6 Flora and fauna

6.1 Introduction

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 by MERC Environmental Consultants in association with the Irish Whale and Dolphin Group. 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 following:

- Subtidal reefs
- Subtidal benthos
- Intertidal habitats and species
- Use of the site by marine mammals
- Terrestrial habitats and species
- Use of the site by birds

Preliminary ecological assessment of the proposed site (test areas, cable route, cable landfall and substation location) was undertaken to identify environmental constraints within the wider area as part of an initial screening assessment process. This indicated Belderra Strand as the optimum site for cable landing from the ecological aspect. Subsequently a full ecological assessment was carried out to establish the baseline for the study area. This study gathered baseline ecological data on a range of environmental factors (habitats and species) in and around the proposed AMETS and assessed the potential impacts that the proposed development might have on them. The baseline assessment is currently being further developed by ongoing surveys at the site. This will provide up to an additional two years of baseline data with which to assess any changes to the ecology of the test site and likely impacts of the development of the AMETS on it.

A detailed study report is provided in **Appendix 3:** Ecological Assessment for the Proposed Atlantic Marine Energy Test Site. This Chapter presents a summary of each of the habitats surveyed and the potential impacts of the AMETS on them.

6.2 Subtidal habitats

6.2.1 Approach and methodology

Subtidal habitats along the proposed cable route and at the test area locations were assessed.

An initial seabed assessment was made based on seabed bathymetry, arising from surveys carried out by the Marine Institute (R.V. Celtic Voyager) in 2007 and 2008 with supplementary shallow water surveys conducted by IMAR Survey in September and October 2009. In addition geotechnical investigation (vibrocoring) was undertaken at various stages by the Marine Institute and Coastline Limited. The initial assessment allowed an overview of the subtidal habitats (defined under the Habitats Directive) present within the wider survey areas and included near shore subtidal areas on the western fringes of Annagh Bay, as far as Annagh Head in the north and Cross Point in the south. As this data indicated the presence of subtidal reef within a large proportion of the survey area it was subsequently used as the target for more detailed ecological studies. In areas not surveyed by remote methods (e.g. multi-beam), concentrated surveys by drop-down video and/or diver surveys were conducted to complete any gaps in coverage.

Dropdown video survey

The test site encompassing the two test areas, the cable corridor and a buffer zone either side of the cable corridor at the Atlantic Marine Energy Test Site were surveyed in July 2010 by drop-down video. The average spacing of drop-down video stations along the cable route between the lower shore and Test Area B was 780m 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 (Figure 6-2).

Data analysis of drop down video surveys

All video footage was reviewed 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.

Diving survey

A scientific dive team surveyed the inshore area of the site extensively in July and October 2010. Dive surveys were conducted using standard Marine Nature Conservation Review MNCR phase 2 survey techniques (Davies et al., 2002) for the *in situ* survey of subtidal (epibiota) biotopes and species. The locations of all dive stations are shown in Figure 6-3. Dive stations were selected to represent the range of reef habitats present based on exposure, depth and reef morphotype. Two additional stations (Station 4 – west of Belderra Strand and station 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 there are any particular seabed feature or species that might account for the presence of long tailed ducks in 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 was assigned on a DAFOR (Dominant, Abundant, Frequent, Occasional, Rare) scale. Biotopes were subsequently assigned to each site surveyed.

6.2.2 Receiving environment

Examination of the relief imagery from the 2008 Celtic Voyager survey of the cable route corridor and berth areas indicated obvious areas of reef habitat (Figure 6-1). 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.

Table 6-1. Estimated area of reef identified within the cable route corridor and test areas

Area	Area (km^2)	Reef habitat extent (km^2)	Reef habitat extent (per cent)
Cable route from beach landing to Test Area B	1.02	0.000	0.0
Test Area B	1.50	0.389	25.9
Cable route from Test Area B to Test Area A	2.22	0.113	5.1
Test Area A	3.64	0.017	0.49
Total	8.37	0.519	6.2

The shallower inshore, infralittoral reefs were characterised by vertical rock walls and pinnacles with numerous crevices, gullies and overhangs.(The infralittoral zone is the algae-dominated zone to approximately five metres below the low water mark.) The only biotope recorded in this area was *laminaria hyperborea* on moderately exposed vertical rock.

The results of the survey in the offshore areas 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' with 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, indicating the likelihood of diverse sponge and bryozoan communities in the circalittoral (the region beyond the infralittoral, that is, below the algal zone) reef habitats. While many of the reefs surveyed in this area are extremely deep (70–108 m) they were still characteristic of high-energy sites indicating that the extreme exposure of the site is effecting the circalittoral reef area.

The species recorded from the deep circalittoral zone are all characteristic of deep, high-energy sites. No rare species or species of conservation importance were recorded, although it is noted that the identification of some encrusting sponges and bryozoans is not possible from video imagery.

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.

Both drop-down video and diver surveys were conducted to examine the shallower infralittoral reefs of the inshore area, with the results being similar and the dive 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.

Subtidal Benthos

In coastal and transitional waters, soft bottom benthic macrofauna is one of the important and frequently used elements in determining habitat quality.

Twenty-five stations (Figure 6-4) were sampled in July and November 2010 at the proposed test site and along the proposed cable route. Four grab samples were taken at each station: one was used for particle size distribution and organic content analysis, and three were preserved for macrofaunal identification.

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.

Macrofauna samples were analysed using standard analytical procedures (National Marine Biological Analytical Quality Control Scheme (NMBAQC). The macrofaunal 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.

Most stations were largely composed of fine sand and were well sorted with unimodal distributions and modes in the fine sand size class. Most stations were classified as sand and muddy sand (SA) under t e European Nature Information System (EUNIS) Marine Habitat Classification scheme (http://eunis.eea.europa.eu/habitats.jsp).

The 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 the 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 data obtained conformed well to established biotopes (as far as possible).

Interdtidal habitats

Belderra Strand 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. The beach is used by walkers and surfers throughout the year. Access is by a public road, and there is small car park at the southern end of the beach. 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).

6.2.3 Impact on subtidal habitats and benthos

The general effects of the development on the reef habitats are likely to be a temporal increase in sediment displacement during the cable burial process, and 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 areas.

Construction phase

Subtidal habitats

There are two main potential impacts of the development on the subtidal reefs within the area:

- The burial of cables by water jetting or cable plough will temporarily increase sedimentation in the water column. This can impact the species and biotopes within the adjacent reef habitats where deposition could occur. Predicted impacts 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. Any sedimentation caused during cable laying is unlikely to have any more effect on these communities than a natural storm event would have.

- Rock armour will be placed over the cable where it passes over cobble beds (reef) and cannot be trenched, and where it passes through the inner test Area B to prevent devices in this area anchoring over the cable. The placement of rock armour 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. However, the impact of placing rock armour over a small area (less than 1%) is likely to be negligible in the context of the overall area of the site.

Subtidal benthos

The effects of buried electrical cable laying on the macrobenthos is poorly known. Some studies that describe the environmental impact of submarine High Voltage Direct Current (HVDC) cables 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 were evident in the composition, abundance or biomass of zoobenthos species (Gill et al 2005). 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.

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 as follows:

- Sandy habitats similar to those present at the site are generally less sensitive to physical disturbance. It is likely that where an offshore renewable energy development occupies less than 1% of the spatial extent of a habitat (as in this instance), the area of habitat removal involved in construction and operation can be considered negligible. 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 re-suspension, it is likely that the impacts of the development will lie within the natural variability of the area.
- Artificial reef that 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 changes in macrobenthic community structure because of predation on benthic fauna. In this instance, the rock armour is likely to develop a rich faunal community, particularly because of the proximity of natural reef habitats in the area.

Operational phase

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 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 1% of the total site area.

- Accidental leakage of the hydraulic fluids used in some of the devices may cause a negative impact on reef communities. However, such an incident 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 Pelamis 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 over time cause an impact on reef communities in close proximity to the WECs – due to nutrient enrichment and alteration of the habitat. The likely impact of increased biomass in the vicinity of WECs is however, considered to be low, as the exposed nature and depth of the site would prevent the accumulation of biomass beneath individual WECs.
- The main concern relating to electromagnetic fields (EMF) in marine systems is their potential effect on organisms that are either magnetoreceptive (for example, marine mammals) or electroreceptive (for example, chondrichthyes such as sharks, rays and skates). While the possible effects of electromagnetic fields on benthic organism, being neither a magnetoreceptive or electroreceptive organism is not well researched in regard to benthic marine invertebrate.) in regard to, such effects are likely to occur only in close vicinity to the cables. The potential for effect and impact is very small and local.
- Other than its direct effects on the marine biota, a 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. However, thermal radiation from the cable will be very low (**Appendix 4**: Impact of Electric and Magnetic Fields from Submarine Cables on Marine Organisms – the Current State of Knowledge (Olson et al., 2010)) and the fine sandy sediment should allow any heat that is created by the cables to dissipate efficiently. Burial will be at a depth that 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 that might cause out-gassing from the reduced sediments at depth.

6.2.4 Mitigation of impacts

Impacts on all aspects of the environment may be minimised by applying the following approach:

Construction phase

- The development should have the smallest possible footprint
- The development should be carried out as efficiently as possible within the shortest possible timeframe
- All vessels used in cable laying should have an Oil Pollution Emergency Response Plan and carry emergency response equipment
- Care should be taken that no oils or hydraulic fluids are allowed to leak from machinery on vessels or WECs

- Any accidental spillage of oils or hydraulic fluids should be cleaned up and contaminated material removed and disposed off in accordance with agreed procedures and recognised best practice
- The composition and morphotype of material used in rock armouring should be suitable for its deployment in the local environment
- Because it has less impact on subtidal benthos, ploughing is the preferred method of cable laying. This technique fills in the trench as the cable is laid, and this helps to shorten the recovery time of the habitat
- The submarine cable should be buried deep enough to minimise any possible warming of the surficial sediments

Operational phase

- The potential effects on adjacent biota of the use of antifoulants on WECs should be monitored as part of the environmental management plan for the facility and the use of antifoulants should be strictly controlled.

Decommissioning phase

- Mitigation of impacts is similar to that during the commissioning phase.

6.2.5 Conclusion

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 greatest potential for impact on subtidal benthos is the creation of artificial reefs which may fragment communities and provide habitat for predatory species leading to impact on benthic species. However, the extent of this will be small in the context of the total available habitat. Conversely the reefs may serve to increase biodiversity in the area providing additional habitat which would result in a positive impact overall.

No significant negative impacts will arise.

6.3 Intertidal habitats

6.3.1 Approach and methodology

Intertidal core samples were collected from two transects at Belderra Strand in July 2010. Figure 6-5 shows the position of the coring stations in relation to the proposed cable landfall and Table 6-2 gives the positions of each sampling station.

The position of the two transects was selected to obtain a description of the biotopes present in the vicinity of the cable landfall and of the biotopes 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.

Table 6-2: Location of stations of intertidal core sampling at Belderra Strand

Transect	Station	EastUTM29N	NorthUTM29N
1	Low shore	430569.7323	6007425.602
	Mid shore	430636.9894	6007365.275
	Upper shore	430682.2219	6007319.413
	Strandline	430695.3803	6007300.853
2	Low shore	430687.2405	6007518.535
	Mid shore	430732.7479	6007478.01
	Upper shore	430788.8862	6007432.987
	Strandline	430801.8992	6007417.768

6.3.2 Receiving environment

The results of 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 contained 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. 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 fauna was dominated numerically by the op, 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. However, the upper shore of Transect 2 contained several small crustacean species, the isopod *eurydice pulchra* and the amphipod *bathyporeia pilosa*, both highly typical of energetic sandy beaches.

The paucity of species in all cores 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.

6.3.3 Impact of the development

Construction phase

Cable installation through sand, which is expected to be completed within one week will involve four trenches approximately 2m deep within a 40m wide working corridor. This will be 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. The route avoids the sand dune area.

The operation of trenching machinery on the beach may cause compaction of sediments in the localised area.

The impact arising is disturbance of the habitat, but its effects are unlikely to be detectable within a very short time since the intertidal area is already frequently disturbed by severe weather conditions.

A potential impact could also occur from oil leakage from machinery used on the beach area.

Overall, the potential impact will be of short duration and will not be significant.

Operational phase

Once the cables are in place there will be no further impact on the intertidal areas.

Decommissioning phase

During decommissioning cables can easily be pulled from the cable ducts if they are to be removed. If there is a requirement to remove the cable ducts, then the impacts will be similar to those of the construction phase. There will be disturbance of the beach along the cable duct corridor and also compaction of sands in the working corridor.

6.3.4 Mitigation

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 40m 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. The risk management report should consider the 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.

Operational phase

No mitigation is foreseen during this phase.

Decommissioning phase

Mitigation required is as set out under the construction phase

6.3.5 Conclusion

The species diversity at Belderra is extremely low, reflecting the exposed harsh nature of the environment in the area. The impact of the development will be low and of short duration over a minor proportion of the beach area. Full recovery would be expected within one year of construction or decommissioning.

6.4 Marine mammals

The waters off north-west Co. Mayo have a long association with marine mammals, especially cetaceans (whales, dolphins and porpoises), as it was the site of two whaling stations that operated at the beginning of the 20th century.

These stations, situated adjacent to Ardelly Point on the Mullet Peninsula 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). Historically large baleen whales migrated annually along the shelf edge around 60 nautical miles from the proposed Atlantic Marine Energy Test Site. Most whaling centred around fin whales but blue, sei and sperm whales were also captured. Only a small number of humpback and right whales were captured reflecting the severe depletion of these species due to over-hunting.

Historic surveys in the area included cetacean reporting as part of broad scale bird surveys and in more recent times dedicated cetacean surveys of the area. These surveys 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. 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. A dedicated cetacean survey using acoustic detection was carried out in 1999 (Gordon et al 1999). Two sightings of minke whale off Erris Head to the north of the proposed test site were made. Sightings of common and white-sided dolphin on the 200m contour about 16 nautical miles directly west of the proposed Test Area A were also made. During a dedicated survey in July-August 2000 there were sightings of northern bottlenose whale. 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 200m contour to the west of the site.

Since 2001 there have 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 (bottle nose dolphin, common porpoise, harbour seal and grey seal) in Annex II of the EU Habitats Directive.

North-west 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 has being carrying out grey seal surveys of the Inishkea Islands some 2.3 km from test area B since at least 1978. O'Cadhla and Strong (2002) estimated a population of 1,3511,737 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.

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.

6.4.1 Approach and methodology

Marine mammal surveys were conducted using both land-based and at-sea survey methods. Techniques included a combination of monthly land based watches (total 13) undertaken between October 2009 and October 2010 from Annagh Head, seasonal vessel-based line transects through the AMETS (total six), towed hydrophone surveys and analysis of data recorded by CPODS deployed at the site and a number of control stations.

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 that systematic line spacing resulted in better precision than randomised line spacing. The track-lines surveyed each day totalled approximately 50 nautical miles in length, which at 10 knots vessel speed took around five hours to complete once the start of the first track line was reached.

A minimum of three people (two primary observers and one logger) was required for each visual survey.

All sightings were recorded, together with bearing and distance from the observer. 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, and so on) were recorded directly onto LOGGER software (©IFAW) every 15 minutes. All effort data and sightings/detections were digitally mapped in both National Grid reference (ITN) and latitude and longitude (WGS84).A towed hydrophone array was used during three dedicated acoustic surveys. This array consisted of a 200m cable with two hydrophone elements (HP-30) situated 25cm apart in a fluid filled tube towards the end of the cable. The collection of acoustic data during visual surveys added an extra dimension to the monitoring dataset allowing for the detection of cetaceans beyond the visual observer's view and so increased the capacity of the survey.

Static acoustic monitoring (SAM) using CPODs (self contained click detectors that log the echolocation clicks of porpoises and dolphins) was carried out. CPODs were deployed at locations nearshore, at both medium depth (50m) and deeper water (100m) locations. SAM can be carried out independent of weather conditions once deployed and thus ensures that high quality data is collected for prolonged periods (months) but only at a small spatial scale (typically around 800m radius for dolphins and 250m for porpoises). The CPOD monitoring included four control sites; two offshore and two inshore .

Additionally, data on sightings was obtained from the Irish Whale and Dolphin Group (IWDG) sighting database, which stores data collected by all-Ireland cetacean sighting schemes. This data is stored on a database, which can be accessed online through www.iwdg.ie.

Survey track lines and CPOD locations are shown in figure 6-6.

6.4.2 Receiving environment

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, harbour porpoise recorded during the current survey and a range of species recorded regularly but infrequently. Densities of common dolphin are similar to those reported elsewhere on the west coast of Ireland.

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. The AMETS 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 (sunfish and basking shark) were recorded within the site and at another three sites 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.

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 (approximately 18 nautical miles out). For example, Broadhaven Bay at the northern end of the Mullet peninsula has been shown to have a rich marine mammal fauna including nine cetacean and two seal species – based on intensive monitoring carried out as part of the Corrib Gas Project (Visser et al., 2010).

A summary of marine mammal and megafauna occurrence at and adjacent to the test site is provided in Table 6-3.

Number of sightings and individuals (in brackets) recorded in the area of interest between 54.36° and 54.05° N and 10.71° to 10.08° W (in order of most abundant) taken from the IWDG database is shown in Table 6-4.

Table 6-3: Summary of marine mammal and maegafauna occurrence at and adjacent to the 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

Table 6-4: IWDG database number of sightings and individuals

Species	Month											
	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

6.4.3 Impact of the development

Although there are currently over 140 wave energy developers actively engaged in developing wave energy converter technology, the devices are all still largely at the development stage with very few devices deployed for any length of time (EMEC http://www.emec.org.uk/wave_energy_developers.asp.). Knowledge of interaction between wave energy converters and marine mammals is largely based on a limited number of reviews, inference from studies on other marine renewables such as tidal energy and offshore wind and on expert opinion. Assessment of potential impacts of marine renewable energy devices on marine mammals is therefore largely intuitive as it is based on literature reviews and experience of other marine devices. Until such time as full size devices are deployed at sea and their effects can be monitored, predicting impacts is speculative. The latter is highlighted in a recent OSPAR publication on environmental interactions of wave and tidal energy generation devices (OSPAR 2010). This emphasised the important role of monitoring early deployments of wave and tidal stream devices to determine possible effects; and these should be followed by rapid publication of results to guide the management of subsequent developments.

Construction Phase

The construction phase is generally regarded as potentially the most disruptive period in the development and operation of a test site. Increased boat traffic during construction and placement of rock armour as a component of mooring deployment 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 are likely to be similar on other marine mammals.

The main potential negative effects on marine mammals are suggested as including the following (OSPAR 2010) :

- Most marine mammals (whales, dolphins, porpoises and pinnipeds) use sound for a variety of purposes such as communication, navigation, foraging, avoidance of predators and hazards, and to locate mates. The presence and absence of behavioural responses of marine life to various sound signals have been documented by scientific studies. Anthropogenic underwater noise is known to give behavioural and physiological disturbances in some marine animals. To date, no universal conclusion on the effect of sound can be drawn and is unlikely to emerge in the near future. Underwater noise generated during construction from intensive boat traffic could potentially lead to avoidance of the area by marine mammals or damage to individuals. However this period of time is very limited and animals are likely to return to the area post construction. Also Construction work associated with rock armouring or deploying of anchoring systems, is not believed to create noise levels that would be of great concern for marine animals. These activities would also be of short duration.
- Loss of habitat from physical displacement could occur if marine mammals avoided the site during construction. This loss or habitat would likely be temporary in nature as animals would return when construction finished. The effect of the temporary loss would also be small as the habitat for marine mammals is extensive and the construction area would be very small in this context
- Collisions with construction vessels could occur but would be unlikely as the cable laying vessel would be very slow moving and easily avoided. A number of other vessels would also be involved in construction (guard vessel, anchor deployment tug and smaller support vessels. The collision risk with these will again be low as they will be relatively slow moving in the area.
- Contamination from oil pollution or chemical leakage from construction vessels could as a result of f accident. Although the risk of an oil spill is low vessels will be required to have a shipboard oil pollution emergency plan, emergency oil spill equipment and crews trained in its use. This will minimise the potential for any impact in the unlikely event that an oil spill occurs
- Physical impact during rock armouring. Could occur as rock is placed on the bottom. This potential impact can be avoided by using a system to drop the rock near to the seabed rather than through the water column.

Operational Phase

During the operational phase two arrays of five WECs each could be deployed at the test site generating power which will be transmitted through the submarine electricity cables to the shore-based substation. 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. Potential impacts on marine mammals include;

- The WECs and associated moorings could create a physical barrier to the movement of marine mammals. The risk of this is low given the relatively small scale of development in the open ocean environment.
- Disturbance of feeding and perhaps migratory behaviour through interference by the effects of EMF along the power cables. Given the water depths at which the submarine cables will be deployed and the fact that they will be almost entirely buried to a minimum of one metre beneath the seabed, migratory and feeding impacts are unlikely to occur. Thus the impact will be of low significance. EMF effects are discussed in more detail in Section 6.7.
- Potential underwater noises from the WECs could lead to disturbance of marine mammals or their avoidance of the area. The extent to which this could occur would be very device specific but given the open ocean location of the test areas it is unlikely to cause significant impact. (Noise impacts are discussed in more detail in Section 6.8.

Decommissioning phase

Noise and vessel movement during decommissioning of WECs could give rise to some short term disturbance of marine mammals leading to their temporary avoidance of the area. The impact of this will be very low and of short duration.

6.4.4 Mitigation

The potential impact from underwater noise of wave and tidal energy farms on marine mammals during operation is likely to be of low frequency and to resemble the effects from offshore wind farms, ship engines or offshore constructions. Underwater noise is also expected from floating and submerged device such as waves hitting the buoys and mooring lines. Such noise disturbance has not been shown to cause significant harm to marine animals (Sparrevik et al., 2010).

Construction phase

- To minimise disturbance to marine mammals, the development should be carried out as efficiently as possible within the minimum timeframe possible.
- All vessels used in cable laying should have an oil pollution emergency response plan and carry emergency response equipment.
- Marine Mammal Observers (MMO) should be used during the placing of rock armour to ensure there is a minimum distance between marine mammals and the vessel when working.

The use of acoustic deterrents has been considered but is not recommended on the advice of NPWS as they could have a greater potential impact on marine mammals in the area.

Operational phase

- Ongoing monitoring of marine mammal activity and noise monitoring in the vicinity of the AMETS during its operational phase should be a component of the environmental management plan.

Decommissioning phase

- Marine Mammal Observers (MMO) should be used during the decommissioning phase and the development should be carried out as efficiently as possible within the minimum timeframe possible.
- All vessels used in cable laying should have an oil pollution emergency response plan and carry emergency response equipment.

6.4.5 Conclusion

Prediction of impacts is difficult in the absence of specific studies on full- scale WECs deployed in the marine environment. Although potential for impact on marine mammals will be highest during the construction phase, the impacts are likely to be low given the overall small scale of the development in the open ocean environment.

Once the WECs are deployed, a comprehensive monitoring programme should be in place to guide the site management and inform future deployments. This programme should include continued onsite observations of marine mammals when devices are operational and noise monitoring using up-to-date equipment and validated techniques.

6.5 Terrestrial habitats

A preliminary ecological assessment was undertaken to examine a number of proposed cable landfall options. This extended the scope of work to the examination of 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 (outlined in red on Figure 6-7). Belderra Strand is located at the south-eastern end of Annagh Bay in the townland of Cross. It is a gently sloping sandy beach backed by a low sand dune system which is unfenced and heavily grazed. A small paved parking area is situated at the extreme south-western end of the beach.

The site of the proposed substation (Figure 3-4) does not lie within any designated area (SAC, SPA or NHA). Belderra Strand lies within the Mullet/Blacksod Bay Complex cSAC (site code 000470)

6.5.1 Approach and methodology

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 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 substation location, data was gathered from three 1 x 1 m^2 relevés. Evidence of mammals of conservation importance (otter spraint, and so on) was sought and literature searches were conducted to determine their likely existence within the survey area.

6.5.2 Receiving environment

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 landfall, 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.

The habitats surveyed are as listed hereunder (Table 6-5) and their locations are presented in Figure 6-8.

Table 6-5: Recorded habitats

Habitat	Designation	Presence
Dry calcareous grassland (GS1)	GS1	Areas 1, 2 and 9
Improved agricultural grassland (GA1)	GA1	Areas 5 & 6
Dune slack (CD5)	CD5	Area 7
Marram dunes (CD2)	CD2	Area 8
Drainage ditches (FW4)	FW4	Throughout the site
Marsh (GM1)	GM1	Area 10
Machair (CD6)	CD6	Area 4
Exposed rocky shores	-	Areas 11 & 12

Dry calcareous grassland occurs extensively throughout the site and covers most of the coastal grassland surrounding Belderra Strand. Improved agricultural grassland is the dominant habitat of the surrounding area. A species list for each of the above areas is provided in Table 6-6.

No rare species or species of conservation importance were recorded.

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, was the only non-domestic mammal recorded at the survey site. No evidence of other EU Habitats Directive Annex II species was noted.

Table 6-6:Species and their abundance within each area

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

Species	Area									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
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			

Key : D: Dominant, A: Abundant, F: Frequent, O: Occasional, R: Rare.

* 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 – they are not included in this table.

6.5.3 Impact of the development

Construction phase

The impacts of the development will include disturbance and temporary loss of dry calcareous grassland habitat in a small area where machinery will be stored and parked during the cable landing operation and in which an underground cable joint bay will be located. The cable joint bay will be buried underground and the site will be reinstated to its original condition. Loss of an area of semi-improved agricultural grassland habitat will arise in the construction of the substation and access road.

Habitats such as these are widespread and there is no conservation concern. The extent of habitat loss, (two acres) is very limited and the impact is not significant.

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.

Decommissioning phase

Should demolition of the substation be part of decommissioning, then demolition material will be removed from the site and disposed of in accordance with legal practice. The site will be restored to semi-improved agricultural grassland.

6.5.4 Mitigation

Construction phase

Movement of vehicles should be restricted to existing roads with unfenced areas of calcareous grassland, dune slack or any other habitat being avoided in parking or turning of vehicles.

Vehicles, machinery and construction materials should only be parked or housed in the designated area.

Any embankments used in screening the substation should be constructed of soil excavated in construction of the substation. Soil from other areas should not be imported to the site to minimise the likelihood of introducing non-native and / or invasive species.

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

Waste materials arising during the construction phase should be removed from site and disposed of according to legal practice.

Operational phase

No mitigation is foreseen.

Decommissioning phase

Any site restoration should use local native species to restore vegetation cover.

6.5.5 Conclusion

The principal impact will be the loss of semi-improved agricultural grassland. Although this will be of long-term duration it is not of conservation interest. The extent of habitat loss (two acres) is very limited and the impact is not significant.

6.6 Avifauna

The study site 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 (Scoping Report, www.seai.ie/oceanenergy). 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 15km west, to include an area of open sea approximately of 12km x 15km. 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. The test site test areas are located within the study area.

The Mullet peninsula and its nearby islands are protected for birds by a number of Special Protection Area (SPA) designations. Six SPAs lie within 5km of the test site test areas , two lie within 15km of the test site and a further two lie 20–30 km from the test site. These SPAs are nationally and internationally important for a range of breeding and wintering birds (Table 6-7).

Table 6-7: Nearby Special Protection Areas (SPAs)

Distance	Site
0–5 km	Inishglora and Inishkeeragh (site code: 4048)
	Termoncarragh Lake and Annagh Machair (site code: 4093)
	Cross Lough (site code: 4055)
	Blacksod / Broadhaven Bay (site code: 4037)
5–15 km	Inishkea Islands (site code: 4004)
	Duvillaun Islands (site code: 4111)
20–30 km	Illaunmaster (site code: 4074)
	Stags of Broadhaven (site code: 4072)

6.6.1 Approach and methodology

Birds were observed through a combination of monthly land-based watches from vantage points (Figure 6-9) and monthly offshore seabird surveys (Figure 6-10). 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, with adaptation where necessary as set out in the Ecology Report (see www.seai.ie/oceanenergy). Sea-based surveys, which were conducted on a total of eight occasions between October 2009 and October 2010, used the European Seabird at Sea (ESAS) standard method.

Sea-based surveys were carried out to establish a general baseline of the bird interest in an area of approximately 180km^2 around the proposed AMETS. 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 4km and 5km from the nearest proposed Test Area, a study zone of this size gives an overall picture of the birds using or moving through the general vicinity.

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 attracted at a suitable nesting habitat using the standard tape playback method in order to establish monitoring plots for future survey (Walsh et al., 1995; Ratcliffe et al., 1998).

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 and Boland et al., 2009). Results from the I-WeBS (Crowe, 2005 and Boland et al., 2009) show that a range of species occur within this site in numbers of national and/or international importance. Belderra Strand is a subsite of The Mullet, Broadhaven and Blacksod Bays I-WeBS count site and lies within the study area. These results have been reviewed and incorporated into the assessment of avifauna in the area.

6.6.2 Receiving environment

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. Survey 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 by beach users, which was regularly recorded at this site. Numbers were highest with a peak of 204 waders recorded in December and nationally important numbers of sanderling recorded in March. The sediment shores within the bay are exposed and mainly sandy. The most sheltered shore is at Annagh (Port Mór) Beach. Exposed sandy shores tend to support a lower abundance of macrofauna compared to sheltered shores. 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 (Port Mór) Beach possibly reflecting the more sheltered conditions 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 probably linked to shelter and foraging opportunities. 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 tern, little tern and sandwich tern were recorded foraging in the bay during the breeding season. Gulls, shags and auk 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*. 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, including auks, terns, gulls and fulmars. Storm petrels were identified on Inishglora by the tape play back method. Passage migrants such as great skua and great and sooty shearwater were present during the autumn. There are no nearby breeding sites for gannets and Manx shearwaters; however, the study site lies within the foraging range of Irish and Scottish breeding colonies of these species. Large rafts of Manx shearwaters are of note, and may be linked to the late arrival of non-breeding birds in Irish waters. Fledged young and adult birds were also present

Species and species groups of particular interest within the survey area are those that may be breeding in nearby SPAs (gulls, auks, terns and storm petrels), and those that were common and/or occurring in high densities within the site (gannets, Manx shearwaters and great shearwaters).

6.6.3 Impacts

Little data exists on the environmental impacts of wave energy devices on avifauna. However, expert group workshops, such as the Equimar workshop (2009) and the MASTS workshop (2010), have discussed and described potential impacts. The potential impacts on birds described will vary depending on nature, age and reproductive stage of the species. Some of those potential impacts, which may affect birds, are described below for the construction, operational and decommissioning phases.

Construction phase

- Construction noise from vessel activity may lead to birds avoiding the area for a brief period. However, this would be a temporary disturbance and birds would return to the area following construction. The impact would be very low
- During cable laying there would be a temporary increase in suspended solids in the water column but this would be confined to an area adjacent to the cable. In shallow depths used by diving birds this could give rise to some temporary loss of feeding area. This would be of short duration and given the extensive area available the impact would be negligible.
- Disturbance of birds using the intertidal area at Belderra beach will also occur from construction activities, (cable duct trenching and cable landing). This area is not used extensively by birds due to recreational activities on the beach giving occasional disturbance. Any disturbance caused by construction would be of very short duration (one to two weeks) and will not give rise to any significant impact.

Operational phase

- Above water collision with WECs may arise in cases where birds fly low over the water. Risk is likely to be greater with nocturnal and crepuscular species, with environmental conditions such as bad weather being an additional factor. However, given the small number of devices which will deployed and which will be well marked the risk of collision will be low and the potential impact will be low also. Risk of underwater collision with WECs will be highest for species diving for prey – when a device is placed within the foraging range of a colony and at a depth within the dive profile of the species. Increased turbidity around devices may increase collision risk. If avoidance of WECs occurs then the risk of underwater collision will be reduced.
- There is a risk of entrapment of birds within the WEC structure but this scan b e mitigated by careful design of the WEC to avoid possibilities of entrapment.
- Disturbance / displacement may arise due to noise during construction and operation of the WECs. In relatively calm conditions the WECs will generate little or no surface noise. As wind and wave increases the WECs become more active but there is less noise propagation. Hence the potential impact is likely to be very low.
- Displacement may also arise due to birds avoiding areas with manmade structures and night lighting.
- Birds may need to navigate around multiple WECs but the impact is considered negligible for most devices unless they are located between breeding, foraging and/or roosting grounds.

Potential negative interactions with marine habitats could also occur from the presence of WECs, thereby effecting prey availability, include the following:

- Reduction in wave energy could impact sediment transport processes with knock-on effects on, for example, spawning grounds. Given the high energy of the test site area (with mobile sands), the impact that the deployed WECs will have will be negligible.
- Changes in food availability due to changes in communities associated with new structures on the seabed could lead to changes in prey availability if preferred prey species are out-competed. The footprint of the WECs will be very small in terms of their anchoring on the seabed the context of the habitat structure in the general area.

Potential positive impacts include the following:

- The deployment of WECs will lead to the creation of roosting structures but this may be balanced by the risk of entrapment within the moving parts of a device.
- The creation of artificial reefs may result in marine organisms being attracted to new hard structures on the seabed, leading to increased prey availability for some bird species.
- WECs may become de facto Marine Protected Areas, as they will act as fishing exclusion zones.

Decommissioning phase

- Temporary disturbance to birds from vessel movement associated with the decommissioning of the site.

6.6.4 Mitigation

Potential impacts on avifauna may be minimised by applying the following approach:

Construction phase

- Cable laying should be carried out as efficiently as possible within the minimum timeframe possible. This will limit disturbance to the area. Long-term negative effects from disturbance should therefore be avoided. Cable laying should take place in the summer months.
- Disturbance impacts should be minimised by limiting intertidal construction activities to the summer months, when wintering waders are not present.
- An ecologist should be present during construction.
- The trenching method with the least disturbance to the seabed should be used.
- Trenching should be avoided if possible in areas favoured by foraging long tailed duck.
- Placing of rock armour should avoid areas where winter and spring moulting occurs (the months October to May).

Operational phase

- Ensure design of WECS minimises the potential for entrapment in the WEC.
- Monitoring of interaction of WECs with birds to determine if unforeseen impacts are occurring.

Decommissioning phase

- Ensure efficient and timely operations to minimise for potential for impact.

6.6.5 Conclusion

The potential impacts from the wave energy installations will vary depending on the species involved, their status and/or behaviour. Considering that wave energy is still an emerging technology with only a limited number of devices deployed there is a lack of documented information on wave energy impacts. The impacts upon birds will vary depending on the location of the installations. The impact will also depend on the timing of construction activities. Careful planning and timing of activities will minimise any potential impact as will efficient construction and operation using the minimum footprint.

It will be important to monitor bird populations in the study area, focusing on those species of note in terms of their conservation status and/or abundance and on any species that may be at particular risk due to their behaviour.

6.7 Electromagnetic Fields (EMF)

6.7.1 Introduction

EMF is an abbreviation for Electromagnetic Field or Electric and Magnetic Fields, depending on frequency range. In the case of frequencies below 400kHz, the term electric and magnetic field is generally used. The electric and magnetic fields can be observed separately from each other. EMF is generated every time electricity is generated, transported or used. This means that all electric equipment and power cables give rise to EMF.

The flow of electric current within an electrical sub-sea cable results in the production of electric and magnetic fields. Sub-sea 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. The electric field (E field) depends on the voltage and the magnetic field (B field) on the current.

Very little practical research into the effects of EMF on marine species has been undertaken to date and although the research is limited, some initial conclusions on potential effects have been arrived at. There have also been a number of extensive literature reviews and some studies carried out on behalf of the OSPAR Commission, Scottish National Heritage, the US Bureau of Ocean Energy Management, COWRIE (Collaborative Offshore Wind Research Into the Environment) and Vattenfall (the Swedish electricity utility). The discussion of potential impacts and possible mitigation is derived principally from these studies and reviews.

6.7.2 Potential EMF impacts

Potential EMF effects could occur during the operational phase of the wave energy test site when the WECs are on site and electrical energy is being transmitted through the submarine electricity cable.

Electromagnetic field emissions may come within the range of bioelectrical emissions utilised by certain electrosensitive species. Hence, there is some potential to interact with aquatic animals. The AMETS submarine electricity cables are industry standard AC cables and will effectively shield against direct electric field emissions but do not completely shield the magnetic component. This magnetic field may result in an induced electric field (iE field). Magnetic fields and their associated induced electric fields are very local and only occur in close proximity to the cable.

These fields may be detected by elasmobranch fish (Poléo et al., 2001; Gill et al., 2005). Marine teleost (bony) fish show physiological reactions to electric fields(Poléo et al., 2001, Gill and Taylor (2001). The OSPAR Commission Report (2009) on assessment of environmental impacts of cables indicated that impacts could include impairment to orientation of fish and marine mammals affecting migratory behaviour. (Fricke, 2000).

A review of impacts on Atlantic salmon, sea trout and European eel (Scottish Natural Heritage SNH, 2010), suggests that EMF may have the potential to interact during the migratory phase of eels and possibly also salmonids in shallow waters (less than 20m deep). However, there was no verifiable evidence to this effect and it remains speculative. Swedish investigations on eel and salmonids regarding HVDC links show no such interaction (Vattenfall). The general finding of the report is that there is insufficient knowledge to conclude if there is any disturbance from EMF or noise on eel, salmon and trout. SNH states that following a precautionary approach resulting from the lack of clear understanding of potential effects could be overly restrictive of an industry targeting global benefit through controlling emissions to the atmosphere. SNH suggested that an adaptive management approach would be more suitable, whereby greater insight into the interactions between migratory fish and EMF, gained from both research and practice, would lead to continued review and adaptation of guidance and decisions for conservation management.

The COWRIE mesocosm study (Gill et al., March 2009), designed to examine the behaviour of fish species to EMF, demonstrated that electrosensitive fish species do respond to the EMF from sub-sea cables but with high variability. They indicated that there is no evidence from the study conducted to suggest any positive or negative effect on elasmobranchs of the EMF encountered..

A US Bureau of Ocean Energy Management report on EMF effects on elasmobranchs (Tricas T and Gill A, May, 2011) drew similar conclusions to those already identified above.

Vattenfall undertook modelling of the magnetic field and induced electric fields for five different AC power cables (10–145 kV, 100–500 A), as part of a study and review of the current understanding of EMF and potential impacts (Olsson et al., November 2010 – see **Appendix 4**: Impact of Electric and Magnetic Fields from Submarine Cables on Marine Organisms – the Current State of Knowledge). The study also included a review of EMF from WECs. The modelling results showed that:

- The maximum strength of the magnetic field produced by the cable is from 2–35 μT, depending on the cable set-up and current load.
- The magnetic fields produced by the generating units (WECs) are negligible compared to the fields from the cables.
- An induced electric field of 0.4–4 mV/m depending on cable set-up and current load will be generated by an AC cable.
- The field strengths decrease rapidly with the distance from the cable. For example,
- A maximum of 35 μT immediately above the cable will be reduced to 2.2 μT at a distance of 2 meters from the cable.

For the specific case of the AMETS cables (10kV) the modelling indicated a maximum field strength of 3.2 μT and an induced electric field of 0.4 mV/m. The magnetic field level rapidly decreases with distance from the cable and at about one metre the magnetic field is lower than 1 μT. At a distance of approximately 10–13 m the magnetic field is smaller than 10 nT. The detection threshold values for magneto-receptive organisms range from 10 nT to 50 nT which would mean that if organisms can respond to this emission they would not be able to do so at a distance of more than 13m from the cable.

The Vattenfall conclusion of the literature study was that currently available information on the subject is very limited. No research results were found that suggested that present sub-sea power cables posed a threat to the marine environment due to EMF.

6.7.3 Mitigation

There is no conclusive evidence that there are adverse impacts associated with exposure to EMFs from undersea cables of a level that would affect populations or ecosystems. However, it has been demonstrated that sensitive fish species are receptive to EMF from cables and that marine mammals could also be influenced by such fields. It is appropriate to consider possible mitigation which could limit any potential impact as follows:

- Magnetic fields are best limited by appropriate technical design of the cable (for example, three-phase AC, bipolar HVDC transmission system). Cable configuration can result in higher mutual cancellation of the magnetic fields from cables. For example, bundled AC three-phase cables will produce lower magnetic fields that will diminish more quickly with distance than single-phase cables carrying similar loads.
- Directly generated electric fields are controllable by adequate shielding. However, induced electric fields generated by the magnetic field will occur.
- The strength of both magnetic and electric fields rapidly declines as a function of the distance from the cable, an additional reduction of the exposure of marine species to electromagnetic fields can be achieved by cable burial. This measure reduces the intensity of the magnetic field and induced electric field reaching the water by increasing the distance between the cable and the aquatic environment. The AMETS cables will be almost entirely buried to a minimum depth of 1m resulting in reduction in the magnetic field from the cable. A similar effect will be achieved where rock armouring is used for cable protection. It is not anticipated that the short section of cable dynamic riser will result in any significant EMF effects.

6.7.4 Conclusion

While understanding remains limited by lack of factual information, there is no conclusive evidence of adverse impacts associated with exposure to EMFs from undersea cables at a level that would affect populations or ecosystems. Behavioural effects have been shown both for species that are believed to use Earth's magnetic field for navigational purposes (eel), and for species using electric fields for detecting prey (elasmobranchs). However the observed effects have been considered to be small or the results have not been appropriate for evaluation of potential negative or positive environmental effects. Good practice indicates that mitigation by burial of the cables should be undertaken and mitigation should be taken into consideration at the cable design stage. A strategy of adaptive management should be followed based on the outcome of industry-wide monitoring of deployed WEC sites and offshore wind power cables coupled with specifically targeted research leading to continued updating of knowledge. Thus increasing understanding of impacts and mitigation at an industry level will lead to continued review of guidance and management for the AMETS.

6.8 Underwater noise

6.8.1 Introduction

This section reviews the available published information with respect to underwater noise potential impacts on marine organisms. Marine renewable energy is an emerging technology with very few WECs actually deployed in the marine environment. As such very little is known about environmental effects on marine ecological systems from wave energy installations. This is particularly the case with respect to the potential impact of underwater noise. The sub-sea noise from marine renewable energy devices has not been suitably characterised to determine their acoustic properties and propagation through coastal waters. Potential negative effects could arise during the construction, operation and decommissioning of the test site leading to disturbance of marine organisms.

Underwater noise standards are included in the European Union's marine environmental policy document but no standards are available for noise from WECs.

Anthropogenic (man made) underwater noise is known to cause behavioural and physiological disturbances in some marine animals (for some of the latest findings, see Popper et al., 2008). An analogous situation exists with respect to offshore wind farms where the question of disturbance from underwater noise, especially on fish and marine mammals, has been a concern.

Less is known about potential noise impacts on fish and research on such impacts has focused on the effects of pile driving and underwater explosions (OSPAR, 2009), which will not be applicable to AMETS. Studies suggest that fish that receive high intensity sound pressures (in close proximity to the test area construction) may be negatively impacted to some degree. Those at distances of hundreds to thousands of metres may exhibit behaviour responses, the long term impact of which is unknown and will be dependent on the received sound. During operation there may be more subtle behavioural effects that should be considered over the lifetime of the test site, but whether such effects will be significant is not known (Gill et al 2010).

There is general agreement in the literature that underwater noise will have its highest potential impact in the construction and decommissioning phases of projects and that operational underwater noise will have significantly lower potential impact.

Although there is a lack of knowledge concerning measurements of underwater noise from WECs, underwater noise from other sources with similar constructions have been measured. For example it is anticipated that construction involving piling or drilling operations into the seabed, as evidenced from offshore wind, will have the highest potential for impact. Neither of these operations will be carried out at AMETS and noise will be associated principally with vessel activity and mooring operations during construction with significantly less potential to impact.

6.8.2 Approach and methodology

A difficulty that arises in assessing the potential for impact from underwater noise is that WECs of the type and scale that will be deployed at AMETS have not yet been constructed and therefore no noise characterisation of these devices is possible at this stage. The noise measurement technology is also important and it is essential that equipment used for baseline characterisation of the test site and deployed WECs should be consistent to provide comparable and meaningful data on which to base actual assessments.

A comprehensive review of the status of understanding of underwater noise has been prepared by Vattenfall (Sparrevik et al., 2010) and a review of EMF and Noise on salmon, trout and eels has been prepared by Scottish National Heritage (Gill, A.B. et al., 2010).

The discussion in this section is therefore based on limited experience from offshore wind developments, limited information from deployments of marine energy devices, up-to-date literature reviews, expert judgement and monitoring recommendations.

6.8.3 Potential impacts

Reaction to underwater noise on wildlife appears to differ both within and between taxonomic groups of animals (Popper et al., 2008). Hearing in marine organisms differs between taxonomic groups such as invertebrates, fish and marine mammals (Sparrevik, 2009). The behavioural reactions to underwater noise in invertebrates are largely unknown. The hearing capacity of fish differs widely from species to species. Marine mammals such as toothed whales and eared seals have different hearing bandwidths but similar sensitivity in the best frequency range. Sound is also used by marine species to communicate and navigate. There is a very large variation in sound propagation depending on frequency content and oceanographic and bathymetric conditions.

Construction phase

During construction, generation of underwater noise may disturb marine organisms. Such noise is likely to come from

- Vessel activity associate with the cable laying process
- Vessel activity associated with rock armouring of sections of the cable and from the rock deposition itself
- Deployment of WEC mooring systems (gravity, suction bucket and embedment anchors)

The conclusion of available information is that the reaction to sound may vary greatly depending on species, location, bathymetric conditions and attenuation factors. Potential impacts include:

- Disturbance of marine mammals
- Avoidance of the area by marine mammals
- Damage to hearing system of marine mammals
- Marine mammal mortality
- Fish avoidance of the area
- Fish mortality
- Damage to hearing of fish
- Masking of normal acoustic-related behaviour in fish species
- Impact on communication and navigation

Construction work on AMETS, such as the deployment of gravitation foundations, anchoring systems or suction anchor installations, is not believed to create noise levels that would be of great concern for marine animals. Vessel activity during the construction period will be intense but of short duration and noise impacts will be unlikely to cause mammalian or fish mortality. No major sound pressure generation will arise from the construction activity as piling or drilling operations are not envisaged at the AMETS. The most probable impact will be short-term avoidance of the immediate construction area. The impact overall will be low and of short duration.

Operational phase

Noise from WECs during operation is likely to be of low frequency and may therefore resemble underwater noise from offshore wind farms or slowly moving ship engines during operation. Underwater noise is also expected from floating and submerged devices as follows:

- WEC generators
- Mooring wires connecting the WEC to the anchor may create sound by strumming
- Noise from water flow around the wires, anchors, and floating structures
- Noise from interaction of the WECs with waves, rain and wind can create noise – most of these sounds would be expected to be of a continuous character and of low intensity
- Maintenance vessels engaged in routine maintenance and period removal and relocation of WECs onsite

The potential impact on marine mammals and fish during operation is likely to resemble effects from offshore wind farms, ship engines or offshore constructions. Such noise disturbance has not been shown to cause any significant harm to marine animals.

Long-term presence of WECs could lead to more subtle behavioural effects, but again it is unknown whether these effects will result in biologically significant impacts at species level.

Overall, it is expected that the impact during the operational phase will be low and of medium duration.

Decommissioning

Potential impacts during decommissioning will be similar to those during the construction phase, with vessel activity and mooring system removal constituting the major source of underwater noise. Any impact will be of short duration and is not expected to be significant.

6.8.4 Mitigation

Construction phase

As there is little conclusive information relating to the effects of underwater noise from WECs on the behaviour of marine organisms, adaptive management provides the best approach to mitigation of impacts.

Prior to the deployment of WECs at the test areas, a full noise baseline will be established using up–to-date marine noise monitoring technology. Noise emissions from deployed WECs will also be measured using the same technology and modelled to predict potential impact areas. This data coupled with ecology data will be utilised to actively manage the site leading to potential modifications of WEC component design, array configurations and mooring systems to mitigate any potential noise impact.

SEAI and IBM are currently engaged in a research project to develop a comprehensive acoustic monitoring system using real-time streaming analytics for monitoring underwater noise generated by wave energy conversion devices. The system will consist of sensing platforms, a communications infrastructure, and advanced stream analytics using cloud computing. When fully operational, the system will produce one of the largest continuous collections of underwater acoustic data ever captured. This data will advance knowledge of natural and man-made underwater sound, and help develop standards and reporting. It will enable environmental assessment of noise from actual deployed WECs in the open ocean environment.

Other ways of mitigating potential noise impacts include minimising the construction activity time periods through good project design, planning and efficient execution of operations.

The use of an adaptive management system and good design measures will ensure minimum impacts from underwater noise.

Operational phase

Prior to deployment at AMETS, WEC developers will be required to provide environmental information relating to their wave energy converter and deployment methodology. This will include noise data which will be used to model the effects of the WEC or array and allow prediction of potential impact area. Once deployed monitoring of the deployed WECs will be undertaken to determine their actual noise signature and area of effect at the test areas. This will allow an assessment of the impact of noise emitted by the WECs, either singly or in combination to be made and will feed it to any design modifications of WECS to limit noise emissions if this is required.

Efficiency of operations during WEC deployment will limit potential for noise impacts to occur.

Decommissioning phase

Decommissioning will be carried out quickly and efficiently and the impact will be of short duration and low.

6.8.5 Conclusion

Underwater noise impact on marine organisms is a topic for concern for the emerging marine renewable industry sector. For the AMETS, underwater noise will mainly be of concern during the construction and decommissioning phase with lesser potential for impact during the operational phase. Data on the extent of impact from underwater noise is limited but effects are postulated based on some studies on offshore wind and extensive literature reviews. At the scale of the development proposed, potential impacts will be low and can be readily mitigated by good project design and adaptive management through comprehensive underwater noise monitoring coupled with ecological monitoring.

Overall the potential impacts are predicted to be of short duration and low.

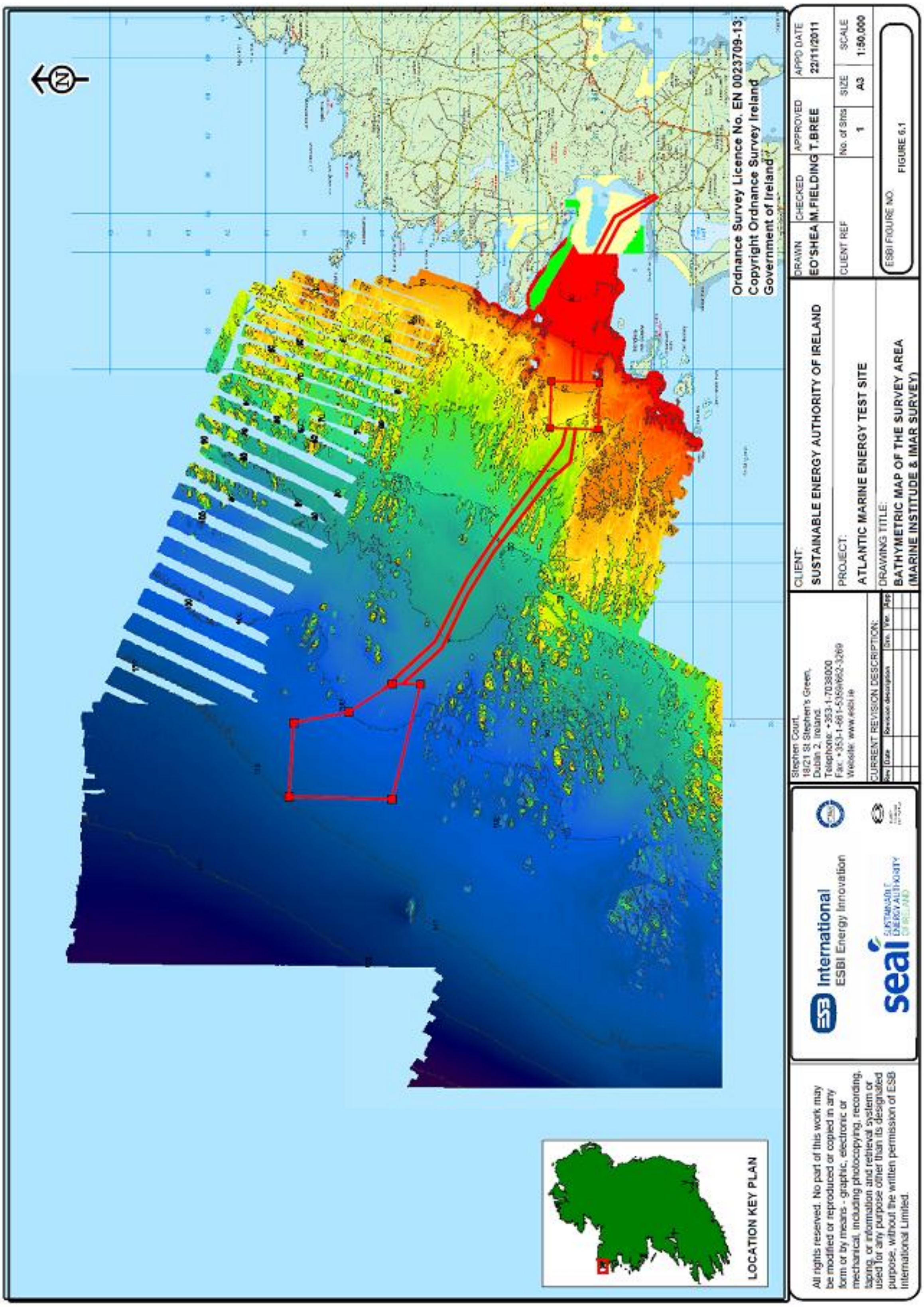

Figure 6-1: Bathymetric map of the survey area (Marine Institute and IMAR Survey)

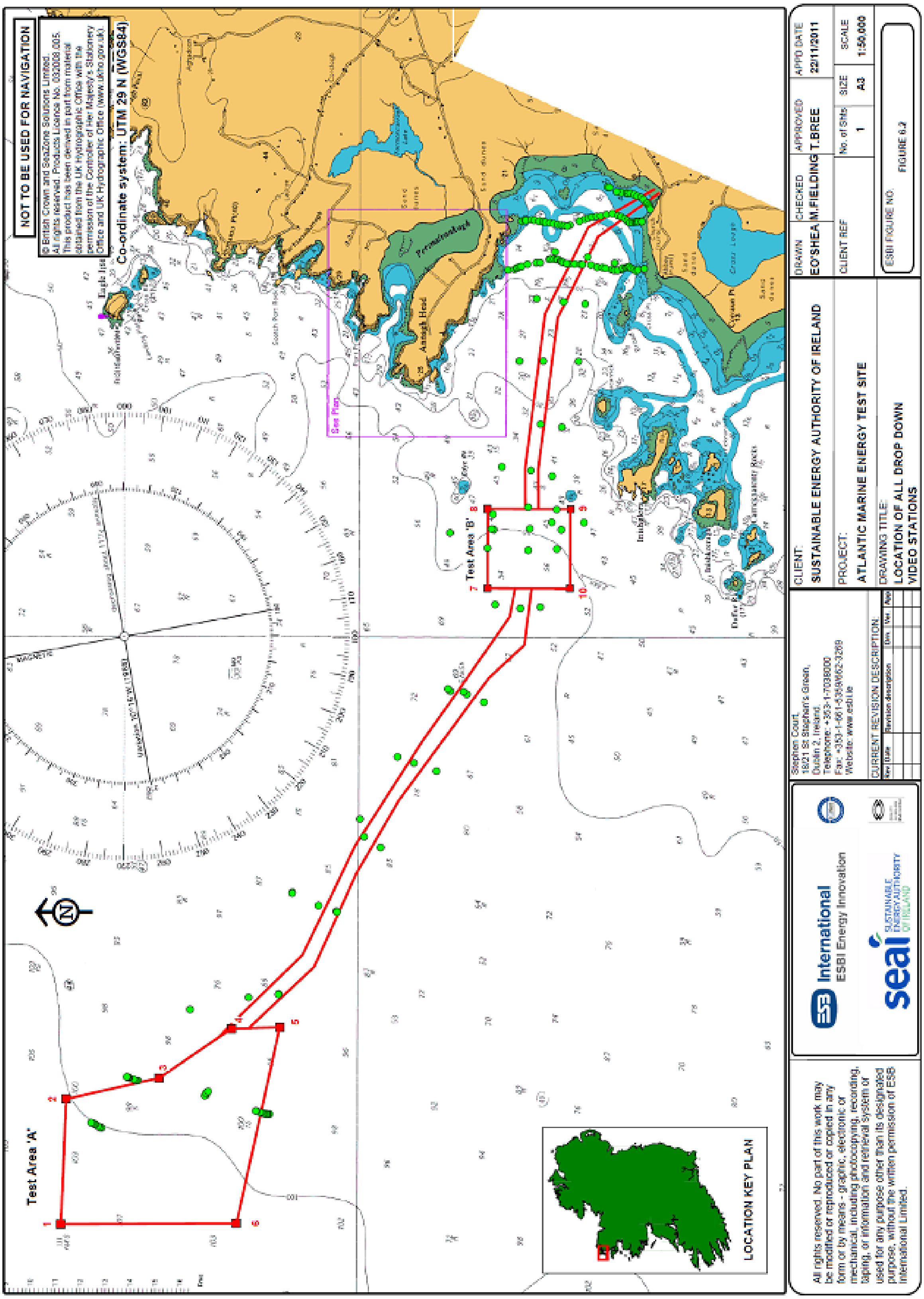

Figure 6-2: Location of all drop-down video stations

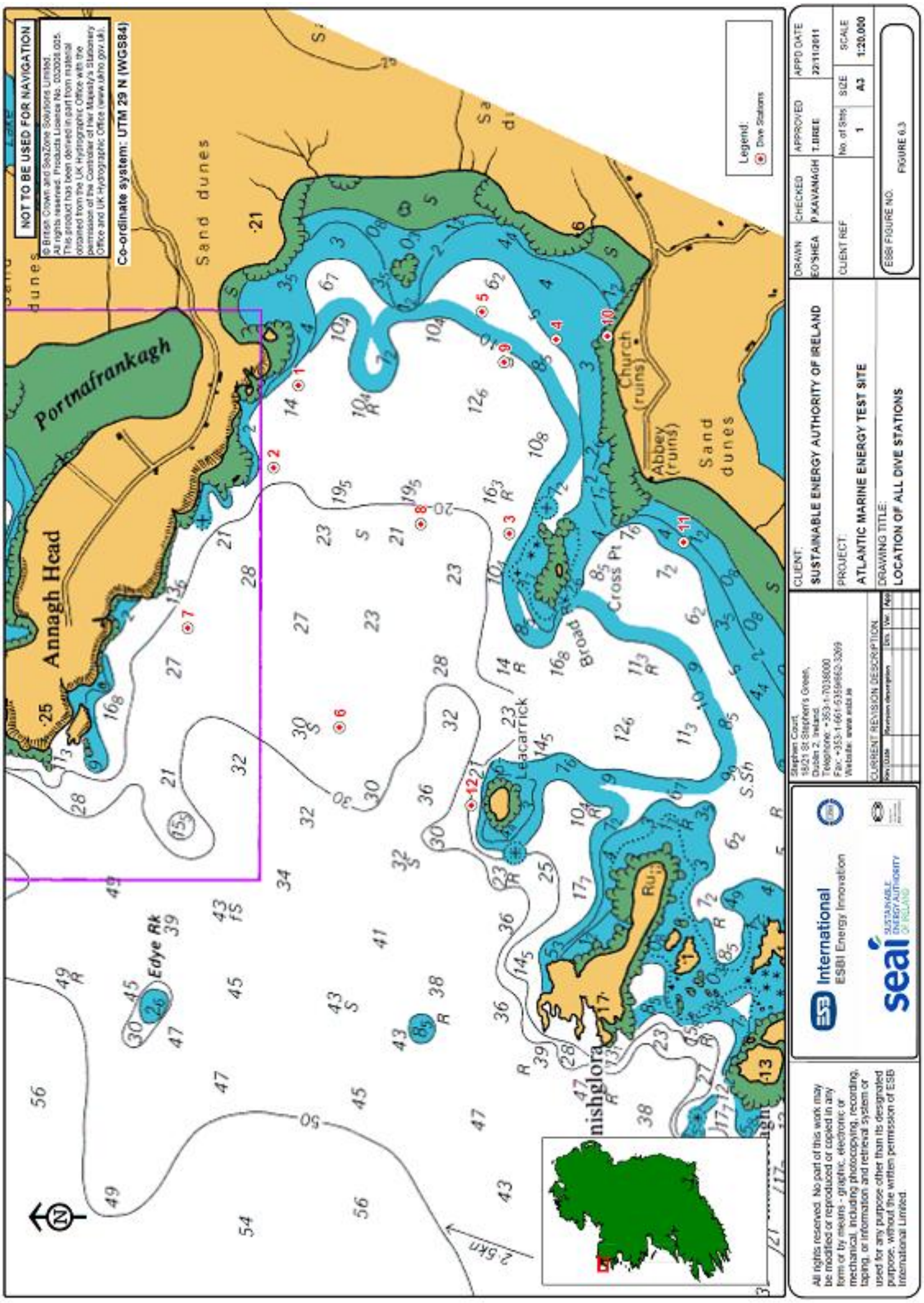

Figure 6-3: Location of all dive stations

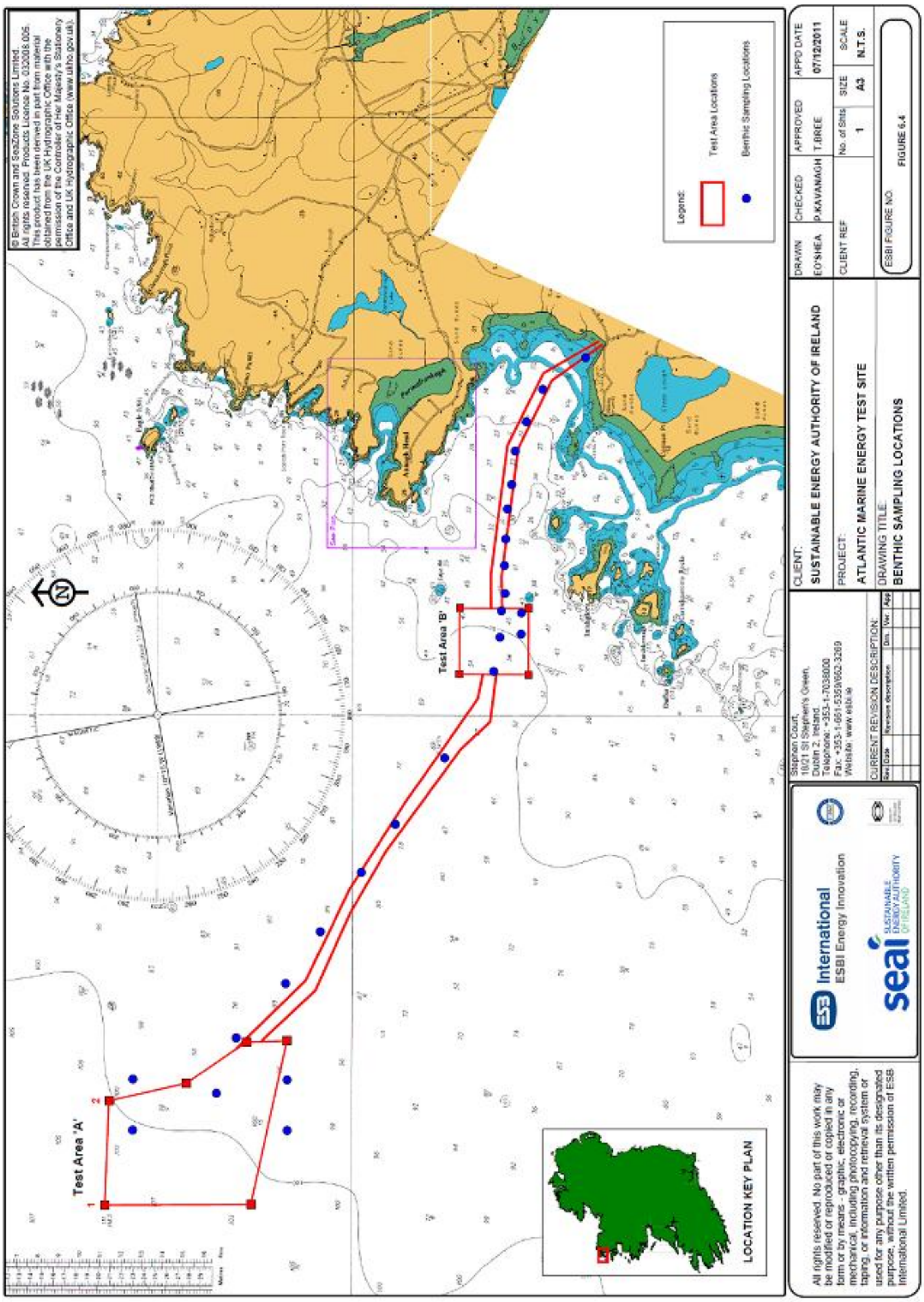

Figure 6-4: Benthic sampling stations

Figure 6-5: Coring stations at each of two transects at Belderra Strand shown relative to the position of the cable landfall

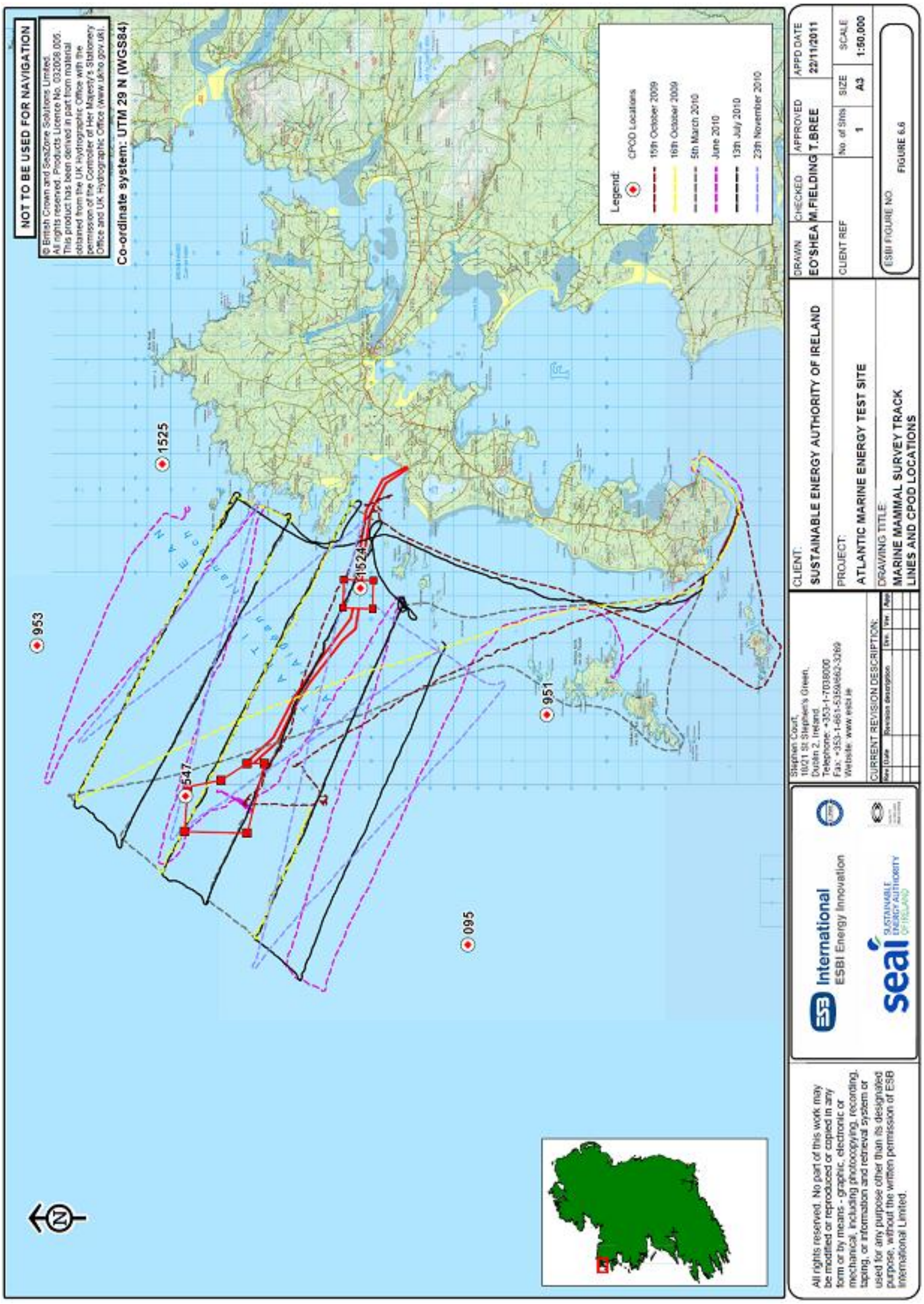

Figure 6-6: Marine mammal survey track lines and CPOD locations

Figure 6-7: Terrestrial habitat study area

Reproduced from the ecology report, **Appendix 3**

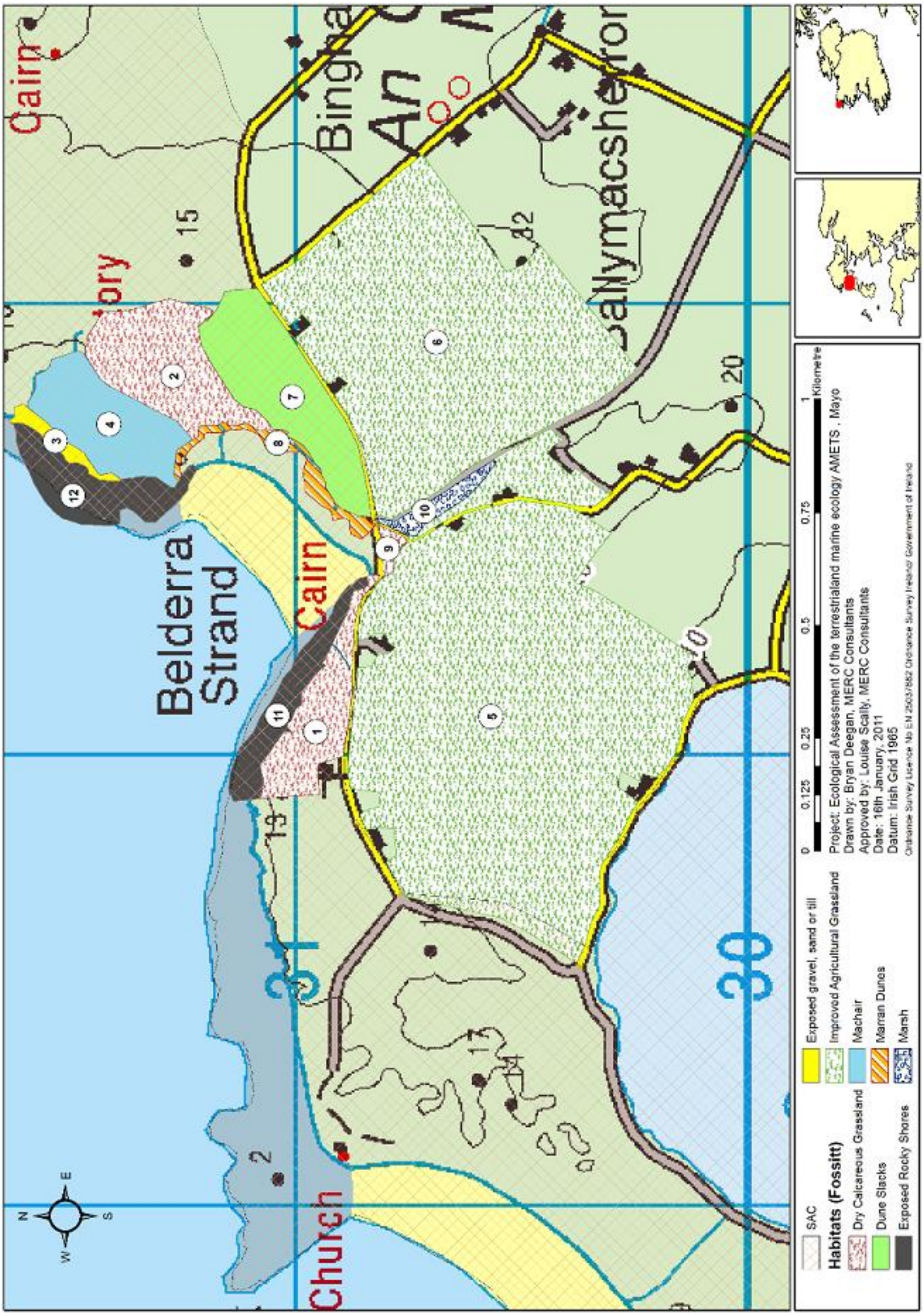

Figure 6-8: Location of habitats surveyed

Reproduced from the ecology report, **Appendix 3**

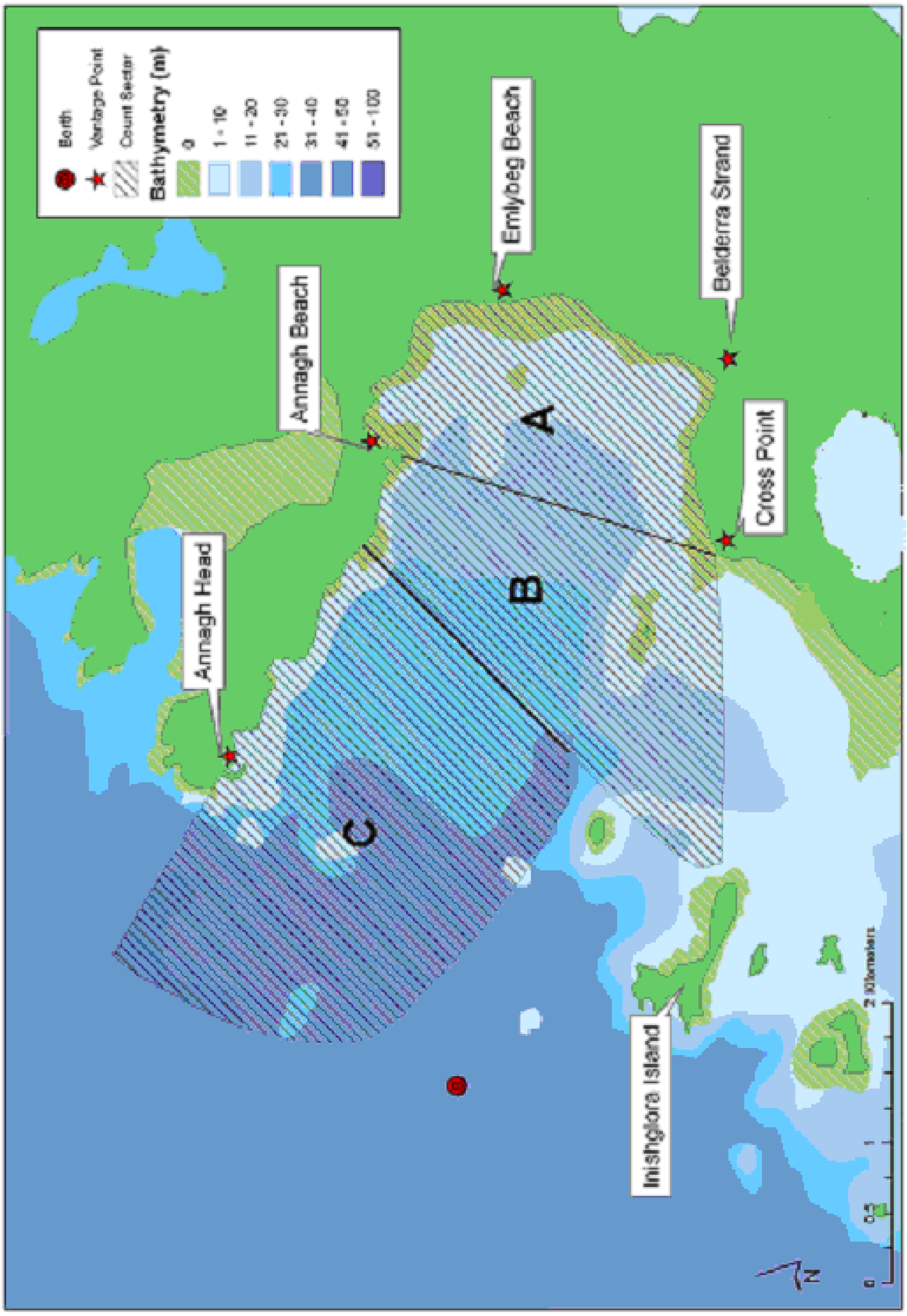

Figure 6-9: Count sectors A, B and C and vantage point locations

Reproduced from the ecology report, **Appendix 3**

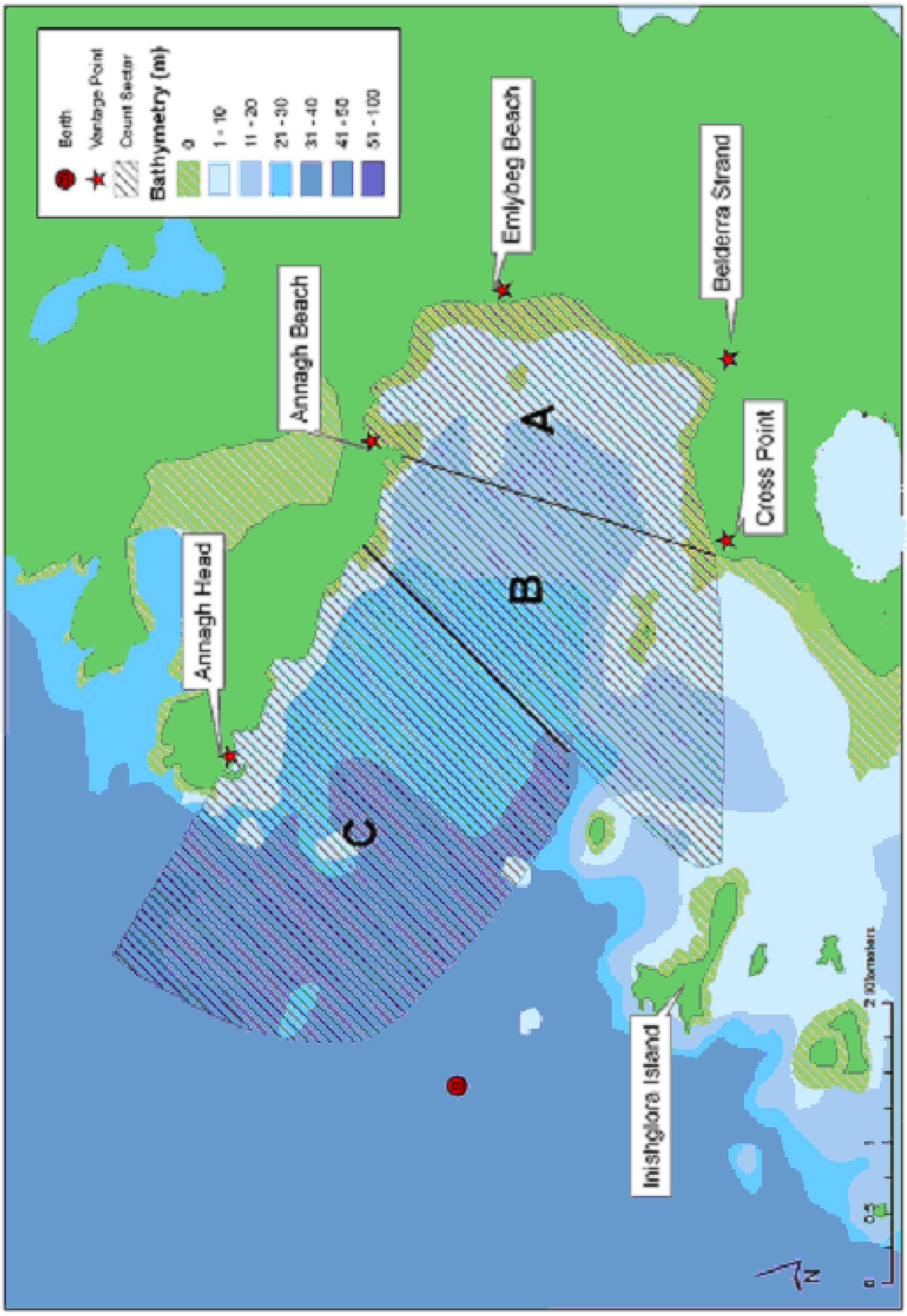

Figure 6-10: Vessel based transect lines followed during surveys for seabirds at sea

Reproduced from the Ecology Report (**Appendix 3**)