34	8

Species/year	1% National	1% International	2003/04	2004/05	2005/06	2006/07	2007/08	Peak	Mean
Purple Sandpiper	35	750		1		6	6	6	3
Bar-tailed Godwit	160	1200				3		3	1
Whimbrel		2000				1		1	0
Curlew	550	8500	2	13	7	87	24	87	27
Redshank	310	3900	3	9	9	3	4	9	6
Turnstone	120	1500	2	12	6	22	5	22	9
Black-headed Gull		20000	10	9	15	17	31	31	16
Common Gull		16000	50	28	62	39	100	100	56
Lesser Black-backed Gull		4500	2					2	0
Herring Gull		13000	5	3	27	27	40	40	20
Glaucous Gull						1	1	1	0
Great Black-backed Gull		4800		4	8	8	3	8	5

Results from these surveys provide a broad picture of seabird numbers and distribution in Irish waters. Results from Mackey *et al.* (2004) show that the inshore waters, off the north-west Mayo coast, were an area of relatively high seabird abundance and were also found to be an area of high species diversity.

While Ireland is obliged under EU legislation to conserve vulnerable and other migratory birds and their habitats, protection of seabirds at sea and away from their breeding sites, is limited. Ireland's Special Protection Areas for birds do not cover open water habitats that may be important for foraging or moulting seabirds. The conservation status of the open sea area in this study is therefore not known.

The study site, comprising both Bay and open sea areas, lies close to several coastal and Island SPA's. The birds using the study site are likely to include those from nearby SPA's. Changes to bird numbers within the study site may therefore have an indirect effect on nearby SPA's. Existing information shows the study site is used by a number of Annex I species including Great Northern Diver, which use the open waters of the Bay, and Storm Petrel, which nest in nationally important numbers on Inishglora and Inishkeeragh Islands. The study site is also used by a number of species of conservation interest such as Long tailed Duck and Eider Duck. Specific background information on the open sea study area is limited, however, surveys of Irish waters show that waters west of north west Mayo support a relatively high abundance and diversity of seabirds e.g. Mackey *et al.* (2004). It is also an area known for relatively high numbers of passage migrants.

Given the bird interest of the study site, land and sea based bird surveys were designed to cover all months of the year, where possible, and to cover terrestrial, shore and open water habitats. A survey of nesting Storm Petrel on Inishglora Island was also undertaken.

The aim of these surveys was to gather data on the study site, which could be used together with any existing data, to characterise the bird interest of the study site and to inform the impact assessment process. This data will also be used as a base line for further survey and monitoring, pre- and, with consent, during and post wave energy test site operation.

6.2 METHODOLOGY

6.2.1 Land based surveys

Land based surveys were completed for shore and open water Bay habitats, for terrestrial habitats at the landfall sites, and on Inishglora Island. All surveys were undertaken using standard bird survey methods (see below) with adaptation, where necessary.

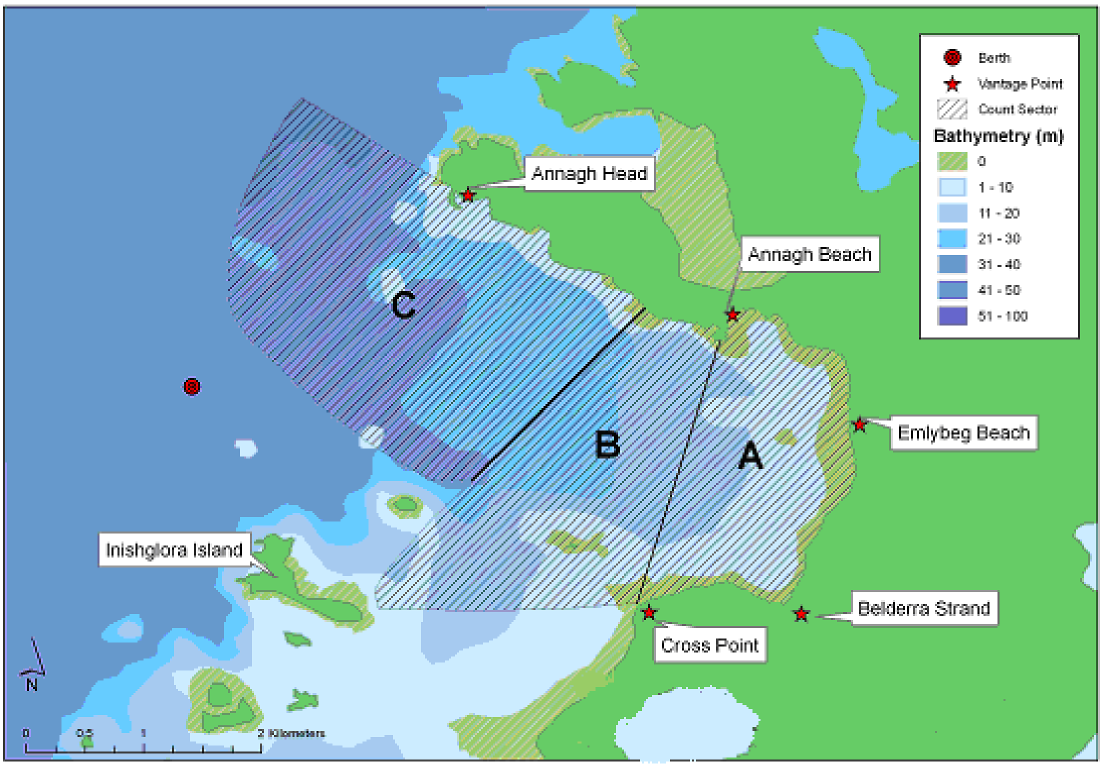
6.2.1.1 Shore and open water Bay habitats

The shore and open waters of the Bay were surveyed monthly from September 2009 until August 2010. Surveys were completed using binoculars and a tripod mounted 32x wide-angle telescope. Surveys were completed in suitable weather and sea conditions.

Occasionally, conditions were not ideal, such as heavy swell and in July, sea fog. All survey conditions are described in Appendix 3. Where conditions were not ideal scan and search time from Vantage Points was increased to compensate. Counts were completed at varying tidal stages (Appendix 2).

The shore or intertidal habitats at Annagh Beach, Emlybeg Beach and Belderra Strand were counted using standard I-WeBS count methods for wintering waterbirds (Gilbert *et al.* 1998; Bibby *et al.* 2005). Shore counts were also completed at Cross Point and along the viewable shore from Annagh Head (Figure 6.2).

Figure 6. 2. Count sectors A, B and C and Vantage Points used for surveys of the inner and outer Bay.



This product has been derived in part from material obtained from the UK Hydrographic Office with the permission of the Controller of Her Majesty's Stationery Office and UK Hydrographic Office (www.ukho.gov.uk). "NOT TO BE USED FOR NAVIGATION"

The open waters of the Bay were counted from five vantage points (Figure 6.2), using inshore marine survey methods for divers, grebes and sea duck (Gilbert *et al.* 1998). For counting purposes the open water area was divided into three sectors. Sectors A and B covered the shallower waters of the inner Bay and were counted from Annagh Beach, Emlybeg Beach, Belderra Strand and Cross Point. Sector C covered the deeper outer Bay waters and was counted from Annagh Head (Figure 6.2). Each count sector was slowly scanned in a series of arcs using binoculars and telescope.

6.2.1.2 Terrestrial Habitats

Terrestrial habitats at Belderra Strand, Emlybeg and Annagh Beach were surveyed using line transect methods (Bibby *et al.* 2005) and as used by the Countryside Bird Survey (Crowe *et al.* 2010). A one-day winter survey was completed in February 2010 and a breeding bird survey was completed in Spring 2009. The breeding bird survey involved a one day early breeding season visit in April, followed by a repeat survey in June, to cover later breeding species.

6.2.1.3 Survey of breeding Storm Petrels on Inishglora Island

Breeding Storm Petrels on Inishglora Island were surveyed using the standard tape playback method (Walsh *et al.* 1995; Ratcliffe *et al.* 1998). Owing to time constraints a full survey of all suitable nesting habitat, together with calibration surveys, could not be completed. Instead a targeted survey to sample all suitable nesting habitat and to set up monitoring plots was planned.

The last survey of breeding Storm Petrels on Inishglora Island was completed during Seabird 2000 (Mitchell *et al.* 2004). Habitat maps and data from the Seabird 2000 survey formed the basis of the targeted survey for this project. The survey was undertaken during the second week of July, which is within the peak incubation period for the Storm Petrel and within the recommended survey period (Walsh *et al.* 1995). Suitable Storm Petrel habitat on Inishglora comprises boulder beaches on the north and south shore of the island, boulder fields on the west end of the island, stone walls which criss-cross mainly the eastern half of the island and old buildings including an old chapel and cairns.

For shore and boulder beach habitats 10 m x 10 m quadrats were surveyed. The tape lure was played at 1m intervals along and across each quadrat. Whilst ideally all quadrat locations would be random, there was a risk that all randomly located quadrats may give a nil response. Given the time available it was decided to use both random and selected quadrats; selected ones being those, which were located in areas known to have nesting Storm Petrel. On the north shore two random and two selected quadrats were surveyed and on the south shore three random and three selected quadrats were surveyed. Irish National grid references (using GPS) were taken for each sample plot so they can be revisited for monitoring purposes. All stone walls on the island were surveyed by playing the tape lure at 1 m intervals along lengths of rope. A selection of building walls were surveyed at 1 m intervals 1 and 2 m parallel to the ground. One of three cairns on the island was also surveyed. The tape lure was played using hand held MP3 players and speakers. All Storm Petrel responses were noted. The survey was completed during one day, using two teams of two surveyors for sample plots and one surveyor for the walls.

6.2.2 Sea based surveys

Seabirds were surveyed offshore using the European Seabird at Sea (ESAS) standard method. This method uses three elements to give an assessment of the numbers and distribution of seabirds. These elements are; the band transect; the snapshot; and the scan. The band transect is an adapted version of the Joint Nature Conservation Committee (JNCC) Seabirds at Sea method (Webb & Durnick 1992) where birds are counted in a 300 m perpendicular distance from the boat’s route. Birds on the water in this 300 m strip are allocated to distance bands from the ships track (A = <50 m, B = 51-100 m, C = 101-200 m, D = 201–300 m, E >300 m).

The snapshot was used for flying birds encountered within the 300 m bow-to-beam quadrat at intervals determined by the speed of the boat. Generally, a speed of 10 knots was maintained throughout the course of the transect which allowed recording of flying birds each minute. This data was used in the density, relative abundance (referred to as ‘abundance’ hereafter), and distribution analyses. Birds considered to be associating with the survey vessel were not included in the analyses.

The scan records all species encountered in a 90^{O} arch (from bow to beam) including their direction of flight and activity. Age class was also noted where possible.

Additionally, marine mammals and other marine megafauna, e.g. basking sharks, sunfish etc., were identified and recorded using the above methods. These results are included in Section 4 (Marine mammals).

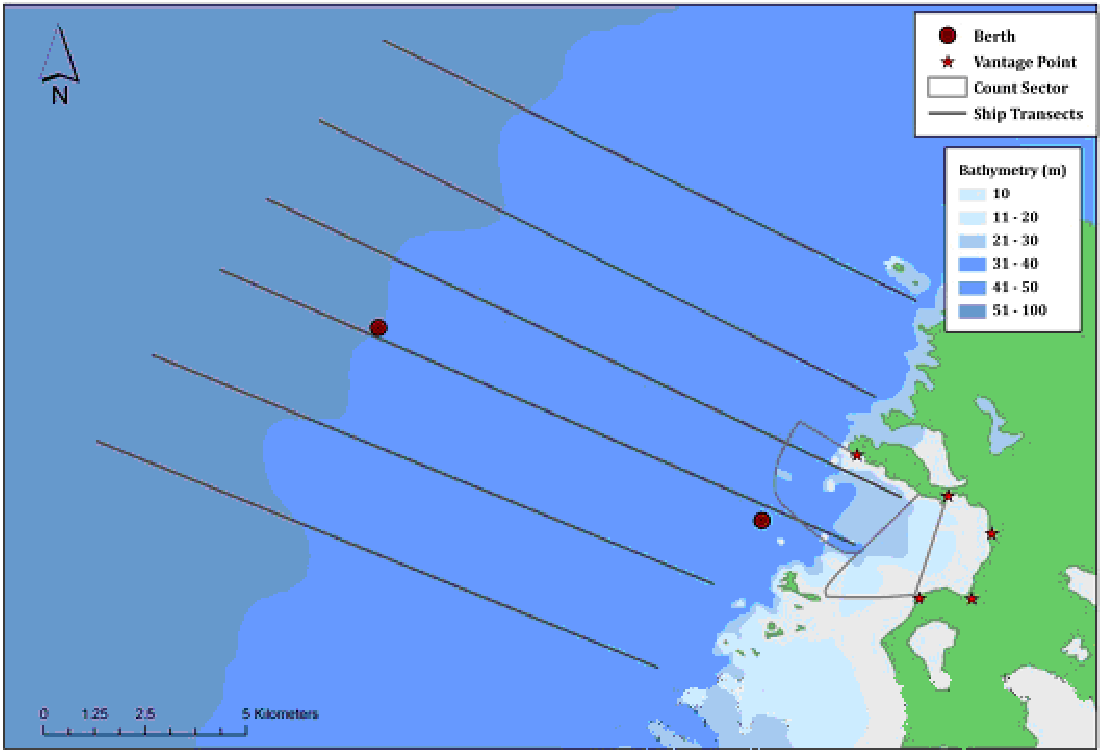
Sea based surveys were conducted on a total of eight occasions. Although the first survey commenced in October 2009, heavy seas in the study area during the winter season hindered any visit between November 2009 and February 2010. The study area was then surveyed monthly from March to October 2010, with the exception of September when no survey was complete due to inclement weather conditions.

The first three surveys covered five transects (October 2009 & March, April 2010) but to ensure a greater area of coverage, a sixth transect (T6) to the south of the initial five, was included for the remaining surveys (Figure 6.3).

The vessel used for all offshore surveys was the M.V. Dúlra na Mara which gave an observer eye-height of 5 m. Principal observer for the surveys was Dave Suddaby and on one occasion Ciarán Cronin (October 2009). Secondary observers were Jackie Hunt and Derek McLoughlin.

All data gathered was inputted into a Microsoft Excel spreadsheet and calculations were made of the monthly relative abundance (no. birds / km travelled) and densities of birds on the water (no. birds / km^2).

Figure 6.3. Transect lines followed during surveys for seabirds at sea.



This product has been derived in part from material obtained from the UK Hydrographic Office with the permission of the Controller of Her Majesty's Stationery Office and UK Hydrographic Office (www.ukho.gov.uk). "NOT TO BE USED FOR NAVIGATION"

The detectability of each species associated with the surface of the ocean (engaging in behaviour such as feeding, preening, etc.) varies considerably depending on size and behaviour of bird, distance from the survey vessel and sea state. For species necessitating density maps correction factors are required to compensate for this varying degree of detectability. These multiplication factors are calculated by comparing the number of species observed at differing distances from the survey vessel. Due to the level of data generated in this study, corrections factors listed in Stone *et al.* 1995 were used (whose correction factors were derived from a much larger sample size). No correction factors were used for flying birds.

Numbers and distribution of the most common seabirds encountered were mapped using ArcGIS v.9.0. Density maps were produced for species where sufficient data was gathered for analysis. Density was calculated by dividing the number of birds in the transect area by the transect area, i.e. the number of birds / km^2. Where insufficient data was gathered to produce density maps, these data have been presented as relative abundance maps (abundance maps). Abundance was calculated by dividing the number of birds observed each month, both in and out of the transect, by the distance travelled by the survey vessel, i.e. number of birds / km. All bird sightings were used in the abundance estimates. Correction factors are not applied to abundance analyses.

6.3 RESULTS

6.3.1 Land based surveys

An overview of all results from the land based surveys is presented followed by more detailed results for each of the habitats surveyed.

Waders and Gulls used the shore habitats all year round. Numbers of waders were generally low, though relatively high numbers of Ringed Plover and Sanderling were recorded at Annagh Beach. The most significant count was a nationally important flock of Sanderling recorded at Annagh Beach in March. Regularly recorded wader species were Oystercatcher, Curlew, Sanderling, and Dunlin. Turnstone and Purple Sandpiper were less frequently recorded and Purple Sandpiper only at Cross Point. Gulls used the shores year round, with highest numbers occurring in the summer months, when flocks of immature, mainly Herring and Common Gull, were roosting there. The inner Bay was used by wintering Long tailed duck, Eider, Great-Northern and occasionally Red-throated Diver. Great-Northern Diver were present from October to May, with peak numbers of 17 recorded in March. In the summer Terns were present from May to July and a raft of 300 Manx Shearwater was recorded in July. Shag and Gulls were present year round and Gannet and Auks were present mainly in the summer months. The outer Bay was used by Auks, Gannets, Gulls, Shearwaters, Shag and divers. Numbers of Auks, Gannets and Manx Shearwater were highest between April and May. Rafts of Manx Shearwater were present in April when two rafts of 690 Manx Shearwater were recorded (this was west of Annagh Head and strictly outside of the survey area). Up to two, Great Northern Diver, were regularly recorded from the outer Bay. Surveys of terrestrial habitats showed winter and summer use by typical species, such as Wheater, Skylark and Meadow Pipit. A sand martin colony was of note at Emlybeg beach. Belderra Strand, the site of the proposed cable landing, was characterised by regular use by small numbers of waders and Gulls and relatively high numbers of wintering Curlew using both the beach area and grassy headland at the north side of the beach. The Storm Petrel survey on Inishglora Island showed numbers nesting in the stone walls to be comparable with those recorded in 2001 and sample plots were successfully established for future monitoring.

6.3.1.1 Shore Habitats

<u>Annagh Beach</u>

Roosting and feeding waders and Gulls regularly used the intertidal sediment and rocky shore habitats at Annagh Beach, especially during the winter months (Tables 6.5a & 6.5b). Ringed Plover and Sanderling occurred in highest numbers during the winter months, with Sanderling exceeding the threshold for national importance during March. Oystercatcher numbers peaked in July. Low numbers of Gulls regularly used the site throughout the year. The beach is flown over by Whooper Swan and Barnacle Geese during the winter months, when flocks are moving to and from Termoncarragh lake and other inland feeding and roosting sites (Table 6.9). The threshold for national importance is shown under “1% Nat”, the mean count for the winter season is shown under “mean”, and the peak count as “peak”.

Table 6.5a. Species and number of individuals recorded on the shore at Annagh Beach during the winter months, 2009/2010.

Species/Month	1% Nat	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Mean	Peak
Shag		3				2				3
Grey Heron	30		1							1
Oystercatcher	680	2	9	7		5	6	5	5	9
Ringed Plover	150				83	2	51		19	83
Sanderling	65	9			65	35	64	85	37	85
Turnstone	120		15	9					3	15
Dunlin	880				55			11	9	55
Greenshank	20		1							1
Curlew	550	4	2	4	1				2	4
Common Gull		5		1	6			1		
Herring Gull			2	1	2			1		
Great Black-backed Gull		1		4						
TOTAL WADERS		15	27	20	204	42	121	101	76	204
TOTAL BIRDS		24	30	26	212	44	121	103	70	212

Table 6.5b. Species recorded on the shore at Annagh Beach during the summer months.

Species/Month	April	May	June	July	Aug
Shag					1
Oystercatcher	15	7		60	46
Ringed Plover		6			
Sanderling		7			5
Turnstone		1			
Dunlin		7			
Curlew	1				7
Common Gull	2			4	2

Species/Month	April	May	June	July	Aug
Herring Gull				1	34
Great Black backed Gull					2
Sandwich Tern*				2	
TOTAL WADERS	16	28	0	60	58
TOTAL BIRDS	18	28	0	67	97

Emlybeg Beach

As counts at Emlybeg began in November, there is no early winter coverage. The sediment shores were used by small numbers of waders in all months except February and June (Table 6.6a & 6.6b). Roosting Gulls used both sediment and rocky shores in summer and winter months. During the summer months flocks of Gull s*pp*. consisted of mainly immature birds. It is likely that small waders such and Sanderling and Ringed Plover have been under counted at this site, due to the large extent of the shore and to sun glare.

Table 6.6a. Species recorded on the shore at Emlybeg Beach during the winter months.

Species/Month	1% Nat	Nov	Dec	Jan	Feb	Mar*	Mean	Peak
Oystercatcher	680	19		2		19	8	19
Ringed Plover	150					8		8
Turnstone	120	6		2				6
Redshank	310			1				1
Curlew	550	3	2			26	6	26
Black headed Gull				1				
Common Gull					1	1		
Herring Gull		1		1	9			
Great Black backed Gull			1					
TOTAL WADERS		28	2	5	0	53		
TOTAL BIRDS		29	3	7	10	54		

The threshold for national importance is shown under “1% Nat”, the mean count for the winter season is shown under “mean”, and the peak count as “peak”.

*March results are from a walkover survey of the shore as nothing was recorded from the Vantage Point.

Table 6.6b. Species recorded on the shore at Emlybeg Beach during the summer months.

Species/Month	April	May	June	July	Aug
Oystercatcher	3	4		29	
Ringed Plover	1	3			
Sanderling	20				24
Turnstone		1			4
Common Gull	2			5	7
Herring Gull	21	1		74	17
Great Black backed Gull					1
Gull *spp*.			127*		
TOTAL WADERS	24	8	0	29	28
TOTAL BIRDS	47	9	127	108	53

* Two groups of mainly immature Herring Gull, Lesser Black-backed Gull and Great Black backed Gull.

Belderra Beach

This site was regularly used by small numbers of waders and Gulls. There were relatively high numbers of wintering Curlew in September, but highest wader numbers were in August, when Sanderling and Curlew flocks were present. It should be noted that Curlew flocks used the beach, but were also recorded feeding on a grassy headland at the north side of the beach. Gull numbers were highest in the summer months, when mainly immature Gulls were present. Highest wintering gull numbers were in September (Tables 6.7a & 6.7b).

Table 6.7a. Species recorded on the shore at Belderra Beach in the winter months.

Species/Month	1% Nat	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Mean	Peak
Oystercatcher	680		2	1		1	2	2		2
Ringed Plover	150		2			3	1	2		3
Sanderling	65		1			1	2			2
Turnstone	120	3		1						3
Redshank	310						1			1
Curlew	550	24				1			4	24
Black headed Gull		11		7			2			11
Common Gull		29		1	1	10	7			29

Species/Month	1% Nat	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Mean	Peak
Herring Gull		2	1		1	1	3	2		3
TOTAL WADERS		27	5	2	0	6	6	4		
TOTAL BIRDS		69	6	10	2	17	18	6		

The threshold for national importance is shown under "1% Nat", the peak count for the winter season is shown "peak". Mean counts were not derived given the low numbers present.

Table 6.7b. Species recorded on the shore at Belderra Beach in the summer months.

Species/Month	April	May	June	July	Aug
Oystercatcher	4			2	
Ringed Plover		2			3
Sanderling					31
Turnstone					1
Dunlin		2			1
Common Sandpiper		1			
Curlew					40
Black headed Gull	1				
Common Gull	9				4
Herring Gull			24	33	2
Great Black backed Gull	1				1
Lesser Black-backed Gull			5		
TOTAL WADERS	4	5	0	2	76
TOTAL BIRDS	15	5	29	35	83

Cross Point

The rocky shore at Cross Point was used by roosting and feeding waders during the winter and summer months, with highest numbers in May (Tables 6.8a & 6.8b). Oystercatcher were recorded here in all months except June. Dunlin and Sanderling recorded in May were mainly in summer plumage. Of note was the presence of Purple Sandpiper in November and January. Shelduck were recorded in Spring and summer, with a chick present in June. Gulls were recorded year round with highest numbers during the summer months, when many were immature. Whimbrel were recorded in April, during their northward migration.

Table 6.8a. Species recorded on the shore at Cross Point during the winter months.

Species/Month	1% Nat	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Mean	Peak
Shag				1	2					2
Oystercatcher	680	27	14	14	7	3	3	4	10	27
Purple Sandpiper	35			4		8				8
Curlew	550	6		2	2		19	18	7	19
Redshank	310			2	5	2	7	5	3	7
Turnstone	120			24			1	1	4	24
Common Gull		16					1			16
Herring Gull							1	2		2
Great Black backed Gull		1					2	4		4
Gull *spp*.								3		3
TOTAL WADERS		34	14	46	14	13	30	28		
TOTAL BIRDS		50	14	47	16	13	34	37		

The threshold for national importance is shown under “1% Nat”, the mean count for the winter season is shown under “mean”, and the peak count as “peak”.

Table 6.8b Species recorded on the shore at Cross Point during the summer months. Species in italics refer to birds in flight only.

Species/Month	April	April dusk	May mid tide	May high tide	June	July	Aug
Shelduck		2	3	1	2(+1*)		
Oystercatcher	25	15	3	25		18	2
Ringed Plover			4			5	
Sanderling			22	14		5	
Dunlin			23	36			
Curlew	2	9				3	
Whimbrel		(12)					
Redshank	2	8					
Turnstone			6	26		3	36
Black headed Gull				2	3	1	
Common Gull	5			21	3	7	

Species/Month	April	April dusk	May mid tide	May high tide	June	July	Aug
Herring Gull	1		41	4	17	3	3
Great Black backed Gull	1			2	8		
TOTAL WADERS	29	32	58	101	0	34	38
TOTAL BIRDS	36	34	102	131	33	45	41

*Sheldduck chick.

6.3.1.2 Geese and Swans

Winter surveys, which included the dawn and dusk period, recorded flying geese and swans moving between nocturnal roost sites and their diurnal foraging areas (Table 6.9). Barnacle Geese were recorded either flying across the Bay from the Inishkea Islands past Annagh Head and then landward to Termoncarragh Lake, or into the Bay, across Annagh Beach and landward to Termoncarragh Lake or other inland feeding sites. Obvious flight paths were observed for the Barnacle Geese. Whooper Swan and Light bellied Brent Goose were recorded less frequently and obvious flight paths were not observed.

Table 6.9. Observations of flying geese and swans.

Vantage Point/ Count sector	Species	Oct	Nov	Jan	Feb	March
Annagh Beach	Whooper Swan	27				
	Barnacle Goose	76	471			
Belderra Beach	Whooper Swan	2				
	Whooper Swan		7			
Sector A and B	Barnacle Goose				49	
	Light bellied Brent Goose				2	100
Sector C	Barnacle Goose		600	461		

6.3.1.3 Open Water Bay Habitats

Twenty-nine species of bird were recorded during surveys of the Bay (Table 6.10). These included sea duck and divers associated with the shallow waters of the Bay, foraging and resting Gulls, Auks, Shag and Cormorant and foraging Terns. Waders were recorded flying across the Bay. Petrels and Gannet, which are associated with more open sea habitats, were also recorded.

The count sector within which the birds were observed or the Vantage Point from which they were observed is shown in column one.

Table 6.10. All birds recorded within the inner and outer Bay. Those species recorded in flight and on the water are listed.

Species		
Mallard	Cormorant	Great Black- backed Gull
Eider	Grey Heron	Kittiwake
Long-tailed Duck	Oystercatcher	Little Tern
Red throated Diver	Golden Plover	Sandwich Tern
Great Northern Diver	Turnstone	Arctic tern
Fulmar	Curlew	Puffin
Great crested Grebe	Black-headed Gull	Black Guillemot
Manx Shearwater	Common Gull	Guillemot
Gannet	Herring Gull	Razorbill
Shag	Lesser Black- backed Gull	

Inner Bay (Sectors A and B)

The seaduck, Eider and Long-tailed duck were present in the inner Bay. The Eider present in August, September and October were all female. In March and April both male and female Eider were present (Table 6.11). Long-tailed duck were recorded on the water in December, January and February, with two noted in flight in March (Tables 6.11 & 6.12). Numbers peaked in February with a maximum count of 18 and a minimum count of 15. Both Red-throated and Great Northern Diver were recorded from the inner Bay. While Red-throated Diver were recorded only in May, Great Northern Diver were recorded each month from October to May. The minimum mean number of Great Northern Diver was 10, with the maximum being 11. The minimum peak number was 13 in the months, March and May with a maximum peak number of 17, recorded in March. Also of note was the presence of large rafts of Manx Shearwater in July. These rafts consisted of an estimated 300 birds on the water with others flying overhead (Table 6.11). Gannets were also recorded in the inner Bay, both foraging and plunge diving, with low numbers recorded on the water.

The inner bay was also used by Shag, which were observed foraging all year round, while Auks were more common during late winter and summer months. Gulls, mainly Common Gull, were recorded on the water all year round, with two Kittiwake present in July.

While records of birds in flight were not quantitative, they show tern activity in the Bay during May, June and July, with records of foraging Arctic, Little and Sandwich Tern. They also show Gannet activity in the inner Bay during early winter and summer.

Table 6.11. Results from the inner Bay (sectors a and b) showing numbers of birds on the water over all survey months.

Species / Month	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	April dusk	May	June	July	Aug
Mallard	4												11
Eider	7	1					4	1					7
Long-tailed Duck				4	9 (+5)	15 (+3)							
Red throated Diver										4			
Great Northern Diver		10 (+3)	9	8 (+2)	7 (+2)	11	13 (+4)	11	11	13			
Great crested Grebe				1									
Manx Shearwater												300	7
Gannet						1					1	6	1
Shag	8	2	5	11	4	7	8	5		1	4	5	2
Cormorant			1										
Black-headed Gull			1	5	11	3							
Common Gull	25	1	7	6	8	22	2	8		2		3	8
Herring Gull		1	1								2	3	1
Lesser Black-backed Gull											16	1	
Great Black-backed Gull	1	1				2			1	4		1	1
Gull *spp*.												15	
Kittiwake												2	
Gulls	26	3	9	11	19	27	2	8	1	6	18	25	10
Puffin		1											
Black Guillemot		1	4				1	9		11	4	11	1
Guillemot							5	1	1	4	2	5	
Razorbill		1					7	12	5	9	1		1

Species / Month	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	April dusk	May	June	July	Aug
Auk *spp*.							4				4		1
Auks		3	4				17	22	6	24	11	16	3
Total numbers of birds	45	19	28	35	39	61	44	47	18	48	34	352	41
Total numbers of species	5	9	7	6	6	7	7	7	4	8	7	10	10

Cells shaded grey highlight the winter months. The numbers in brackets represent possible additional records, which could not be confirmed without a coordinated count effort.

Table 6.12. Results from the inner Bay (sectors a and b). Cells shaded grey highlight the winter months. Observations of birds in flight only.

Species / Month	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	April dusk	May	June	July	Aug
Long tailed Duck							2						
Great Northern Diver	1												
Manx Shearwater												c.180	8
Gannet	17	1								4	1	31	5
Cormorant				1		1						2	
Shag					1		1				2	4	1
Cormorant/Shag			5										
Oystercatcher										50		54	
Turnstone						5							
Curlew						12						1	
Black- headed Gull												2	
Common Gull				31				1			5	4	6
Herring Gull				1	1		1	1			1		2
Great Black - backed Gull	3			2	1	2						3	3
Gulls	3			34	2	2	1	2			6	9	11

Species / Month	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	April dusk	May	June	July	Aug
Little Tern										1			
Sandwich Tern												1	
Arctic Tern										2	9	3	
Black Guillemot											1		
Guillemot/ Razorbill				1		5							
Auks				1		5					1		

Outer Bay (Sector C Results)

Low numbers of birds were present on the water in most months, with highest numbers in April and May (Table 6.13). The number of species recorded ranged from one to six. Rafts of 690 Manx Shearwater were recorded west of Annagh Head in April. Auks were present in most months with peak numbers in April and May. Small numbers of Shag and Gulls, most regularly Great Black-backed Gull, were present in most months with small numbers of Gannet on the water in October, June and July.

Larger numbers of birds were recorded in flight than on the water (Table 6.14). However, numbers of birds in flight were not recorded in a quantitative manner, and only general conclusions can be drawn from this data. Within the outer Bay, Table 6.14 shows activity by Fulmar, Gannet and Manx Shearwater in April, June, July and August. Also of note is tern activity in May and June when the breeding colony at Annagh Islet (next to Annagh Head) was active (Table 6.15). Gulls again, mostly Great Black-backed Gull, were recorded in most months. Auk activity was also recorded in most months, with a peak in March, though this is attributable to a train of Auks passing west of Annagh Head.

Table 6.13. Results from the outer Bay (sector C). Numbers refer to birds recorded on the water only. Asterixed species are Annex I species. Shaded cells refer to winter months

Species/Month	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July*	Aug
Great Northern Diver*					1	2	1	1	2			
Manx Shearwater								690			1	4
Gannet		1								1	4	
Shag	2	1	5	2		1	1	1	1			1
Common Gull	1						1	2				1
Herring Gull				3					7			

Species/Month	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July*	Aug
Great Black-backed Gull	1	1				1	1		1			1
Gull *spp*.							2					
Total Gulls	2	1		3		1	4	2	8			2
Black Guillemot								1		1		
Guillemot								25	16	1		
Razorbill	1	1							9	1		
Guillemot/ Razorbill			1						6	2		1
Auk *spp*.							2	7	2			1
Total Auks	1	1	1				2	33	33	5		2
Total numbers of birds	5	4	6	5	1	4	8	727	44	6	5	9
Total number of species	3	4	2	2	1	3	5	6	6	4	2	5

* Not considered to be new birds in terms of total diver numbers for the month.

Table 6.14. Results from the outer Bay (Sector C). Records refer to flying birds only. Shaded cells refer to winter months.

Species / Month	Sept	Oct	(Nov)	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July*	Aug
Mallard								2					
Great Northern Diver	1				1				1				
Fulmar						2			2			1	33
Manx Shearwater									207		19	12	34
Gannet									12		12	16	45
Cormorant			1		1				1				
Shag		1		4		4		2			2	2	2
Grey Heron													1
Oystercatcher				1		1	1	3					3

Species / Month	Sept	Oct	(Nov)	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July*	Aug
Golden Plover				30									
Curlew				2									
Common Gull	2							1			12		1
Herring Gull					2			2			1		
Great Black - backed Gull			11	8	7	6	2		1		1		3
Lesser Black-backed Gull								1		1			
Kittiwake					4							2	
Gulls	2		11	8	13	6	2	4	1	1	14	2	3
Arctic Tern										10	6		
Puffin									1		3		1
Guillemot									8				
Razorbill	1												
Guillemot/ Razorbill				1	1	6							
Auk *spp*.						3		132		4			
Auks	1			1	1	9		132	9	4	3		1

Table 6.15. Apparently Occupied Sites (AOS) recorded on Annagh Islet for nesting Common Gull and Arctic Tern in June, 2009.

Species	AOS	Young
Common Gull	24	Plus 5, 5-10 day old young
Arctic Tern	48	

6.3.1.4 Terrestrial Habitats

__Winter Birds__

Dune and coastal grassland habitats at Annagh Beach, Emlybeg and Belderra Strand were used by resident species typical of these habitats such as Meadow Pipit and Skylark (Table 6.16). Common and widespread ubiquitous species, such as Jackdaw, Hooded Crow and Magpie were also recorded. Species more associated with winter foraging were Raven, Goldfinch and the migratory species Fieldfare and Redwing. Large foraging flocks of the latter two species are common in winter. Snipe and Golden Plover, which typically use coastal habitats during the winter season, were present. Rock Dove, a species with limited distribution within Ireland (Cabot, 1999), was present.

Table 6.16. Birds recorded during walkover surveys of terrestrial habitats at Annagh Beach, Emlybeg and Belderra Strand. '*' represents an Annex I species. Red Listed species (Lynas et al. 2007) are shown in italics.

Species	Annagh	Emlybeg	Belderra
Golden Plover*		165	
Snipe	2		
Herring Gull		7	
Rock dove		5	
Skylark		3	1
Meadow Pipit	1		2
Rock Pipit			1
Fieldfare			35
Redwing		30	22
Jackdaw			5
Raven		2	1
Hooded Crow		2	
Starling		11	41
Magpie			1
Goldfinch			2

Summer Birds

Typical breeding birds of coastal dune and grassland habitats were recorded during the breeding season (Table 6.17). These included both resident species such as Skylark and Meadow Pipit and migratory species such as Wheatear. Small breeding numbers of the waders, Ringed Plover and Common Sandpiper were recorded. Of note was a small Sand Martin colony of about 20 nest holes in a sand bank at Emlybeg. During breeding bird surveys, birds using the shore were also noted, with large numbers of roosting Gulls recorded and flocks of the passage wader Whimbrel.

Other species recorded during the breeding bird survey, but not observed to be breeding are shown in Table 6.18.

Table 6.17. Results from breeding bird survey, where CF is breeding confirmed, PR is probable breeder, PO is possible breeder. Data refers to breeding pairs .

Species/Location	Belderra			Emlybeg			Annagh		
Breeding status	**CF**	**PR**	**PO**	**CF**	**PR**	**PO**	**CF**	**PR**	**PO**
Ringed Plover		1	1						
Common Sandpiper				1					
Skylark	1	2	3	1	4	7	1	1	8
Sand Martin				35					
Meadow Pipit		4	1		6	2		6	1
Pied Wagtail		1	2						
Wheatear	1	1	1	3	2			1	
Wren			2						

Table 6.18. Other species recorded during the breeding bird survey, but not observed to be breeding.

Species/Location	Belderra	Emlybeg	Annagh	Behaviour
Light bellied Brent goose			13	Roosting on beach
Mallard		1		Flushed from dunes
Sanderling		30		Foraging on sandy shore
Whimbrel		46		Roosting
Black-headed gull		4		Roosting
Common Gull		25		Roosting
Herring Gull	2	63		Roosting on shore/ dunes
Great black-backed gull	1	11		Roosting on shore/ in dunes
Rock Dove		27		Feeding at cattle feeder in dunes
Swallow		<25	<25	Numerous flying
Rock pipit		1		
Jackdaw	10			Foraging in dunes
Hooded Crow	2			
Starling		10	20	Foraging

6.3.1.5 Storm petrel survey

On the south shore, thirty-five responses to the tape-lure were recorded from six quadrats sampled (Table 6.19). Nine responses were recorded from the four quadrats sampled on the north shore. At the west end of the island two separate boulder fields were sampled, there were sixteen responses from one quadrat and one response from the other. All stone walls on the island were surveyed with forty-seven responses. Some of the stone walls surveyed in Seabird 2000 are now grassed over and could not be surveyed. One of the three cairns on the island was surveyed, giving no responses. The building walls of the church and chapel at the east end of the island were surveyed, giving 3 responses, all from less than 1 m up the wall (Table 6.20).

Table 6.19. Results from breeding Storm Petrel surveys of shore and boulder field habitats showing the number of quadrats surveyed and the number of responses gained using the tape playback method.

Habitat	Quadrat	Responses
South shore	3 random; 3 selected	35
North shore	2 random; 2 selected	9
Boulder field 15	1 selected	1
Boulder field 16	1 selected	16

Table 6.20. Results from breeding Storm Petrel survey of wall and building habitats, showing the length of stone or building wall surveyed and the number of responses gained using the tape playback method.

Habitats	Length sampled (m)	Responses
Walls	1207	47
Buildings walls < 1m	23	3
Buildings walls > 1m	23	0

6.3.2 Sea based surveys

This section presents the bird species recorded during the sea based surveys. Species and total numbers of birds recorded from one sea based survey in October 2009 together with seven sea based surveys between March and October 2010 are presented in Table 6.21. A total of 8,092 birds of 33 (taking Guillemot and Razorbill combined) species were recorded during the eight survey days. Of the total of 33 species, 19 were recorded in numbers <18 birds (Table 6.22). Due to the paucity of data on these birds they are not dealt with in detail in this report. There is no data related to the winter months, February to March.

Table 6.21. List and count of all species observed during sea based surveys.

Species	Count	Species	Count
Gannet	2369	Common Gull	14
Manx Shearwater	1425	Arctic Skua	6

Great Shearwater	869	Lesser Black-backed Gull	6
Fulmar	805	Black Guillemot	5
Razorbill	716	Oystercatcher	4
Puffin	541	Dunlin	2
Kittiwake	280	Balearic Shearwater	1
Storm Petrel	257	Black-headed Gull	1
Great Black-backed Gull	207	Common Tern	1
Guillemot	162	Cormorant	1
Guillemot/Razorbill*	138	Great Northern Diver	1
Arctic Tern	127	Grey Phalarope	1
Sooty Shearwater	75	Little Auk	1
Herring Gull	27	Little Tern	1
Great Skua	25	Pomarine Skua	1
Shag	17	Red-throated Diver	1
Barnacle Goose	14	Skylark	1

*Guillemot and Razorbill were combined, as definitive distinction between these two species could not always be made due to distances at sea.

Table 6.22. Less common species (≤17 birds for all eight visits) recorded in the study area.

Incidental Species		
Arctic Skua	Cormorant	Little Tern
Balearic Shearwater	Dunlin	Oystercatcher
Barnacle Goose	Great Northern Diver	Pomarine Skua
Black-headed Gull	Grey Phalarope	Red throated Diver
Black Guillemot	Lesser Black-backed Gull	Skylark
Common Gull	Little Auk	Shag
Common Tern		

Gannets were by far the most common bird encountered throughout the survey, occurring in relatively high numbers throughout all months (Table 6.23). The Auk species (Razorbill, Puffin and Guillemot) were also present in all survey months with the exception of Razorbill, which was absent during August 2010. Fulmar, Kittiwake and Great Black-backed Gull were the remaining three species recorded during all survey visits. Manx Shearwater, Storm Petrel and Arctic Tern were recorded only during the summer months, which most likely reflects their return to breeding colonies near the study site and along the west coast of Ireland. Neither Great Shearwater nor Sooty Shearwater were recorded between March and July indicating the migratory nature of these birds. All Shearwater species (Manx, Great and Sooty) observed in the study area were observed both flying and in rafts.

Table 6.23. Raw count data by month for more commonly observed bird species (>18 birds for all eight visits) in the study area.

Species	Oct	Mar	Apr	May	Jun	Jul	Aug	Oct	Total
Gannet	535	187	80	88	150	199	111	1019	2369
Manx Shearwater	1	-	195	421	238	514	54	2	1425
Great Shearwater	869	-	-	-	-	-	-	-	869
Fulmar	35	236	88	147	61	89	127	22	805
Razorbill	36	244	18	288	24	74	-	32	716
Puffin	12	1	77	240	38	131	12	30	541
Kittiwake	70	61	45	33	12	3	5	51	280
Storm Petrel	-	-	-	-	122	76	57	2	257
Great Black-backed Gull	14	11	26	40	42	44	6	24	207
Guillemot	8	62	5	8	19	18	1	41	162
Auk spp.	11	127	-	-	-	-	-	-	138
Arctic Tern	-	-	-	77	40	10	-	-	127
Sooty Shearwater	70	-	-	-	-	-	3	2	75
Herring Gull	5	9	3	-	3	-	3	4	27
Great Skua	11	-	-	-	-	-	1	13	25
Monthly Total	1677	938	537	1342	749	1158	380	1242	8023

The total mean densities of birds observed throughout the monthly surveys varied considerably. Highest monthly densities occurred in October 2009 and 2010 although particularly large numbers of single species may distort this picture with over 50% of the birds recorded in October 2009 being Great Shearwater. Gannets accounted for over 80% of the October 2010 total (Figure 6.4). Relatively high mean bird densities from April through to July are apparent with lowest mean densities being recorded in August.

The cumulative numbers of species in each 300 x 300 m segment (Figure 6.5) appears to be relatively evenly distributed throughout the study area. It should be noted that the most southerly transect route (T6) was only surveyed on five occasions. Further surveys along this transect will add to this baseline to improve the robustness of the dataset. .

Figure 6.4. Relative species contributions to observed mean avian density (birds / km²) by month.

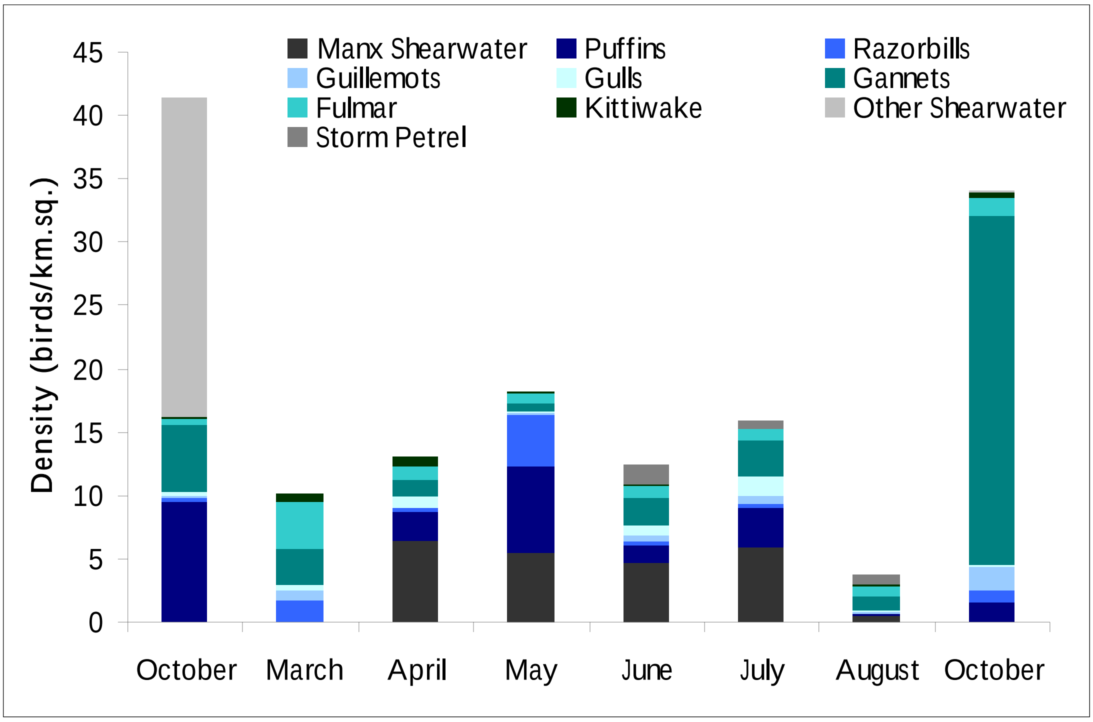
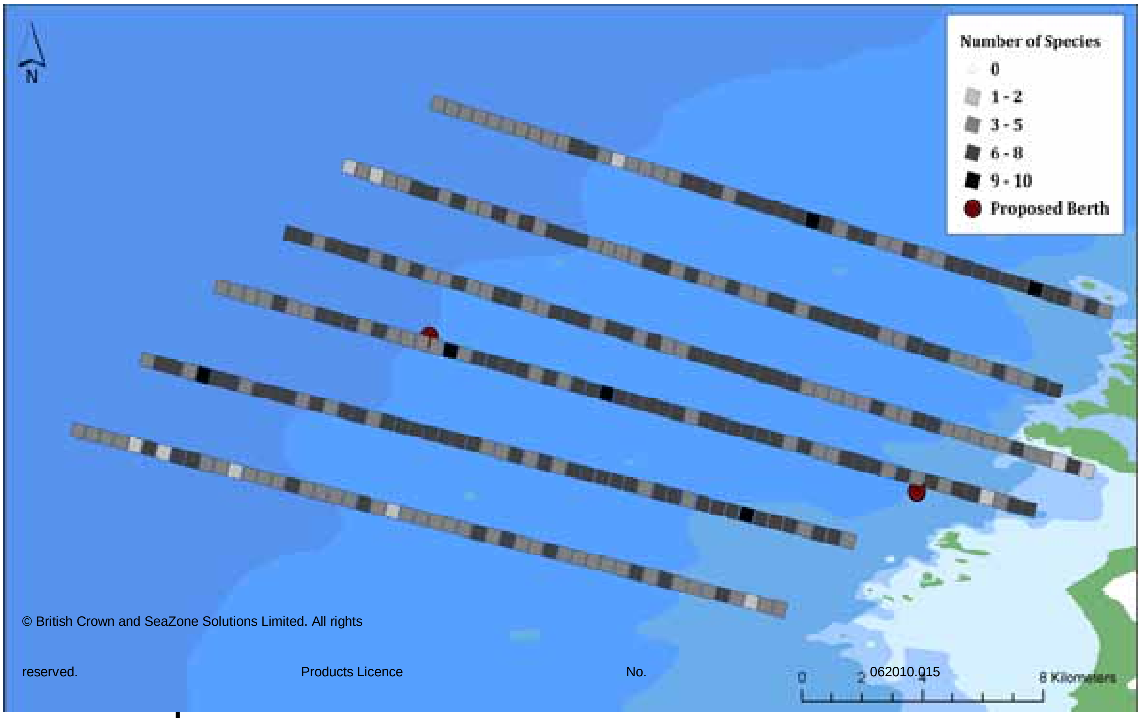


Figure 6.5. Cumulative number of species observed in each 300 m x 300 m segment over the eight surveys with the exception the most southerly transect (T6), which was only surveyed on five occasions.



This product has been derived in part from material obtained

Fulmar were recorded in all survey months with October having the lowest number (35 in 2009 and 22 in 2010). Peak numbers of Fulmars were recorded during the March survey

(Figure 6.6) with 236 being recorded. Although birds were generally evenly distributed throughout the study area, highest densities appeared to occur along the 100 m bathymetric contour line.

Figure 6.6. Density of Fulmar (birds / km²) observed in the study area with the proposed test areas presented in red.

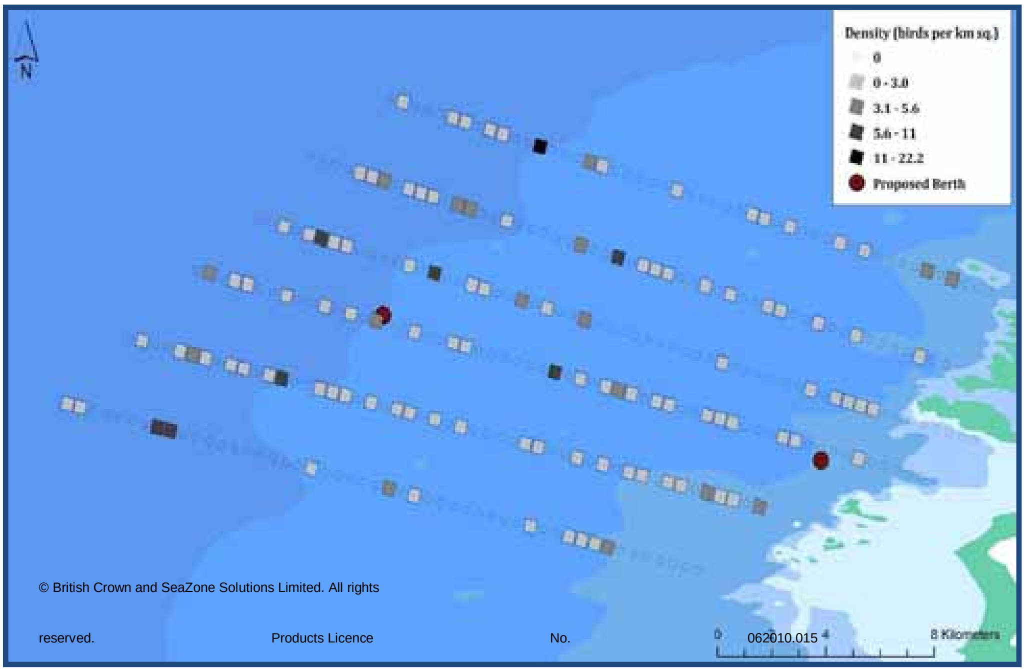
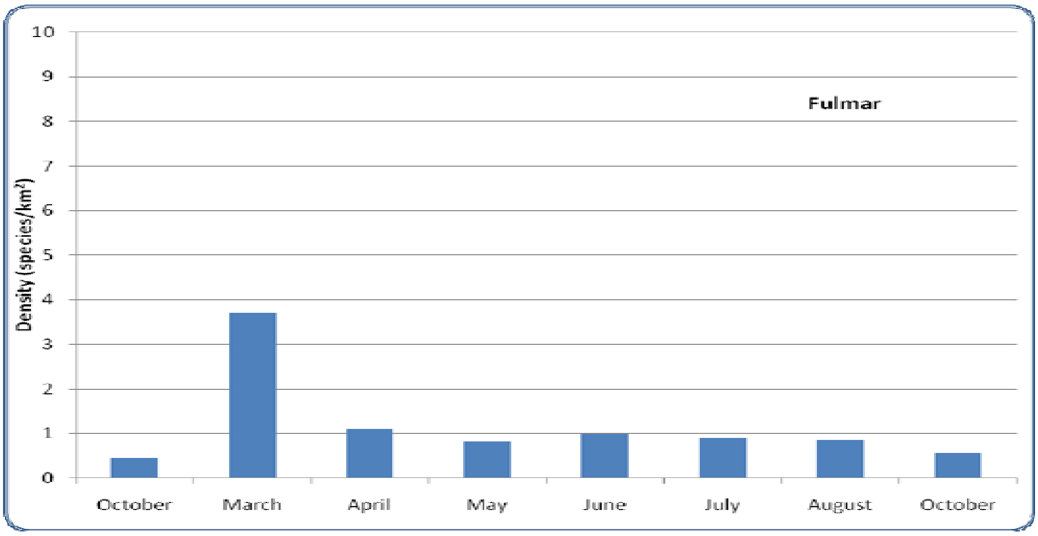


Figure 6.7. Monthly densities of Fulmar (birds / km²) observed in the study area.



6.3.2.2 Species Accounts - Manx Shearwater

Manx Shearwater observations, with the exception of 3 individuals recorded in the October surveys, were made between April and August (Figure 6.8). This gave rise to the greatest densities being recorded in April, May, June and July with a total of 1,368 birds being recorded (Table 6.23). In the study area, the largest densities were recorded within 8 km of the coastline (Figure 6.9).

Figure 6.8. Density of Manx Shearwater (birds / km²) observed in the study area.

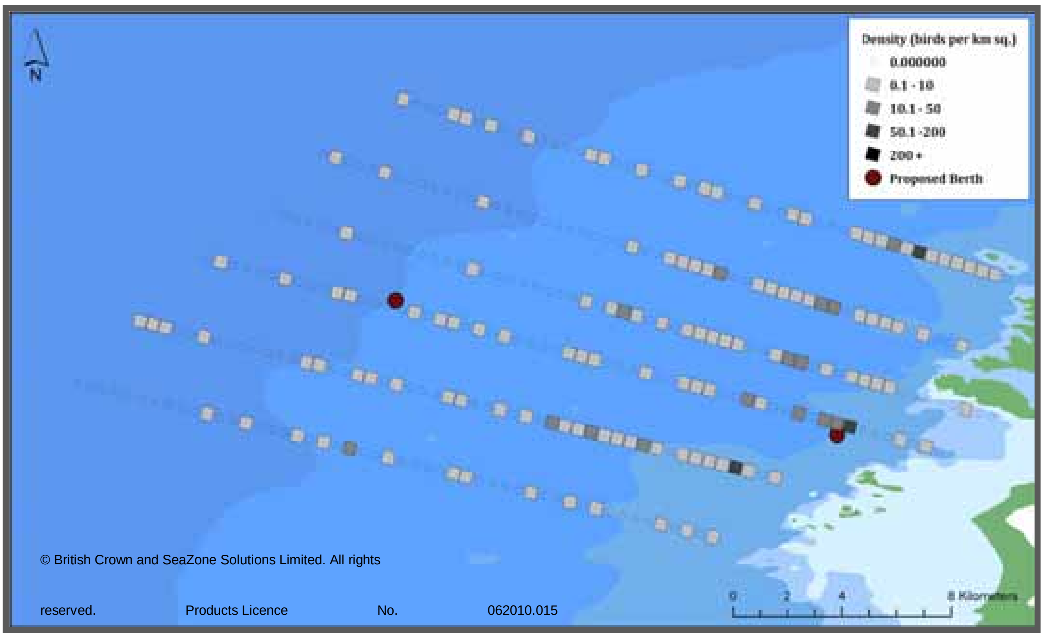
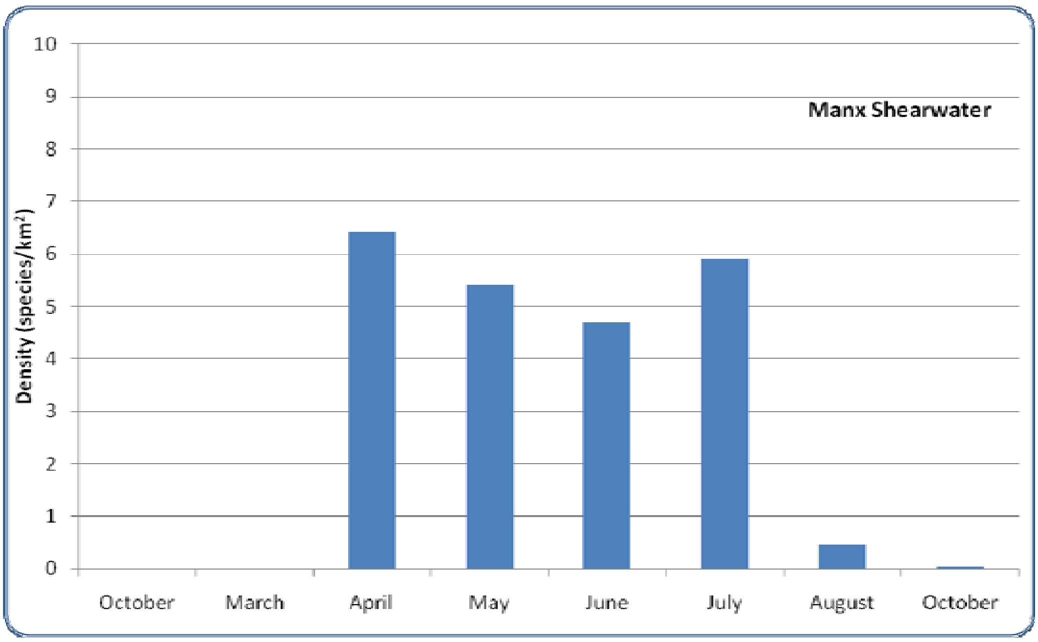


Figure 6.9. Monthly densities of Manx Shearwater (birds / km²) observed in the study area.



6.3.2.3 Species Accounts - Great Shearwater

Great Shearwater was recorded in large densities during the October 2009 survey congregated near the 100 m isobath (Figures 6.10 & 6.11). This was a large concentration of Great and Sooty Shearwater, most likely a feeding or post feeding flock. Great Shearwater were not recorded in any other month.

Figure 6.10. Abundance of Great Shearwater (birds / km) observed in the study area.

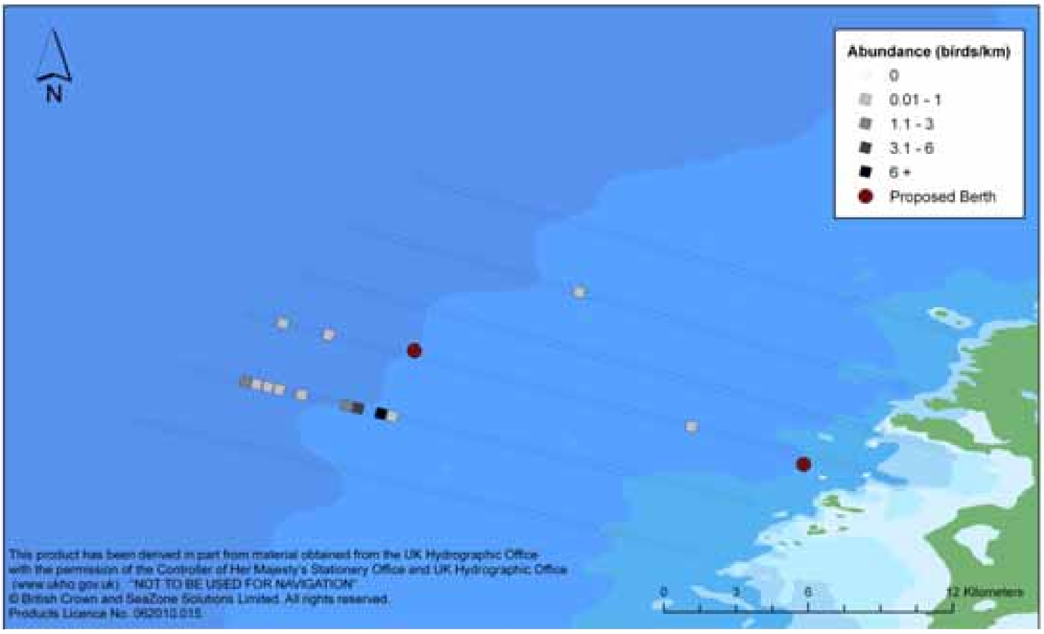


Figure 6.11. Monthly abundance of Great Shearwater (birds / km) observed in the study area.

6.3.2.4 Species Accounts - Sooty Shearwater

A larger number of Sooty Shearwater (75 birds) were recorded in October 2009 along the 100 m isobaths (Figure 6.12), associated with a large flock of Great Shearwater. Sooty Shearwater breeds on islands in the southern Pacific and Atlantic Oceans and thus the birds observed during this study are clearly long-range migrants.

Sooty Shearwater abundance was generally low with small numbers being recorded in August and October 2010 (Figure 6.13).

Figure 6.12. Abundance of Sooty Shearwater (birds / km) observed in the study area.

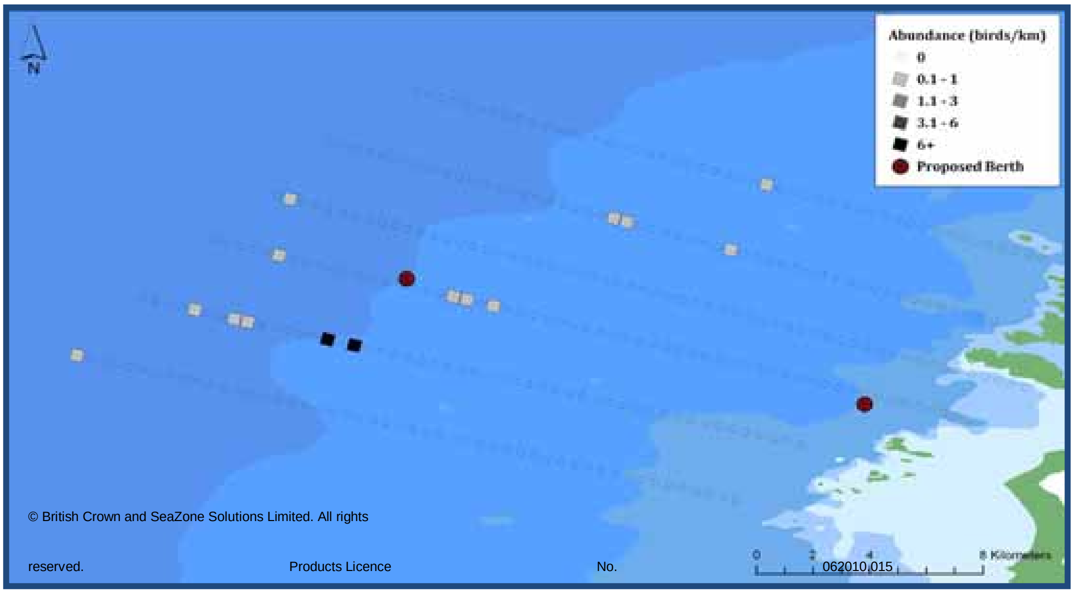
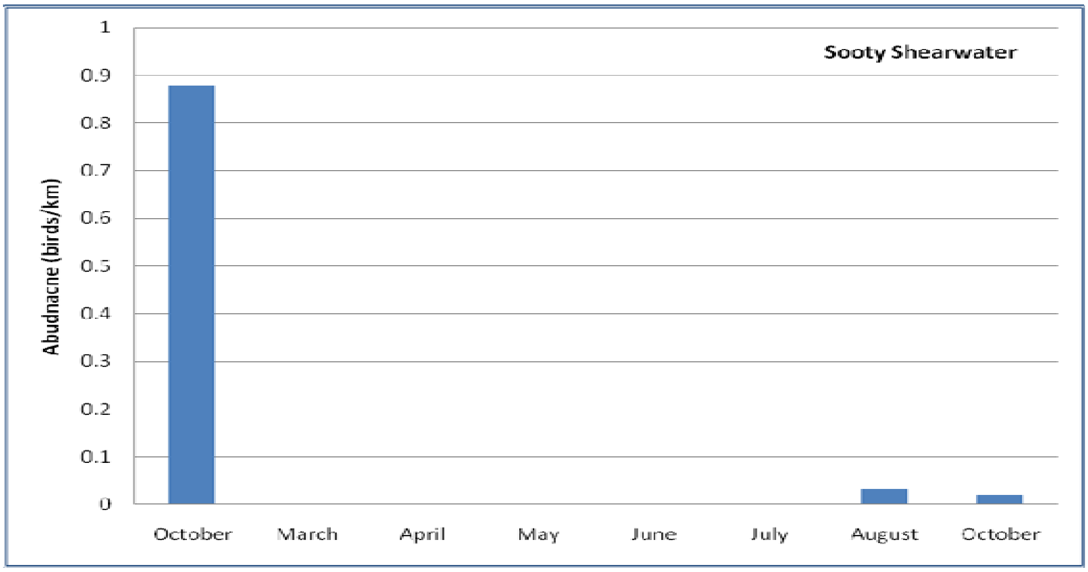


Figure 6.13. Monthly abundance of Sooty Shearwater (birds / km) observed in the study area.



6.3.2.5 Species Accounts - Storm Petrel

Most sighting of storm Petrel were made >8 km off the shore and along the 100 m isobath (Figure 6.14). Of a total of 257 Storm Petrels recorded during the survey, 255 of these birds occurred between June, July and August (Figure 6.15).

Figure 6.14. Abundance of Storm Petrel (birds / km) observed in the study area

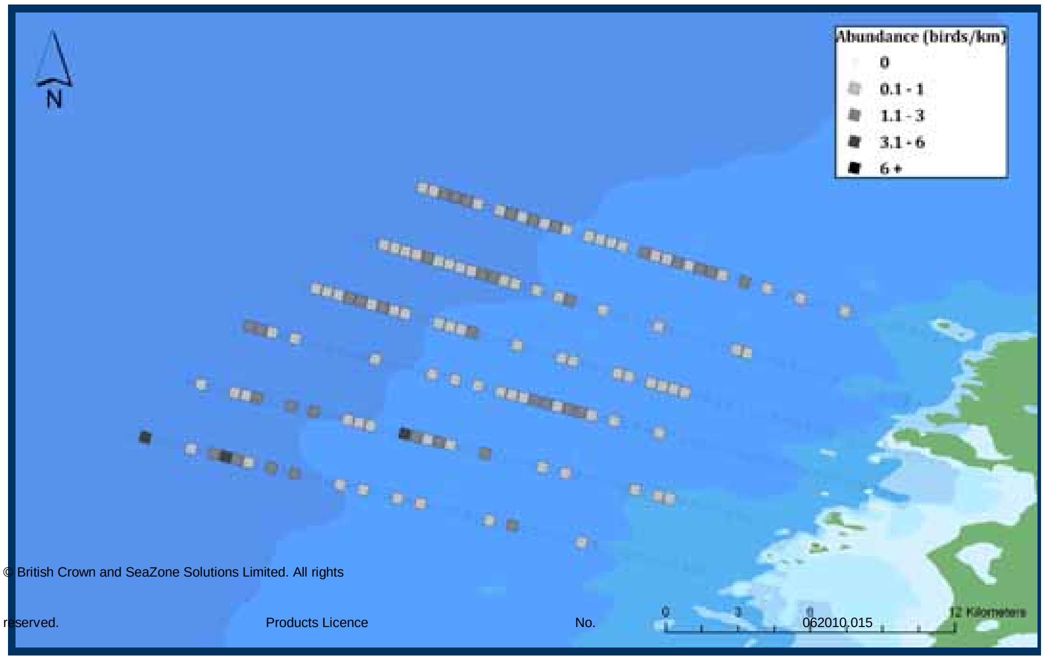
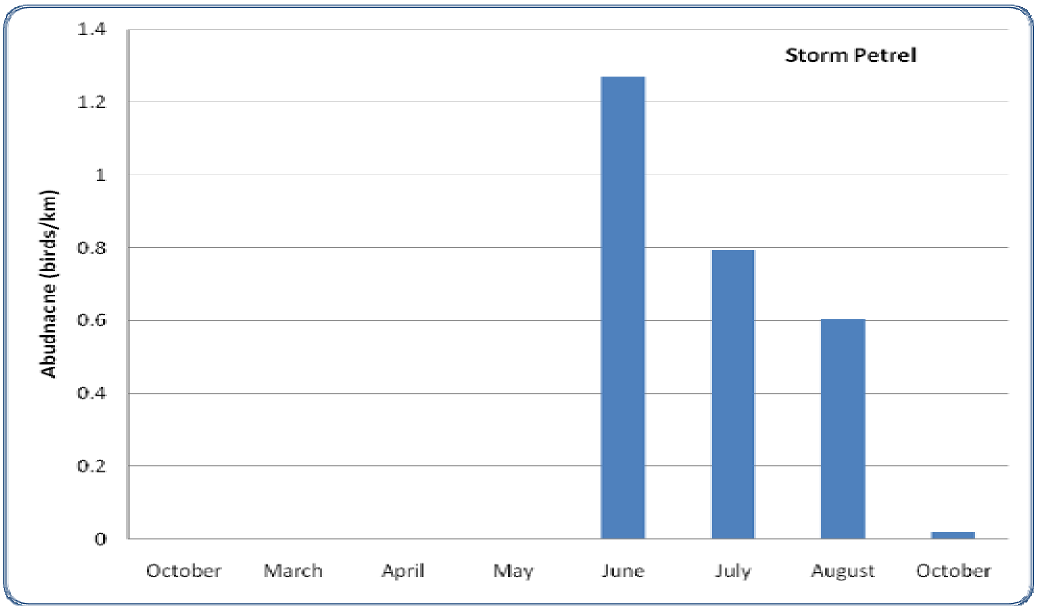


Figure 6.15. Monthly abundance of Storm Petrel (birds / km) observed in the study area.



6.3.2.6 Species Accounts - Gannet

Gannets were the most common bird observed during the sea-based surveys with a total of 2,369 birds being recorded over the eight visits. They were generally well distributed throughout the study area with an increase in density towards the 100 m isobath towards the west of the study area (Figure 6.16). Densities were relatively low during May and greatly increased in October 2010 (Figure 6.17).

Figure 6.16. Abundance of Gannets (birds / km²) observed in the study area.

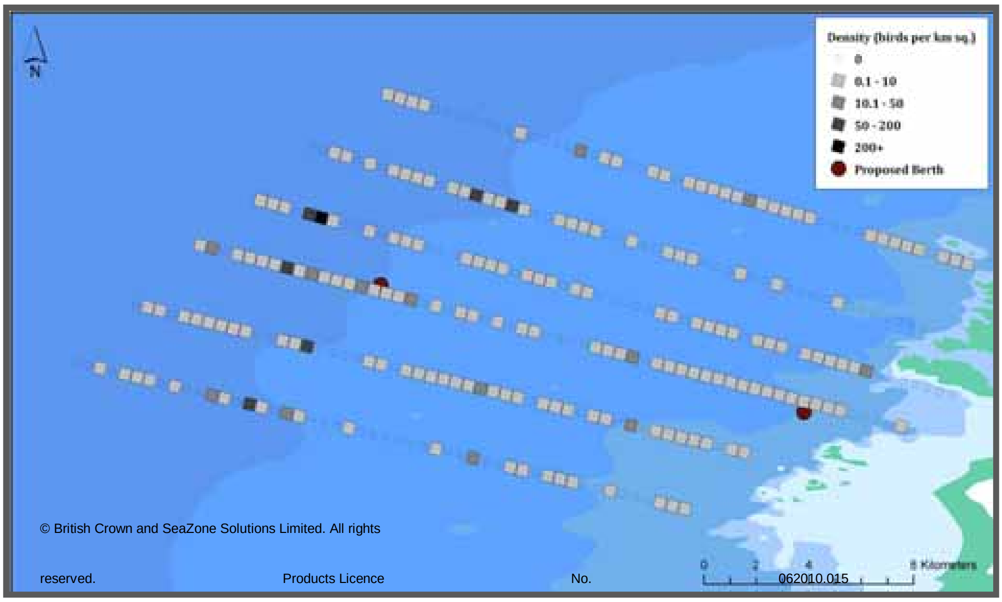
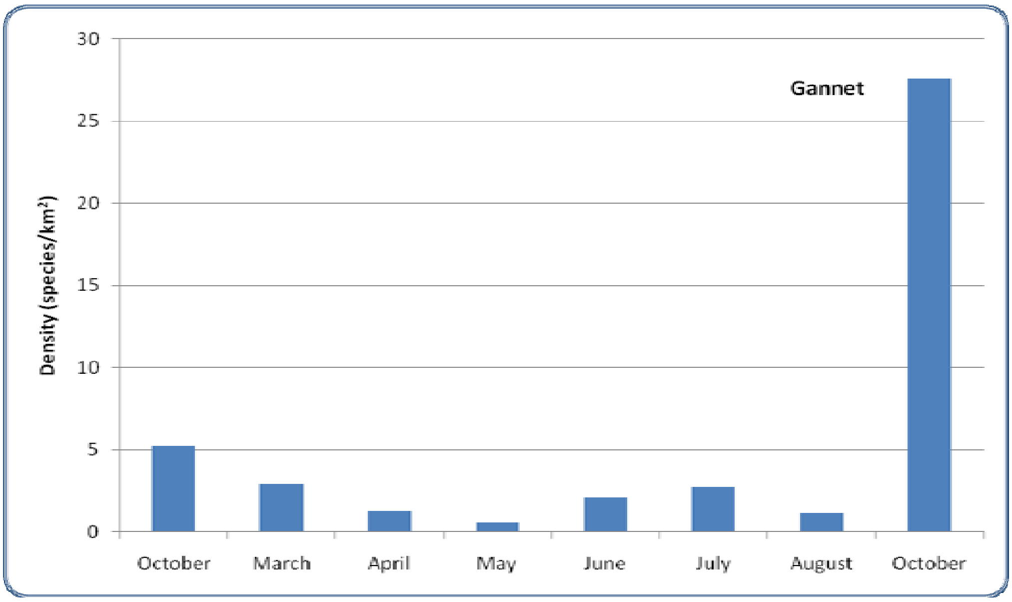


Figure 6.17. Monthly densities of Gannets (birds / km²) observed in the study area.



6.3.2.7 Species Accounts - Great Skua

Great Skua were recorded in low numbers in October of 2009 and 2010, with a single bird being recorded during the August survey. The birds observed tended to occur to the west of the 100 m isobath (Figures 6.18 & 6.19).

Figure 6.18. Abundance of Great Skua (birds / km) observed in the study area.

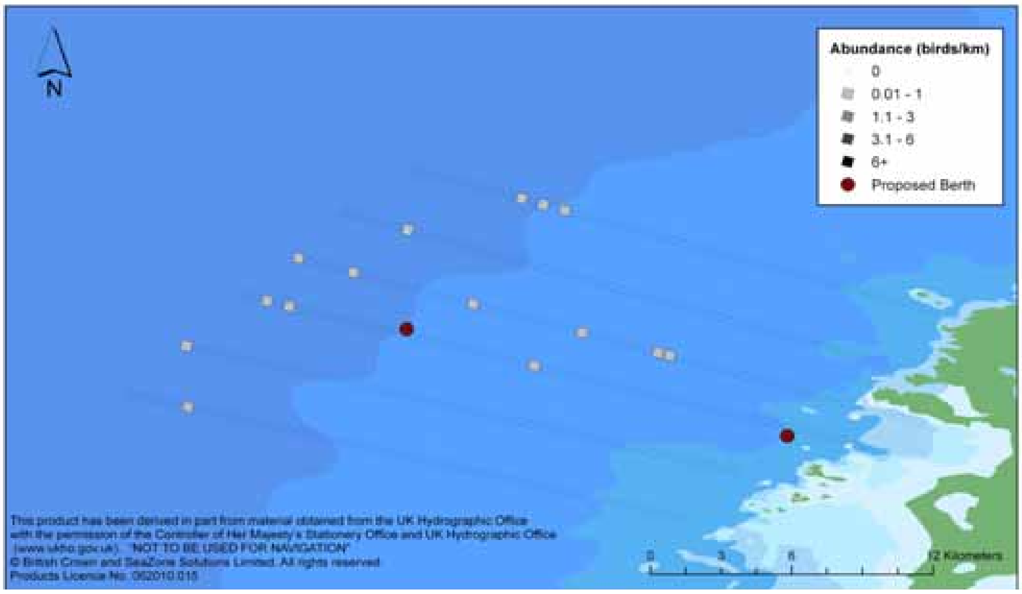
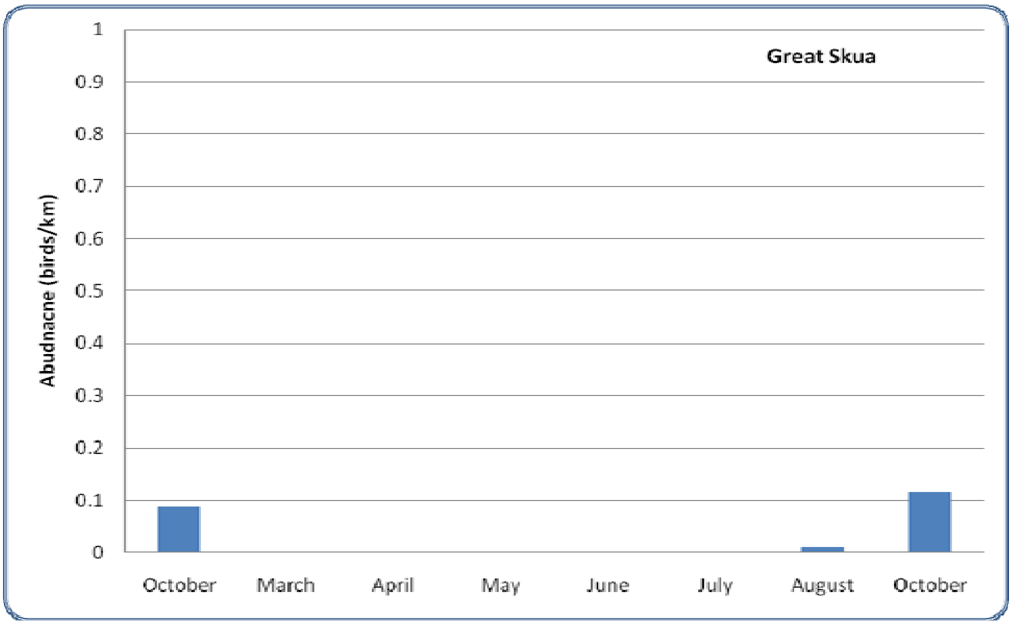


Figure 6.19. Monthly abundance of Great Skua (birds / km) observed in the study area.



6.3.2.8 Species Accounts - Herring Gull

Herring Gull were only recorded in low numbers throughout the study area (Figures 6.20 & 6.21). Numbers varied between 3 and 9 individuals in all months except May and July when none were recorded. The total number of birds recorded over the study period was 27.

Figure 6.20. Abundance of Herring Gull (birds / km) observed in the study area.

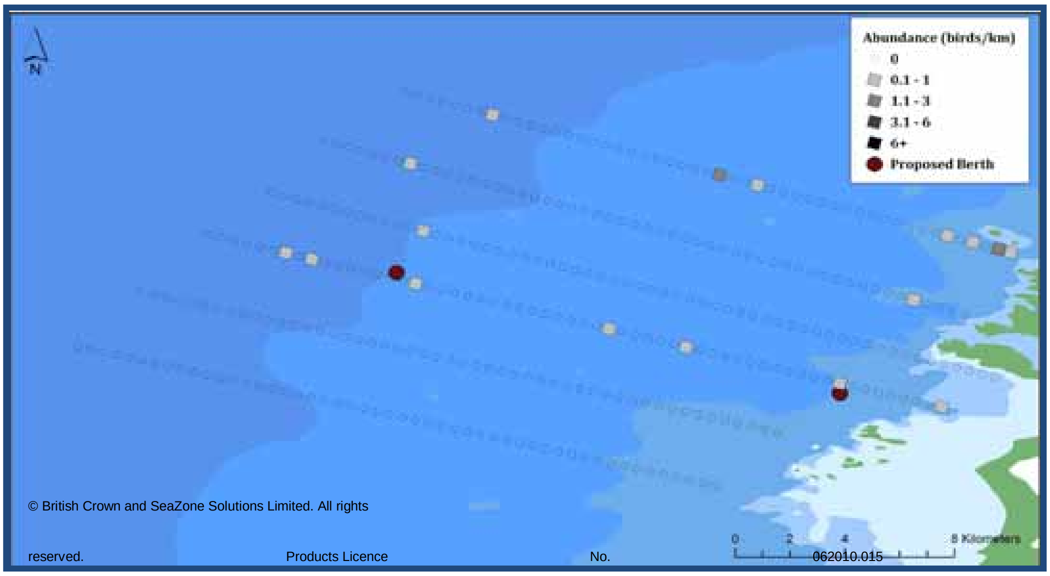
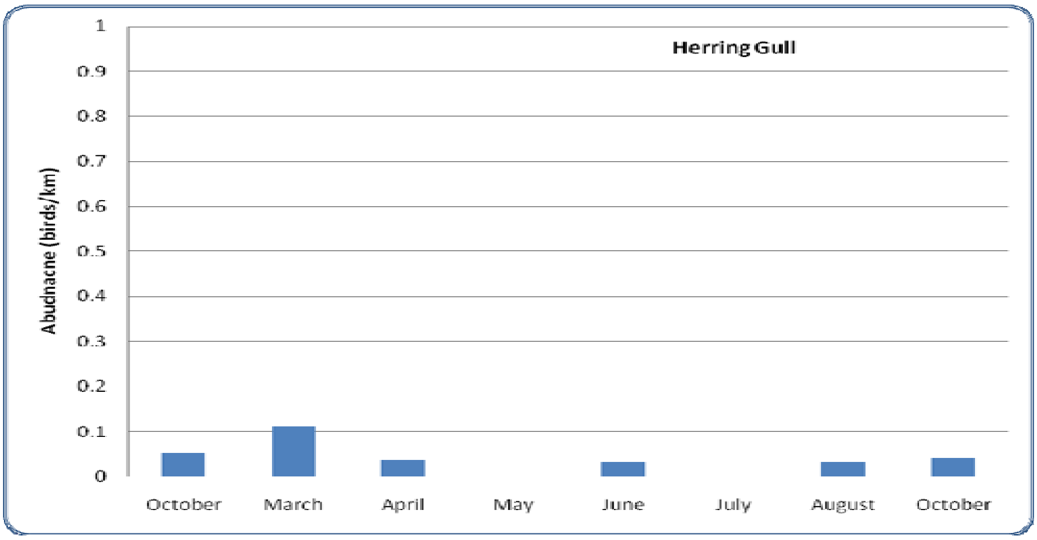


Figure 6.21. Monthly abundance of Herring Gull (birds / km) observed in the study area.



6.3.2.9 Species Accounts - Greater Black-backed Gull

Greater Black-backed Gulls were recorded in relatively low abundance throughout the study area (Figure 6.22) with most birds (over 60%) occurring during May, June and July (Figure 6.23). Birds where observed in all months giving a total of 207 individuals for the study period.

Figure 6.22. Abundance of Greater black-backed Gull (birds / km) observed in the study area

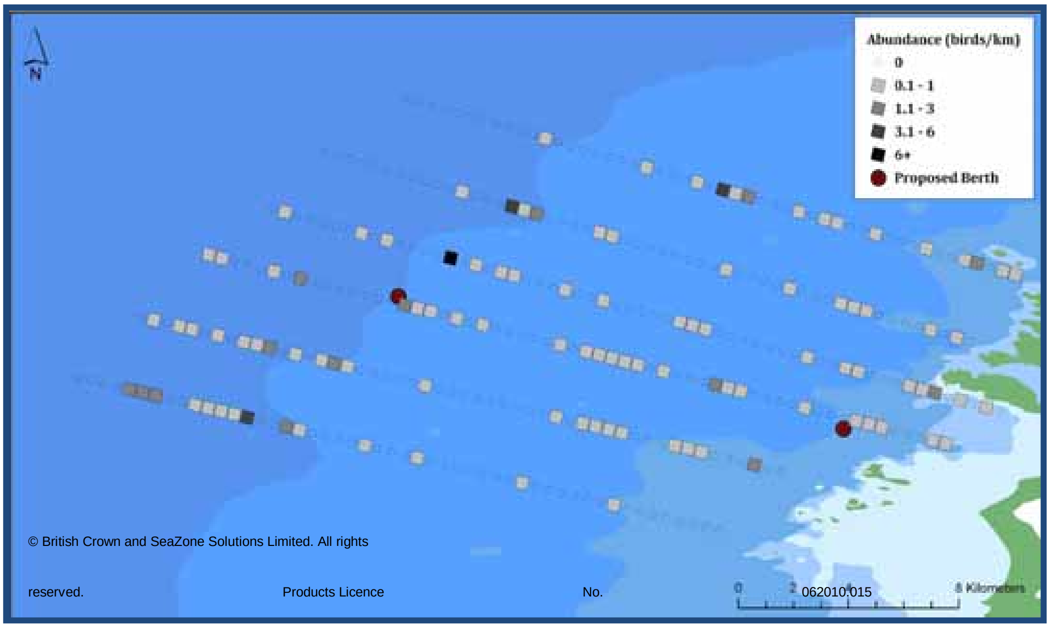


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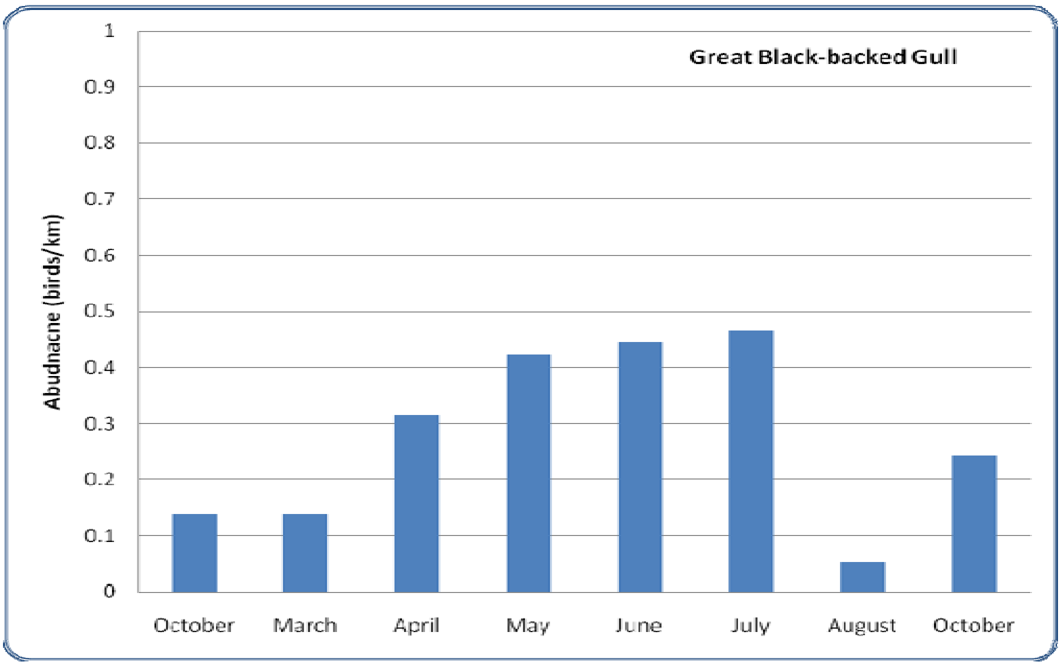
Figure 6.23. Monthly abundance of Gull (birds / km) observed in the study area.



6.3.2.10 Species Accounts - Kittiwake

Kittiwake was recorded in each survey month. Birds were relatively evenly distributed throughout the study area (Figure 6.24). Of a total of 280 birds recorded during the survey, less than 10% were in the months of June, July and August, during their breeding season (Figure 6.25).

Figure 6.24. Abundance of Kittiwake (birds / km) observed in the study area.

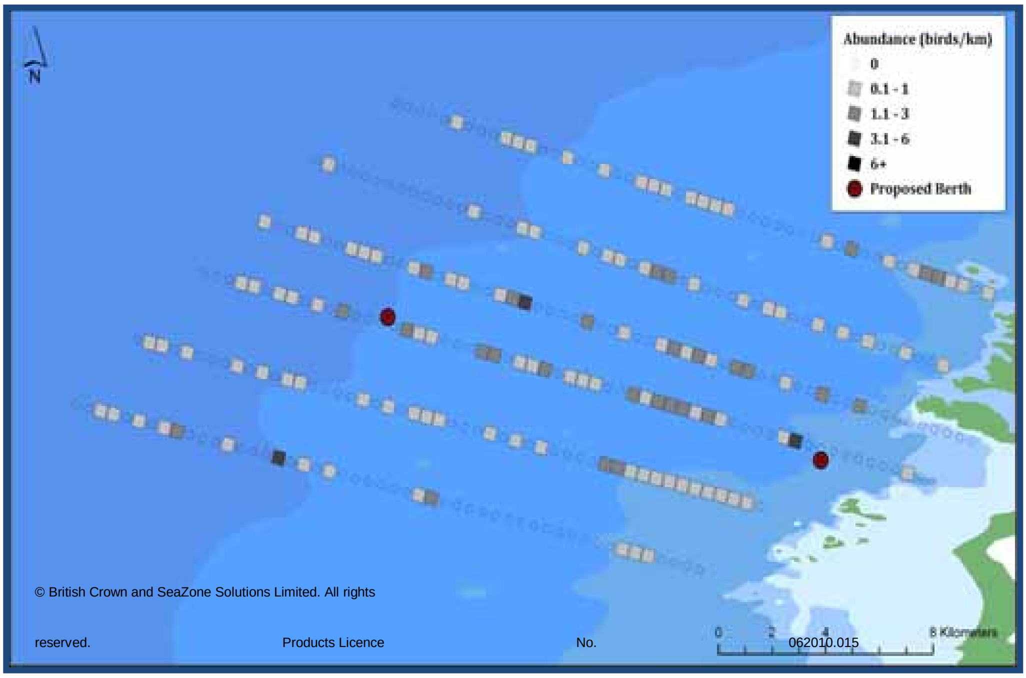
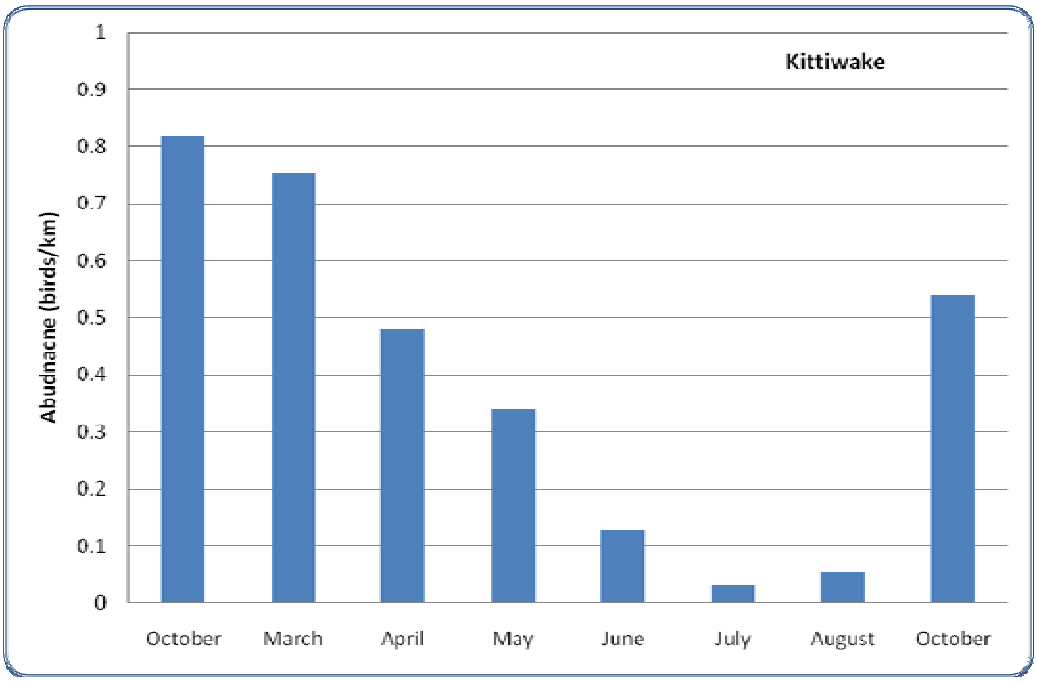


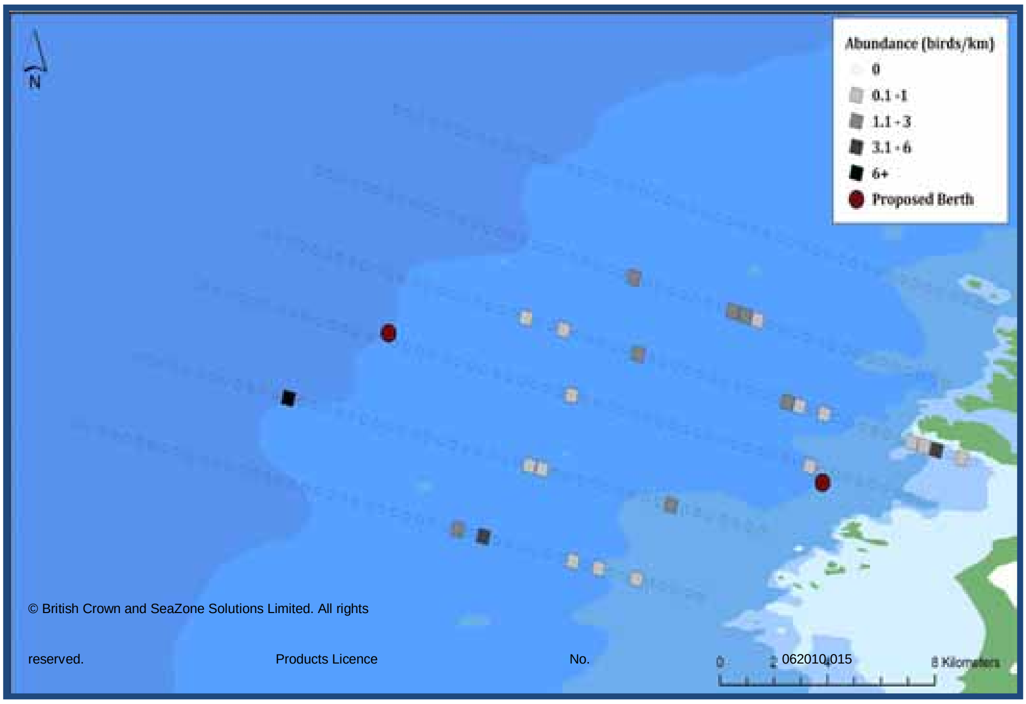
Figure 6.25. Monthly abundance of Kittiwake (birds / km) observed in the study area.



6.3.2.11 Species Accounts - Arctic Tern

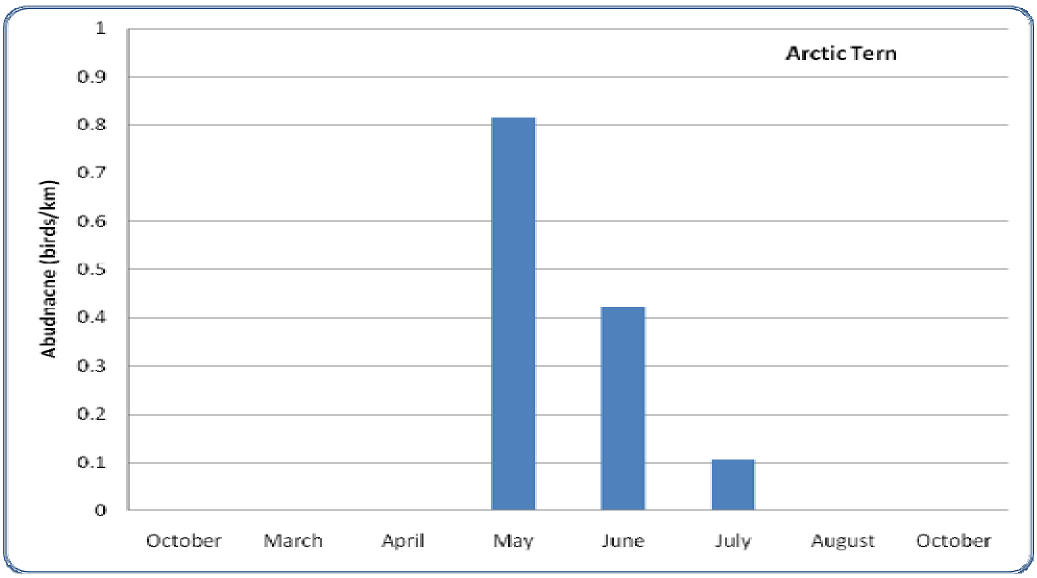
Arctic Tern abundance was relatively low, but widespread, throughout the study period (Figure 6.26). A total of 127 birds were observed only during May, June and July (Figure 6.27).

Figure 6.26. Abundance of Arctic Tern (birds / km) observed in the study area.



This product has been derived in part from material obtained

Figure 6. 27. Monthly abundance of Arctic Tern (birds / km) observed in the study area.

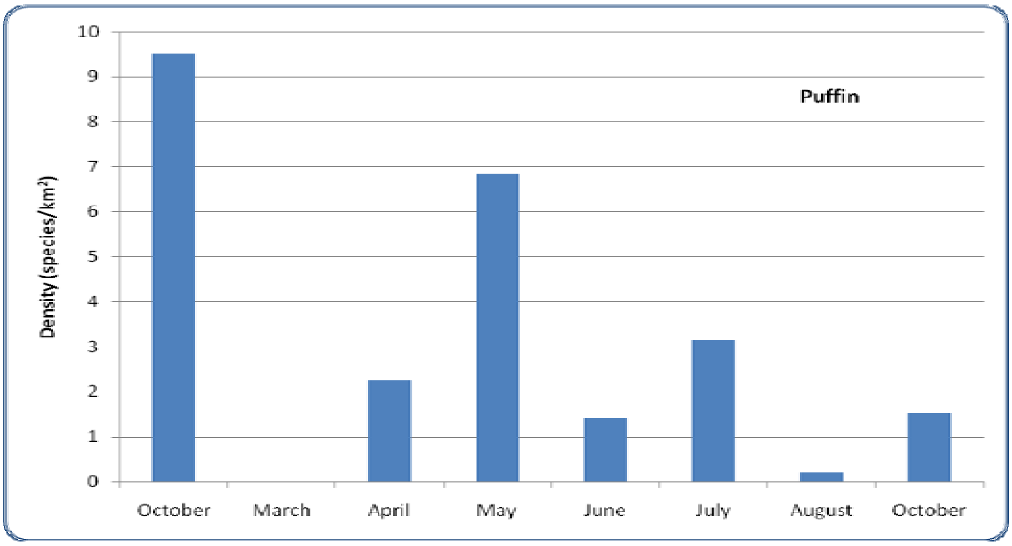


6.3.2.12 Species Accounts - Puffin

Puffin densities were well dispersed throughout the study area (Figure 6.28) and were observed during all monthly surveys. Approximately 90% of the total number of 541 birds observed occurred in the study area from April to July inclusive (Figure 6.29). Within this period notable monthly fluctuations are apparent. The total number of 240 birds for May contrasts with the June total of 38.

Figure 6.28. Density of Puffin (birds / km²) observed in the study area.

Figure 6.29. Monthly densities (birds / km²) of Puffin observed in the study area.



6.3.2.13 Species Accounts - Guillemot

Guillemot in the study area were relatively widely, albeit sparsely, distributed (Figure 6.30). A slightly higher abundance of birds appeared to occur along the 100 m isobath. They were recorded in each of the monthly surveys, although larger numbers occurred in March (n=62) and October (n=41) 2010 from a total of 162 recorded across all monthly surveys (Figure 6.31).

Figure 6.30. Abundance of Guillemot (birds / km) observed in the study area.

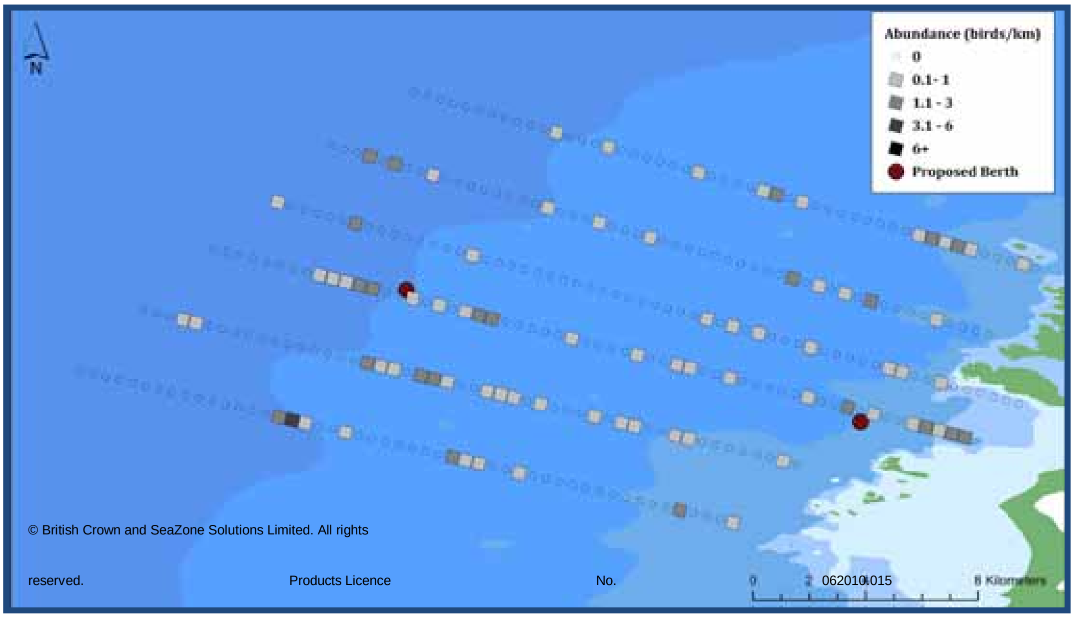
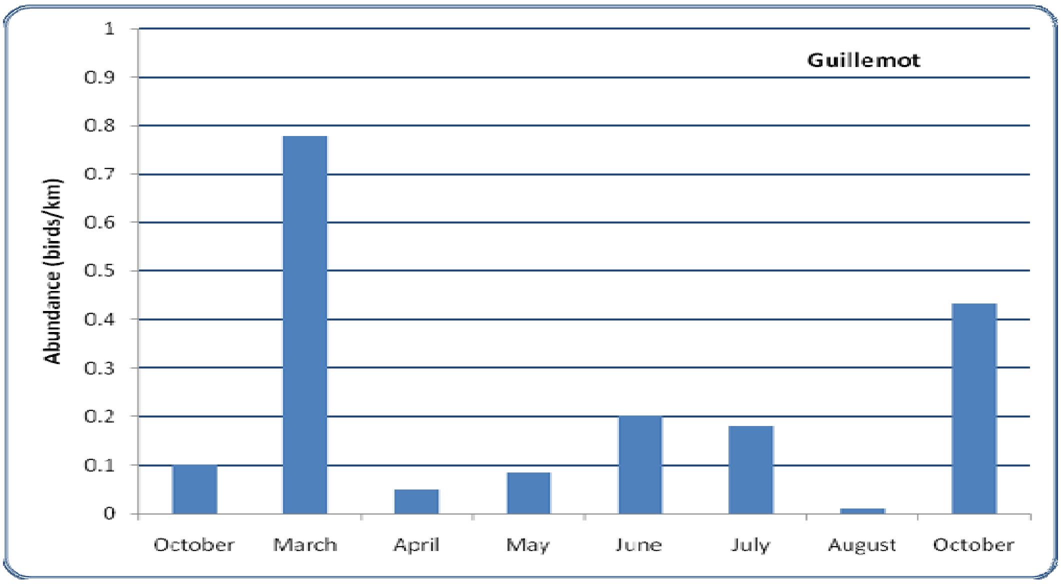


Figure 6.31. Monthly abundance of Guillemot (birds / km) observed in the study area.



6.3.2.14 Species Accounts - Razorbill

Razorbill were the most common Auk species recorded in the survey. A total of 716 birds were recorded across all months except August when none were observed. They occurred at relatively low densities throughout the survey area (Figure 6.32). Peak numbers occurred in March (n=244) and May (n=288) (Figure 6.33).

Figure 6.32. Density of Razorbill (birds / km²) observed in the study area.

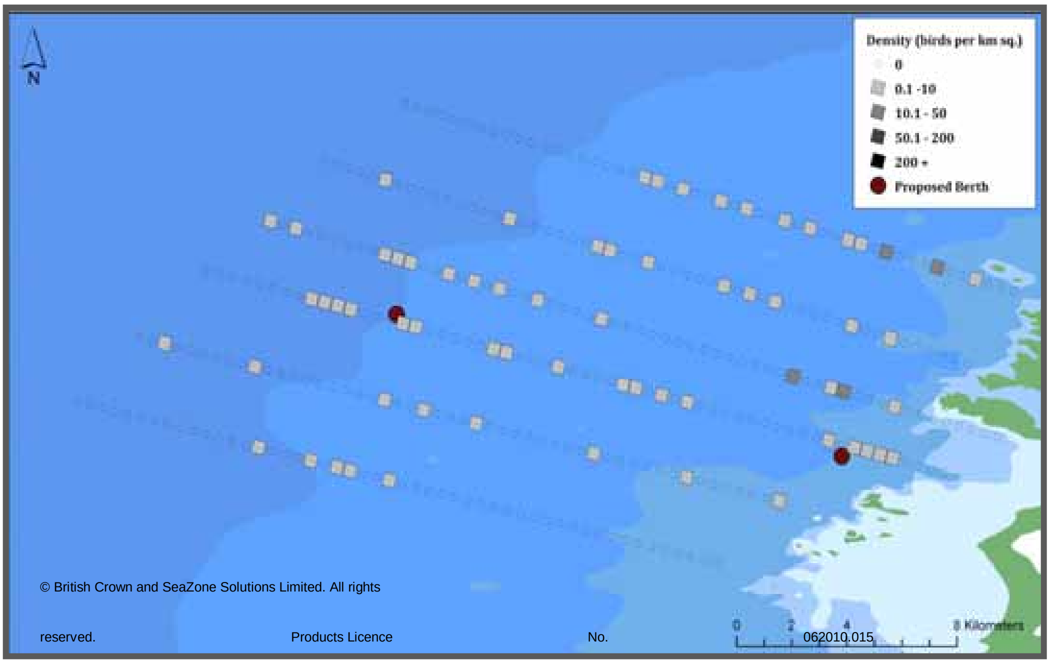
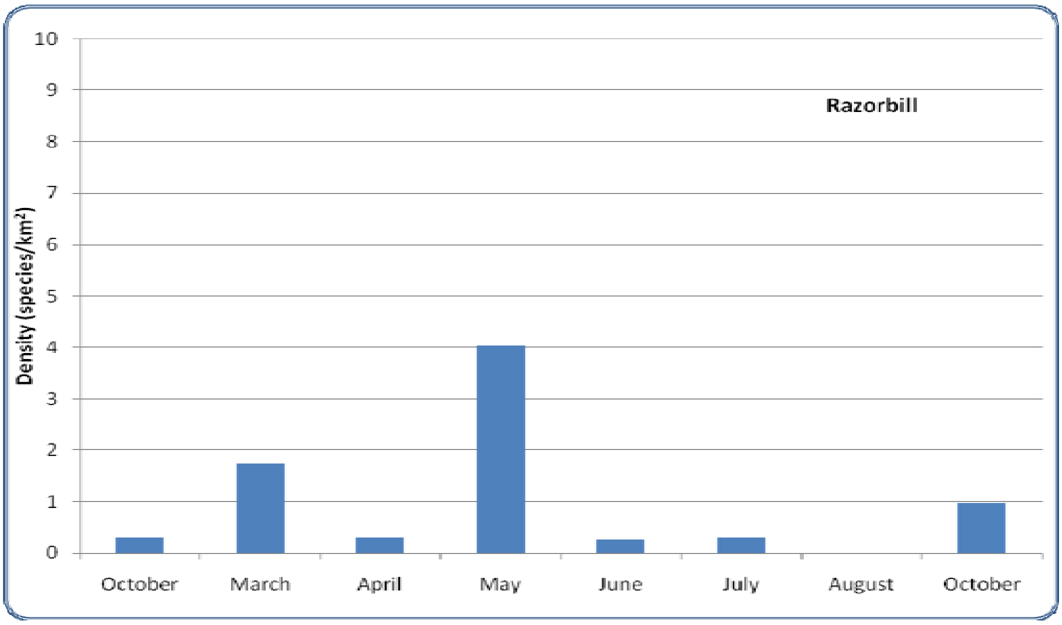


Figure 6.33. Monthly densities (birds / km²) of Razorbill observed in the study area



6.4 DISCUSSION

6.4.1 Shore Habitats

With the exception of Annagh Beach wintering wader numbers were generally low at Emlybeg Beach and Belderra Strand. At Annagh Beach numbers were highest with a peak of 204 waders recorded in December and nationally important numbers of Sanderling recorded in March (Table 6.24). The sediment shores within the Bay are exposed and mainly sandy. The most sheltered shore is at Annagh Beach. Exposed sandy shores tend to support a lower abundance of macrofauna compared to sheltered shores, e.g. Yates *et al.* 1993. The low numbers of waders generally is likely to be linked, at least in part, to limited prey availability with higher wader numbers at Annagh Beach possibly reflecting the more sheltered conditions at this site. Disturbance may be another factor. Throughout the survey period, walkers and other recreational users disturbed the shore at Belderra Strand more often than the other shores. It is also of note that Annagh Beach, like the other sites, is part of a network of shore habitats and that flocks of birds will move around the Bay and across the land to other sites, depending on the tide and weather. The counts presented reflect only a brief picture of activity, within one winter season. The total number of counts recorded during the summer season is presented in Table 6.25.

Table 6.24. Total numbers of waders and birds at shore habitats on Annagh Beach, Emlybeg Beach and Belderra Strand during the winter months. "nc" denotes "not counted".

Species/Month	Sept	Oct	Nov	Dec	Jan	Feb	Mar
Annagh Beach							
Total waders	15	27	20	204	42	121	101
Total birds	24	30	26	212	2	0	2
Emlybeg Beach							
Total waders	nc	nc	28	2	5	0	53
Total birds	nc	nc	29	3	7	10	54
Belderra Strand							
Total waders	27	5	2	0	6	6	4
Total birds	69	6	10	2	17	18	6

Table 6.25. Total numbers of waders and birds at shore habitats on Annagh Beach, Emlybeg Beach and Belderra Strand during the summer months

Species/Month	April	May	June	July	August
Annagh Beach					
Total waders	16	28	0	60	58
Total birds	18	28	0	65	97

Species/Month	April	May	June	July	August
Emlybeg Beach					
Total waders	24	8	0	29	28
Total birds	47	9	127	108	53
Belderra Strand					
Total waders	4	5	0	2	76
Total birds	11	5	29	35	83

Belderra Strand and the inner Bay is counted as part of the The Mullet, Broadhaven and Blacksod Bays I-WeBS site. Results from the I-WeBS counts are not directly comparable to data gathered during this project due to differences in survey effort and coverage, however, they can be broadly compared. I-WeBs data for the Belderra Strand subsite for the period 2003/2004 – 2007/2008 (Table 6.4) shows it was regularly used by the waders, Oystercatcher, Sanderling, Purple Sandpiper, Curlew, Redshank and Turnstone and less frequently by Ringed Plover. Shore counts completed for this project found the shores to be used by the same species recorded during I-WeBS counts and also by Dunlin. I-WeBs data also shows the site is used by Gulls, with greatest numbers of Black-headed, Common and Herring Gull. These species were also recorded during this survey.

The shores surveyed for this project are not part of the Blacksod/Broadhaven Bay SPA. However, they are part of this wetland complex and are likely to be used by the same birds that occur in the SPA. Sanderling occurred at Annagh Beach in numbers of national importance and this is a species for which the Blacksod/Broadhaven Bay SPA is designated. Ringed Plover, Dunlin and Curlew are also part of the qualifying interest for Blacksod/Broadhaven Bay SPA (Table 6.1) and these species were recorded during surveys of the shore-based habitats.

I-WeBs data does not show use of the study site during the summer months. Data from this survey shows its use by Sanderling, Dunlin and Whimbrel in Spring. Flocks of birds at this time of year are likely to be on passage i.e. stopping over from wintering grounds further south before moving north to their breeding grounds or gathering before migration from their Irish wintering grounds. Whimbrel are known to occur in Ireland during migration north. Large flocks of immature Gulls, mainly Common and Herring Gull were also recorded during the summer. These are non-breeding birds, which tend to gather during the breeding season.

During the breeding bird survey, Ringed Plover was recorded at Belderra Strand, while Common Sandpiper was recorded at Emlybeg Beach. Ringed Plover is an Amber listed species (Lynas *et al.* 2007) and breeds on shingle and sandy shores. The Common Sandpiper is also an Amber listed species and breeds on shingle, stone and rocky edges to coastal and freshwater shore habitats (Cramp *et al.* 1983). While Common Sandpiper and Ringed Plover are not a Red-listed species, breeding waders are of conservation interest, with a number of Irish populations in serious decline (Suddaby *et al.* 2009)

Overview

Important species and species groups that use the shore habitats of the Bay are wintering waders, which are likely to be part of the nationally and internationally important populations of the Blacksod/Broadhaven Bay SPA and the breeding waders, Common Sandpiper and Ringed Plover. Use of shore habitats by flocks of roosting Gulls and by waders during the summer months is also of note. Without data for other sites, gathered at this time of year, the importance of this use cannot be assessed.

Coverage of shore habitats and their use by birds was considered good. It is likely that, due to the extent of shore at Emlybeg Beach, small numbers of waders such as Ringed Plover, Purple Sandpiper, Dunlin and Sanderling may have been missed. . Counts of birds at Belderra Strand were consistently low. This may be due in part to disturbance, which was regularly recorded at this site.

6.4.2 Open Waters Of The Bay

The Bay was used year-round by bird species (Tables 6.26 & 6.27). Some species were clearly winter visitors and only occur within the Bay in the winter months, such as Long tailed Duck. Other species such as Great Northern Diver occur in the winter months, but also into Spring. Records of birds in flight show activity by migratory Terns, which is clearly linked to the breeding season. There were a number of resident breeding birds such as Gulls, Shag and Black Guillemot, which were present in surveys year round. Manx Shearwater, Gannet and Fulmar were also recorded in the Bay, although these species are mainly associated with open sea habitats. The results suggest the Bay provides foraging and shelter to a range of species year round. These species are considered in more detail in the Species Accounts.

Table 6.26. Monthly occurrence of birds on the water in the inner and outer Bay.

Species/Month	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug
Mallard												
Eider												
Long-tailed Duck												
Red throated Diver												
Great Northern Diver												
Great crested Grebe												
Manx Shearwater												
Gannet												
Shag												
Cormorant												
Gulls												

Species/Month	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug
Auks	■	■	■				■	■	■	■	■	■

Table 6.27. Monthly occurrence of birds in flying birds within the inner bay and outer Bay.

Species/ Month	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug
Mallard							■					
Long tailed Duck							■					
Great Northern Diver	■			■				■				
Fulmar					■			■			■	■
Manx Shearwater								■		■	■	■
Gannet	■	■						■	■	■	■	■
Cormorant			■	■		■		■				
Shag		■	■		■		■			■	■	■
Oystercatcher			■		■	■	■		■		■	■
Turnstone						■						
Golden Plover			■			■						
Curlew			■			■					■	
Gulls	■		■	■	■	■	■	■	■	■	■	■
Little Tern									■			
Sandwich Tern											■	
Arctic Tern									■	■	■	
Auks	■		■	■	■	■	■	■	■	■		■

6.4.3 The Inner and Outer Bay

The habitats of the Bay can be divided into the deeper and more exposed waters of the outer Bay (mainly >20-30 m deep) and the shallow and more sheltered waters of the inner Bay (<20 m deep). It should be noted that birds move between the inner and outer bay and indeed elsewhere. It should also be noted that while the outer Bay has deeper waters, shallow waters are present around Inishglora Island and along the shores of Annagh Head.

Based on data for birds on the water only, the inner Bay tended to support greater numbers of individuals (Table 6.28) and greater species richness. Total numbers of birds in both the inner and outer Bay were similar throughout the year, with a peak in April and July, owing to large rafts of Manx Shearwater. The inner Bay is shallower, offers greater shelter and has a greater diversity of shore habitats. It is likely that these factors and others make the inner Bay waters more attractive to birds.

Table 6.28. Total numbers of birds and species recorded on the water in the inner and outer Bay over the survey period. Shaded cells indicate winter months.

Species/Month	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	April dusk	May	June	July	Aug
Inner Bay													
Total birds	45	19	28	35	39	61	44	47	18	48	34	352	41
Total species	5	9	7	6	6	7	7	7	4	8	7	10	10
Outer Bay													
Total birds	5	4	6	5	1	4	8	727	nc	44	6	5	9
Total species	3	4	2	2	1	3	5	6	nc	6	4	2	5

Due to survey limitations all open waters across the Bay from Annagh Head to Inishglora Island were not viewable. Successful detection and identification of birds beyond 2 km is not considered effective (Roycroft *et al.* 2007), thus limiting survey coverage of the far side of the Bay. Surveys of open water areas are difficult during moderate and heavy swell conditions. At these times detection of smaller species on the water, such as Auks is difficult. The number of Auks should therefore be taken as a minimum. While existing data from I-WeBs counts can be used to compare with data for this survey, there is no existing data on summer use of the Bay.

6.4.4 Species Accounts

Further detail on a number of species that occurred within the Bay is provided. Mallard, Great Crested Grebe, Cormorant, Kittiwake and Grey Heron were recorded in low numbers and/or on one occasion during surveys. These species are not considered further in the species accounts. The waders, Oystercatcher, Turnstone, Curlew and Golden Plover, were recorded moving across the bay or along its shores. These species do not use open water habitats and are not considered further.

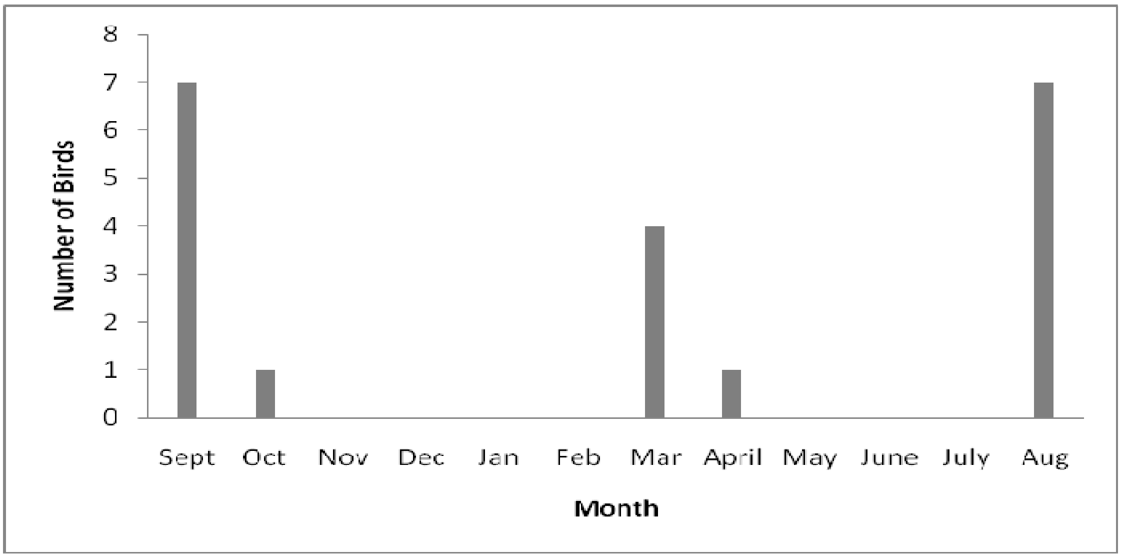
6.4.4.1 Eider

Eider winter along the north-east and north-west coast of Ireland and breed along the north and north-west coast (Crowe, 2005). In 2001 breeding Eider were recorded on Inishkeeragh Island in County Mayo (Murray and Cabot, 2002). Twenty-five pairs of Eider are now known to breed on Inishglora and Inishkeeragh Island and on Inishkea Island North.

Within the study site a group of seven, female Eider were present in September and August. Small numbers of both male and female Eider were present in March and April

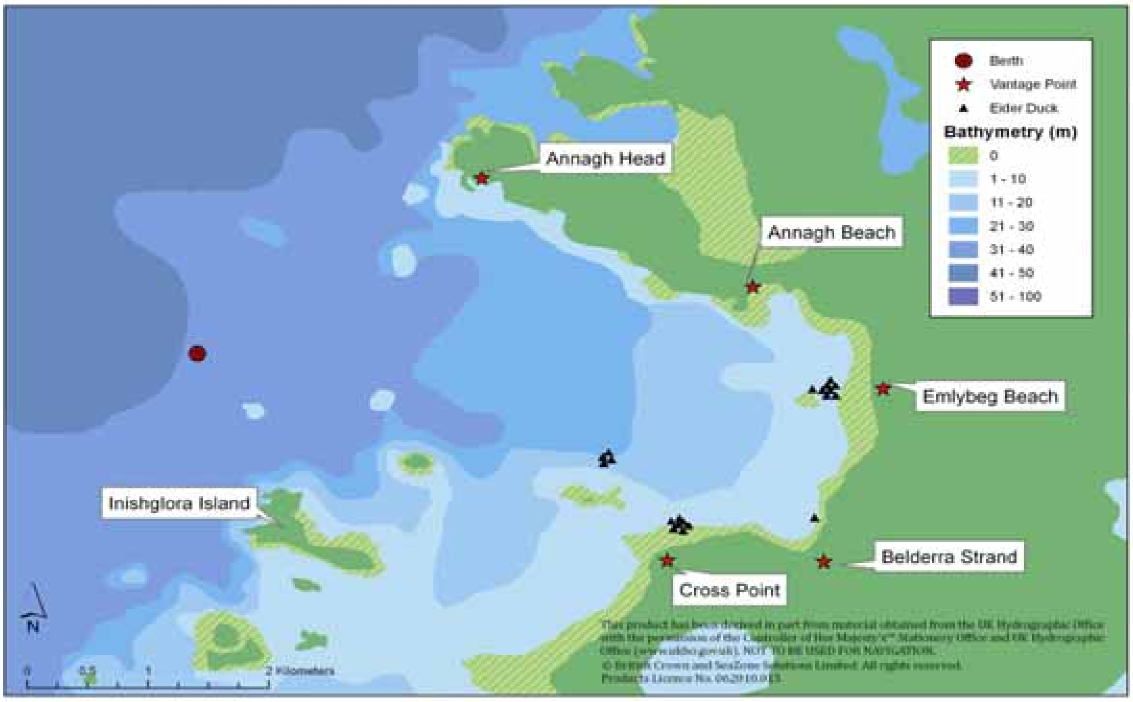
(Figure 6.34). I-WeBS data for the period 2003/04 to 2007/08 (Table 6.4) show a peak of 6 and a mean of 2 Eider over this period, which is comparable to results from this survey.

Figure 6.34. Occurrence of Eider within the Bay.



It is likely that the Eider present in the Bay were part of the local breeding population. It is known that male Eider depart their breeding grounds in June and July while female Eider depart 3-4 weeks later, in August and September Cramp *et al.* (1977). This may explain why groups of only female Eider were present in autumn, but absent thereafter. The distribution map for Eider (Figure 6.35) shows that they were recorded in the shallow waters (<20 m depth) of the inner Bay. Eider are known to feed by diving in waters up to 20 m, where they feed primarily on molluscs, but also on crustaceans and echinoderms (Cramp *et al.* 1977). Their distribution within the study site is likely to be linked to prey availability.

Figure 6.35. Gross distribution map of Eider Duck within the study site. Data for all survey months is presented.



6.4.4.2 Long tailed duck

Numbers of this scarce winter visitor have been increasing nationally with a peak of 229 in November 2000. Crowe (2005) found Long tailed Duck to occur at just 40 sites within Ireland and five of these supported nationally important numbers (>20) (Crowe, 2005).

Long tailed Duck were present in the inner Bay during the months December to February (Figure 6.36). Long tailed Duck have been regularly recorded in the Bay during I-WeBS counts, with a peak of 29 and mean count of 21 for the period 2003/04 to 2007/08. These figures show the Bay to be of national importance for this species (Crowe pers. comm.). Dave Suddaby (pers. comm.) has observed that Long-tailed Duck regularly occur off Belderra Strand. The distribution map for this species concurs with these observations (Figure 6.37). It is suspected that Long tailed Duck favour this area due to its foraging opportunities. Scuba dive surveys of the area found a small gastropod feeding on sea lettuce in this area, which was otherwise sediment dominated. Long tailed duck feed on molluscs, gastropods and crustaceans (Cramp *et al.* 1977) and it is possible that the crustaceans and gastropods recorded during the dive surveys attract Long tailed Duck to this area, although the abundance of these species recorded during the dive surveys was not particularly high.

Figure 6.36. Monthly occurrence of Long tailed duck within the Inner Bay

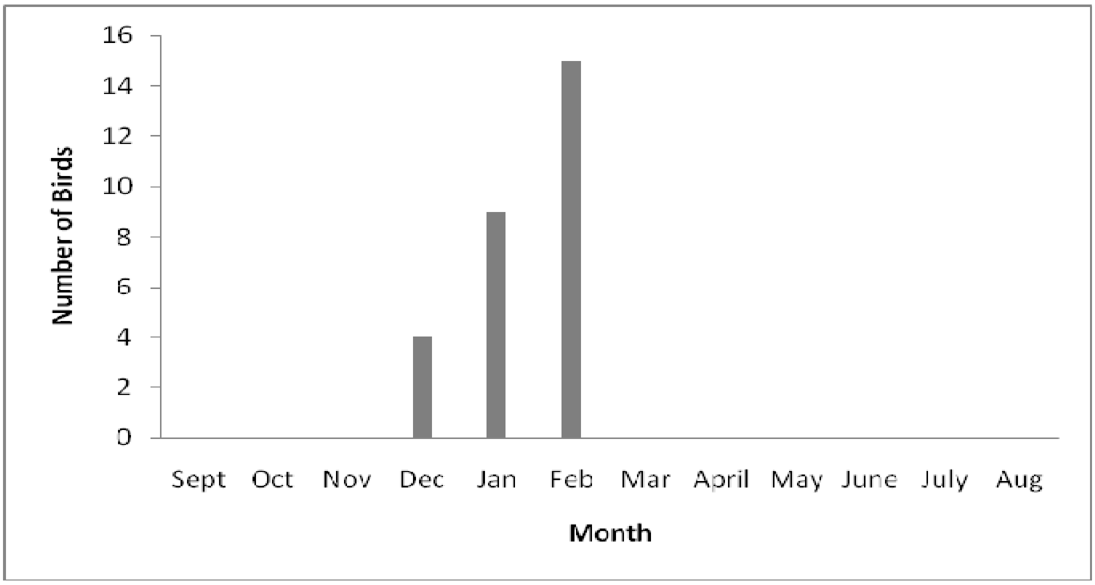
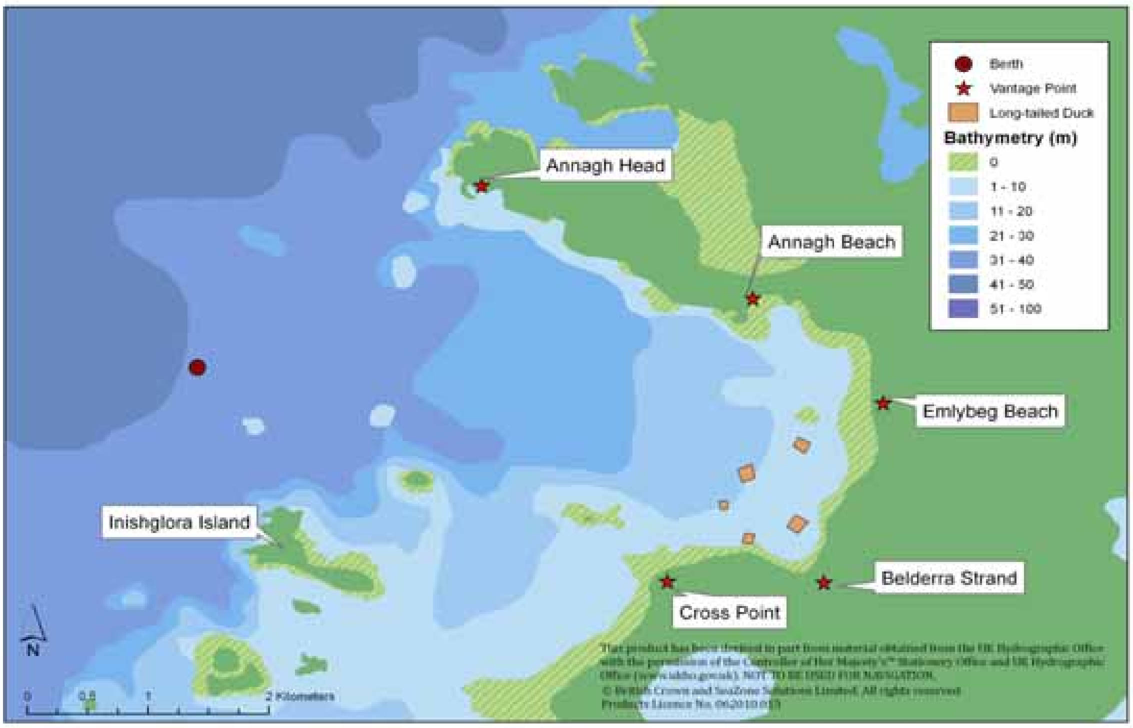


Figure 6.37. Gross distribution map for Long-tailed Duck. Data for all months is presented together. Orange blocks represent groups of Long-tailed Duck.



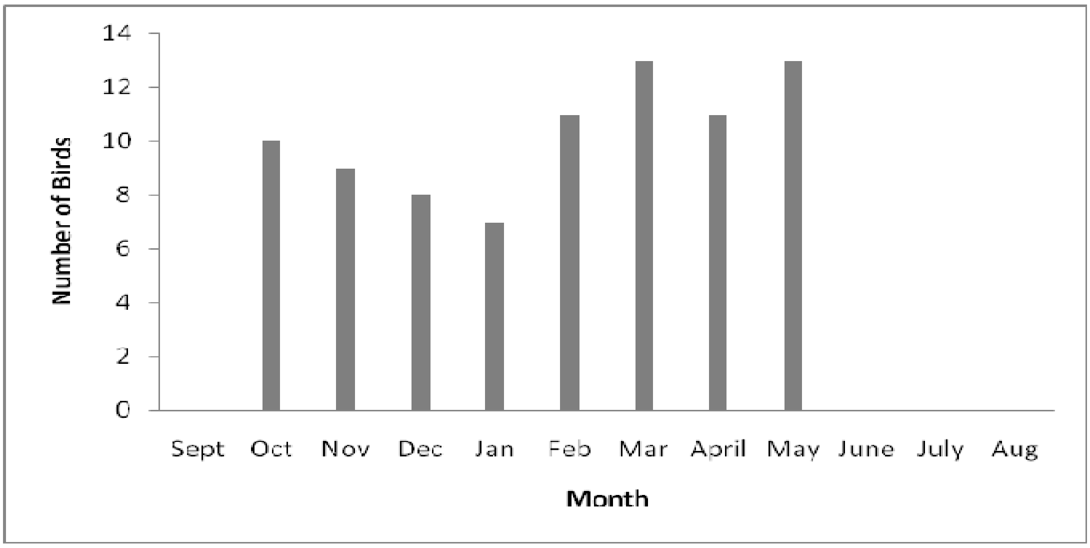
6.4.4.3 Great Northern Diver

Great Northern Diver is an Annex I species under the EU Birds Directive. It occurs within Ireland as a wintering species in numbers of international importance. While described as a wintering species some birds remain in Ireland until Spring. The Mullet, Broadhaven and

Blacksod Bays is one of the top sites for Great Northern Diver in Ireland, regularly supporting numbers of international importance (Crowe, 2005, Boland, 2009).

Great Northern Diver were present within the Bay from October to May (Figure 6.38). Mean numbers were 10-11, and peak numbers of 13-17 were present in March. I-WeBS data for the Belderra Strand sub-site shows this species is regularly present within the Bay, with mean numbers of 10 and peak numbers of 12 (Table 6.4). Results from this survey found slightly higher peak numbers within the Bay, which may be due to differences in survey coverage or year-to-year variation.

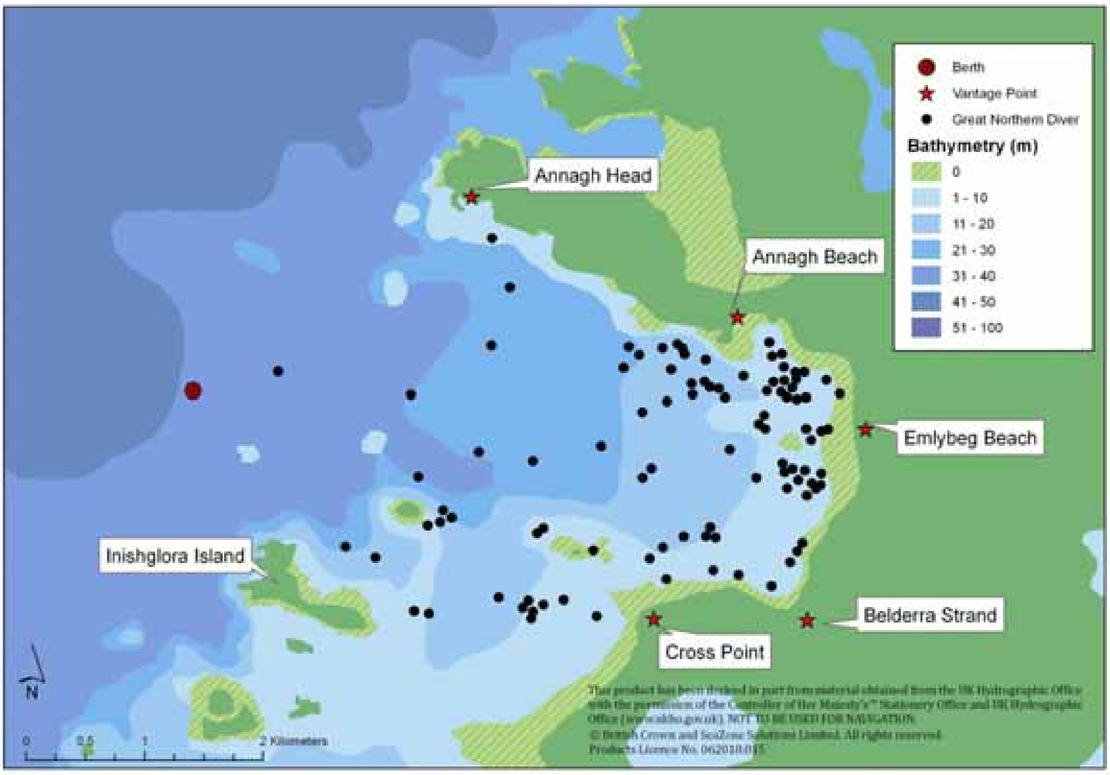
Figure 6.38. Monthly occurrence of Great Northern Diver within the inner Bay



The Blacksod/Broadhaven Bay SPA is of international importance for Great Northern Diver. The SPA does not include waters on the west side of the Mullet Peninsula, which are also important for this species, and which include the study site. Suddaby (in press) presents count data for the west side of the Peninsula and found 64 (March, 2005), 46 (April, 2006) and 132 (March, 2010) Great Northern Diver in this area. Combined data for Broadhaven/Blacksod Bay and the west side of the Mullet Peninsula gave a total count of 254 Great Northern Diver in March 2010. It is clear that the population of Great Northern Diver associated with the Mullet Peninsula is of considerable importance and that although the study site is not in the SPA, it supports part of the internationally important Great Northern Diver population of this area. Furthermore the data presented by Suddaby shows an increase in Great Northern Diver numbers in March, April and May. This increase is associated with the Spring moult, were wintering numbers are augmented by new birds arriving in the area to moult. There is some evidence (Suddaby in press), that Great Northern Diver are site faithful and it is possible that some of the wintering birds return to the area annually. These factors combined emphasise the importance of the area for this species.

The gross distribution map for Great Northern Diver (Figure 6.39) shows that they use most of the Bay but are concentrated in the inner Bay, in waters of <20 m depth. Great Northern Diver are known to feed principally on small fish, but also on crustaceans, molluscs, cephalopods and flatfish (Crowe *et al.* 2005; Cramp *et al.* 1977). Great Northern Diver can feed in deeper waters, but normal depths are 4-10 m (Cramp *et al.* 1977). Their distribution it therefore most likely linked to prey availability and shallower waters for diving.

Figure 6.39. Gross distribution map for Great Northern Diver. Records for all survey months are presented.



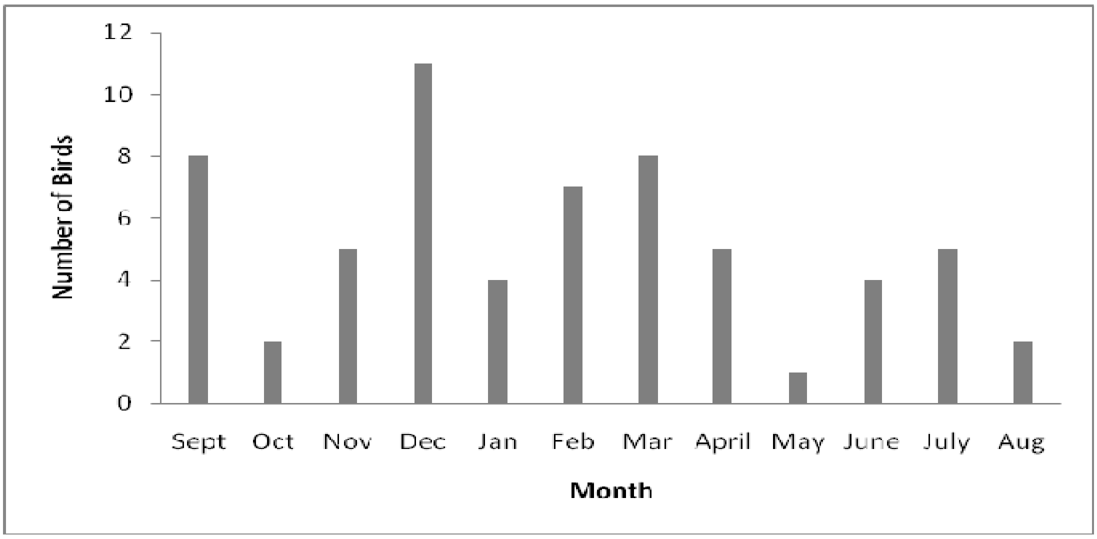
6.4.4.4 Shag

Shag is an inshore species, which breeds only in northwest Europe (Mitchell *et al.* 2004). Britain and Ireland holds over 40% of the world's population. Seabird 2000 detected an overall decline in the Britain and Ireland population of Shag since the mid 1980's. While an overall increase in breeding numbers in County Mayo was reported there were declines on Inishkeeragh Island, close to the study site and part of the Inishglora and Inishkeeragh SPA. Inishkeeragh is listed as one of the major colonies of European Shag in Britain and Ireland. In the Seabird Colony Register (SCR) Census of 1995-1988 Inishkeeragh supported 174 Apparently Occupied Nests (AON). By the SB2000 survey (1998-2002; Mitchell *et al.* 2004) this number had declined by 65%, with only 61 AON's. The reasons for these declines are not understood.

Shag breed at a number of sites around the Mayo Coast, with the largest colonies being west of the Mullet Peninsula. Both Inishkeeragh and Inishglora Island SPA, and the

Inishkea Islands SPA are of national importance for breeding Shag. Shag were present during all survey months, with peak numbers of 11 in December (Figure 6.40). I-WeBS data for the period (2003/04 – 2007/08) show peak numbers of 31 and mean numbers of 14, for the Belderra sub-site. The Shag present in the bay were observed actively foraging. Shag feed on small fish caught on or near the seabed over rocky and sandy substrates (Mitchell *et al.* 2004). It is most likely that the Shag present during surveys are part of the resident breeding population which use the Bay as part of their foraging habitat throughout the year. The relative importance of the Bay compared to other foraging sites around the Mullet Peninsula is not known without further study.

Figure 6.40. The monthly occurence of European Shag within the inner Bay.



6.4.4.5 Manx Shearwater

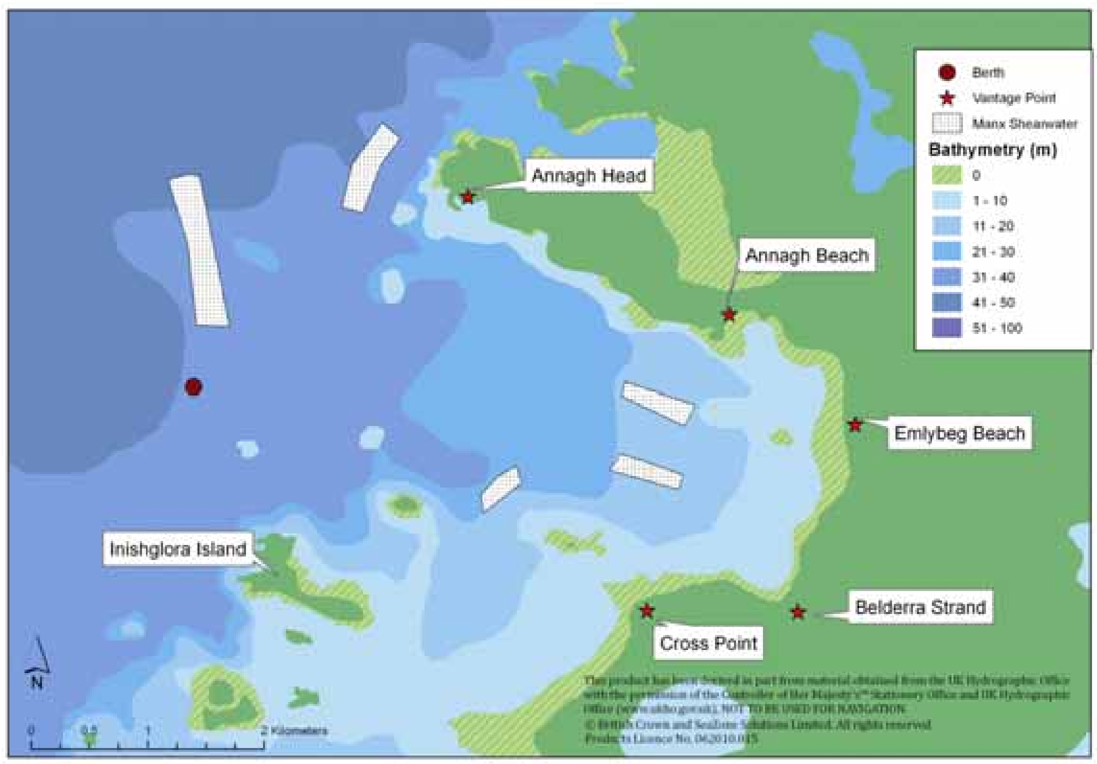
This is an AMBER listed species (Lynas *et al.* 2007) due its unfavourable European conservation status and concentration within Europe and due to its localised breeding distribution. Most of the worlds Manx Shearwater population breeds within Britain and Ireland (Mitchell *et al.* 2004). Manx Shearwater may breed in low numbers at nest sites on islands off the Mayo coast, with the most northerly colony in Ireland being Kid Island off Broadhaven Bay. However, the nearest large colonies of > 3,000 AOS's are located off the Galway coast and then further south off the Kerry coast, where colonies of up to 9,000 AOS's are present. Within Ireland, County Kerry holds the largest concentration of nesting Manx Shearwater with over 28,000 AOS's. The British population of Manx Shearwater, located on islands off the west coast, including west of Scotland, is much larger with 295,000 AOS's. Manx Shearwater is a migratory species arriving back at their breeding colonies in March (Pollock *et al.* 1997) and departing for their wintering grounds off the east coast of South America in autumn.

Rafts of hundreds of Manx Shearwater were observed within the Bay in April and July and west of Annagh Head in April (Figure 6.41). Surveys at sea recorded Manx Shearwater between April and September with greatest densities between April and July, which is consistent with the findings from the land survey.

Pollock *et al.* (1997) noted that Manx Shearwater might forage up to 360 km away from breeding colonies in a day, not returning until dusk. Pollock also noted that Manx Shearwater do not breed until five or six years old and in May there is an influx of immature non breeding birds who leave their wintering areas later than breeding birds. During surveys of Irish waters in August 2000, Mackey *et al.* (2004) found Manx Shearwater were not numerous except in grid squares located close to Achill Island in County Mayo where some large feeding flocks of up to 400 birds were encountered. Phillips & Lee (1966) noted large rafts of migratory Manx Shearwater off Erris Head.

Manx Shearwater recorded during this survey may have been foraging breeding birds from distant Scottish or Irish colonies or non-breeding immature birds. While Suddaby pers. comm. has previously observed Manx Shearwater rafts in the Bay, there is no previous data for the site with which to compare results. However, the occurrence of large rafts Manx Shearwater off nearby Achill Island in 2000 and of Erris Head in the 1960's is of note.

Figure 6.41: The location of Manx Shearwater rafts during surveys of the Bay.



6.4.4.6 Gannet

About 60% of the East Atlantic population of Gannet nests in Britain and Ireland (Wernham *et al.* 2002). In SB2000 the total British and Irish Gannet population was estimated to be 259,000 distributed amongst only 21 colonies. SB2000 found the breeding population of Gannet to have increased, since previous surveys. Gannet colonies in Ireland are located mainly in the south-west and south-east. The nearest colony is at Clare Island, with 3 AOS recorded in SB2000. Large colonies exist at the Skelligs, Bull Rock and Great Saltee, with nearly 30,000 AOS on Little Skellig and just fewer than 2,000 AOS at the other two sites. When feeding chicks, Gannets can travel huge distances. Foraging ranges of up to 240 km from Great Saltee and 540 km from the Bass rock have been recorded (Mitchell *et al.* 2004).

Gannets were recorded within the Bay in all months except November to January (Table 6.29). They were observed plunge diving within the Bay as well as apparently moving through the Bay to forage elsewhere. While Gannets are a marine species, they are widely distributed within coastal waters around Ireland (Mackey *et al.* 2004; Pollock *et al.*1997) and are noted by Cramp *et al.* (1977) to forage inshore when there are feeding opportunities. Given the foraging range of Gannets during the breeding season, birds observed within the Bay may have travelled from large colonies off the South Coast of Ireland or off the west coast of Scotland. They may also have been immature non-breeding birds. It is of note that Gannet were only absent for surveys in the months November to January, as it is during these months that Pollock *et al.* (1997) recorded lowest densities of Gannet in inshore waters. Gannet feed on fish by plunge diving and were observed actively foraging during surveys.

Table 6.29. Activity of Gannet within the Bay. Shaded cells indicate the months were Gannet activity was recorded.

Species/Month	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug
Gannet												

6.4.4.7 Gulls

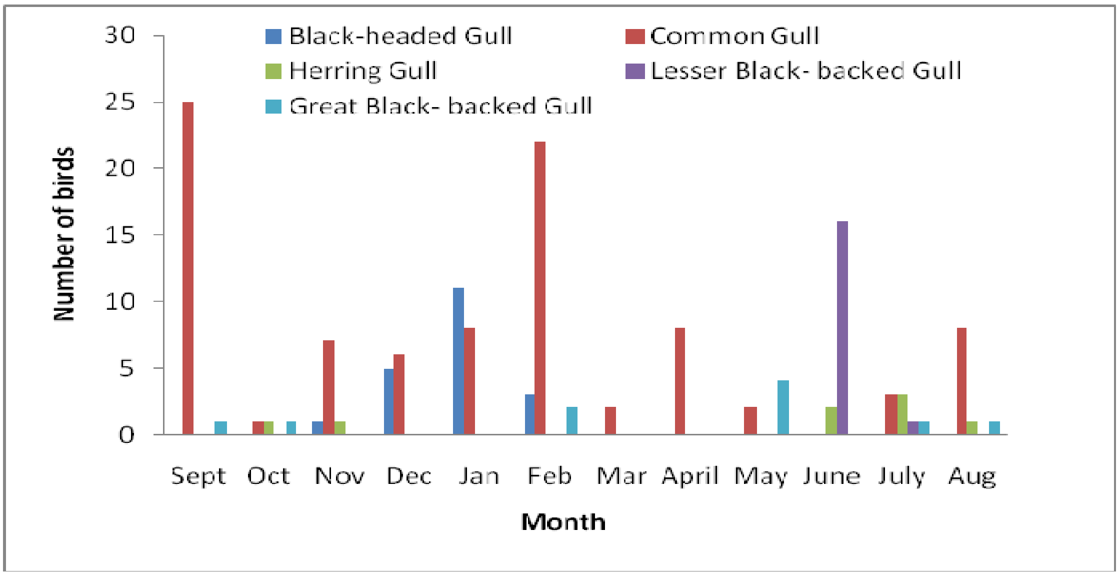
Black-headed Gull, Common Gull, Lesser-Black backed Gull, Herring Gull and Great Black-backed Gull were frequently recorded sitting on the water, in flight and roosting on the shore. Herring Gull and Common Gull were the most abundant gull species using the Bay and it shores. Black - headed Gull occurred in the winter months and Great Black backed Gull were most frequently recorded in the outer Bay. As discussed under shore habitats, large numbers of mainly Herring and Common Gull, mainly immature birds, were recorded roosting on the shores in the summer months. The monthly occurrence of Gulls within the Bay is shown in Table 6.30 and in Figure 6.42.

Table 6.30. Monthly occurrence of Gulls on shore habitats within the Bay.

Site	Annagh Beach		Emlybeg Beach		Belderra Strand	
Species/Season	**Winter**	**Summer**	**Winter**	**Summer**	**Winter**	**Summer**
Black-headed Gull						
Common Gull						

Site	Annagh Beach		Emlybeg Beach		Belderra Strand	
Species/Season	**Winter**	**Summer**	**Winter**	**Summer**	**Winter**	**Summer**
Herring Gull						
Great Black backed Gull						
Lesser Black-backed Gull						

Figure 6.42. Numbers of Gulls on the water within the inner Bay over all survey months.



Black-headed Gull

This is a RED Listed species owing to a substantial decline in its breeding population and contraction in breeding range in the last 25 years (Lynas *et al.*). Seabird 2000 reported declines in the Irish breeding population of 16% since the mid-1980's (Mitchell *et al.* 2004). There are no coastal breeding sites for Black-headed Gull in County Mayo. The closest breeding sites are some distance inland on Loughs Carra and Mask. The Black-headed Gulls recorded in this survey were present in the winter months, when they are known to disperse widely (Wernham *et al.* 2002).

Common Gull

The Common Gull is an AMBER listed species (Lynas *et al.* 2007) due to moderate contraction in breeding range and a localised breeding distribution. The Irish Common Gull population is restricted to the north and west of Ireland. Results from Seabird 2000 found this population to be stable at coastal colonies but with declines at inland sites (Mitchell *et al.* 2004). Common Gull are known to disperse widely during the winter months (Wernham *et al.* 2002).

Common Gull was the most abundant gull recorded during the survey and was present in most months. Both adult and immature Common Gull were recorded during surveys. The

Inishkea Islands SPA supports a nationally important breeding population of Common Gull and Annagh Islet within the Bay has a small colony of breeding Common Gull (24 AOS in 2010). Common Gull present during the summer months may be part of the local breeding population. I-WeBS surveys between 2003/04 and 2007/08 for the Belderra subsite found Common Gull to be the most abundant Gull over this period.

Lesser Black-backed Gull

Lesser Black-backed Gull is an AMBER listed species (Lynas *et al.* 2007), due to its restricted breeding distribution. Seabird 2000 reported an increase in the Irish breeding population of Lesser Black-backed Gull (Mitchell *et al.* 2004). Inishglora and Inishkeeragh Islands SPA and Inishkea Islands SPA both support nationally important breeding populations of Lesser Black-backed Gull. Small numbers of Lesser Black-backed Gull were found during surveys of the Bay and were present only in the breeding season. This suggests their occurrence is linked to the breeding colonies on nearby islands. Lesser Black-backed Gulls breeding in Britain and Ireland are known to move south to winter (Wernham *et al.* 2002).

Herring Gull

The British and Irish population of Herring Gull is a resident species. It breeds mainly on coastal sites and disperses along the coast and inland during winter (Mitchell *et al.* 2004). The Herring Gull is an RED listed species (Lynas *et al.* 2007) due to a severe historical decline in its breeding population since the 1800's and due to a substantial decline in its breeding population in the last 25 years. Seabird 2000 found a 90% decline in the Herring Gull breeding population since the late 1960's. Fatalities due to botulism is considered to be a major factor leading to the population crash in Ireland (Mitchell, *et al*, 2004)

Inishglora and Inishkeeragh Islands SPA and Inishkea Islands SPA both support nationally important breeding populations of Herring Gull. I-WeBS surveys between 2003/04 and 2007/08 found the Belderra Strand sub site to regularly support Herring Gull over this period (peak of 40 and mean of 20). During this survey, Herring Gull was present in most months and after Common Gull was the most abundant gull species recorded.

Herring Gull is an opportunistic feeder, being both scavenger and predator and taking all types of food (Mirthell *et al.* 2004, Cramp *et al.* 1983). It is likely that Gulls from the local breeding population were present within the Bay, in the summer months, with Gulls from other areas being present during the winter.

Great Black-backed Gull

Great Black-backed Gull is an AMBER listed species (Lynas *et al.* 2007) due to a moderate decline in its breeding population over the last 25 years. Seabird 2000 reported a 32% decline in the Irish breeding population of Great Black-backed Gull since the late 1960's (Mitchell *et al.* 2004).

Nationally important numbers of Great Black-backed Gull breed on the Inishkea Islands SPA and on Duvillaun Islands SPA. I-WeBS surveys between 2003/04 and 2007/08 for the Belderra subsite found winter numbers of Great Black-backed Gull to be low over this period (max 11). Though present in most months, this survey found low numbers of Great Black-backed Gull using the Bay and its shores.

6.4.4.8 Terns

Little, Arctic, Common and Sandwich Tern breed in Ireland and are listed under Annex I of the EU Birds Directive. They are all AMBER listed species due to their localised breeding distributions and Little Tern has suffered moderate declines in its breeding population in the last 25 years. The Inishkea Islands SPA supports nationally important numbers of breeding Arctic and Little Tern and smaller numbers of Common Tern. Inishglora and Inishkeeragh Island SPA support internationally important numbers of breeding Arctic Tern and Blacksod/Broadhaven Bay SPA support nationally important numbers of Sandwich Tern. Terns are a migratory species, arriving in Ireland during the summer months to breed and depart southward during the non-breeding season.

Terns were recorded foraging within the shallow waters around the bay during the months May, June and July (Table 6.31). They were also recorded attending nests at the Annagh Islet Arctic Tern colony. The Terns recorded during the survey all feed on small fish (Cramp *et al.*1985). Little Tern will also feed on crustaceans such as shrimps, while Sandwich Tern is a specialist forager and are dependent on dense shoals of clupeids and sand eel (Mitchell *et al.* 2004). The results show that the Bay was used by foraging Arctic and Little tern during the breeding season. Sandwich Tern may also forage in the Bay, though they were recorded less frequently in 2010 than the other tern species. The terns observed may have been feeding young at nesting colonies. Adequate food during this time is critical to chick survival. While alternative habitat is available, the relative importance of the Bay to foraging terns is not known and would require further studies.

Table 6.31. Activity by Terns within the Bay.

Species/Month	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug
Little Tern												
Sandwich Tern												
Arctic Tern												

6.4.4.9 Auks –Guillemot, Razorbill, Puffin, Black Guillemot

Guillemot, Razorbill and Puffin are AMBER listed species due to their localised breeding distribution. Puffin is also a SPEC 2 species with an unfavourable conservation status and concentrated within Europe (Lynas *et al.* 2007). Black Guillemot is an inshore resident species. The monthly occurrence of auk species within the Bay is shown in Figures 6.43 & 6.44. A single Puffin was recorded within the Bay and is not considered further in this section; see instead Surveys At Sea Section – Species Accounts.

Guillemot

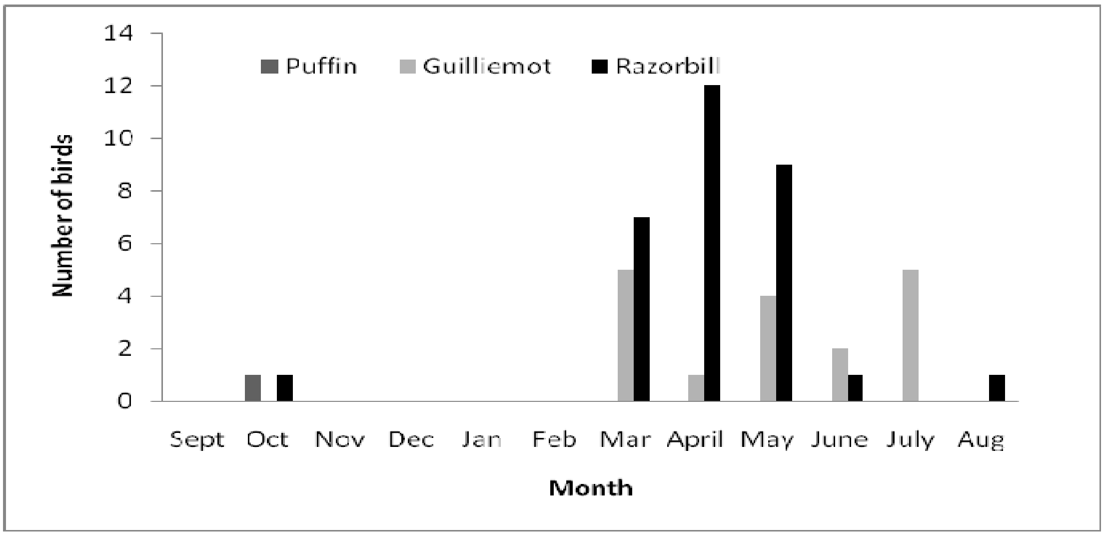
With the equivalent of over one million pairs recorded, Seabird 2000 found Guillemot to be the most numerous seabird in Britain and Ireland (Mitchell *et al.* 2004). In Ireland the breeding population was found to increase since surveys in the late 1960's (Operation Seafarer 1969 – 1970). Similarly breeding numbers in County Mayo during this period were also reported to have increased, though a decline in numbers was reported in the 1980's. There are no nesting colonies of Guillemot on Islands off the Mullet Peninsula. The nearest colonies are off the north Mayo and the Galway Coast (Mitchell *et al*. 2004).

Surveys of the Bay recorded Guillemot from March to July. Pollock *et al.* (1997) found densities of Guillemot to be highest inshore and in waters close to colonies during March and April. It is likely that the Guillemot recorded during surveys are associated with breeding sites on the North Mayo coast, given their occurrence during the breeding season. Guillemot tend to moult in large flocks (Pollock *et al.* 1997), which were not recorded during the survey.

Razorbill

Seabird 2000 reported an increase in the number of Razorbill breeding in Ireland since surveys in the late 1970's and a decline in numbers in the 1980's (Mitchell *et al.* 2004). In Mayo there was also an increase in breeding numbers after declines in the mid 1980's. Colonies in Mayo are located off the north coast of the county, where there is suitable rocky cliff nesting habitat. Razorbill were recorded within the Bay during the breeding season, which is likely to be linked to breeding, non-breeding and immature birds returning to nearby nest sites.

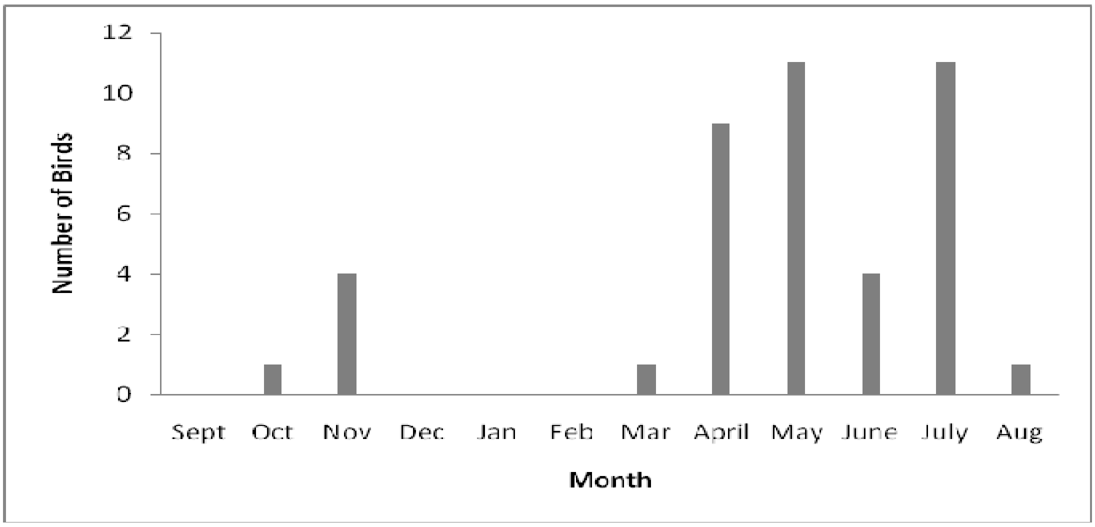
Figure 6.43. Numbers of Guillemot, Razorbill and Atlantic Puffin recorded on the water and within the inner Bay.



Black Guillemot

Black Guillemot is an AMBER listed species due to its unfavourable European conservation status and its concentration within Europe. Black Guillemot is a sedentary species which is distributed inshore where there is suitable habitat for nesting. During a pre-breeding survey of Black Guillemot during Seabird 2000, 8% of the national population was present in County Mayo. Unlike the other auk species, they do not disperse away from their breeding sites during winter. During surveys of the Bay Black Guillemot were recorded during both the winter and the breeding season, reflecting the sedentary nature of this species. Most records were from the breeding season, when fledged young are likely to be present.

Figure 6.44. Monthly occurence of Black Guillemot recorded on the water in inner Bay.



6.4.5 Overview

The Bay is used year round by a range of birds, including wintering waterfowl, and foraging seabirds. The shallow waters of the inner Bay support a greater abundance and diversity of birds, most likely linked to shelter and foraging opportunities. Of note is the use of the Bay by the Annex I species Great Northern Diver, which winters in numbers of international importance in waters around the Mullet Peninsula, with further birds arriving during the Spring moult. Of further note is the occurrence of Eider Duck, which are part of a recently established, local breeding population. Long tailed Duck regularly occur in nationally important numbers within the Bay. The distribution of seaduck and divers is associated with shallower waters; presumably more suitable for foraging and the Long tailed Duck appear to forage, annually, within a specific area of the Bay. Of further note was the presence of large rafts of Manx Shearwater. The Annex I species, Arctic, Little and Sandwich Tern were recorded foraging in the Bay during the breeding season. Gulls, Shag and Auks, species, also used the Bay and breed locally. While it is difficult to put the importance of the Bay into context, it is clearly used by a range of species including Annex I species, species which breed locally in numbers of national importance and those of other conservation interest.

6.4.5.1 Terrestrial Habitats

Winter and summer surveys of terrestrial habitats found that they were used by a range of species typical of coastal dune and grassland habitats, none of which appear on the RED List of Birds Of Conservation Concern (Lynas *et al.* 2007). The presence of breeding waders, Ringed Plover and Common Sandpiper was of note.

6.4.5.2 Storm Petrel Survey

The aim of the Storm Petrel survey was to establish monitoring plots on the Island, which can be surveyed annually. Data from these plots can be used to monitor breeding numbers in sample plots, pre, during and post development of the wave energy test site, should it proceed. These plots were successfully established.

As not all suitable Storm Petrel nesting habitat was sampled, data from the survey cannot be used to estimate the current breeding population on the island.

Studies of the Storm Petrel response rate to the tape playback, show that not all males will respond when the “purr” call is played (Mitchell, *et al.* 2004). Survey data must therefore be calibrated before an actual estimate of breeding numbers can be achieved (Ratcliffe *et al.* 1998). A calibration survey allows for the calculation of the probability of a bird responding to the tape lure (Money and Newton, 2009). Should an estimate of the breeding population be sought in future years a calibration survey will be required, alongside a sample survey of all suitable nesting habitat.

In July 2010, sample surveys of boulder field, shore and building habitats were completed, however the full extent of each habitat could not be sampled due to time constraints. A full survey of the all stone walls was achieved and results from this survey can be compared directly to those from the Seabird 2000 survey. Table 6.32 shows the length of wall surveyed in SB200 and in 2010 and the number of responses gained. The adjusted figure for Apparently Occupied Sites (AOS) was derived by applying the correction factor of 2.9 estimated from calibration surveys on Inishglora in 2001 (Mitchell *et al.* 2004. Calibration surveys were completed on Inishglora Island during Seabird 2000 (Mitchell *et al.* 2004) and the correction factor derived from these surveys has been applied to the 2010 wall survey data. As the SB2000 calibration survey dates from 2002 and there can be year-to-year variation in response rates, this correction factor has been used with caution. While results between the two wall surveys are comparable, a slight decline in breeding numbers is suggested. Further surveys, with current calibration data are necessary to confirm this trend and to determine if these results reflect the status of the rest of breeding population on Inishglora.

Table 6.32. Comparison of results between 2000 and 2010 surveys of stone walls for Storm Petrel.).

Habitat	Length (m)	No. Of Responses	Estimate of AOS (adjusted figure)
Walls 2010	1207	47	136
Walls 2000	1569	51	148

6.4.5.3 Sea based surveys

Sea based surveys were carried out to establish a general baseline of the bird interest in an area of approximately 180 km^2 around the proposed AMETS Areas. An area of this size was chosen, as it was the largest area that could be covered in a single-day survey. As the survey boundary is between 4 km and 5 km from the nearest proposed Area site, a study area of this size gives an overall picture of the birds using, or moving through, the broader area.

Surveys were completed during daylight hours and start times were varied where possible to cover the early morning and late evening periods, as recommended by Camphuysen *et al.* (2004). Survey start points alternated between the south and north end of the survey area, to remove temporal bias. While it was known that nocturnal species e.g. Storm Petrel and Manx Shearwater were likely to use the survey area, night-time surveys were not undertaken. Such surveys were considered logistically problematic.

The study site is located within inshore Irish waters. The study site extends out to the 100 m isobath and is part of the shallower inshore Irish waters of the continental shelf, i.e. compared to the deeper waters west of the continental shelf. The study site overlaps with the coastal waters of the Bay and shore habitats of the Mullet Peninsula, where sea depths are <30 m.

The continental shelf is at its narrowest off the coast of north-west Mayo and therefore the study site is part of one of the narrowest sections of the continental shelf. Seabird distribution is linked to the shallower waters of the continental shelf, to the shelf edge and to deeper offshore waters of e.g. the Porcupine Bank (Pollock *et al.* 1997, Mackey, *et al.* 2004). Seabird distribution is also linked to waters north, south and west of Ireland e.g. the sea of Hebrides, the Celtic Sea and the Atlantic Ocean. Seabirds migrate through Irish waters from wintering and breeding grounds to the north, south and west. The study site is therefore linked by various bird populations to the coast of Ireland and to a much larger pattern of seabird distribution within Irish waters and the wider Atlantic Ocean.

Surveys at sea began in October 2009. Surveys over the following winter months (November to February) were not possible due to adverse sea conditions. Surveys resumed in March 2010 and continued until October 2010. No survey was completed in September 2010 due to poor weather conditions. Survey conditions on all survey days were considered at least adequate and in some months excellent.

The results from the at sea surveys present a picture of bird activity within the survey area during the day of the survey. Given the dynamic nature of the marine environment and of seabird populations, it must be noted that this picture can vary considerably from one day to the next. Only with data gathered over a number of years can patterns of use be considered. Given the lack of data from winter surveys use of the area during these months remains unknown.

Notwithstanding the limitations of the data presented and the dynamic nature of the study area, survey results can be used to give a general picture of the species present. The species present and their monthly occurrence can be linked to breeding patterns, breeding sites and migratory movements. To do this, results from two surveys of seabirds in Irish waters were considered (Pollock *et al*. 1997 and Mackey *et al*. 2004). In addition, results from the last national survey of breeding seabirds in Britain and Ireland (1998-2002; hereinafter referred to as Seabird 2000) (Mitchell *et al.* 2004) gave locations of nearby seabird colonies and the status of breeding populations. Further information on the status of seabird populations and on migratory movements was gathered from BirdLife International (2004 & 2010), the Migration Atlas (Wernham *et al.* 2002) and from Lynas *et al.* (2007).

The species groups encountered in greatest numbers during surveys at sea were petrels (Manx Shearwater, Great Shearwater, Storm Petrel and Fulmar), Auks (Razorbill, Puffin, Guillemot), Gulls (Kittiwake and Great Black-backed Gull) and terns (Arctic Tern). Gannet was the most commonly encountered species. During surveys of Irish waters in the mid 1990's petrels, Gulls and Auks were the most frequently recorded species groups and Gannet was the second most numerous species recorded (Pollock *et al.* 1997). Surveys of the Atlantic margin in the late 1990's found Fulmar, Gannet, Kittiwake, Guillemot and Manx Shearwater, to be the dominant species (Mackey *et al*. 2004). Although the AMETS survey was restricted only to inshore and coastal waters, the dominant species found during this survey are comparable to those found during the larger inshore and offshore surveys

The total number of birds recorded during each survey month was similar, with the exception of October, when much higher numbers were recorded. In October 2009 a large feeding flock of Great Shearwater was responsible for the peak, with 50% of all birds recorded being Great Shearwater. In October 2010 Gannets accounted for over 80% of the birds present. During the October 2010 survey, shoals of fish were observed jumping from the water and the high numbers of Gannet were most likely linked to food supply.

There is no obvious change or pattern in the cumulative distribution of species within the study site. Additional data, being gathered as part of the continued programme of baseline data collection, may provide more detail on distribution patterns.

Further consideration is given to species distribution, abundance or density patterns and within the species accounts.

6.4.5.4 Species Accounts

Northern Fulmar

Northern Fulmar is GREEN listed as a breeding species within Ireland (Lynas *et al.* 2007). As such this species requires no direct conservation action, though populations should be monitored. Fulmar are present year round, with no pronounced migration, once they are adult (Mitchell *et al.* 2004). Since the mid – 18th century Fulmar populations underwent a dramatic increase in distribution and a huge growth in population (Mitchell *et al.* 2004). The Irish breeding population has continued to increase since surveys in the late 1960's (Mitchell *et al.* 2004). Seabird 2000 recorded a total of 38,910 AOS, with the largest proportion of these (12,750) in County Mayo. Two major Irish colonies are present in County Mayo, one at Benwee Head and one at Duvillaun Island. These colonies support 5.1% and 1.7% of the British and Irish breeding population of Fulmar, respectively. Duvillaun Islands SPA is of national importance for its breeding population of Fulmar. It is of note that breeding numbers at this site declined by 21% since the 1980's.

The Fulmar was the most frequently sighted seabird species during surveys of Ireland's Atlantic Margin. Mackey *et al*. (2004) found very few locations, in any season, either in shallow or deeper waters where Northern Fulmar was not recorded. Likewise, Pollock *et al*, (1997) found this species to be the third most abundant during surveys and to be widely distributed on both the continental shelf and slope. Mackey noted, that during the months of July and August, reasonably high numbers of Fulmar were present west of County Mayo.

Surveys for this project found Fulmar to be the fourth most abundant species. Fulmar were recorded at densities of <1 / km^2 during most survey months, with peak density of 3-4 Fulmar / km^2 in March. These results are broadly comparable to those of Pollock *et al. (*1997) and Mackey *et al,* (2004). Fulmar recorded within the study site may include birds from local breeding colonies, including those of national importance. Fulmar feed mainly on crustaceans, cephalopods and fish (Cramp *et al.* 1977) and were likely to be both feeding within and moving through the site.

Great Shearwater

The Great Shearwater is a passage migrant in Irish waters. Great Shearwater breed on a small number of islands in the South Pacific and has a breeding population of nearly three million pairs (Wernham *et al.* 2002). The population of Great Shearwater is considered to be stable (Birdlife International, 2004). Great Shearwater migrate north to reach the Atlantic coasts of North America during May and June. They then begin returning south to their breeding colonies during August. During their southward migration Great Shearwater are recorded in Irish waters.

Pollock *et al.* (1997) recorded high densities of Great Shearwater on the continental shelf, west of Ireland, in November, when a flock of over 100 birds was recorded. Elsewhere they were recorded in low densities. 87% of all Great Shearwater sightings during surveys of the Atlantic Margin were in September and October (Mackey *et al.* 2004).

In this survey Great Shearwater was recorded in large densities during October 2009 when a flock of 700 birds was recorded on the sea. Forty, Sooty Shearwater, Gannet and Great Skua were also recorded with the Great Shearwater. Great Shearwater were not recorded in any other month and their occurrence in autumn is clearly linked to their southward migration at this time. While Great Shearwater are known to associate with fishing vessels (Mackey *et al*, 2004) which may lead to high densities, no such vessels were present during the October, 2009 survey. Great Shearwater feed on fish, squid and fish offal, crustaceans (BirdLife International, 2010) and macroplankton (Mackey *et al.* 2004). It is likely that an abundance of suitable prey was present within the survey area to attract such a large feeding flock. Interestingly, the only other similar concentration of birds, this time Gannet, occurred in October 2010.

Sooty Shearwater

Sooty Shearwater is a passage migrant. Its breeding population is decreasing and it is classified as a SPEC 1 species, or of global conservation concern by BirdLife International (2004). Impacts of fisheries, harvesting of young and climate change are listed as reasons for population declines. Sooty Shearwater breed in the Southern hemisphere and small numbers are recorded off the west coast of Ireland during the late summer (mainly August and September) (Wernham *et al.* 2002).

Pollock *et al*. (1997) found Sooty Shearwater in low densities (≤0.1-0.19 birds / km^2) off the west coast of Ireland. During September and October, highest numbers of Sooty Shearwater were recorded and these were mainly concentrated off the south west coast of Ireland. High densities (>5 birds / km^2) were also noted off the Galway coast. The Atlantic Margin survey recorded Sooty Shearwater between May and November, with a peak in August (Mackey *et al*, 2004). Highest densities on the continental shelf were off the Mayo coast (2-5 birds / km^2), between July and September.

During this survey Sooty Shearwater were recorded in the months August and October only. As for Great Shearwater, their occurrence within the study is clearly linked with their southward migration. Abundance was generally low (<1 bird / km) except during October 2009, when a large flock of Sooty Shearwater (75 birds) were associated with the feeding flock of Great Shearwater (see above). Sooty Shearwater feed on fish, crustacean and cephalopods (BirdLife International, 2010). It is likely that a concentration of suitable prey was available during the October 2009 survey. It is of note that Mackey *et al.* (2004) and Pollock *et al.* (1997) do not refer to any concentrations of Sooty Shearwater, such as observed during this survey.

Manx Shearwater

Background information on this species is presented under land-based surveys – species accounts.

In March and April Pollock *et al*. (1997) found low densities (<1 bird / km^2) of Manx Shearwater on the continental shelf west of Ireland. In May and June large concentrations were recorded off the west of Ireland, but none around the immediate vicinity of the large colonies on the Blasket Islands. In July and August numbers recorded at sea increased greatly and included large feeding flocks that raft on the water. Pollock notes that Manx Shearwater may forage up to 360 km from their breeding colonies during the day. It is also noted by Pollock that there is an increase in Manx Shearwater numbers in May due to the late arrival of non-breeding birds from their wintering grounds (Pollock *et al.* 1997).

Results from this survey found Manx Shearwater was the second most abundant species recorded. Monthly densities of Manx Shearwater were greatest between April and July (4-7 birds / km^2). Within the study site densities were greatest within 8 km of the coastline.

As there are no large Manx Shearwater breeding colonies near the study site it is likely to be used by foraging birds from large colonies in Ireland and Scotland and by non-breeding birds. The largest rafts of Manx Shearwater recorded during at sea surveys was a group of 40 in April and 45 in July. This compares with the much larger rafts (<100 birds) recorded during the surveys from land (section land based surveys) and recorded by Mackey *et al.* (2004) (400 birds). The occurrence of large rafts of Manx Shearwater, although not picked up in surveys at sea, remains of note. These are likely to be flocks of foraging birds. Seabirds also flock whilst moulting, however, Manx Shearwater undergo their main moult in their South American wintering grounds (Cramp *et al.* 1977). The higher densities of Manx Shearwater closer to land is of note but cannot be explained without further study.

<u>Storm Petrel</u>

The Storm Petrel is an Annex I species under the EU Birds Directive. Storm Petrels are pelagic returning to land only to breed. They nest below ground and appear above ground only during darkness (Mitchell *et al.* 2004). Storm Petrels winter in Southern Africa and are summer visitors to the waters around Ireland (Pollock *et al.* 1997). Storm Petrels nest in burrows and crevices on remote islands. They lay a single egg in May or June and the peak incubation period is July (Mitchell *et al*, 2004). During July and August Storm Petrels forage in coastal and offshore waters west of Ireland, to feed their chicks. Numbers of non-breeding immature birds are also present in these months (Pollock *et al*. 1997). The current status of the breeding population cannot be assessed as Seabird 2000 provided the first comprehensive survey of this species.

Pollock *et al.* (1997) found Storm Petrels to be most abundant during July and August, with very high densities off south-west Ireland. Pollock notes that Storm Petrel feeds on plankton and are found in oceanic waters greater than 100 m deep with a salinity > 35%. Pollock recorded low densities of Storm Petrel in May and June when birds arrive back at their nesting sites and between September and November as birds disperse after breeding and move south to their wintering grounds. Similarly Mackey *et al.* (2004) found Storm Petrel to be most abundant between July and September with low densities in May and June and few records in all other months. Mackey describes Storm Petrel to be widely but thinly distributed between July and September. They were mainly recorded along the shelf edge and further west. Densities were largely < 1 bird / km^2, though slightly higher densities are shown for waters west of the north Mayo coast (1-2 birds / km^2).

Mitchell *et al.* (2004) note that during the breeding season Storm Petrel feed all along the north and west coasts of Britain and Ireland in both deep waters and shallower waters of the continental shelf. While known to feed off shore during the day Mitchell describes how recent evidence suggests that Storm Petrel move inshore at night to feed on intertidal benthic crustaceans.

During Seabird 2000 Inishglora Island was found to support 1,788 AOS's while its neighbour Inishkeeragh Island had 1,635 AOS's. The total population for the Inishglora and Inishkeeragh Island SPA is therefore 3,423 AOS's, which represents 6% of the Irish national breeding population. Counties Mayo and Kerry hold the greatest numbers of breeding Storm Petrel. The Kerry colonies alone hold 86% of the Irish breeding population, while the Mayo colonies hold 12%. A further six Storm Petrel colonies are listed for County Mayo including major colonies at the Stags of Broadhaven with 1,912 AOS and Duvillaun Beg (950 AOS) (Mitchell *et al*. 2004).

Surveys at sea recorded 255 out of 257 Storm Petrels during the months June to August. This pattern of occurrence is consistent with the findings of Mackey *et al.* (2004) and Pollock *et al.* (1997). It is interesting to note that most sighting were made >8 km off the shore and along the 100 m isobaths. Storm Petrel are known to forage in deeper waters and this seems to be reflected in results from this survey. Storm Petrels recorded within the study site are likely to include foraging adults from local breeding sites as well as non-breeding birds. The nocturnal occurrence of Storm Petrel within the study site remains unknown.

<u>Gannet</u>

Background information on this species is presented under land-based surveys – species accounts.

Gannet was found to be one of the most numerous species in Irish waters by both Pollock *et al.* (1997) and Mackey *et al*, (2004) and was found to be the most common bird observed, during surveys at sea for this project.

Pollock *et al.* (1997) recorded low densities (<2 birds / km^2) of Gannet inshore off the west of Ireland from June to August. In September and October Pollock recorded high densities of Gannet away from breeding sites, such as in Galway Bay. Mackey *et al.* (2004) found peak abundance of Gannet in September.

This survey found Gannet were generally well distributed throughout the study area with an increase in density towards the 100 m isobaths. Gannet occurred in low densities (<3 birds / km^2) during all months except October, when densities were higher, which is broadly consistent with the finding of Pollock *et al.* (1997) and Mackey *et al.* (2004). Gannets were observed both moving through the study site and actively feeding within it. There are no large breeding sites for Gannet near the study site. Both adult breeding birds from distant colonies and immature non-breeding birds are likely to use the study site. The very high numbers of Gannet recorded in October 2010 were associated with very calm seas and shoals of small fish, offering obvious feeding opportunities. Any link between Gannet distribution and the 100 m isobath cannot be explained without further study.

Great Skua

Great Skua is an AMBER listed species owing to its rarity as a breeding bird in Ireland (Lynas *et al*, 2007). Great Skua is a large predatory seabird, which mainly breeds in Scotland and further north. The British and Irish population of Great Skua is largely restricted to the islands of Orkney and Shetland in Scotland. The only Irish breeding site is located in County Mayo and was first recorded during Seabird 2000 (Mitchell *et al*, 2004). Great Skua winter in shallow seas off southern Europe and it is during their migrations south to winter and north to breed that they are recorded in Irish waters. Pollock *et al.* (1997*)* recorded higher densities of Great Skua along the edge of the continental shelf indicating migration west of Ireland in Spring. Low densities were recorded between May and June. The Great Skua was most abundant within inshore waters between July and October, although they did not occur in high densities (Pollock *et al*, 1997). Great Skua were present in the study site during the months October 2009 and 2010 and August 2009. Their occurrence at this time is likely to be linked to their southward migration.

It should be noted that both Pomarine and Arctic Skua were also observed within the study site. In this survey, as with Pollock *et al* (1997) and Mackey *et al* (2004), the Great Skua was the most frequently recorded Skua species.

Herring Gull

Background information on this species is presented under land-based surveys – species accounts.

During surveys at sea Herring Gull were recorded in low numbers throughout the study area. The total number of Herring Gull recorded in the survey area for all survey months was 27. Herring Gull are opportunistic feeders which may have been passing through the survey area or foraging within it.

Great Black-backed Gull

Background information on this species is presented under land-based surveys – species accounts.

During at sea surveys Greater Black-backed Gulls were recorded in relatively low abundance throughout the study area with most birds (over 60%) occurring during May, June and July. Great Black backed Gull breed in nationally important numbers on the Inishkea Islands and on the Duvillaun Island SPA's. Great Black backed Gulls are a sedentary species, closely associated with coastal regions. Birds present in the survey area are likely to be part of the local breeding population. Non-breeding immature birds were also observed.

Kittiwake

Kittiwake is the most numerous gull breeding in Britain and Ireland (Wernham *et al*, 2002). Outside the breeding season the Kittiwake is the most oceanic of Gulls and is distributed across the north-Atlantic Ocean (Wernham *et al.* 2002). Kittiwake is an AMBER listed species due to its localised breeding distribution (Lynas *et al*. 2007).

Seabird 2000 recorded a 23% decline in the British and Irish Kittiwake population. Several colonies of breeding Kittiwake occur along the north coast of Mayo where suitable cliff nesting habitat is available. Despite marked regional declines numbers of breeding Kittiwake in Ireland were stable and numbers at colonies in County Mayo have increased (Mitchell *et al*, 2004). Declines in the Kittiwake population have been linked to food supply and prey availability. During the breeding season Kittiwake do not forage far from their breeding colonies. In contrast during the winter months they disperse across the Atlantic.

Between February and March Pollock *et al.* (1997) found low densities (<1 bird/ km^2) or no Kittiwake within inshore survey areas west of the Mullet Peninsula. During April and May Kittiwake distribution shifted to coastal and inshore waters, reflecting the start of the breeding season. Kittiwakes were widespread in coastal waters during June and July, with immature birds present in deeper offshore waters. During August and September coastal densities increased as fledged young left their colonies. Mackey *et al.* (2004) reported low densities (<1 bird / km^2) of Kittiwake off the Mayo coast in the January to March and July to August periods.

During this survey Kittiwake was recorded in each survey month. While monthly abundances, show a peak in the October months, and in March and April, less than 1 bird / km was present in all survey months. Kittiwake nest north of the study site along the north Mayo coast. It is possible that foraging birds from these colonies were present during the breeding season. Perhaps slightly higher October abundances reflect winter dispersal of Kittiwake. There is no clear pattern of occurrence, other than their very low abundance during June, July and August, when perhaps higher abundances associated with fledged young might be expected. However, this peak may have occurred closer to the breeding colonies.

Arctic Tern

Background information on this species is presented under land-based surveys – species accounts.

Mackey *et al.* (2004) found the Arctic Tern to be the most commonly encountered tern species. Arctic Tern were recorded by Mackey *et al.* (2004) in May, June, August and September and their occurrence, which was mainly offshore was linked to their migratory movements. Pollock *et al.* (1997) noted that the distribution of Arctic Terns during May and June was mainly coastal and linked to their breeding colonies. Densities were higher in July and August when chicks had fledged.

During this survey Arctic Tern were only recorded during May, June and July, reflecting their occurrence in the northern hemisphere during the breeding season. Within the survey area abundance was relatively low and most records were from within 8 km of the shore and in waters <100 m depth. High densities were also present around Annagh Head, were there is a breeding colony. It is likely that terns recorded during May, June and July were foraging terns linked to breeding sites on Inishglora, Inishkeeragh and the Inishkea Islands. Their inshore distribution may be linked to foraging opportunities. During May a group of 60 Arctic Terns on migration were recorded, further offshore within the study area.

Guillemot

Background information on this species is presented under land based surveys – species accounts.

Between March and June Pollock *et al.* (1997) recorded highest densities of Guillemot inshore, associated with the breeding season and attendance at breeding sites. High densities were recorded in July and August when large moulting flocks were present. Guillemots tended to disperse from October and lower densities were generally recorded inshore. Mackey *et al.* (2004) reported the relative abundances of Guillemot to be lower in Spring and summer and higher in autumn and winter. The lower abundance in Spring and summer reflects their inshore distribution during these months, linked to their breeding sites.

Guillemot were present in low abundance (<1 birds / km) in all survey months and were generally widely dispersed. Peaks in abundance in March and October were not associated with rafts of Guillemot. No rafts of moulting birds were recorded. Guillemot were recorded with young. The survey area is likely to fall within the foraging range of birds from colonies off the north Mayo coast. Non-breeding immature birds are also likely to be present.

Razorbill

Background information on this species is presented under land-based surveys – species accounts.

During March to July Pollock *et al*. (1997) recorded moderate to low densities of Razorbill in coastal and inshore waters on the west of Ireland, with low densities recorded west of Achill Island, County Mayo. During these months Razorbill are nesting and by July chicks are beginning to fledge and go to sea. Between August and October, high densities of Razorbill were recorded in coastal waters of e.g. Clew Bay. This is the moult period when Razorbills often occur in mixed flocks with Guillemot.

During this survey Razorbills were the most common Auk species recorded in surveys at sea. 716 birds were recorded across all months except August when none were observed. They occurred at relatively low densities throughout the survey area (up to 4 birds / km^2 in May, but mostly <1 bird / km^2). No large flocks of Razorbill were recorded, as described by

Pollock *et al.* (1997). Higher numbers recorded in March and May is likely to be linked to the breeding season. The nearest breeding colonies are off the north Mayo coast and both breeding and non breeding birds are likely to have been present in the survey area. Parent Razorbill with young were sighted during surveys.

Puffin

Puffin is an AMBER listed species due to its localised breeding distribution. It is also a SPEC 2 species with an unfavourable European conservation status and a distribution concentrated within Europe (Lynas *et al.* 2007). Illaunmaster and Stags of Broadhaven Bay SPAs off the north Mayo coast, support nationally important breeding populations of Puffin. Seabird 2000 reported a decline in the Irish breeding population of Puffin while numbers in Britain had increased (Mitchell *et al.* 2004).

Puffin was the second most frequently encountered auk during the Atlantic Margin survey (Mackey *et al.* 2004). From September to February the relative abundance of Puffin was low when compared to abundance during the breeding season (April to August) (Mackey *et al*, 2004).

During April and May Pollock *et al.* (1997) recorded low to moderate densities (generally <2 birds / km^2) of Puffin, generally close to their colonies. Pollock found highest inshore densities of Puffin during June and July when adults are feeding their chicks. The pattern was similar in August, as the breeding season extends into this month, when most chicks fledge and immature birds visit the colonies. During the winter Puffins disperse widely and are only found at low densities in inshore waters (<1 bird / km^2).

Puffin densities were well dispersed throughout the study area and were observed during all monthly surveys, except March. The occurrence of Puffin within the survey area appears to reflect the return of Puffin to coastal waters during the breeding season. Given that Puffin colonies are present off the north and west Mayo coast, their occurrence at this time of year is likely to be linked to breeding areas. Given the known winter dispersal pattern of Puffin, into deep pelagic waters, they are unlikely to be present within the survey area during winter months, except possibly in low densities.

6.4.5.5 Overview

The survey period covers Spring migration, the breeding season, and the start of autumn migration. The results found that species that breed at nearby colonies were present during the breeding season, such as Auks, Terns, Gulls, Fulmar and Storm Petrel. Passage migrants were present during the autumn, such as Great Skua and Great and Sooty Shearwater. There are no nearby breeding sites for Gannet and Manx Shearwater, however the study site lies within the foraging range of Irish and Scottish breeding colonies of these species. The large rafts of Manx Shearwater are of note, and may be linked to the late arrival of non-breeding birds in Irish waters. While the occurrence of many species can be linked to the breeding season, both breeding and immature non-breeding birds are likely to have been present in the survey area. Fledged young and adults birds were also present. The distribution of some species within the survey area appears to show either a more coastal or off shore pattern e.g. Storm Petrels were mainly recorded further out to sea, while Arctic Tern were more closely associated with the coast. Further surveys are required however, before conclusions can be drawn.

Species and species groups of particular interest within the survey area are those that may be breeding in nearby SPA's, i.e. Gulls, Auks, Terns and Storm Petre,l and those that were common and/or occurring in high densities within the site, i.e. Gannet, Manx Shearwater and Great Shearwater.

6.5 IMPACT OF THE DEVELOPMENT

The harnessing of wave energy is at an early stage of development, although and there are operational wave energy test sites, for example at Lysekil in Sweden (Langhamer *et al*. 2010) and in Orkney, Scotland (The European Marine Energy Centre (EMEC)). A commercial wave energy development, WAVE HUB, has recently been consented in the UK (Halcrow, 2006). A study into the interaction between birds and wave energy devices is underway at this site and environmental impact data is being collected at the Orkney and Swedish test sites. However, there is currently little available data on the environmental impacts of wave energy devices.

Despite this lack of data, workshops, such as the Equimar workshop (2009) and the MASTS workshop (2010), have discussed and described potential impacts. They have also discussed possible solutions for dealing with both the development of the industry and the lack of data on environmental impacts.

An immediate problem in terms of the industries development is the lack of guidance in appropriate survey methods for wave energy Environmental Impact Assessment. This situation should improve with the imminent provision of draft guidance on survey and monitoring in relation to Wave and Tide renewables by Scottish Natural Heritage and other organisations.

6.5.1 General effects

Various reports, reviews and workshops (Langhamer et al, 2010; MASTS workshop, 2010, Equimar 2000, Grecian, 2010) have outlined the potential impacts from wave energy devices. Some of those potential impacts, which may affect birds, are listed below.

- Above water collision with wave energy converters. Collision risk is likely to vary depending on species, age and reproductive stage and is likely to be greater with nocturnal and crepuscular species. Environmental conditions such as bad weather may increase collision risk.

- Under water collision with mobile energy converters, anchor chains, and cabling (highest risk to species diving for prey, when a device is placed within the foraging range of a colony and when at a depth within the dive profile of a species). Increased turbidity around devices may increase collision risk.

- Risk of entrapment within the moving parts of a device (depends on the device).

- Disturbance due to noise during construction and maintenance. This will be greater where pile driving is involved. Disturbance due to noise as the device is in operation (level of impact will depend on the existing sound scape).

- Displacement due to avoidance of areas with man made structures.

- Displacement due to altered environment making it unsuitable for prey species e.g. changes to hydrological processes due to foundations and associated cabling. (Impact of displacement on birds will depend on area of habitat available to them, e.g. birds which have restricted foraging on shallow sandy areas which are also suitable for wave energy devices)

- Redirection around wave energy arrays. Birds may need to navigate around arrays increasing energy expenditure. Impact is considered negligible for most devices unless devices are located between breeding, foraging and/or roosting grounds.

- Impacts on water quality due to use of antifoulants and use oil and lubricants. Risk of spillage.

Potential negative interactions with marine habitats and prey:

- Changes in local food web interactions. Reduction in wave energy could impact sediment transport processes with knock on effects on, for example, spawning grounds. These impacts will vary depending on where the devices are located.

- Changes in food availability due to changes in communities associated with new structures on the seabed. This could lead to changes in prey availability if preferred prey species are out competed.

- Influence of magnetic fields and induced electric fields on the behaviour of marine mammals (changes in fish behaviour may have secondary impacts on birds)

- Disturbance and /or disorientation due to night lighting

- Connectivity impacts, where birds from Special Protection Areas, are using the wave energy test site.

Potential positive interactions due to WECs

- Creation of roosting structures

- Creation of artificial reefs. Marine organisms will be attracted to new hard structures on the seabed. This may increase prey availability for some bird species.

- Fish aggregation devices. Wave energy arrays may attract and recruit fish species seeking protection and food. Large wave energy arrays may be better at recruiting fish species, providing foraging opportunities for piscivorous birds.

- Creation of Marine Protected Areas. Wave energy installations may become de facto Marine Protected Areas, as they will act as fishing exclusion zones.

6.5.2 Cumulative Impacts

Potential changes to the ecosystem were identified by Grecian (2000) and have been described above. However, it is also noted by Grecian that unforeseen ecosystem changes and responses may take place and that the inappropriate placement of multiple wave energy converters may lead to cumulative negative impacts on birds, potentially at a population level.

Relevant project details in terms of impacts on birds.

The proposed development will involve installation of wave energy converters (WECs) at two Areas, one at 50 m depth and one at 100 m depth. The most likely WECs, which will be installed, are Wave Bob and Pelamis and they will operate at full scale within the test site. The potential for other WECs to be deployed at the site is also possible. The landfall will be at Belderra Strand as this shore was considered to be the most suitable for environmental and other reasons (Preliminary Ecological Assessment, Tonn Energy, 2009). Of relevance in terms of bird impacts are the following aspects of the development:

6.5.3 Construction phase

- Construction of a substation, located behind Belderra Beach, with associated traffic and human activity

- Cabling across intertidal habitat which will take place between June and October.

- Cabling within the Bay, which depending on the construction method used, may take 3 days over a four-week period between June and October. There will be four separate cable deployment runs,. Either jetting or ploughing will be used to trench the cables. The trench may take one month to back fill after jetting. Jetting fluidises the sand so can be more damaging. It also throws up more sediment than ploughing. After ploughing the sediment back fills almost immediately. Cable trenches will be about 1 m wide. Cabling will be carried out by a large size vessel, which will operate from a suitable convenient pier. Ballyglass.

- Placement of rock armour on cables where the cable cannot be trenched. Inert material will be used.

- Increased boat activity in the Bay due to workboat presence for cabling for a specific duration.

- Increased boat activity at sea due to deployment of WECs for specific durations. This will require three tugs (20 m work boat). Deployment of devices takes one day for Pelamis and three days for WaveBob. A maximum of 20 days activity at the Area is possible. (Based on up to a maximum of 5 Wave Bob and 5 Pelamis WECs being located within a Test Area).

6.5.4 Operational phase

- Presence of WECs (Wave Bob and Pelamis) with a maximum height of 4 m above the surface and 65 m below and maximum length of 180 m. WECs may have moving parts, will generate noise and will require lubrication. They may require use of antifoulants or material may be allowed to grow until it falls off.

- Presence of an array of structures (up to a maximum of 5 Wave Bob and 5 Pelamis WECs located within a Test Area) on the open sea requiring an exclusion zone, which will be marked by navigational lights (one per Test Area using navigational lights as used on cardinal buoys).

- Presence of new hard structures on the seabed i.e. anchors, which will be linked by chains to the WECs. Anchor chains will move with the swell. Anchors may also be rock armoured to avoid seabed scour.

Relevant species or species groups and potential impacts.

The potential impacts from the wave energy installations will vary depending on the species involved, their status and/or behaviour. Given the lack of information on wave energy impacts, it will be important to monitor all bird populations using the study area. However, in terms of impacts it is necessary to focus on those species of note in terms of their conservation status and/or abundance and to focus on any species that may be at particular risk due to their behaviour.

The impacts upon birds will vary depending on the location of the installations. The impact will also be dependent on the timing of construction activities. Impacts at this site are considered in three sections; the landfall impacts on shore habitats, the cabling impacts within the Bay and the impacts due to construction; operation and maintenance of the WECs at Test Areas A (50 m depth contour) and C (100 m depth contour) see Tables 6.33 - 6.39.

Table 6.33. Construction Phase Impacts - Potential interactions within shore habitats.

Species Groups	Status	Behaviour	Potential impacts
Breeding waders and passerines	Common and typical passerines. Waders in decline generally.	Nesting Foraging	Intertidal cabling at Belderra Beach may disturb breeding birds, especially Ringed Plover which nest on shingle shores if carried out during the breeding season.. Increased traffic associated with substation construction and landfall activities may disturb breeding birds.
Migratory water-birds.	Linked to nationally important populations of Blacksod/Broadhaven Bay SPA	Foraging and roosting shore birds. Regular winter use extending into summer months for some species.	Landfall activities may disturb migratory and resident shorebirds during the construction phase.

Table 6.34. Construction Phase Impacts - Potential interactions within the Bay

Species	Status	Behaviour	Potential impacts
Great Northern Diver	Annex I species Mullet peninsula population of international importance. Linked to internationally important populations of	Regular use of Bay by wintering birds. Possible regular use by additional moulting birds. Possibly site faithful wintering adults. Diving bird feeding on fish.	Disturbance due to boat and cabling activity if carried out during the winter period.

Species	Status	Behaviour	Potential impacts
	Blacksod/Broadhaven Bay SPA.	Distribution appears to favour habitats <20 m depth. Occurs across entire Bay during winter and Spring.	
Long tailed Duck	Restricted range within Ireland The Mullet area is one of the top five sites in Ireland Nationally important numbers in the Bay.	Regular use of the Bay in the winter. Evidence of favoured foraging area within the Bay	Disturbance due to boat and cabling activity if carried out during the winter period.
Eider	Part of small local breeding population at the southern edge of its range.	Regular use of the Bay. Autumn and Spring occurrence May favour shallow Bay waters for foraging.	Disturbance due to boat and cabling activity if carried out during the winter period. .
Terns	Annex I species Nationally important breeding colonies locally.	Foraging in shallow Bay waters Nesting on Annagh Islet	Disturbance due to boat and cabling activity.
Manx Shearwater	Internationally important breeding population within Ireland. Migratory seabird.	Foraging and resting flocks forming rafts. Surface feeders Nocturnal feeding	Disturbance due to boat and cabling activity.
Barnacle Goose	Annex I species. Inishglora and Iniskeeragh Island SPA.	Regular winter use in internationally important numbers.	Disturbance due to boat and cabling activity if carried out during the winter period.

Table 6.35 Construction Phase Impacts - Potential interactions at Test Area B, 50 m isobath and Test Area A, 100 m isobath.

Species/ Group	Status	Behaviour	Potential impacts
Storm Petrel	Annex I species Internationally important breeding population on Inishglora and Iniskeeragh Island SPA.	Diurnal and nocturnal foraging Fledged young foraging. Surface feeders. Known to feed in deeper waters. Only come ashore at night during the breeding season.	Disturbance due to boat, cabling and Test Area deployment activity.
Arctic Tern	Annex I species. Internationally important population breeding on Inishglora and Iniskeeragh Island SPA.	Diurnal foraging Chick provisioning. Fledged young. Plunge diving.	Disturbance due to boat, cabling and Test Area deployment activity.
Manx Shearwater	Migratory seabird. Internationally important breeding population in Ireland	Large flocks in foraging and resting rafts. Foraging birds from large breeding colonies. Diurnal and nocturnal foraging. Shallow diver.	Disturbance due to boat, cabling and Test Area deployment activity.
Gannet	Migratory seabird	Foraging	Disturbance due to boat, cabling and Test Area deployment activity.

Species/ Group	Status	Behaviour	Potential impacts
	Internationally important breeding population in Ireland	Resting Plunge diving.	
Auks	Local breeding colonies of national importance.	Foraging, resting, rafting. Adults with flightless young. Shallow diving.	Disturbance due to boat, cabling and Test Area deployment activity.

Where likely impacts have been identified in terms of a species or species group, the significance of this impact has been assessed, following a standard assessment process detailed below.

Table 6.36a. Assessment of significance (Construction Phase) Area of potential Impact: Shore at Belderra Strand used by wintering waders and breeding Ringed Plover. Low numbers, year round use.

Potential impact:	**Changes and disturbance to shore habitats and birds at Belderra Strand due to landfall activities on the shore.**
Significance criteria	
Character and perceived value of affected environment	No Annex I species, but wintering wader populations are linked to Blacksod/Broadhaven Bay SPA. Low numbers of waders present, though winter use likely to be more important than summer. Low level recreational disturbance apparent on the shore. Strand is part of a generally undisturbed complex of wetland habitats along the west side of the Mullet Peninsula, although the immediate vicinity of the strand includes disturbance due to recreational use, grazing and drainage works undertaken by locals.
Confidence in the accuracy of predictions of change	The presence of diggers on the shore will cause disturbance to birds for a short period of time. Cabling activity on the shore will disturb sediments. It is likely that they will recover quickly, given that this is a dynamic coastal environment. It is possible that Belderra Strand supports higher numbers of waders than found in this survey, given that annual variation in wader numbers that can take place.
Magnitude, spatial extent and duration of anticipated change	The intertidal habits will be directly impacted by digger activities for two to five days in the summer/autumn period. Intertidal habitats should recover within 3-6 months
Resilience of environment to	This is a dynamic environment, subject to constant change and should be able to recover quickly

cope with change	
Scope for mitigation, sustainability and reversibility	Disturbance impacts should be minimised by limiting construction activities to the summer months, when wintering waders are not present. Disturbance to shingle habitats should be avoided. Ecologist to be present during excavation of trenches to provide advice and guidance
Significance of impact	**LOW**
Potential impact	**Disturbance to wintering birds and breeding Ringed Plover due to noise from landfall and substation activities, including increased road traffic and human activity.**
Significance criteria	
Character and perceived value of affected environment	No Annex I species, but wintering wader populations are linked to Blacksod/Broadhaven Bay SPA. Low numbers of waders present with winter use likely to be more important than summer. Small numbers of breeding Ringed Plover likely on the shingle shore. Low level recreational disturbance apparent on the shore. Shore is part of a generally undisturbed complex of wetland habitats along the west side of the Mullet Peninsula
Confidence in the accuracy of predictions of change	Birds can habituate to some types of noise disturbance. However, activity on the shore is likely to cause birds to move elsewhere. It is unlikely that the substation construction will cause direct disturbance to shore birds, however increased traffic and associated human activity may do so. While there is some recreational disturbance at Belderra Strand this is a sparsely populated remote area and disturbance levels are relatively low.
Magnitude, spatial extent and duration of anticipated change	Intertidal cabling will take 2 – 5 days. Substation construction will take 6 months over Spring/Summer
Resilience of environment to cope with change	Noise disturbance to wintering birds will cause birds to forage elsewhere and can cause breeding birds to desert nesting sites. Winter foraging is critical to the survival of and successful breeding by migratory birds.

Scope for mitigation, sustainability and reversibility	Disturbance impacts should be minimised by limiting construction activities to the summer months, when wintering waders are not present. Disturbance to shingle habitats should be avoided. .
Significance of impact	**LOW – if intertidal activities are limited to two - five days in the summer months and consideration is given to breeding Ringed Plover.** **LOW – if increased traffic and human activity associated with the substation construction does not extend onto the shore and dune habitats at Belderra Strand.**

Table 6.36b. Assessment of significance (Construction Phase) - Area of potential Impact: The Bay

Potential impact:	**Changes to subtidal habitat due to cabling potentially disturbing the benthos with indirect effects on feeding birds.**
Significance criteria	
Character and perceived value of affected environment	Regular use by the Annex I species Great Northern Diver in winter and Spring (October to May). Regular use by the Annex I species Arctic Tern in Spring (May to July) Regular use by nationally important numbers of wintering Long tailed Duck, with favoured feeding area. Regular use by Eider in Autumn and Spring, linked to local breeding population at southern edge of range. Use by rafts of Manx Shearwater between April and July.
Confidence in the accuracy of predictions of change	Cabling involves creating a 1 m wide trench for each of the four cables. Impacts upon the sediment will vary depending on method. It is difficult to predict how these changes might affect the feeding resource, e.g. crustaceans, small fish, molluscs. Given that it is a dynamic environment it may be unlikely to cause any long-term changes. Cabling may cross an area which appears to be favoured by Long tailed Duck and which is colonised by a small gastropod species. Cabling may damage this area. It is impossible to predict the effect this will have on Long tailed Duck, however winter foraging is critical to survival for migratory birds. Changes to the feeding resource are likely to have a greater effect on Long tailed Duck, which appear to be linked to a specific feeding area, than on the other species, which use a greater area of the Bay. However, significant changes to the benthic environment may cause a general degradation of the feeding resource with implications for all species.
Magnitude, spatial extent and duration of anticipated change	Area of change will be at a minimum a 1 m wide trench for the length of each of the cables. Direct disturbance will last for the period of cable laying. Recovery time will depend on the cabling method used. Duration of change will depend on seabed recovery and any long terms effects, which may arise.
Resilience of environment to	The Bay is a dynamic environment. Sediment habitats will most likely recover quickly.

cope with change	It is possible that the feeding area favoured by the Long tailed Duck will not recover as quickly. This area appears to be cobbled in places, with large densities of *Ulva* species where the Gastropod spp. feeds. It is not known if it is this Gastropod which is attracting the Long tailed Duck.
Scope for mitigation, sustainability and reversibility	The trenching method with the least disturbance to the seabed should be used. Avoidance of trenching in areas favoured by foraging Long tailed duck, if possible.
Significance of impact	**Low- as the Long tailed Duck foraging area will be avoided** **Low – for other species as they appear to have a wider range of foraging habitat.**
Potential impact:	**Disturbance to birds due to activity of cable laying boat.**
Significance of criteria	
Character and perceived value of affected environment	Regular use by the Annex I species Great Northern Diver in winter and Spring (October to May). Regular use by the Annex I species Arctic Tern in Spring (May to July).Regular use by nationally important numbers of wintering Long tailed Duck with favoured feeding area. Regular use by Eider in Autumn and Spring, linked to local breeding population at southern edge of range. Use by rafts of Manx Shearwater between April and July.
Confidence in the accuracy of predictions of change	The presence of a boat active within the Bay is likely to cause birds to move away from the area it is active within.
Magnitude, spatial extent and duration of anticipated change	Disturbance should be limited to the area and time in which the boat is active (three days for each cable)
Resilience of environment to cope with change	The Bay is generally undisturbed and activities in this environment are likely to have a greater effect than in an environment, which is subject to regular disturbance.

Scope for mitigation, sustainability and reversibility	The cable laying should last for three days only for each cable. Long-term negative effects from disturbance should therefore be avoided. Cable laying should take place in the summer months (April to September inclusive).
Significance of impact	**Low – due to short period of disturbing activity and if activity is limited to the summer months.**

Table 6.36c: Assessment of significance (Construction Phase) - Area of potential impact: open sea and wave energy Test Area areas A and B

Potential impact:	**Disturbance to birds due to activity of cable laying and deployment activities**
Significance criteria	
Character and perceived value of affected environment	Supports a range of foraging seabirds including migratory, locally breeding and non-breeding birds. Inishglora Island, which is part of Inishglora and Iniskeeragh Island SPA supports wintering Barnacle Geese.
Confidence in the accuracy of predictions of change	Birds will be displaced as the cable laying boat moves through the study site. There are no studies into the impact of noise disturbance on marine birds due to deployment activities relating to WECs. Disturbance to birds is known to be greater where pile driving is used; pile driving will not be used for this development. Disturbance to birds due to deployment activity is likely. This will displace birds from the area of activity.
Magnitude, spatial extent and duration of anticipated change	The magnitude of disturbance due to deployment activity is unknown. Disturbance will be for a limited period with each WEC requiring 1-3 days for deployment. Disturbance due to deployment will be for a maximum of 20 days at each Area. Disturbance due to cable laying will be for a shorter period.
Resilience of environment to cope with change	Noise disturbance due to WEC deployment is likely to have a greater impact in this environment than in one which is subject to regular human activity. Research into the impacts of noise disturbance to birds is limited. It is not possible to predict what effect noise and disturbance from cable laying will have on birds. They may not be using the area during cable laying operations or they may be foraging close by. Data so far does not indicate any favoured feeding areas within the study site, which is expected as it is an offshore dynamic environment with no features which might be linked to increased feeding opportunities, e.g. steep shelf. Foraging rafts and feeding flocks of birds have been recorded in the area. Any displacement effects are likely to be minimised, given that the cable laying operations will be of a relatively short duration. There appears to be no particular attraction by birds to specific features within the study area. As foraging is a dynamic activity it is not possible to predict the extent of the effect of noise disturbance on birds.
Scope for mitigation, sustainability and reversibility	Steps should be taken to minimise noise disturbance and to minimise the duration of cabling and deployment activities. All activities should avoid a buffer zone of 500 m around Inishglora Island.

Significance of impact	**UNKNOWN**

Table 6.37. Operational Phase Impacts - Potential interactions within the Bay

Species	Status	Behaviour	Potential impacts
Great Northern Diver	Annex I species Mullet peninsula population of international importance. Linked to internationally important populations of Blacksod/Broadhaven Bay SPA.	Regular use of Bay by wintering birds. Possible regular use by additional moulting birds. Possibly site faithful wintering adults Diving bird feeding on fish Distribution appears to favour habitats <20 m depth. Occurs across entire Bay during winter and Spring.	1. Changes to feeding resource as a result of cabling and its impact on the seabed. 2. Changes to sediment patterns resulting from changes to the wave energy within the Bay linked to the WECs and with indirect impacts on feeding resources.
Long tailed Duck	Restricted range within Ireland The Mullet area is one of the top five sites in Ireland Nationally important numbers in the Bay.	Regular use of the Bay in the winter. Evidence of favoured foraging area within the Bay	As above plus, Direct impacts on a favoured feeding area due to cabling.
Eider	Part of small local breeding population at the southern edge of its range.	Regular use of the Bay. Autumn and Spring occurrence May favour shallow Bay waters for foraging.	1. to 3. as above
Terns	Annex I species Nationally important breeding colonies locally.	Foraging in shallow Bay waters Nesting on Annagh Islet	1. to 3. as above

Manx Shearwater	Internationally important breeding population within Ireland. Migratory seabird.	Foraging and resting flocks forming rafts. Surface feeders Nocturnal feeding	1. to 3. as above

Table 6.38. Operational Phase Impacts - Potential interactions at Area B, 50 m isobath and Area C, 100 m isobath

Species/ Group	Status	Behaviour	Potential impacts
Storm Petrel	Annex I species Internationally important breeding population on Inishglora and Iniskeeragh Island SPA.	Diurnal and nocturnal foraging Fledged young foraging. Surface feeders. Known to feed in deeper waters. Only come ashore at night.	1. Displacement or re-direction of foraging birds due to Area array. 2. Water pollution due to use of lubricants and/or antifoulants which may affect the feeding resource. 3. Changes to feeding resource due to accumulation of organic matter below WECs (where antifoulant not used). 4. Above water collision with WECs Plus: Disturbance owing to lighting of Test Areas at night.
Arctic Tern	Annex I species. Internationally important population breeding on Inishglora and Iniskeeragh Island SPA.	Diurnal foraging Chick provisioning. Fledged young. Plunge diving	1. to 4. Above Plus: Underwater collision with mooring chains and devices owing to plunge diving
Manx Shearwater	Migratory seabird. Internationally important breeding population in Ireland	Large flocks in foraging rafts Foraging birds from large breeding colonies. Diurnal and nocturnal foraging Shallow diver	1. to 4. Above Plus: Underwater collision with mooring chains., Disturbance owing to night lighting of Areas
Gannet	Migratory seabird	Foraging	1. to 4. Above

	Internationally important breeding population in Ireland	Resting Plunge diving.	Plus: Underwater collision with mooring chains and devices owing to plunge diving.
Auks	Local breeding colonies of national importance.	Foraging, resting, rafting Adults with flightless young. Shallow diving.	1. to 4. Above Plus: Underwater collision with mooring chains and devices.

Where likely impacts have been identified in terms of a species or species group, the significance of this impact has been assessed, following a standard assessment process detailed below.

6.39a. Assessment of significance (Operational Phase) - Area of potential Impact: The Bay

Potential impact:	**Changes to the feeding resource due to any long term effects of cabling and the presence of rock armour on the benthos and due to any changes in sediment patterns resulting from the wave energy arrays.**
Significance criteria	
Character and perceived value of affected environment	Regular use by the Annex I species Great Northern Diver in winter and Spring (October to May). Regular use by the Annex I species Arctic Tern in Spring (May to July) Regular use by nationally important numbers of wintering Long tailed Duck with favoured feeding area. Regular use by Eider in Autumn and Spring, linked to local breeding population at southern edge of range. Use by rafts of Manx Shearwater between April and July.
Confidence in the accuracy of predictions of change	Changes to the benthic environment due to cabling should be short term, but where sensitive habitats are affected recovery may take longer. Placement of rock armour will cause local changes to the subtidal environment. The rock armour will be inert, however a hard substrate will be colonised by marine organisms. Wider changes to sediment patterns within the Bay may take place as a result of the wave energy arrays
Magnitude, spatial extent and duration of anticipated change	Changes due to cabling and the placement of rock armour should be localised. Potential changes to sediment patterns due to the wave energy arrays are unlikely to be more than 20 m either side of the cable and as the analysis of infaunal grabs has shown this is a very dynamic environment subject to constant physical disturbance due to wave action.
Resilience of environment to cope with change	The shallow habitats of the Bay are likely to support suitable feeding habitat for divers and sea duck and Long tailed Duck appear to favour one area of the Bay. Changes to this feeding resource are likely to affect use of the Bay by these birds. Localised changes due to cabling and rock armour are unlikely to have long term effects on the Bay and therefore on the feeding resource (though attention is required for Long tailed Duck feeding area). Wider changes due to changes in sediment

	patterns may be more significant. Any changes to sediment patterns will depend on the scale of the development and cannot be assessed without modelling/ expert opinion on this matter.
Scope for mitigation, sustainability and reversibility	The amount of rock armour used should be minimised. Changes to the benthos resulting from cabling should be minimised. Potential changes to sediment patterns due to the wave energy arrays are not known.
Significance of impact	**Low – if changes to the benthos are minimised and are limited to the cabling and rock armour areas.** **High – if there are wider changes to sediment patterns due to the wave energy arrays with potential indirect effects on the feeding resource. TBC**

Table 6.39b. Assessment of significance (Operational Phase) - Area of potential impact: Wave energy Test areas A and B

Potential impact:	**Noise disturbance due to operational WECs**
Significance criteria	
Character and perceived value of affected environment	Supports a range of foraging seabirds including migratory, locally breeding and non-breeding birds.
Confidence in the accuracy of predictions of change	There are no studies into the impact of noise disturbance on marine birds due to WECs. Noise disturbance during deployment likely to be greater than during operation. Data on base line noise levels pre deployment should be gathered to allow meaningful consideration of this potential impact.
Magnitude, spatial extent and duration of anticipated change	Likely to be low, given only a small number of WEC devices will be deployed.
Resilience of environment to cope with change	Depends on the existing soundscape. Insufficient information on this potential impact.
Scope for mitigation, sustainability and reversibility	Minimise noise levels as much as possible. Further information on this potential impact is required.
Significance of impact	**UNKNOWN**
Potential impact:	**Displacement and/or redirection of birds due to wave energy array.**
Significance criteria	
Character and perceived	Use by foraging seabirds, including plunge diving species such as Gannet.

value of affected environment	Possible use by rafts of Manx Shearwater. Possible use by foraging Arctic Tern. Possible use by foraging Storm Petrel breeding on nearby Inishglora.
Confidence in the accuracy of predictions of change	It is not possible to predict what effect the wave energy array will have on birds. They may not use the area occupied by the devices or they may still forage close by. There is likely to be some species which adapt and others which don't. Data so far does not indicate any favoured feeding areas within the study site, which is expected as it is an offshore dynamic environment with no features which might be linked to increased feeding opportunities, e.g. steep shelf. Foraging rafts and feeding flocks of birds have been recorded in the area. Any displacement effects are likely to be minimised, given that the Test areas will occupy only a small proportion of available habitat and given that there appears to be no particular attraction by birds to specific features within the study area.
Magnitude, spatial extent and duration of anticipated change	Any displacement effects will last for the duration of the project, however resident birds may habituate to the WECs during this time. The magnitude of changes cannot be predicted and monitoring is necessary in this regard.
Resilience of environment to cope with change	The open sea is a vast and dynamic environment. However, this area is of considerable interest in terms its use by birds. It seems likely that any displacement effects will not be significant due to the availability of alternative habitat, however monitoring is necessary.
Scope for mitigation, sustainability and reversibility	No mitigation possible until further data on interactions and effects is known. Number of arrays at the test site should be limited until effects have been studied and to limit potential cumulative impacts.
Significance of impact	**UNKNOWN**
Potential impact:	**Disorientation due to night lighting**
Significance criteria	
Character and perceived	Open sea area used by the nocturnal foraging species, Storm Petrel, which breed on Inishglora.

value of affected environment	Open sea area used by the nocturnal foraging species, Manx Shearwater
Confidence in the accuracy of predictions of change	Night lighting can attract birds and in the case of for example lighthouses can cause mortality due to collision. Night lighting can also cause disorientation, especially to newly fledged young. However, in this case the lighting of the Test Areas will be the same as lights used on cardinal buoys, with only one light at each Area. Disorientation is therefore considered unlikely.
Magnitude, spatial extent and duration of anticipated change	Duration of development being in place.
Resilience of environment to cope with change	There are already some lighting of buoys in the area and two further marker buoys are unlikely to have any serious effects.
Scope for mitigation, sustainability and reversibility	No mitigation.
Significance of impact	**Low– as lighting arrangement will be limited to one cardinal marker at each corner of the test and use of normal navigational lights..**
Potentiall impact:	**Collision with underwater cables between anchors and WECs. Above water collision with WECs.**
Significance criteria	
Character and perceived value of affected environment	Area used by foraging sea birds including species which plunge dive, shallow dive and surface dive Area used by foraging Arctic Tern and Storm Petrel which may be feeding chicks.
Confidence in the accuracy of predictions of change	There is no data on seabird mortality due to collision with WECs. It seems likely that plunge diving species such as Gannet and Terns are most at risk from collision and that this risk will be greater where there is an array of devices and a concentration of underwater chains or cables. The number of birds which are likely to collide and the significance of any mortality on breeding

	population levels cannot be assessed until studies on this potential interaction have taken place.
Magnitude, spatial extent and duration of anticipated change	This cannot be estimated at present. However, alternative habitat is available and at present the data does not show any obvious attraction by birds to the proposed test areas.
Resilience of environment to cope with change	Given the threats to seabird populations from a range of other factors, it would seem unlikely that mortality due to collision with WECs would be significant, at a population level. However, any mortality may be significant to local breeding populations that may include Annex I species and nationally important populations linked to Special Protection Areas.
Scope for mitigation, sustainability and reversibility	Consideration should be given to any possible ways that may reduce the collision risk.
Significance of impact	**Low – at a population level, though this interaction has not been studied and base line data on the study site is limited as present.** **High – if locally breeding species are impacted such as Arctic Terns which breed in nationally important numbers. However, monitoring is required to assess collision risk.**
Potential impact:	**Changes to sediment process resulting from wave energy arrays and indirectly affecting food web interactions**
Significance of criteria	
Character and perceived value of affected environment	Supports a range of foraging seabirds including migratory, locally breeding and non breeding birds.
Confidence in the accuracy of predictions of change	Wave energy devices will remove wave energy from the environment in which they are placed. It would seem unlikely that the devices at 100 m depth would have any effect on wave energy levels, given the vastness of the sea area in which they are located. However, the Area at 50 m depth may have some effect on wave energy and sediment processes around Inishglora Island and within the Bay.

Magnitude, spatial extent and duration of anticipated change	Unknown
Resilience of environment to cope with change	A dynamic environment which should be adaptable to change.
Scope for mitigation, sustainability and reversibility	None
Significance of impact	**UNKNOWN**
Potential impact:	**Impacts on water quality due to oil spillage, use of antifoulants and due to non use of antifoulants**
Significance criteria	
Character and perceived value of affected environment	Inishglora Island SPA lies close to Area at 50 m depth. Eider, divers and terns foraging around Inishglora Birds breeding on Inishglora Area is generally important for a range of wintering and foraging breeding and non breeding birds.
Confidence in the accuracy of predictions of change	Unsure as to risk of spillage and quantities which may be involved. Biodegradable lubricants will be used on Pelamis. No antifoulants to be used on Pelamis but algae may accumulate on the seabed.
Magnitude, spatial extent and duration of anticipated change	Local effects on water quality possible due accumulations of organic matter below devices. However, It is likely that in such an exposed sea area any accumulations will be rapidly dispersed. Magnitude of change due to lubricant spillages is unknown.
Resilience of environment to	Spillages are likely to be quickly dispersed, given the exposed nature of the site. However, leakages of any toxic materials into

cope with change	the marine environment must be avoided.
Scope for mitigation, sustainability and reversibility	Use of biodegradable materials only.
Significance of impact	**Low – if only appropriate materials used and all steps taken to avoid spillages.**
Potential impact:	**Creation of artificial reef, roosting habitat, marine protected area, fish aggregation area**
Significance criteria	
Character and perceived value of affected environment	Supports a range of foraging seabirds including migratory, breeding and non breeding birds.
Confidence in the accuracy of predictions of change	The presence of hard substrates such as anchors in an otherwise sediment dominated environment will provide habitats for sessile macrofauna. This in turn may lead to a community of species associated with the wave energy devices which would not have been present otherwise. The exclusion of fishing vessels from the Test areas may have the effect of creating small fish aggregation areas or de facto marine protected areas. It is likely that some birds such as Gulls, Cormorants and Shags will use the WECs as roosting sites. These are potentially positive effects which may results from the proposed test site. These effects have yet to be proven and will require monitoring and consideration of other test sites or similar developments.
Magnitude, spatial extent and duration of anticipated change	Unknown. However, only localised changes are anticipated.
Resilience of environment to cope with change	Unknown

Scope for mitigation, sustainability and reversibility	When the WECs are decommissioned the habitat should revert to pre wave energy test site conditions.
Significance of impact	**UNKNOWN – potentially positive.**

6.6 MITIGATION OF IMPACTS

6.6.1 Construction phase

Potential impact	Scope for mitigation, sustainability and reversibility
Changes and disturbance to shore habitats and birds at Belderra Strand due to landfall activities on the shore.	Disturbance impacts should be minimised by limiting construction activities to the summer months, when wintering waders are not present. Disturbance to shingle habitats should be avoided or assessed for breeding wader activity. An ecologist should be present during construction
Disturbance to wintering birds and breeding Ringed Plover due to noise from landfall and substation activities, including increased road traffic and human activity.	Disturbance impacts should be minimised by limiting construction activities to the summer months, when wintering waders are not present. Disturbance to shingle habitats should be avoided or assessed for breeding wader activity. Construction activity should take place in July and August, outside of key wintering and breeding months. An ecologist should be present during construction
Changes to subtidal habitat within the Bay due to cabling potentially disturbing the benthos with indirect effects on feeding birds.	The trenching method with the least disturbance to the seabed should be used. Avoidance of trenching in areas favoured by foraging Long tailed duck, if possible.
Changes to subtidal habitat where rock armouring is used with direct impacts on the benthos and potential indirect effects on the feeding resource.	The amount of rock armour used should be minimised. Placing of rock armour should take place in July and August or at least not in the months October to May when wintering and Spring moulting birds are present.
Disturbance to birds due to activity of cable laying boat within the Bay	The cable laying should be carried out as efficiently as possible within the minimum timeframe possible. Long-term negative effects from disturbance should therefore be avoided. Cable laying should take place in the summer months.
Disturbance to birds due to cable laying at sea and deployment activities within the Area areas.	Steps should be taken to minimise noise disturbance and to limit the duration of cable laying and deployment activities.

6.6.2 Operational phase

Potential impact	Scope for mitigation, sustainability and reversibility
Disturbance due to noise from operational WECs.	The impacts of noise disturbance on birds due to WECs has not been studied. Disturbance should be minimised. Further information on this potential impact is required. Noise propagation is at its maximum in flat calm conditions when the WECs will be largely inoperable, hence there will be little or no surface noise a this time. As wind and wave increase the WECs become more active but the surface noise is propagated less. Hence the potential impact is likely to be very low.
Changes to the feeding resource due to any long term effects of cabling and the presence of rock armour on the benthos and due to any changes in sediment patterns resulting from the wave energy arrays.	The amount of rock armour used should be minimised. Changes to the benthos resulting from cabling should be minimised by ensuring the minimum footprint possible. Potential changes to sediment patterns due to wave energy arrays are not known.
Displacement and/or redirection of birds due to wave energy array.	No mitigation possible until further data on interactions and effects is known. Research data is lacking due to the relatively recent and limited number of wave energy arrays globally. Future monitoring will contribute to the knowledge base required to make informed decisions in this regard.
Disorientation due to night lighting	No mitigation required.
Collision with underwater cables between anchors and WECs. Above water collision with WECs.	Consideration should be given to any possible ways that may reduce the collision risk.
Changes to sediment process resulting from wave energy arrays and indirectly affecting food web interactions	If changes are anticipated it may be possible to move the Area to another location, e.g. further away from Inishglora Island.
Impacts on water quality due to oil spillage, use of antifoulants and due to non use of antifoulants	Use of biodegradable materials where feasible.
Creation of artificial reef, roosting habitat, de factor marine protected area, fish aggregation area.	Potentially positive impact.

6.7 MONITORING

Mitigation during the operational phase:	
Potential impact	Scope for mitigation, sustainability and reversibility
Disturbance due to noise from operational WECs.	The impacts of noise disturbance on birds due to WECs is not known due to the limited number of wave energy arrays globally. Future monitoring will contribute to the knowledge base required to make informed decisions in this regard.
Changes to the feeding resource due to any long term effects of cabling and the presence of rock armour on the benthos and due to any changes in sediment patterns resulting from the wave energy arrays.	The amount of rock armour used should be minimised. Changes to the benthos resulting from cabling should be minimised..
Displacement and/or redirection of birds due to wave energy array.	No mitigation possible until further data on interactions and effects is known.
Disorientation due to night lighting	No mitigation required.
Collision with underwater cables between anchors and WECs. Above water collision with WECs.	Consideration should be given to any possible ways that may reduce the collision risk. This potential impact requires further study.
Changes to sediment process resulting from wave energy arrays and indirectly affecting food web interactions	No mitigation required as the impact is likely to be very localised and short-lived.
Impacts on water quality due to oil spillage, use of antifoulants and due to non use of antifoulants	Use of biodegradable materials where feasible.
Creation of artificial reef, roosting habitat, de factor marine protected area, fish aggregation area.	Potentially positive impact.

Continue land based monitoring of open water, Bay and shore habitats to assess any impacts on wintering birds and to build on existing data. Future monitoring will add to the current baseline dataset by continuing land and sea based surveys monthly throughout 2011 and 2012.

Continue sea-based surveys for a further 10 years to gather sufficient data to detect any change in use of the study area by seabirds, which may be linked to the wave energy test site.

Where possible complete point counts within the open sea survey area to assess positive and/or negative interactions between the wave energy convertors and birds.

Continue to monitor the Storm Petrel colony on Inishglora Island to assess any changes in breeding numbers, which may be linked to the proposed wave energy test site.

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Appendix 2: Survey coverage for land based surveys of shore and inshore habitats.

Vantage Point		Annagh Beach				Emlybeg Beach				Belderra Beach				Cross Point				Annagh Head			
Surveyor	**2009-10**	**Start**	**Fin.**	**Tot. Mins**	**Tide**	**Start**	**Fin.**	**Tot. Mins**	**Tide**	**Start**	**Fin.**	**Tot. Mins**	**Tide**	**Start**	**Fin.**	**Tot. Mins**	**Tide**	**Start**	**Fin.**	**Tot. Mins**	**Tide**
JH	29/09	1010	1100	50		ns				1130	1310	100		1255	1530	155		1630	1800	90	
JH	26/10	745	845	60	mid	ns				1500	1550	50		930	1100	90		1310	1425	75	
JH	10/11	750	900	70	mid-rising	1400	1421	20	high	1300	1330	30	high	940	1220	160	rising	1500	1720	140	Falling
JH	28/11																	1030	1340	200	Rising
JH/DMcL	15/12	930	1000	30	HW	1400	1430	30	Falling	1250	1320	30	falling	1300	1500	120	Falling	910	1145	155	HW
JH	20/01	1110	1130	20	falling	1205	1300	55	Falling	1330	1400	30	low	1430	1600	90	LW	830	1040	130	HW
JH/DMcL	08/02	1600	1630	30	high-falling	1340	1430	50	HW	930	1015	45	low	900	1115	135	LW	1540	1720	100	Falling
JH	10/03	1420	1440	20	mid-rising	1235	1330	55	rising	1140	1145	5	low	915	1100	105	Falling	1505	1700	120	rising
JH	21/04	1200	1230	30	mid-falling	1345	1440	55	falling	1500	1530	30	falling	1530	1710	100	low	915	1115	120	HW
JH	21/04 - dusk													1940	2045	65	rising				
JH	21/05	1445	1530	45	HW	1310	1350	40	HW	1140	1240	60	near HW	730	1115	225	mid-rising	1605	1745	100	Falling

Vantage Point		Annagh Beach				Emlybeg Beach				Belderra Beach				Cross Point				Annagh Head			
Surveyor	**2009-10**	**Start**	**Fin.**	**Tot. Mins**	**Tide**	**Start**	**Fin.**	**Tot. Mins**	**Tide**	**Start**	**Fin.**	**Tot. Mins**	**Tide**	**Start**	**Fin.**	**Tot. Mins**	**Tide**	**Start**	**Fin.**	**Tot. Mins**	**Tide**
JH	14/06	1600	1635	35	mid-rising	1740	1835	55	HW	1900	1920	20	HW	1945	2150	120	Falling	1140	1450	190	LW
JH	25/07	1545	1615	30	mid-rising	1420	1510	50	low-rising	1245	1325	40	LW	945	1230	165	Falling	1650	1800	70	HW
JH	21/08	1245	1320	35	LW	1400	1500	60	low-rising	1600	1640	40	mid-rising	1700	1850	110	HW	850	1200	190	mid-falling

Appendix 3: Environmental conditions during land – based surveys of shore and inshore waters

Vantage Point	Annagh Beach							Emlybeg Beach							Belderra Beach						
Month	**Wind drn**	**Force**	**Sea state**	**Swell**	**Vis**	**Rain**	**Cloud cover**	**Wind drn**	**Force**	**Sea state**	**Swell**	**Vis**	**Rain**	**Cloud cover**	**Wind drn**	**Force**	**Sea state**	**Swell**	**Vis**	**Rain**	**Cloud cover**
September	SW	3	3	<2m	mod	None	8/8								SW	3	3	<2m	mod	None	8/8
October	var	1	1	0	exc	None	2/8								NE	4	2	<2m	mod	drizzle	8/8
November	var	1	1	0	exc	None	4/8	NW	1	breakers	2-4m	poor	none	0/8	NW	2	2	4	good	showers	6/8
December	NW	1-2	1	<2m	good	showers	8/8	NW	1-2	1	<2m	good	showers	8/8	NW	1-2	1	<2m	good	showers	8/8
January	var	2	1	<2m	good	None	3/8	var	2	1	<2m	good	None	3/8	var	2	1	<2m	good	None	3/8
February	NE	3	2	<2m	good	none	6/8	NE	2	2	2-4m	good	none	6/8	NE	3	2	<2m	good	none	6/8
March	var	1	1	0	good	none	0/8	var	1	1	0	good	none	0/8	var	1	1	0	good	none	0/8
April	var	2	2	<2m	exc	None	0/8	var	2	2	<2m	exc	None	0/8	var	2	2	<2m	exc	None	0/8
May	SW	1	1	0	good	none	8/8	SW	1	1	0	good	none	8/8	SW	1	1	0	good	none	8/8
June	S	2	2	2	good	None	8/8	N	3	3	>4m	good	None	0/8	N	3	3	>4m	good	None	0/8
July	W	2	2	<2m	poor	drizzle	8/8	W	2	2	<2m	poor-mod	drizzle	8/8	W	2	2	<2m	poor-mod	drizzle	8/8
Aug	S	4-5	4	<2m	exc	showers	8/8	SW	4-5	4	2-4m	exc	showers	8/8	SW	4	4	2-4m	good	showers	8/8

Appendix 3 (cont'd)

Vantage Point	**Cross Point**							**Annagh Head**							
Month	**Wind drn**	**Force**	**Sea state**	**Swell**	**Vis**	**Rain**	**Cloud cover**	**Wind drn**	**Force**	**Sea state**	**Swell**	**Vis**	**Rain**	**Cloud cover**	**NOTES**
September	SW	3	3	<2m	mod	Drizzle	8/8	3	3	<2m	mod	8/8			
October	var	1	1	0	exc	none	2/8	W	3	4	2	good	none	8/8	Conditions deteriorated in the afternoon, but still with good visibility. Heavy sea.
November	NW	4-2	4-2	2-4 m	exc	none	3/8	var	2	2	2	poor	none	0/8	Waves breaking at Emlybeg. Glare from sun at Emlybeg and Annagh Head
November								var	0	1	2-4m	exc	none	1/8	Repeat count from Annagh Head only
December	N	2-3	1	<2m	good	showers	6/8	NW	3-4	1	<2m	good	showers	8/8	
January	var	2	1	<2m	good	none	0/8	var	2	1	2-4m	mod	none	3/8	Some fog patches on the sea. Low sun limiting viewing from some VP's
February	NE	2	2	<2m	good	none	6/8	NE	3	2	2-4m	good	none	6/8	Good visibility but low sun and glare limited viewing in parts of sector C
March	var	1	1	0	good	none	0/8	N	2	1	<2m	good	none	0/8	Glare from sun limiting viewing between Inishglora and Annagh Head
April	var	2	2	<2m	exc	none	0/8	var	1	2	<2m	exc	none	0/8	
May	var	1	0	0	good	light shower	8/8	Var	1	1	2-4m	mod	none	8/8	

Vantage Point	Cross Point							Annagh Head							
Month	**Wind drn**	**Force**	**Sea state**	**Swell**	**Vis**	**Rain**	**Cloud cover**	**Wind drn**	**Force**	**Sea state**	**Swell**	**Vis**	**Rain**	**Cloud cover**	**NOTES**
June	N	3	3	>4m	good	None	0/8	N	2 up to 4	3	>4m	good	none	7/8	Detection of birds on water difficult due to sea conditions hence longer time taken for survey
July	W	2	2	<2m	poor-mod	drizzle	8/8	W	3	3	<2m	poor	drizzle	8/8	Sea fog limited survey. At times visibility only to 1 km.
Aug	S	4-5	4	2-4m	exc	showers	6/8	SW - S	4-5	4	2-4	exc	light showers	6/8	Strong winds made detection harder, but scans made slower to compensate.

Appendix 4: Common, Species and Scientific names of birds referred to in the text.

Common Name	Species Name	Scientific Name
Red-throated Diver	Red-throated Diver	Gavia stellata
Great Northern Diver	Great Northern Diver	Gavia immer
Great crested Grebe	Great crested Grebe	Podiceps critatus
Fulmar	Northern Fulmar	Fulmarus glacialis
Great Shearwater	Great Shearwater	Puffinus gravis
Manx Shearwater	Manx Shearwater	Puffinus puffinus
Sooty Shearwater	Sooty Shearwater	Puffinus griseus
Balearic Shearwater	Balearic Shearwater	Puffinus mauretanicus
Storm Petrel	European Storm Petrel	Hydrobates pelagicus
Gannet	Northern Gannet	Morus bassanus
Cormorant	Great Cormorant	Phalacrocorax carbo
Shag	European Shag	Phalacrocorax aristotelis
Grey Heron	Grey Heron	Ardea cinerea
Whooper Swan	Whooper Swan	Cygnus cygnus
Barnacle Goose	Barnacle Goose	Branta leucopsis
Brent Goose	Light-bellied Brent Goose	Branta bernicla
Shelduck	Common Shelduck	Tadorna tadorna
Mallard	Mallard	Anas platyrhynchos
Eider	Common Eider	Somateria mollissima
Long tailed Duck	Long tailed Duck	Clangula hyemalis
Oystercatcher	Eurasian Oystercatcher	Haematopus ostralegus
Ringed Plover	Ringed Plover	Charadrius hiaticula
Golden Plover	Golden Plover	Pluvialis apricaria
Sanderling	Sanderling	Calidris alba
Purple Sandpiper	Purple Sandpiper	Calidris maritima
Common Sandpiper	Common Sandpiper	Actitis hypoleucos
Turnstone	Ruddy Turnstone	Arenaria interpres
Dunlin	Dunlin	Calidris alpina

Common Name	Species Name	Scientific Name
Redshank	Common Redshank	Tringa totanus
Greenshank	Common Greenshank	Tringa nebularia
Curlew	Eurasian Curlew	Numenius arquata
Whimbrel	Whimbrel	Numenius phaeopus
Common Snipe	Common Snipe	Gallinago gallinago
Grey Phalarope	Grey (Red) Phalarope	Phalaropus fulicarius
Great Skua	Great Skua	Stercorarius skua
Arctic Skua	Arctic Skua	Stercorarius parasiticus
Pomarine Skua	Pomarine Skua	Stercorarius pomarinus
Black-headed Gull	Black-headed Gull	Larus ridibundus
Common Gull	Mew Gull	Larus canus
Herring Gull	Herring Gull	Larus argentatus
Lesser Black-backed Gull	Lesser Black-backed Gull	Larus fuscus
Great Black-backed Gull	Great Black-backed Gull	Larus marinus
Kittiwake	Black-legged Kittiwake	Rissa tridactyla
Little Tern	Little Tern	Sterna albifrons
Sandwich Tern	Sandwich Tern	Sterna sandvicensis
Common Tern	Common Tern	Sterna hirundo
Arctic Tern	Arctic Tern	Sterna paradisaea
Little Auk	Little Auk	Alle alle
Puffin	Atlantic Puffin	Fratercula arctica
Black Guillemot	Black Guillemot	Cepphus grylle
Guillemot	Common Guillemot	Uria aalge
Razorbill	Razorbill	Alca torda
Rock dove	Rock dove	Columba livia
Skylark	Common Skylark	Alauda arvensis
Sand Martin	Sand Martin	Riparia riparia
Barn Swallow	Barn Swallow	Hirundo rustica
Meadow Pipit	Meadow Pipit	Anthus pratensis
Rock Pipit	Rock Pipit	Anthus petrosus

Common Name	Species Name	Scientific Name
Wren	Wren	Troglodytes troglodytes
Wheatear	Northern Wheatear	Oenanthe oenanthe
Redwing	Redwing	Turdus iliacus
Fieldfare	Fieldfare	Turdus pilaris
Magpie	Common Magpie	Pica pica
Jackdaw	Jackdaw	Corvus monedula
Hooded Crow	Hooded Crow	Corvus corone cornix
Raven	Raven	Corvus corax
Starling	Common Starling	Sturnus vulgaris
Pied Wagtail	Pied Wagtail	Motacilla alba
Goldfinch	European Goldfinch	Carduelis carduelis

Appendix 5 Biotope Descriptions for the biotopes assigned to the macrofaunal stations.

SS.SCS.CCS Circalittoral coarse sediment

Habitat classification

Salinity: Full (30-35ppt)

Wave exposure: Exposed, Moderately exposed

Tidal streams: Moderately strong, Weak, Very weak

Substratum: Coarse sand and gravel with a minor finer sand fraction

Zone: Infralittoral - lower, Circalittoral

Depth band: 10-20 m, 20-30 m, 30-50 m

Biotope description

Tide-swept circalittoral coarse sands, gravel and shingle generally in depths of over 15-20 m. This habitat may be found in tidal channels of marine inlets, along exposed coasts and offshore. This habitat, as with shallower coarse sediments, may be characterised by robust infaunal polychaetes, mobile crustacea and bivalves. Certain species of sea cucumber, e.g. *Neopentadactyla*, may also be prevalent in these areas along with the lancelet *Branchiostoma lanceolatum*.

Situation

No situation data available.

Temporal variation

No temporal data available.

SS.SSA.IFiSa.NcirBat *Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand

Habitat classification

Salinity: Full (30-35ppt)

Wave exposure: Exposed, Moderately exposed

Tidal streams: Weak, Very weak

Substratum: Medium to very fine sand

Zone: Infralittoral

Depth band: 0-5 m, 5-10 m

Biotope description

Well-sorted medium and fine sands characterised by *Nephtys cirrosa* and *Bathyporeia* spp. (and sometimes *Pontocrates* spp.) which occur in the shallow sublittoral to at least 30 m depth. This biotope occurs in sediments subject to physical disturbance, as a result of wave action (and occasionally strong tidal streams). The magelonid polychaete *Magelona mirabilis* may be frequent in this biotope in more sheltered, less tideswept areas whilst in coarser sediments the opportunistic polychaete *Chaetozone setosa* may be commonly found. The faunal diversity of this biotope is considerably reduced compared to less disturbed biotopes (such as FfabMag) and for the most part consists of the more actively-swimming amphipods. Sand eels *Ammodytes* sp. may occasionally be observed in association with this biotope (and others) and spionid polychaetes such as *Spio filicornis* and *S. martinensis* may also be present. Occasional *Lanice conchilega* may be visible at the sediment surface.

Situation

No situation data available.

Temporal variation

Stochastic recruitment events in the *Nephtys cirrosa* populations may be very important to the population size of other polychaetes present and may therefore create a degree of variation in community composition (Bamber 1994).

Similar biotopes

SSA.NcirMac The current biotope is very similar to NcirMac, which occurs in reduced/variable salinities with additional reduced salinity fauna.

LSA.AmSco.Pon AmSco.Pon is closely allied to NcirBat but occurs in the intertidal zone

LSA.Po Po is closely allied to NcirBat but occurs in the intertidal zone

SSA.IMoSa As sediment disturbance increases NcirBat may grade into IMoSa with only the most robust species able to tolerate the mobile sand environment

SSA.FfabMag As sediment disturbance decreases and the finer silt fraction can begin to sediment out of the water column NcirBat may grade into the muddy sand biotope FfabMag.

Characterising species	% Frequency	Abundance (SACFOR)	% Contrib Similarity	No. / m2
POLYCHAETA	••	Present	4	
Nephtys cirrosa	•••••	Common	43	40
Nephtys hombergii	••	Present	1	4
Scoloplos armiger	••	Present	1	4
Spio filicornis	••	Frequent	1	14
Spio martinensis	••	Present	1	23
Spiophanes bombyx	••	Present	2	7
Magelona mirabilis	••••	Frequent	15	38
Chaetozone setosa	•••	Common	5	16
Lanice conchilega	•••	Occasional	57	
Pontocrates arenarius	••	Frequent	2	16
Bathyporeia elegans	•••	Frequent	14	140
Bathyporeia guilliamsoniana	••	Frequent	5	18
Crangon crangon	••	Rare	5	
Pagurus bernhardus	••	Occasional	8	
Liocarcinus depurator	••	Occasional	8	
Fabulina fabula	••	Present	1	5
Echinocardium cordatum	••	Present	4	
Ammodytes tobianus	••	Rare	8	
Pomatoschistus	••	Occasional	8	

SS.SSA.CFiSa Circalittoral fine sand

Habitat classification

Salinity: Full (30-35ppt), Variable (18-35ppt)

Wave exposure: Moderately exposed, Sheltered, Very sheltered

Tidal streams: Weak, Very weak

Substratum: Clean fine sands

Zone: Circalittoral

Depth band: 10-20 m, 20-30 m, 30-50 m

Biotope description

Clean fine sands with less than 5% silt/clay in deeper water, either on the open coast or in tide-swept channels of marine inlets in depths of over 15-20 m. The habitat may also extend offshore and is characterised by a wide range of echinoderms (in some areas including the pea urchin *Echinocyamus pusillus*), polychaetes and bivalves. This habitat is generally more stable than shallower, infralittoral sands and consequently supports a more diverse community.

Situation

No situation data available.

Temporal variation

No temporal data available.

Characterising species	**% Frequency**	**Abundance (SACFOR)**	**% Contrib Similarity**	**No. / m^2**
Virgularia mirabilis	••	Occasional		
Cerianthus lloydii	•••	Frequent		
Nephtys	••	Common		
Spiophanes bombyx	••	Frequent		
Chaetozone setosa	••	Common		
Lanice conchilega	•••	Occasional		
Pagurus bernhardus	•••	Occasional		
Nucula nitidosa	••	Frequent		
Pecten maximus	••	Occasional		
Abra alba	••	Common		
Asterias rubens	•••	Occasional		
Amphiura filiformis	•••	Abundant		
Ophiura albida	•••	Frequent		
Ophiura ophiura	••	Frequent		

SS.SSA.CFiSa.EpusOborApri *Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand

Habitat classification

Salinity: Full (30-35ppt)

Wave exposure: Not known

Tidal streams: Not known

Substratum: Medium to fine sand.

Zone: Circalittoral

Biotope description

Circalittoral and offshore medium to fine sand (from 40 m to 140 m) characterised by the pea urchin *Echinocyamus pusillus*, the polychaete *Ophelia borealis* and the bivalve *Abra prismatica*. Other species may include the polychaetes *Spiophanes bombyx*, *Pholoe* sp., *Exogone* spp., *Sphaerosyllis bulbosa*, *Goniada maculata*, *Chaetozone setosa*, *Owenia fusiformis, Glycera lapidum, Lumbrineris latreilli* and *Aricidea cerrutii* and the bivalves *Thracia phaseolina* and *Moerella pygmaea* and to a lesser extent *Spisula elliptica and Timoclea ovata*. This biotope has been found in the central and northern North Sea.

Situation

No situation data available.

Temporal variation

No temporal data available.

Similar biotopes

SCS.MedLumVen This biotope is similar to MedLumVen but it occurs in finer sediments with a lower proportion of venerid bivalves.

Appendix 6. Biotope Descriptions for the biotopes assigned from video survey

CR.HCR.XFa Mixed faunal turf communities

Habitat classification

Salinity: Full (30-35ppt) CR.MCR.XFa 97.06

Wave exposure: Extremely exposed, Very exposed, Exposed, Moderately exposed

Tidal streams: Strong, Moderately strong

Substratum: Bedrock, boulders

Zone: Circalittoral - upper, Circalittoral - lower

Depth band: 5-10 m, 10-20 m, 20-30 m

Biotope description

This biotope complex occurs on wave-exposed, circalittoral bedrock, and boulders subject to strong to moderately strong tidal streams. This complex is characterised by its diverse range of hydroids (*Halecium halecinum*, *Nemertesia antennina* and *Nemertesia ramosa*), bryozoans (*Alcyonidium diaphanum*, *Flustra foliacea*, *Bugula flabellata* and *Bugula plumosa*) and sponges (*Scypha ciliata*, *Pachymatisma johnstonia*, *Cliona celeta*, *Raspalia ramosa*, *Esperiopsis fucorum*, *Hemimycale columella* and *Dysidea fragilis*) forming an often dense, mixed faunal turf. Other species found within this complex are *Alcyonium digitatum*, *Urticina felina*, *Sagartia elegans*, *Actinothoe sphyrodeta*, *Caryophyllia smithii*, *Pomatoceros triqueter*, *Balanus crenatus*, *Cancer pagurus*, *Necora puber*, *Asterias rubens*, *Echinus esculentus* and *Clavelina lepadiformis*. Nine biotopes have been identified within this complex: ByErSp, FluCoAs, FluHocu, CvirCri, SwiLgAs, Mol, SubCriTf, SpNemAdia and SpAnVt.

Characterising species (SACFOR)	% Frequency	Abundance
Scypha ciliata	••	Occasional
Pachymatisma johnstonia	•••	Occasional
Cliona celata	••••	Occasional
Raspailia ramose	•••	Occasional
Esperiopsis fucorum	•••	Occasional

Hemimycale columella	•••	Occasional
Dysidea fragilis	•••	Occasional
Halecium halecinum	•••	Occasional
Nemertesia antennina	••••	Frequent
Nemertesia ramosa	•••	Occasional
Alcyonium digitatum	•••••	Frequent
Urticina felina	•••	Occasional
Sagartia elegans	•••	Occasional
Actinothoe sphyrodeta	•••	Occasional
Caryophyllia smithii	•••	Frequent
Pomatoceros triqueter	•••	Occasional
Balanus crenatus	•••	Frequent
Cancer pagurus	•••	Occasional
Necora puber	•••	Occasional
Calliostoma zizyphinum	•••	Occasional
Alcyonidium diaphanum	••••	Frequent
Flustra foliacea	••••	Frequent
Bugula flabellate	•••	Occasional
Bugula plumosa	•••	Frequent
Asterias rubens	•••••	Frequent
Echinus esculentus	•••	Occasional
Clavelina lepadiformis	•••	Occasional

CR.MCR.EcCr Echinoderms and crustose communities

Habitat classification

Salinity: Full (30-35ppt)

Wave exposure: Extremely exposed, Very exposed, Exposed, Moderately exposed

Tidal streams: Moderately strong, Weak

Substratum: Bedrock, boulders

Zone: Circalittoral - upper, Circalittoral - lower

Depth band: 10-20 m, 20-30 m, 30-50 m

Biotope description

This biotope complex occurs on wave-exposed, moderately strong to weakly tide-swept, circalittoral bedrock and boulders. Echinoderms, faunal (*Parasmittina trispinosa*) and algal crusts (red encrusting algae) dominate this biotope, giving a 'sparse' appearance. Typical echinoderms present are the starfish *Asterias rubens*, the brittlestar *Ophiothrix fragilis* and the sea urchin *Echinus esculentus*. There may be isolated clumps of the hydroids *Nemertesia antennina* and *Abietinaria abietina*, *Alcyonium digitatum*, the anemone *Urticina felina* and the cup coral *Caryophyllia smithii*. Other species present may include the polychaete *Pomatoceros triqueter* and the top shell *Calliostoma zizphinum*. Five biotopes have been identified within this biotope complex: CarSwi, CarSp, FaAlCr, AdigVt and UrtScr.

Characterising species	% Frequency	Abundance *(SACFOR)*
Nemertesia antennina	•••	Occasional
Abietinaria abietina	•••	Occasional
Alcyonium digitatum	•••••	Frequent
Urticina felina	•••	Occasional
Caryophyllia smithii	•••	Frequent
Pomatoceros triqueter	•••	Frequent
Calliostoma zizyphinum	•••	Occasional
Parasmittina trispinosa	•••	Frequent
Asterias rubens	••••	Occasional
Ophiothrix fragilis	••	Frequent

Echinus esculentus	•••••	Frequent
Corallinaceae	••••	Common

IR.HIR.KFaR.LhypRVt *Laminaria hyperborea* and red seaweeds on exposed vertical rock

Habitat classification

Salinity: Full (30-35ppt) SCAs.ByH in part 97.06

Wave exposure: Extremely exposed, Very exposed, Exposed, Moderately exposed

Tidal streams: Moderately strong, Weak, Very weak

Substratum: Bedrock

Zone: Infralittoral

Depth band: 0-5 m, 5-10 m, 10-20 m

Other features: Vertical rock.

Biotope description

On exposed coasts with moderately strong to weak tidal currents generally at depths of 0 10 m, vertical rock communities dominated by frequent *Laminaria hyperborea* and its commonly associated red seaweeds *Delesseria sanguinea*, *Cryptopleura ramosa* and *Plocamium cartilagineum* can be found. Within this biotope the jewel anemone *Corynactis viridis* is frequently found in dense aggregations attached to the vertical rock surface. This biotope contains 5 sub-biotopes, distinguished by their biogeography. On the west coast of Scotland, the Northern Isles and the Isle of Man on extremely exposed coasts a variant of this biotope characterised by frequent *Metridium senile* and occasional *Sagartia elegans* can be found. Further south on the west coast of Ireland, southern Scotland, Wales, and south west England a second variant characterised by frequent *Alcyonium digitatum* and occasional *Cliona celata* can be distinguished. A third variant has been recorded from Northern Ireland characterised by the red seaweeds *Lithophyllum* and *Ptilota gunneri*, the sea squirt *Dendrodoa grossularia* and the bryozoan *Membranipora membranacea*. South from the Isle of Man, on the Welsh Coast, and on the south west and southern English coasts a fourth variant of this biotope is found, which is characterised by the barnacle *Balanus crenatus*, which may be more frequent in this subbiotope, and the rarity of *Alcyonium digitatum*, a species which is more frequent in other variants. This variant has mainly been recorded in shallow water (0-5m). The final biogeographic variant of this biotope is, as with the previous variant, found on the coasts of Wales and south west England. It can be distinguished from the previous variant by the frequent *Diplosoma listerianum* and occasional *Lissoclinum perforatum*, although these species are not always present.

Situation

Open rocky coasts of the south-west, west and north-west.

Temporal variation

No temporal data available

Similar biotopes: MIR.LhypVt Much more species poor, with red algae sparse or absent.

SS.SSA.IFiSa.IMoSa Infralittoral mobile clean sand with sparse fauna

Habitat classification

Salinity: Full (30-35ppt) IGS.Mob 97.06

Wave exposure: Exposed, Moderately exposed, Sheltered

Tidal streams: Strong, Moderately strong, Very weak

Substratum: Medium to fine sand

Zone: Infralittoral

Depth band: 0-5 m, 5-10 m, 10-20 m

Biotope description

Medium to fine sandy sediment in shallow water, often formed into dunes, on exposed or tide-swept coasts often contains very little infauna due to the mobility of the substratum. Some opportunistic populations of infaunal amphipods may occur, particularly in less mobile examples in conjunction with low numbers of mysids such as *Gastrosaccus spinifer*, the polychaete *Nephtys cirrosa* and the isopod *Eurydice pulchra*. Sand eels *Ammodytes* sp. may occasionally be observed in association with this biotope (and others). This biotope is more mobile than SSA.NcirBat and may be closely related to LSa.BarSa on the shore. Common epifaunal species such as *Pagurus bernhardus*, *Liocarcinus depurator*, *Carcinus maenas* and *Asterias rubens* may be encountered and are the most conspicuous species present.

Situation

No situation data available.

Temporal variation

No temporal data available.

Similar biotopes

SSA.MoSaVS MoSaVS occurs in reduced salinities but differs in that the sparse fauna of

IMoSa are not tolerant of reduced salinities.

SSA.NcirBat Where sediment disturbance decreases in less exposed or weaker tidal currents, IMoSa may grade into NcirBat with an increase in species richness as the environment becomes more stable.

Characterising species % Frequency Abundance %Contribution to similarity

(SACFOR) Abundance (nos / m 2)

Nephtys	•	Present	4 3
Nephtys cirrosa	•	Present	11 2
Gastrosaccus spinifer	•	Present	13 2
Pontocrates arenarius	•	Present	17 4
Urothoe brevicornis	•	Present	15 2
Bathyporeia elegans	•	Present	1 1
Eurydice pulchra	•	Present	6 2
Pagurus bernhardus	•••••	Present	41
Liocarcinus depurator	••	Rare	4
Ammodytes	••	Frequent	3
Ammodytes tobianus	••••	Present	46
Pleuronectes platessa	••	Present	6

SS.SSA.OSa Offshore circalittoral sand

Habitat classification

Salinity: Full (30-35ppt) part of COS 97.06

Wave exposure: Not known

Tidal streams: Not known

Substratum: Fine sands and muddy sands.

Zone: Circalittoral

Biotope description

Offshore (deep) circalittoral habitats with fine sands or non-cohesive muddy sands. Very little data is available on these habitats however they are likely to be more stable than their shallower counterparts and characterised by a diverse range of polychaetes, amphipods, bivalves and echinoderms.

Situation

No situation data available.

Temporal variation

No temporal data available.