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Broad-scale biotope mapping of potential reefs in the Irish Sea (north-west of Anglesey)

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1. Introduction

1.1 Background to study

Implementation of the EU 'Habitats Directive' (92/42/EEC) in UK marine waters, which involved the designation of Special Areas of Conservation (SACs), alongside Special Protection Areas (SPAs) established under the earlier 'Birds Directive' (79/409/EEC) was initially confined to the area within UK territorial seas (i.e. within 12 nautical miles). The SACs and SPAs collectively form the Natura 2000 network of sites. In 1999, a UK court judgement resulted in the decision being taken to extend the designation of SACs into the UK offshore marine area, which includes those waters beyond 12nm and within the British fishery limits and the seabed within the UK Continental Shelf Designated Area. This judgement was ultimately transcribed into UK legislation through the Offshore Marine Conservation (Natural habitats, & c.) Regulations which came into force on 21 August 2007 (Statutory Instruments 2007 No. 1842), and the Joint Nature Conservation Committee (JNCC) was tasked with advising the UK Government on suitable areas to designate as SACs and SPAs in offshore waters.

The habitats listed on Annex I of the Habitats Directive (known hereafter as Annex I habitats) that are known to occur in offshore waters are:

- H1110, Sandbanks which are slightly covered by sea water all the time
- H1170, Reefs; and
- H1180, Submarine structures made by leaking gases

The first stage in the process of designating SACs in offshore waters was to collate existing data on known or likely occurrence of Annex I Habitats in UK offshore waters. This initial data collation exercise was completed in 2002 and culminated in the publication of a technical report, "Natura 2000 in UK Offshore Waters: Advice to support the implementation of the EC Habitats and Birds Directives in UK offshore waters" (Johnston *et al.,* 2002). This report listed areas where Annex I habitats were known or likely to occur, supported by scientific information. Several areas within the Irish Sea were identified as potentially containing Annex I reef.

In the context of the EC Habitats Directive, Annex I reefs are described as being "hard compact substrata on solid and soft bottoms, which arise from the sea floor in the sublittoral and littoral zone" (EC 2007, Box 1).

Three types of reefs are recognised in UK waters; bedrock reefs, stony reefs (including cobble and boulder reefs) and biogenic reefs made by cold-water corals, ross worms (*Sabellaria spinulosa*) or horse mussels (*Modiolus modiolus*). Whilst the definition of bedrock reef is relatively straightforward, the definition of stony reefs can be more problematic, and so further guidance will be developed by JNCC and the Country Agencies (Countryside Council for Wales, Natural England, Scottish Natural Heritage, Environment Agency Northern Ireland) to assist with this process.

1170 "Reefs"
Definition of the habitat:
Reefs can be either biogenic concretions or of geogenic origin. They are hard compact substrata on solid and soft bottoms, which arise from the sea floor in the sublittoral and littoral zone. Reefs may support a zonation of benthic communities of algae and animal species as well as concretions and corallogenic concretions.

Clarifications:
"*Hard compact substrata*" are: rocks (including soft rock, e.g., chalk), boulders and cobbles (generally >64 mm in diameter).
"*Biogenic concretions*" are defined as: concretions, encrustations, corallogenic concretions and bivalve mussel beds originating from dead or living animals, i.e. biogenic hard bottoms which supply habitats for epibiotic species.
"*Geogenic origin*" means: reefs formed by non biogenic substrata.
"*Arise from the sea floor*" means: the reef is topographically distinct from the surrounding seafloor.
"*Sublittoral and littoral zone*" means: the reefs may extend from the sublittoral uninterrupted into the intertidal (littoral) zone or may only occur in the sublittoral zone, including deep water areas such as the bathyal.
Such hard substrata that are covered by a thin and mobile veneer of sediment are classed as reefs if the associated biota are dependent on the hard substratum rather than the overlying sediment.
Where an uninterrupted zonation of sublittoral and littoral communities exist, the integrity of the ecological unit should be respected in the selection of sites.
A variety of subtidal topographic features are included in this habitat complex 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.

Box 1. Definition of Annex I Reefs (from CEC 2007)

Currently there are six SACs in the Irish Sea that have been designated with bedrock or stony reef habitat as a qualifying feature (Strangford Lough; Pembrokeshire Marine; Y Fenai a Bae Conwy/Menai Strait and Conwy Bay; Pen Llŷn a'r Sarnau; Cardigan Bay; Luce Bay and Sands). These SACs cover a range of types of reef, including soft and hard rock, low to high topographic complexity, reduced to full salinity, and low to high energy, however none include deep circalittoral reefs (>50m water depth). Therefore, the network of UK marine SACs would be improved by the inclusion of deeper, offshore reefs.

One of the main aims of this project therefore, was to obtain information on the extent and characteristics of such reefs in the Irish Sea, to enable gaps in the UK network of marine SACs to be filled.

To the north and northwest of Anglesey, the British Geological Survey (BGS) identified an extensive area of bedrock outcrops forming a submerged platform extension of the Pre-Cambrian rocks found on the Skerries and at Carmel Head (BGS 1:250,000 seabed sediment map). In places these outcrops extend beyond the 12nm Territorial Waters Limit. These rock outcrops were identified as areas of potential Annex I habitat by BGS, as part of a JNCC contract to map Annex I habitats within UK offshore waters (Graham *et al.,* 2001).

The geological interpretations also indicated that the Irish Sea as a whole had very extensive areas of glacial till and outwash deposits overlying the bedrock, which are classified on the

BGS seabed sediment maps as 'gravel' and which (according to the modified Folk classification used) can include cobbles and boulders. The reworking of these sediments during the marine transgression has, in areas with moderate to strong tidal currents and in bedload parting zones, left the seabed with a superficial coarse lag. Depending on the nature and morphology of the glacial deposits, the lag often comprises boulders and cobbles. Where these boulders and cobbles form a stable substratum, elevated above the surrounding areas, they can be classified as "reefs". Due to lack of data, it was not possible for BGS to map specific patches of Annex I reef within these broader gravel areas, and therefore all of the gravel areas were identified as having the potential to contain Annex I stony reef (Graham *et al.,* 2001).

The mapped areas identified as potential bedrock or stony reef defined the four survey areas for this project, as described in section 1.3.1.

It was anticipated that areas of biogenic reef may also be found within the survey areas, as patches of *Modiolus modiolus* had previously been recorded within this part of the Irish Sea, although the present day extent of any *M. modiolus* reefs is unknown (Johnston *et al.,* 2002) (Section 1.3.1).

In the summer of 2005, the opportunity arose for JNCC to collaborate with partners of the INTERREG funded HABMAP project (http://www.habmap.org) who were surveying areas in the southern Irish Sea. Additional funding, provided by establishing a Memorandum of Agreement between JNCC, Countryside Council for Wales (CCW) and University College, Cork (UCC) allowed the HABMAP survey to be extended by seven days, which enabled the areas of potential Annex I habitat to be surveyed. This collaborative survey would provide much needed data on the extent and characteristics of Annex I habitats in offshore waters, as well as provide additional data to support the validation of the HABMAP modelling outputs. By collaborating in this way, the cost of surveying was much reduced. The project also provided additional benefits to the INTERREG funded MESH project (Mapping European Seabed Habitats, http://www.searchmesh.net), by enabling MESH Recommended Operating Guidelines to be tested, and by providing valuable data on seabed habitats within the MESH study area. Due to conflicts in timing, it ultimately not possible to incorporate the data obtained through this current study into the HABMAP validation process, which took place in January 2008. It will be used, however, to support future work of CCW, in particular with the ongoing HABMAP project extension.

This report presents the approach used for seabed habitat mapping within this study, the results of this survey, and describes the conservation interest of the areas surveyed.

1.2 Background to approaches in seabed habitat mapping

Traditionally, seafloor habitats have been investigated through the use of direct sampling devices such as grabs, trawls and dredges or visual techniques such as diver observations or underwater video/photography. These techniques are however limited in their spatial coverage. Grabs provide information only on a very small seabed area (e.g., $0.1m^2$) whilst towed gear such as beam trawls gather information over a wider area (e.g., towing a 2m beam for 100s of metres). Visual techniques such as diver survey or underwater videos allow seabed habitats to be observed *in situ*, and can provide valuable information about the spatial relationship of adjacent habitats because they cover a reasonably large area of seabed (e.g., video with field of view for 0.5m may be towed for several hundreds of metres). However all of these techniques still provide information for only a relatively small area of seabed.

The advent of acoustic imaging techniques such as multibeam echosounders and sidescan sonar has allowed large areas of seabed to be mapped to a high resolution in a relatively short space of time. Multibeam echosounders emit a swath of 'sound' towards the seafloor, and record the speed at which these signals are reflected back to the source. The speed of acoustic return can be used to calculate water depth, and once cleaned and processed, these soundings data can be used to produce a 3-D image of the seafloor. Vessel mounted multibeam echosounder systems can image the seafloor at speeds of around four to eight knots, with a swath width varying from hundreds to thousands of metres (depending on water depth). Adjacent lines of multibeam data can be mosaiced to produce a complete topographic map of an area of seabed. Such techniques allow rapid mapping of the seabed, and enable users to be able to visualise the topographic nature of the seafloor in a given area.

Whilst these acoustic techniques were primarily designed to provide information on the bathymetry of the seafloor, the strength of the reflected acoustic signal (backscatter) can also provide information about the physical nature of the seafloor (Kostylev *et al.,* 2001; Todd *et al.,* 1999). Although the exact nature of the relationship between backscatter amplitudes and the physical characteristics of the seafloor is complex and not fully understood, backscatter amplitudes can still be used to determine changes in seafloor character. Where ground-truthing data such as sediment samples are available, these can be used to try to determine the nature of the relationship between acoustic signature and sediment type. A reasonable assumption can then be made that wherever the same acoustic signature occurs, the nature of the sediment would also be similar. However, the nature of the sediment is only one of the parameters that can contribute to backscatter amplitude, and other factors such as the overlying biology can also affect backscatter, and so such an assumption should be treated with caution. Therefore, whilst backscatter should not be used in isolation, if it is used alongside bathymetry, biological and geological data, it can provide an additional layer of information that can be used to map seabed habitats (Kostylev *et al.,* 2001; Todd *et al.,* 1999; Todd *et al.,* 2000).

As with bathymetric data, backscatter amplitude can be mosaiced to produce a mapped product. This map can then be investigated, either by eye or using automated techniques (e.g., QTC Multiview) in various software packages to delineate areas with different backscatter characteristics. Whilst the resulting map is essentially a map of acoustic facies (where acoustic facies are areas with a similar acoustic signature), due to the close relationship between benthic communities and the physical nature of the seafloor (Gray 1974; Rhoads 1974), these acoustic facies can be characterised by the benthic habitats recorded within them. If biological ground-truthing data can allow such a relationship to be established in a given area, then the relationship can be used to extrapolate across the whole of the acoustically mapped area. For example, if a number of acoustically similar areas have been delineated (acoustic signature 'a'), and biological samples collected in some of these areas are revealed to be biological community type 'b', then it may be assumed that wherever acoustic signature 'a' is found, biological community 'b' can also be found. Naturally, the greater the number of biological ground-truthing samples there are, the greater confidence there can be in such assumptions.

There are obviously limitations to the approach. For example where the seafloor is particularly acoustically complex or where changes occur very gradually and clear acoustic facies can not be delineated. A further problem can occur due to the different resolutions at which acoustic and biological data are obtained. For example acoustic mapped products (bathymetry and backscatter) are often gridded, and depending on the resolution of the data collected, data may be gridded to metres or tens of metres. If data has been 'binned' into a grid of several metres, then changes in acoustic signature which can be delineated are likely to be in the order of tens of metres, to be confident that the change in acoustic signature is 'real' rather than an artefact of the data. Importantly, the biological techniques used to ground-truth such acoustic data may be measuring changes on a much smaller scale. These different resolutions may make it very difficult or even impossible to match changes in biology to changes in acoustic data and thus determine any relationships between the two (Davies *et al.,* 2008). For this reason, a robust ground-truthing strategy should be undertaken using a suite of different ground-truthing techniques, such as grab samples, and underwater video/photography.

A final limitation is that there is often insufficient biological data available to ground-truth the acoustic data. It is relatively easy to quickly cover large areas of seafloor with acoustic techniques; however biological sampling is more time intensive, both in the collection and subsequent analysis. Therefore biological sampling can be a major cost in terms of both time and money. Due to limited resources on many projects, the necessary volume of ground-truthing data required to produce a robust habitat map is often not achieved. This is particularly problematic in heterogeneous areas, a fact which may only be discovered once the survey is in progress, and the number of biological samples to be taken has been pre-determined. The end result is that there is insufficient biological information to adequately ground-truth the acoustic data and relationships between acoustic facies and biological communities cannot be made with any confidence, or cannot be made at all. In such situations, data can be presented as layers, and preliminary assessment of relationships between acoustic facies and biological communities can be made, but it is not possible to produce a full coverage habitat map.

The method of using a combination of acoustic and biological survey techniques to produce seabed habitat maps is now widely used, and methods are continually improving. It has been successfully applied to large scale projects (James *et al.,* 2007 and Mackie *et al.,* 2006) as well as more focussed studies (Brown *et al.,* 2002; Brown *et al.,* 2004; Davies *et al.,* 2008; Kostylev *et al.,* 2001). Recently, the Mapping European Seabed Habitats (MESH) project has attempted to draw together seabed habitat mapping expertise, compile existing habitat maps across the project area, promote consistent habitat mapping techniques and provide habitat mapping guidance to both those involved in habitat mapping, and end users of such maps.

The use of seabed habitat maps can be wide ranging, and have provided tools for, among other things, Marine Protected Area (MPA) identification, marine spatial planning, impact assessment and monitoring (e.g., Boyd *et al.,* 2004; James *et al.,* 2007; Mackie *et al.,* 2006; Pickrill and Todd 2003).

1.3 Survey Areas

1.3.1 Location

Four patches of potential Annex I reef within UK offshore waters (outside 12nm) of the Irish Sea were targeted within this study, covering a total area of approximately 140km^2 (Table 1 and Figure 1). The four survey areas area each located between approximately 11 – 16nm from the coast of Anglesey.

Table 1. Details of four survey areas.

Survey Area	Approximate area (km^2)	Target
Area 1	50	Part of large gravel area, identified on BGS seabed sediment map
Area 2	44	Gravel patch
Area 3	23	Diamicton patch
Area 4	24	Part of large rock area

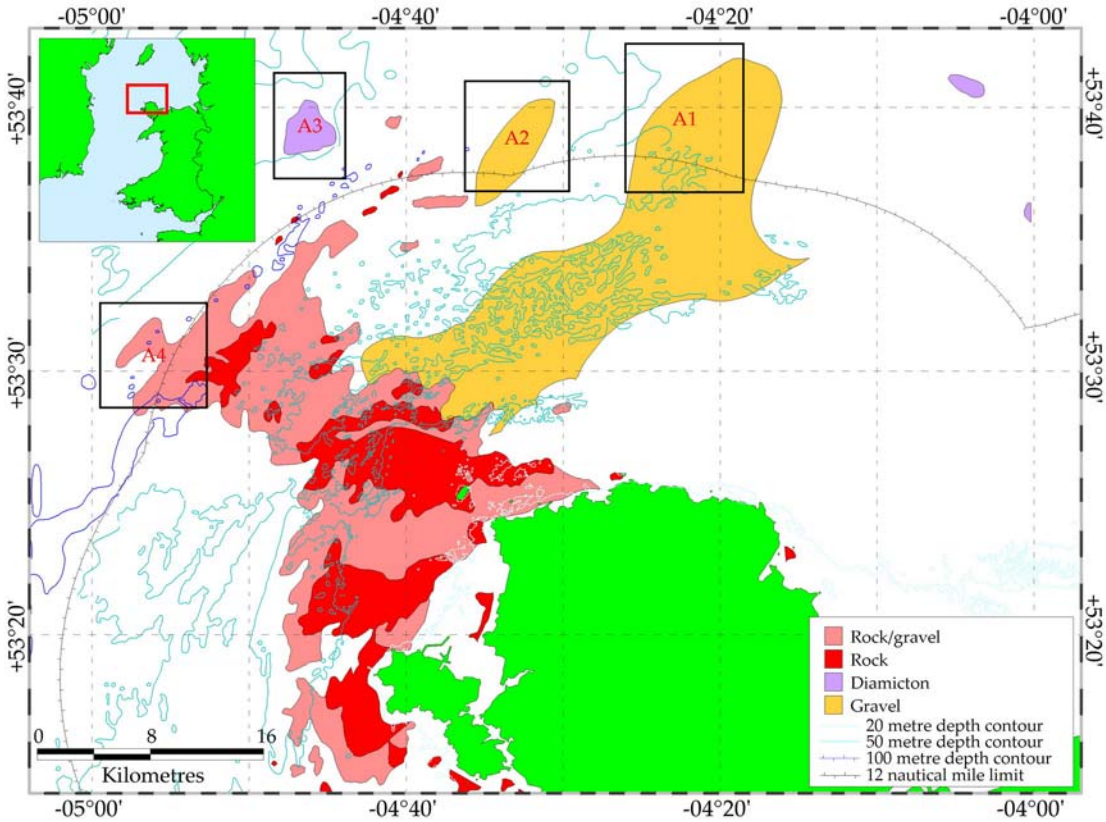

Figure 1. Four survey areas investigated within this project, encompassing areas of predicted occurrence of Annex I reef. Areas of potential Annex I reef are coloured according to the sediment type (seabed habitat derived from BGS 1:250,000 seabed sediment maps, © NERC).

1.3.2 Physical environment

The Irish Sea contains a deep channel running down its centre, which is roughly orientated north to south, and ranges from 80m to 110m in depth. This channel shelves on either side, with the four survey areas in this report lying on the eastern shelf edge, in depths ranging from 40m to 100m.

A salinity gradient exists from north to south of the Irish Sea, with the northern Irish Sea having a lower salinity due to increased riverine inputs (Bowden 1950). The salinity of the four survey areas within this project is between 34 and 35ppt, due to their location south of the reduced salinity area. In addition, although a seasonal stratification occurs in the northern Irish Sea this does not occur within the area of study (Proudman Oceanographic Laboratory data, as presented in Connor *et al.,* 2006). The tidal currents in this part of the Irish Sea are high, particularly around the north and west of Anglesey (Proudman Oceanographic Laboratory data, as presented in Connor *et al.,* 2006).

The seabed of the Irish Sea is strongly influenced by historic processes, resulting in a complex mixture of relict and modern features. A number of glaciation events have markedly influenced the seabed physiography and shallow sub-sediments. Glacial retreat following the last glaciations resulted in deposition of diamicton; a poorly sorted gravelly, sandy and muddy sediment (Holmes and Tappin 2005). In addition, glacial deposits were subject to surf zone processes during the marine transgression (Rees 2000).

In this region of the Irish Sea the nature of the seabed sediments is largely sedimentary. Survey areas 1 and 2 lie within an extensive gravel plain, including a mixture of gravel, sandy gravel and muddy sandy gravel (Figure 2). Area 3 encompasses a small patch of diamicton. The seabed sediment map produced by the BGS shows Area 4 to be the only one of the four study areas that includes areas of rock, encompassing a finger of rock extending from a large sub-sea platform of pre-Cambrian rock that reaches the north-west coast of Anglesey (Rees 2005).

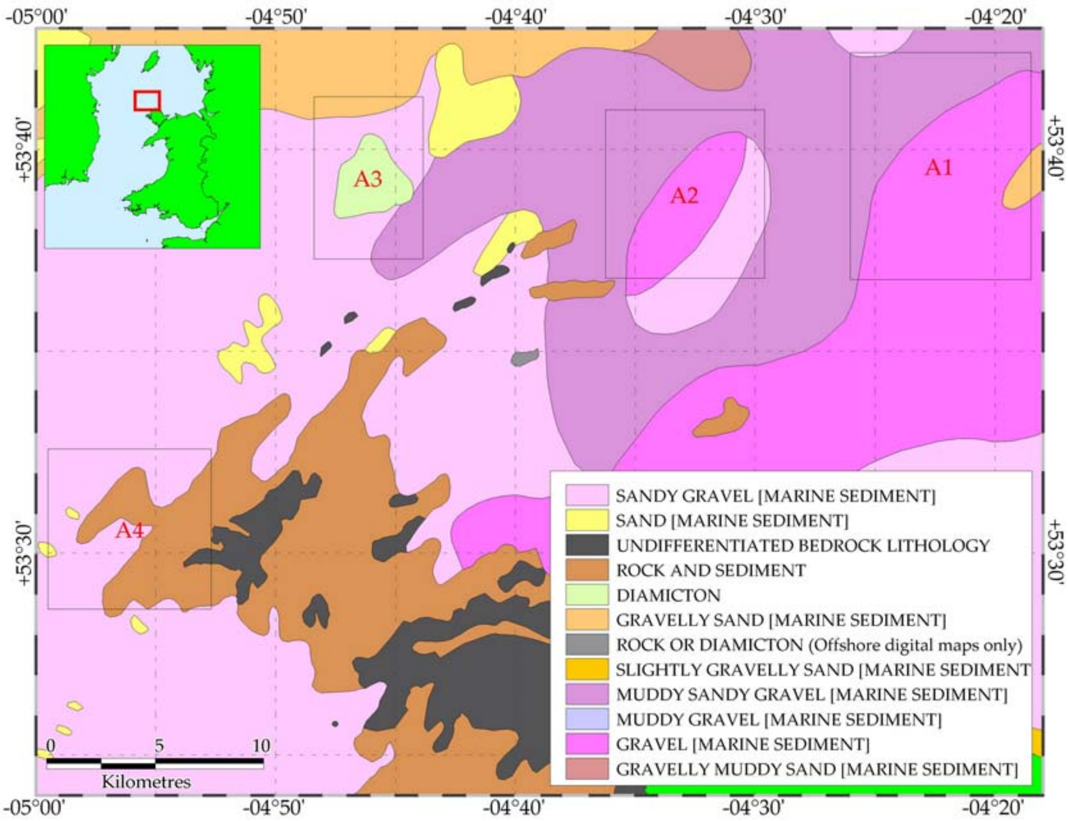

Figure 2. Distribution of surficial sediments around Anglesey (BGS DigSBS250, license 2003/062).

The recently completed UKSeaMap project produced a predictive landscape map (Connor *et al.,* 2006; Figure 3) in which 'marine landscape types' were described and mapped across the whole of the UK sea area. The landscape types, derived by carrying out a supervised classification of physical data sets relating to seabed substratum, light attenuation, depth, bottom temperature, wave-base and near-bed stress, were physical in their description. Overlaying the four study areas in NW Anglesey on the UKSeaMap landscape types reveals the following marine landscapes: Areas 1 and 3 both contain a mixture of Shallow coarse sediment plain – moderate tide stress, Shelf coarse sediment plain – moderate tide stress, and Shelf mixed sediment plain – moderate tide stress. Area 2 also includes both the Shelf coarse and Shelf mixed sediment plain – moderate tide stress. Finally Area 4 includes the Shelf coarse sediment plain – moderate tide stress as well as Aphotic rock and Shelf mound or pinnacle.

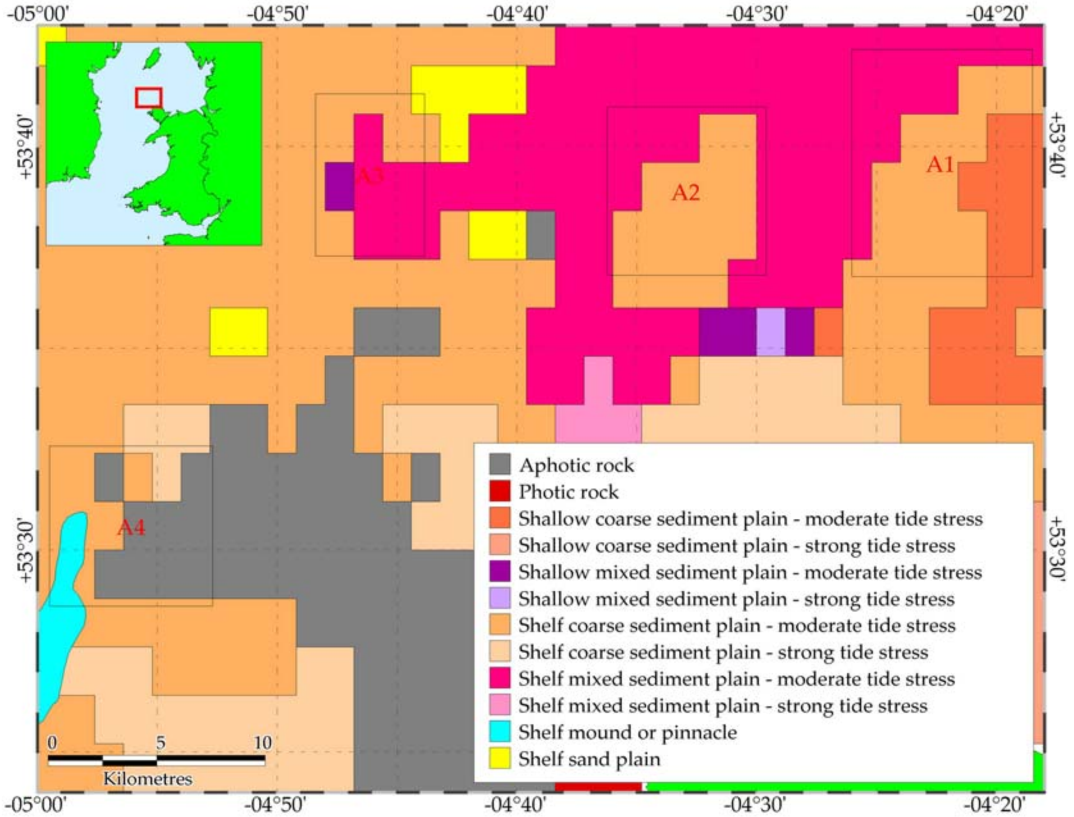

Figure 3. Marine landscapes predicted for study region (From Connor *et al.,* 2006).

Both the BGS seabed sediment map and UKSeaMap (which uses information from the BGS sediment map) indicate that the three northern study areas (Areas 1, 2 and 3) lie within a large area of coarse and mixed sediment plain. The nature of the seabed changes further south, with increased tidal stress and a large area of rock, which extends from the coast of Anglesey westward into the Irish Sea.

1.3.3 Biology

Although the biology of the Irish Sea has been well studied in some areas, the study area for this project has received little attention historically. Previous biological research in the Irish Sea has been well documented (e.g., Mackie *et al.,* 1995; Wilson *et al.,* 2001) and will not be dealt with in detail here. Many historic studies have tended to focus on impact studies (e.g., relating to sewage sludge or dredge disposal (Rees *et al.,* 1992)), be very geographically focussed (e.g., more attention in Liverpool Bay, Morecambe Bay or coastal areas, or linked to industrial activities (e.g., surveys to support oil and gas exploration), and therefore have limited application to the current project.

In general, studies within the part of the Irish Sea north and west of Anglesey have described coarse sediment communities, strongly influenced by the high tidal currents that operate in the area (Hensley 1995; Mackie *et al.,* 1995; Wilson *et al.,* 2001). Mackie (1990) produced a generalised map of Irish Sea faunal communities based on previous studies and personal observations (Figure 4). Work completed through the BIOMÔR benthic biodiversity studies in the southern Irish Sea increased knowledge of the biological assemblages present (Mackie *et al.,* 1995; Wilson *et al.,* 2001).

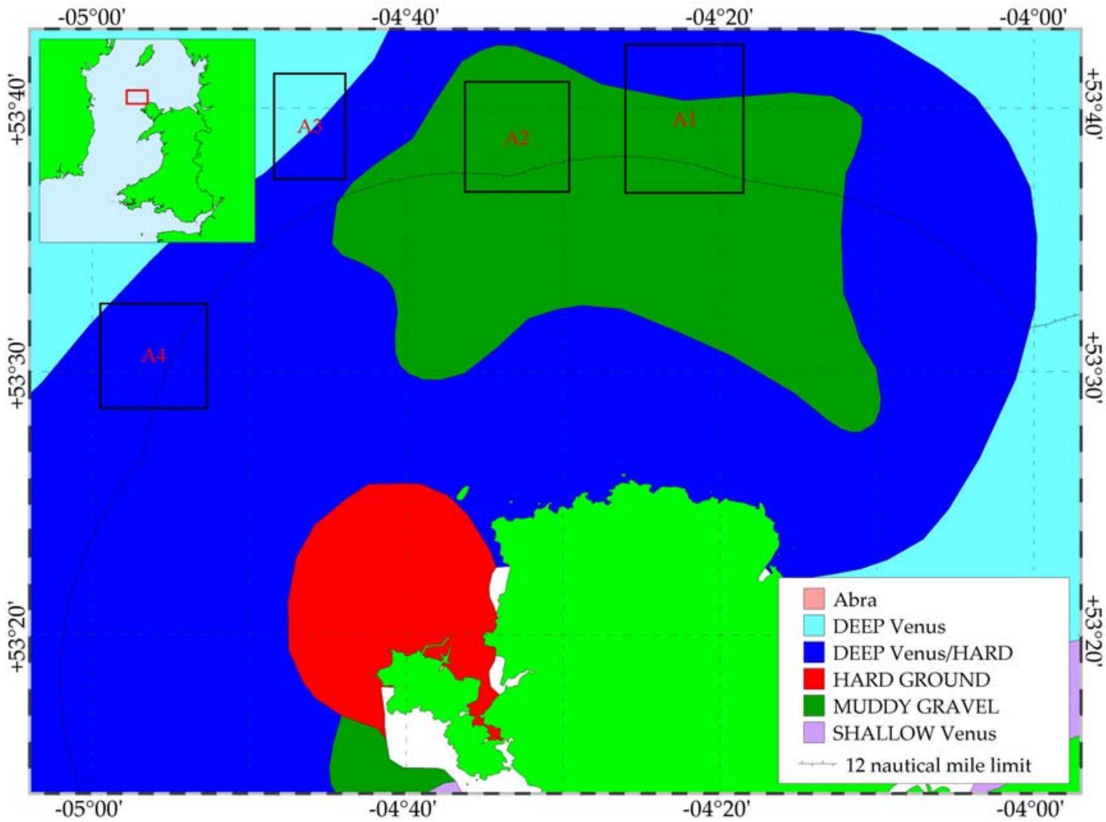

Figure 4. Map of faunal assemblages (Mackie *et al.,* 1995).

The faunal assemblages described by Mackie (1990) in the vicinity include:

- A Deep Venus community which is equivalent to the Polychaete-rich deep Venus community in offshore mixed sediments biotope (SS.SMx.OMx.PoVen) described in the Marine Habitat Classification for Britain and Ireland version 04.05 (Connor *et al.,* 2004, hereafter referred to as The Marine Habitat Classification), and
- A Deep Venus/Hard community, which has no direct equivalent within the Marine Habitat Classification, but which is most closely related to Sublittoral mixed sediment biotope complex (SS.SMx).

Both of these assemblages extend through much of the central Irish Sea. Also present within the study areas are regions of muddy and sandy gravel (equivalent to deep circalittoral coarse and sublittoral mixed sediment biotope complexes within The Marine Habitat Classification).

Other studies have noted the presence of beds of the horse mussel, *Modiolus modiolus*, throughout the Irish Sea, documented by Rees (2005). As part of the Department for Business, Enterprise & Regulatory Reform (formerly the Department of Trade and Industry) Strategic Environmental Assessment for the SEA6 region, Rees (2005) conducted additional survey work in an area thought to contain *M. modiolus* beds. This involved limited side-scan surveying around locations where *Modiolus* clumps had been recorded in the past, followed by targeted dredge sampling of features that might represent mussel aggregations. Four of the locations surveyed were found to contain beds and other locations may also have contained beds, but the patchiness of the habitat meant that successful targeting of the beds was difficult (Rees 2005). Although these areas of high *M. modiolus* density were within the vicinity of the current study areas, none occurred within any of the four study area boundaries. *Modiolus modiolus* beds are an important feature of conservation interest, being protected under the EU Habitats Directive as a sub-type of Annex I Reef (sub-type: biogenic) and under the OSPAR convention on the Initial List of Threatened and Declining Habitats and Species (OSPAR 2004). Rees (2005) also recorded several locations where *Sabellaria spinulosa* occurred in high densities. In general, these formed 'crusts', but in one location, the *S. spinulosa* colonies were fully developed into reef structures, although it was not possible to determine their extent. Whilst the *S. spinulosa* reef was recorded inshore of the current project study areas, several records of *S. spinulosa* crust lay within and around the four study areas of this project. As with *M. modiolus*, *S. spinulosa* reefs are protected under both the EU Habitats Directive (as a sub-type of Annex I Reef) and OSPAR.

Most recently the HABMAP project has developed predicted seabed biotope maps for the southern Irish Sea (Robinson *et al.,* 2007). Through this project, biological and physical datasets were collated within a Geographic Information System (GIS) and the spatial relationship between physical and biological parameters was then used to create a rule-based predictive tool. The project resulted in the production of a series of maps showing the predicted distribution of biotopes, based on their observed relationships with the physical environment in the study area. A final biotope map for the area was also produced, and the confidence with which biotopes were likely to occur in any given area was assessed against known occurrences as detailed in the Marine Habitat Classification biotope manual (Connor *et al.,* 2004). In areas where more than one biotope was predicted, these were ranked in order of their confidence scores, so that the final visual representation of the map showed the most confident prediction for every area (though information on all biotopes was retained within the GIS). This map predicted that the four study areas of the current project were likely to be predominantly characterised by *Flustra foliacea* and *Hydrallmania falcata* on tideswept circalittoral mixed sediment (SS.SMx.CMx.FluHyd). Other biotopes were also predicted to be present throughout the four study areas, although with a lower confidence. The predictions made by the HABMAP project in this area were thought to be less reliable than elsewhere in the HABMAP study area, due to the lack of offshore input data available for use in the model.

1.4 Objectives

The aim of the project was to improve understanding of the habitats and communities present beyond 12nm north of Anglesey in order to support nature conservation initiatives such as the EU Habitats Directive and the sustainable use of seas around the United Kingdom.

This was to be achieved by fulfilling the following objectives:

- Map the distribution of biotopes within the four study areas;
- Identify and map the extent of areas of Annex I reef, as defined by the EC Habitats Directive (92/43/EEC) within the study areas;
- Provide sufficient biological and acoustic data to allow the subsequent assessment of potential Annex I reef habitat against the interpretation of Annex I reef according to the EU Habitats Directive; and
- Provide biological and acoustic data to supplement that obtained by the INTERREG funded HABMAP project in order to help that project achieve its own objectives.