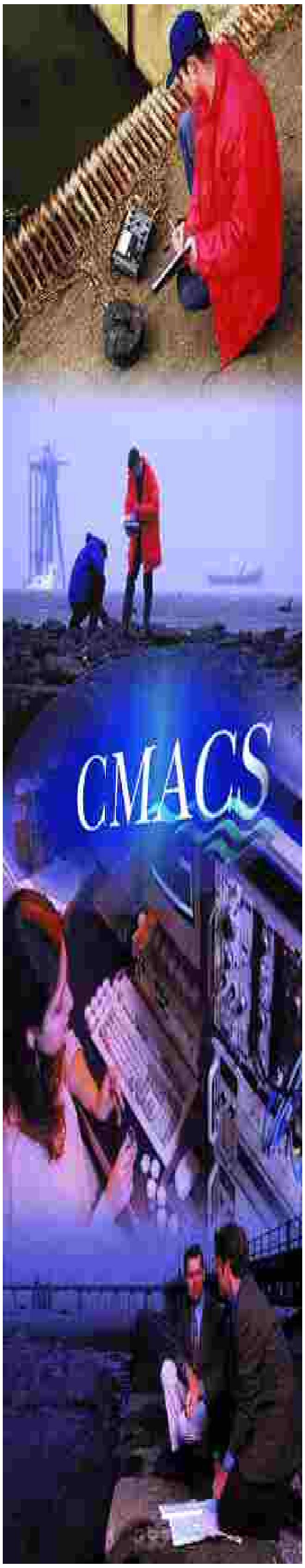

Gwynt y Môr Offshore Wind Farm

Marine Ecology Technical Report

2005

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Centre for Marine and Coastal Studies Ltd

CMACS Ltd.
Cammell Lairds Waterfront Park
Campbeltown Road, Birkenhead
Wirral CH41 9HP

Tel 0151 650 2275
Fax 0151 650 2274

CMACS Ltd.
Port Erin Marine Laboratory
Breakwater Road, Port Erin
Isle of Man, IM9 6JA

Tel 01624 831 018
Fax 01624 831 043

Centre for Marine and Coastal Studies Ltd.
Registered in England No. 4883990

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1. Introduction

The production of electricity through the burning of fossil fuels produces large quantities of the greenhouse gas carbon dioxide. Such greenhouse gases have been attributed as contributors to global temperature rise the consequences of which include; increased erratic climatic events such as flooding and drought, and rising sea levels attributed to the melting of the polar ice caps, threatening coastal and small island communities. In 1997, worldwide governments (including the United Kingdom (UK)) agreed on the Kyoto Protocol. This protocol established legally binding targets, following ratification, for the reduction of greenhouse gases emitted by industrial nations. The UK Government has put in place an additional target, recently revised to a 14% cut in carbon dioxide emissions by 2010 compared to 1990 levels. As one third of all carbon dioxide emitted in the UK comes from fossil fuelled power generation, and because of the rising demand for energy, both in the UK and worldwide, electricity from clean renewable sources such as wind power will therefore be essential for the UK to meet its targets on taking action on climate change (BWEA, 2005).

In 2003, the UK's first commercial offshore wind farm (North Hoyle) was commissioned off the North Wales coast between Rhyl and Prestatyn by npower renewables. Thirty turbines generate up to 60MW of electricity and provide energy from a renewable source to meet the needs of approximately 40,000 homers per annum. It is expected that this renewable energy development will offset the release of approximately 160,000 tonnes of carbon dioxide (the main greenhouse gas contributing to global warming and climate change) every year (npower renewables, 2005) bringing the UK closer to meeting the governments commitment to renewable energy targets.

Under the DTI (Department of Trade and Industry) Round 2 offshore wind farm allocation process npower renewables are now seeking to build Gwynt y Môr Offshore Wind Farm within Liverpool Bay some 13-15km offshore from the North Wales coastline stretching from Prestatyn in the East to Penrhyn Bay in the West. The Gwynt y Môr project will generate a capacity of up to $750MW_e$ of electricity and at this size would generate enough clean electricity each year to meet the demand of around 500,000 homes - equivalent to approximately all of the households in Anglesey, Gwynedd, Conwy, Denbighshire, Flintshire, Wirral, Sefton and West Lancashire (npower renewables, 2004).

The Centre for Marine and Coastal Studies Ltd (CMACS) has been commissioned by npower renewables to undertake the Environmental Impact Assessment (EIA) of the Gwynt y Môr project on the marine ecological environment, namely the water and sediment quality, areas of conservation interest and marine species including benthic invertebrates, plankton, fish and marine mammals. This has been undertaken through the review of available literature and, where necessary, undertaking site-specific surveys to provide baseline information on which the assessment of any impacts of the Gwynt y Môr Offshore Wind Farm project are then based. It should be noted that impacts of the project on terrestrial species (including birds) and terrestrial habitats have been assessed for within other reports (e.g. see ERM, 2005) and are not detailed within this report.

The impacts of the Gwynt y Môr Offshore Wind Farm project have been considered on the marine fauna and flora of Liverpool Bay and the wider eastern Irish Sea. For the purpose of this assessment the definition of the eastern Irish Sea follows the area from Luce Bay and the

Rinns of Galloway in the North due South to the Northern Coastline of Angelsey and to include all waters located to the east (Proudman Oceanographic Institute, pers comm). Within this area further definition is given to Liverpool Bay, which is defined as the area from the Ribble Estuary (Lancashire) to the Great Ormes Head located at Llandudno (North Wales). However, this has been extended for the purpose of this assessment to include the mouth of the Conwy Estuary and the south east coastline of the Isle of Angelsey due to the position of Gwynt y Môr in relation to these areas.

The assessment for the impacts of Gwynt y Môr Offshore Wind Farm and the baseline information upon which these assessments have been made are presented within this following report. This information has then been used to produce the summary sections for the Environmental Statement (ES) (detailed in npower renewables, 2005). Any site-specific studies, which were undertaken as part of this assessment, have been appended to this report.

2. Project Details

The extended programme schedule for large offshore wind farms such as Gwynt y Môr Offshore Wind Farm means that at this stage it is not possible to predict which methods or structures may be used. The following section therefore describes the proposed methods and wind farm structures which are currently under consideration for the Gwynt y Môr project. These details have been used to consider the potential impacts upon the marine environment for the three phases (construction, operation and decommissioning) of Gwynt y Môr. Because of the different methods and structures under consideration the worst-case scenario for each potential impact has been identified (this is considered within section 4) from these project details. This is to ensure that all aspects of the development on the marine ecological environment have been appropriately assessed for.

The Construction Phase

This phase of the project is anticipated to take 2-3 years. During this time all aspects of the wind farm construction including turbine and offshore sub station construction and cable laying would be completed.

Offshore Structures

The main offshore structures of the Gwynt y Môr Offshore Wind Farm would be the wind turbines, and 2-4 offshore sub stations in addition to met masts to gather meteorological information (2-3 required during the planning process and a further 2 may be constructed along with the turbines). Turbines may be of the 3MW class up to 5MW class and three illustrative layout scenarios detailing one of solely 3MW, one of 5MW and one of a mixture of the 2 turbine classes are given in Figures 2.1 to 2.3. Table 2.1 displays the maximum area of seabed (including the estimated area occupied by scour protection) and the number and class of turbines for each of these illustrative layout scenarios.

Different options are under consideration for the installation of structure foundations (turbines, sub stations and met masts). These are: **Monopile**- the most common method used for offshore wind farm installation within the UK. The drill drive approach would be used for installation, whereby the pile is driven into the seabed using a hydraulic hammer which is replaced by a drill when resistance is met by hard substratum such as bed rock. This technique was successfully used at the North Hoyle Offshore Wind Farm. Each pile installation would be expected to take up to 12 hours out of a 7 day period. The drill drive approach produces spoil which would then be distributed over the seabed in proximity to the installation (as was done at North Hoyle). See Table 2.2 for the estimated volume of spoil generated using this technique. **Multipiles**- these foundations consist of a three legged frame of smaller steel tubules which are driven into the seabed to support the tower. These follow a similar installation technique as for the monopile but would take an anticipated 24 hours out of a 7 day period for the installation of one multipile (see Table 2.2 for the anticipated amount of spoil generated). **Gravity base**: this is a large diameter steel or concrete base which sits on the seabed and supports the turbine tower. Installation is undertaken using a heavy lifting barge used to place the base directly onto the seabed. Prior to this installation it may be necessary to level the seabed either through dredging or rock dumping. The estimated volume of spoil generated by this foundation installation type is listed in Table 2.2. **Suction-caisson**- this foundation type is similar to the gravity base but smaller in diameter with perimeter skirts which penetrate deeper into the seabed. Installation methods would be as for the gravity base turbine foundation type with the exception that no preparation of the seabed is necessary and no spoil is generated.

Cabling

The final cable design will be subject to further work through the procurement process, the finalisation of the detailed electrical design of the Gwynt y Môr Offshore Wind Farm is therefore not currently defined. However, a number of indicative options are being considered as a basis for the EIA and preliminary design process and may involve the following arrangements:

There will be an estimated 150- 200km of inter-turbine cables. These will most likely be 33kV, 3-core copper conductors with steel wire armour and XLPE insulation. Conductor size may vary with expected current load (i.e. thicker conductors at the sub station end of inter-turbine cable strings). Inter-turbine cables will merge at offshore sub stations where cables may be separated by less than 10m.

There will be between 2 and 4 offshore substations which may be interconnected by cables rated between 132 and 245kV (3-core copper conductors with steel wire armour, XLPE insulation and a lead sheath). Sub stations may be towards the centre or landward edge of the Gwynt y Môr Project Area (see Figures 2.4 and 2.5).

There will be 3 to 6 export cables rated between 132 and 245kV (3-core copper conductors with steel wire armour, XLPE insulation and a lead sheath). Each export cable will be circa 15 to 20 km in length, giving a total indicative length of 45 to 120km for the export cables.

Cables could be installed by different methods including ploughing, a trenching tool or water jetting (which disturbs the largest volume of sediment) (see Table 2.3 for the total length of all cables, area disturbed by installation and estimated volume displaced during installation). Subsea cables will be buried to a depth of circa 0.5 to 1m, although the final burial depth will be subject to a burial depth design process taking account of prevailing geological and sediment mobility conditions. Export cables will be separated by a minimum of circa 50m offshore and by a minimum of circa 10m in the intertidal zone at the chosen landfall location located at four possible sites between Pensarn and Towyn (County of Conwy). For cable installation in the shallow subtidal and across the lower intertidal, it is anticipated that a cable plough will be landed at the beach landfall and then towed offshore by the cable installation vessel. Further up the beach (from above the low water mark to the high water mark) the cables will either be trenched using an excavator and the beach re-instated following installation or cable ducts will be installed below the beach using directional drilling techniques.

Alternatively a combination of both trenching and directional drilling may be required. Where trenching is used across the intertidal area, each cable trench is likely to be 2-3m wide and will be supported by the installation of temporary sheet piling. The area of beach around the cable installation area will be fenced off to ensure public safety. An area of approximately 100metres wide may be required for the cable installation and plant access. Burial depth at the beach will be subject of further engineering studies but will be sufficient to ensure cables remain buried. Any solid coastal defences will be crossed by means of directional drilling underneath the sea walls to ensure the integrity of the coastal defences are maintained.

The time taken for cable installation it is currently estimated as: Export cabling: 30 to 40 days per 2 cables (maximum of 120 days for 6 export cables). Inter turbine cables 120 days per 250MW phase. This totals an approximate 360 days for cable installation over the 2-3 year wind farm construction period.

In addition to these underwater structures scour protection such as rock, sandbags or concrete filled mattresses may be used to diminish scour from turbine bases and cabling and to protect areas of existing pipeline at the site. The amount of seabed scour protection anticipated to be required is displayed in Table 2.1.

<u>Vessel movements</u>

The construction vessels required during the construction phase, in addition to the estimated number of journeys for these vessels between a port and the Gwynt y Môr project area are detailed within Table 2.4. The ports under consideration for the construction phase are Holyhead, Mostyn, Liverpool, Heysham and Barrow.

<u>Marine Noise</u>

Underwater noise is expected to be generated during the construction phase of the Gwynt y Môr Offshore Wind Farm from the following activities: Vessel activity, offshore structure foundation installation, scour protection installation (rock armour), drilling and cable installation.

Of these noise sources it is considered that the high-energy noise levels generated during foundation installation using the pile driving method will be the greatest noise source generated during the construction of the wind farm. Pile driving will be used for both mono-pile and multipile foundation installation however, it is also considered that multipiling will generate a lower noise level than monopiling as the individual piles of the multipile are smaller in diameter and piling noise is considered to be proportional to the diameter of the pile (Nedwell, 2004).

The measurements of the pile driving steel monopiles at the North Hoyle Offshore Wind Farm yielded a source level of 260dB re 1 μPa @ 1metre for 5 metres depth for a pile 4m in diameter (Nedwell, 2004). No measurements exist for the piling of monopiles of a larger diameter, however, maximum noise levels for the piling of 6m piles at the London Array Offshore Wind Farm have been estimated at 271 dB re 1uPa @1m (LAL, 2005). Noise levels predicted for the construction of mono-pile foundations for the 5MW class turbines (up to 6m in diameter) have been predicted at 273 dB re 1 μPa @1m for the Gwynt y Môr Offshore Wind Farm project (QinetiQ, 2005 (Appendix 3)).

Noise generated from cable trenching was measured at the North Hoyle Offshore Wind Farm and found to be at a level of 178dB re 1 μPa @ 1metre (Nedwell, 2004). If cable trenching is to be used at Gwynt y Môr it would be using the same plant as was used at North Hoyle. Noise levels would therefore be expected as similar. No literature is available concerning noise levels generated during the installation of cables using water jetting.

The noise levels generated from increased vessel activity at the project area are not thought to significantly enhance the background noise levels of Liverpool Bay.

No literature is available concerning the noise levels generated during other wind farm construction activity such as rock dumping for scour protection or for the installation of turbine foundations using other options such as gravity base and suction caisson. However, it is considered that these noise levels would be far less than those predicted for the high-energy activity of pile driving. The installation of the foundations through the use of monopiling is therefore considered to be the worst-case scenario for the generation of underwater noise during the construction phase.

Hazardous Material

All offshore structures will be covered by a corrosion protection system consisting of a paint system and a cathodic protection system likely to be the standard system employed by other offshore industries. The implementation of these systems would be undertaken onshore prior to the movement of the structures to the offshore project area.

Grout may also be required for joining sections of turbine, or it may be utilised during piling operations in the event of rock being present near to the seabed during monopile installation. A hole greater than the diameter of the pile is then drilled into the seabed and once the pile is in place, grout is pumped into the base of the pile and allowed to set. For multipiles, grout is used between the pile and the pile sleeves.

The Operational Phase

The operational phase and therefore the lifetime of the Gwynt y Môr Offshore Wind Farm will be 50 years. During this time the offshore structures will be subject to six monthly service schedules on generators, gearboxes, transformers and switchgear. Offshore sub stations will be subject to annual inspections and planned maintenance.

During these services, lubricants and hydraulic oils will be routinely changed and it is estimated that this will generate some 2500 litres of gearbox oils and 100 litres of hydraulic fluid per annum which will be subsequently disposed of via licensed recycling contractors onshore. Routine transport of crew and equipment to and from turbines will be by specifically designed boats which can operate in all weathers. It is currently anticipated that the operational phase will require the operation of three permanent vessels out of a number of regional ports (possibly Holyhead, Mostyn, Liverpool, Heysham and Barrow). See Table 2.5 for details of the types of vessels and the estimated schedule of vessel trips required throughout the operational phase.

During the lifetime of the Gwynt y Môr Offshore Wind Farm it is probable that some components will reach the end of their design life and will have to be replaced. Component replacement would require the utilisation of similar equipment, vessels, components and methods as for the construction and decommissioning phases of the project.

The underwater sections of the foundation structures will also be subject to periodical scraping during the operational phase to maintain structural integrity by removing biofouling. Currently, there is no defined time period for scraping and it is considered that during this process not all of the biofouling would be removed.

Marine Noise

During the operational phase the offshore structures will generate noise from the mechanical parts such as the changing of gears and the movement of the turbines. The noise generated will be of a low frequency level which will be transmitted through the water column and will contribute to the background noise levels of the surrounding area.

The operational marine noise levels of the Gwynt y Môr Offshore Wind Farm were assessed using actual measurements of the operational North Hoyle Offshore Wind Farm which were then uplifted to account for the larger turbines and the increased number of turbines at the Gwynt y Môr Offshore Wind Farm (see section 7 and Appendix 3). The source level of the operational wind farm was estimated as 159.1 dB re 1μPa/band level @1m. However, this noise level was found to be weakly dependant upon the transmission loss suggesting that most of the sound would be ambient noise and not wind farm noise (see section 7 and Appendix 3).

Underwater noise would also be generated during the operational phase through increased vessel activity and any necessary maintenance works. However, such noise levels arising from these activities are not thought to enhance the existing background noise levels at the Gwynt y Môr project area.

The Decommissioning Phase

Decommissioning of the Gwynt y Môr Offshore Wind Farm project would subsequently take place at the end of the 50 year operational phase. It is expected that all offshore structures would be removed and that this would occur within a 2-3 year period.

Offshore structures

It is anticipated that offshore structure monopile and multipile foundations would be cut away at the seabed and the pile transition piece and any subsequent debris would be lifted by jack-up rig and transported to shore for subsequent recycling. It is not anticipated that the removal of offshore structures would occur using explosives. For gravity base structure removal, suction dredging would be carried out to remove the ballast. A heavy lift vessel would then remove the base off the seabed onto a transportation vessel to take ashore for recycling. Suction-caisson bases would be removed intact from the seabed using a combination of underbase pressure and heavy lift vessel. These would then also be taken ashore for subsequent recycling.

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It may be preferable to leave any scour protection, which has been used during the life of the project, in place to preserve the marine habitat established over the life of the wind farm, subject to discussions with key stakeholders and regulators.

Cabling

The removal of cabling is likely to be undertaken by a similar method to that employed during the construction phase for cable installation. This would involve either peel out (using a grapnel runner to pull the cable from the sea be), an under runner (this pushes the cable from the seabed) or by the method of water jetting (high pressure water jets remove overlaying seabed material). Once removed from the seabed cables would then be winched onto vessels (similar to those employed for cable installation during the construction phase) and then taken ashore for recycling.

Vessel activity

The types and journeys of vessels necessary for the decommissioning phase of Gwynt y Môr is considered as being similar to those utilised during the construction phase. The vessels and journeys detailed within Table 2.4 are therefore also considered as being a suitable prediction for those required during the decommissioning phase.

Marine Noise

As similar methods, plant and vessels would be used for the decommissioning phase as for construction, it is anticipated that generated underwater noise levels would also be similar. However, it is anticipated that high-energy noise levels such as those generated from piling would not be experienced during the decommissioning phase.

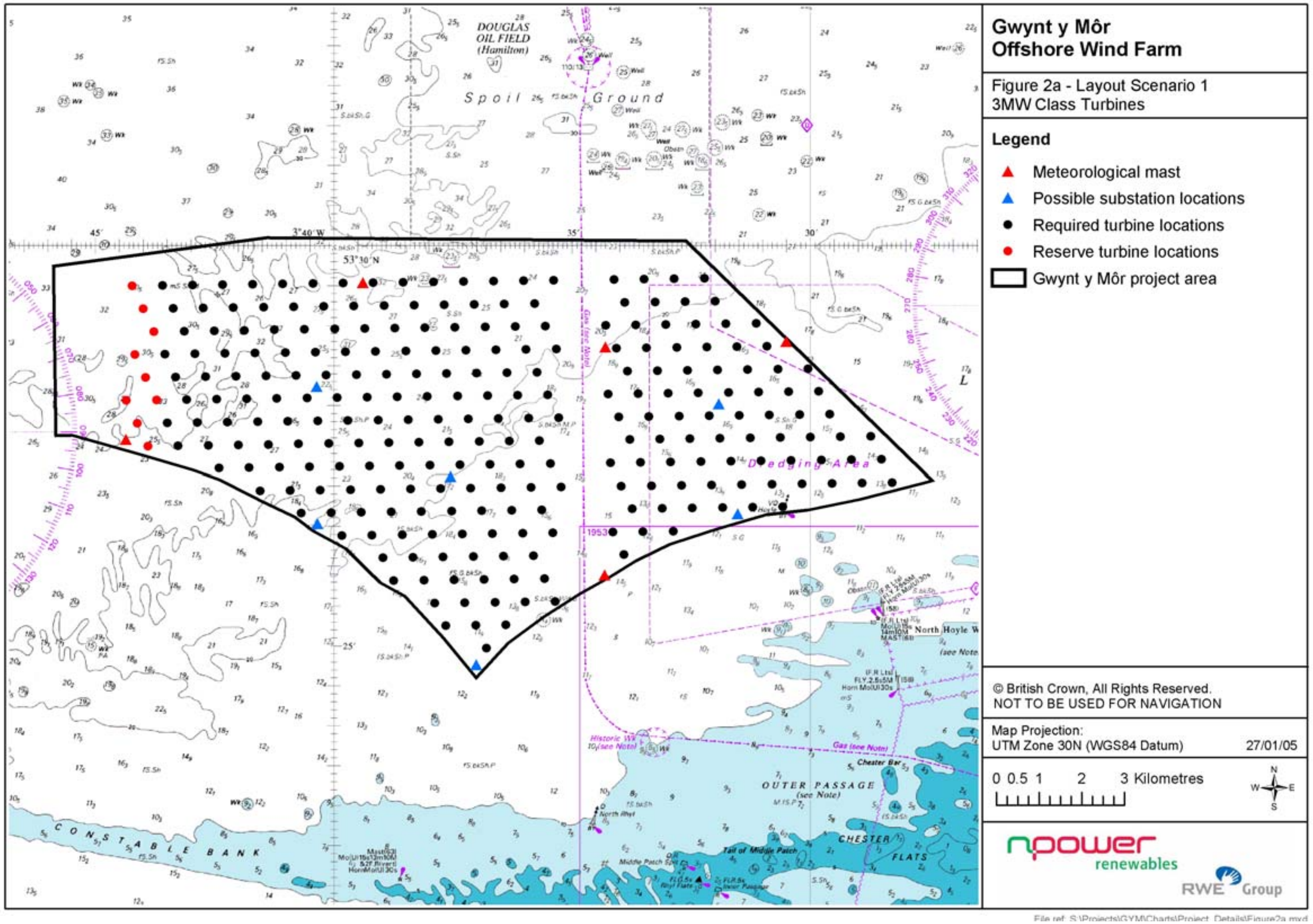


Figure 2.1: illustrative layout scenario 1 for the offshore structures at the Gwynt y Môr Offshore Wind Farm

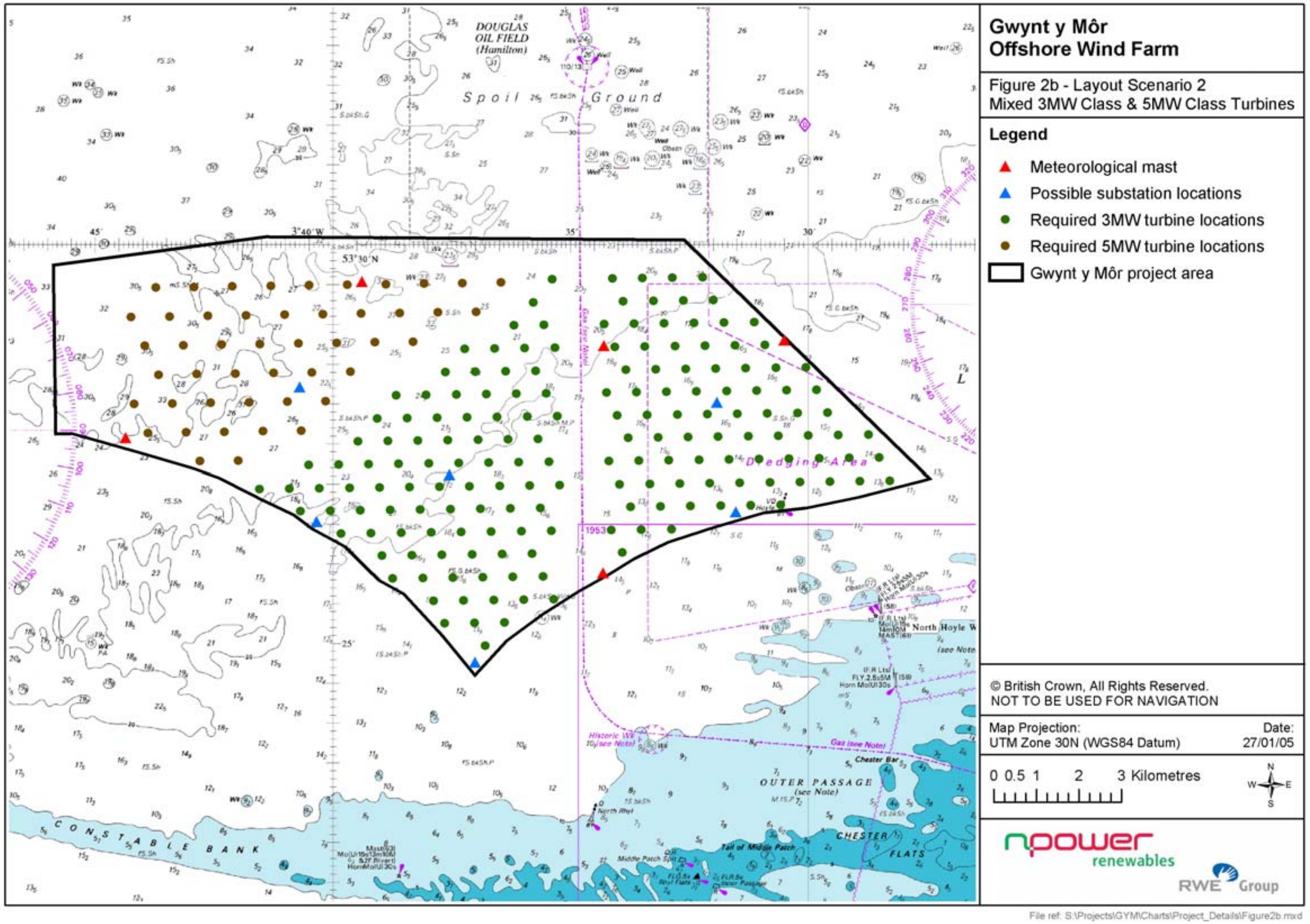


Figure 2.2: illustrative layout scenario 2 for the offshore structures at the Gwynt y Môr Offshore Wind Farm

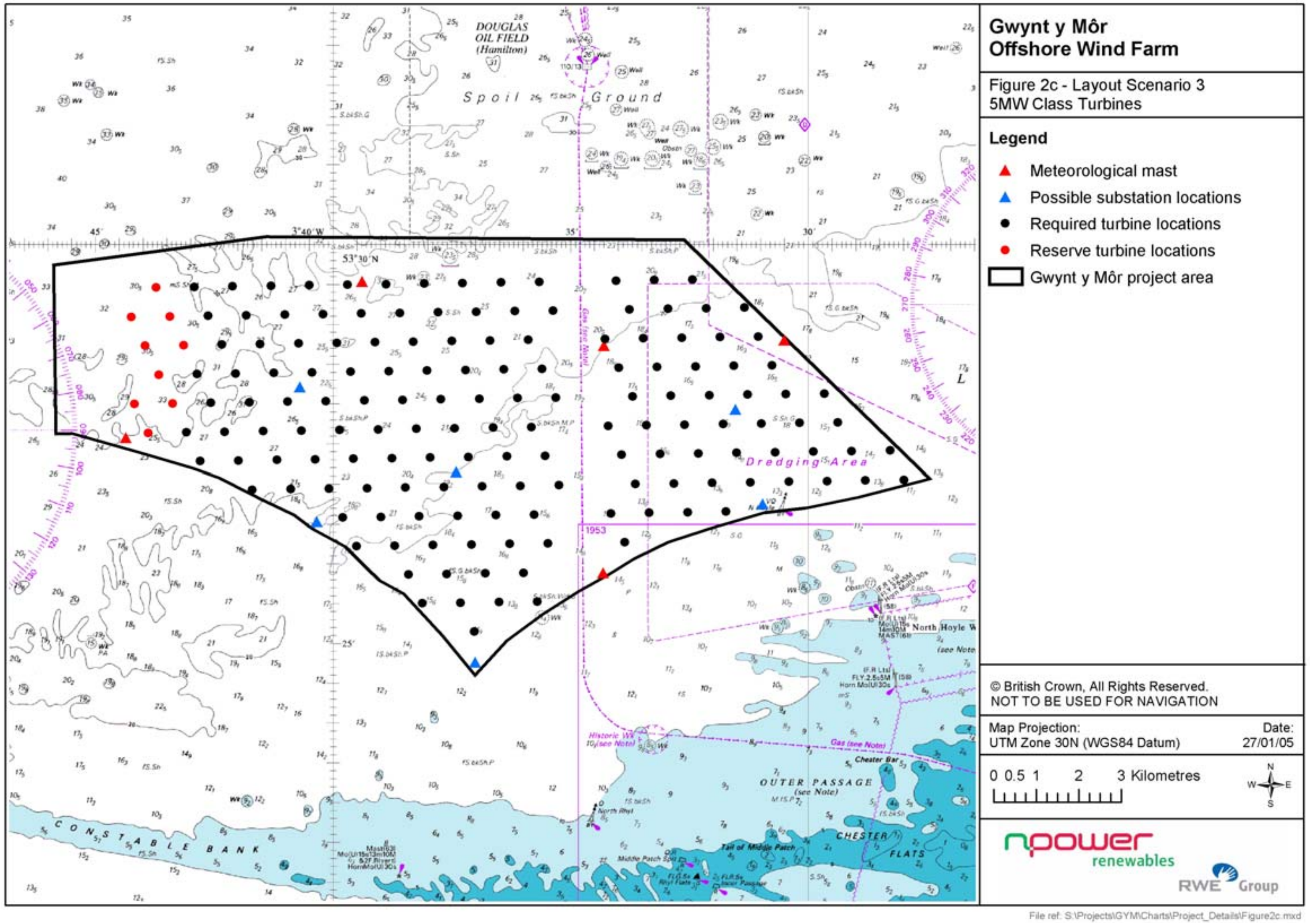


Figure 2.3: illustrative layout scenario 3 for the offshore structures at the Gwynt y Môr Offshore Wind Farm

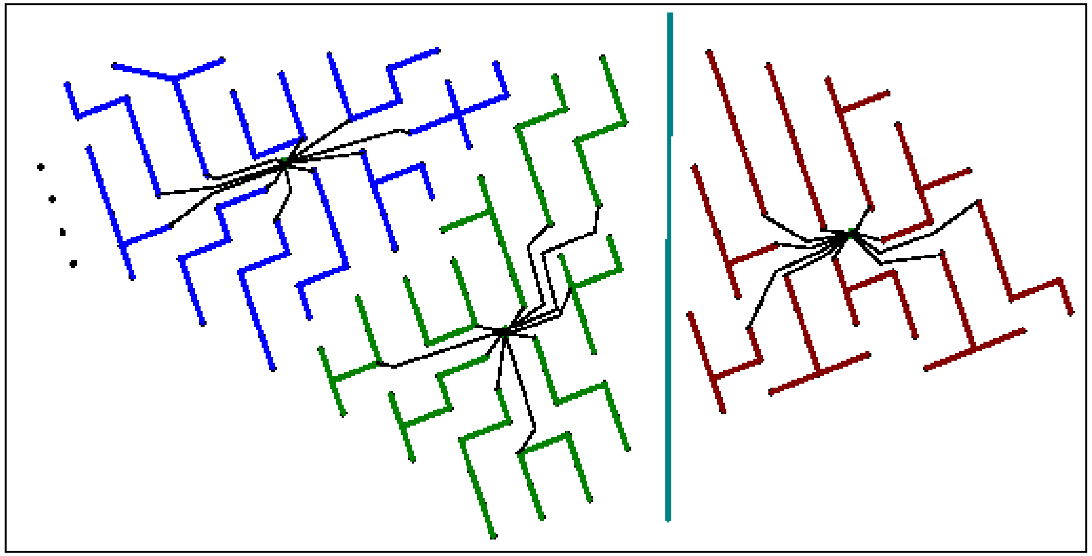


Figure 2.4: Tentative layout of the Inter-turbine cabling with sub stations located towards the centre of the Gwynt y Môr project area.

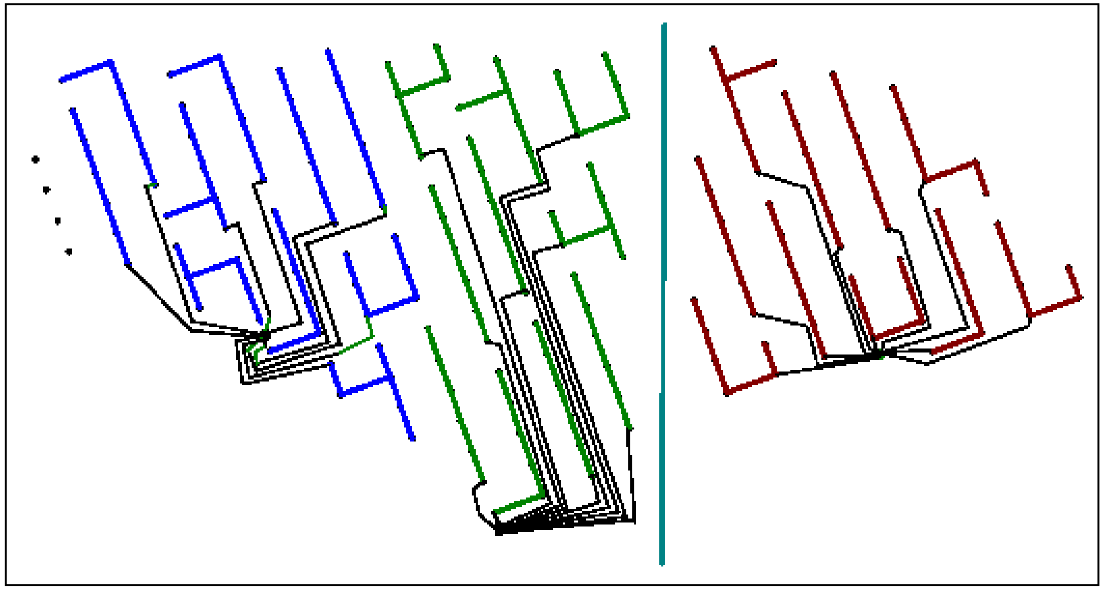


Figure 2.5: Tentative layout of the Inter-turbine cabling with sub stations located at the edge of Gwynt y Môr project area.

Table 2.1: Area of seabed utilised by the three different Illustrative layout scenarios at the Gwynt y Môr Wind Farm.

	Illustrative layout scenario 1	Illustrative layout scenario 2	Illustrative layout scenario 3
Turbine Rating	3MW	Combined 3MW & 5MW	5MW
Number of turbines	250	172 & 47 (219 total)	150
Total Seabed area occupied by all turbines (km^2)	Monopile: 0.005 Multipile: 0.003 Gravity base: 0.40 Suction caisson: 0.06	Monopile: 0.005 Multipile: 0.003 Gravity base: 0.41 Suction caisson: 0.055	Monopile: 0.004 Multipile: 0.003 Gravity base: 0.424 Suction caisson: 0.05
Maximum area of seabed occupied by offshore sub stations (km^2) (assumes 4 sub stations)	Monopile: 0.0001 Multipile: 0.0001 Gravity base: 0.011 Suction caisson: 0.0012		
Estimated total seabed area covered by rock scour protection (km^2)	Monopile: 0.079 Mutlipile: 0.028 Gravity base: 0.079 Suction caisson: 0.079	Monopile: 0.069 Mutlipile: 0.025 Gravity base: 0.069 Suction caisson: 0.069	Monopile: 0.047 Mutlipile: 0.017 Gravity base: 0.047 Suction caisson: 0.047

Table 2.2: Estimates of the maximum volume of spoil that would be generated are summarised in the following table.

	Illustrative layout scenario 1	Illustrative layout scenario 2	Illustrative layout scenario 3
Est. volume of spoil generated by foundation installation per turbine (m^3)	Monopile: 800 Multipile: 550 Gravity base: 800 Suction caisson: nil	Monopile: 800 and 1300 Multipile: 550 and 1,100 Gravity base: 800 and 1,400 Suction caisson: nil	Monopile: 1300 Multipile: 1100 Gravity base: 1,414 Suction caisson: nil
Est. total volume of spoil generated by foundation installation (m^3)	Monopile: 150,000 Multipile: 100,000 Gravity base: 205,000 Suction caisson: nil	Monopile: 150,000 Multipile: 105,000 Gravity base: 210,000 Suction caisson: nil	Monopile: 150,000 Multipile: 135,000 Gravity base: 212,100 Suction caisson: nil

Table 2.3: Estimated volume of sediment displaced from cable laying activities as part of the construction phase of the Gwynt y Môr Wind Farm.

Estimated total length of all subsea cables (km)	210 – 350km
Estimated area of seabed disturbed by cable installation (km^2)	0.063 – 0.105km^2
Estimated maximum volume of sediment displaced during cable installation (m^3)	68,250 – 113,750 (assumes all water jetting)

Table 2.4: Vessel types, numbers and estimated trips required to complete the construction phase.

Construction Activity	Vessel Type	Estimated Number Vessels	Indicative Time On Site (per vessel)	Estimated Trips to/from Port (per vessel)
Turbine Support Structure Installation	Shallow water Jack-up	2	500 days	20
	Deep water Jack-up	2	350 days	16
	Cargo Barge	2	850 days	1700
	Tug/Mooring	4	850 days	1700
	Personnel Transfer	2	850 days	3400
Turbine Installation	Shallow water Jack-up	2	225 days	10
	Deep water Jack-up	2	125 days	6
	Cargo Barge	2	350 days	700
	Tug/Mooring	4	350 days	700
	Personnel Transfer	2	350 days	1400
Sub station Support Structure Installation	Shallow water Jack-up	1	35 days	6
	Deep water Jack-up	1	15 days	2
	Cargo Barge	1	50 days	100
	Tug/Mooring	1	50 days	100
	Personnel Transfer	1	50 days	200
Sub station Topsides Installation	Heavy Lift Vessel	1	15 days	6
	Tug/Mooring	3	15 days	30
	Personnel Transfer	1	15 days	60
Met Mast Installation (2 masts in total as pre-construction masts excluded)	Shallow water Jack-up	1	5 days	2
	Deep water Jack-up	1	7 days	2
	Tug/Mooring	1	12 days	24
	Personnel Transfer	1	12 days	48
Inter-turbine Cables Installation	Cable Laying Vessel	1	350 days	100
	Tug/Mooring	1	350 days	700
	Personnel Transfer	1	350 days	1400
Export Cables Installation (incl. pipeline crossings)	Cable Laying Vessel	1	90 days	30
	Installation Vessel	1	10 days	20
	Tug/Mooring	1	100 days	200
	Personnel Transfer	1	100 days	400
Commissioning	Installation Vessel	2	300 days	600
	Personnel Transfer	6	300 days	1200

Table 2.5: Vessel types, numbers and estimated trips required to complete the operation phase.

Vessel	Estimated Daily Movements	Nature of Movements
Tender 1 (smaller catamaran operating in lower sea states	3 – 4 return trips	Shore to flotel, 7 days/week, 0600 – 2200 nominal operating hours
	4 return trips	Flotel to turbines
Tender 2 (larger vessel with high sea state capability)	10 return trips	Flotel to turbines
	20 movements	Inter-turbine trips ranging from 1 – 20 nautical miles
Flotel	I return journey every other week	Wind farm site to service port
	2 return trips	From the main mooring to other parts of the wind farm (depending on maintenance schedules)

3. The Existing Marine Environment

This section provides a site-specific description, in addition to a regional overview, of the existing marine environment for the following:

- *Water and Sediment Quality*
- *Plankton communities*
- *Benthic Communities*
- *Fish and Shellfish*
- *Marine Mammals*
- *Sites or Species of Nature Conservation Interest*

Information used to produce this section has been assembled from site-specific studies (detailed within the Appendices), in addition to a wider literature review as appropriate. The information presented within this following section has then been used to identify any potential impacts of the Gwynt y Môr Offshore Wind Farm upon the above listed subjects and formulate the impact assessment detailed within section 4.

3.1 Water & Sediment Quality Environmental Background

3.1.1 The Existing Water Quality within Liverpool Bay

The Gwynt y Môr Offshore Wind Farm project area is located off the North Wales coastline within Liverpool Bay, a relatively shallow, semi-enclosed body of water localised in the southern part of the eastern Irish Sea. The region receives inputs of wastes from coastal sewage outfalls, trade effluent outfalls and contaminated riverine discharges particularly from the Rivers Mersey and Dee. The River Mersey and its estuary receive substantial amounts of sewage and industrial wastes from the heavily populated area of North West of England which includes the conurbations of Liverpool and Manchester. The shoreline of the Mersey Estuary and its catchment contain a particularly high concentration of chemical industries in addition to other manufacturing industries and a high population density (Collings *et al.,* 1996). Any discharges into the estuary are inevitably carried into the waters of Liverpool Bay.

Discharges to the aquatic environment within England and Wales are controlled under legislation such as the Water Resources Act (1991) with the Environment Agency having overall control for discharges and the overall water quality of the sea (Defra, 2000). Trade effluents involving hazardous substances are subject to Integrated Pollution Control under the Environmental Protection Act (1990). European legislation such as The Water Framework Directive (WFD) also requires all inland and coastal waters to reach "good status" by 2015. As a result of such legislation the water quality of Liverpool Bay has considerably improved over recent years with a significant reduction in the amount of hazardous substances entering the marine environment and a decline in the loads from industrial and sewage treatment works.

This section reviews the water quality of both the offshore waters and the inshore bathing waters of Liverpool Bay.

Offshore Water Quality

Offshore water quality is affected by contaminants which may enter the water column either directly from rivers, sewage effluent or industrial discharges, or arrive on currents from sources further away or by airborne means such as rainfall. Once in the water column contaminants can occur either in solution or attached to particles both of which will act to affect the water quality. The levels of contaminants in seawater are judged against Environmental Quality Standards (EQS), which are a series of guidance levels designed to protect marine life (Wither, 2000).

Metals occur naturally in sea water as a consequence of geological weathering processes and subsequent land run off. However, inputs are increased as a consequence of mining and industrial activities. In seawater, dissolved metals rarely achieve concentrations that are directly toxic to marine biota but through bioaccumulation, some metals can occasionally achieve tissue concentrations that are toxic to organisms and their predators.

Within Liverpool Bay heavy metals are dispersed from trade and sewage outfalls and levels of lead, cadmium and mercury are known to be higher than Background Reference Concentration (BRC) values which were set by OSPAR in 1997. Studies regarding metal concentration in sea water of the Irish sea have been carried out by Abdullah *et al* (1973) and Preston (1972) and these studies found a gradient of metal concentration from high levels near the Mersey and Dee Estuaries to lower concentrations offshore. The most important sources of dissolved metals within Liverpool Bay therefore appear to be riverine and estuary discharges.

The whole of Liverpool Bay has been historically contaminated with mercury (MAFF, 1991) attributed to inputs from the Mersey Estuary, which has long been the recipient of high levels from industrial effluents specifically from the chlor-alkali industry. The Irish Sea also receives the largest single input of lead nationally from the River Mersey (Defra, 2005) and elevated copper levels in the region (when compared to the rest of the Irish Sea) are also sourced to inputs from the Rivers Dee and Mersey (although these levels are below the EQS level) (MPMMG, 1998). River discharge is also a major source of cadmium and zinc in the region (Norton *et al.,* 1984).

Other contaminants, which also act to affect water quality, include man-made compounds such as pesticides and contaminants arising from the oil and gas industry. Liverpool Bay is also subject to low level inputs of hydrocarbons from the River Mersey (Defra, 2000) and the existing Liverpool Bay oil and gas production activity, although investigations by the National Marine Monitoring Programme (NMMP) have found the concentrations of hydrocarbons within the waters of the Bay to be below Environmental Quality Standards (EQS) (Ospar, 2000). Polychlorinated biphenyls (PCBs) are persistent man-made compounds and have the potential for long-range atmospheric transportation. However, they have an extremely low water solubility and as a result their concentrations in sea water tend to be generally very low and they are more often associated with sediments.

Radioactive isotopes are relatively soluble in sea water and are dispersed throughout the eastern Irish Sea from the Sellafield reprocessing plant on the Cumbrian coastline, which is the largest single input of artificial radionuclides in the Irish Sea (Defra, 2000). Exposure levels to marine species in the eastern Irish Sea and Liverpool Bay are considered to be well below those known to cause adverse effects (Defra, 2000).

Liverpool Bay also has a sizeable amount of shipping, port operations, offshore developments, commercial fishers and recreational users all of which can contribute to offshore marine litter which may also act to affect water quality. In many cases, such as shipping, controls are in place, but improvements in education and enforcement are needed to make them fully effective (Defra, 2005). Plastics are the most prevalent litter type in the marine environment and marine litter can have adverse ecological impacts, including: entanglement, ingestion; smothering, and the transport of invasive species (MPMMG, 1998).

Coastal Bathing Water Quality

Along the Liverpool Bay coastline are many sewage outfalls with largest being at Liverpool, which discharges approximately 950,000m^3 of primary treated sewage daily (Defra, 2002). Sewage outfalls in proximity to the Gwynt y Môr project area are located at Pensarn, Kinmel Bay, Prestatyn and Colwyn Bay. Sewage outfalls release human wastes as well as other organic matter, heavy metals, pesticides, detergents and petroleum products. Sewage also delivers pathogenic viruses and bacteria which may make contaminated receiving waters unsafe for bathing.

The legislation of the European Union bathing water directive (76/160/EC) sets the standards for water quality guidelines for the coastal environment and requires the identification and monitoring of bathing waters. The bathing water directive is intended to primarily safeguard public health and the environment by reducing the pollution of bathing waters and protecting such waters against further deterioration. There are two standards; the EC Mandatory Standard and the EC Guideline Standard, which stipulate the maximum levels of faecal coliforms, total coliforms and faecal streptococci that may be present in seawater. Within England and Wales the monitoring of marine bathing waters is co-ordinated by the Environment Agency which takes samples from designated beaches at regular intervals between May 1st and September 30th (the designated “Bathing season”) each year.

Within this region of the eastern Irish Sea (along the Merseyside, Wirral and North Wales coastlines) there are 17 EU identified bathing water locations subjected to testing by the Environment Agency (see Figure 3.1.1). In addition a further 20 non-EU identified bathing waters are also tested by the Environment Agency along the North Wales coastline (see Figure 3.1.1). This is to enable local councils within Wales to continue to apply for the various bathing beach awards at non-EC bathing waters, an initiative which is coordinated by the Environment Agency involving the Welsh Assembly Government, Wales Tourist Board, Keep Wales Tidy (KWT), Dŵr Cymru Welsh Water (DCWW) and the maritime local authorities (Environment Agency, 2005).

Overall the coastal bathing water quality within this region is considered to be good with the majority of the EU identified sites passing the mandatory standards over the last five years. The only exceptions were failures during 2001 at the sites of Prestatyn, Rhyl, Kinmel Bay, Llandudno and Llandudno West. Of the non-EU identified sites also tested along the North Wales coastline, all passed the mandatory standards over the last five years with the exception of Penrhyn Bay (failed 2000), Towyn (failed 2000 and 2004), Rhyl (failed 2000) and Talacre (failed 2002).

EU identified bathing waters within the region, which have been identified by the Environment Agency as having a risk of future non-compliance with mandatory standards (based upon historical data), are Rhyl (32% risk of non compliance) and Kinmel Bay (7% risk). These sites are identified as being most at risk from faecal coliforms and previous water quality failures have also been attributed to agricultural run off increasing bacteria levels within the River Clwyd which is then carried onto Rhyl beach also affecting the bathing waters at Kinmel Bay, which are situated on the opposite bank of the River Clwyd to Rhyl. It is thought that during certain wet conditions high levels of bacteria in the river in combination with a high tide act to reduce water quality in these areas (Environment Agency, 2005).

At beaches where strict water quality (compliance with EU “Guideline” standards for total and faecal coliforms and for faecal streptococci) are met in addition to other land based requirements a blue flag maybe awarded as part of the European Blue Flag Scheme. Within this region Benllech and Llandona (Angelsey) and Formby and Ainsdale (Merseyside) beaches have all been awarded blue flags. Other beaches in the region with awards include Kinmel Bay, which received a “Green Coast Award” (developed by the Green Sea Partnership) in 2004 (Environment Agency, 2005). This award is designed to acknowledge beaches which meet EU guideline water quality and are prized for their natural and unspoiled environment.

3.1.2 The Existing Sediment Quality within Liverpool Bay

As discussed in section 3.1.1 the Liverpool Bay region receives inputs from coastal sewage outfalls, trade effluent outfalls and contaminated riverine discharges particularly from the Rivers Mersey and Dee and, until 1998; specific sites in Liverpool Bay were also used for the dumping of sewage sludge and industrial waste. The sediments of Liverpool Bay will reflect and integrate these contaminant inputs to the marine environment. This section reviews the sediment quality of the region and also discusses the results of site-specific sampling for sediment contaminants undertaken within the Gwynt y Môr project area.

Historic review of Liverpool Bay Sediment Quality

The sediments of the eastern Irish Sea and Liverpool Bay ultimately act as a sink for those contaminants occurring in the water column originating from coastal discharges or riverine input from estuaries such as the Mersey and Dee. As a consequence this is an area historically contaminated with a wide variety of different pollutants.

The concentration of metals within marine sediments in the coastal zone and around the estuaries of the region are generally higher than offshore as a result of contaminants originating from riverine input and tending to accumulate in sediment sinks. Cadmium, mercury, lead and zinc have relatively high residues occurring in the eastern Irish Sea sediments, particularly off the estuary of the Mersey (Defra, 2000). Camacho-Ibar (1992) found the level of mercury within sediments at the mouth of the Mersey Estuary to be almost six times higher than natural background levels as a result of the past discharges into the river from the chlor-alkali chemical industry. However, reduced inputs of mercury in recent times have resulted in some long-term reduction in sediment concentrations throughout the area (Leah, *et al* 1993).

Arsenic is also known to occur above background levels within the sediments of Liverpool Bay (e.g. Camacho-Ibar *et al.,* 1992). Studies have revealed that such elevated arsenic levels are not attributable to loads from the River Mersey or offshore dumping activities (although sewage sludge does contain some arsenic) (Leah *et al* 1992). Instead the main sources are thought to be of natural origin resulting from lithogenic inputs from the North Wales area as a result of weathering. Thornton *et al* (1975) reported high values of arsenic in the sediments of the River Conwy whose tributaries drain the mineralised areas of North Wales. Other trace elements present in very high concentrations in the sediments of the Conwy Estuary are zinc and lead which are as a result of sphalerite and galena mining in the past (Elderfield *et al* 1971).

Contaminants such as Polyaromatic Hydrocarbons (PAHs) and Polychlorinated Biphenyls (PCBs) reach the sediments of the marine environment via sewage discharges, surface run-off, industrial discharges, oil spillages, offshore oil and gas production activity and deposition from the atmosphere. The Irish Sea as a whole is thought to contain relatively large amounts of hydrocarbons attributable in particular to oil and gas extraction activity, shipping and proximity to pyrogenic sources. However, PAHs were not detected within sediments at offshore sites within Liverpool Bay (Defra, 2000). PCBs are of concern in the Liverpool Bay area because of elevated levels recorded in fish and other biota. It is known that relatively high levels can be contained in sewage sludge. However, PCB levels in the sediments of the wider Liverpool Bay area are not reported as being amongst the highest concentrations within the UK although levels within the Mersey Estuary have been reported as relatively high (NMMP, 2004). There is a general trend for PCB sediment concentration within the region to decrease further offshore from the estuary (Camacho-Ibar, 1996). The sediments of the eastern Irish Sea, including Liverpool Bay, also act as a long term sink for plutonium and other artificial radionuclides originating from Sellafield, Cumbria (Defra, 2000).

The Gwynt y Môr project area is located to the south of, and relatively close to, the sewage sludge disposal site used for the dumping of sewage sludge generated in the Liverpool and Manchester areas (Norton *et al.,* 1984). Approximately 50,000 dry tonnes of treated and untreated sewage sludge and of industrial wastes were disposed of annually (Norton *et al.,* 1984) at this dumping ground before disposal ceased in 1998. When dumping was still occurring the fine sediments at this location showed elevated concentrations of organic carbon and metal concentrations similar to levels found within the sediments at the mouth of the Mersey Estuary (Norton *et al.,* 1984). The sewage sludge disposal site was, however, seen as dispersive due to the prevailing high-energy environment and mobile sediments of the region, which prevented any long-term accumulation of pollutants (Jones *et al.,* 1997).

A specific study of contaminant concentrations within Liverpool Bay sediments was undertaken as part of the baseline survey at the North Hoyle Offshore Wind farm site. This survey sampled surface sediments at eight sites in 2001 within and around the North Hoyle area. Arsenic was found to exceed recommended sediment quality guidelines at five sites with all other contaminants (e.g. other metals, pesticides and hydrocarbons) demonstrating low levels either being non-detectable or below their respective sediment quality guideline (CMACS, 2001).

Site-Specific Sediment Sampling and Analysis

Due to the lack of specific knowledge concerning the concentrations of contaminants within the sediments at the Gwynt y Môr project area, a site-specific survey was undertaken. This was to gain an understanding of the various contaminants within the surface sediments and to allow the assessment of potential impacts arising from sediment disturbance during construction activities within the project area.

Due to the nature of the physical processes of Liverpool Bay, the continual reworking of the surface sediments makes it unlikely that there are sinks for contaminated fine sediments within the Gwynt y Môr Offshore Wind Farm project area. It is, therefore, reasonable to assume that the results from the spot sampling of the surface sediment should be representative of the contaminant loading across the wider project area.

Sites where sediments were sampled for contaminants were incorporated as part of the benthic characterisation survey detailed in the subtidal ecology section (see section 3.3). Survey methods were agreed with the relevant bodies (CCW and CEFAS) with the number of sites sampled for contaminants being approximately 10% of the sites where benthic grab samples were collected. For contaminant testing approximately 1-2kg of surface sediment was taken for analysis from 24 sites both within and around the project area and at inshore locations (see Figure 3.1.2). Samples were analysed for the contaminants listed in Table 3.1.1. However, full details of survey methodology and the quality control procedures used for sample collection and storage are given within the Field Survey Report (CMACS, 2005) in Appendix 1.

There are currently no statutory guidelines for assessing the environmental quality of marine sediments. However, the Habitats Directive Water Quality Technical Advisory Group (HDTAGWQ, 2001) determined that in the absence of such guidelines in England and Wales, it is appropriate to use guidelines that have been developed and used elsewhere; this group specifically note the Canadian Interim Sediment Quality Guidelines (ISQGs) (CCME, 2001). These are set as quality guidelines to provide reference points for observing adverse biological effects in aquatic systems (NATURA, 2000). The guidelines are derived from the available toxicological information according to the formal protocol established by the Canadian Council of Ministers of the Environment (CCME, 1999).

The Threshold Effects Levels (TEL) represent the lower end of the range of concentrations at which biological effects are occasionally observed on the native fauna of Canada; they therefore represent only an indication of the concentrations that may occasionally cause effects within UK waters. The Probable Effect Level (PEL) represents the level of contaminant within sediments, which would be likely to have an affect on a wider range of organisms.

Comparisons of contaminant concentrations to sediment quality guidelines are important as where the contaminant concentrations are above the TEL levels they are a cause for concern and further inputs into the marine environment should therefore be minimised (Cole *et al*, 1999). The results from the survey were therefore compared to the appropriate TEL and PEL levels (detailed in Appendix 1) of these Interim Marine Sediment Quality Guidelines to assess the levels of contamination within the surface sediments at the Gwynt y Môr Offshore Wind Farm project area.

The results for the heavy metals analysis found low concentrations within the sediments of the Gwynt y Môr project area with all being below the TEL levels of the Interim Marine Sediment Quality Guidelines (ISQG), with the exception of Arsenic. Arsenic was recorded at slightly above the TEL at nine of the sites sampled (95, 108, 156, 166, 176, 185, 197, 239 and 244) (See Figure 3.1.2) but at all of these locations the concentration level was found to be well below the Probable Effects Level (PEL) standard. Although the concentration of this heavy metal is higher than might be expected for other UK locations, elevated arsenic concentrations levels are common within sediments throughout Liverpool Bay and are attributable to lithogenic inputs from the North Wales region as a result of weathering (as has been noted previously above).

The levels of heavy metals recorded from the project area were found to be comparable to results from the adjacent North Hoyle sediment contaminant survey (including the levels of Arsenic which were also the only metal to exceed its TEL during the North Hoyle survey) (CMACS, 2001).

Of the pesticides tested, all were below the minimum limit of detection, which was also lower than the relevant TEL and PEL (where available) with the exception of Lindane and Dieldrin for which the minimum limit of detection was above the TEL and in the case of Lindane the PEL also.

The levels of PAHs within the sediments were also found to be of low concentration and were generally below the relevant TEL and PEL levels (where available). For the majority of PAHs tested the levels were either below the limits of detection or below the equivalent TEL or PEL values. Exceptions to this were noted at sites 40 (Napthalene), 47 (Napthalene), 108 (Napthalene) and 156 (Acenaphthene) where one PAH slightly exceeded the TEL (but was well below the PEL). Other elevated levels above the sediment quality standards for PAHs were found at sites 68 (7 TELs exceeded: Napthalene, Acenaphthylene, Acenaphthene, Fluroene, Phenanthrene, Anthracene, Fluoranthene and Pyrene), 75 (3 TEL exceeded: Napthalene, Acenaphthylene and Acenaphthene), 110 (5 TEL: Fluoranthene, Pyrene, Benz(a)anthracene, Chrysene, Dibenzo(ah)anthracene and 6 PEL exceeded: Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene) and 197 (4 TEL: Pyrene, Benz(a)anthracene, Chrysene, Dibenzo(ah)anthracene and 7 PEL: Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene and Fluoranthene exceeded). The overall highest levels of PAHs were found at sites 110 and 197, the latter being within the boundary of the Gwynt y Môr Offshore Wind Farm project area. However the value for the total PAH EPA 16 at these two sites (6.14 and 9.415 mg/kg respectively) is below the marine sediment quality guidelines recommended within the USA for total PAH EPA16 (9.6mg/kg- no adverse effects on biota and 53mg/kg- minor effects on biota) (see Sediment Management Standards, 1991). In conclusion, although some of the individual polyaromatic hydrocarbons tested for do exceed probable effects levels at two of the sites (110 and 197) the overall value for the total EPA 16 PAHs tested for at these two sites do not exceed recommended total guideline levels.

Such levels of PAHs are not unexpected within the area due to the proximity of potential contaminant sources such as adjacent shipping lanes, riverine discharges and the oil and gas extraction industry. However, the overall levels of PAHs within the project area are thought to be at a level which would rarely cause adverse biological effect.

The levels of PCBs recorded from the sediments at the Gwynt y Môr Offshore Wind Farm project area were also low with concentrations being below the limits of detection at all sites. No guideline levels exist for the individual PCB congeners tested for, but a TEL (0.0215 mg/kg) and PEL (0.189mg/kg) do exist for the value of Total ICES PCB 7 congeners. At all the sites the values of Total PCB 7 congeners was less than the level of detection (<0.001mg/kg) which is below both the TEL and PEL levels suggested by the sediment quality guidelines.

Overall, the results show that within the sediments of the Gwynt y Môr Offshore Wind Farm project area the majority of contaminants are at low concentration and are below the threshold levels likely to cause effects to marine biota. The elevated levels of Arsenic found within certain areas are below probable effects levels and are in keeping with results from previous surveys of Liverpool Bay such as the North Hoyle Offshore Wind Farm baseline survey (CMACS, 2002). Some PAH levels exceeded probable effects levels at two sites (110 and 197- see Fig 3.1.2 for locations), one of which is located within the western boundary of the project area but the total PAH levels for all sights do not exceed the quality guidelines and overall, it is not considered that the sediments within the Gwynt y Môr Offshore Wind Farm project area contain significant contaminant loading considered to pose a risk of adverse impact upon the marine environment.

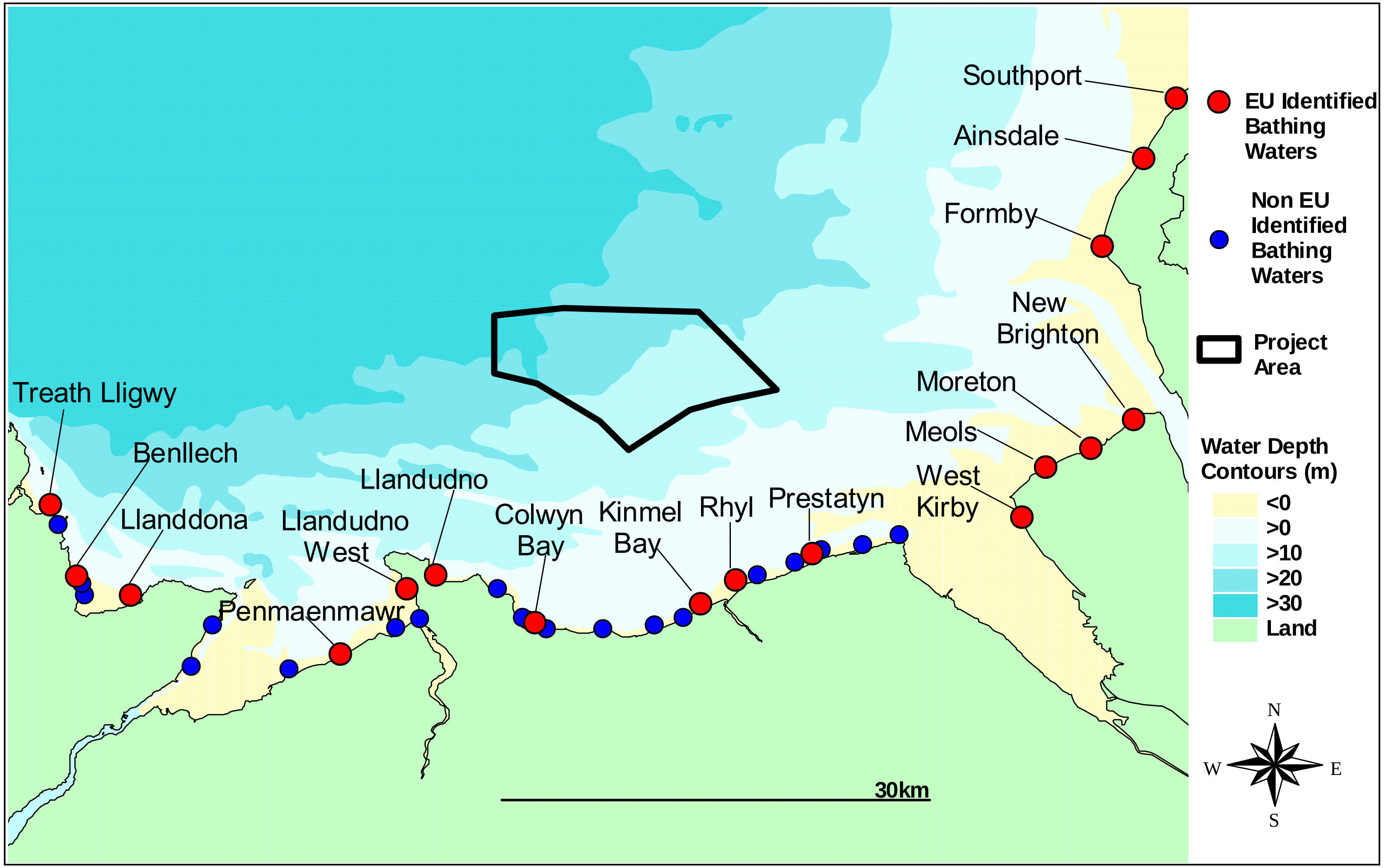


Figure 3.1.1: EU and non-EU identified Bathing Waters tested by the Environment Agency for Bathing Water Quality within Liverpool Bay.

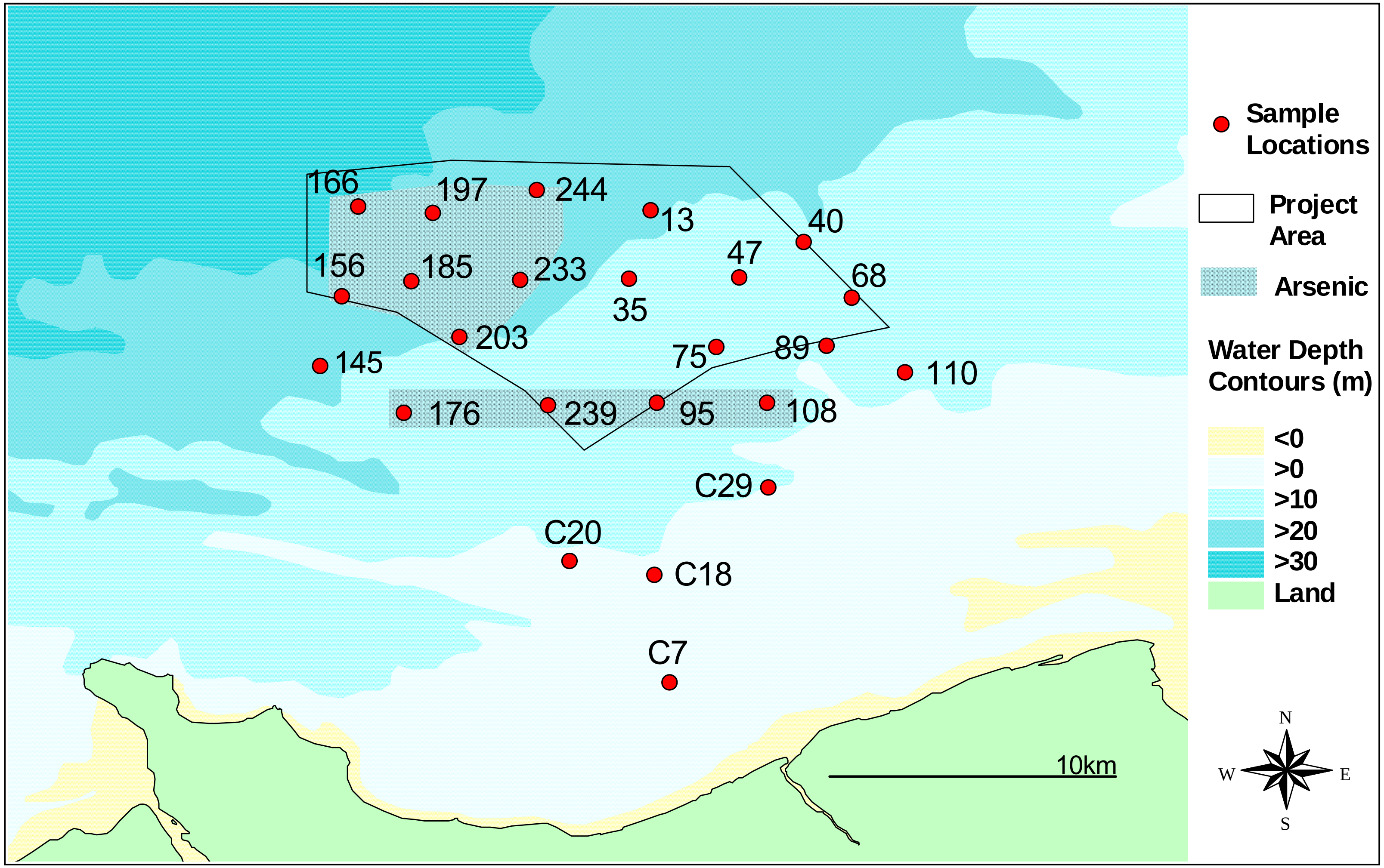


Figure 3.1.2: Sample locations for contaminant testing and areas where Arsenic exceeded the Threshold Effects Level (TEL). Sites 110 and 197 also exhibited elevated PAH levels.

Table 3.1.1: The determinands, outline methods and limits of detection (LOD) used for contaminant analysis of surface sediments.

Determinand	Analysis method	LOD (mg/kg)
Metals Cu, Cd, Cr, Pb, Zn, Hg, Ni and As	ICP-OES Aqua Regia Digest	1
Organochlorines Organochlorine Suite including pp-DDE, pp-DDD, pp-DDT, op-DDD, A-HCH, B-HCH, G-HCH, HCB, Aldrin, Endrin and Dieldrin	GC-MS	0.001
PCB **ICES 7 Congeners** **(**28, 52, 101, 118, 153, 138 and 180)	GC-MS	0.001
PAH **EPA 16** (Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, Fluoroanthene, Pyrene, Benzo(a)anthracene, Chrysene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Indeno(1,2,3-cd)pyrene, Dibenzo(ah)anthracene, Benzo(ghi)perylene)	GC-MS	0.001
Total EPA	EZ Flash	0.001

3.2 Plankton Environmental Background

Plankton is the collective term for a group of organisms ranging in size from <0.001mm to approximately 8mm and includes bacteria (bacterioplankton), plants (phytoplankton) and animals (zooplankton). Plankton has a significant role within the marine environment as it is an important food source at the bottom of the food chain and any environmental stress upon the plankton will be mirrored throughout the food chain limiting the amount of food available to fish, birds and marine mammals.

As with plankton communities elsewhere, the distribution of plankton species within the eastern Irish Sea and Liverpool Bay is influenced by factors such as depth, tidal mixing, stratification of the water column and the water flows within the area. The Continuous Plankton Recorder (CPR) survey collects data from the North Atlantic and the North Sea on biogeography and the ecology of plankton, and surveys conducted in Liverpool Bay have shown that the plankton assemblage is mostly composed of neritic (coastal) and intermediate (mixed) species (SAHFOS, 1996).

Within Liverpool Bay and running northwards to Morecambe Bay is a frontal system occurring between stratified and low salinity and stratified and high salinity waters. The approximate position of this frontal system is displayed in Figure 3.2.1, although the location of this salinity front will fluctuate depending upon factors such as freshwater inputs and the stratification of the water column. As a result of increased nutrient levels owing to the freshwater inputs from the Dee, Mersey and Ribble Estuaries this front is found to be rich in plankton which, in turn, will attract other marine wildlife.

Phytoplankton is the collective term used to describe single-celled microscopic algae which may form chains or clumps. In the temperate waters of the UK continental shelf seas such as the Irish Sea the phytoplankton assemblage is dominated by diatom and dinoflagellate species. Within Liverpool Bay the dinoflagellates of the genus *Ceratium* are two of the most frequently sampled phytoplankton with the other three taxa in the top five species most frequently recorded all being diatoms: *Thalassiosira sp* (centric diatom) *Rhizosolenia imbrica shrubsolei* (pinnate diatom) and *Chaetoceros* (centric diatom) (Edwards & Johns, 1996). These are all ubiquitous phytoplankton taxa. Over the past few decades there have been clear changes within the composition of the phytoplankton population of Liverpool Bay and the Irish Sea. These changes are seen as widespread and are attributed as a reflection of a North-Atlantic wide change which may be a result of changing climatic conditions (OSPAR commission, 2000).

Within Liverpool Bay high concentrations of phytoplankton are usual with the concentrations of chlorophyll (an indicator of phytoplankton) being almost three times as high as the rest of the Irish Sea. The highest production areas are notably inshore areas, which are influenced by nutrient rich waters from riverine input (Foster *et al.,* 1982).

Phytoplankton are able to form dense aggregations which generally consist of one species dominating the surface waters for a relatively short period of time. This is known as a bloom. Environmental conditions required to stimulate a bloom include the availability of inorganic plant nutrients such as nitrate and phosphate, sufficient light and an imbalance between phytoplankton production and their grazing herbivores, advection or sedimentation. Blooms are a normal feature of seasonal development of the local plankton populations and the most common type of bloom occurs in spring within temperate waters as a result of stratification of the water column. Some plankton blooms may have deleterious affects on other organisms in the marine environment due to the release of toxins or may influence the recreational use of coastal regions by causing foam or noxious deposits on beaches or by affecting water quality.

These phytoplankton blooms are a regular occurrence within Liverpool Bay and can affect some beaches along the North Wales coastline. Blooms include: *Phaecystis pouchetti* which is non-toxic but causes aesthetic problems due to gelatinous material washing ashore and noxious smells; and *Chaetoceros sp* blooms are also common to the area and can cause fish deaths as the algae is an irritant to fish gills. Blooms of the dinoflagellate *Gyrodinium aureolum* occur in the south east waters of Liverpool Bay and are associated with marine invertebrate mortality due to toxins produced. Such blooms are known as “Red Tides” attributed to the colour of the plankton species (Rogers & Lockwood, 1990).

Zooplankton are the animal component of plankton and communities tend to be dominated by crustacea most of which are copepod species, although most animal phyla are represented at some stage including temporary planktonic stages of the eggs and larvae of many marine species. In general, zooplankton growth and abundance closely reflects that of phytoplankton production (but they do not form bloom aggregations). Liverpool Bay’s zooplankton community is dominated by the copepod species *Calanus helgolandicus* (Edwards & Johns, 1996). A distinct maximum of copepod abundance is found at the Liverpool Bay Front.

An important aspect of the Irish Sea zooplankton community is that it contains the eggs and larvae of many important commercial fish species including exploited fish. Studies by Nichols *et al* (1993) revealed 21 species of fish eggs and 40 species of fish larvae in the plankton of the Irish Sea, 17 of which were commercially important species.

In addition to phytoplankton and zooplankton, bacteria are also present in sea water and these are referred to as Bacterioplankton. Very little is known regarding the different communities or the detailed species composition of bacterioplankton within sea water however, they are considered to have an important role in the breakdown of organic matter and it is considered that a litre of sea water may contain up to $10x^9$ bacteria (OSPAR commission, 2000).

The composition of the Liverpool Bay plankton community is typical of relatively shallow enclosed waters around the British Isles and the taxa recorded within the region are all generally associated with coastal waters. The area has a high productivity level of plankton located at the Liverpool Bay front which has a distinct copepod abundance. Within the Irish Sea the highest concentrations of chlorophyll (i.e. phytoplankton) can be found in Liverpool Bay especially in waters associated with the estuaries of the Dee, Mersey and Ribble and algal blooms are known to occur within the Bay. The overall stocks of plankton within the Irish Sea are considered to be much less than other areas such as the North Sea (Kennington & Rowlands, 2005)

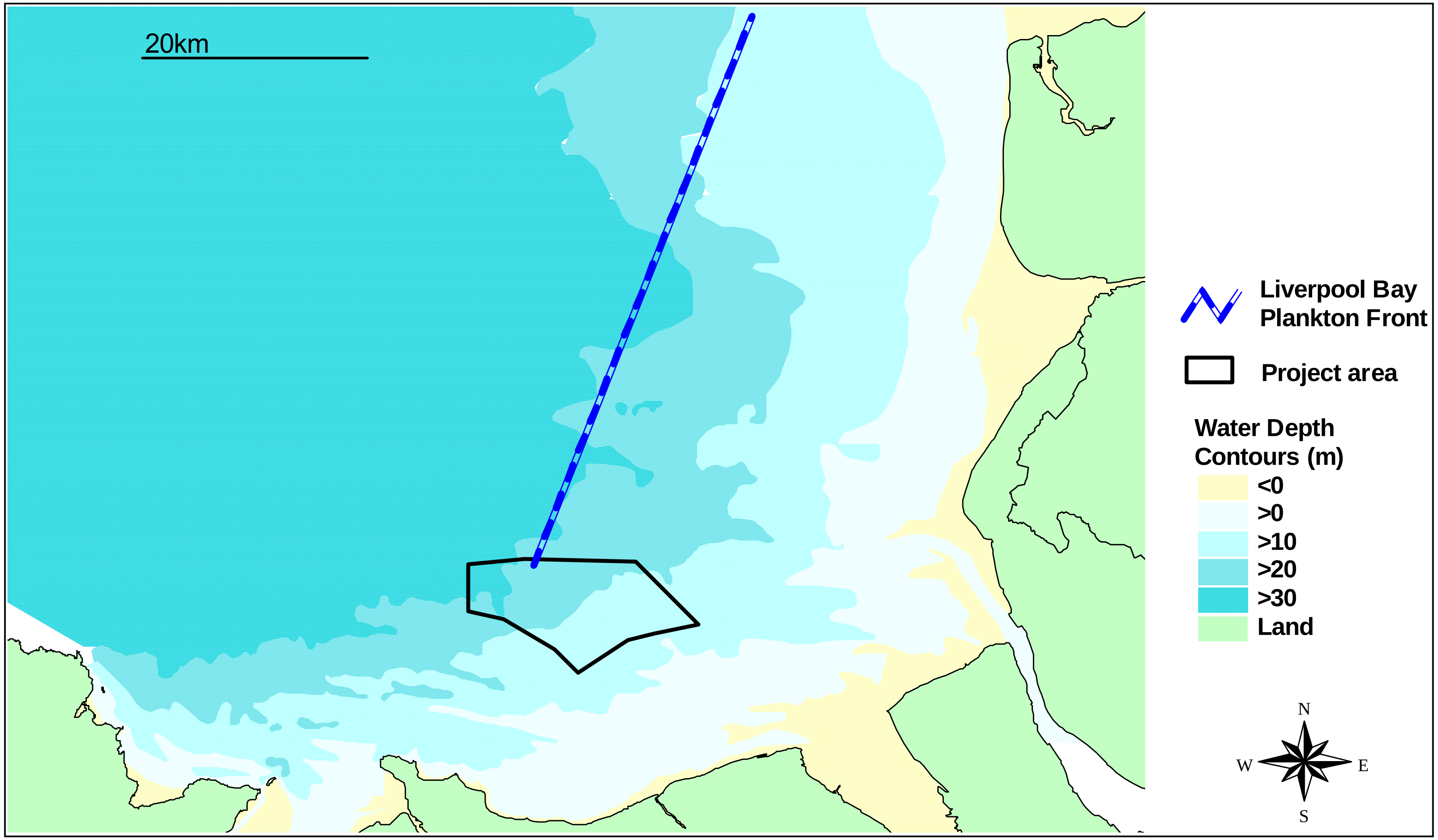


Figure 3.2.1: Approximate position of the Liverpool Bay plankton front (source: Continuous Plankton Recorder, SAHFOS, 1996).

3.3 Benthic Ecology Environmental Background

This section describes the existing marine benthic species and communities found within Liverpool Bay and the eastern Irish Sea, drawing upon information from available literature in addition to the site-specific benthic characterisation surveys (CMACS, 2005) detailed in Appendix 1. This section also describes the existing intertidal environment of the North Wales coastline, with specific consideration given to the area of the proposed Gwynt y Môr cable landfall. Any rare, unusual or protected species either identified as part of the literature review or recorded as part of the characterisation survey have been discussed within section 3.6: Nature conservation.

3.3.1 Regional Review of Subtidal Benthic Communities in the eastern Irish Sea & Liverpool Bay

The subtidal benthic communities of the eastern Irish Sea have previously been described by Mackie (1990) and Jones (1950), using a combination of existing biological survey data and geological data, to outline the distributions of important communities in the northern Irish Sea benthos. This tends to have been the main source of information for other summaries for example by Taylor and Parker (1993) or Irving *et al* (1996). Further studies include Rees *et al.,* 1972 and Rees & Walker, 1984. However, most of this data was used in the preparation of Mackie's (1990) community distributions. The Joint Nature Conservation Committee (JNCC) has incorporated information from these and other workers in their ongoing production of subtidal biotope classifications (Connor *et al.*, 1997 and Connor *et al.,* 2004). These standardise definitions of biotopes in terms of both the biological community as well as the habitat in which they occur. Detailed existing information of benthic communities for the Liverpool Bay area is generally restricted to surveys in support of specific developments such as the North Hoyle, Burbo Bank and Rhyl Flats Offshore Wind Farms, marine aggregate dredging licence areas and offshore oil and gas activities.

Overall much of the subtidal benthos in the eastern Irish Sea is considered to be composed of sedimentary communities. These communities tend to be dominated by burrowing animals known as infauna although epifauna (species living on the surface of sediments) are also important, especially in areas of coarser substratum. Mackie (1990) describes most of the eastern Irish Sea as being dominated by *Venus* communities, the Deep *Venus* community occurring on coarser sands and gravels and the shallow *Venus* community on finer sands, usually in shallower waters. However, it is considered that it is the shallow *Venus* community which dominates areas around the Irish Sea coastline, including much of Liverpool Bay. This community occurs in shallow (5-40m) nearshore sands which are often subjected to strong currents. Mackie further describes two sub-communities which belong to the shallow *Venus* community relating to their preferred sand grades. These are; the *Spisula* sub-community that occurs in medium to coarse sands subject to disturbance (typical species include the bivalve *Spisula elliptica* and the polychaete worm *Nephtys cirrosa)* and the *Fabulina* sub community occurring in fine stable sands (typical species including the bivalve *Fabullina fabula* and the polychaete worm *Magelona johnstoni)*. In more detailed community descriptions in the JNCC's MNCR marine biotope classification (Connor *et al.,* 1997), these communities equate to IGS.Sell (*Spisula elliptica* and venerid bivalves in infralittoral clean sand or shell gravel) and IGS.Fab/Mag (*Fabulina fabula* and *Magelona johnstoni* with venerid bivalves in infralittoral compacted fine sand).

Offshore and towards the outer area of Liverpool Bay sublittoral communities are thought to be of the Deep *Venus* community which occurs on coarse sand/gravel/shell sediments at moderate depth (40-100m) (Mackie, 1990). The Deep Venus community is characterised by the presence of a variety of bivalves including *Glycimeris glycimeris* and *Venus* spp., and the burrowing Purple Heart urchin *Spatangus purpureus.* This biotope equates to the JNCC CGS.Ven biotope (venerid bivalves in circalittoral coarse sand or gravel). Further offshore in Liverpool Bay, in the area of the Douglas platform, there appear to be patches of muddy gravel which support relatively rich and diverse communities which have not been well classified (e.g. Rees *et al.,* 1972 and Rees & Walker, 1984 quoted in Mackie, 1990). Areas of sand waves located in the west of the Liverpool Bay region are thought to contain elements of both the Deep and Shallow *Venus* communities (Mackie, 1990).

Inshore from the Gwynt y Môr Offshore Wind Farm project area and along the North Wales coastline are thought to be pockets of *Abra* communities. These occur in patches of shallow, nearshore muddy sands and are dominated by the bivalve species *Abra alba* and the polychaete worm *Lagis koreni* (Rees *et al.,* 1977). This community occurs in small localised patches in embayments throughout the Irish Sea and probably equates best to the JNCC biotope CMS.AbrNucCor (*Abra alba*, *Nucula nitida* and *Corbula gibba* in circalittoral muddy sand or slightly mixed sediment). At other inshore locations such as the Dee Estuary sediment habitats and communities are representative of the east basin of the Irish Sea whilst the fauna of the outer Mersey Estuary is largely of low diversity due to the prevailing mobility of the sand flats in that area.

Detailed grab surveys undertaken at the North Hoyle Offshore Wind Farm site in 2001 found the overall benthic community fitted with Mackie's description of a shallow *Venus* community but equated better with the *Spisula* (IGS.Sell) subcommunity. This was due to the presence of quite large numbers of the bivalves *Spisula elliptica, Spisula subtruncata* and *Spisula solida*, and large numbers of the polychaetes *Spiophanes bombyx* and *Nephtys cirrosa*, and the occasional presence of *Echinocardium cordatum*. To the north and west of the North Hoyle Offshore Wind Farm area species more indicative of coarser sediments were recorded similar to the biotope IGS.ScupHyd (*Sertularia cupressina* and *Hydrallmania falcat*a on tide-swept subtidal cobbles or pebbles in coarse sand) which often contains the '*Venus'* associations in the infauna. Overall the dominant biotope here was better described as IGS.Sell with variable amounts of overlying stones and associated hard fauna (Innogy, 2002).

Inshore areas surveyed during the North Hoyle studies showed strong similarity with Mackies's *Abra* community with *Abra alba*, *Nucula nitida* and *Corbula gibba* in circalittoral muddy sand or slightly mixed sediment but also retained elements of the *Spisula* community, (*E. cordatum* and *Ensis* spp are also found in the *Spisula* (IGS.Sell) biotope) (Innogy, 2002).

Benthic surveys undertaken at the proposed Burbo Bank Offshore Wind Farm site located at the mouth of the Mersey Estuary described the benthic communities from across much of the surveyed area to be dominated largely by the IGS.FabMag (*Fabulina fabula* and *Magelona mirabilis* with venerid bivalves in infralittoral compacted fine sand) in deeper areas and by IGS.NcirBat (*Nephtys cirrosa* and *Bathyporeia* spp in infralittoral sand) in shallower areas including most of the subtidal part of the cable route. However, it was stated that neither biotope was a particularly clear match with the biotope description (SeaScape Energy, 2002).

Results from the site-specific surveys undertaken at the Rhyl Flats Offshore Wind Farm development area, which is located inshore from the Gwynt y Môr project area, indicate that the benthic community is similar to that described at Burbo Bank with the main biotope being IGS.NcirBat (*Nephtys cirrosa* and *Bathyporeia* spp in infralittoral sand). This biotope is typical of well sorted medium and fine sands, sometimes with some shell fragments or occasional small stones, and is subject to considerable disturbance by wave and/or tidal action. The characterising species *Nephtys cirrosa* and *Bathyporeia elegans* and *B. guilliamsoniana* were generally abundant, and the bivalve *Fabulina fibula* was present in small numbers, as is typical. Other fauna typical of disturbed sediments included other burrowing amphipods such as *Pontocratees* spp amd cumaceans such as *Diastylis* spp and *Pseudocuma* spp. This biotope is, as expected, generally fairly species poor and with relatively low numbers of organisms. The other main biotope identified was IGS.FabMag (*Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand) which was also identified at Burbo Bank (COWL, 2002 & Sea Scape Energy, 2002).

Baseline benthic surveys undertaken at the Hamilton and Douglas offshore rig installations within Liverpool Bay also identified benthic communities of the type IGS.Sell (*Spisula elliptica* and venerid bivalves in infralittoral clean sand or shell gravel) and IGS.FabMag (*Fabulina fabula* and *Magelona mirabilis* with venerid bivalves in infralittoral compacted fine sand) both of which are sub-communities of the shallow Venus communities found throughout Liverpool Bay (BHP Billiton Petroleum Ltd., 2001).

Potentially important benthic species which have previously been recorded within Liverpool Bay include the fan mussel *Atrina fragilis* which is nationally scarce and is protected under schedule 5 of the Wildlife and Countryside Act (1981) and the Wildlife (NI) Order 1985 and is recorded as being present in Liverpool Bay by the UK Biodiversity Action Plan (BAP) (Anon 1999c). However, this occurrence is based upon a single record in Liverpool Bay and more recently the Marine Life Identification Network (MARLIN) have produced a map which indicates it as being present at only one site in the northern Irish Sea (on the Irish Coast North of Carlingford Lough). Numerous surveys have been carried out in Liverpool Bay in recent decades, from which there appear to be no further records.

The thumbnail crab, *Thia scutellata*, is described as being nationally scarce and, although not a BAP species, is included in the "Atlas of Marine Biodiversity Action Plan Species and Habitats and Species of Conservation Concern in Wales" (Moore, 2002). Within British waters it has a very distinct distribution due to its narrow habitat requirements of loose, well-sorted medium sands into which the crab can easily burrow and with a low fine sand/silt/clay content so that water can percolate freely, allowing the crabs to respire (Rees, 2001). Its main populations within the Irish Sea have been described as being 6-12 miles offshore from the North Wales coast, with some off the east coast of Anglesey. These appear to represent the major known populations in British waters. It is also known to occur in limited areas in central Cardigan Bay and Carmarthen Bay. Older records for North Wales include Constable Bank and Menai Straits (Rees, 2001).

Within Liverpool Bay this species has also been recorded from site-specific grab surveys undertaken at the North Hoyle Offshore Wind Farm (Innogy, 2002), the offshore rig installations (BHP Billiton Petroleum Ltd., 2001) and also at the Burbo Bank Offshore Wind Farm (CMACS, 2002b) and during the site-specific surveys undertaken in support for the Rhyl Flats Environmental Impact Assessment. This species and its distribution are further discussed within section 3.6.

3.3.2 Site-Specific Subtidal Benthic Studies

Due to the lack of detailed knowledge of the benthic communities located specifically at the Gwynt y Môr Offshore Wind Farm project area, The Centre for Marine and Coastal Studies (CMACS) was commissioned by npower renewables to undertake a characterisation survey of the benthic environment (CMACS, 2005- see Appendix 1). A comprehensive grab survey was undertaken to gain information concerning macroinvertebrate fauna and sediment types. Due to the developing nature of the Gwynt y Môr project, the grab survey was completed in three stages to ensure complete coverage of the project area and the associated export cable route corridor. To complete the characterisation of the benthic communities across the project area a beam trawl survey was also undertaken to gather data on demersal fish species and epifaunal communities of the area and any major fluctuations in seasonality of these populations. The results from the surveys were then used to characterise the subtidal environment at the Gwynt y Môr Offshore Wind Farm project area.

Survey Design

In 2002, the Centre for Marine and Coastal Studies (University of Liverpool) was commissioned to undertake a characterisation study of the benthic communities existing in the eastern section of the Gwynt y Môr Offshore Wind Farm project area. Survey methodology was discussed and approved through consultation with the Countryside Council for Wales (CCW) and the Centre for Environment, Fisheries and Aquaculture Sciences (CEFAS). In 2003, the Centre for Marine and Coastal Studies Ltd (CMACS) was subsequently commissioned to undertake a characterisation survey of the western part of the project area using the same methodology used during the 2002 survey. A grab survey was also undertaken during October 2004 by CMACS within the proposed export cable route corridor, again using previously agreed methodology.

The basic approach for the surveys was to use a stainless steel Day grab which samples a 0.1m^2 area of seabed to ascertain the infaunal species and abundance of marine invertebrates of the project area, in combination with a beam trawl study which provides a good indication of the epifaunal marine invertebrates and demersal fish species of the area. As marine community compositions are also heavily influenced by substrate, sediment sampling for particle size analysis was completed at each site where a benthic grab was obtained. During the grab survey sediment samples were also obtained for chemical analysis at a representative number of the sampling locations.

The grab survey was designed using a grid system of stations to gain maximum coverage of the project area and surrounding environment (see Figure 3.3.1). At approximately 10% of the locations an extra faunal sample was taken to provide a replicate to investigate the heterogeneity of the fauna and sediment over small scales (see Figure 3.3.2). This methodology was utilised for both the 2002 and 2003 surveys of the main area where two replicate samples were collected; for the 2004 survey three samples were taken at the replicate sites, at the request of CCW.

To complete the characterisation of the benthic communities across the project area a beam trawl survey was completed during 2003/2004. This was undertaken in December, March and August to gather data on demersal fish and epifaunal communities of the area and to describe any major fluctuations in seasonality of these populations. Methodologies were discussed and approved by the relevant agencies. Trawls were undertaken at 47 locations (see Figure 3.3.3) during each of the three survey periods, including a number of sites outside of the boundaries of the Gwynt y Môr project area, in order to identifying benthic communities over a wider area around the proposed development location. Six more beam trawl sites were added during the August 2004 survey period to sample the export cable route corridor, although due to the developing nature of the project design, the eastern strip of the cable corridor was not included in the sample array (see Figure 3.3.3).

For all beam trawl surveys a CEFAS approved 2m beam trawl was used equipped with a chain matrix and 4mm square mesh cod-end. All tows of the trawl were completed into the current over a distance of 300m at a speed of 2 knots using a sufficient warp length of a minimum of 2.5 times the water depth to allow the gear to “fish” the bottom properly. In interpreting the beam trawl data it should be bourne in mind that small beam trawls are designed to survey epibenthic invertebrates and smaller demersal fish, and are not intended to be efficient for the surveying of larger demersal or pelagic fish. Where larger fish species are caught, the samples will tend to be heavily skewed towards the smaller end of the size range. This problem is compounded by the need in this area for chain matting over the trawl mouth (to prevent boulders from entering the trawl net), which would make it impossible for very large species, especially flatfish such as rays, to be caught should they be encountered. Furthermore, the small seabed areas covered by each tow ($600m^2$) also means that encounter rates with relatively dispersed species such as rays would in any case be very low.

Sample Treatment & Analysis

Full details of quality control procedures used for sample collection and specimen sorting and identification were agreed with the relevant agencies prior to survey and are given in the benthic survey field report (CMACS 2005- Appendix 1).

Each faunal grab sample was sieved on board the survey vessel over a 1mm mesh and samples were preserved in formalin at a final dilution of c 5% in phosphate buffered seawater. After the fauna from each sample had been sorted into the major taxonomic groups the individual organisms were identified to species level and recorded quantitatively using nomclenture as defined by the Ulster Museum and Marine Conservation Society Species Directory (Howson and Picton, 1997). Where this was not possible, either due to juvenile specimens or damage, the organisms were identified to genus level or to higher taxa. Colonial organisms such as hydroids, sponges and bryzoans were recorded on a presence/absence basis. A labelled reference collection was prepared and all faunal samples subsequently stored in alcohol. Digital photographs of each sample and written descriptions of visual appearance of sediments were taken at the time of sampling on board the vessel and the position of each sample location was recorded using DGPS.

To obtain the sediment samples grabs were allowed to stand to drain off excess water before a trowel was used to obtain a sufficient sample from the surface of the grab through the “trap door” at the top of the grab. This sample was then placed into a labelled sediment container. All sediment samples were then stored in impermeable cool-storage transportation boxes and frozen as soon as possible. Particle Size Analysis (PSA) was undertaken by a UKAS (United Kingdom Accreditation Scheme) accredited laboratory. All sediment samples for PSA analysis were dried to a constant weight using ovens set at a temperature of 70°C. The sediments from each sample were then sieved using a set of Endecott BS 410 test sieves (10.0mm, 5.0mm, 2.00mm, 1.00mm 600μm; 425μm; 300μm; 212μm; 150μm; 63μm meshes).

The organic content of each sediment sample was also investigated using loss on ignition as an index of organic carbon content. Analysis was carried out on a subsample of the <1mm fraction by ashing at 450^{o}C after drying at 60^{o}C.

Beam trawl hauls were retrieved on deck at the end of each tow and the whole catch was photographed. At this time, the scientific surveyor also completed notes regarding the trawl date, time and a brief description of the trawl contents. The catch was then sorted and all fish species identified to species level with commercial species also being measured and any elasmobranch species also being measured as well as sexed. Invertebrate species were identified to species level where possible in the field, with some being retained for confirmation of identification in the laboratory (these were preserved in small receptacles using a 10% formalin solution). Once identified, all invertebrates were counted and recorded with colonial organisms such as hydroids and bryzoans being weighed (kgs) or recorded as "present" when found in only small numbers.

At some sites where very large hauls were obtained subsampling was required. Here the catch was first thoroughly searched for all fish species and large invertebrate species, which were removed, identified and recorded. The remaining catch was then subsampled to a manageable fraction before all smaller organisms were identified, counted and recorded. These numbers were then multiplied by the appropriate fraction to get an estimate of the true sample remainder and these numbers added to those found during the initial search.

Data Analyses

The raw data from all grab and beam trawl surveys was subsequently transferred into electronic format and a combination of multivariate and univariate statistical analyses were applied to the data. Univariate statistics were used to provide information concerning the number of taxa and individuals including diversity indices (Shannon Wiener index) to provide an indication of community features.

A combination of techniques were then used to investigate community structure. The majority of the analysis was carried out on faunal data from the grabs with multivariate statistics using the programme PRIMER v5 to undertake SIMPER analyses and produce dendrograms and multi dimensional scaling plots (MDS) using the using the Bray-Curtis similarity coefficient (Bray and Curtis, 1957). Stress values are provided for each MDS plot; a stress value of <0.05 indicates that there is an excellent representation of the relationship between the various samples; 0.1 indicates good ordination and 0.2 indicates a potentially useful 2-dimensional picture (Clarke and Warwick, 1994). SIMPER (Similarity percentages – species contributions) analysis was performed to identify the contribution of individual species to any dissimilarity between faunal communities. Dendrograms were plotted using hierarchical clustering with group average linking. MDS plots were also used to investigate the interrelationships between replicated grab samples from replicate grab sites to identify any small scale variation enabling the suitability of single grab samples as representations of the benthic communities to be established and a description of small scale heterogeneity to be made.

For analytical purposes those colonial fauna recorded on a presence or absence basis were assigned a value of 1 and different life history stages recorded for the same species were combined. A moderately strong data transformation (square-root) was used for all multivariate analyses as it provides a sensible balance between common and scarce species and would thus reduce the effect of variations in numbers of organisms, which is likely to have occurred as a result of surveys being undertaken during different times of the year, as well as in different years. Exploratory analyses carried out using stronger (4^{th} root) data transformation suggested that there was in fact little, if any, noticeable difference between the two treatments.

To define the main benthic community relationships a broad initial site classification was prepared using a dendrogram based on a matrix of similarity indices, with a single replicate from each site being used in order that they were all comparable (see Appendix 1 for dendrogram). A square-root transformation was used to reduce the influence of variations in numbers due to seasonality and inter-annual variation. Data was limited to those species contributing 10% of fauna in at least one sample in order to reduce undue influence from rare taxa as is usually recommended. A similarity level of 20% was chosen from the dendrogram as a suitable similarity level to produce a reasonable number of groupings.

The main benthic communities identified by these classification methods were inevitably fairly broad and variable, but in the majority of cases the communities were a reasonable match to the sublittoral biotopes as defined by Connor *et al* (2004). However, the groupings were then refined (i.e. a number of sites were re-assigned to different groups) by taking account of the distribution of important indicator species as well as the dominant species, and by taking account of information from the beam trawl surveys, as well as bathymetric and sediment data. During this process it was found that many of the outlying sites in Figure 3.3.2 represented species poor communities which could realistically be categorised with one or other of the main groupings. Using this process it was possible to produce an indicative map of the main biotopes and communities present. However, in order for this to make sense one of the initial groupings had to be split into two biotopes by expert analysis of characteristic species.

The main benthic communities established (using the same methodology) as part of the North Hoyle Offshore Wind Farm baseline survey (Innogy, 2002) were also added to the overall biotope map to allow a wider area of the sub-tidal benthic communities of the region to be considered as part of the assessment.

Data from the sediment sample particle size analysis was used to establish the mean and median particle sizes, and the determination of sorting index by calculating the standard deviation of Phi, which were then used to determine the sediment type for each sample. The classification system used to distinguish sediment type and the sorting index were carried out in accordance to the methods of Buchanan *et al* (1984) (see Table 3.3.1 and 3.3.2). Further classification was also made using JNCC's version of the Folk triangles. These results were also used in the establishment of the main community sublittoral biotopes of the survey area.

Summary of the Results of the Site-Specific Studies

Sediment Environment

The seabed within the project area was found to be mainly composed of medium or coarse sands, often poorly sorted with varying amounts of coarser material such as gravel or stones. Inshore sites tended to be well-sorted sands with those sites located in the north and the east of the survey area being coarser and composed of poorly sorted gravelly sands. Sandier areas were found towards the south west of the survey area (see Figure 3.3.4 and Figure 3.3.5).

This agrees broadly with the maps of seabed features supplied by OSIRIS Ltd (OSIRIS, 2005) and also with the description of the eastern Irish Sea (to include Liverpool Bay) by the British Geological Survey, which describes the area as predominantly sandy with varying mud, gravel and stone content with, gravel content increasing with distance offshore and towards the east of the overall survey area (BGS, 1995).

Results from the Total Organic Carbon (TOC) analysis showed the offshore sediments from the study area to be relatively low in organic matter with the richest site containing <1% TOC. Higher values were seen at the inshore locations (although these were still mostly below 1%) with a maximum value of 2.5% from site number C11 within the cable route corridor survey area. These results were in keeping with previous records of TOC levels in Liverpool Bay e.g. Camacho-Ibar (1992) where records of offshore TOC levels in Liverpool Bay were found to be <1% with higher values at inshore locations. Surveys carried out at 51 locations at and around the nearby North Hoyle Offshore Wind Farm site in August 2001 found generally similar levels of TOC within sediments (Innogy, 2002).

Subtidal Benthic Communities

Results from the grab and trawl surveys are given in full in the field survey report (CMACS, 2005- see Appendix 1) and the results of both are included in the following summary.

Overall, the survey coverage of the Gwynt y Môr Offshore Wind Farm project area and the surrounding area was good with only six of the intended 261 grab sites being impossible to sample due to hard substratum (see Figure 3.3.2). A small area to the south of the main project area was noted, mainly encountered during the cable route survey of 2004, where cobble substratum was more dominant and adequate samples for analysis were unobtainable from eight of the intended locations despite numerous attempts at grab deployment and despite the intended grab locations being moved a few tens of metres in different directions around the originally agreed site. A reference site to the west of the cable route corridor was also not sampled for the same reason. In these areas, results from the geophysical surveys indicate that this area is composed of "sandy gravel with patches of cobble" (OSIRIS, 2005). However, beam trawl sites within this area have provided results concerning the epibenthic fauna within this area.

From the grab survey 44,445 individuals from 487 taxa were recorded from a total of 326 samples taken at 296 sites. All taxa were previously recorded from Liverpool Bay and the Irish Sea. Annelid worms (mostly polychaetes) were the most abundant group in terms of both the number of taxa (51%) and individuals (63%). Crustacea were the next most abundant group, comprising 18% taxa and 17% individuals, and echinoderms were the smallest group with only 5% of organisms and 2% of total individuals. The most numerous species recorded was the polychaete keel worm *Pomatoceros triqueter* which comprised over 11% of all enumerated fauna and was over 3 times more numerous than the next most abundant species which was the ribbon worm *Nemertea sp.*

In most cases, a high number of taxa coincided with a high number of individuals and most of the samples from the eastern sides of the survey area contained over 100 individuals per $0.1m^2$. The exceptions to this general pattern were observed at some of the cable route sites where relatively high numbers of individuals but a low number of taxa were noted. Overall, the richness and diversity of the fauna was not especially high, although there were exceptions in some areas. If the results are considered in conjunction with the sediment data it can be seen that a higher diversity is generally associated with those sites characterised by a gravelly/coarser substratum i.e. in the east and north of the survey area, rather than the sandier areas recorded inshore and to the west of the survey area. Distribution maps displaying the numbers of organisms, numbers of taxa and diversity of each grab site are plotted in Figure 3.3.6, Figure 3.3.7 and Figure 3.3.8.

The interrelationships between grab samples taken at replicate sites were studied statistically and the similarity relationship between replicate samples is displayed in the dendrogram given in Figure 3.3.9. Overall, the results indicated that small-scale variation was low over the area as a whole, the small number of exceptions being largely on some, but not all, sites with slightly gravelly, probably mobile, sands carrying very low numbers and diversity of animals. Nevertheless, it can be concluded that for the most part single replicate grabs are likely to be a good representation of the communities found for the purposes of general community.

The analysis of the grab survey results was used to establish similarities between fauna at different sites across the area to identify and enable the description of the different benthic communities present. Figure 3.3.10 displays the MDS plot for this analysis and from this six different benthic communities can be identified. However, it was necessary to split one of these community groups (group 6) into two by expert analysis of characteristic species (see data analysis section above). Sediment characteristics are known to influence benthic community structure so the sediment types (according to JNCCs version of the Folk classification) were also superimposed onto the site classification MDS plot (see Figure 3.3.11). This confirms that sediment type is a major influence on the communities found in this case, although considerable overlap between communities found on the sandy gravel and the gravelly sand habitats can be seen.

The epifaunal results from the beam trawl surveys yielded a total of 42,440 epifaunal individuals from 139 taxa over the three survey periods. Surveys in December and March showed very similar numbers of both epifaunal taxa and individuals, whereas the August survey had a higher number of taxa but fewer individuals. All species were previously recorded from Liverpool Bay and the Irish Sea.

The common starfish *Asterias rubens* and the green urchin *Psammechinus miliaris* were amongst the three most abundant epifaunal organisms in all three surveys. The third species was the plumose anemone *Metridium senile* in the December and March surveys, and the hermit crab *Pagurus bernhardus* in the August survey. Results from the December and March surveys show *Asterias rubens* to be recorded at all sites, with the single exception of site 11 (located in the north of the project area). During the August survey, *A. rubens* was absent from eight sites in the main survey area but was present at all others, including the cable route sites, where it was particularly abundant at the inshore site of C1. In all three surveys *A. rubens* appeared to be more abundant towards the east of the survey area.

The green sea urchin, *Psammechinus miliaris* was present at most sites in all three surveys and was more abundant at the northern sites in the December and March surveys, but showed no obvious pattern of abundance throughout the August survey. The plumose anemone, *Metridium senile* was present at about half of the survey sites and was more abundant towards the eastern half of the survey area. *Pagurus bernhardus* was well distributed over the area, but generally in low numbers and appears to be among the three most abundant epifaunal organisms for August due to high abundance at four sites. Both *Psammechinus miliaris* and *Pagurus bernhardus* were absent from the four inshore cable route sites.

Many of the sites sampled in each of the beam trawl surveys had >1000 individuals, mostly due to high numbers of the sea urchin *Psammechinus miliaris*, the starfish *Asterias rubens* and/or the plumose anemone *Metridium senile,* but also the hermit crabs *Pagurus bernhardus* and *P. prideauxi* at a number of sites. In the December and March surveys, all sites had at least one species of epifauna present but in August epifauna were absent from two sites within the project area (sites 11 and 30 see Figure 3.3.3 for locations).

The cable corridor beam trawl survey sites generally had <500 epifaunal organisms per trawl with the exception of site C1 where over 3,000 brittle stars (*Ophiura ophiura)* were recorded (this is discussed further in section 3.6). In the central part of the survey area (sites 8-12, 18-23 and 27-32, see Figure 3.3.3 for locations) epifaunal numbers were lower in August than in March or December. This is perhaps contrary to what would normally be expected; in March, numbers of epifaunal invertebrates would be expected to be low after winter mortality due to predation and inclement weather with no reproduction to replace losses. Numbers would be expected to be high in August after a summer of rapid growth and high reproduction. It is not clear why these patterns were not observed, although it is noted that the summer of 2004 was exceptionally windy which might have resulted in epifaunal species being driven into deeper water by wave action.

Fish species recorded during the beam trawl survey are considered separately within section 3.4: Fish and Shellfish.

Although all species recorded from the grab and beam trawl surveys were previously known from the Irish Sea, it is necessary to consider if any of these species or indeed communities described are protected by legislation or are considered to be rare or indeed unusual within the context of UK or international waters. This is further discussed within section 3.6.4.

Subtidal community structure

The main community relationships identified during the statistical analysis of the grab survey results were inevitably fairly broad and variable, but in the majority of cases the communities were a reasonable match to sublittoral biotopes as defined by Connor *et al* (2004). However, the groupings were then refined (i.e. a number of sites were re-assigned to different groups) by taking account of the distribution of important indicator species as well as the dominant species, and by considering information concerning epibenthos from the beam trawl survey, as well as bathymetric and sediment data. Detailed descriptions of the biotopes found, including site numbers, are given in Table 3.3.3. These were then used to produce the biotope map displayed in Figure 3.3.12, which also includes biotopes in areas to the south east of the survey area, based on information collected during the surveys conducted for the North Hoyle Offshore Wind Farm. However, it should be remembered that the biotope interpretation is not definitive and there will be substantial variation within each broad zone. This is due to the inherent difficulty in biotope assignation for wide areas based on small numbers of samples. In addition, many of the fauna within seabed sediments are highly variable in both time and space and there are numerous overlaps and similarities between different biotopes.

Description of the Benthic Environment at the Gwynt y Môr Offshore Wind Farm Project Area

The sediments at the Gwynt y Môr project area were mostly composed of gravelly sands. This was most apparent in the eastern half of the project area and in parts of the north with patches of pebbles in the central region. The west of the area is mostly comprised of coarse and medium sands. The sediments in the east supported marine fauna of a higher diversity and abundance than those in the west.

The epifaunal communities described from the benthic trawl survey found the Gwynt y Môr project area to be roughly the boundary between the two assemblages of *Pleuronectes-Limanda* (Plaice-Dab) assemblage (as described by Ellis *et al* (2000), which is found within and around the 20m contour of the Liverpool Bay area) and the *Microchirus-Pagurus* assemblage which occurs in slightly deeper areas (see section 3.4- Figure 3.4.13). Areas of hard substratum were found in the central part of the project area which supported fauna associated with a hard substratum such as *Alcyonium digitatum*. Generally, sites within the Gwynt y Môr project area had lower numbers of epifauna when compared to surrounding sites outside the wind farm boundary which were also surveyed as part of the characterisation survey.

In the context of the wider survey area the Gwynt y Môr Offshore Wind Farm project area was characterised by only three biotopes with two of these biotopes making up a sizeable part of the area. All of these biotopes were represented in other regions of the wider survey area.

The richest and most diverse sites were identified in the eastern part of the project area, associated with a coarser substratum of gravely sand. Most of this eastern section of the project area is dominated by the biotope **SS.SCS.CCS.MedLumVen (***Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel). This is a polychaete dominated community, often moderately rich in taxa and individuals, characterised by *Mediomastus fragilis* and *Lumbrineris* spp (in this case mainly *L.gracilis*). Numerous other polychaetes typical of this biotope were also found within this area, including; *Spiophanes bombyx*, *Protodorvillea kefersteini*, *Owenia fusiformis*, and *Poecilochaetus serpens,* as well as the urchin *Echinocyamus pusillus,* and the brittle star *Amphipholis squamata. V*enerid and other robust bivalves occur, especially *Moerella* spp, *Thracia* spp and *Dosinia* spp, with smaller numbers of *Timoclea ovata*. A number of other typical bivalves such as *Abra alba*, and the extremely small species *Mysella bidentata* are fairly widespread. Connor *et al* (2004) point out that venerid bivalves, which are often quite large, are frequently under-recorded by grab surveys. They also point out that on more gravelly substrates examples of this biotope epifauna are common. This is the case here, particularly in the central part of the project area, and notable epifauna include encrusting tubeworms, particularly *Pomatoceros triqueter*, dead man's fingers *Alcyonium digitatum*, and anemones such as *Cerianthus lloydii* and *Metridium senile*. This biotope was one of the most common identified during the survey and is considered by Connor *et al* (2004) to be a deep water variant of the **SS.SCS.ICS.MoeVen** biotope which was the second most dominant biotope within the Gwynt y Môr Offshore Wind Farm project area and was also one of the most common biotopes identified across the whole survey area.

The **SS.SCS.ICS.MoeVen (***Moerella* spp. with venerid bivalves in infralittoral gravelly sand) biotope is characterised by shallow water venerid bivalves such as *Moerella* spp, *Dosinia* spp and others, which were commonly found in the project area. The polychaete *Glycera lapidum* is also normally characteristic but more or less absent here, but other typical groups such as spionid and nephtyd worms and amphipods were frequent, and overall there is a good match with the biotope description.

Three small patches of the biotope **SS.SSA.IfiSa.NcirBat (***Nepthtys cirrosa* and *Bathyporeia* spp. in infralittoral sand) were also identified within parts of the Gwynt y Môr project area (see Figure 3.3.12). These were mostly limited to the areas of moderately- to very-well sorted medium sands, probably representing the more mobile sands in the area. In parts, this biotope was relatively species poor, occasionally resembling the relatively barren biotope "Infralittoral mobile clean sand with sparse fauna" (ImoSa) (these two biotopes are considered by Connor *et al.,* 2004, to grade into each other). Characteristic species such as the predatory polychaete *Nephtys cirrosa* and burrowing amphipods, including *Bathyporeia guillamsonia* and *B. elegans*, were well represented, along with a variety of less abundant species. Elements of the more dominant surrounding biotope of "MoeVen" were also occasionally represented within these areas.

In the context of the wider Liverpool Bay area, the fauna seems broadly typical, with common biotopes in the Gwynt y Môr Offshore Wind Farm project area being also dominant at the North Hoyle Offshore Wind Farm site (Innogy, 2002). The NcirBat biotope (*Nephtys cirrosa* and *Bathyporeia* spp in infralittoral sand), which was found in small patches in the project area, was also identified at the Burbo Bank Offshore Wind Farm development site (SeaScape Energy, 2002). Previous versions of the biotope classification included the biotope MoeVen (one of the widespread biotopes in the project area) as part of the IGS.Sell biotope (Connor *et al.,* 1997), which is a sub division of the shallow Venus community previously described by Mackie. This shallow *Venus* community dominates much of the shallow subtidal margin of the Irish Sea, particularly in the Liverpool Bay area. The dominant biotope at the Gwynt y Môr project area (MedLumVen) is considered by Conner *et al* (2004) to be a deep water variant of the MoeVen biotope and is similar to Mackies deep *Venus* community. As discussed in section 3.3.1, much of the central northern Irish Sea is dominated by this Deep *Venus* community occurring on coarser sands and gravels, as found at the Gwynt y Môr Offshore Wind Farm project area.

3.3.3 Intertidal Ecology

Regional Review of the Intertidal Benthic Ecology

The intertidal and coastal habitats within the study area of Liverpool Bay are mostly charcterised by shingle and sandy shores, with areas of sand dunes and saltmarsh, associated with the regions estuaries, also present.

Most of the regions intertidal area is sandy shore often giving way to shingle deposits, strandline vegetation or, to a lesser extent, sand dune habitats. Studies such as Bamber (1988) and Garwood & Foster-Smith (1991) have investigated the sandy intertidal zone between Rhos-on-Sea (Conwy) and New Brighton (Wirral) and CCW have also undertaken Phase I habitat mapping of the North Wales coastline. Results from these studies describe mostly areas of medium sands supporting populations of polychaetes such as *Scolelepis squamata*, burrowing crustaceans such as the amphipod *Bathyporeia pelagica* and the isopod *Eurydice pulchra,* found above the mid-tide level on the open shore. Below the mid-tide level, communities are dominated by the polychaetes; *Spio martinensis*, *Magelona mirabilis*, *Nephtys cirrosa*, *Lanice conchilega* and *Arenicola marina*. Areas of hard substratum are usually artificial such as sea defences: rip rap, sea walls and concrete encased pipelines, and these are encrusted by species such as *Mytilus edulis*, *Elminium modestus* and *Semibalnus balnoides,* in addition to lichens and algae.

Along the coastline, intertidal areas are often bordered by shingle, where deposits have formed ridges, bars and spits (Rice and Putwain, 1987). Extensive areas of shingle are present throughout the coastline of the eastern Irish Sea but its extent is thought to represent only a relatively small proportion of the United Kingdoms shingle habitat (Randall, 1996). Much of this shingle is described as barren supporting little community infrastructure with very few invertebrate species.

Within the region there are also a number of major estuaries, notably the Conwy, Dee, Mersey and Ribble. These comprise much of the intertidal habitat, which are mostly mudflats and sandflats and almost all of the saltmarsh within Liverpool Bay. The mudflats support faunal communities characterised by the estuary ragworm and oligochaete worm communities in addition to molluscs such as cockles. Mobile banks of intertidal sediments are common at the mouths of these estuaries supporting species such as the burrowing amphipod, *Bathyporeia pelagica* and the polychaete worm, *Nephtys cirrosa*. The majority of the saltmarsh habitat is concentrated within the Dee and Ribble Estuaries with smaller pockets found in the Clwyd, Mersey and Conwy. Saltmarsh plant species commonly associated with these estuaries are: *Potomageton, Ceratophylum, Zannichella, Myophyllum, Pucinellia maritima* and *Salicornia* spp. (BHP Billiton Petroleum Ltd., 2001).

Sand dune habitats are present along the North Wales coastline at Kinmel Bay (landward of the Gwynt y Môr project area), Talacre and Gronant with the latter two areas representing the last surviving complex of north facing dunes in Wales east of Anglesey (BHP Billiton Petroleum Ltd., 2001). Small areas of dune habitats are also found along the Wirral coastline but by far the most important and extensive sand dune systems within Liverpool Bay are to be found at Sefton (Doody, 1989). These sand dunes are characterised by plants such as marram grass *Ammophilia arenaria* and lyme grass *Elymus arenarius,* whilst the dune slacks of the area contain nationally rare northern centuary *Centaurium littorale,* Portland spurge *Euphorbia portlandica*, white horehound *Marribium vulgarea* and dune fescue *Vulpia fasciculate* (BHP Billiton Petroleum Ltd., 2001).

The coastline landward from the Gwynt y Môr project area along the north-facing coastline of North Wales is predominantly sandy with shingle habitats and a small area of sand dunes located at Kinmel Bay. The intertidal area for this region is discussed in further detail within the following section with specific emphasis upon the intertidal areas for the four cable landfall options.

Site Specific Intertidal Ecology

The cable route corridor for the Gwynt y Môr Offshore Wind Farm export cables comes ashore at a stretch of coastline between Kinmel Bay and Abergele on the North Wales coast. This area of the coastline has been previously mapped using Phase I methodology by CCW in 2002 and 2003 (CCW, 2004). This information has been interpreted below to describe the existing biotopes present at the four intertidal cable landfall options currently under consideration. Within this corridor four possible locations are being considered for the landfall of the export cables. An overview of the intertidal area within the boundaries of the entire corridor swath is discussed before separate consideration is given to the four possible sites where the cables may be brought onshore within the margins of this section of coast. For the consideration of the intertidal areas at the landfall options a 100m width of beach has been studied as, although actual cabling will only utilise circa 50-60 m of beach (2-3 metres per cable trench, separated by circa 10 m between each of up to six cables), a wider area of circa 100m will be roped off during the construction (see section 2). The biotopes described here will be used to formulate the assessment concerning the impacts of cable beach crossing on the intertidal fauna of the area.

The intertidal area of this swath of coastline is mainly composed of sand with species such as burrowing amphipods, burrowing polychaetes and the isopod *Eurydice pulchra*, all of which are very common on all British coasts. A small patch of mussel bed is located in the western side of the area of interest and there are also 3 metal pipelines in the area (one in the east and two in the west), which also provide hard substratum for species such as limpets and barnacles. The upper shore contains a long strip of barren shingle (LGSSH.BarSh), which is present along most of the western side of the study area and is backed by a sea wall at the top of the shore. The top of the shore in the eastern side of the area has a large amount of hard substratum from sea defences such as riprap, which has been colonised by hard substratum species such as barnacles and limpets (see Figure 3.3.13).

Landfall Option 1 – Pensarn Gap (Figure 3.3.14)

Option 1 for the cable landfall is located at the western edge of the cable corridor. Five biotopes exist within the 100m swath with the majority of the shore being dominated by the sand biotopes LGS.S.Aeur (mobile coarse sand shores with burrowing amphipods and *Eurydice pulchra*) and LGS.S.AP.P (mid shore clean sand with burrowing amphipods, *Nephtys cirrosa* and *Arenicola marina*). These two biotopes are the most common within the overall cable corridor interface section and are the main biotopes to be found along this stretch of coastline. Located within the mid shore section of the landfall strip is a small patch of the biotope SLR.MX.MytX (*Mytilus edulis* beds on eulittoral mixed substrata). This biotope is found throughout the area at various heights along the shoreline and contains small LRH rock pools covered with *Porphyra sp* and *Enteromorpha* (CCW, 2004). The top of the shoreline contains an area of barren shingle with no evident fauna (LGS.Sh.BarSh) which again is typical for the coastline of this region. The back of the shore has a small strip of the biotope LR.L.YG which is part of the sea wall covered by yellow and green lichens.

Landfall Option 2 – Belgrano (Figure 3.3.16)

Four intertidal biotopes exist within the area designated for the cable route landfall at option 2. The sand biotopes of LGS.S.Aeur (mobile coarse sand shores with burrowing amphipods and *Eurydice pulchra*) and LGS.S.AP.P (mid shore clean sand with burrowing amphipods, *Nephtys cirrosa* and *Arenicola marina*) dominate the majority of the intertidal area. The continuation of the barren shingle biotope along the coastline means that it is again present at this landfall option at the upper end of the shore. At the back of the shore is the biotope MLR.Eph.Ent which indicates hard substrate with *Enteromorpha.*

Landfall Option 3 – Towyn East (Figure 3.3.17)

The majority of the shore at cable landfall option 3 consisted of bands of the sand biotopes LGS.S.AEur (burrowing amphipods and *Eurydice pulchra* in mobile coarse sand shores) and LGS.S.AP.P (burrowing amphipods and polychaetes in clean sandy shores). There is also a small area of LGS.S.Lan (dense *Lanice conchilega* in tide-scoured lower shore sand) located in the mid shore area. At the top of the shore located on the riprap sea defences are three biotopes associated with hard substratum. These are: ELR.MB.MytB (*Mytilus edulis* and barnacles on very exposed eulittoral rock), SLR.F.Fspi (*Fucus spiralis* on moderately exposed to sheltered upper eulittoral rock) and at the top of the shore MLR.Eph.Ent (*Enteromorpha* spp.). Along this coastline these three biotopes are common covering numerous sea defence structures located within the area.

Landfall Option 4- Towyn West (Figure 3.3.16)

The fore and mid shore areas of this cable landfall site are dominated by bands of the sand biotopes LGS.S.AEur (burrowing amphipods and *Eurydice pulchra* in mobile coarse sand shores) and LGS.S.AP.P (burrowing amphipods and polychaetes in clean sandy shores). The top of the shore section demonstrates some hard substratum biotopes exisiting on the sea defences present at this location. These biotopes are: SLR.F.Fspi (*Fucus spiralis* on moderately exposed to sheltered upper eulittoral rock) and MLR.Eph.Ent (*Enteromorpha* spp.). There is also a small amount of barren shingle at the back of the shore described by the biotope LGS.SH.BarSh. At the back of the shore exisiting on the sea wall is the biotope LR.L.YG (the sea wall covered by yellow and green lichens).

Overall the intertidal habitats found within each cable landfall option and throughout the entire cable route corridor land interface are typical of the sandy shores along this section of coast with species and communities found being the same as those identified by Bamber (1998) and Garwood & Foster-Smith (1991) for the wider North Wales coastline. None of the biotopes are classed as being of conservation interest and are considered as being relatively common within the context of the Irish Sea and the wider UK coastline.

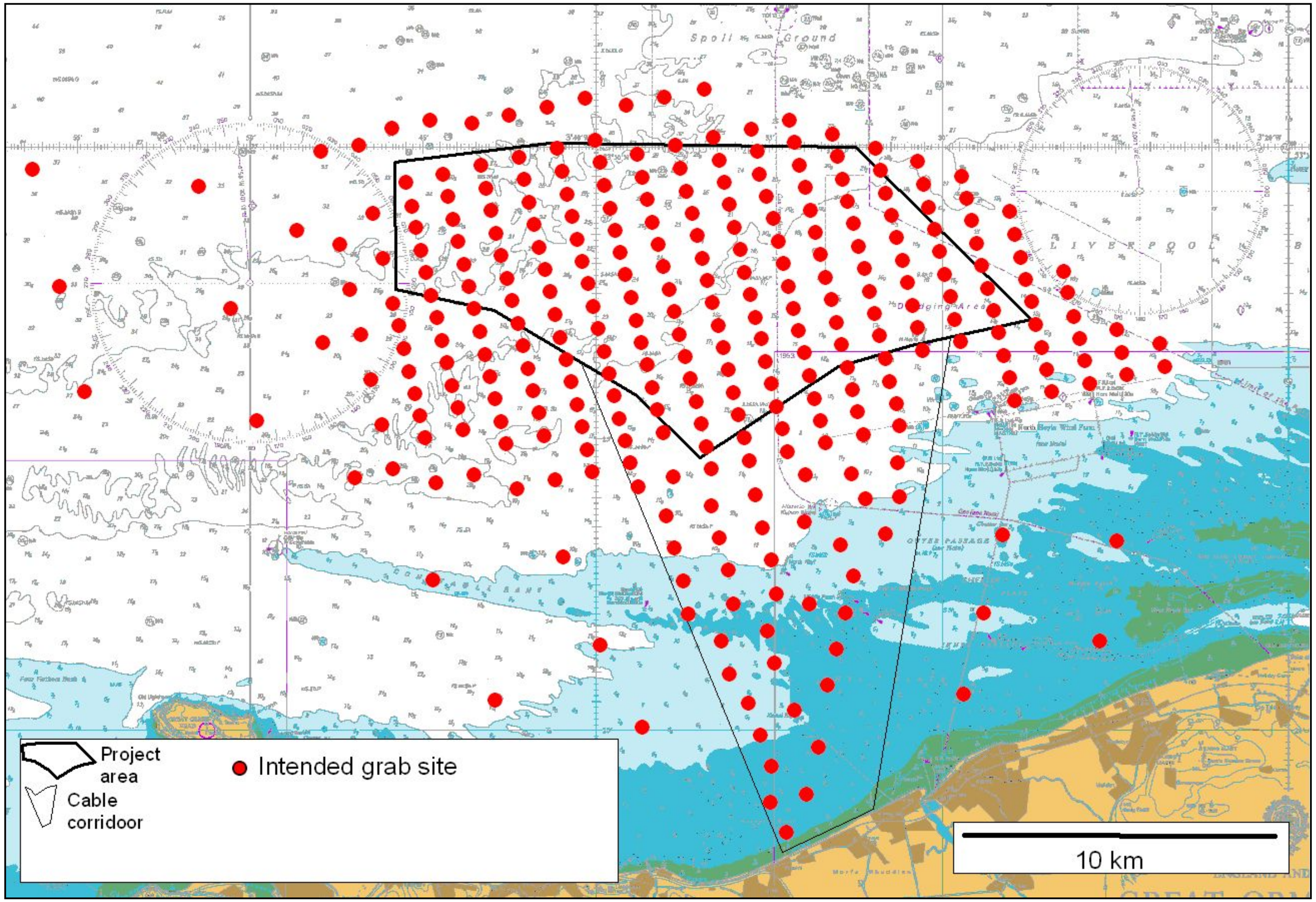


Figure 3.3.1 Layout of intended grab sample sites (See figure 3.3.2 for further detail).

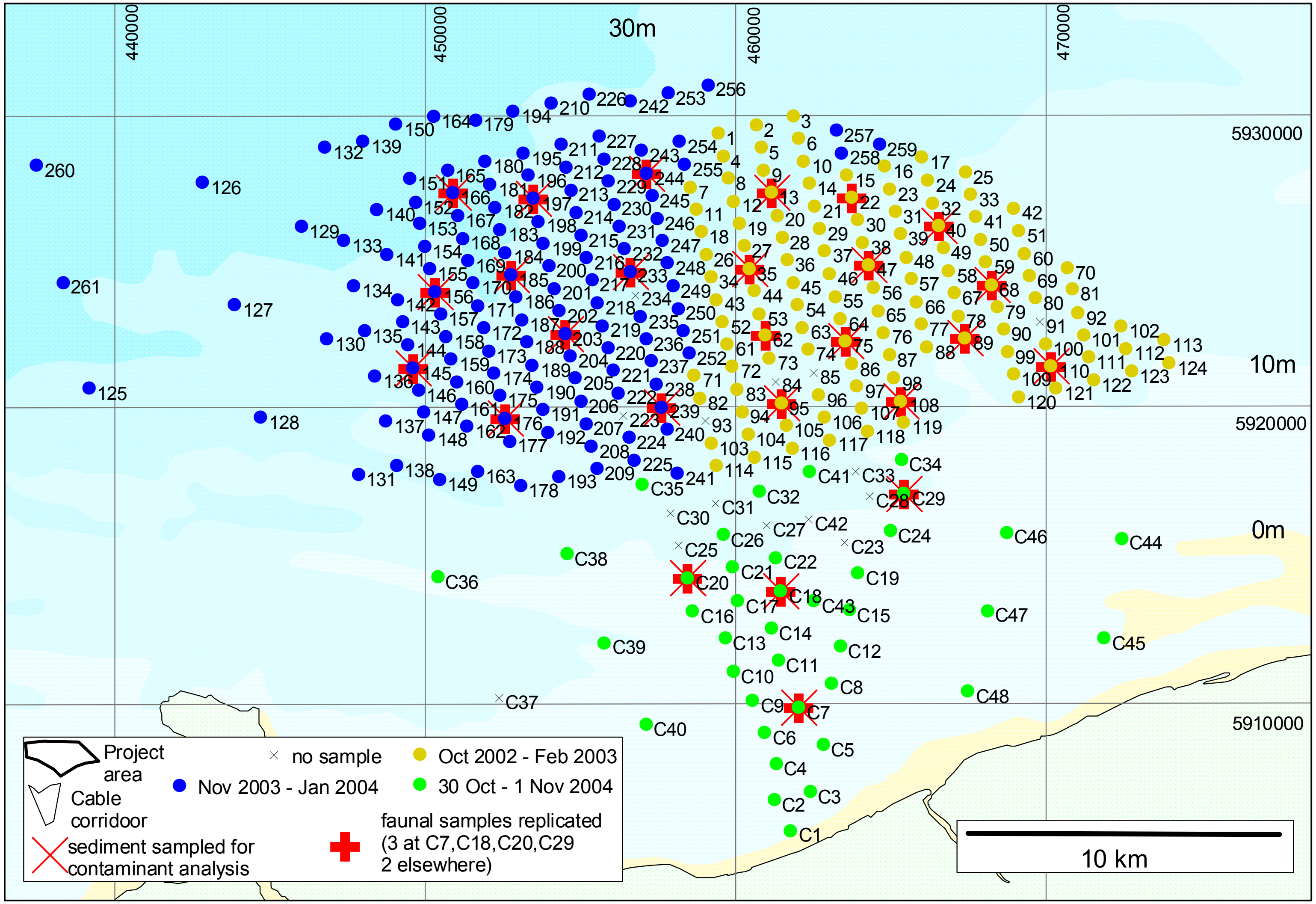


Figure 3.3.2 Locations of grab sampling sites for faunal analysis and sediment contamination (October 2002 to November 2004). Single faunal replicate samples were taken at each site except where duplicate or triplicate samples are indicated or where no sample could be obtained.

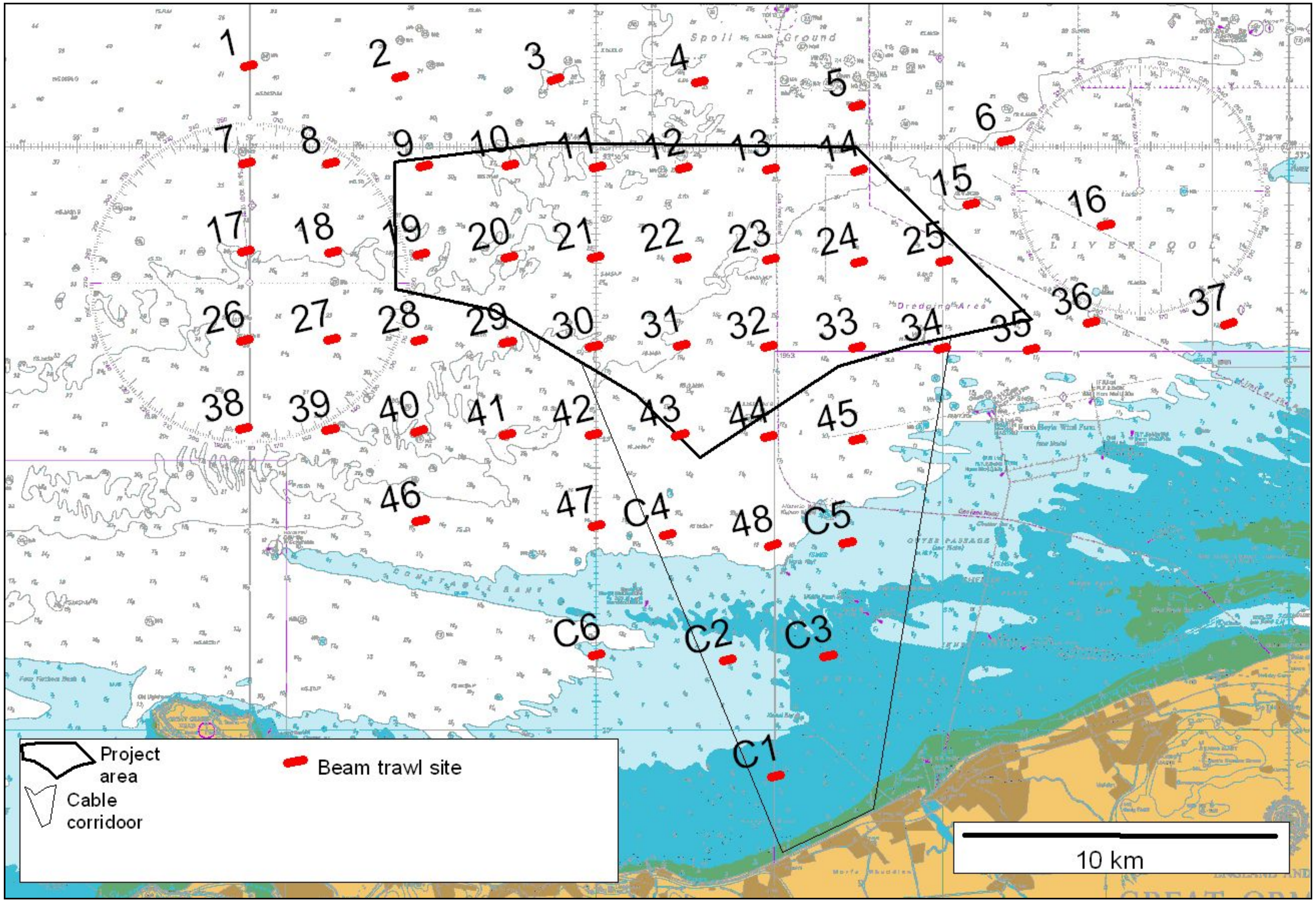


Figure 3.3.3: Location of beam trawl sites. Sites 1-48 surveyed in December 2003, March 2004 and August 2004; C1-C6 surveyed August 2004 only.

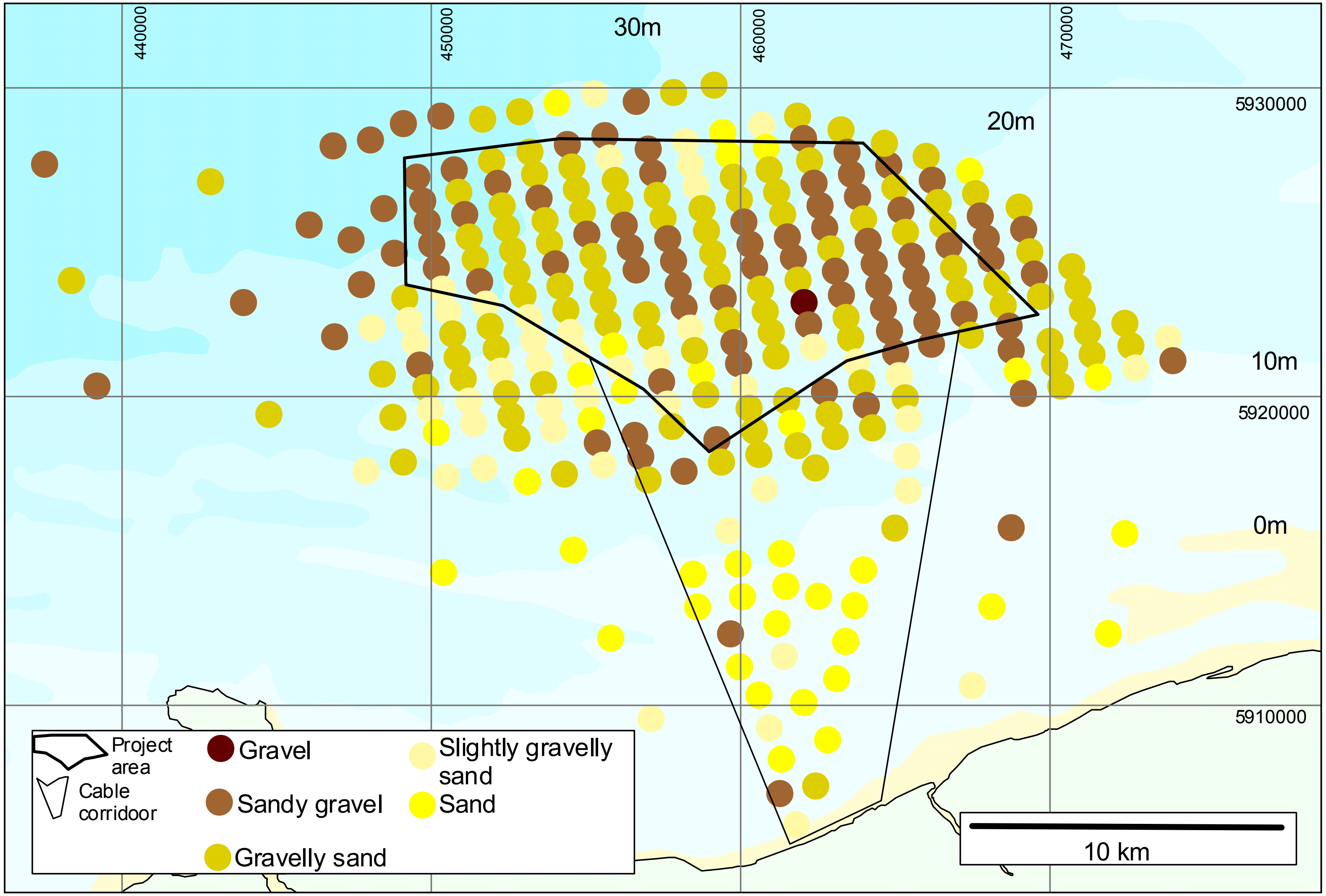


Figure 3.3.4: Distribution of sediment type classified according to Folk (1954) as used by the British Geological Society.

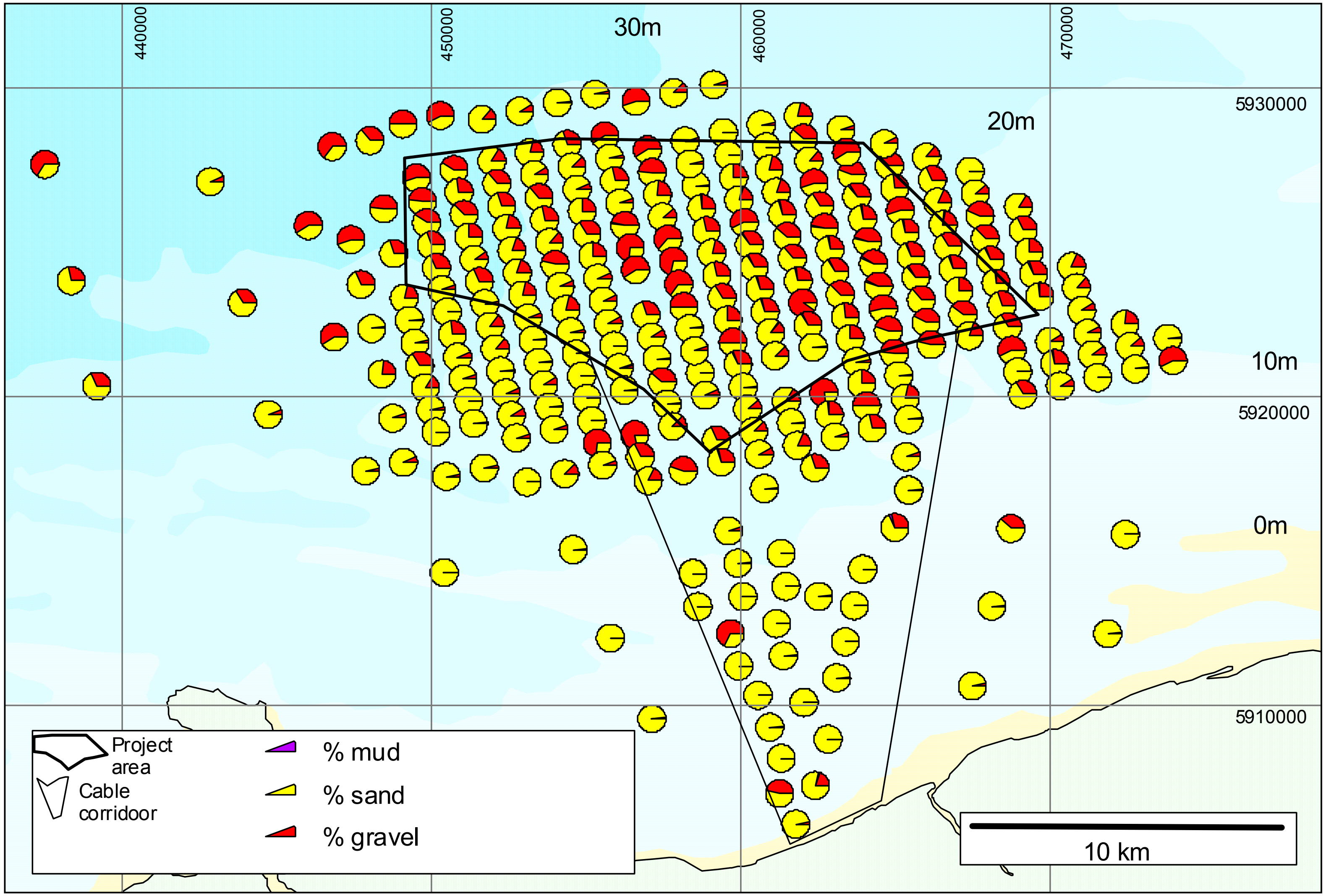


Figure 3.3.5 Percentage of sand, gravel and mud found in the sediment samples after particle size analysis.

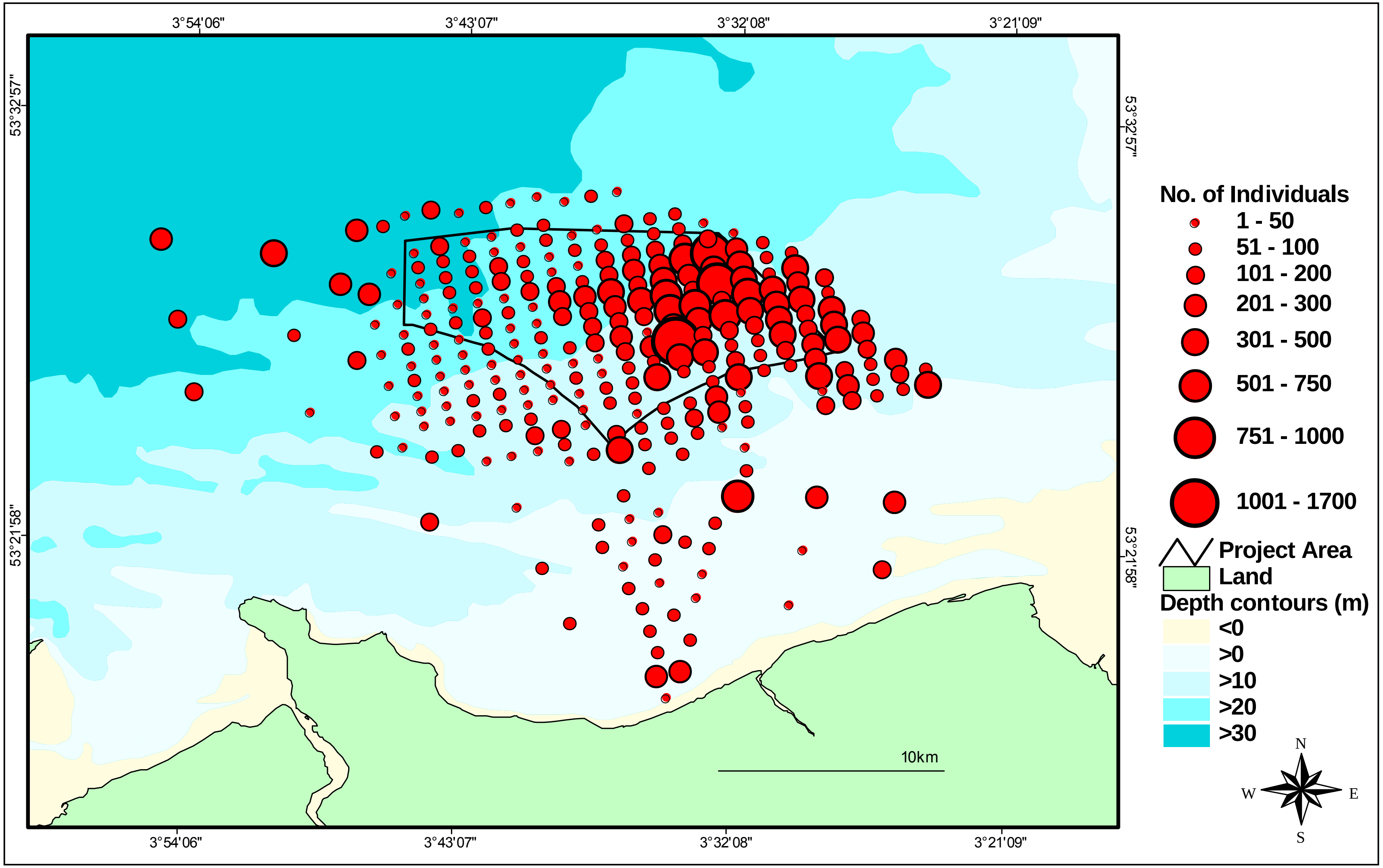


Figure 3.3.6: Number of individuals found in grab samples from the characterisation surveys 2002-2004.

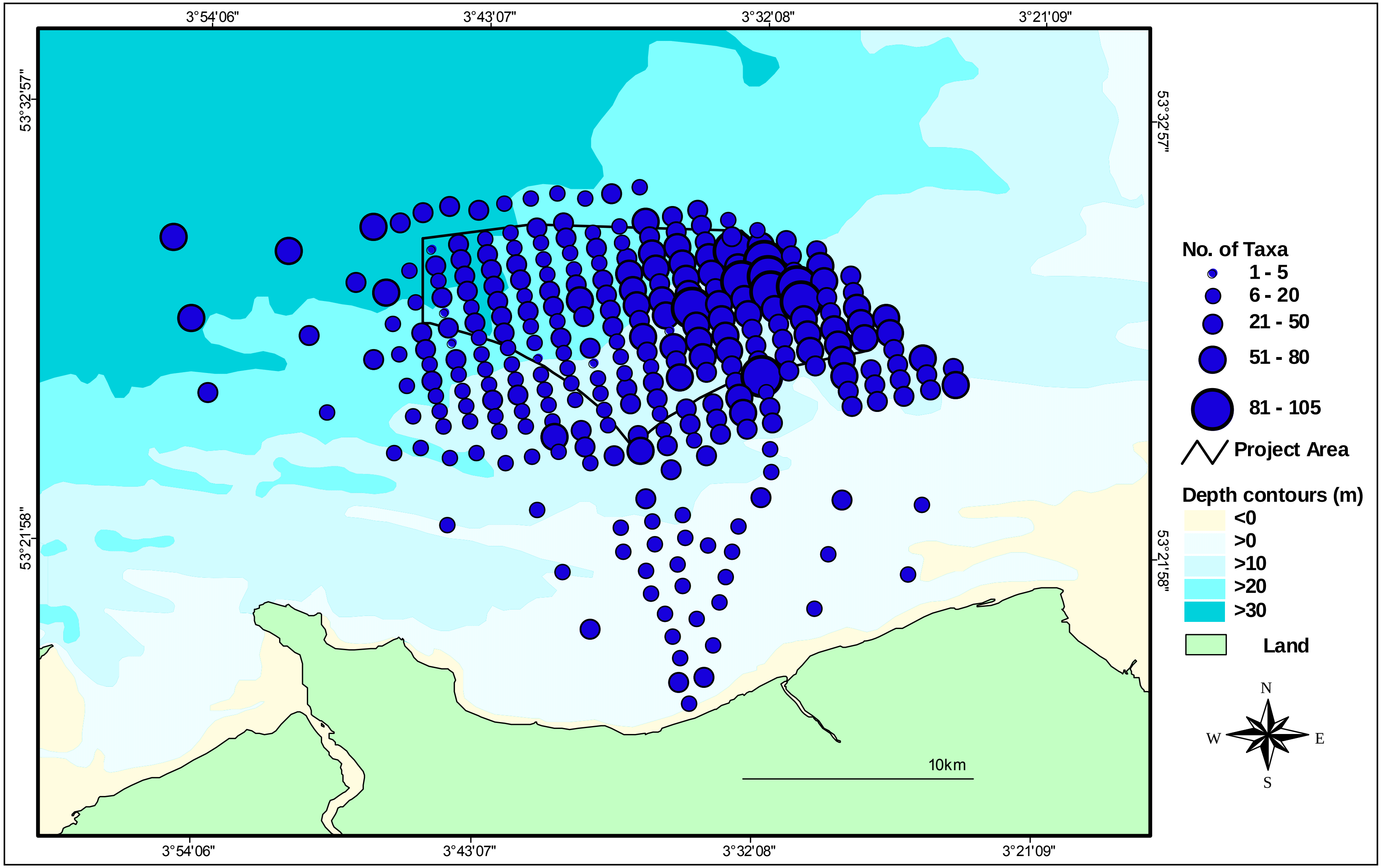


Figure 3.3.7: Number of taxa found in grab samples from the characterisation surveys 2002-2004.

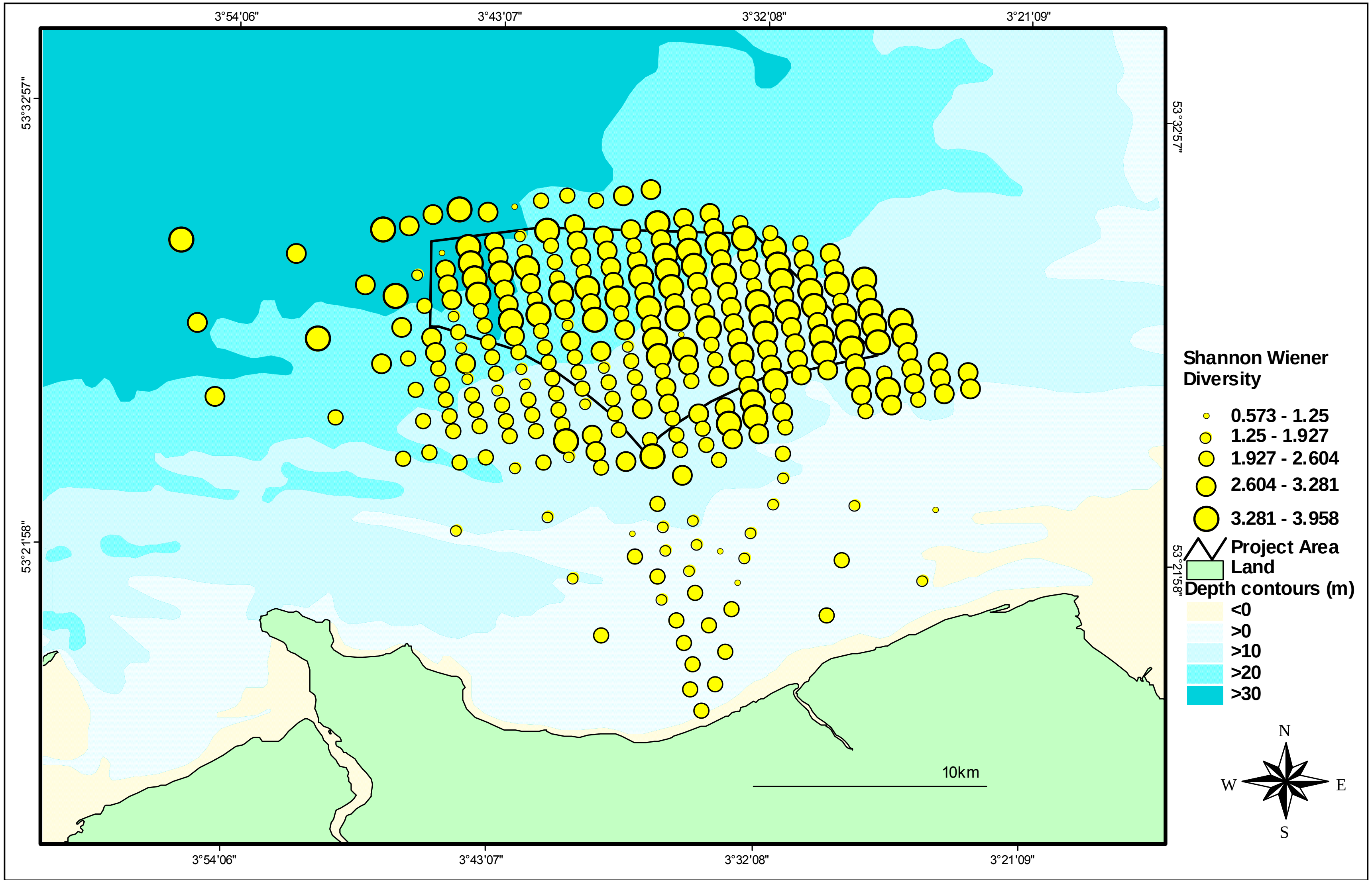


Figure 3.3.8: Biological diversity for each grab site according to the Shannon Wiener diversity index.

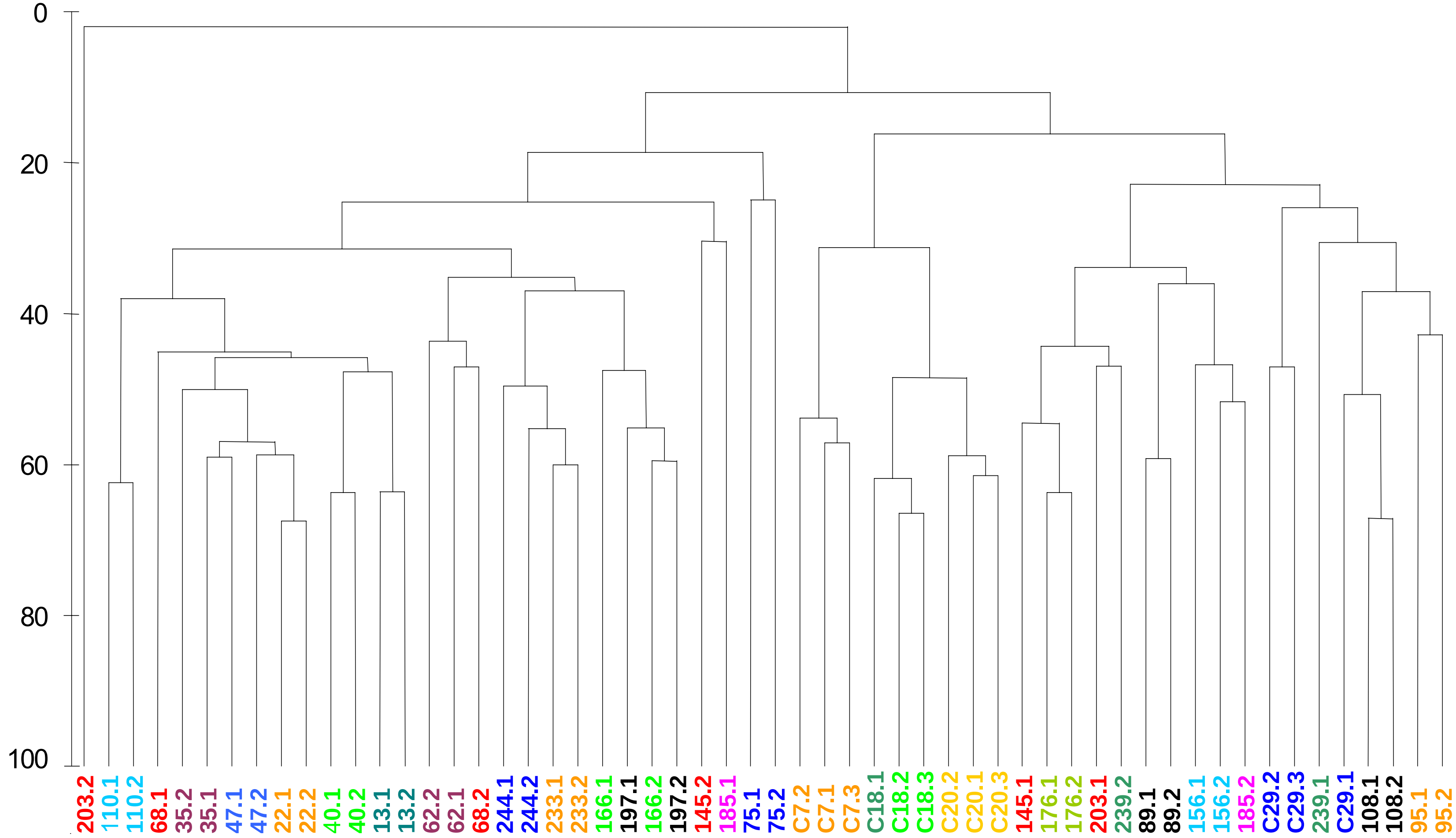


Figure 3.3.9: Dendrogram to show the relationships between the benthic fauna of each replicate grab sample. Replicates from the same site have been given the same colour (but note that it has been necessary to use each colour more than once).

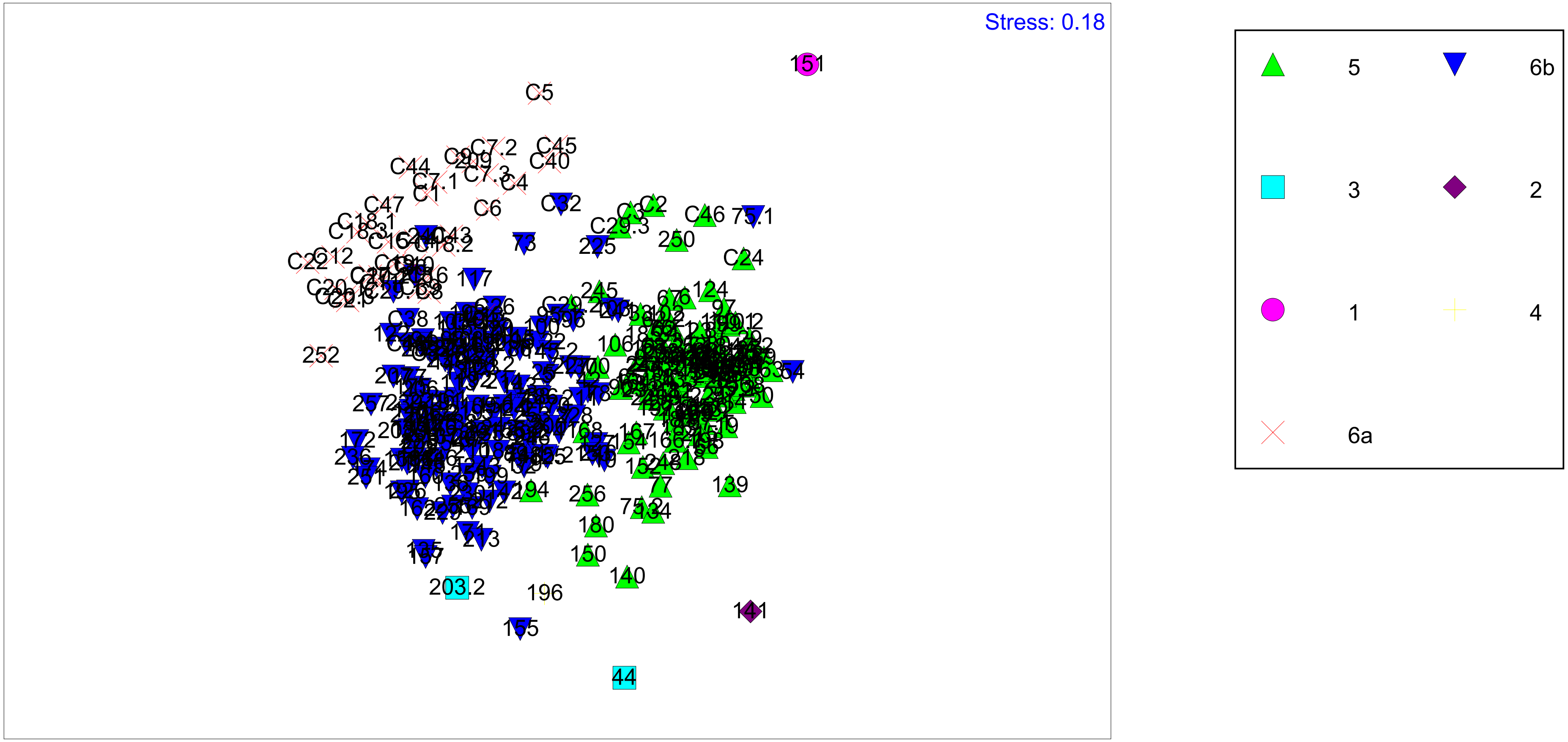


Figure 3.3.10: Multi dimensional scaling plot from the previous figure with seven initial community groupings superimposed. These provisional groupings were produced from a dendrogram based on the same similarity analysis as the MDS plot. Groupings were produced using a cutoff based on the 20% similarity level**.**

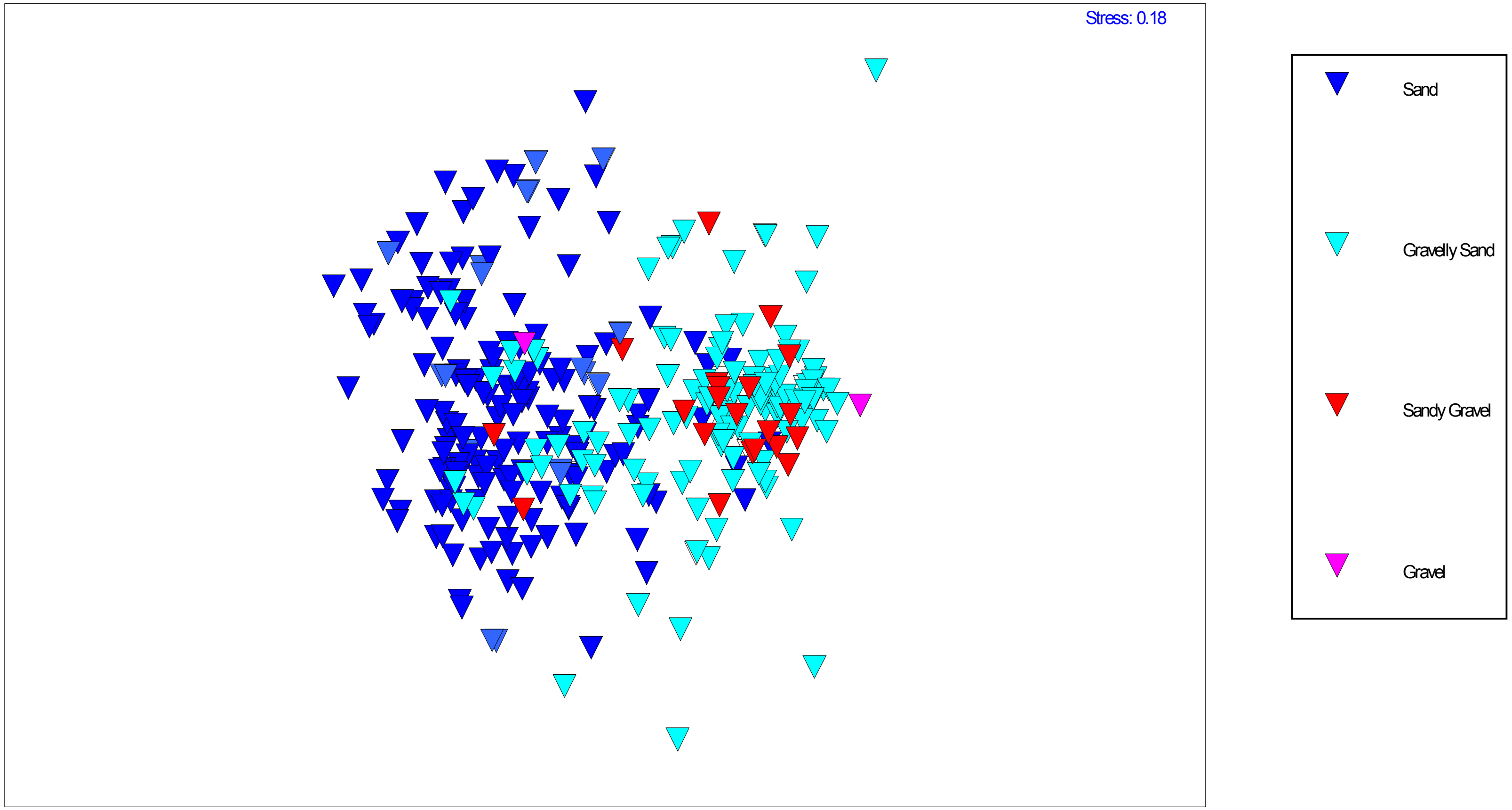


Figure 3.3.11: Multi dimensional scaling plot from the previous figures with sediment classification according to JNCC (unpublished) superimposed.

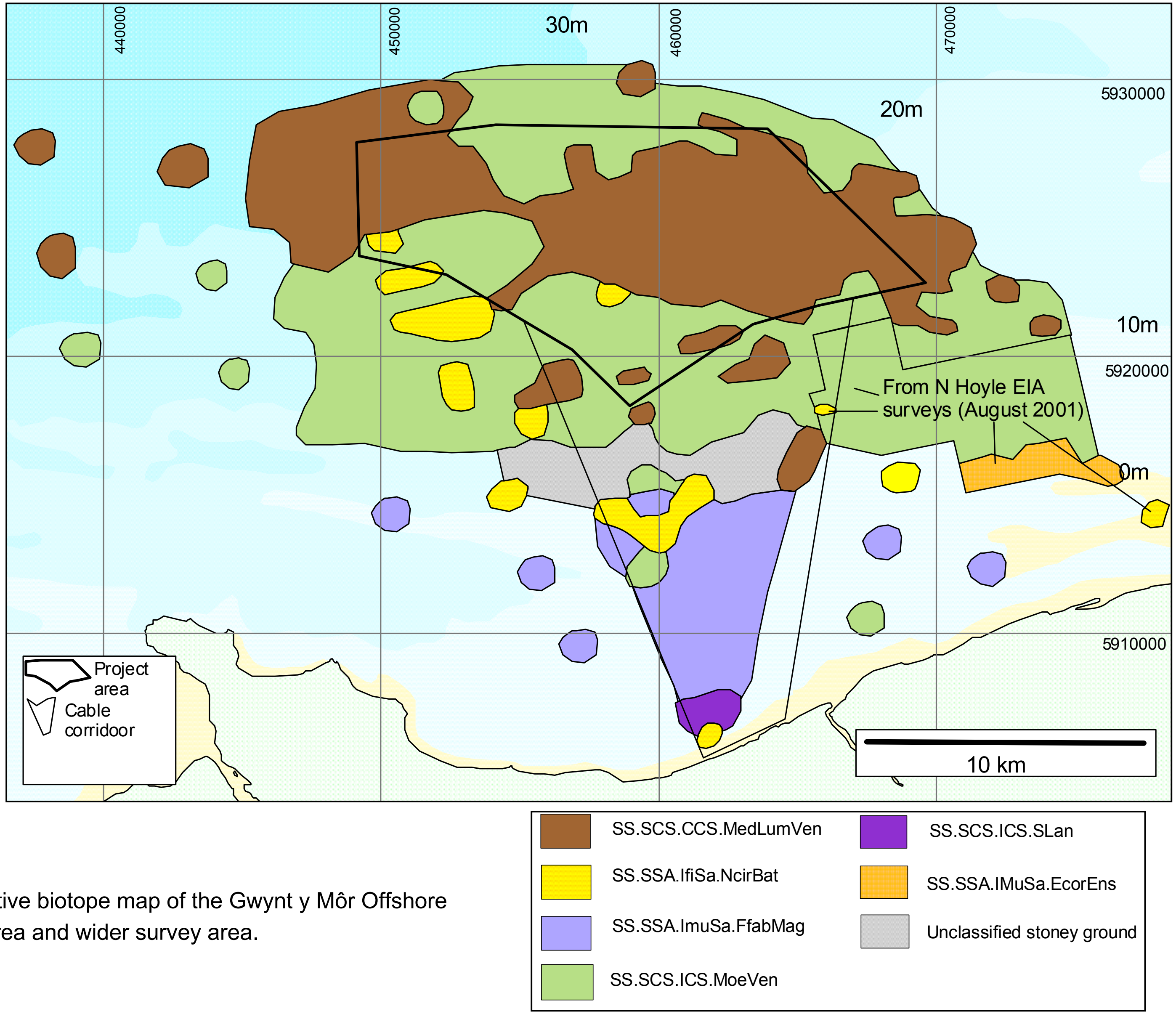


Figure 3.3.12: Indicative biotope map of the Gwynt y Môr Offshore Wind Farm project area and wider survey area.

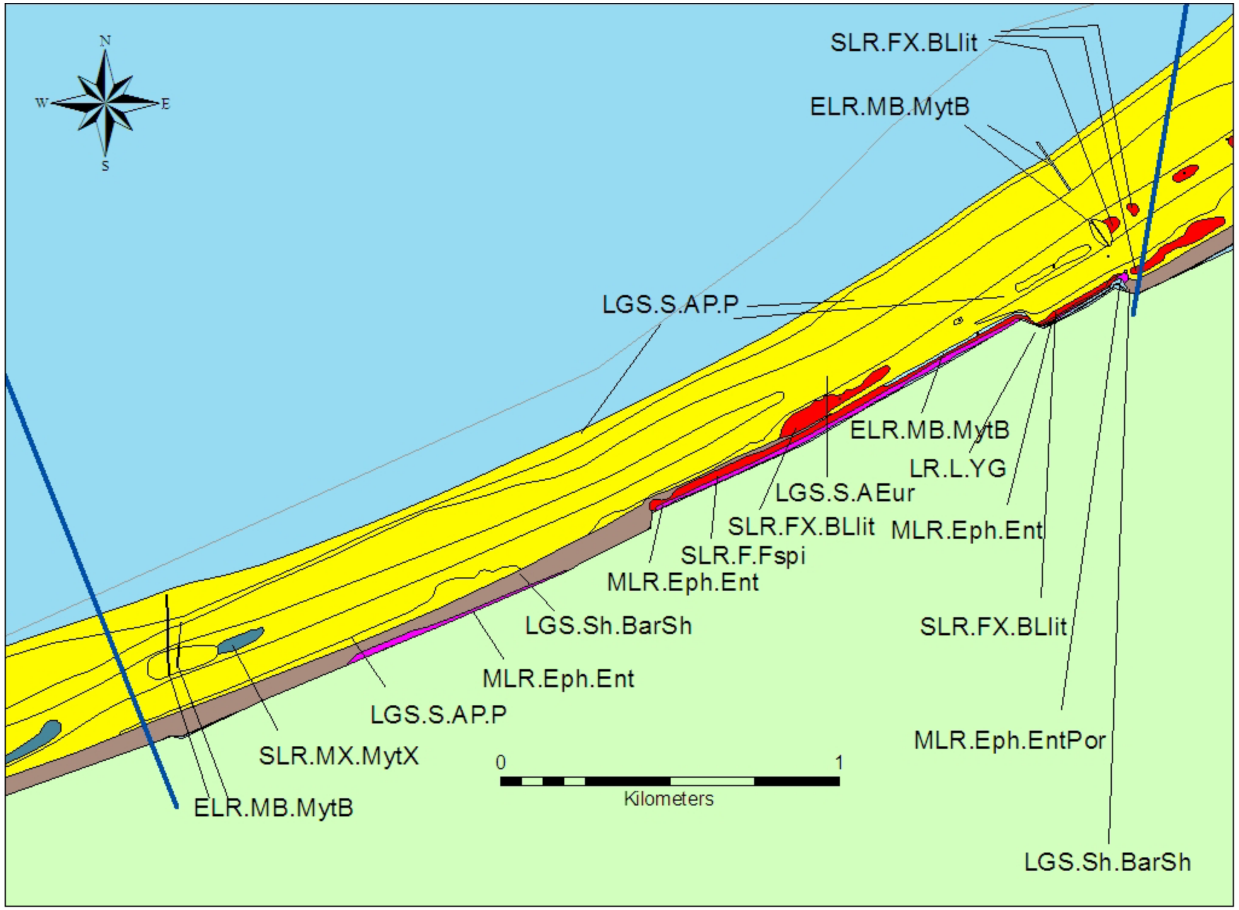


Diagram reproduced using data from CCW Phase I intertidal mapping (© **Crown copyright. All rights reserved. Countryside Council for Wales, 100018813** [2003].)

Figure 3.3.13: Overview of the main intertidal biotopes found at the cable corridor interface (see Table 3.3.4 for biotope definitions).

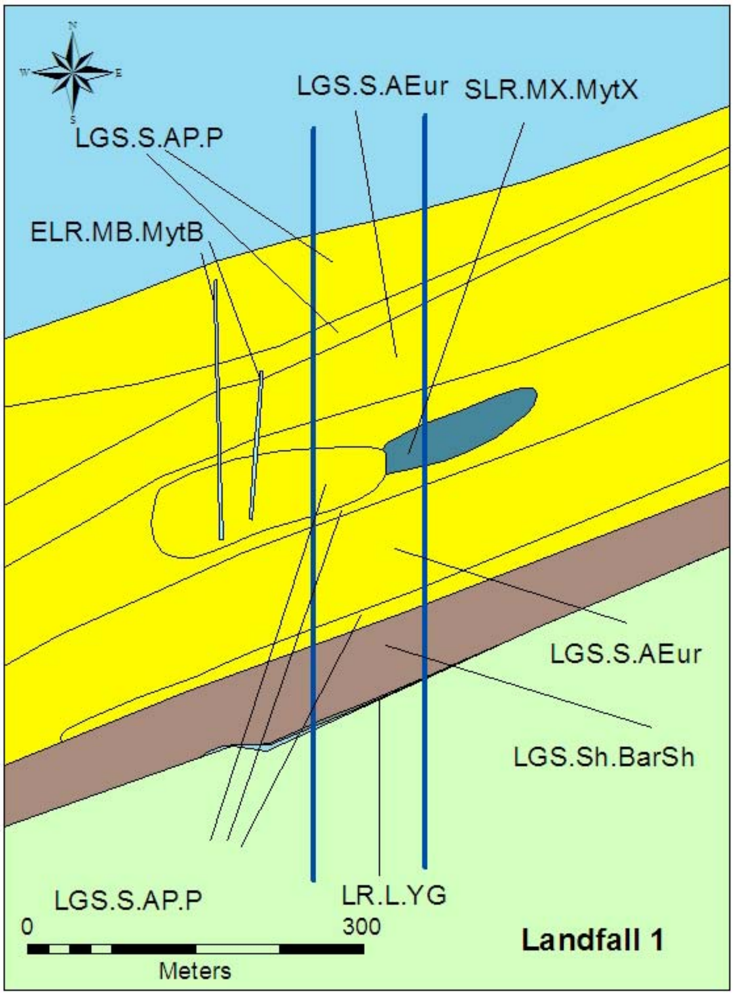


Diagram reproduced using data from CCW Phase I intertidal mapping ()

Figure 3.3.14 Main biotopes contained within the area for Landfall Option 1 – Pensarn Gap

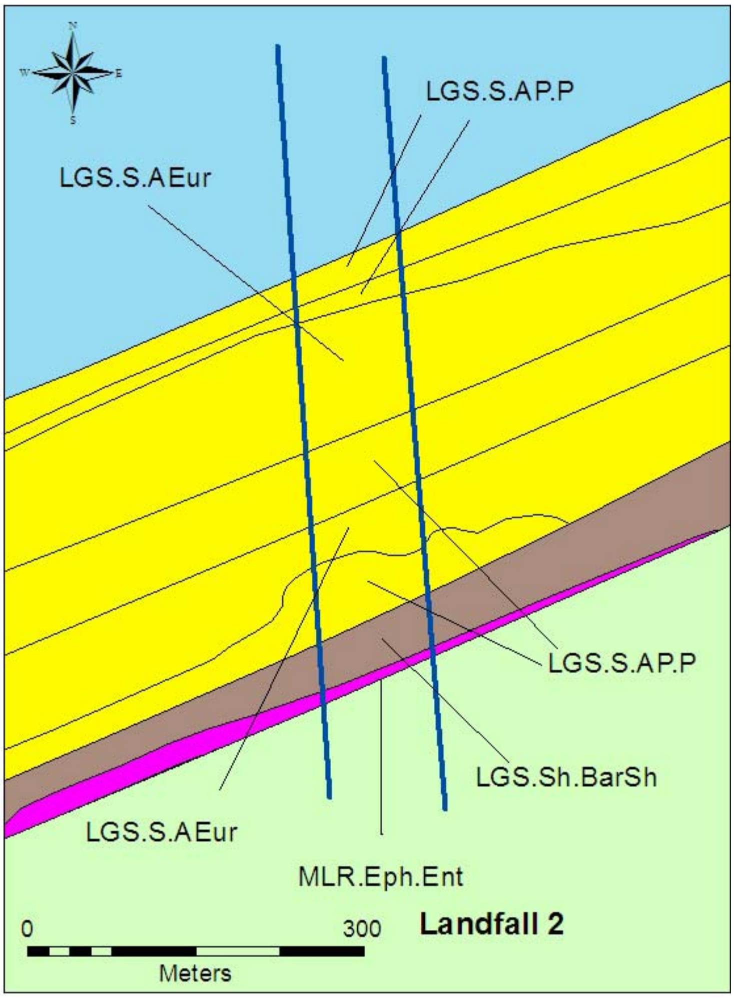


Diagram reproduced using data from CCW Phase I intertidal mapping ()

Figure 3.3.15: Main biotopes contained within the area for Landfall Option 2 - Belgrano

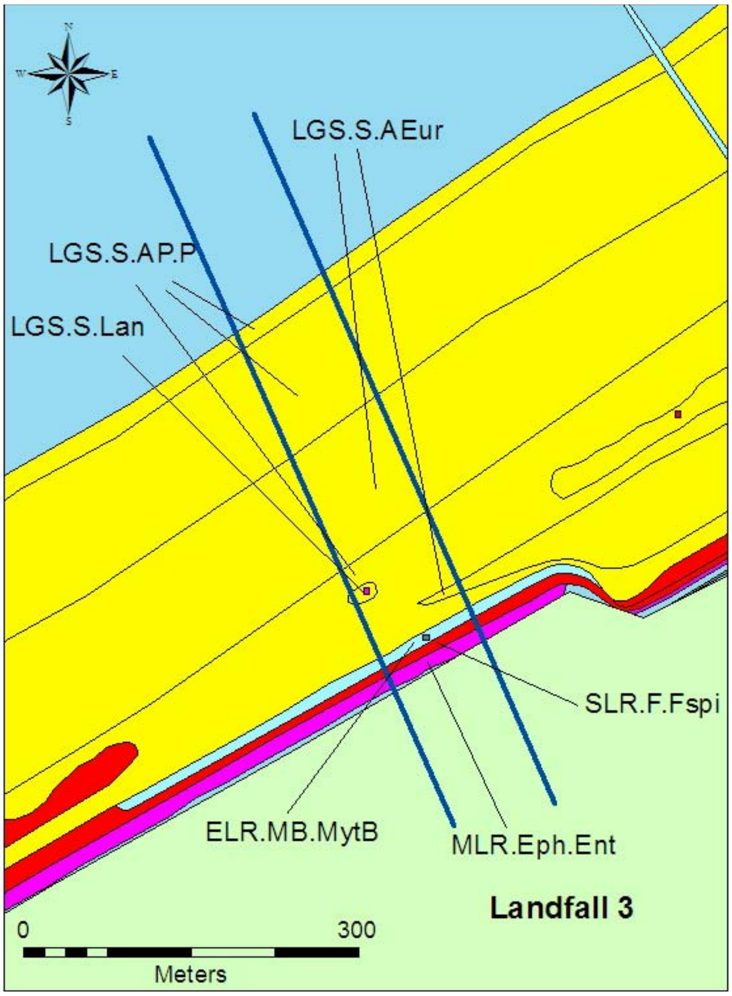


Figure 3.3.16: Main biotopes contained within the area for Landfall Option 3 – Towyn East

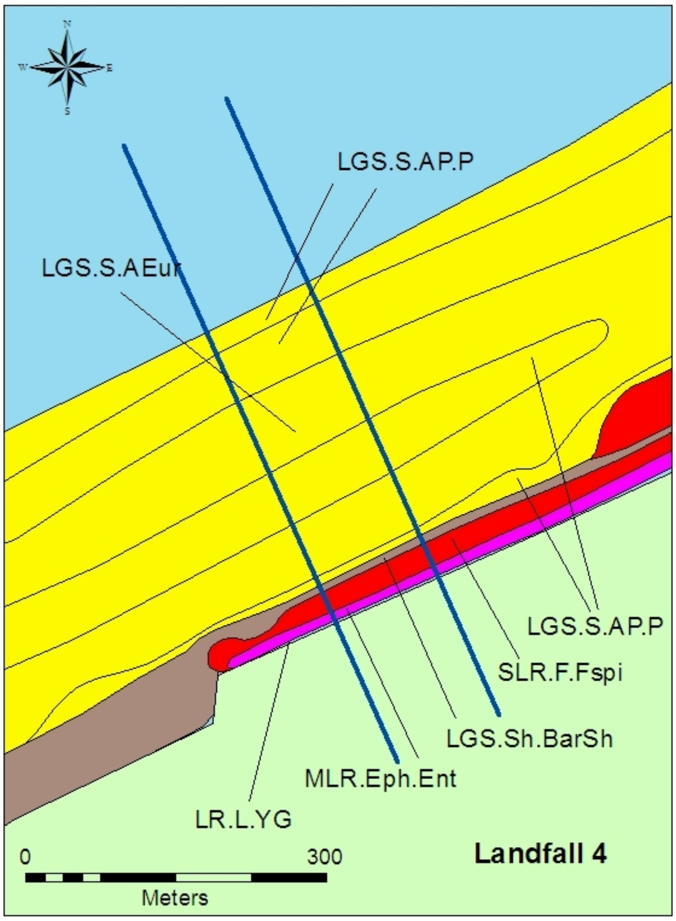


Diagram reproduced using data from CCW Phase I intertidal mapping (**© Crown copyright. All rights reserved. Countryside Council for Wales, 100018813** [2003].)

Figure 3.3.17: Main biotopes contained within the area for Landfall Option 4 – Towyn West.

Table 3.3.1: Wentworth Scale Classification used for defining sediment type (from Buchanan, 1984)

Wentworth Scale (mm)	Phi units	Sediment types
>256 mm	<-8	Boulders
64 - 256 mm	-8 to -6	Cobble
4 - 64 mm	-6 to -2	Pebble
2 - 4 mm	-2 to -1	Granule
1 - 2 mm	-1 to -0	Very coarse sand
0.5 - 1 mm	0 - 1	Coarse sand
250 - 500 µm	1 - 2	Medium sand
125 - 250 µm	2 - 3	Fine sand
63 - 125 µm	3 - 4	Very fine sand
<63 µm	>4	Silt

Table 3.3.2: Classification used defining degree of sediment sorting (from Buchanan, 1984)

Standard Deviation of mean Phi	Classification
<0.35	Very well sorted
0.35 - 0.5	Well sorted
0.5 - 0.71	Moderately well sorted
0.71 - 1	Moderately sorted
1 - 2	Poorly sorted
2 - 4	Very poorly sorted
>4	Extremely poorly sorted

Table 3.3.3: A summary of the main biotopes and communities identified from the characterisation surveys, including descriptive notes and the sites where these biotopes were identified (see Figure 3.3.9 for a map of these biotopes).

Biotope code and name	Notes
SS.SSA.IfiSa.NcirBat *Nepthtys cirrosa* and *Bathyporeia* spp. in infralittoral sand **Sites**: 155, 157, 159, 171, 173, 174, 184, 189, 209, 251, C1, C17, C20, C22	This biotope is quite species poor in places, and so occasionally resembles the relatively barren biotope "Infralittoral mobile clean sand with sparse fauna" (ImoSa) (these two biotopes are considered by Connor *et al.,* 2004, to grade into each other), but overall there is probably sufficient fauna to justify retaining them within NcirBat. There are no extensive areas of this biotope which appears to be limited to patches of moderately- to very-well sorted medium sands, probably representing the more mobile sands in the area. Characteristic species such as the predatory polychaete *Nephtys cirrosa* and burrowing amphipods, including *Bathyporeia guillamsonia* and *B. elegans*, are well represented, along with a variety of less abundant species. Not surprisingly, elements of surrounding biotopes are occasional represented (e.g. *Moerella pygmaea* from "MoeVen" and *Magelona johnstoni* from "FfabMag") but overall the community fits quite well with the biotope description provided by Connor *et al* (2004).
SS.SSA.ImuSa.FfabMag *Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand **Sites**: C4, C5, C6, C7, C8, C9, C10, C11, C12, C14, C15, C16, C18, C19, C21, C36, C39, C40, C43, C44, C45, C47,	This biotope contains most of the characteristic species of the NcirBat biotope but the sediment is less disturbed and the fauna consequently somewhat richer, with large numbers of polychaete worms such as *Magelona johnstoni* (usually considered part of the *M. mirabilils* group), as well as moderate numbers of the bivalve *Fabulina fabula*. In these examples the venerid component appears to be almost absent, but this nevertheless appears to be the most appropriate biotope. The area seems to be less muddy than some examples of the FfabMag biotope, and possibly for this reason, is not particularly rich. The bivalve *Donax vittatus*, frequently found in shallow sands, was very abundant at a single site (C44) in the south east of the surveyed area. This species is particularly variable in numbers from year to year and appears not to be closely associated with any particular biotope. The polychaete worm *Lagis koreni*, considered an important food item for many flatfish, was similarly very abundant only at site C45 located in the south east.
SS.SSA.IMuSa.EcorEns *Echinocardium cordatum* and *Ensis spp.* in lower shore and shallow sublittoral slightly muddy fine sand Sites: None from Gwynt y Môr characterisation surveys. This biotope mapped from	This community was mapped in 2001 during baseline surveys in support of the EIA for the North Hoyle Offshore Wind Farm. A single grab site (C44) surveyed in this area during the present work had many of the characteristic species although it arguably had a greater similarity to the FfabMag biotope, (with which this EcorEns shares a great many species), since there were no *Echinocardium.* However, the 2001 surveys were based on a much greater amount of information from grabs, trawls and anchor dredges, so the area is still considered to be EcorEns.

Biotope code and name	Notes
an area surveyed during development of the North Hoyle Offshore Wind Farm	
SS.SCS.CCS.MedLumVen *Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel **Sites**: 6, 8, 9, 11, 12, 13, 14, 15, 16, 18, 19, 20, 21, 22, 23, 26, 27, 28, 29, 30, 31, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 52, 53, 54, 55, 56, 57, 58, 59, 60, 62, 63, 64, 65, 66, 67, 68, 69, 70, 75, 76, 77, 79, 80, 81, 87, 90, 97, 99, 102, 106, 107, 110, 114, 124, 126, 129, 132, 133, 134, 139, 140, 141, 150, 151, 152, 153, 154, 164, 165, 166, 167, 168, 180, 181, 182, 183, 194, 196, 197, 198, 203, 208, 215, 218, 224, 231, 232, 233, 244, 245, 246, 247, 248, 249, 250, 256, 258, 260, 261, C24, C29, C46	This is a polychaete dominated community, often moderately rich in taxa and individuals, characterised by *Mediomastus fragilis* and *Lumbrineris* spp (in this case mainly *L gracilis*). Numerous other polychaetes typical of this biotope were found, including *Spiophanes bombyx*, *Protodorvillea kefersteini*, *Owenia fusiformis*, and *Poecilochaetus serpens,* as well as the urchin *Echinocyamus pusillus,* and the brittle star *Amphipholis squamata. V*enerid and other robust bivalves occur, especially *Moerella* spp, *Thracia* spp and *Dosinia* spp, with smaller numbers of *Timoclea ovata*. A number of other typical bivalves such as *Abra alba*, and the extremely small species *Mysella bidentata* are fairly widespread. Connor *et al* (2004) point out that venerid bivalves, which are often quite large, are frequently under-recorded by grab surveys. They also point out that on more gravelly examples of this biotope epifauna are common. This is the case here, particularly in central areas of the study area, and notable epifauna include encrusting tubeworms, particularly *Pomatoceros triqueter*, dead man's fingers *Alcyonium digitatum*, and anemones such as *Cerianthus lloydii* and *Metridium senile*. The community appears to be a good match with this biotope. This biotope is considered by Connor *et al* (2004) to be a deep water variant of the MoeVen biotope which is also common within the Gwynt y Môr project area.
Unclassified stoney ground Similar to SS.SCS.CCS.MedLumVen and SS.SCS.ICS.MoeVen but very stoney. **Sites;** None successfully sampled	This area consisted of a mixture of sands and gravels with a particularly high stone content so that successful grabbing was impossible. Evidence from the OSIRIS seabed survey, as well as visual observations from stones and small amounts of sand/gravel trapped in the jaws of the grab during grabbing attempts, suggest the overall community is likely to be broadly similar to the stoniest areas of the MedLumVen biotopes located to the north. Beam trawl sites C4, C5, & 47 were found within this area and the catches from them support this possibility to some degree, 47 and C4 showing catches fairly high in hard ground epifauna such as *Alcyonium digitatum*, *Metridium senile* and bushy hydroids and bryozoa, though noticeably low in *Psammechinus miliaris* which seems to be restricted to sites further offshore. Beam trawl C5 appears to have less coarse ground, however, with numerous flatfish species, sand gobies etc but much less hard ground epifauna. The seabed survey had incomplete coverage in this area, but results suggest that much of the area consists of medium sands and gravels with frequent streaks of coarser material. Thus it is likely that there are frequent less coarse areas, perhaps with fauna more similar to the MoeVen biotope (see below). The difficulty in grabbing despite numerous attempts would suggest that

Biotope code and name	Notes
	overall the amount of coarse material is high, however.
SS.SCS.ICS.MoeVen *Moerella* spp. with venerid bivalves in infralittoral gravelly sand **Sites**: 1, 2, 3, 4, 5, 7, 10, 17, 24, 25, 32, 51, 61, 71, 72, 73, 74, 78, 82, 83, 86, 88, 89, 92, 94, 95, 96, 98, 100, 101, 103, 104, 105, 108, 109, 111, 112, 113, 115, 116, 117, 118, 119, 120, 121, 122, 123, 125, 127, 128, 130, 131, 135, 136, 137, 138, 142, 143, 144, 145, 146, 147, 148, 149, 156, 158, 160, 161, 162, 163, 169, 170, 172, 175, 176, 177, 178, 179, 185, 186, 187, 188, 190, 191, 192, 193, 195, 199, 200, 201, 202, 204, 205, 206, 207, 210, 211, 212, 213, 214, 216, 217, 219, 220, 221, 222, 225, 226, 227, 228, 229, 230, 235, 236, 237, 238, 239, 240, 241, 242, 243, 252, 253, 254, 255, 257, 259, C13, C26, C32, C34, C35, C41, C48, Plus areas surveyed in August 2001 during N Hoyle wind farm EIA	This biotope is characterised by shallow water venerid bivalves such as *Moerella* spp, *Dosinia* spp and others which were commonly found in this survey. The polychaete *Glycera lapidum* is also normally characteristic but more or less absent here, but other typical groups such as spionid and nephtyd worms and amphipods were frequent, and overall there is a good match with the biotope description. MoeVen is considered by Connor *et al* (2004) to be the shallow water variant of the MedLumVen biotope. Previous versions of the biotope classification included this community as part of the IGS.Sell biotope that, in the most recent version of biotope descriptions, is no longer recognised. IGS.Sell has now been split into this MoeVen biotope plus SS.SSA.ImuSa.SsubNhom (characterised by *Spisula substruncata* and *Nephtys hombergi,* and generally occurring on muddier sediments than MoeVen). Large areas identified as IGS.Sell at the North Hoyle Offshore Wind Farm appear to match the MoeVen biotope rather than SsubNhom. These areas also share some similarity with the MedLumVen biotope, mainly due to quite high densities of *Mediomastus fragilis*, but nevertheless appear best to match MoeVen and have been mapped as such here, with the exception of sites located on the North Hoyle cable route which have been updated using the information from the 2004 surveys.
SS.SCS.ICS.SLan: Dense *Lanice conchilega* and other polychaetes in tide-swept infralittoral sand and mixed gravely sand **Sites**: C2, C3	This area is defined on the basis of only two single replicate grab sites, one of which contained *L conchilega* at the equivalent of over 200/m^2, while the other had a single specimen. Both sites had a high proportion of pebbles as well as some silt. The fauna was rich in numbers of individuals, though less so in terms of numbers of taxa, and was dominated by other polychaetes, especially *Owenia fusiformis* and *Anaitides mucosa*. *Lagis koreni*, an important food item for flatfish, was quite abundant. The community appears only to be a reasonable match for the biotope community given by Connor *et al* (2004), but the latter do acknowledge that the infauna associated with this biotope is likely to be highly variable.

Table 3.3.4: A description of the intertidal biotope classifications found within the Gwynt y Môr proposed cable landfall corridor.

Biotope	Description
LGS.Aeur	Mobile coarse sand shores with burrowing amphipods and *Eurydice pulchra*
LGS.S.App	Mid shore clean sand with burrowing amphipods, *Nephtys cirrosa* and *Arenicola marina*.
SLR.Mx.Mytx	Eulittoral mixed substrata with *Mytilus edulis* beds
LGSSH.BarSh	Barren shingle with no apparent fauna
LR.L.YG	Yellow and grey lichens on supralittoral rock
MLR.Eph.Ent	Hard substratum with *Enteromorpha sp*
LGS.S.Lan	Dense *Lanice conchilega* on lower shore sand
ELR.MB.MytB	*Mytilus edulis* and barnacles on very exposed eulittoral rock
SLR.F.Fspi	*Fucus spiralis* on moderately exposed to very sheltered upper eulittoral rock

3.4 Fish & Shellfish Environmental Background

Information regarding the fish species, spawning and nursery grounds and the commercial fish and shellfish stocks of Liverpool Bay and the eastern Irish Sea have been collated by Coastal Fisheries Conservation and Management (CFCM) and detailed within this section. In addition, information regarding fish species recorded at the Gwynt y Môr project area obtained as part of the benthic characterisation surveys have also been discussed. Rare and protected fish species have been described separately within section 3.6: Nature conservation, and are only briefly discussed within this section with regard to the commercial implications for these species.

3.4.1 Regional Review of the Fish & Shellfish Fauna of Liverpool Bay

Since the early 1970s, the government fishery laboratory at Lowestoft (CEFAS) has maintained a series of trawl surveys in Liverpool Bay. Originally the surveys were restricted to an area along the North Wales coast between Anglesey and the Dee Estuary; they were undertaken with two locally-based trawlers using modified commercial otter trawls (see, for example, Innogy, 2002). Since 1992, however, the surveys have covered the greater part of the Irish Sea (Parker-Humpreys, 2004) and sampling has been carried out from the CEFAS research vessel *Corystes* towing a commercial-pattern 4m beam trawl fitted with a fine mesh cod-end liner (Ellis *et al.,* 2000; Parker-Humphreys, 2004). Analyses of these data have been published by Ellis *et al.,* (2000) and Parker-Humphreys (2004) but the data were also made available for the assessment presented here and subject to further analysis by Ellis & Parker-Humphreys (2004).

The survey is based on a fixed array of trawl stations (see Figure 3.4.1) that, weather permitting, are fished every September. At each station the catch is sorted and, whenever possible, the species of each fish and macro-benthic invertebrate (including commercial shellfish) is identified; the total number and combined weight of each species (or higher taxon) are recorded. As the gear is designed for demersal fish species, primarily flatfish, pelagic species are under- represented in the catches, as are the smallest of the non-commercial demersal species, e.g. gobies (*Pomatoschistus* spp.). Throughout the Irish Sea as a whole, more than 100 species of marine fish were recorded (Parker-Humphreys, 2004) but in Liverpool Bay the number of common species is less than 70 (see Table 3.4.1).

Marine Fish

The average annual catch in number (1992-03) from the CEFAS beam-trawl survey is shown by species in the right-hand half of Table 3.4.1. The average annual aggregated catch from stations across Liverpool Bay as a whole is ranked 1-65 by abundance (3929 dabs through to less than one blue whiting per year). Similarly, the average aggregated annual catch in number and the ranking by species is given for the six stations encircling the Gwynt y Môr Offshore Wind Farm project area (see Table 3.4.1) are given for comparison. In both series, over 95% of the total catch is accounted for by the top twenty species and, although the rankings differ between the two sets, it is only the sand (*Pomatoschistus minutus*) and common (*P. microps*) gobies (ranked 22 at the sites in proximity to the Gwynt y Môr project area) which fall outside the Liverpool Bay 'top 20'. Of the remaining species (approximately forty-five), all are relatively commonplace in UK coastal waters, although some are more usually associated with deeper, offshore waters (e.g. blue whiting, *Micromesistius poutassou,* and hake, *Merluccius merluccius*), while others are probably at or near the northern limits of their normal geographic distributions (e.g. red mullet, *Mullus surmeletus,* john dory, *Zeus faber* and the triggerfish, *Balistes carolinensis*).

The CEFAS data demonstrated that the greater part of the catch is contributed to by a relatively small number of species. These data also show that the fish are most abundant in depths less than 20-25 m. In their analysis of the trawl survey data, Ellis *et al* (2000) found a distinct difference in the depth distribution of fish populations in the Irish Sea. They identified a shallow-water 'plaice-dab' community which included Dover sole (*Solea solea*) in depths less than 20-25 m. They also found this community to be associated with fine, inshore sediments. Not all of the species that have high ranking in Table 3.4.1 are of commercial importance. For example, the most abundant species at the Gwynt y Môr project area was the common dragonet (*Callionymus lyra* – ranked 4 for Liverpool Bay as a whole) and solenettes (*Buglossidium luteum*) were ranked 2 in Liverpool Bay and 6 at sites in the vicinity of the Gwynt y Môr project area. The commercial and non-commercial species (i.e. fish for which there is not even a casual value on the fish markets) are separated in Table 3.4.2 but shown in the same grouping used to describe commercial species in section 3.4.4: Gadoids (cod family), Flatfish, Elasmobranchs (sharks, rays and dogfish), Other Demersal (bottom dwelling), Pelagic (mid-water shoaling fish), Crustacea and Mollusca. In addition to these species recorded in the CEFAS trawl surveys, there are also migratory species and fish of nature conservation interest that are described below in section 3.4.3 and 3.6 respectively.

The wider, geographic distributions of some typical species within the eastern Irish Sea and Liverpool Bay are shown in Figures 3.4.2 and 3.4.3; others can be found in Parker-Humphreys (2004). These data indicate the overall distributions of fish species across the area but not necessarily the distribution of fishing effort. (CORDAH, 2003, found that the greatest intensity of fishing effort was between the Isle of Man and Cumbria while the area off the North Wales coast, in Liverpool Bay supported the lowest intensity of fishing.) Although cod (*Gadus morhua*), for example, appear to be relatively abundant in Liverpool Bay, these fish were predominantly small, juvenile fish (Parker-Humphreys, 2004); the exploitation of mature fish is concentrated in the northern and north-western Irish Sea.

In contrast, the distribution of rays (*Raja* spp) shown in Figure 3.4.3 is indicative of the mature and immature rays distribution. Although these fish are caught in the CEFAS trawl survey, and landed in commercial catches, throughout the eastern Irish Sea, the only fishery that specifically targets rays is in Liverpool Bay off the North Wales coast (Lockwood, S., pers obs).

Although sea bass (*Dicentrarchus labrax*) were not caught with sufficient regularity in the CEFAS surveys to feature in Figure 3.4.2, they have an iconic status among recreational anglers and, to a lesser extent, among inshore commercial fishermen. In recent decades, they appear to have become increasingly abundant throughout Liverpool Bay where anglers pursue them with enthusiasm and there are small-scale seasonal net-fisheries from Conwy Bay around to Morecambe Bay and beyond.

The abundance of all these species, commercial and non-commercial, varies considerably year-to-year and place-to-place but all are relatively commonplace. Concern is expressed for the status of some commercial species, most notably the cod, but they are given specific consideration below (see section 3.4.4), as are migratory species (see section 3.4.3), and species of nature conservation interest (see section 3.6).

Shellfish

The CEFAS beam-trawl survey is not designed to sample commercial shellfish but each of the principal species for which there are fisheries in Liverpool Bay was recorded in the catches (Table 2): king scallop (*Pecten maximus*) and queen scallop (*Chlamys opercularis*), whelks (*Buccinum caudatum*), brown crab (*Cancer pagurus*), lobster (*Homarus gammarus*) and brown shrimp (*Crangon crangon*). Brown shrimps are most abundant in very shallow water, particularly adjacent to the major estuaries (Figure 3.4.4). Hence, there are commercial fisheries from the Dee to Morecambe Bay but virtually none along the North Wales coast. The relatively few brown crab and lobsters that were taken in the trawl survey were widespread and their total distribution probably embraces most of Liverpool Bay. However, commercial exploitation (potting) is concentrated around the Great Orme and Little Orme and off Anglesey (Figure 3.4.4).

Nephrops (*Nephrops norvegicus*) were not recorded in the trawl survey but they are an important shellfish resource to the north of Liverpool Bay, between the Isle of Man and the Cumbria coast (Figure 3.4.4). Occasionally, spider crabs (*Maia squinado*) are also recorded from commercial landings but they are more abundant off the west coast of Wales.

Commercially exploited cockle (*Cerastoderma edule*) stocks are found in all the major estuaries of Liverpool Bay (Figure 3.4.4) but they are not fished in the Mersey and only sporadically in the Dee. Mussel (*Mytilus edulis*) stocks are also widely distributed; the main exploited stock is in the Conwy Estuary (Figure 3.4.4) but there are also small beds in the Dee and Ribble Estuaries and there are extensive cultivated (farmed) mussel beds in the eastern part of the Menai Straits.

None of the commercial shellfish species that is found most frequently, and support specific fisheries is considered as being ‘rare’ or ‘endangered’ (see IUCN website, www.redlist.org/info/categories, for definitions), and none is subject to non-fishery management conservation measures.

3.4.2 Spawning and Nursery Areas

The vast majority of fish and shellfish spawn between late winter and early summer which enables the larvae to take advantage of the spring phytoplankton bloom, and allows the juveniles time to feed and grow to a size that enables them to survive the winter drop in prey abundance. A similarly high proportion of fish, including the overwhelming majority of commercially exploited fish, have pelagic, i.e. free-floating, eggs. In contrast, the herring (*Clupea harengus*), sandeels (Ammodytidae) and several of the non-commercial species, e.g. pogge (*Agonus cataphractus*), gobies (Gobiidae) and blennies (Blenniidae), deposit their eggs on the seabed where they remain until the larvae hatch. These demersal spawners are potentially more sensitive to offshore developments than are the pelagic spawners. The spawning distribution and season for some species listed in Tables 1 & 2 are shown in Figure 3.4.5, others may be found in Fox *et al* (1997).

Marine fish

Herring spawn off the east coast of the Isle of Man in August and September (Hillis & Grainger, 1990; Coull *et al.,* 1998; Figure 3.4.5), well away from the proposed Gwynt y Môr Offshore Wind Farm project area. Some commercial species spawn more or less ubiquitously throughout the eastern Irish Sea, including Liverpool Bay but others have more defined centres of spawning. A centre of plaice spawning, for example, is found (February-April) in the area between the Great Orme and the Isle of Man and a similar area for Dover sole is found (April-May) further to the east within Liverpool Bay itself. There is another centre of spawning in the outer Solway Firth (Figure 3.4.5; Riley *et al.,* 1986). Whiting (*Merlangius merlangus*, April-May) and dab (*Limanda limanda*, April-May) do not have such clearly defined spawning areas but cod spawning (March-April) is principally in the northern half of Liverpool Bay and flounders (*Platichthys flesus*) spawn (April-May) off all the major estuaries but most notably off the Dee and Solway Firth (Figure 3.4.5).

Many of the non-commercial species also spawn in the spring and release planktonic eggs but many of them have demersal eggs that they deposit within the area in which the adult population is found, few of these species undertake more than small-scale, seasonal, inshore-offshore migrations and probably maintain relatively discrete, locally-based populations rather than the Irish Sea-wide stocks of the larger species.

The elasmobranchs, rays and dogfish, are found throughout Liverpool Bay (Ellis & Parker-Humphreys, 2005); they differ from the finfish in that they have internal fertilisation. With the exception of spur dogs (*Squalus acanthias*) and tope (*Galeorhinus galeus*), both of which are ovo-viviparous, rays and dogfish lay a small number of eggs, each protected within its own horny egg-case, commonly known as a mermaid's purse. The eggs are deposited in spring, in shallow areas of rough ground where the tendrils at each corner of the egg case help anchor the egg to stones or weed to keep it *in situ*. Although elasmobranch spawning is widespread, not least for the lesser spotted dogfish, thornback ray (*Raja clavata*) are most likely to be found in proximity to the major river estuaries. Hence, the area of rough ground in the vicinity of the North Hoyle Offshore Wind Farm, off the Dee Estuary, is one area where thornback ray may congregate to spawn.

Planktonic fish eggs and larvae drift wherever the tides and winds take them. For the majority of species, however, the juvenile stage is spent in shallow coastal waters. Whiting and herring are found more or less throughout the coastal margin of Liverpool Bay (Figure 3.4.6) while the dogfish and rays remain in close proximity to the areas in which the eggs were laid, as do most small non-commercial species.

In contrast to other (commercial) finfish, the distribution of juvenile flatfish is fairly precise and predictable (Figure 3.4.6). Post-larval turbot (*Psetta maxima*) and brill (*Scophthalmus rhombus*), for example, settle in the surf zone of exposed shores with relatively coarse sand beaches, e.g. along the Sefton-Fylde coast. Plaice prefer less exposed environments with somewhat finer sands. Although the juveniles may be found from the surf zone to 10 m depth off any sandy shore in Liverpool Bay, they are most abundant along the north Wales coast (Rogers, 1993, 1994; Innogy, 2002) and in the outer Dee and Ribble Estuaries.

Juvenile sole also prefer a sheltered habitat but one that is most often associated with reduced salinity and a higher mud content (Rogers, 1993 & 1994); hence, they are more likely to be found in the vicinity of estuaries such as the Dee and Ribble in Liverpool Bay. Juvenile dabs tend to be less discriminating than other flatfish and although they are most likely to be found in similar areas to juvenile plaice they may also be found in greater depths of water throughout Liverpool Bay.

The principal, known, spawning grounds for bass are in the English Channel (Picket & Pawson, 1994) but there are statutory designated bass nurseries in the Conwy and Dee Estuaries in Liverpool Bay (MAFF, 1990; Defra, 1999) and another small area around the cooling water discharge pipe to Heysham nuclear power station in Morecambe Bay (Figure 8). It is reasonable to assume, therefore, that there is some bass spawning in Liverpool Bay despite the absence of bass eggs or larvae from the samples analysed by Fox *et al* (1997).

Shellfish

Bivalve molluscs such as cockles, mussels and scallops all have planktonic larvae but the principal settlement (spatfall) tends to be in close proximity to the parent population. Spawning for all these species is from late spring to mid summer. If for any reason the spat do not settle in close proximity to the areas occupied by the parent stock (Figure 3.4.4) there is likely to be poor recruitment with concomitant risks to the future well being of the stock.

Of the commercial mollusc species taken in the surveys (Table 3.4.2), the whelk does not have pelagic eggs but lays clumps of demersal egg cases from which miniature; bottom-dwelling whelks hatch and adopt a proto-adult lifestyle. This life history tends to limit the distribution of juveniles to areas very close to, but possibly shallower than, the adult stock.

Crustaceans differ from other shellfish species listed in Table 3.4.2 as they carry their fertilised eggs until they hatch. Egg-bearing shrimps undertake seasonal inshore-offshore migrations but the highest abundance of juveniles is found within sandy bays and major estuaries (see, for example, Neal, 2004). Lobster and crabs carry their eggs over winter and they hatch in spring or early summer (see, for example, Wilson, 2004). The larvae are widespread, as are juvenile brown crab (see, for example, Neal & Wilson, 2004) once they settle. Lobster, however, have very specific nursery habitat requirements, usually cobble scars over consolidated mud in which the juveniles burrow for the first 2-4 years of demersal life; no lobster nursery areas have yet been identified in Liverpool Bay. Although nephrops may occasionally occur in commercial catches in the northern parts of Liverpool Bay, it is not an area recognised as supporting a nephrops stock.

3.4.3 Migratory Species

The migratory species are diadromous fish, either they spawn in freshwater and feed at sea such as the anadromous salmon (*Salmo salar*) and sea trout (*Salmo trutta*), or feed in freshwater and spawn at sea such as the catadromous European eel (*Anguilla anguilla*). All three are found in virtually all the rivers draining into Liverpool Bay (Apprahamian & Apprahamian, 1999; Figure 3.4.5) and although the Mersey is not named in Figure 3.4.7, it supports an eel run and even the occasional salmon has been reported as testament to the gradual improvement in Mersey river-water quality.

Salmon

Atlantic salmon spend a year or more at sea feeding before returning to the specific river of their birth (natal river) to spawn between November and January in the river's headwaters (see, for example, Mills, 1989 or Maitland & Campbell, 1992 for reviews of salmon biology, behaviour and life histories). Once they have spawned the majority die but a few survive to spawn a second or even a third time (multi-sea-winter fish – MSW). Once hatched, the young fish (parr) spend 2-4 years in the river system before developing into smolts that swim downstream and migrate to sea between late April and early June.

The smolts leave the estuaries in cohorts but whether they remain in shoals or migrate individually to their feeding areas is not known, but it is known that they remain relatively close to the surface. During their first year, after leaving their natal river, it appears that the young salmon do not migrate any further than the west coast of Ireland but if they remain at sea for several years, they may migrate as far as the Faeroe Islands or Greenland.

Multi-sea-winter fish tend to arrive in coastal waters off their natal river in the late winter and enter the river system during the spring. These large fish are highly prized by anglers but are currently very scarce throughout Europe. Within the UK there is a policy that anglers must not retain these fish but return them to the river. In the late spring to early summer the smaller, single-sea-winter (SSW) fish return and move into the rivers.

The route by which they return through the Irish Sea in search of their natal river is not known but it is generally acknowledged that they swim along the coast seeking olfactory clues that help identify the correct river. Locally, on the North Wales coast, commercial fishermen take the view that the salmon approach from the west, through the Menai Strait, moving on the flood tide over the intertidal areas rather than further offshore. (This suggested pattern of behaviour is consistent with the traditional method of fishing on the NE coast of England and Scotland with salmon T-, J- and bag-nets. These are set at right angles to the beach from the intertidal zone – Galbraith et al., 2004.). Assuming that this pattern of migration is followed, it suggests that salmon seeking North Wales rivers are unlikely to make direct contact with a wind farm at Gwynt y Môr or even the inshore Round 1 site at Rhyl Flats.

Once the natal river is found, the initial entry is not always a smooth, continuous process. The process may involve the fish waiting off the estuary for a freshet of rainwater to bring stronger clues to them or they may enter and leave more than one estuary before identifying their natal river and moving on into the freshwater river system. Even after identifying the home river, some fish may remain within the tidal estuary for a prolonged period and then make a determined late run for the spawning grounds; others may take several weeks for the upstream migration.

Sea trout

The life cycle of the migratory sea trout is almost identical to that of salmon (see, for example, Maitland & Campbell, 1992, or Bagliniere & Maiss, 1998) but there are two significant differences. In contrast to the salmon, the majority of sea trout survive spawning and will return to their natal spawning river on numerous occasions during their life time. The other significant difference is that they do not appear to undertake the same sea migration but remain in coastal waters, probably close to their natal river. In addition, sea trout are more likely to enter an estuary and wait there in the pools for conditions to be right for the run up-river rather than remaining at sea off the estuary mouth as salmon tend to do. For all practical purposes, the early life history and emigration of sea trout smolts is the same as for salmon smolts.

European eels

Eels spawn in an area of the west-central Atlantic, east of the Caribbean known as the Sargasso Sea (see, for example, Maitland & Campbell, 1992, or Moriarty, 2000). The eggs and larvae (leptocephali) drift with the North Atlantic Drift and arrive in European coastal waters 2-4 years after spawning. Once in coastal waters, the leptocephali undergo metamorphosis to become elvers or ‘glass’ eels and these young fish enter the estuaries of most UK rivers. The main elver run occurs each spring and although the numbers may never be as great as are found in the Severn Estuary, it is reasonable to assume that elvers will run up all the rivers entering Liverpool Bay.

Eels spend many years in upper estuaries or freshwater where they feed and grow as ‘yellow eels’. When they are ready to return to the spawning grounds they move downstream and on re-entering an estuary in late summer to early autumn they undergo a process of pigment change to become ‘silver eels’ ready for the return sea migration. Once the eels are at sea it is assumed that they leave coastal waters relatively rapidly.

3.4.4 Commercial Fish and Shellfish stocks of Liverpool Bay

All fishing within Liverpool Bay is subject to EU regulations of the Common Fisheries Policy (CFP). Most commercially exploited species of fish are subject to TAC (total allowable catch) and quota management control with specific quotas being allocated to EU member states that are allowed to fish within a fishery management area – in this instance ICES Division VIIa, the Irish Sea. States that have quota to fish in the Irish Sea are: Belgium, France, Ireland, Netherlands and the UK. Within Liverpool Bay, Fishing vessels registered in Belgium or the Netherlands may only fish beyond the 12 mile limit of the UK Territorial Sea; vessels registered in France or Ireland have ‘historic rights’ to fish for demersal species between 6′ and 12′ from UK baselines.

Although the Isle of Man is not a member of the EU, nor a constituent part of the UK, it fishes against the UK quota. In common with all other UK registered fishing vessels, Isle of Man vessels can fish anywhere in Liverpool Bay (subject to the current vessel size-limitation byelaws of the North Western and North Wales Sea Fisheries Committee (NWNW SFC)).

The quantities of fish landed by EU member states fishing within the Irish Sea (ICES Division VIIa) are published each year but they are not broken down into statistical rectangles However, these data are available from Defra Fisheries Statistical Unit for UK registered fishing vessels fishing within Liverpool Bay; ICES Rectangles 35E6 and 36E6. Reported UK landings from these rectangles are used as the basis for assessing the relative importance of commercially exploited species in Liverpool Bay. With the exception of cockle and mussel stocks, however, both of which are assessed locally, the main fish-stock assessments are made by ICES for the Irish Sea (Division VIIa) as a whole or for even more extensive areas.

The quantity of fish landed at UK ports is recorded by port-based staff of the government fishery departments. Vessels over 10m in length are obliged to maintain up-to-date records of when and where they fish and how much of the catch is retained, by species. Vessels under 10m in length are neither required to keep records nor are they obliged to make any declaration of quantity landed to the fishery departments. Hence, all official landing statistics refer to ‘nominal landings’, i.e. they represent a ‘best estimate’ rather than an absolute figure. Such information that is available is usually provided through vessel owners’ catch selling-agents or local sea fishery committee permit schemes, e.g. for shellfish.

The 49 species and categories of finfish and the 13 species and groups of shellfish caught by UK registered vessels in Liverpool Bay are summarised in Table 3.4.3. The principal species of finfish, by weight landed, are: plaice (129 t), skates and rays (predominantly thornback ray) (127 t), whiting (44 t), flounder and Dover sole (both 36 t), cod (35 t), gurnards (34 t) and spurdog (25 t). Virtually all of the reported crustacean shellfish landings are accounted for by nephrops (20 t) but 85% of the 3546 t (all species of fish and shellfish combined) landed from Liverpool Bay are accounted for by four species of molluscan bivalve shellfish: queen scallops (2094 t), cockles (367 t), king scallops (366 t) and mussels (175 t).

From the relative distribution of major groupings of fish catch within Liverpool Bay it can be established that there are no large-scale (UK) catches made in Liverpool Bay. Within Rectangle 35E6 (southern Liverpool Bay-in which are found most of the Liverpool Bay existing and proposed wind farms) supports less fishing activity than Rectangle 36E6 (northern part of Liverpool Bay and upwards into the eastern Irish Sea). In addition, the quantity of queen scallops landed (2094 t) is almost 20 times greater than the greatest quantity of fish (plaice- 129 t) and the value of ‘queenies’ (£796 803) is four and half times greater than the most valuable finfish (sole-£176 004). This ‘queenie’ fishery is overwhelmingly in the deeper water of Rectangle 36E6 (northern Liverpool Bay) (Lockwood, S., personal consultation with the industry) but inshore grounds are of importance for flatfish, and rays.

Summary of ICES Stock Assessments for the Irish Sea

Of the fish landed from the Irish Sea, including Liverpool Bay, only cod, haddock, whiting, plaice, Dover sole, herring and nephrops stocks are subject to analytical assessment by ICES. Many of the other species are subject to EU catch limitations within a broader western area encompassing, but not limited to, the Irish Sea. The stock-status summaries that are given below are based on the assessment results and management advice presented by ICES to the international fishery commissions and European Commission (ACFM, 2004).

Cod

Although a small quantity of cod is reported from Rectangle 36E6, most Irish Sea cod landings are from areas north of Liverpool Bay and well away from the proposed Gwynt y Môr Offshore Wind Farm project area. The Irish Sea cod stock is being fished unsustainably; the spawning stock biomass in 2004 was estimated to be ≈ 5000 t (Figure 3.4.8). The stock has a reduced reproductive capacity and for the past 16 years has experienced below long-term average recruitment. The 2002 and 2003 year classes (broods) are the second and third lowest on record. Even if catches in the immediate future are restricted to very low levels, ICES does not anticipate that the spawning stock biomass will recover in the medium term to the minimum limit of biomass (ie B_{lim} ≈ 6000 t) that might maintain long-term viability; the precautionary approach to a minimum acceptable biomass (ie B_{pa}) is ≈ 10 000 t.

The EU agreed a total allowable catch for cod from the whole of the Irish Sea in 2003 of 1950 t: ICES estimate of landings was 1810 t, the first time the probable catch had not exceeded the agreed TAC since 1999. To optimise conditions for the recovery of the Irish Sea cod stock ICES advised a closure of all cod fisheries in the Irish Sea. The EU did not adopt this advice, but there are seasonal (spring) closures in the northern Irish Sea and the EU set a TAC for 2005 of 2150 t (UK quota 619 t).

Dover sole

The value of Dover sole landed from Liverpool Bay (Figure 3.4.9) makes a significant contribution to the total value of fish landings even though the weight is relatively small. Irish Sea sole stock is fully exploited with the current spawning stock biomass at the precautionary long-term minimum, ie B_{pa} ≈ 3800 t (Figure 3.4.7). At this level, there is a heightened risk of reduced reproductive capacity and in recent years recruitment of juvenile fish has been at or below the long-term average.

The ICES estimates of recent catches have been in line with the TAC agreed by the EU Council of Ministers at 1000 t; the TAC set for 2005 is 960 t (UK 213 t).

Haddock

Haddock is not a major resource in Liverpool Bay and is not a species for which there is a directed fishery in this area; this is reflected in the small quantity landed compared with cod or whiting. Irish Sea haddock is assessed as part of a western waters stock, an area extending from the Irish Sea and west of Ireland south through the Celtic Sea, into the Bay of Biscay and the Iberian Peninsula. This stock is being fished unsustainably; the spawning stock biomass in 2004 was estimated to be ≈ 3000 t. In common with other haddock stocks, recruitment of juvenile fish is erratic; there was a relatively strong year class in 2002 but both 2001 and 2003 were among the lowest recorded. There are medium to long-term objectives (ie B_{lim} and B_{pa}) for the management of this western waters stock.

There is little scientific information available for an analytical assessment but the EU set a precautionary TAC for the Irish Sea in 2003 of 600 t; the EU official landing statistics amounted to 410 t. The EU set a TAC for 2005 of 1500 t (UK 718 t).

Herring

There are three separate fisheries in the Irish Sea: southern Irish Sea, western Irish Sea and Isle of Man; the most important of these is the western fishery between the Isle of Man and Ireland. There is no directed fishery for herring in Liverpool Bay, nor any significant by-catch.

The ICES assessment and the EU fishery management measures for Irish Sea herring focus on the Isle of Man fishery; the TAC for 2005 is 4800 t (UK 3550 t)

Plaice

In recent years plaice have dominated the fish landings from Liverpool Bay reflecting the relatively robust condition of the spawning stock biomass which is currently ~6000 t, or double the precautionary long-term minimum – $B_{pa} \approx 3100$ t (Figure 3.4.10). The stock has full reproductive potential with recent juvenile recruitment levels running at about the level of the long-term average; the stock is being exploited at a sustainable level.

Irish Sea fisheries are mixed fisheries in which a range of species are caught irrespective of the principal target species. Current EU policy is to manage fishing for plaice so that it minimises the risk to the cod stock rather than what the plaice stock could otherwise support. The TAC for 2005 is 1608 t (UK 485 t).

Whiting

There is virtually no directed fishing for whiting as it is a low-value species. Most of the whiting landed from the Irish Sea is taken as by-catch in the nephrops fishery to the north of Liverpool Bay and in the western Irish Sea. In Liverpool Bay, whiting forms a staple of the finfish catch from general trawling activity. The spawning stock biomass is 'low' (Figure 3.4.11) with reduced reproductive capacity and is being harvested unsustainably. Although ICES has not specified the size of the current stock it has defined the minimum stock for long-term viability (B_{lim}) as 5000 t but would prefer it to be in excess of 7000 t (B_{pa}). The EU agreed a TAC for 2003 of 500 t but the actual catch is unknown due to the high level of discarding in the nephrops fishery. The EU set a TAC for 2005 of 514 t (UK 199 t).

Nephrops

There is no nephrops stock in Liverpool Bay although it is always possible that small catches may be made in deeper areas along the northern fringes of Rectangle 36E6, particularly if the seabed is mud rather than sand or gravel. Although nephrops populations occupy relatively discrete, localised areas of seabed, the EU sets a broad-based TAC for all nephrops fisheries throughout ICES Subarea VII (Irish Sea, west of Ireland, Celtic Sea and English Channel); this is currently set at 17 790 t, almost double the 9550 t recommended by ICES. ICES, however, recognises the localised distribution of nephrops and its associated fisheries and assesses 'functional units' (ICES, 2003) within the wider TAC management area; Liverpool Bay is one such functional unit (FU 14 - between the Isle of Man and Cumbria).

Landings from the eastern Irish Sea population of nephrops (see Figure 3.4.12) have been stable since the mid 1980s (Figure 3.4.10) and such assessment data as are available indicate that the spawning stock biomass and the recruitment of juveniles are also stable. ICES recommends that nephrops in the Irish Sea should be assessed and managed separately from elsewhere in Subarea VII but, at present, the EU continues to include it in the wider area – TAC for 2005, 19544 t (UK 6411). Landings from Liverpool Bay, FU 14, are 5-600 t pa, most of which (400+ t) are landed by UK registered vessels.

Skates, rays and other commercial finfish

The EU sets precautionary TACs for a range of other species but they invariably cover wider areas, typically from the west of Scotland southwards to Spain and Portugal, including the

Irish Sea. Species in this category for which the UK receives a quota allocation include: hake (*Merluccius merluccius*), horse mackerel (*Trachurus trachurus*), mackerel (*Scomber scombrus*), megrim (*Lepidorhombus whiffiagonis*), monkfish (*Lophius piscatorius*), pollack (*Pollachius virens*) and saithe (coley, *Pollachius pollachius*). There are no directed fisheries for these species in the Irish Sea and none features very strongly in UK landings from Liverpool Bay.

In contrast, there are directed UK fisheries for rays, including a set-net fishery off the North Wales coast in Rectangle 35E6, but there is no TAC or quota control. Over the 30-year period to 2003, international landings from the Irish Sea have fluctuated around the long-term average of 3314 t (Figure 3.4.13). There was a 35% fall in landings from 1987 to 1997 since when there has been a sustained recovery to a level approaching the long-term average. Nevertheless, there is widespread concern, specifically among the statutory and voluntary nature conservation bodies, that rays are vulnerable to over exploitation and measures should be taken to limit catches.

Bass is another species for which the EU does not yet set a TAC or national quotas but recreational anglers are concerned about the effect commercial catches, particularly in the western English Channel, are having on European stocks. Some anglers advocate the designation of bass as a ‘recreational species’ that should not be fished by commercial fishermen but the commercial fishing industry is strongly opposed to any such change in status. The current view among fishery scientists is that bass stocks in UK waters are in robust condition (Graham Pickett, CEFAS, pers. comm.).

Shellfish Stocks

Crustaceans

The principal fishery for crustacean shellfish in the eastern Irish Sea, north of Liverpool Bay (Figure 3.4.4), is the trawl fishery for nephrops but only small quantities are taken along the northern margin of Rectangle 36E6 (~20 t, Figure 3.4.10 and Table 3.4.3). All other fisheries for crustaceans are undertaken inshore. Very small quantities of brown shrimp (*Crangon crangon*), crabs (brown - *Cancer pagurus*, and velvet - *Liocarcinus depurator*) and lobster (*Homarus gammarus*) are landed (Table 5) by under 10 m boats from areas around the Great and Little Orme Heads, North Wales (Rectangle 35E6), but none of these populations are subject to stock assessment.

Directed fishing for brown shrimps on the North Wales coast and Wirral is undertaken primarily within the Dee Estuary but there is also a regular, shallow-water, lorry-based (*sic*) fishery on the Sefton coast, near Southport. None of these fisheries is subject to assessment; management measures are limited to net specifications and restrictions.

Molluscs

Scallops - Offshore dredge fisheries for both king and queen scallops are widespread throughout the Irish Sea from Cardigan Bay in the south to the outer Firth of Clyde in the north (Hillis & Grainger, 1990). The king scallop fisheries are predominantly in areas west and south of Liverpool Bay but relatively small quantities are taken from within this area (~400 t); the quantity of queen scallops taken from Liverpool Bay is significantly greater (~2100 t, Table

3.4.3). Neither species is subject to stock assessment beyond the territorial waters of the Isle of Man. However, there are more widespread restrictions on fishing in summer and other, local restrictions within the North Western and North Wales SFC district.

Cockles - All cockle fisheries in Liverpool Bay are intertidal, wild-stock fisheries, principally hand gathered but occasionally tractor dredging takes place in the Ribble Estuary. Stocks in the Dee Estuary are assessed and managed by the Environment Agency under its powers to act as a sea fisheries committee. Elsewhere the stocks are assessed annually and managed by the North Western and North Wales Sea Fisheries Committee. All of the assessments and management programmes are carried out in consultation with the statutory nature conservation agencies (English Nature and Countryside Council for Wales) and individual beds are often shut if stocks are too low to sustain a fishery without putting bird populations at risk.

In recent years, the 5-year (1990-03) average annual yield from the Dee Estuary has been the most productive (~400 t, Table 3.4.3) but the beds have been closed to fishing since January 2004. There are also commercial cockle beds in the Ribble Estuary, between Fleetwood and Heysham in Morecambe Bay South, and on the Lavan Sands (eastern Menai Strait, North Wales), immediately to the west of the Liverpool Bay assessment area.

Mussels - Mussels are harvested from both wild-stock and cultivated (aquaculture) shallow-water beds in Liverpool Bay. In the eastern Menai Strait (just outside Rectangle 35E6), there is an extensive area of cultivation that typically yields in excess of 2000 t per annum. The NW SFC occasionally license fishing for juvenile mussels (mussel spat) off Rhos on Sea and Llandulas (Colwyn Bay) for relaying on these cultivated beds. Elsewhere on the North Wales coast, there is a small-scale, hand-raked, wild-stock fishery in the Conwy Estuary and occasional mussel harvesting in the Dee Estuary off West Kirby; together they have a 5-year annual average yield of ~175 t (Table 3.4.3). As with cockles, the fisheries are assessed and managed by the sea fisheries committee (Conwy) and the Environment Agency (Dee).

Whelks – this species is widely distributed and fished with pots, albeit in relatively small quantities (5-year annual average (<5 t, Table 3.4.3) throughout Liverpool Bay, including the proposed Gwynt y Môr Offshore Wind Farm site. The stocks are subject neither to stock assessment nor catch limitations.

Migratory Species

Formally, 'migratory species' are the anadromous salmon and sea trout (fish that spawn in freshwater and feed at sea) and the catadromous European eel (fish that spawn at sea and feed in freshwater). The status of individual salmonid stocks in UK waters is assessed by the Environment Agency (EA) in England and Wales (EA, 2004); the EA also monitors the state of eel stocks in freshwater. All are subject to international assessment jointly by ICES and EIFAC – the European Inland Fisheries Advisory Committee, a body sponsored by the Food and Agriculture Organisation of the United Nations (FAO).

Internationally, all three species are giving cause for concern as stocks appear to be subject to a process of long-term decline. Whilst fishing inevitably contributes to this cause for concern, environmental factors are also assumed to be at play. There are no directed offshore sea-fisheries for any of the migratory species in Liverpool Bay although there are licensed commercial net fisheries in the Conwy and Dee Estuaries.

Salmon & sea trout

All fishing for salmon and sea trout in coastal waters of England and Wales is licensed by the Environment Agency. In 2003, commercial fishing licences were issued for two nets in the Conwy Estuary, 16 in the Dee and 6 in the Ribble. Net licences for the Clwyd and Wyre have not been issued for some years past but recreational rod licences are issued each year for all five salmonid rivers entering Liverpool Bay: Conwy, Clwyd, Dee, Ribble, Wyre.

Salmon catches reported to the Environment Agency for 2003 (EA, 2004; Figure 3.4.14) from commercial and recreational fisheries in north-west England (6154 fish) were 26% down on the 1998-02 5-year mean (8267 fish). In Wales the 2003 catch (3490 fish) was 36% down on the 5-year mean (5468 fish) but the more grilse (single-sea-winter fish) caught in the Conwy and more multi-sea-winter fish were caught in the Dee during 2003 than were taken in 2003 (EA, 2004).

As part of the annual assessment of salmon stocks the EA sets 'conservation criteria' by which to judge the status of individual river stocks. Of the four salmon rivers draining into Liverpool Bay only the River Conwy salmon stock met the criteria set for acceptable stock status, stocks in the other three rivers failed to meet these criteria. However, the quinquennial stock assessment undertaken in the River Ribble in 2003 found more salmon parr (juveniles) than was the case in 1998 (www.environment-agency.gov.uk/regions/ northwest).

The Environment Agency does not include sea trout statistics in its annual report on salmon stocks but sea trout data are included in the Scottish report (FRS, 2003). Records for Scottish salmon rivers draining into the eastern Irish Sea show an almost identical picture to the salmon stocks – a sustained 40-year decline. It is assumed, therefore, that the EA assessment of Liverpool Bay salmon stocks provides an indication of the state of sea trout stocks in the same rivers even though they are generally more abundant than salmon The key difference, perhaps, is that the sea trout catch each year is invariably higher than the salmon catch; in the case of the River Clwyd an average of six times as many sea trout as salmon (EA, 2000).

Eels

Fishing for eels in inland and coastal waters of England and Wales is licensed by the Environment Agency. The Agency monitors catches, maintains records and contributes to the ICES-EIFAC assessment of European eel. There are no trawl fisheries for silver eels in Liverpool Bay nor are there any significant net fisheries in any of the estuaries; commercial eel fishing in North Wales and NW England is undertaken in freshwaters.

Since the 1970s there has been a steady downward trend in the recruitment of juvenile eels each spring to European rivers, including those in the UK (ACFM, 2003; ICES, 2003). During the 1990s there was some indication that the decline may have begun to stabilise but numbers are still only a fraction of what they were in the period 1950-80. The ICES-EIFAC assessment of European eel fisheries concludes that all are outside safe biological limits (ICES, 2003). In some European countries, including Ireland, glass eels are caught and transported to areas where eel fisheries occur in an effort to enhance stocks locally (Moriarty,

2000) but this is not practised in Britain. It is reasonable to assume, therefore, that eel stocks in Great Britain are at or near a 50-60 year low point with no imminent sign of improvement.

Fish of Nature Conservation Interest

Fish of nature conservation interest (see section 3.6 for full descriptions and relevant legislation) are rarely, if ever, subject to formal analytical assessment in the way that commercially exploited species are. Their status tends to be assessed in relation to monitored or perceived long-term trends and, where appropriate, non-fishery conservation measures put in place (Costello *et al.,* 2002). Some of these measures are based exclusively on UK legislation but more generally they are in response to international treaties or conventions.

Basking shark- General concern for the basking shark relates to its low fecundity (birth rate), high age of maturity and its vulnerability to overexploitation. It is a regular summer migrant to the coastal waters of the Isle of Man and the western Irish Sea where, until recently, it was fished by Norway under licence from the EU. The EU has ceased issuing a TAC for this species and UK legislation prohibits its exploitation by UK registered fishing vessels. It is rarely recorded in Liverpool Bay. Overall, basking sharks are protected from commercial fishing by legislation (see section 3.6), however, occasional accidental catches are made by trawls and surface-set gill nets.

Common and sand gobies- these are abundant in sandy environments throughout UK coastal waters, including Liverpool Bay. Neither species is subject to any specific management measures in UK waters (although they are covered by the Bern Convention (see section 3.6)). Both species are too small to be retained by anything other than the small-mesh shrimp trawls, they have no commercial value nor do recreational anglers target them.

Allis and twaite shad- The Environment Agency monitors shad numbers as part of a UK Biodiversity Shad Species Action Plan; both species are subject to protection under UK and European legislation (see section 3.6). There are no fisheries, neither commercial nor recreational, for either species.

River and sea lampreys- The status of lamprey stocks is not known; they are subject to protection under UK and EU legislation (see section 3.6). There are no directed fisheries.

Smelt- There is a small run of smelt into the Conwy Estuary where it may occasionally be taken by Environment Agency licensed beach-seines (personal observation). However, there is no directed fishery for commercial exploitation. The long-term status of the Conwy smelt population is unknown.

3.4.5 Site-Specific Fish Information

Information from the site specific beam trawl surveys undertaken as part of the benthic characterisation survey (detailed in section 3.3 and full report provided in Appendix 1) also provide semi-quantitative data concerning the fish species and assemblages found at the Gwynt y Môr project area.

The results from the beam trawl surveys recorded a total of 3,681 individuals from 43 fish species. Only one site, located in the north of the project area, recorded no fish in the trawls from each of the three surveys. Sites which recorded the highest numbers of fish species in all three surveys relative to other sites, were located to the south west of the Gwynt y Môr project area (Sites 38-41, see Figure 3.3.2) and two sites to the east (Sites 16 and 36, see Figure 3.3.2) also outside the Gwynt y Môr project area. In addition, numbers of fish species at each site were generally lower in August than recorded in the December and March surveys, with the exception of one site in the south west (site 41, see Figure 3.3.2) where over 200 individuals were recorded in August however, this is mostly attributable to one species (dab, *Limanda limanda*).

The five most abundant fish species recorded during the December 2003 survey were; scaldfish *Arnoglossus laterna*, solenette *Buglossidium luteum,* dragonet *Callionymus lyra*, dab *Limanda limanda* and sand goby *Pomatoschistus minutus*. All five of these species were caught at 17 of the trawl sites and in especially high abundance at sites 45 and 48 (see Figure 3.3.2). In March 2004, scaldfish, dragonet and dab were still amongst the 5 most abundant fish species but solenette and sand goby were replaced with poor cod *Trisopterus minutus* and pogge *Agonus cataphractus*. All five of these species were caught at 12 sites but unlike December, there were fewer sites which demonstrated a high abundance of all five species. In August 2004, dragonet and dab were once again among the top five most abundant species; the other three were; solenette, sand goby and poor cod. All five of these species were recorded together from just two of the survey sites with high abundances at one site in the south west of the survey area, outside the Gwynt y Môr project area.

Only dragonet, *Callionymus lyra* and dab, *Limanda limanda* were among the 5 most abundant species in all three surveys and were less widespread in August 2004 than in December 2003 and March 2004, which is the opposite to the expected trend of wider distribution in summer. Only site 11 (located to the north within the Gwynt y Môr project area), which had none of the most abundant fish species, and site 41 (in the south west outside the Gwynt y Môr project area), which had all of the most abundant fish species, showed any consistency between the three surveys. The rest of the sites showed great variation in both the number of fish and the proportion of the five most abundant species. The proposed cable corridor was only surveyed during August 2004 and of the six sites, all five most abundant fish species were caught at C4 (see Figure 3.3.2) but in relatively low numbers. The nearest inshore survey site had very high numbers of dragonet, *Callionymus lyra*.

Overall elasmobranchs were recorded in small numbers and infrequently with a total of 27 individuals from 5 taxa recorded from all the surveys. The most common was the Thornback ray, *Raja clavata* of which a total of 11 individuals were recorded. This species is one of the most abundant ray (*Rajid*) species in the Irish Sea and in UK waters. Although elasmobranches are usually found at fairly low abundances, these numbers are likely to be under-representative due to the semi-quantitative nature of beam trawls. No elasmobranchs were recorded at the inshore cable route sites and no obvious patterns of distribution were evident across the survey area. Only two sites showed records of elasmobranchs from more than one survey, these sites were both located outside the Gwynt y Môr project area. Elasmobranchs are thought to migrate offshore after the summer, to winter in deeper water. However, no large differences in abundance or distribution were noted between the December and August trawls. The trawl survey from March did yield a higher number of elasmobranchs but this was only by 4 individuals and these were from the same number of sites as in the August surveys.

The results from the beam trawl survey were used to quantify the epifaunal /demersal communities of the Gwynt y Môr project area (detailed in section 3.3) (Figure 3.4.15). These communities identified from the results of the characterisation beam trawl surveys showed some similarity to the *Pleuronectes-Limanda* (Plaice-Dab) assemblage as described by Ellis *et al* (2000), which found this assemblage within and around the 20m contour of the Liverpool Bay area. Although species such as *Alcyonium digitatum* (Dead Man's Fingers), hydroids and bryozoans and the plumose anemone *Metridium senile* are indicative of coarser, harder grounds. Ellis *et al* (2000) states that the hermit crab *Pagurus bernhardus,* the flatfish dab, and the scaldfish are important as important discriminating species all of which were found in abundance during the characterisation survey. Overall, the majority of the area does seem to correspond with the *Pleuronectes-Limanda* (Plaice-Dab) assemblage but further offshore some elements of the *Microchirus-Pagurus* assemblage are apparent (see Figure 3.4.15), particularly increasing importance of *Callionymus lyra* and increasing numbers of *Pagurus prideauxi* as opposed to *P. bernhardus*, but *Microchirus* itself was only found very occasionally. The *Microchirus-Pagurus* assemblage is found in slightly deeper areas than the *Pleuronectes-Limanda* assemblage and it may be that the Gwynt y Môr Offshore Wind Farm project area more or less represents the beginning of a boundary area between the two. Some places, especially the central part of the survey area (see Figure 3.4.15), may have some match with Ellis *et al's* (2000) "*Alcyonium*" assemblage due to the amount of hard substrate.

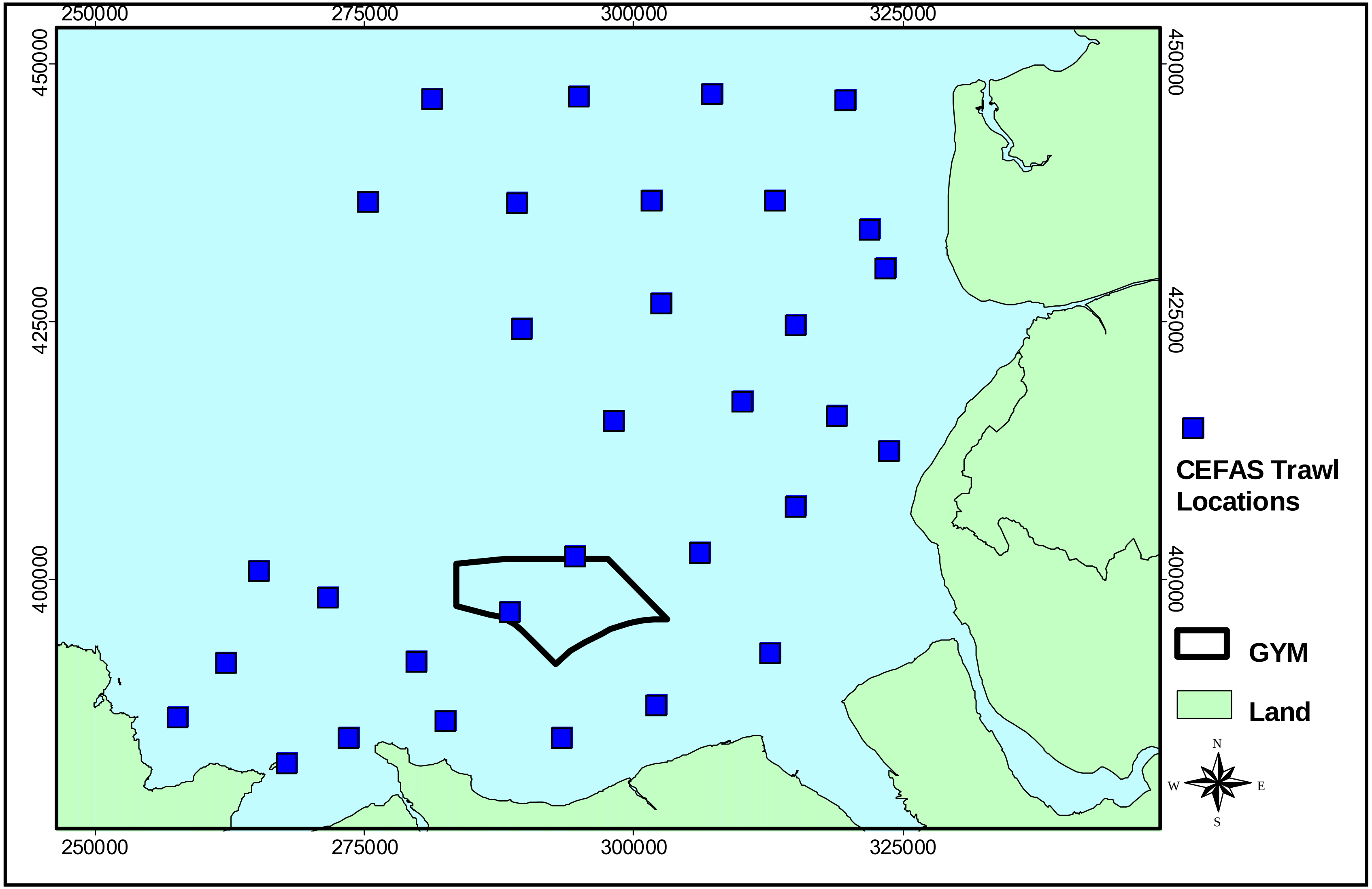


Figure 3.4.1: Approximate locations of CEFAS autumn beam trawl survey locations within Liverpool Bay.

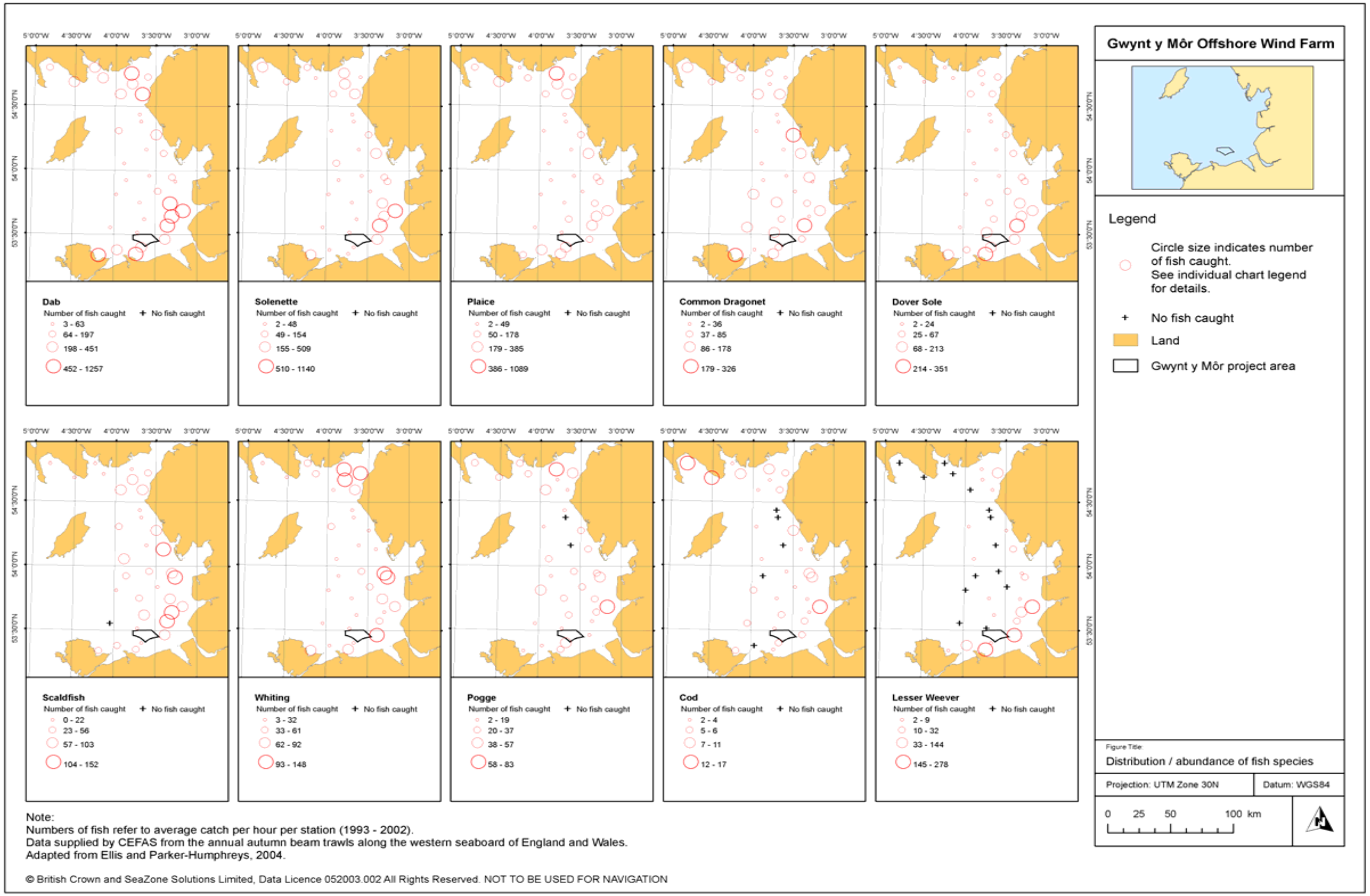


Figure 3.4.2: Average distribution and relative abundance of the principal commercial finfish and the five most abundant non-commercial species in Liverpool Bay.

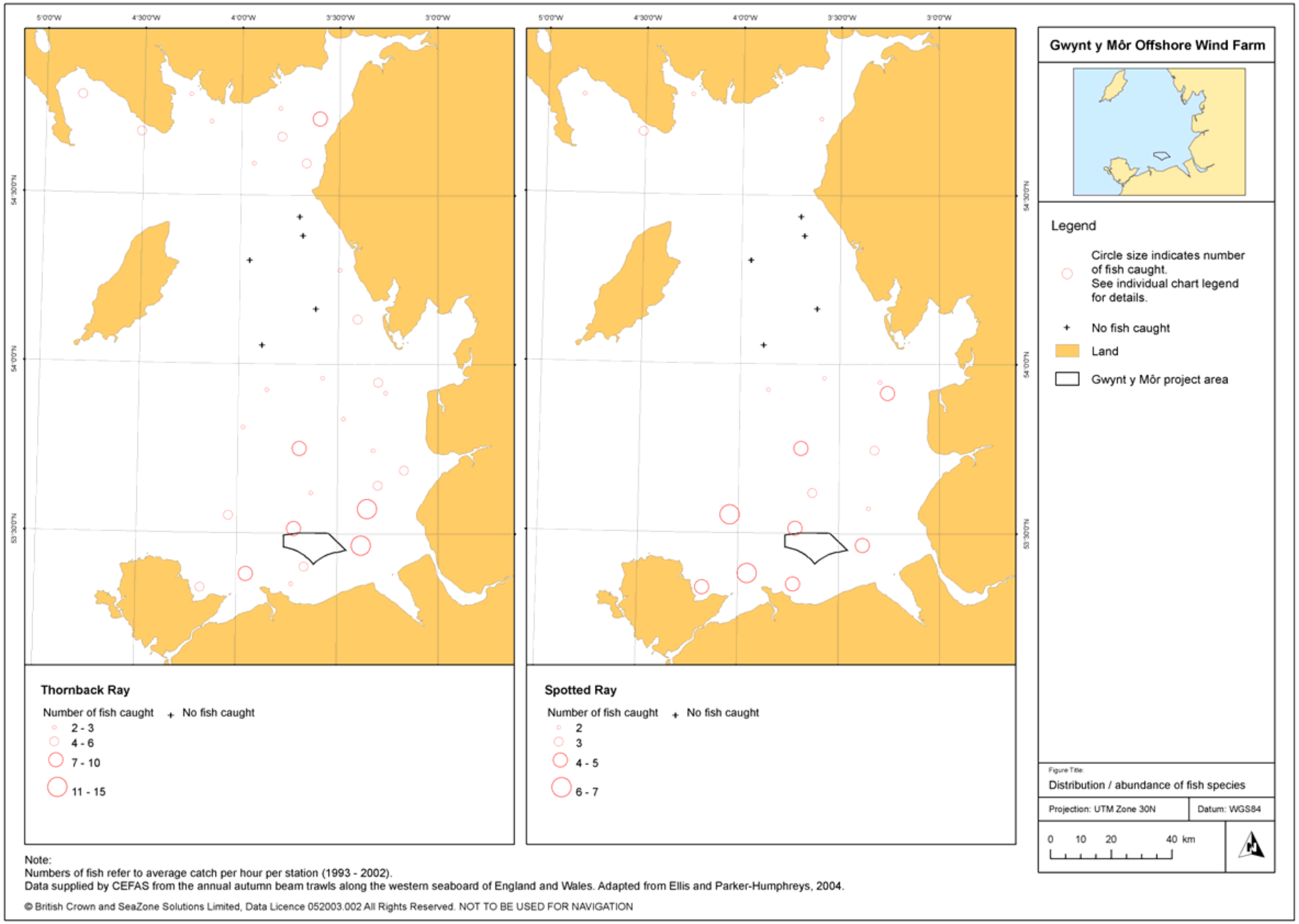


Figure 3.4.3: The average relative abundance of thornback ray, spotted ray and lesser spotted dogfish taken during the CEFAS trawl surveys 1993-03 for Liverpool Bay.

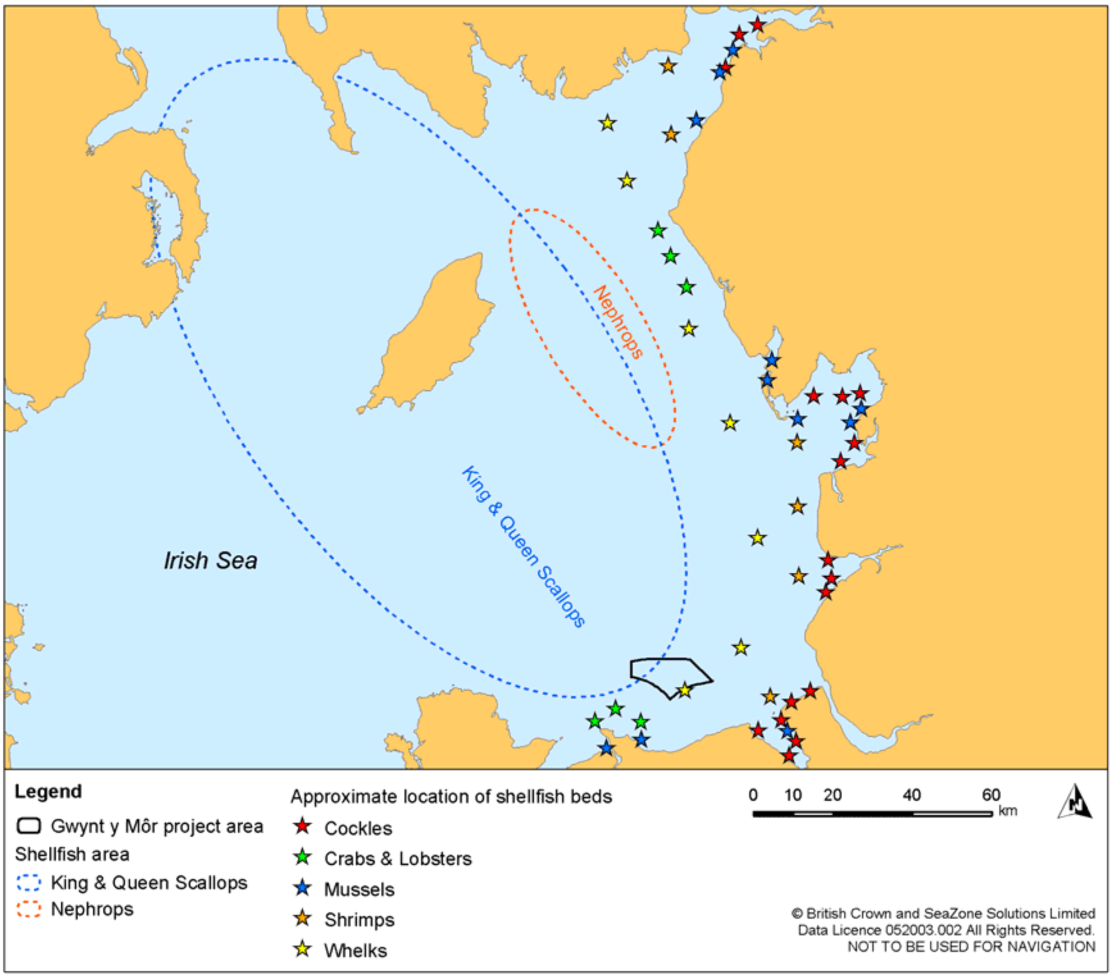


Figure 3.4.4: The distribution of major shellfish resources in the eastern Irish Sea (modified from CORDAH, 2003).

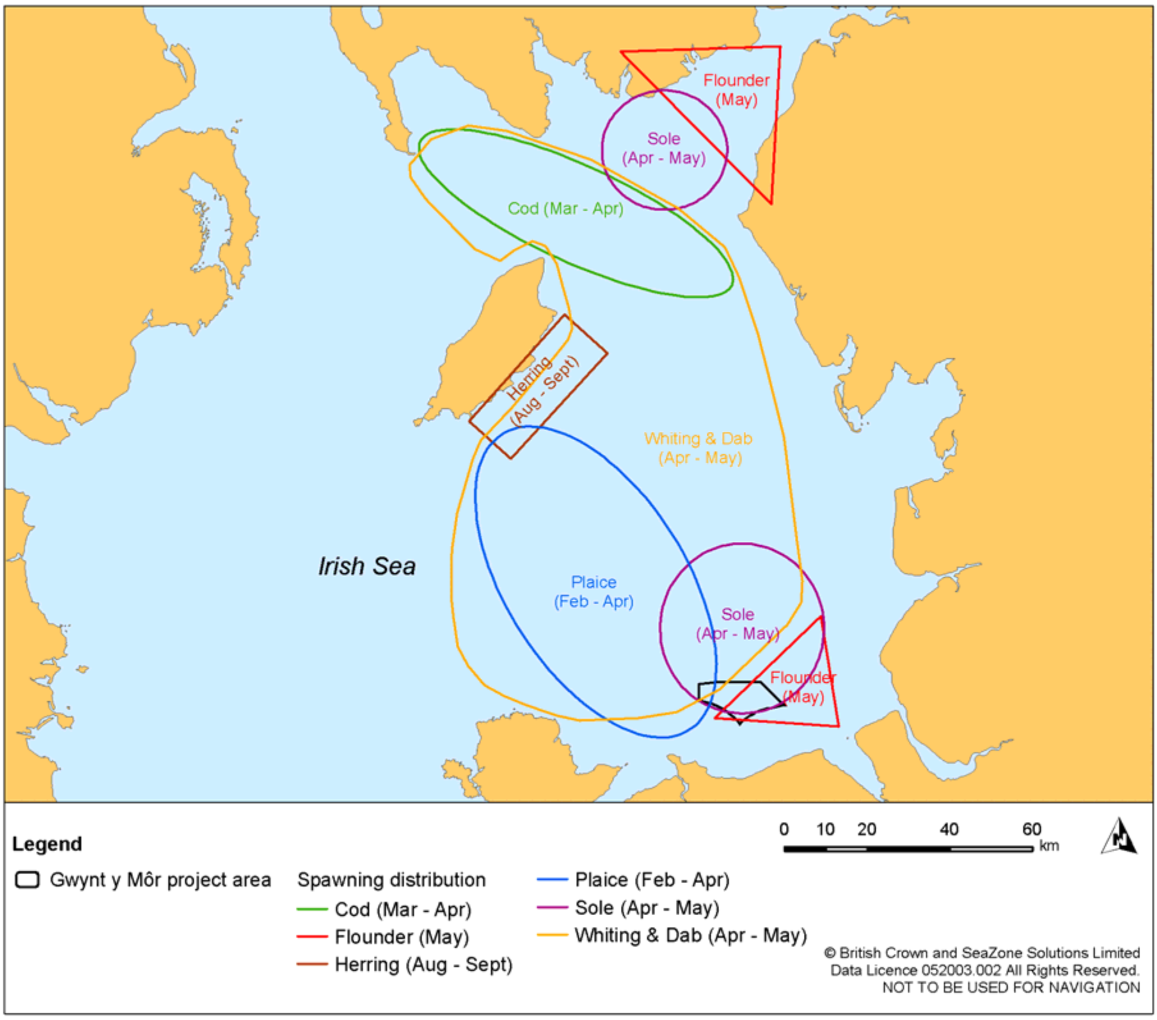


Figure 3.4.5: An indication of the spawning distribution of some fish species within Liverpool Bay and the eastern Irish Sea (based on data from Fox *et al.*, 1997).

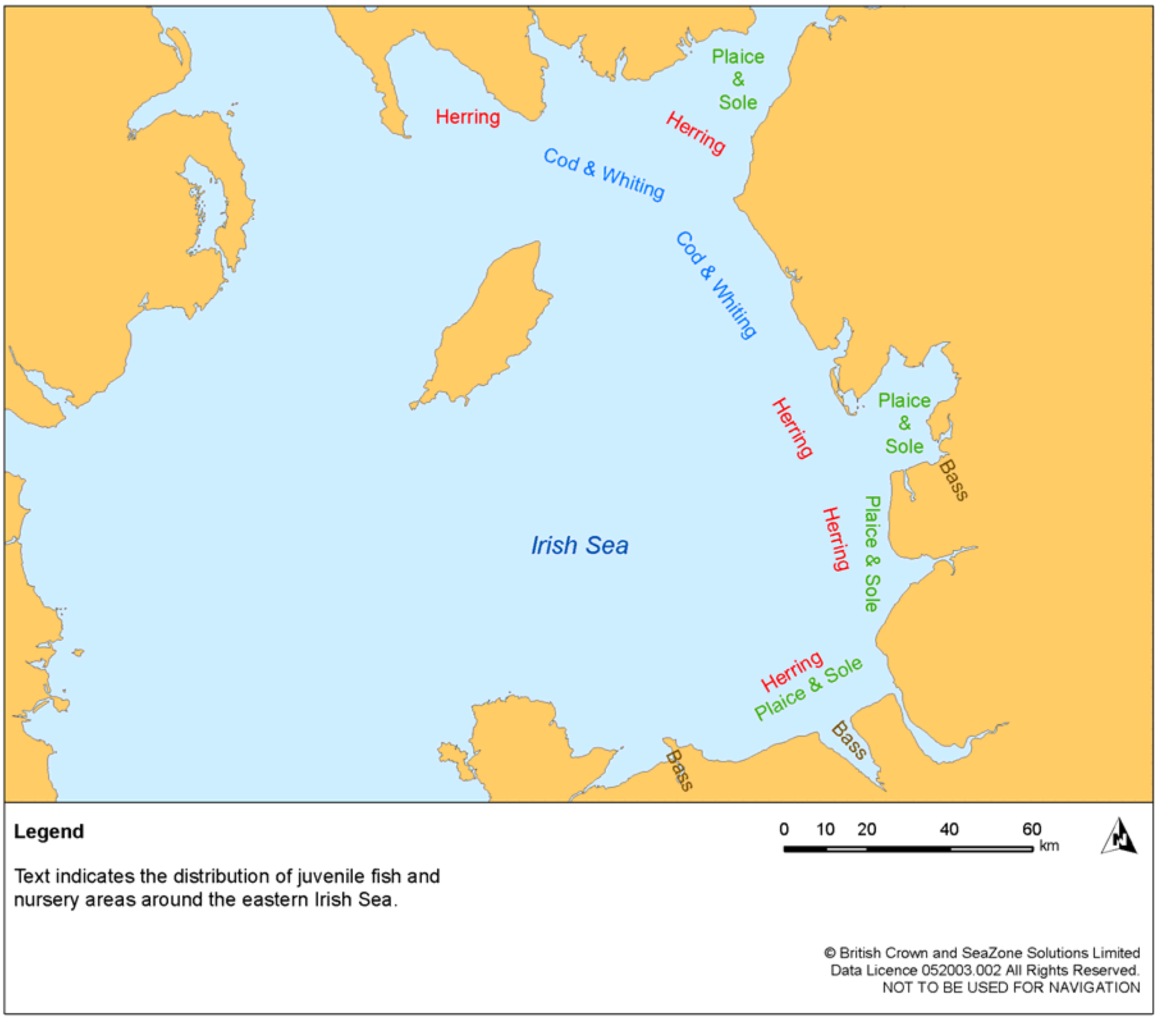


Figure 3.4.6: The distribution of juvenile fish and nursery areas around the eastern Irish Sea (After Hillis & Grainger, 1990 and Coull *et al.,* 1998).

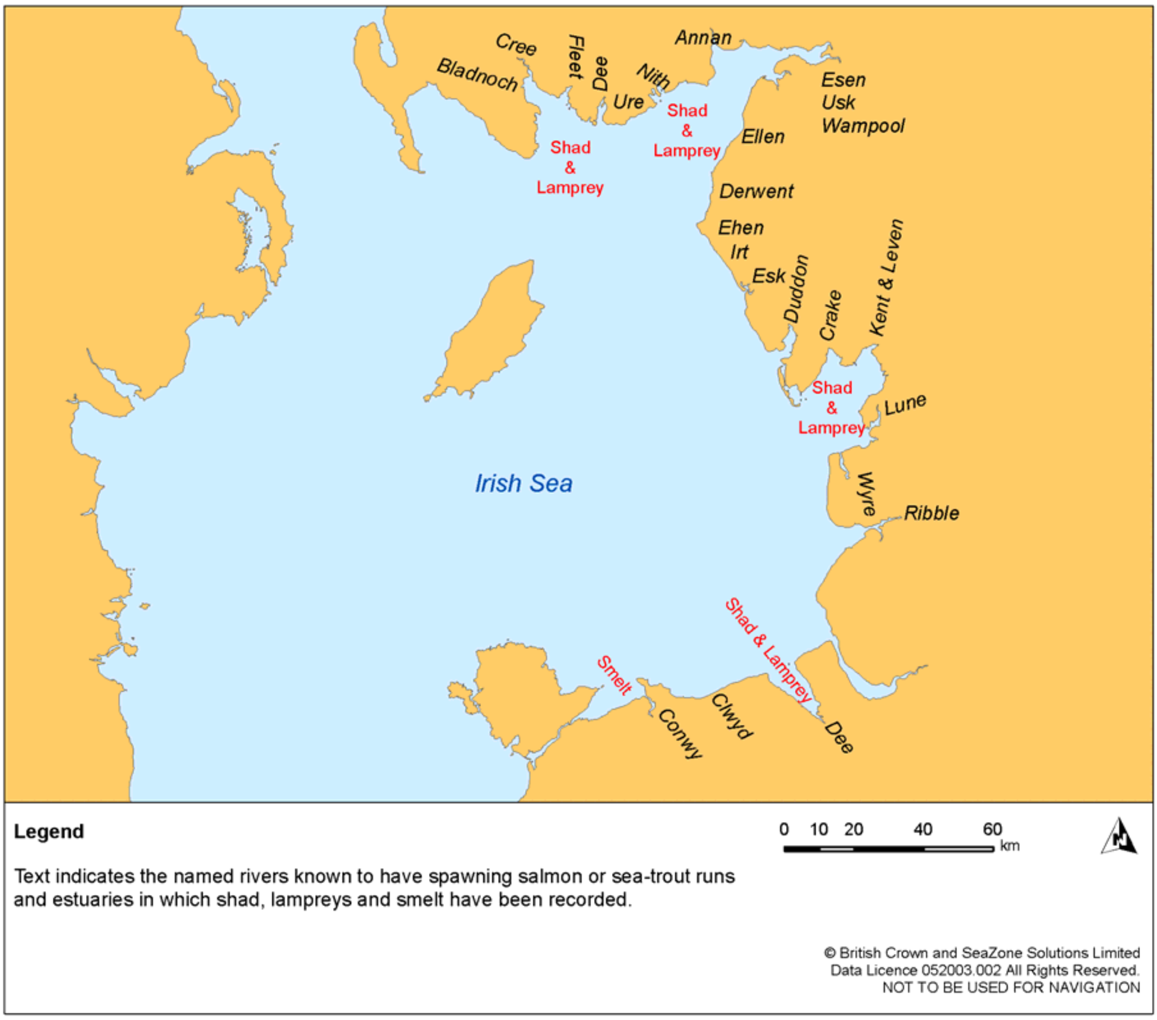


Figure 3.4.7: The named rivers known to have spawning salmon and or sea trout runs and estuaries in which shad, lampreys and smelt (species of nature conservation interest) have been recorded (Information from JNCC, 1999).

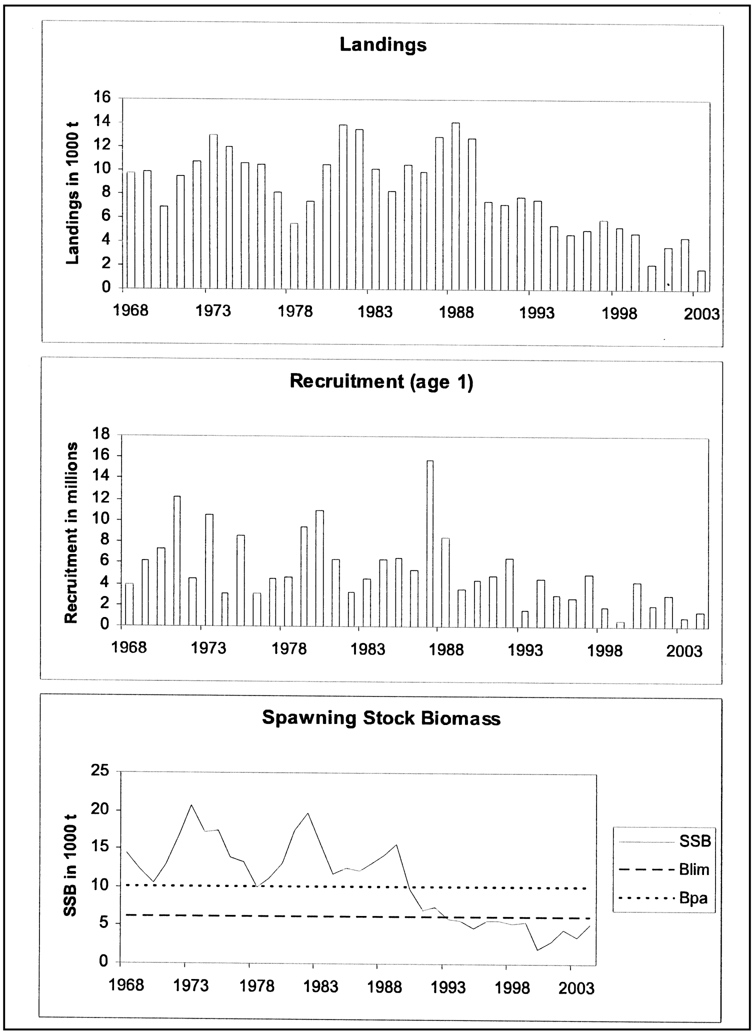


Figure 3.4.8: International landings of cod from the Irish Sea and ICES estimates of juvenile recruitment and spawning stock biomass (from ACFM, 2004).

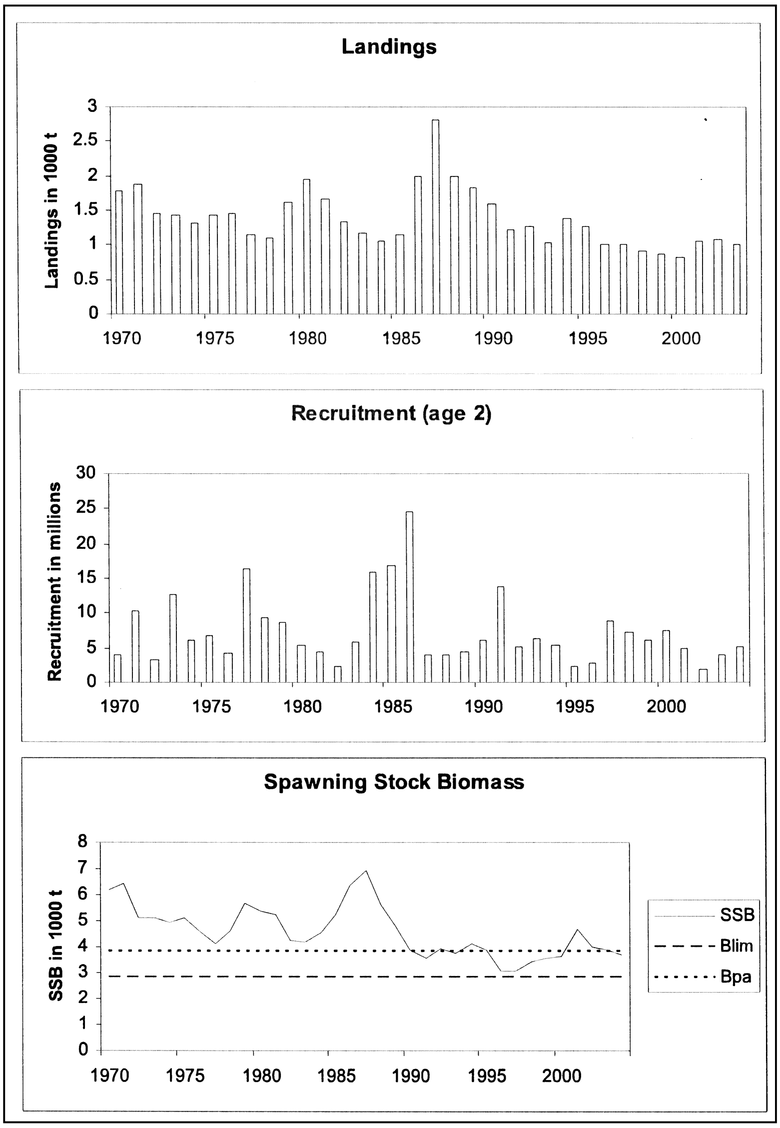


Figure 3.4.9: International landings of Dover sole from the Irish Sea and ICES estimates of juvenile recruitment and spawning stock biomass (from ACFM, 2004).

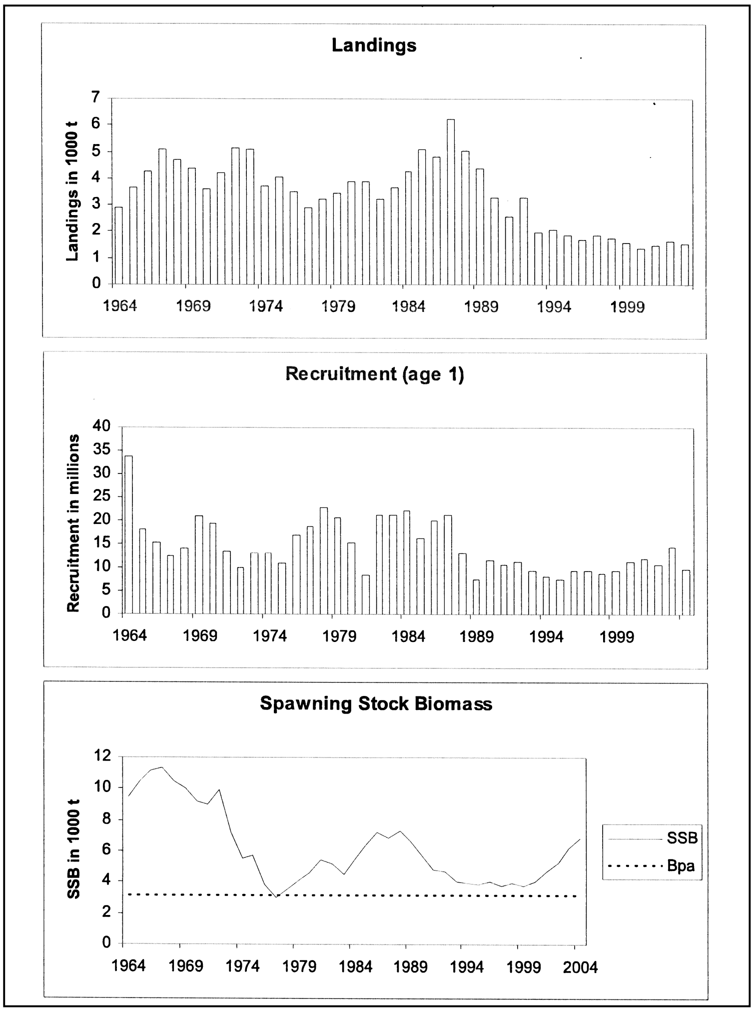


Figure 3.4.10: International landings of plaice from the Irish Sea and ICES estimates of juvenile recruitment and spawning stock biomass (from ACFM, 2004).

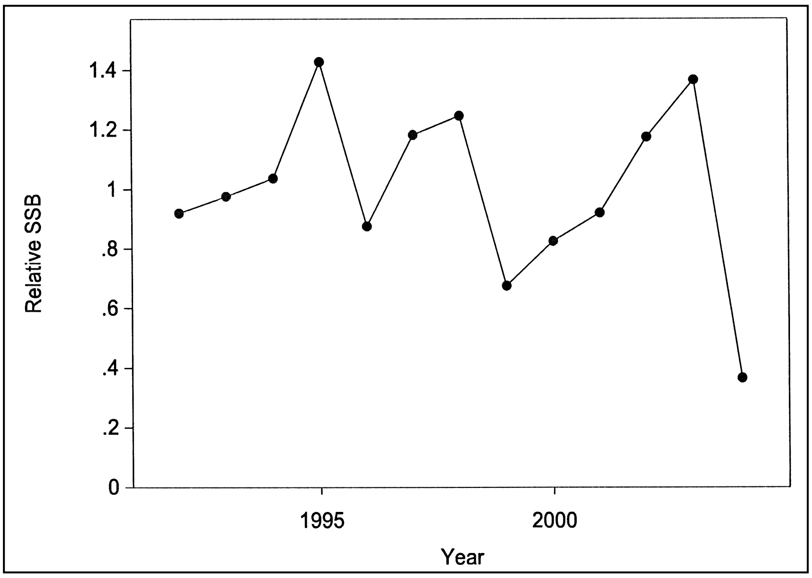


Figure 3.4.11: Estimates of relative spawning stock biomass of whiting from UK research vessel surveys in the northern Irish Sea (from ACFM, 2004).

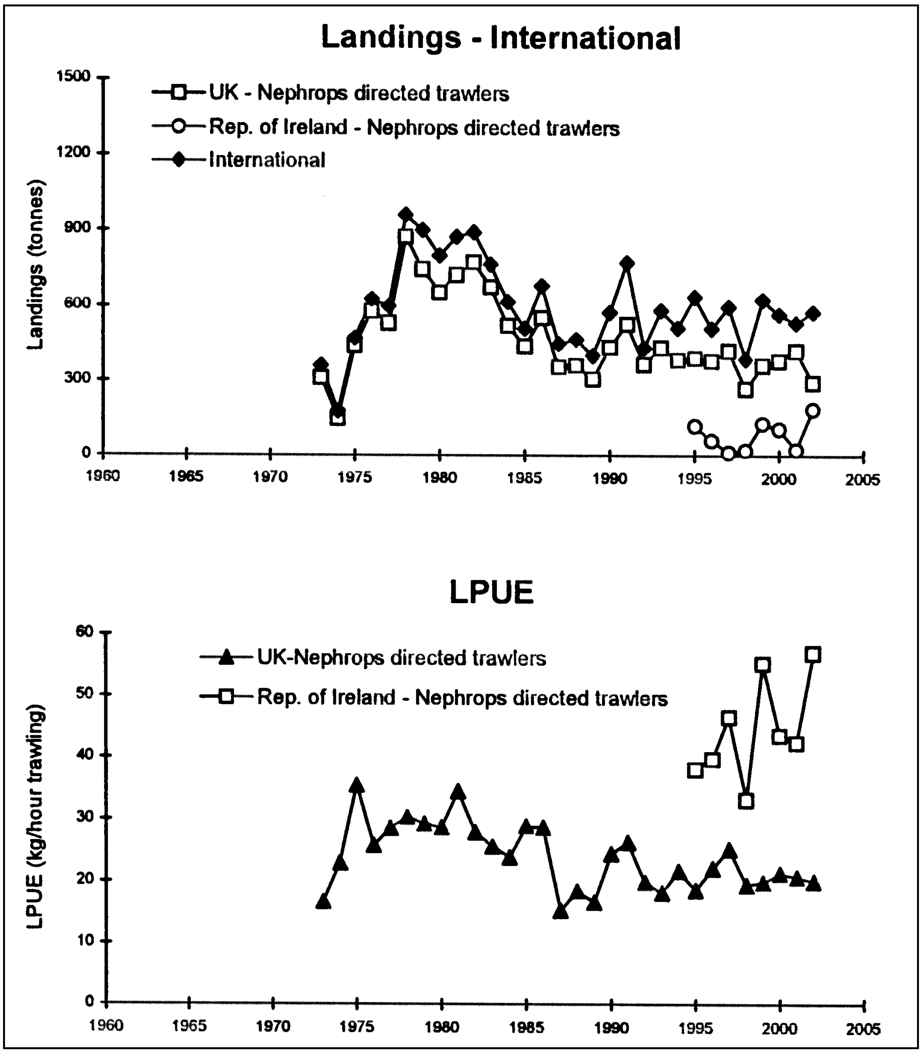


Figure 3.4.12: Long-term trend in international landings of nephrops from the Irish Sea and landings per unit of effort, an index of spawning stock biomass (from ACFM, 2003).

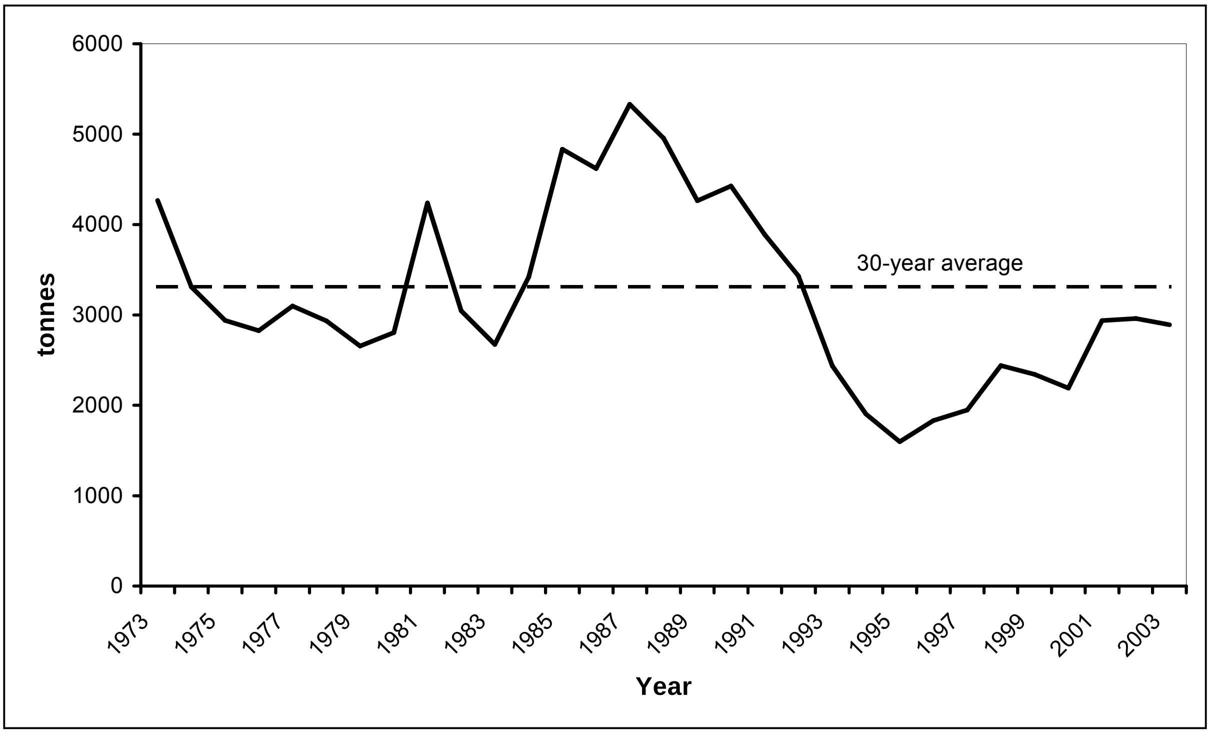


Figure 3.4.13: International landings of skates and rays (all species combined) from the Irish Sea 1973-03 (data from ACFM, 2004).

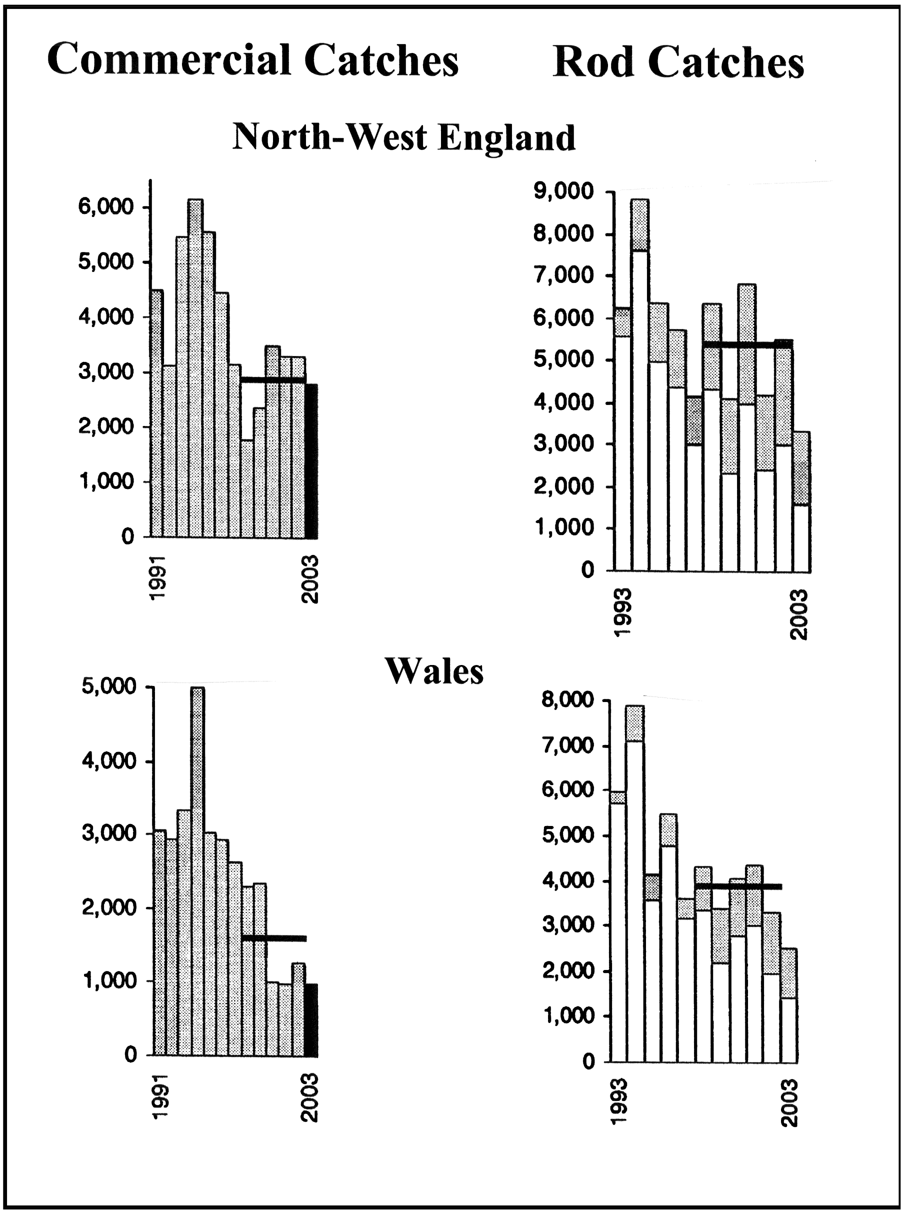
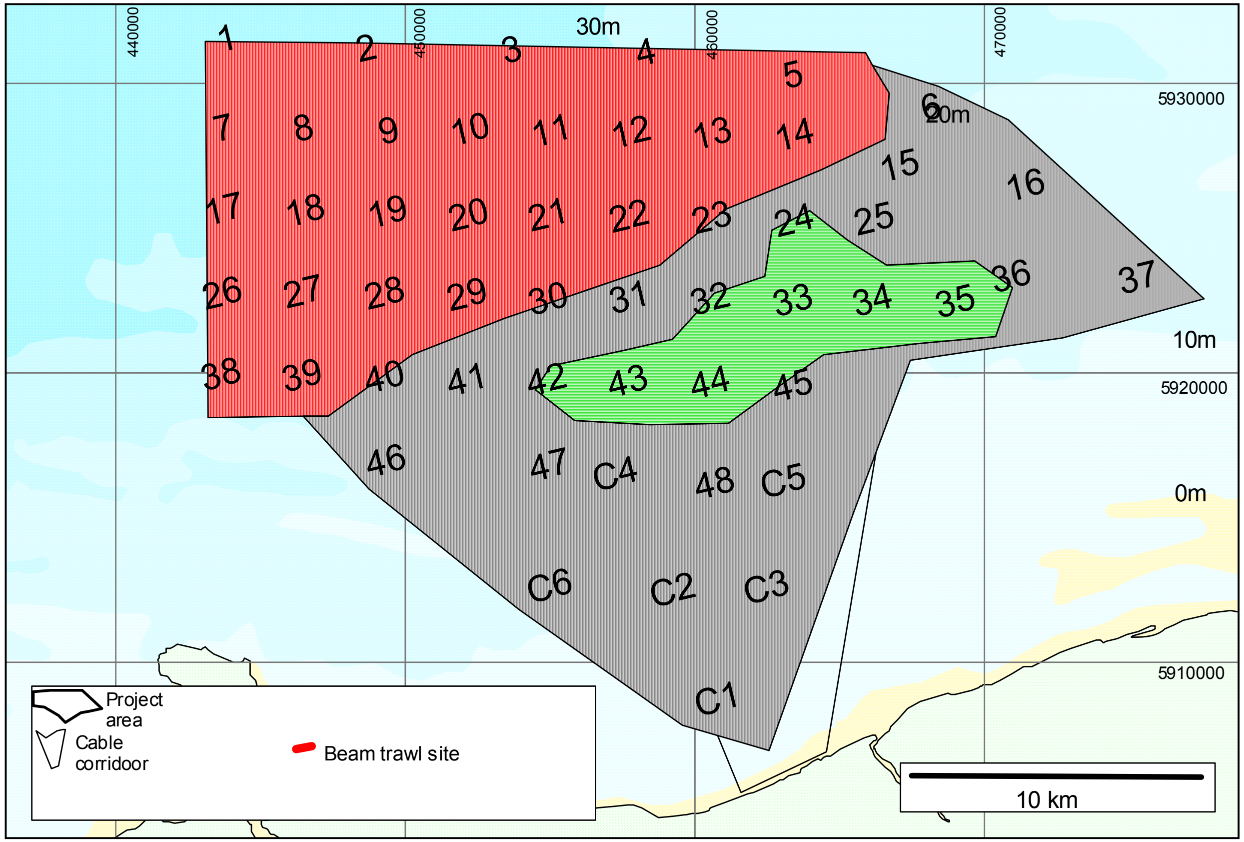


Figure 3.4.14: Commercial and recreational catches of salmon reported to the Environment Agency in NW England and Wales (from EA, 2004). The shaded areas in the Rod Catch histograms indicate fish that were released after capture (from EA, 2004).



Red – *Microcheirus-Pagurus* assemblage Green – *Alcyonium* assemblage Black – *Pleuronectes-Limanda* assemblage

Figure 3.4.15: Tentative map of possible assemblages from beam trawl data, based on the assemblages of Ellis *et al* (2000).

Table 3.4.1: Marine fish species including listing in order of actual abundance recorded during the CEFAS beam-trawl surveys of Liverpool Bay (1992-03);

Fish Species Recorded		Average Annual Catch				
Common Name	Scientific Name	Common Name	Liverpool Bay		GyM	
			N	Rank	Rank	N
Bib or pout whiting	*Trisopterus luscus*	Dab	3929	**1**	**5**	239
Brill	*Scophthalmus rhombus*	Solenette	2997	**2**	**6**	184
Bull rout	*Myoxocephalus scorpius*	Plaice	2313	**3**	**2**	268
Butterfish	*Pholis gunnellus*	Dragonet, common	1884	**4**	**1**	684
Butterfly blenny	*Blennius ocellaris*	Dover Sole	1735	**5**	**4**	242
Clingfish, two-spot	*Diplecogaster bimaculata*	Gurnard, grey	706	**6**	**7**	174
Cod, Atlantic	*Gadus morhua*	Scaldfish	684	**7**	**9**	75
Cod, poor	*Trisopterus minutus*	Cod, poor	677	**8**	**3**	257
Conger eel	*Conger conger*	Weever, lesser	673	**9**	**8**	110
Dab	*Limanda limanda*	Whiting	650	**10**	**13**	42
Dogfish, lesser spotted	*Scyliorhinus canicula*	Pogge or Hooknose	564	**14**	**10**	74
Dogfish, nurse hound or bull huss	*Scyliorhinus stellaris*	Dogfish, lesser spotted	236	**11**	**12**	56
Dogfish, starry	*Mustelus asterias*	Gurnard, tub	153	**12**	**18**	17
Dogfish, starry smooth hound	*Mustellus mustellus*	Octopus, northern	136	**13**	**11**	60
Dragonet, common	*Callionymus lyra*	Sole, thickback	126	**15**	**14**	37
Dragonet, reticulated	*Callionymus reticulata*	Bib or pout whiting	112	**16**	**16**	30
Dragonet, spotted	*Callionymus maculatus*	Ray, thornback or roker	78	**17**	**20**	13
Flounder	*Platichthys flesus*	Goby, sand/common	73	**18**	**22**	8
Garfish	*Belone belone*	Gurnard, red	65	**19**	**19**	16
Goby, sand	*Pomatoschistus minutus*	Sole, lemon	63	**20**	**15**	32
Gurnard, grey	*Eutrigla gurnardus*	Bull rout	60	**21**	**17**	21
Gurnard, red	*Aspitrigla cuculus*	Cod, Atlantic	37	**22**	**23**	7
Gurnard, tub	*Trigla lucerna*	Flounder	31	**23**	**38**	<1
Hake	*Merluccius merluccius*	Sea scorpion	28	**24**	**31**	2
John Dory	*Zeus faber*	Ray, spotted	27	**25**	**21**	8
Ling	*Molva molva*	Dragonet, reticulated	19	**26**	**20**	10
Lumpfish	*Cyclopterus lumpus*	Dogfish, nurse hound or bull huss	16	**27**	**25**	6
Mackerel, Atlantic	*Scomber scombrus*	Brill	14	**28**	**62**	<1
Monk or anglerfish	*Lophius piscatorius*	Monk or anglerfish	14	**29**	**27**	3
Mullet, red	*Mullus surmuletus*	Pipefish, greater	14	**30**	**24**	7
Octopus, northern	*Eledone cirrhosa*	Sprat	12	**31**	**37**	1
Pipefish, greater	*Syngnathus acus*	Butterfly blenny	9	**32**	**40**	<1
Pipefish, Nilsson's	*Syngnathus rostellatus*	Ray, cuckoo	8	**33**	**26**	4
Plaice	*Pleuronectes platessa*	Scad or horse mackerel	8	**34**	**29**	3
Pogge or Hooknose	*Agonus cataphractus*	Ray, blonde	7	**35**	**41**	<1
Ray, blonde	*Raja brachyura*	John Dory	6	**36**	**32**	2
Ray, cuckoo	*Raja naevus*	Topknot, Norwegian	5	**37**	**33**	2
Ray, spotted	*Raja montagui*	Turbot	5	**38**	**34**	1
Ray, thornback or roker	*Raja clavata*	Wrasse, goldsinney	4	**39**	**44**	<1
Rockling, five-bearded	*Ciliata mustela*	Sandeel	4	**40**	**30**	3
Rockling, four-bearded	*Rhinonemus cimbrius*	Dragonet, spotted	2	**41**	**48**	<1
Sandeel	*Ammodytes tobianus*	Garfish	2	**43**	**45**	<1
Sandeel, greater	*Hyperoplus lanceolatus*	Butterfish	1	**42**	**50**	<1
Scad or horse mackerel	*Trachurus trachurus*	Mackerel, Atlantic	1	**44**	**51**	<1
Scaldfish	*Arnoglossus laterna*	Rockling, five-bearded	1	**45**	**47**	<1
Sea scorpion	*Taurulus bubalis*	Pipefish, Nilsson's	1	**46**	**52**	<1
Sea urchin, edible	*Echinus esculentus*	Squid, *Alloteuthis* sp	1	**48**	**53**	<1
Seabass	*Dicentrarchus labrax*	Squid, *Loligo* sp.	1	**47**	**49**	<1
Sole, Dover	*Solea solea*	Witch	1	**49**	**48**	<1
Sole, lemon	*Microstomus kitt*	Clingfish, two-spot	<1	**50**	**59**	<1
Sole, thickback	*Microchirus variegatus*	Conger eel	<1	**51**	**55**	<1
Solenette	*Buglossidium luteum*	Dogfish, starry	<1	**52**	**41**	<1
Sprat	*Sprattus sprattus*	Dogfish, starry smooth hound	<1	**53**	**62**	<1
Squid	*Loligo vulgaris*	Hake	<1	**55**	**58**	<1
Squid	*Alloteuthis subulata*	Ling	<1	**54**	**60**	<1
Tope	*Galeorhinus galeus*	Lumpfish	<1	**56**	**57**	<1
Topknot, Imperial	*Phrynorhombus regius*	Mullet, red	<1	**57**	**61**	<1
Topknot, Norwegian	*Phrynorhombus norvegicus*	Rockling, four-bearded	<1	**58**	**65**	<1
Triggerfish	*Balistes carolinensis*	Sandeel, greater	<1	**59**	**57**	<1
Turbot	*Psetta maxima*	Sea bass	<1	**60**	**58**	<1
Weever, lesser	*Echiichthys vipera*	Squid	<1	**61**	**28**	3
Whiting	*Merlangius merlangus*	Tope	<1	**62**	**56**	<1
Whiting, blue	*Micromesistius poutassou*	Topknot, Imperial	<1	**63**	**64**	<1
Witch	*Glyptocephalus cynoglossus*	Triggerfish	<1	**64**	**54**	<1
Wrasse, goldsinney	*Ctenolabus rupestris*	Whiting, blue	<1	**65**	**59**	<1

Table 3.4.2: Fish and (commercial) shellfish species caught at least once during the CEFAS beam-trawl survey of Liverpool Bay (1992-2003) arranged in the same groupings used to describe the UK commercial landings from the same area (see section 3.4.4).

Commercial		Non-Commercial	
Common Name	**Scientific Name**	**Common Name**	**Scientific Name**
		Gadoids	
Bib or pout whiting	*Trisopterus luscus*	Poor cod	Trisopterus minutus
Cod	*Gadus morhua*		
Hake	*Merluccius merluccius*		
Ling	*Molva molva*		
Whiting	*Merlangius merlangus*		
Whiting, blue	*Micromesistius poutassou*		
		Flatfish	
Brill	*Scophthalmus rhombus*	Scaldfish	*Arnoglossus laterna*
Dab	*Limanda limanda*	Solenette	*Buglossidium luteum*
Dover sole	*Solea solea*	Topknot, Imperial	*Phrynorhombus regius*
Flounder	*Platichthys flesus*	Topknot, Norwegian	*Phrynorhombus norvegicus*
Lemon sole	*Microstomus kitt*		
Plaice	*Pleuronectes platessa*		
Thickback sole	*Microchirus variegatus*		
Turbot	*Psetta maxima*		
Witch	*Glyptocephalus cynoglossus*		
Elasmobranchs			
Blonde ray	*Raja brachyura*		
Cuckoo ray	*Raja naevus*		
Lesser spotted dogfish,	*Scyliorhinus canicula*		
Nurse hound or bull huss	*Scyliorhinus stellaris*		
Spotted ray	*Raja montagui*		
Starry dogfish,	*Mustelus asterias*		
Starry smooth hound	*Mustellus mustellus*		
Thornback ray or roker	*Raja clavata*		
Tope	*Galeorhinus galeus*		
		Other Demersal	
Conger eel	*Conger conger*	Bull rout	*Myoxocephalus scorpius*
Grey gurnard	*Eutrigla gurnardus*	Butterfish	*Pholis gunnellus*
John Dory	*Zeus faber*	Butterfly blenny	*Blennius ocellaris*
Monk or anglerfish	*Lophius piscatorius*	Clingfish, two-spot	*Diplecogaster bimaculata*
Octopus, northern	*Eledone cirrhosa*	Dragonet, common	*Callionymus lyra*
Red gurnard	*Aspitrigla cuculus*	Dragonet, reticulated	*Callionymus reticulata*
Red mullet	*Mullus surmuletus*	Dragonet, spotted	*Callionymus maculatus*
Seabass	*Dicentrarchus labrax*	Goby, sand	*Pomatoschistus minutus*
Squid	*Alloteuthis subulata*	Lumpfish	*Cyclopterus lumpus*
Squid	*Loligo vulgaris*	Pipefish, greater	*Syngnathus acus*
Triggerfish	*Balistes carolinensis*	Pipefish, Nilsson's	*Syngnathus rostellatus*
Tub gurnard	*Trigla lucerna*	Pogge or Hooknose	*Agonus cataphractus*
		Rockling, five-bearded	*Ciliata mustela*
		Rockling, four-bearded	*Rhinonemus cimbrius*
		Sea scorpion	*Taurulus bubalis*
		Squid	*Sepeiola*
		Weever, lesser	*Echiichthys vipera*
		Wrasse, goldsinney	*Ctenolabus rupestris*
		Pelagic	
Garfish	*Belone belone*	Sandeel	*Ammodytes tobianus*
Mackerel, Atlantic	*Scomber scombrus*	Sandeel, greater	*Hyperoplus lanceolatus*
Scad or horse mackerel	*Trachurus trachurus*		
Sprat	*Sprattus sprattus*		
Crustacea			
Crab, brown	*Cancer pagurus*		
Crab, spider	*Maia squinado*		
Lobster, European	*Homarus gammarus*		
Shrimp, brown	*Crangon crangon*		
Molluscs			
Scallop, king	*Pecten maximus*		
Scallop, queen	*Chlamys opercularis*		
Whelk	*Buccinum caudatum*		

Table 3.4.3: The five-year (1999-03) average annual nominal landings (tonnes) by ICES rectangles from all UK-registered vessels fishing in Liverpool Bay: landings less than 1 tonne are shown as zero, a blank space indicates no reported landing. The total five-year average value is also shown.

	Rectangle Species	35 E6 N Wales Coast	36 E6 Sefton & Fylde	36 E7 Morecambe Bay S	Liverpool Bay Total t	 Total £
Gadoids	Whiting	14	30		44	20 714
	Cod	3	32	0	35	52 807
	Haddock	4	12	0	16	21 231
	Hake	1	1		2	2 694
	Pollack	0	1	0	1	1 343
	Saithe or Coley	0	1		1	377
	Pout Whiting	0	0	0	0	96
	Ling	0	0		0	139
	Total	**23**	**77**	**0**	**100**	**99 401**
Flatfish	Plaice	10	119	0	129	114 964
	Dover Sole	8	28	0	36	176 004
	Flounder	1	35	0	36	6 499
	Dab	0	11	0	11	1 893
	Brill	1	5	0	6	21 666
	Turbot	1	2	0	3	14 301
	Lemon Sole	0	1		1	3 558
	Megrim	0	0		0	18
	Sand Sole	0	0		0	91
	Witch		0		0	72
	Total	**21**	**201**	**0**	**221**	**339 066**
Elasmobranchs	Rays	40	87	0	127	128 629
	Spurdog	8	17		25	23 748
	Tope	0	1		1	224
	Unidentified Dogfish	0	1		1	564
	Greater Spotted Dogfish	0	0		0	10
	Lesser Spotted Dogfish	0	0		0	71
	Sharks	0	0		0	88
	Total	**48**	**106**	**0**	**154**	**153 334**
Other Demersal	Gurnards	5	29	0	34	11 553
	Monkfish	1	3		4	8 473
	Squid	1	2		3	8 646
	Bass	2	0		2	7 947
	Sea bream		0		0	4
	Catfish		0		0	1
	Conger Eel	0	0	0	0	252
	Cuttlefish	0	0		0	10
	Eel		0		0	46
	Greater Weever		0		0	12
	Grey Mullet	0	0		0	166
	John Dory	0	0		0	132
	Mixed Demersal	0	0	0	0	576
	Mixed Squid & Octopus	0	0		0	602
	Octopus	0	0		0	57
	Red Mullet	0	0		0	57
	Rockling	0		0	0	67
	Redfish	0			0	3
	Wrasse	0	0		0	0
	Total	**10**	**34**	**0**	**44**	**39 003**
Pelagic	Herring	0	0		0	0
	Mackerel	0	0		0	53
	Sprats	0			0	31
	Total	**0**	**0**	**0**	**0**	**84**
Crustacea	Nephrops		20	0	20	45 448
	Lobsters	2	0		2	18 008
	Brown Shrimps	0	0	0	0	2 237
	Crabs		0		0	117
	Total	**2**	**20**	**0**	**22**	**65 810**
Molluscs	Queen Scallops	145	1,949		2094	796 803
	Cockles	367			367	322 201
	Scallops	57	309		366	679 930
	Mussels	166	5	4	175	42 012
	Whelks		3		3	1 103
	Mixed Clams		0		0	213
	Periwinkles	0			0	175
	Total	**735**	**2,266**	**4**	**3005**	**1 842 437**

3.5 Marine Mammals Environmental Background

This section reviews the available literature to identify the species and distribution of marine mammals present within Liverpool Bay and the eastern Irish Sea. In addition, the results of a site-specific marine mammal survey undertaken within and around the Gwynt y Môr project area have also been drawn upon, to provide suitable baseline information (see Appendix 2 for survey report (Goold *et al.,* 2005)). Within UK waters all marine mammals are protected under both national and international legislation and this is further discussed within section 3.6.5.

3.5.1 Regional Review of Marine Mammal Distribution in the eastern Irish Sea & Liverpool Bay

There are few data sets concerning marine mammal distribution in this region either from effort-based dedicated survey vessels, land-based surveys, or from records of opportunistic sightings. As a result of this there is very little quantitative data available regarding the population sizes for marine mammals existing in Liverpool Bay and the eastern Irish Sea. However, some qualitative data does exist for the region resulting from marine mammal sightings. These sightings are normally reported to the Sea Watch Foundation (SWF) and such data is useful in providing an indication of the species likely to be present in or moving through particular regions.

Overall, the waters of this region are not considered to be rich in mammals compared to other parts of the United Kingdom, indeed, numbers in this region are considered to be so low that the SCANs project (an international investigation to estimate small cetacean abundance around UK waters, coordinated by the Sea Mammal Research Unit (SMRU) in 1994) chose not to survey this area (Hammond *et al*., 2002).

The marine mammals considered as being present within Liverpool Bay and the wider eastern Irish Sea are of the order Cetacea (whales and dolphins) and Pinnipeds (seals). Marine mammal species recorded within the region are as follows:

Fifteen species of cetaceans have been recorded within nearshore waters (within 60km of the coastline) in the eastern Irish Sea since 1975 (Evans, 1998). Of these fifteen species six are either present all year round or are recorded consistently as seasonal visitors. These are: harbour porpoise (*Phocoena phocoena*), bottlenose dolphin (*Tursiops truncates*), common dolphin (*Delphinus delphus*) and Risso's dolphin (*Grampus griseus*), minke whale (*Balaenoptera acutorostrata*) and long finned pilot whales (*Globicephala melas*). Of these the most commonly recorded within Liverpool Bay is the harbour porpoise (Evans, 1998).

In addition to these six species, a further nine cetacean species have been infrequently recorded in the eastern Irish Sea. These are: the striped dolphin (*Stenella coeruleoalba),* white-beaked dolphin (*Lagenorhynchus albirostris),* northern bottlenose whale (*Hyperoodon ampullatus)*, killer whale (*Orcinus orca),* Sowerby's beaked whale (*Mesoplodon bidens),* Atlantic white-sided dolphin (*Lagenorhynchus acutus),* sperm whale (*Physeter macrocephalus),* fin whale (*Balaenoptera physalus)* and the sei whale (*Balaenoptera borealis).* Due to the infrequent sightings of these nine species, it is generally considered that they are transitory visitors to the area.

Two species of pinnipeds (seal) are recorded as present in the eastern Irish Sea; these are the harbour seal (*Phoca vitulina*) and the grey seal *(Halichoerus grypus)* (Duck, 1996). The grey seal is the most commonly recorded pinniped within Liverpool Bay (Duck, 1996).

Cetaceans

This section further describes the distribution and ecology of the six cetacean species which are described as being either present all year round, or are recorded consistently as seasonal visitors within the waters of the eastern Irish Sea.

Harbour porpoise- This is the most widespread and abundant cetacean within UK waters (Baines, 2003). It is a small cetacean (approximately 1.5m in length), typically seen individually or in small groups of two to five animals, with occasional occurrences of larger feeding aggregations and is largely thought of as being a coastal species (Hoek, 1992; Reeves *et al*., 2002). Harbour porpoise are thought to be resident in the eastern Irish Sea throughout the year, although peak numbers are recorded within coastal areas between July and September (Evans, 1992; Northridge *et al.,* 1995; Bjørge & Øien, 1995; Rogan and Berrow, 1996; Read, 1999). In winter the coastal population is considerably reduced, and it is thought harbour porpoise movement is offshore towards the continental shelf, probably due to availability of prey (DETR *et al*., 2000). Prey species include benthic and demersal fish species e.g. gadoids, as well as pelagic schooling fish such as herring and mackerel, and cephalopods (Yasui and Gaskin, 1986; Aarefjord *et al*., 1995; Brodie, 1995; Gannon *et al*., 1998; Rogan *et al*., 2001).

Within this region, sightings of small numbers of harbour porpoise have been recorded close to Hilbre Island (Dee Estuary) as well as offshore from the Great Ormes' Head (Llandudno, Conwy). However, these recorded sightings within Liverpool Bay are limited when compared with data for areas surrounding Anglesey and the Isle of Man (Reid *et al.,* 2003).

Within the eastern Irish Sea harbour porpoise presence is described as 'regular' (NERC, 1998) and of all the cetacean species recorded within the region the harbour porpoise is by far the most common.

Bottlenose dolphin- These cetaceans are present year- round in Welsh waters, however, most sightings occur in April and between July and September (Reid *et al.,* 2003). They are seen in greatest abundance in and around Cardigan Bay, where a resident population of between 100-300 is present (Lewis, 1992; Arnold *et al*., 1997; Sea Watch Foundation, unpublished data). Within the eastern Irish Sea this species is generally uncommon with clusters of sightings occurring along the north coast of Anglesey, the south and southwest coasts of the Isle of Man, and in Morecambe Bay.

Bottlenose dolphin can grow up to 4m in length and, like the harbour porpoise, they often occur in small groups (2 to 15 animals) in coastal environments, also moving offshore during winter months. Prey species include benthic and pelagic fish such as eels, founder, dab, sole, salmon and trout all of which are present in Liverpool Bay (Reid *et al*., 2003).

Overall in Liverpool Bay bottlenose dolphin are described as being 'scarce/casual', although in adjacent waters to the north and west their presence is more regular (NERC, 1998). Records from the SWF show a small number of sightings of bottlenose dolphin off the Great Orme Headland in Liverpool Bay (Baines, 2003) and in the context of the wider Irish Sea and UK waters, the numbers of bottlenose dolphins present in Liverpool Bay are of minor importance, the nearest established resident populations being located in Cardigan Bay.

Common dolphin- This species is mostly associated with deeper waters as it is principally a pelagic species (Hui, 1979), although it can also be present in near shore areas. Within the Irish Sea, this species is thought to be significantly less common than other parts of the UK such as the west coast of Scotland and Ireland and the southwest of England (Reid *et al*., 2003). Most sightings in the Irish Sea occur between June and September, with group sizes numbering usually between one and twenty animals although occasionally up to fifty individuals or more are seen. Prey species are mainly pelagic fish such as mackerel, sardine, sprat and anchovy, and tend to forage in groups (Reid *et al*., 2003). Common dolphin are described as being 'scarce/casual' in the eastern Irish Sea (NERC, 1998).

Minke Whale and Long finned pilot whale- Both the minke whale and the long finned pilot whale belong to the cetacean suborder mysticetes (baleen whales). These are large oceanic whales that have adapted to the use of low-frequency sounds to communicate over long distances. Minke whales may be observed in UK coastal waters especially during summer months usually alone or in small groups (Reeves *et al*., 2002). Long-finned pilot whales are more common in deeper, offshore waters. Prey items for these species include pelagic fish, cephalopods and crustaceans.

The distribution of minke whales within Liverpool Bay and the eastern Irish Sea is described as 'occasional' and the presence of long-finned pilot whale is described as 'scarce/casual' (NERC, 1998).

Risso's dolphin- This cetacean is more commonly associated with deeper, offshore waters and regular sightings are reported off the southwest coast of the Isle of Man. Within Liverpool Bay the presence of Risso's dolphin is described as 'occasional' (NERC, 1998) and it is more regularly sighted around the Lleyn Peninsula and Bardsey Island off the north-west Welsh coastline.

Pinnipeds

This section further describes the distribution and ecology of the two pinniped species recorded within the waters of the eastern Irish Sea.

Grey seal- these are the most common pinniped species within UK waters, although they are comparatively rare worldwide. The UK population represents approximately 40% of the world population and 95% of the EU population (JNCC, 2004). Until the late 1970's there was licensed hunting and control measures of grey seals in the UK. Since this has ceased, numbers have increased; at the start of the 2000 breeding season, the British population numbered approximately 124,000 grey seals (JNCC, 2004).

Within Liverpool Bay grey seals are present along the coastline with haul-out sites at the mouth of the Dee Estuary and at West Hoyle Bank/Hilbre Island. Approximately 200 individuals are present throughout the year peaking in summer months between May to September to approximately 500 individuals. There are no records of major grey seal breeding sites within the region (Duck, 1996). These numbers and the size of the Irish Sea populations of Grey Seals as a whole are considered to be insignificant compared to the overall UK population (Duck, 1996).

Prey items include small flat fish and gadoids (cod and whiting) and invertebrates such as squid. Tracking studies undertaken by the Sea Mammal Research Unit have shown that grey seals may forage for prey over a very large area (SMRU, 2002). Also, investigations of seal foraging behaviour at the Rødsand offshore wind farm (Denmark), established average foraging ranges of 3,980km^2 for grey seals (Dietz *et al.*, 2001). From this it can be concluded that grey seals, which are present at the haulouts at the mouth of the Dee Estuary, will forage throughout the whole of Liverpool Bay and a large proportion of the eastern Irish Sea.

Harbour seal- these are the most widespread pinniped species worldwide, inhabiting the seas of the North Atlantic and North Pacific. Within this region they are rare visitors with only very occasional individuals being reported in proximity to Hilbre Island (Duck, 1996) and are much more common on the east coast of England and the west coast of Scotland. Harbour seals are opportunistic hunters feeding on fish, molluscs and crustaceans.

The overall paucity of sightings of marine mammals within Liverpool Bay is likely to reflect a genuine low level distribution of marine mammals within the area. Although, it may also be due in part to a low survey coverage of the area resulting in a limited data set concerning populations of cetaceans and pinnipeds within this region. It is also important to consider that marine mammals are highly mobile with their distribution primarily led by food and feeding (Northridge *et al.*, 1995). Therefore, although high numbers of marine mammals are not regularly sighted within the region, there are larger numbers of many species recorded in other parts of the Irish Sea to the north and the west of the region and it is possible that these marine mammals will pass through the Liverpool Bay area in transit to other locations, even if their presence is not prolonged or regular.

3.5.2 Site-Specific Marine Mammal Monitoring at the Gwynt y Môr Offshore Wind Farm Project Area

Introduction

Records of sightings of marine mammals within Liverpool Bay, and more specifically, at the Gwynt y Môr Offshore Wind Farm project area itself are relatively low. As discussed above, this may be as a result of low densities of marine mammals within the region or possibly due to low marine mammal survey intensities of the area. It was therefore deemed necessary, following detailed consultation with the Countryside Council for Wales (CCW) to undertake a site-specific survey of the Gwynt y Môr project area to gain a better understanding of marine mammal population distributions.

The Institute of Environmental Science, University of Wales, Bangor undertook this program of surveys between the months of December 2003 and March 2005 (see Goold, 2005 (Appendix 2)). The survey was conducted over an annual cycle to gain a full seasonal data set allowing any increases in populations (as suggested occurs over summer months for certain species for example) to be studied.

Survey Design & Methods

Marine mammal population assessments are generally undertaken using ship-based surveys along line transects using observers. Other methods include the use of hydrophones which allow the vocalisations of marine mammal species to be detected, including in conditions which would prevent visual monitoring such as low visibility. Hydrophones can either be static, to detect marine mammals within a certain radii, or can also be towed along transects. However, marine mammals must be actively vocalising for hydrophone systems to be effective.

Due to the advantages and disadvantages of both techniques it was decided that a multi faceted approach to the survey would be the most effective to collect data concerning the marine mammal distribution and species found at Gwynt y Môr and within the surrounding environment. A combination of ship based surveys, static hydrophone loggers and land-based surveys were undertaken to collect both visual and acoustic data.

Vessel Based Line Transects- These were undertaken monthly between December 2003-November 2004 over a two day period along ten east-west transect lines across the survey area (see Appendix 2 for locations). Observer pairs were used to scan 90^o swaths of the sea from positions on the high foredeck using both the naked eye and binoculars. Environmental factors such as sea state and visibility were recorded and when marine mammals were sighted entries were made onto encounter forms regarding information such as number, species, position, direction of travel and assessment of behaviour e.g. foraging.

In addition to observers, towed hydrophones and TPODs were also used along the same transects as both a complementary survey tool and to extend the survey effort through the visual off-effort periods and through the night. The hydrophone was towed some 400m behind the vessel and was linked to a click detector, the output from which was recorded onto time coded digital audio tape (DAT). The click detector was used because the primary target species was harbour porpoise (which produce ultrasonic echolocation clicks) but it should be noted that dolphin clicks would also trigger the click detector. However, since harbour porpoise were the only cetacean species expected to occur within the survey area with any regularity, it was a reasonably assumption that click detections would result from harbour porpoise encounters. Therefore, when acoustic detections were made in the absence of a visual sighting, it was assumed to be a porpoise encounter, although it is acknowledged that the species ID cannot be confirmed. The towed TPODs were able to differentiate between the harbour porpoise and bottlenose dolphin clicks.

Static loggers- these were deployed on the seabed at three locations: Constable Bank, North Hoyle Cardinal and Offshore (located within the Gwynt y Môr project area) from March 2004-2005 (see Appendix 2 for exact locations). These locations were chosen due to the presence of Cardinal Buoys to reduce the risk of vessel collision or the accidental dredging up of the loggers by fishing vessels. The offshore location was considered to be high risk due to its exposure and the frequent use of the area by fishing boats and as a result the logger was only deployed here after successful recoveries and redeployments at the other two sites during the months of March and April.

Land based Visual Survey- A total of 18 visual surveys were undertaken between March-November (2004) at the Great Orme Headland (Llandudno) chosen for its suitability as a promontory for visual observations of inshore waters. Reticulated binoculars were used to sweep an area from Anglesey to the western end of the Gwynt y Môr project area in an 180^o arc. Data concerning the date, time, magnetic bearing, reticule reading, species number, adult, juvenile, calf, sea-state, bird activity and general notes were all recorded.

Data Analysis

Overall the vessel based surveys covered a total transect line mileage of 3,068 nautical miles (5,685 km) during the 12 month survey period. The combined visual and towed acoustic survey component of the transects totaled 1,681 nautical miles (3,114 km), the remaining 1,387 nautical miles (2,571 km) was run as acoustic only surveying, typically during the night-time periods.

Visual data- data collected from the vessel based observational monthly surveys were used to assess the distribution of marine mammals throughout the survey area during each month as well as the composite distribution throughout the year. Results were also used to calculate the frequency of group size as well as compare with results from the acoustic surveys and assess mammal behaviour. Results from the land based visual surveys were compared and the percentage of marine mammal positive scans (i.e. scans within which a marine mammal was sighted) per month could be expressed and, in addition, a comparison of relative abundance was also possible.

Acoustic data sets- for the towed hydrophone the click detector produced audible pulsed signals that could be recognised as a cetacean click train in post-cruise analysis of the recordings. Detections were scored simply as events with no indication of the number of animals, due to the uncertainty of how many animals were involved in a particular encounter. The hydrophone was unable to distinguish the range and direction of the mammal(s); because detection ranges are likely to be small (within a few hundred metres) the interpolated vessel position was used as an adequate indicator of the mammals position. The data was used to produce maps of cetacean distribution throughout the area, which were then compared with other data such as visual recordings.

Data from the static TPOD loggers was downloaded monthly and processed to express data as Train Positive Minutes (TPM) per day, which equates to the number of minutes per day when echolocation click trains were detected. These results were then plotted out to express any trends in TPM for the total deployment using a high and low probability detection category.

Summary of the Results of the Site Specific Studies

Cetacean Species

Harbour porpoise and bottlenose dolphins were the only cetacean species recorded from the surveys.

Harbour porpoise were the only species sighted during the visual transect surveys with a total of 60 sightings comprising of 84 individuals throughout the twelve month period. Sightings were generally of single adults, although small groups of between 2-5 porpoise were also observed on occasion and both feeding activity and travelling behaviour were reported.

Peak numbers were observed during the months of April and May (28 and 8 porpoise respectively) with intermediate numbers recorded each month from August to November and only one sighting incidence during the months of December, January and March with no individuals recorded during the months of February, June and July.

Sightings of harbour porpoise as part of the land based survey occurred in the inshore waters around the Great Orme in 8 out of 9 months surveyed, from March to November. The highest proportion of porpoise positive scans occurred in March, April and November. Calves were sighted for 4 out of 8 months in which porpoises were observed. Between March and June the maximum number of porpoises per scan were low ranging only between 2 and 3. This increased in the month of July but decreased again from August to October, finally peaking at a maximum value of 16 in the month of November. Bottlenose dolphins were observed on only one occasion from the Great Orme during November when approximately 20 individuals, including calves, were observed travelling through the area.

The results from the towed hydrophone surveys recorded 153 cetacean detections throughout the survey period (these were assumed to be harbour porpoise). Although hydrophone detections were more numerous than the visual sightings they did show similarities in monthly distribution and frequency with the visual data. There were only 2 towed TPOD cetacean detections (both of harbour porpoise) throughout the survey both occurring during the month of September.

Results from the static TPODs indicate that the area is utilised by harbour porpoise throughout the year. However, data from these also indicated a seasonal trend of population with increased activity registered between January and March at the offshore location. The TPOD located at Constable Bank also displayed elevated echolocation activity during the month of April coinciding with the peak sightings recorded from the transect surveys. The highest records overall of harbour porpoise activity were also from the inshore static TPOD deployed at Constable Bank located outside the Gwynt y Môr Offshore Wind Farm project area with much higher train clicks recorded than at the other two TPOD locations.

On one occasion, during the month of May, bottlenose dolphins were also detected by the static TPODs deployed at the North Hoyle cardinal buoy. As bottlenose dolphins were only detected once from the TPODs and once from the land based survey it suggests that they are only transitory visitors to the area unlike harbour porpoise which are present year round.

The results are suggestive of sightings clustering along depth contours of Liverpool Bay. The relatively high count of porpoises during April and May could be due, in part, to the availability of food at that time. Porpoises were seen engaging in both traveling and feeding activity, and anecdotal reports and local knowledge from fishermen suggest a run of herring through the survey area during April (Jones, *pers comm*). In June-July there was a noticeable 'scum' of phaeocystis plankton bloom on the water surface. This type of algal bloom produces a protenaceous scum that may reduce dissolved oxygen levels in the water and may deter fish species that would be preyed upon by marine mammals.

Harbour porpoise were considered to be the most widespread and abundant cetacean species within UK waters and the results from this survey indicate that it is the most abundant species within the waters of Liverpool Bay. Results also support the fact that this species is considered to be resident throughout the year in the waters of Liverpool Bay and are in agreement with the statement based on sightings data that this species is considered to be 'regular' within the eastern Irish Sea (NERC, 1998). The two incidences of bottlenose dolphin detections are also consistent with the statement that within the eastern Irish Sea bottlenose dolphins are described as being scarce/casual (NERC, 1998).

Overall the results do tend to confirm that the waters of this part of Liverpool Bay, including the Gwynt y Môr project area, are not rich in cetacean species when compared to other parts of the United Kingdom.

Pinniped Species

The Grey seal (*Halichoerus grypus*) was the only pinniped species recorded within the region throughout the visual transect and the land based surveys and all records were of solitary adults.

Grey seals were recorded from six of the months surveyed as part of the visual transect surveys. The highest numbers sighted were during the months of April and May (24 and 19 individuals respectively). No sightings were recorded during the period of December-March and June and July. From the period August to November there were intermediate numbers of sightings by month with the exception of September, in which a relatively high number of sightings occurred (15 individuals). The frequency of high seal numbers in the months of April and May mirrored that of the harbour porpoise. Distribution patterns show that during April and May sightings were concentrated to the north of the Gwynt y Môr Offshore Wind Farm project area (see Figures 3.5.1), and several of the animals were seen to be feeding. During September, the pattern seemed to have changed, with sightings concentrated to the south west of the Gwynt y Môr project area (see Figure 3.5.2). For the remainder of the year sightings were too sporadic to discern a pattern.

Low numbers of grey seals (1 or 2 individuals) were also recorded during the land based visual surveys between the months of March, April and June.

These results are in keeping with information that the grey seal is the most common pinniped species within the waters of the eastern Irish Sea. The low numbers of seals recorded during this survey are also in agreement with previous information that numbers of grey seals in this region are not considered to be significant within the context of the whole UK population. It is thought that seals from Hilbre Island/West Hoyle Bank haul out areas will forage throughout the whole of Liverpool Bay. The patterns of seals recorded indicate that seal distribution is throughout the wider area.

Distribution of Marine Mammals at the Gwynt y Môr Offshore Wind Farm Project Area

Harbour porpoise were the only cetacean species recorded within the Wind Farm project area. The distributions of harbour porpoise from the visual and acoustic surveys are given in Figures 3.5.3 and 3.5.4. Data from the visual sightings shows that harbour porpoise were recorded across the entire survey area including within the Gwynt y Môr project area itself. Elevated concentrations of sightings can be noted to the north east, south and west of the Gwynt y Môr project area and, to a certain extent, these concentrations (especially in the southern area) seem to mirror the water depth contours of Liverpool Bay. Acoustic distribution data shows that harbour porpoise are recorded consistently along transects both within and outside the Gwynt y Môr project area (see Figure 3.3.4). Although greater incidences are recorded within the project area from the acoustic data when compared to data from the visual surveys, the distribution within the Gwynt y Môr is generally similar to the distribution throughout the wider survey area and is not considered to represent an area of any specific significance to these species when compared to the wider Liverpool Bay area.

The static TPOD loggers showed that the highest number of cetaceans were found at the inshore Constable Bank TPOD (located to the south west of the project area) rather than those deployed within/close to the boundary of the Gwynt y Môr Offshore Wind Farm project area. Observational behaviour recorded within the project area included feeding and travelling by harbour porpoise.

Casual observations of common dolphin were also made on one occasion within the project area during the marine benthic characterization surveys (CMACS, field observation, 2004) where a large number of individuals with calves were sighted moving from east to west through the Gwynt y Môr project area. This is in keeping with the statement that common dolphin are scarce/casual visitors to the region (NERC, 1998).

The results from the annual site-specific visual transect survey reveal that grey seals are found throughout the area including within the boundary of the Gwynt y Môr Offshore Wind Farm project area (see Figure 3.5.5). However, the overall pattern reveals that these sightings are mostly concentrated in the region to the north of the project area and, to a lesser extent, at the south east of the Gwynt y Môr project area with actual numbers within the project area being relatively low. There also appears to be a slight trend of sightings following the depth contours of Liverpool Bay, most notably in the south of the survey area. If the results of the annual transect surveys are considered on a monthly basis for Grey Seals a clear pattern emerges for the months of April and May with concentrations of grey seals to the north of the Gwynt y Môr project area (see Figure 3.5.1). In September, this distribution switches to higher concentrations of seals inshore from the project area (see Figure 3.5.2).

Reasons postulated for this are that the seals are feeding at the highly productive Liverpool Bay Plankton front (see section 3.2) which is located to the north of the project area. In September, sea temperatures are at their warmest and productivity is high and it is likely that the seals are following their prey species and feeding in the inshore areas. No other patterns of distribution were discernable for other months due to the sporadic nature of the sightings.

3.5.3 The Eastern Irish Sea Seal Tagging Studies

As part of the Department of trade and Industry's (DTI) Strategic Environmental Assessment (SEA) process for the Irish SEA (SEA6) the Sea Mammal Research Unit (SMRU) has undertaken a study to provide information concerning the distribution of Grey Seals around the waters of Wales (*Hammond et al.,* 2005).

This study utilised satellite-linked telemetry to track 19 seals from a period of July- December 2004 from various haul out areas around Wales (including Hilbre island within Liverpool Bay) allowing any emergent patterns of movement to enable identification of certain usage of particular areas by grey seals.

The results from this study revealed several areas displaying a pattern of high use by the tagged seals. One of these areas was the North Wales coastline offshore to a distance of 40km. Other identified areas including from the west of the Lleyn peninsula over to the coast of Ireland, showed that much of the southern part of the Irish Sea is also extensively used by grey seals.

As the predicted, at-sea usage was based upon return trips to the same haul-out site where these seals were tagged, the identified high-use areas are considered to be foraging areas and overall, from the results of the study, it was concluded that a significant portion of the SEA6 area (Irish Sea) is clearly important as foraging habitat for the grey seals which haul out in both Wales and Ireland (Hammond *et al.,* 2005).

3.5.4 Summary

The eastern Irish Sea and Liverpool Bay areas are not considered as having extensive marine mammal populations. Six species of cetacean are either present all year round in the eastern Irish Sea or are recorded consistently as seasonal visitors and the most common species found is the harbour porpoise. Pinnipeds occur in low numbers in this region compared to the wider UK populations. The grey seal is the most common pinniped species in the area with haul outs recorded at the mouth of the Dee Estuary (although in low numbers). The harbour seal is recorded very rarely in these waters. All marine mammals are protected under both national and international legislation.

Due to a lack of data sets specifically concerning the distribution and numbers of marine mammals within Liverpool Bay a site-specific survey was undertaken. This was conducted at Gwynt y Môr Offshore Wind Farm and the surrounding area using a multi-faceted approach of ship and land based visual surveys and acoustic data collection methods using towed hydrophones and TPODs as well as static TPODs over an annual cycle. Overall marine mammal numbers were relatively low with three marine mammal species recorded from the survey; harbour porpoise, bottlenose dolphin and grey seal. Harbour porpoise and grey seals were the only marine mammal species sighted or detected in the survey area with any regularity. Bottlenose dolphins were sighted and detected infrequently and are considered to be transient or occasional visitors.

The recorded distributions indicated a seasonal pattern in the occurrence of marine mammals which was similar for both harbour porpoises and grey seals and showed elevated numbers in late spring/early summer then again in Autumn possibly indicating movements to inshore waters following food or to breed, followed by an offshore migration in late Autumn. Within the project area itself only harbour porpoise and grey seal were recorded during the site-specific marine mammals surveys although casual sightings of common dolphin at the site were also noted.

The results from the Gwynt y Môr site-specific study are in agreement with the literature and confirm that the area is generally poor in marine mammal diversity and numbers when compared to other areas around the UK coast, and that the harbour porpoise is the most common cetacean within Liverpool Bay.

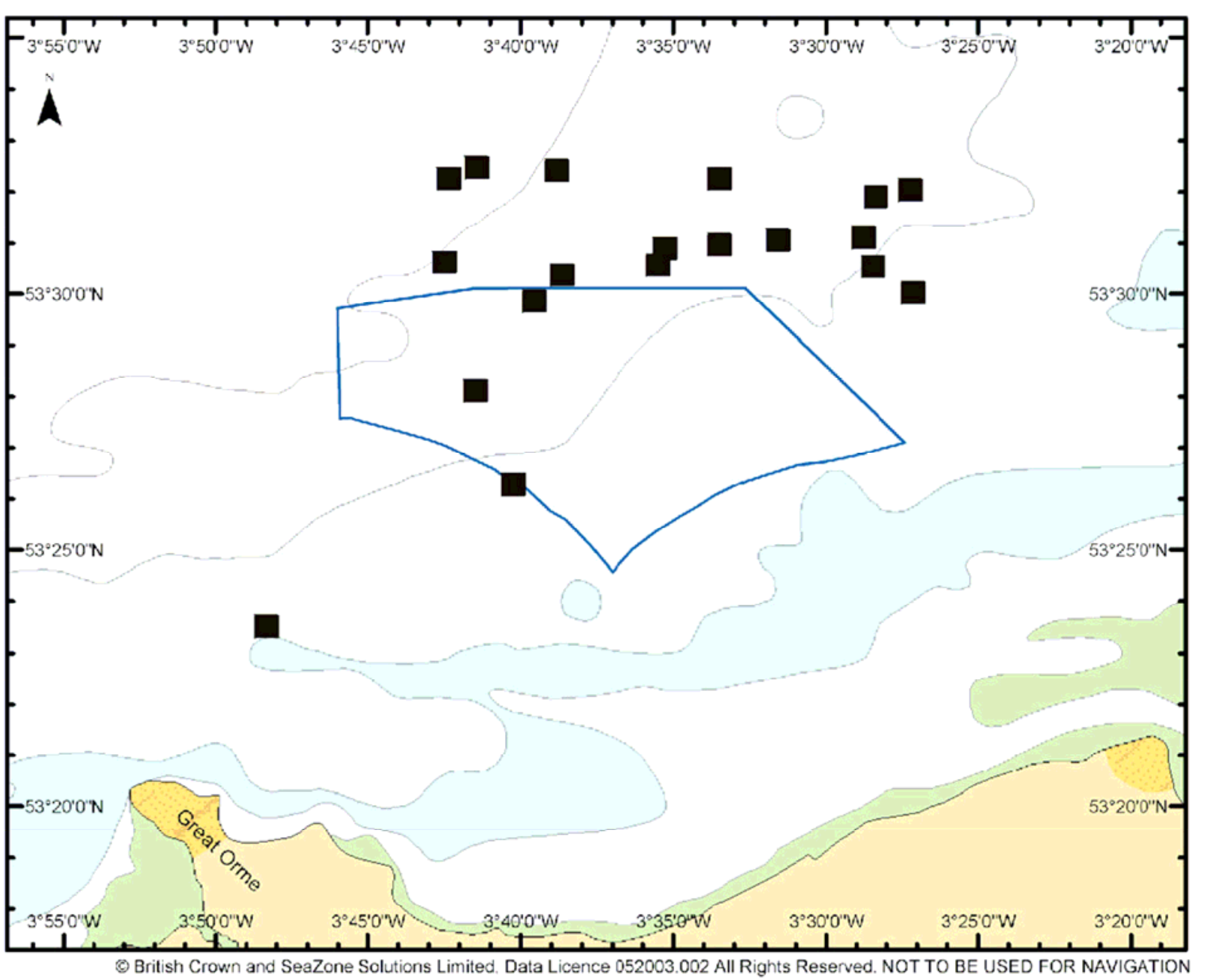


Figure 3.5.1: Position of Grey seal sightings during the survey month of May 2004

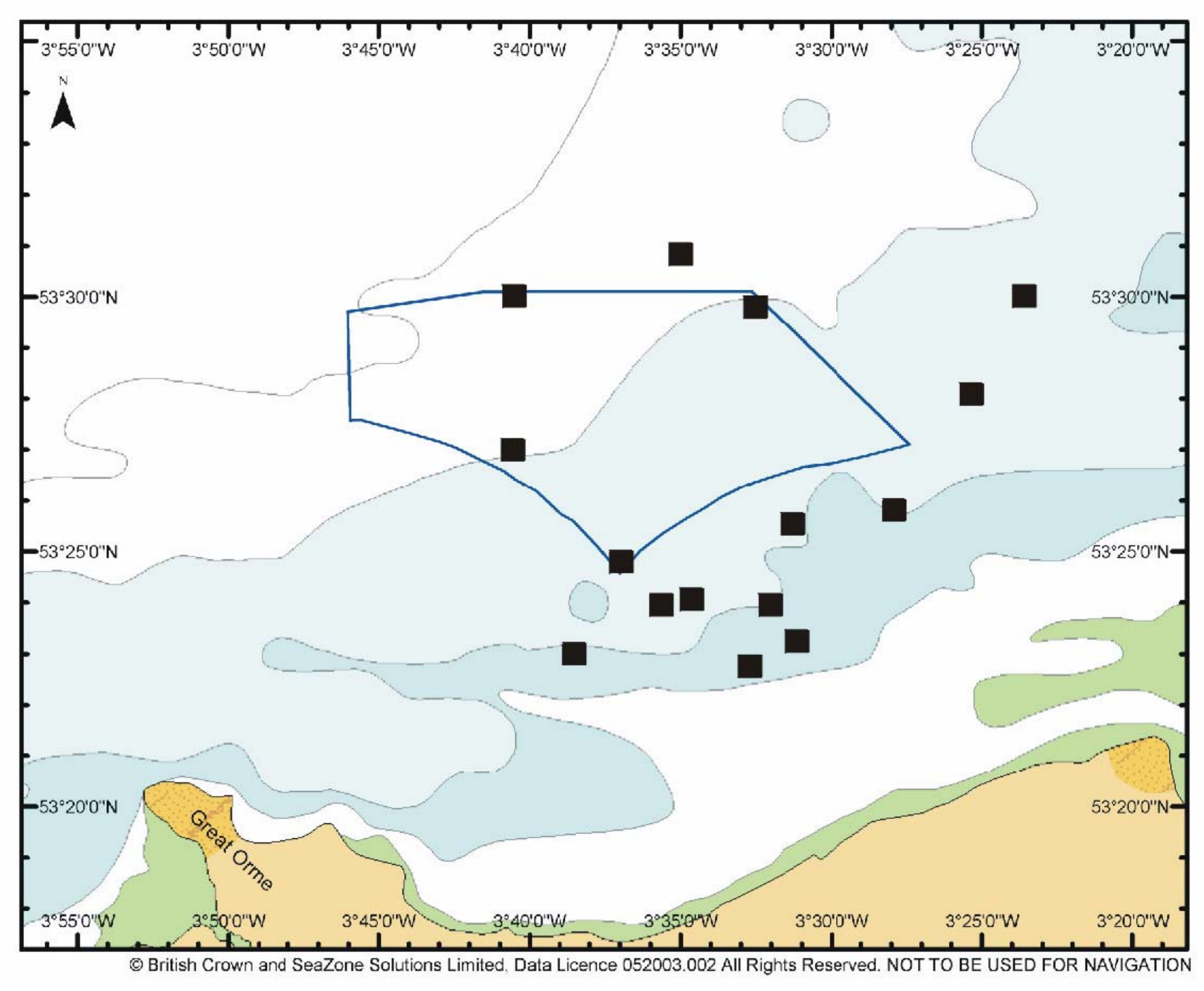


Figure 3.5.2: Position of Grey seal sightings during the survey month of September 2004

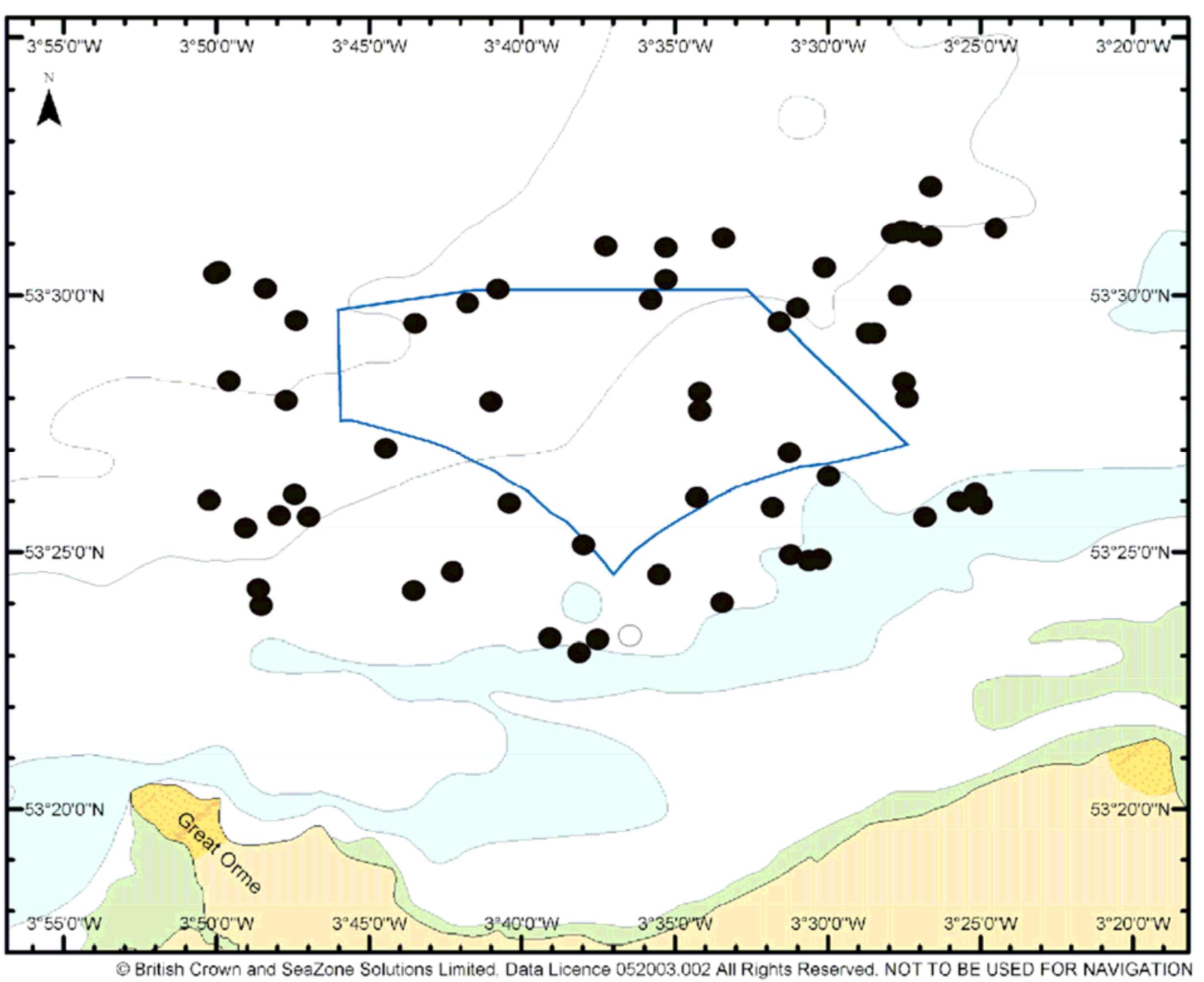


Figure 3.5.3: Distribution of harbour porpoise within and around the Gwynt y Môr project area between December 2003 and November 2004 (based upon pooled data from the visual transect surveys).

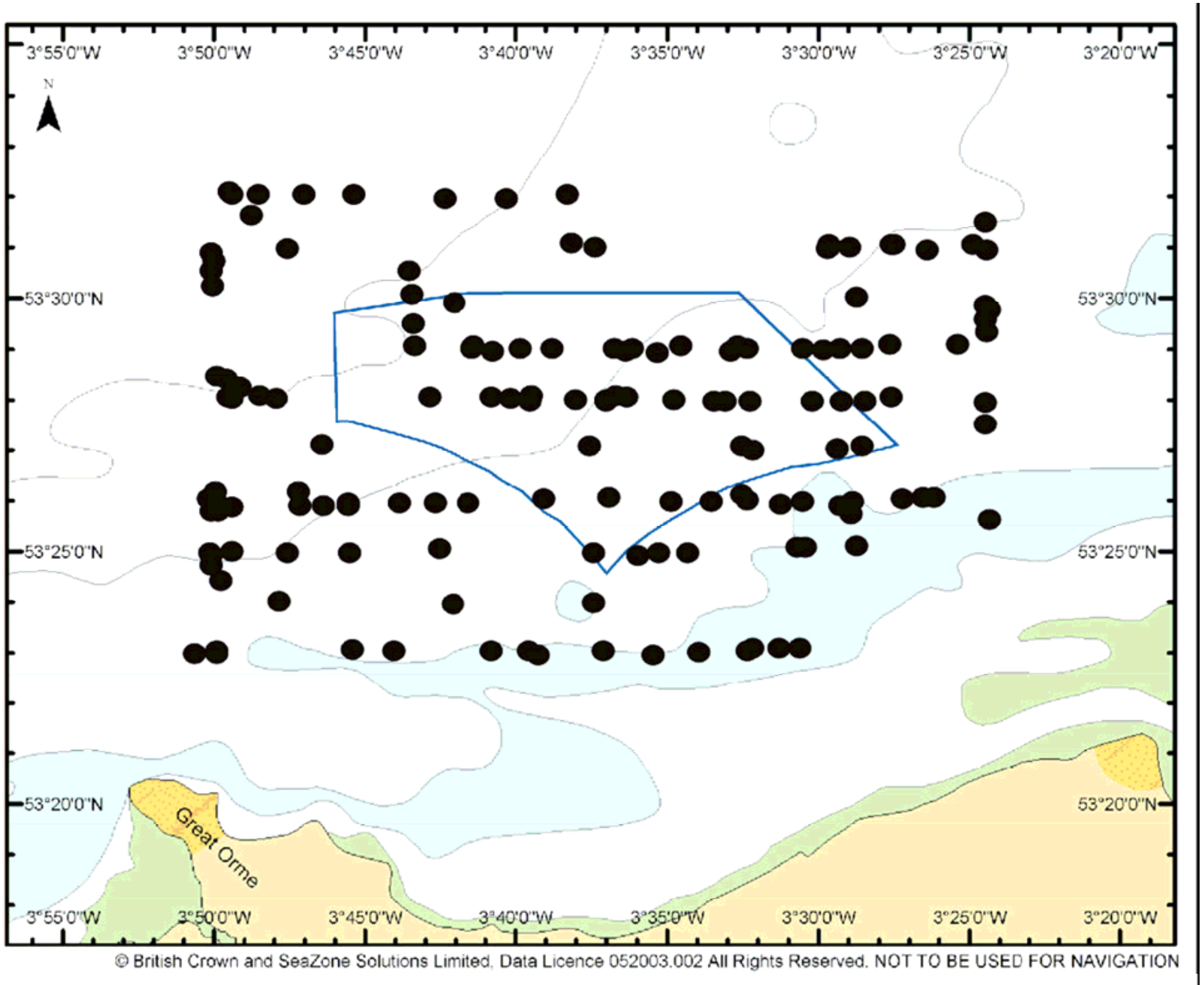


Figure 3.5.4: Distribution of harbour porpoise within and around the Gwynt y Môr project area between December 2003 and November 2004 (based upon pooled data from the acoustic transect surveys).

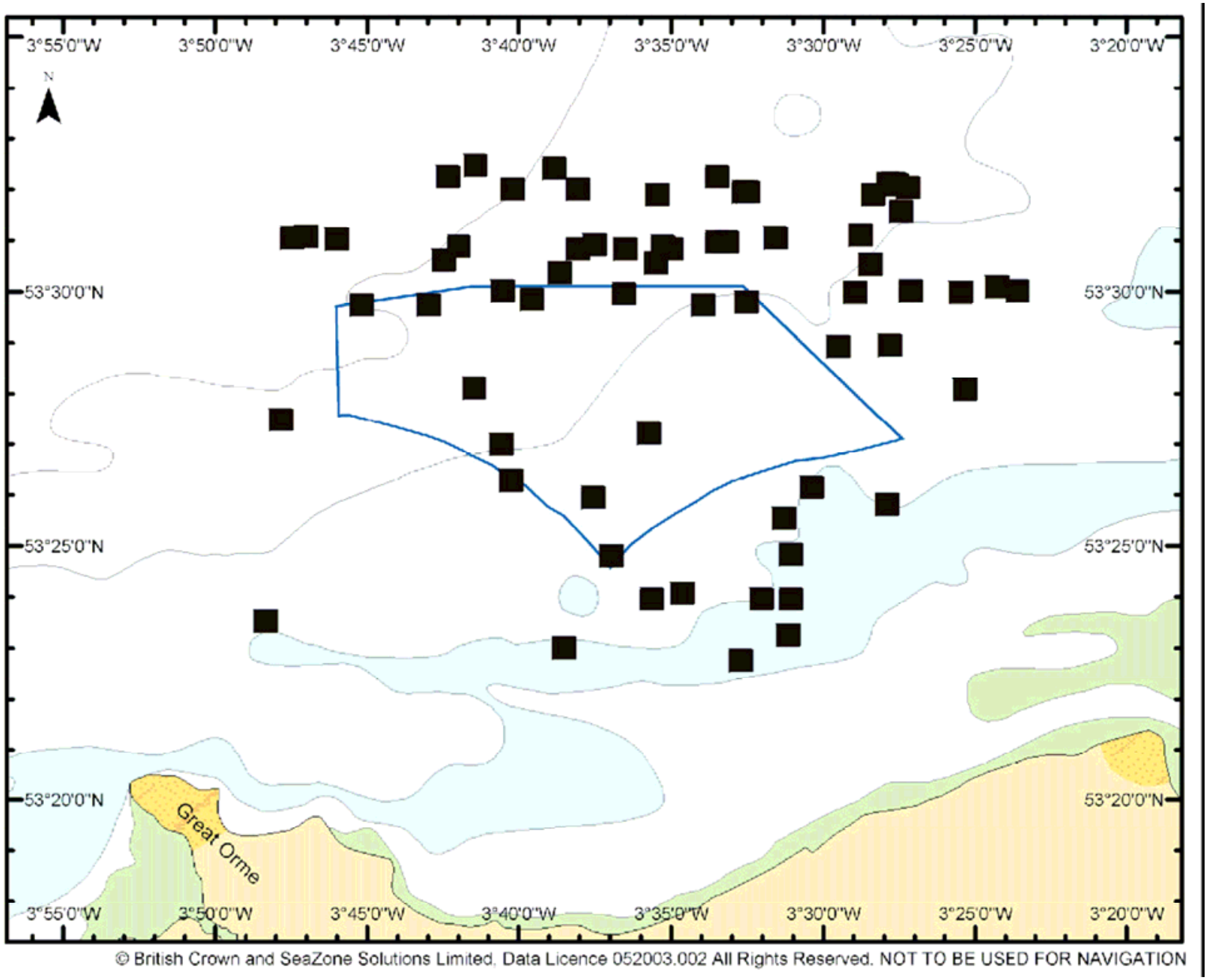


Figure 3.5.5: Distribution of grey seals within and around the Gwynt y Môr project area between December 2003 and November 2004 (based upon pooled data from the visual transect surveys).

3.6 Nature Conservation Environmental Background

This section is a review of the habitats and species found within Liverpool Bay in proximity to the Gwynt y Môr Offshore Wind Farm project area and the wider region, which are considered as being important for their nature conservation aspect. Much of the United Kingdoms biodiversity is to be found within its marine and coastal environment, including internationally important populations of birds, mammals and commercially important fish stocks. Many of these habitats and species are afforded international protection through a number of international natural heritage obligations which the UK government has entered into. Such habitats and species may also be protected under national legislation or through non-statutory designations such as those implemented by local authorities and agencies. It should be noted that whilst some consideration has been given to terrestrial sites and species and areas designated for their ornithological interest, not all have been mentioned here and these have been considered in further detail within other reports (e.g. ERM, 2005) and this section is concerned with areas and species found within the marine and coastal environment.

3.6.1 International Designations

Ramsar Sites

Ramsar sites are wetlands of international importance and are designated under the intergovernmental treaty: "The convention on wetlands" as signed in Ramsar, Iran (1971). These sites are designated for their waterfowl populations, their important plants and animal assemblages, their wetland interest or a combination of these and the convention allows for such sites to extend to 6m below mean low water (JNCC, 2005).

Within Liverpool Bay and the surrounding area there are six Ramsar sites. These are identified in Table 3.61 and their locations, with respect to Gwynt y Môr, displayed in Figure 3.61. The closest designated RAMSAR site to the Gwynt y Môr is the Dee Estuary located 14.2 km to the south east of the project area.

Special Areas of Conservation (SACs) and Special Protection Areas (SPAs)

SACs arise from the Habitats Directive (Council Directive 92/43/EEC on the Conservation of Natural habitats and of Wild Fauna and Flora) which requires European member states to set up a series of sites for the purpose of contributing to the maintenance/restoration of favourable conservation status of habitats or species listed in Annexes I and II of the Directive (WWF-UK, 2001).

Special Protection Areas (SPAs) arise from the Birds Directive (Council Directive 79/409/EEC on the Conservation of wild birds). This directive requires member states to conserve habitats for certain rare or vulnerable species in addition to regularly occurring migratory species of birds. This is achieved through the designation of statutory special protection areas (SPAs) by the UK government acting on the advice of the statutory conservation agencies, and such designation is implemented through the Wildlife and Countryside Act 1981. Within the UK all SPAs are first notified as SSSIs (WWF-UK, 2001).

Collectively SACs and SPAs are referred to as Natura 2000 sites. SAC and SPA areas identified within the coastal areas of Liverpool Bay are discussed below and displayed in

Figures 3.6.2 and 3.6.3 (as noted previously; SPAs are discussed in further detail in ERM, 2005).

- **Corsydd Mon/Anglesey Fens SAC (distance and direction to project area: 36km SW)**

The Anglesey Fens support the second-largest area of calcareous fens in the UK and is composed of four component fen systems that are heavily influenced by the underlying carboniferous limestone and fed by calcareous groundwater. The site contains one of the largest known populations of Geyer's whorl snail, *Vertigo geyeri,* and this Annex II species is a primary reason for this SAC's selection. Other Annex II species, which are present as a qualifying feature, but not a primary reason for site selection, are the Southern damselfy, *Coenagrion mercuriale* and the March fritillary butterfly *Euphydryas aurinia.*

- **Conwy Bay and Menai Straits SAC (26.3km SW)**

This SAC extends from the western entrance of the Menai Strait to Llandudno's Little Orme in the east and includes Lavan Sands (Traeth Lafan), Four Fathom Banks, the Foryd Estuary, part of the Conwy Estuary, in addition to part of the northeast Anglesey coastline as far as Traeth Lligwy.

This SAC is important for the importance of its qualifying habitats of reefs, subtidal sandbanks, intertidal mudflats and sandflats, in addition to a significant presence of sea caves and large shallow inlets and bays.

The reef areas are dominated by a diverse range of fauna, which because of the turbid and strong tidal environment are mostly filter feeders such as large colonies of sponges. Similar sponge-dominated communities are only recorded from a few other areas in UK waters such as Plymouth Sound and Milford Haven. Other filter-feeding organisms such sea squirts, hydroids and bryozoans are also abundant.

The limestone reefs and caves located around Anglesey's south-eastern shores, Puffin Island and the Great and Little Orme represent another distinctive and relatively rare habitat. The reefs are home to several rock-boring species together with some limestone specialists, including the rock-boring sponge *Cliona celata*, piddocks *Hiatella arctica,* and acorn worms *Phoronis hippocrepia.* The intertidal rocks present in proximity to the caves are also abundant in species.

The extensive intertidal mudflats and sandflats within the Menai Strait and Conwy Bay are also very rich in species, including worms, crustaceans and bivalves and are an important food source for many bird and commercially important fish species. The Four Fathom Banks is also a relatively rare habitat within Welsh waters as the large subtidal sandbank is fairly sheltered from wave action even though it is situated in an area of open coast.

In other parts of Conwy Bay and in the waters off Red Wharf Bay, differing tidal strengths and exposure to waves and salinity result in a wide variety of habitats, including mud, sand, gravel and mussel beds. The Foryd Estuary, which is also included as part of this SAC, contains patches of dwarf eelgrass, along with several areas of saltmarsh and muddy sediment communities.

- **Eryri/Snowdonia SAC (28.2km SW)**

Llyn Idwal, in the mountains of Snowdonia, represents oligotrophic waters and no overall change in the lake's water chemistry has been found since the mid-19th century, and the water quality is considered to be high. The site has a good representation of typical plant species, including quillwort *Isoetes lacustris*, water lobelia *Lobelia dortmanna*, shoreweed *Littorella uniflora*, bulbous rush *Juncus bulbosus*, alternate water-milfoil *Myriophyllum alterniflorum* and intermediate water-starwort *Callitriche hamulata*. Bog pondweed *Potamogeton polygonifolius* has been recorded from stream inlets, and pillwort *Pilularia globulifera* is reported from this site. Emergent and floating vegetation is mainly confined to the shallow sub-basin at the south end of the site, where floating bur-reed *Sparganium angustifolium* forms extensive mats, alongside stands of common reed *Phragmites australis*, water horsetail *Equisetum fluviatile* and bottle sedge *Carex rostrata*.

In addition, Snowdonia has the best-developed and most extensive areas of Siliceous alpine and boreal grasslands in Wales. It is also the largest site in Wales representative of siliceous scree and is representative of Calcareous rocky slopes with chasmophytic vegetation at one of its most southerly outposts in the UK, and contains the most extensive and diverse examples of these communities in Wales.

- **Coedwigoedd Penrhyn Creuddyn/ Creuddyn Peninsula Woods SAC (16km SW)**

Creuddyn Peninsula Woods has developed on a series of craggy Carboniferous limestone hills, and is a large example of *Tilio-Acerion* forest near its western extreme at this latitude in the UK. The site is one of three selected to represent the geographic range and variation of this habitat across the Carboniferous limestone of north Wales. The canopy is primarily of ash *Fraxinus excelsior* and sycamore *Acer pseudoplatanus*, with a calcicolous understorey and ground flora. Characteristic species include dog's mercury *Mercurialis perennis*, hart's-tongue *Phyllitis scolopendrium* and spurge laurel *Daphne laureola*. Yew *Taxus baccata* dominates locally, and there are gradations to oak *Quercus petraea* woodland. In places there are mosaics with rich calcareous grassland containing many rare species.

- **Great Orme Head land SAC (14.7km SW)**

The Great Orme is designated as an SAC due to the presence of three Annex I habitats, which are its qualifying features. These are: vegetated sea cliffs, European dry heaths (of which the Great Orme is considered as being one of the finest examples within the UK), and semi-natural dry grasslands and scrub on calcareous substrate (*Festuca-Brometalia*).

- **Coedwigoedd Dyffryn Elwy/ Elwy Valley Woods (21km S)**

Elwy Valley Woods is one of three sites selected to represent *Tilio-Acerion* forest across its geographic range on the Carboniferous limestone of north Wales, and is an example of the habitat with an outstanding lower-plant flora. The canopy is quite varied: ash *Fraxinus excelsior* is the commonest tree, but there is also occasional small-leaved lime *Tilia cordata* and wild service-tree *Sorbus torminalis*. There is a rich, calcicolous understorey and ground flora, and rare bryophytes include *Bryum canariense*, *Cololejeunea rossettiana*, *Plagiochila britannica*, *Platydictya confervoides* and *Isothecium striatulum*. The woods have developed along steep valley-sides and ravines that are also important for their cave systems and Pleistocene fossil mammal assemblages.

- **Llwyn SAC (30km S)**

Llwyn is one of the largest examples of alluvial forest in Wales. The woodland has formed on level ground on the floodplain of the River Clywedog, and has a canopy of alder *Alnus glutinosa*, with transitions to ash *Fraxinus excelsior* dominance on relatively drier ground. The structure is mature, with massive trees, abundant dead wood, and a rich understorey including abundant bird cherry *Prunus padus* and guelder rose *Viburnum opulus*, and occasional buckthorn *Rhamnus cathartica* and alder buckthorn *Frangula alnus*. The ground flora is diverse, including both wet woodland species, such as yellow iris *Iris pseudacorus* and remote sedge *Carex remota*, and those characteristic of drier ash-maple woodlands, such as ground-ivy *Glechoma hederacea* and moschatel *Adoxa moschatellina*. Although one of the largest examples of this woodland type in Wales, the total area is only modest, and the site is constrained by agricultural land and lack of natural dynamic disturbance.

- **Deeside and Buckley Newt Site SAC (37.5km SE)**

This site in north-east Flintshire is located on coastal slopes overlooking the Dee Estuary. Waterbodies created by the extraction of clay, sand and coal, as well as for agricultural purposes, provide breeding habitat for one of the largest populations of great crested newt *Triturus cristatus* in Great Britain. Some ponds on the site have been created for nature conservation purposes following post-industrial reclamation. Terrestrial habitat is rich and varies from neutral and acid grasslands, through *Molinia* mires to scrub and mature broad-leaved woodland. The site also supports considerable numbers of all the widespread amphibian species.

- **Halkyn SAC (25.5km SE)**

Halkyn Mountain has the most extensive recorded area of the metalliferous NVC type OV37 *Festuca ovina – Minuartia verna* grassland community in Wales. Stands of this vegetation type are associated with a number of old lead and zinc ore mines, which date back to Roman times and were intensively worked during the 19th century. They include relatively open, lichen-rich swards, as well as more closed examples with abundant wild thyme *Thymus polytrichus*. The stands are scattered over an extensive undulating plateau of Carboniferous limestone, most of which is unenclosed common land. They are associated with more extensive areas of open and closed calcareous and acidic grassland and dwarf shrub heath vegetation vegetation, some of which is upland in character.

- **Sefton SAC (35km E)**

This site is proposed as an SAC because many of the dune habitats along this stretch of coastline are identified as being Annex I habitats. In addition, the presence of the Annex II listed species of the Petalwort, *Petalophyllum ralfsii,* is another primary reason for designation and the presence of the Great Crested Newt, *Triturus cristatus* (Annex II species) is also a qualifying feature.

- **Ynys Seriol (Puffin Island) SPA (23km SW)**

Ynys Seiriol is located less than a kilometre off the eastern tip of the Isle of Anglesey and is considered as being a site of European importance for its breeding population of Cormorants *Phalacrocorax carbo,* which feed in the surrounding waters outside the SPA. This breeding population totals more than 1% of entire UK breeding population of this species. Other seabirds, which breed on the sea-cliffs and open grassland areas of the island include puffins, guillemots, razorbills, shag, fulmar, auks, and a large gullery dominated by herring gull is also present.

- **Traeth Lafan SPA (26.8km SW)**

Traeth Lafan (Lavan Sands) is located within Conwy Bay and is a large intertidal area of sand- and mudflats which is also designated as part of the Menai Straits and Conwy Bay SAC. Lavan Sands experience a range of sea water exposures and a diversity of conditions, enhanced by freshwater streams that flow across the flats. The site is of importance for wintering waterbirds, especially Oystercatcher *Haematopus ostralegus* and, during periods of severe winter weather, Traeth Lafan acts as a refuge area for the Oystercatchers displaced from the nearby Dee Estuary SPA.

- **Dee Estuary SPA and pSAC (14.2km SE)**

The Dee Estuary is designated as an SPA for the passage and wintering populations of waterfowl and for regularly holding more than 20,000 waterfowl, which feed on the extensive areas of saltmarsh and mudflats. The site is of special interest for its populations of tern species, whose numbers reach national and in some cases internationally important numbers. These tern species include; the common tern *Sterna hirundo*, Little tern, *Sterna albifrons* and the sandwich tern, *Sterna sandvicensis* with the previous two species breeding within the area.

The Dee Estuary is also a proposed SAC (pSAC) due to the presence of Annex I habitats such as embryonic shifting dunes, salt meadows, fixed dunes with herbaceous vegetation, dune slacks, vegetated sea cliffs and mud flats and sandflats which are exposed at low tide.

- **Mersey Estuary SPA (34km SE**)

The Mersey Estuary is a large, sheltered estuary with large areas of saltmarsh and extensive intertidal sand and mudflats. These intertidal flats and saltmarshes provide feeding and roosting sites for large populations of waterbirds regularly supporting more than 20,000 individuals. The site is designated as an SPA due to its importance during winter periods for ducks and waders and also during the spring and autumn migration periods, when it is considered as having particular importance for wader populations moving along the west coast of Britain.

- **Mersey Narrows and North Wirral foreshore SPA (28.9km E)**

The Mersey Narrows and North Wirral Foreshore SPA spans across the mouths of the Dee and Mersey Estuaries and includes the intertidal habitats at Egremont foreshore, man-made lagoons at Seaforth Nature Reserve, and the extensive intertidal flats at North Wirral Foreshore. Egremont is important as a feeding habitat for waders at low tide whilst Seaforth is primarily a high-tide roost site, as well as a nesting site for terns. North Wirral Foreshore supports large numbers of feeding waders at low tide and also includes important high-tide roost sites. The most notable feature of the site is the exceptionally high density of wintering Turnstone *Arenaria interpres*. Mersey Narrows and North Wirral Foreshore has clear links in terms of bird movements with the nearby Dee Estuary SPA, Ribble and Alt Estuaries SPA, and (to a lesser extent) Mersey Estuary SPA. This SPA is not shown on the map in Figure 3.6.3.

Over winter, the area regularly supports 20,269 individual waterfowl and is supports breeding populations of the common tern, *Sterna hirundo*, which is a qualifying species.

- **Martin Mere SPA (43km NE)**

Martin Mere is located inland from Southport and is considered as being a wildfowl refuge of international importance with a large and diverse wintering, passage and breeding bird community. In particular, there are significant wintering populations of Bewick's Swan *Cygnus columbianus bewickii* and Whooper Swan *Cygnus cygnus*, Pink-footed Goose *Anser brachyrhynchus* and Pintail *Anas acuta*. It should be noted that there is considereable movement of wintering birds between this site and the nearby Ribble and Alt Estuaries SPA.

- **Ribble and Alt Estuaries SPA (35km E)**

The Ribble and Alt Estuaries SPA is composed of the two estuaries together with an extensive area of sandy foreshore along the Sefton Coastline. The site consists of extensive sand and mudflats and, particularly in the Ribble Estuary, large areas of saltmarsh. There are also areas of coastal grazing marsh located behind the sea embankments. The intertidal flats are rich in invertebrates, on which waders and some of the wildfowl feed. The saltmarshes and coastal grazing marshes support high densities of grazing and seed-eating wildfowl and these, together with the intertidal sand and mudflats, are used as high-tide roosts.

Important populations of waterbirds in winter, including swans, geese, ducks and waders. The SPA is also of major importance during the spring and autumn migration periods, especially for wader populations moving along the west coast of Britain. The larger expanses of saltmarsh and areas of coastal grazing marsh support breeding birds during the summer, including large concentrations of gulls and terns. These seabirds feed both offshore and inland, outside the SPA. Several species of waterbirds (notably Pink-footed Goose *Anser brachyrhynchus*) utilise feeding areas on agricultural land outside the SPA boundary.

Qualifying species include the common tern, *Sterna hirundo* and the lesser black-backedgull, *Larus fuscus.*

- **Potential SAC and SPA areas**

In addition to these identified designated SAC and SPA areas within Liverpool Bay, there are occurrences of potential Annex I habitat that may in the future be possibly designated as SACs. These are: “sublittoral sandbanks, permanently submerged” and “Reef” habitats.

Large areas of the inshore areas of Liverpool Bay and the eastern Irish Sea are composed of sandy substrate in less than 20m water depth which is identified as being potential Annex I habitat (Defra, 2005). Such sandbanks may be non-vegetated or vegetated with species such as the seagrass *Zosteretum marinae* and can be split into four categories: gravelly sands, muddy sands, eelgrass (*Zostera marina*) and maerl beds. The latter two being of high conservation value due to the high diversity of species they support and their relative scarcity in the UK. These shallow sandy sediments are typically colonized by burrowing infauna of worms, crustaceans, molluscs and echinoderms and have associated epifauna such as crabs and gastropods. Where surface material is coarse e.g. shell, species of algae, bryozoans, hydroids and ascidians may form distinct communities. These areas are often utilised as important nursery areas for fish and feeding grounds for seabirds such as common scoter (*Melanitta nigra*).

These sandbank habitats are widely distributed on the Atlantic coastlines of north-west Europe and within the UK they are considered as being widespread in inshore waters (JNCC, 2005). Most of the sites selected as SACs for this habitat include a range of other qualifying interest features such as other marine and coastal sites or qualifying species such as seals. The SAC located at Conwy Estuary and the Menai Straits also contains part of this habitat.

Reef habitat for potential designation as an SAC may be defined as “submarine or exposed at low tide, rocky substrata and biogenic concretions, which arise from the seafloor in the sublittoral zone but may extend into the littoral zone where there is an uninterrupted zonation of plant and animal communities”. Such reef habitats generally support a zonation of benthic communities of algae and animal species including concretions, encrustations and corallogenic concretions.”

Small-scattered areas of bedrock and gravel reef habitat are present within Liverpool Bay and in addition there are identified areas of *Modiolus modiolus* (Horse mussel) reef habitat located off the north and western coastlines of Anglesey. Such reef areas are widespread around the coast of Europe and occur widely around the UK coastline in both inshore and offshore waters (JNCC, 2005). The selection of such sites has favoured extensive examples of such habitats supporting diverse community structure. The Conwy Estuary and Menai Straits SAC contains areas of such habitat with both rocky and limestone reefs being present.

Liverpool Bay is also currently being considered as a proposed marine SPA for non-breeding seabirds in inshore waters. This is primarily attributed to the populations of common scoter, *Melanitta nigra.* Aerial surveys of the area have revealed that numbers of scoter regularly exceeded 1% of the biogeographic population (16000 individuals) which, under the proposed marine SPA classification Stage 1 criteria would qualify Liverpool Bay for designation as an SPA for common scoter (see ERM (2005) for further details).

During the benthic characterisation survey a large number of brittlestars (over 3000 *O.ophiura*) were recorded from the furthest inshore site within the cable route corridor (C1- see section 3.3 for location). Brittlestars of some kind can be found in almost any marine benthic biotope in the British Isles, and are often common members of the fauna. In some areas, however, they occur in dense aggregations on the seabed, with hundreds or even thousands of individuals per m^2, and sometimes to the virtual exclusion of any other animals. These brittlestar beds may be patchy and local in distribution or may cover several square kilometers of seabed. Brittlestar beds can be found in several of the habitats defined in Annex I of the EU Habitats Directive. Examples occurring on hard substrata come within the category of ‘Reefs’, while some of those on gravel or mixed sedimentary substrata can be classed within ‘Sandbanks covered by sea water at all times’ (provided these are shallower than 20 m depth). Geographically, examples can be found in ‘Large shallow inlets and bays’.

Only a few species of the British brittlestar fauna occur in dense aggregations. Individual beds may be formed by a single species or contain a mixture of several. None of the bed-forming brittlestar species occurs exclusively in dense aggregations. All can be found in smaller numbers in other benthic biotopes. There is therefore no clear-cut population density above which a ‘bed’ can be defined. Nevertheless, there are certain benthic communities around the UK and Ireland so numerically dominated by brittlestars that they have been recognised as distinct biotopes within the MNCR classification. The bed-forming species are *Ophiothrix fragilis, Ophiocomina nigra* and, more rarely, *Ophiopholis aculeata*. Epifaunal, sediment-dwelling brittlestars of the genus *Ophiura* may also occur in large numbers but do not usually dominate their biotopes to the same extent as the other species.

In addition, although a large number of brittlestars were recorded at this site, this was from over a large area (600m^2) and they were all identified as being the species *Ophiura ophiura*, which is not considered to be a bed forming species within British waters. Also, no large numbers of brittle stars were recorded from the grabs undertaken within this inshore area as part of this characterisation survey. The presence of a brittlestar bed as defined under MNCR biotope classification and included within Annex I of the Habitats Directive at this location is therefore considered as being unlikely.

The predominant benthic habitats at the Gwynt y Môr project area were identified during the benthic characterisation survey as being dominated by sublittoral sand and gravel habitats (CMACS, 2005). These are UK BAP habitats and sublittoral sand habitats in less than 20m depth are also listed as Annex II habitats. These sediments are also the most common habitats found below the level of the lowest low tide around the coast of the United Kingdom and are occur in a wide variety of environments, from sheltered (sea lochs, enclosed bays and estuaries) to highly exposed conditions (open coast). Such habitats are also important as they can support populations of commercial fish species and include areas of feeding, spawning and nursery grounds for commercially important fish species such as sole and plaice (these species are included under the grouped UKBAP for commercial fish species) and potentially could represent possible sites for designation as marine SACs.

The selection of sand and gravel habitats for marine SACs aims to protect the quality and extent of a representative range of sublittoral sand and gravel habitats and communities. The variation in sediment structure and extensive range of this key habitat type means that it is included in a total of 17 sublittoral biotopes as identified under the Marine Nature Conservation Review (MNCR). The characterisation survey of the Gwynt y Môr Offshore Wind Farm site identified three existing biotopes within the site of the proposed wind farm (section 3.3) however, substantial variation was identified within these biotopes and the main community relationships were relatively broad and variable, but overall most communities were a reasonable match to sublittoral biotopes as defined by Connor *et al* (2004). The actual extent of the biotopes found at the Gwynt y Môr project area throughout Liverpool Bay is unknown, however, all would appear to be common outside the project areas and have previously been described throughout the wider Irish Sea and British waters. The status of these habitats as possible areas for future nature conservation designation e.g. SAC is not therefore considered to be likely.

Offshore Natura 2000

The UK government is currently taking steps to implement the Habitats Directive in offshore waters in response to the 1999 High Court Judgement, and has also agreed to take parallel steps to apply the requirements of the Birds Directive. As part of this implementation the JNCC have identified areas which may qualify as possible offshore SACs and SPAs as part of the Offshore Natura 2000 project (JNCC, 2005).

The area considered for the identification of possible SACs and SPAS under the Offshore Natura 2000 project extends from 12 nautical miles (nm) out to the UK continental shelf limit which is the area of seabed beyond the territorial sea limit over which the UK exercises sovereign rights.

The JNCC has developed a methodology for identifying areas of seabed, which may qualify as Annex I habitats, in areas previously not considered for SAC designation. This approach uses geological and bathymetric datasets, mostly from the British Geological Survey (BGS), to identify areas of habitat, which may then be assessed against the Directive's selection criteria and, if deemed suitable, may be proposed as SACs. Four of the marine habitats listed in Annex I of the Council Directive 92/43/EEC as amended by Directive 97/62/EC are either known to occur or may occur within UK offshore waters. These are reefs, sandbanks; structures made from leaking gas and submerged caves.

The nearest offshore potential Annex I habitat to the Gwynt y Môr Offshore Wind Farm was identified by the Offshore Natura 2000 project as being occurrence of potential reef habitat within an area on the north side of Ynys Mon (Isle of Anglesey). This area is approximately 31km to the West of the Gwynt y Môr Offshore Wind Farm project area. This reef habitat occurs within the UK territorial limit but also extend across this boundary into offshore waters and it is therefore considered as a potential offshore Natura 2000 site. The main habitat is an extensive area of gravel containing patches of gravelly sand with scattered rock outcrops. Within this area are patches of *Modiolus modiolus* reef (although the exact location of these areas is not clearly defined).

Potential reef habitat is much more common in western UK offshore waters and is virtually absent from UK offshore waters in the North Sea. Other areas highlighted as potential reef habitat in the Irish sea are offshore from Cardigan Bay, Lleyn peninsula and to the west of the Isle of Man.

In addition to Annex I habitats in offshore areas, Annex II species are also considered for potential implementation of SACs. Annex II species occurring in offshore waters of the Irish Sea, and therefore considered for possible offshore SACs selection, are; Grey Seal *Halichoerus grypus*, Common Seal *Phoca vitulina*, Bottlenose dolphin, *Tursiops truncates,* and the Harbour porpoise *Phocoena phocoena*. Potential offshore SAC sites for these species would need to fulfil certain criteria, in particular whether they are essential to the life and reproduction of these species.

SACs currently exist for grey seal and common seal breeding sites within UK coastal areas and there is potential to identify preferred feeding areas in offshore waters. There are currently three SACs for bottlenose dolphin within UK waters (Cardigan Bay and the Lleyn peninsula are both in Wales) with the boundaries of these SACs extending to the 12nm limit of the territorial sea. Further investigations are needed to identify aggregations of this species in offshore areas and it will then be necessary to determine if such areas are essential to the life and reproduction of this species before they can become designated.

The identification of offshore marine feeding areas for Annex I and migratory birds also forms part of the offshore Natura 2000 project in the identification of SPAs. Work on this aspect of SPA classification under offshore Natura 2000 is not as far advanced as the identification of inshore SPA areas; such as seaward extensions of breeding colonies and inshore areas used by birds in the non-breeding seasons.

UK Biodiversity Action Plan (UKBAP)

The UK Biodiversity Action Plan (UKBAP) is the response of the UK government to the Convention of Biological Diversity as signed at the 1992 Rio Earth Summit and the overall goal of UKBAP is to conserve and enhance biological diversity within the UK and to contribute to the conservation of global diversity.

The objectives underpinning this goal are to conserve and, where practicable, enhance overall populations and ranges of native species and the quality and range of wildlife habitats and ecosystems. These objectives form the basis of action plans and targets produced for individual habitats and species. The Countryside and Rights of way act (2000) now adds statutory weight to this process (WWF-UK, 2001).

Within the UK three types of Action Plans have been developed which set priorities for nationally and locally important habitats and wildlife. These are; Habitat Action Plans which are broad habitat statements with priority habitats stated within these classifications, Species Action Plans (which may be for individual or grouped species e.g. commercial fish), and Local Action Plans which are determined by individual areas e.g. counties to identify local priorities and determine the contribution they can make to the delivery of the national Species and Habitat Action Plan targets (UKBAP, 2005). Some 60 action plans relating to marine species and habitats currently exist but it is acknowledged that the marine environment presents a number of particular challenges for Action Plan implementation (JNCC, 2004).

UKBAP Habitats- The UK has identified and drafted Biodiversity Action Plans (BAP) for priority marine habitats as part of its implementation; however, the full distribution of such habitats within UK waters is currently unknown (Defra, 2005). The following marine UKBAP priority habitats are thought to occur within Liverpool Bay (UKBAP, 2005):

Coastal and floodplain grazing marsh, coastal saltmarsh, Coastal sand dunes, seagrass beds, sublittoral sands and gravels, tidal rapids, mudflats, mud habitats in deep water, *Modiolus modiolus* beds, sheltered muddy gravels, *Sabellaria alveolata* (honeycomb worm) reefs, maerl beds, maritime cliffs and slopes and coastal vegetated shingle.

All of these habitats are found throughout UK waters.

UKBAP Species- BAPs exist for the following species known to occur within Liverpool Bay and the eastern Irish Sea:

- **Molluscs:** *Atrina fragilis* Fan mussel and *Ostrea edulis* Native oyster.
- **Fish:** *Alosa alosa* Allis Shad, *Alosa fallax* Twaite Shad, *Cetorhinus maximus* Basking shark. There is also a grouped action plan for UK commercial fish species such as whiting, cod, plaice and sole, all of which are present within Liverpool Bay.
- **Mammals:** *Phocoena phocoena* Harbour porpoise. Grouped BAP action plans also exist for baleen whales, toothed whales and small dolphins.

UKBAP Local Action Plans- Local BAP action plans currently in existence for marine and coastal habitats and species within the counties bordering Liverpool Bay are displayed in Table 3.6.2.

Biosphere Reserves

Biosphere reserves are areas of terrestrial, coastal or marine ecosystems internationally recognised under the Man and Biosphere (MAB) Programme of the United Nations Educational, Scientific and Cultural Organisation (UNESCO). They are non-statutorily protected areas nominated by national governments and remain under sovereign jurisdiction of the countries where they are located. Such sites are nominated as biosphere reserves if they are considered to represent significant examples of biomes-terrestrial and coastal environments, throughout the world, which are protected for conservation purposes.

There are a total of eight coastal biosphere reserves within the UK, however no such reserves are identified within Liverpool Bay and the closest existing biosphere reserve to the Gwynt y Môr Offshore Wind Farm is the Dyfi estuary located on the Cardigan Bay coastline in mid-Wales (Defra, 2005)

Environmentally Sensitive Areas

Environmentally Sensitive Areas (ESAs) are statutory areas in which the government seeks to encourage environmentally sensitive farming practices, allowing enhancement of the conservation, landscape and historical values of the key environmental features of an area. ESAs include important landscapes such as uplands, wetlands, moors, coastal marshes and river valleys protecting rare plants and establishing suitable environments for native species such as water vole and otters. Authorisation for ESAs by the European Community is derived from Article 19 of Council Regulation (EEC) No. 797/85 - National Aid in Environmentally Sensitive Areas (Keddie, 1996).

The entire Isle of Anglesey and the Llyn peninsular are designated as ESAs, and these are the closest of such areas to the Gwynt y Môr Wind Farm. The closest point of the Angelsey coastline is located 25km to the South West of the Gwynt y Môr project area.

3.6.2 National Designations

National Nature Reserves (NNRs)

NNRs are statutorily protected areas designated under Section 19 of the National Parks and Access to the Countryside Act 1949, or Section 35 of the Wildlife and Country side Act 1981 (Keddie, 1996). They are established to protect examples of important natural and semi-natural areas of wildlife habitat and geological formations within the UK, and as places for scientific research of the habitats, communities and species represented within them. NNRs are defined as being "nationally important" as they are amongst the best examples of a particular habitat. They are managed by relevant agencies such as Countryside Council for Wales (CCW), English Nature (EN) or by others such as the Royal Society for the Protection of Birds (RSPB) and the National Trust (NT)(WWF-UK, 2001). Within the UK all NNRs are also designated as Sites of Special Scientific Interest (SSSIs).

There are three coastal NNRs identified within Liverpool Bay and these are (source: English Nature, 2005):

- **Ainsdale Sand Dunes NNR** totals 508 ha and forms part of the Sefton Coast. The NNR is within the SPA, Ramsar and cSAC areas of the Sefton coastline and habitats include intertidal sandflats, dunes and slacks and pine woodland. These habitats support nationally important species such as natterjack toads, great crested newt and red squirrel. This NNR is located 35km to the North East of the project area.

- **Ribble Estuary NNR** is considered to be the most important site in the UK for wintering wildfowl. The NNR occupies over half of the total area of the Ribble Estuary, including extensive areas of mud and sandflats and almost all of the saltmarsh habitat (one of the largest single areas of saltmarsh in England). The Reserve is internationally important for 16 species of birds each winter and is located approximately 50km to the North East of the Gwynt y Môr project area.

- **Cabin Hill NNR** totals 28ha and also forms part of the Sefton Coast. The extensive areas of shore within this reserve are considered as important for migrating and over-wintering birds. Other key species include sand lizard, natterjack toad and dune helleborine. This NNR is located approximately 35km North East from the Gwynt y Môr project area.

Within the North Wales area there are no coastal NNRs. The nearest such site to Gwynt y Môr is located inland at Coedydd Aber (Llanfairfechan, Gwynedd) approximately 28km to the south west. This is the steepest river in England and Wales and supports a variety of habitats including a diversity of woodlands, open farmland and scrub. Species include nesting raven and peregrine found on the cliff face and tree pipit, redstart, pied flycatcher and wood warbler found in the oak woods (CCW, 2005).

Marine Nature Reserves

Within the UK, designated Marine Nature Reserves (MNRs) are areas recognised for their special marine features and have a level of protection broadly equivalent to National Nature Reserves (NNRs). They are designated under Section 36 of the Wildlife and Countryside Act

1981 to conserve marine flora and fauna, geological and geomorphological features of special interest and to allow opportunities to study such features (Keddie, 1996).

MNRs may be established within areas below the mean water mark and up to 3 miles offshore or up to the UK territorial limit, following an Order in Council, and include both the sea and the seabed (WWF-UK, 2001). There are currently only three designated MNRs within the UK and these are: Strangford Lough (Northern Ireland), Skomer Island (South west Wales) and Lundy Island (Devon).

Sites of Special Scientific Interest

Sites of Special Scientific Interest (SSSI) are areas (including intertidal) designated under the Wildlife and Countryside Act 1981 (Section 28) as being of national nature conservation interest (Defra, 2005). They are intended to provide the best examples of wildlife habitats, geological features and landforms and receive greater protection through the Countryside and Rights of Way Act 2000, which introduces new procedures for landowners and public bodies in relation to activities which may affect SSSIs (WWF-UK, 2001).

Government Departments, local authorities, statutory undertakers and other public bodies are required to carry out their functions so as to further the conservation and enhancement of the special features of the SSSI. All sites of national and international importance on land (including National Nature Reserve (NNRs), Nature Conservation Review (NCR) and Geological Conservation Review (GCR) sites, Special Protection Areas (SPAs), Special Areas of Conservation (SACs) and Ramsar Sites) are notified as SSSI.

Designated SSSIs identified within the area under consideration are listed in Table 3.6.3 with locations displayed in Figure 3.6.4.

Local Nature Reserves (LNRs)

LNRs are statutory areas designated by local authorities under section 21 of the National Parks and Access to the Countryside Act for the same purpose as NNRs, but because of their local rather than national interest. Designated LNRs within proximity to the Gwynt y Môr Offshore Wind Farm and the surrounding region are described in Table 3.6.4 and displayed in Figure 3.6.5.

Area of Special Protection (AoSP)

AoSPs are statutory protected areas under the Wildlife and Countryside Act (1981). The designation aims to prevent the disturbance and destruction of particularly vulnerable groups of birds, making it unlawful to damage or destroy either the birds or their nests, and in some cases, by prohibiting or restricting access to the site. Areas of Special Protection may be designated on land or territorial waters and have replaced many areas formerly designated as bird sanctuaries. The closest AoSP site to the Gwynt y Môr Offshore Wind Farm project area is located at Southport (Lancashire) (approximately 38km to the North east of the project area).

Nature Conservation Review (NCR) sites

NCR sites are non-statutory sites containing the best representative examples of wildlife habitat above a critical standard of nature conservation importance. The NCR helps identify sites that may qualify for declaration as National Nature reserves. Coastal NCR sites include sites supporting nationally and internationally important bird populations, as well as sites holding the best representative examples of vegetative habitats.

The closest NCR site to the Gwynt y Môr Offshore Wind Farm is located at Sefton where the dune system is considered to be important for its habitats and associated flora and fauna (EAB, 2005).

Geological Conservation Review (GCR) Sites

GCR sites are non-statutory sites identified as having national or international importance for earth science in the context of their geology, palaeontology, mineralogy or geomorphology and are the earth science equivalent of NCR (Keddie, 1996). GCR sites located within proximity to the Gwynt y Môr Offshore Wind Farm and the surrounding regions are identified in Table 3.6.5 and Figure 3.6.6.

Sensitive Marine Areas (SMAs)

SMAs are non-statutory marine areas considered to be nationally important and notable for their marine flora and fauna communities or which provide ecological support to adjacent statutory sites such as Marine Nature Reserves (MNRs) or SSSIs (JNCC, 2005, WWF-UK, 2001). English Nature identifies such sites with the additional aim of raising awareness and disseminating information to be taken into account within estuarine and coastal management planning (Keddie, 1996).

Of the 27 SMAs designated around the English coastline there is only one found within the area under consideration and this is the Dee Estuary and North Wirral coastline (MacDonald et al., 2001).

3.6.3 Other Protected Sites

Heritage Coastline

Heritage coastlines are non-statutory landscape designations agreed between local authorities and agencies (CCW in Wales and the Countryside Agency in England) as an aid to local authorities to both planning and managing their coastlines.

Coastlines are awarded heritage status if they are substantially undeveloped and are considered as having exceptionally fine scenic quality, which exceeds 1 mile in length, and containing features of special significance (Keddie, 1996). Overall there are 43 such heritage coastlines throughout England and Wales, however within this area the only designated heritage coastlines are the Great Orme Headland at Llandudno (Conwy) which is a total 4miles in length (14.7km to the South West of the project area), and the North Anglesey coastline which is a total of 18 miles in length (34km to the West of the project area) (see Figure 3.6.7) (Countryside Agency, 2005).

The Wildfowl and Wetlands Trust & RSPB

The Wildfowl and Wetlands Trust (WWT) promotes the conservation of wetlands with focus on rare wetland bird species. Throughout the UK there are a total of nine such reserves covering approximately 4000ha of wetland in total. These areas are non-statutory but many are found within statutorily protected areas e.g. Ramsar sites. The closest WWT area to the Gwynt y Môr Offshore Wind Farm is the WWT Martin Mere Reserve located 10 miles inland from Southport at Burscough, Lancashire (43km to the North East of the project area) (this site is also designated as a Ramsar, SAC and SPA site) (see Figs 3.6.1, 3.6.2, and 3.6.3). This reserve is renowned for large flocks of migrating geese (WWT, 2005).

The RSPB manages a large number of reserves within the UK covering a diverse range of habitats. Again, like the WWT reserves, these areas have no statutory protection but many are also designated as statutory protected areas such as Ramsar.

Within the area under consideration RSPB reserves are located at Conwy (over 20km to the South West of the project area) where pools alongside the Conwy Estuary are utilised by a variety of wading birds and ducks, Point of Ayr/Dee Estuary which is an important area for wading birds and wildfowl which feed on the mud flats and saltmarshes, and at Marshside (Ribble Estuary), which contains lowland wet grassland important for pink-footed geese, widgeons, black-tailed godwits and golden plovers in winter and provides nesting places for lapwings and redshanks during the spring (RSPB, 2005).

Wildlife Trust Sites

Wildlife Trust sites are non-statutory reserves (but some may be protected by statutory designations such as SSSI) which are managed or owned by the Wildlife Trusts of Wales, England, Northern Ireland and the Isle of Man, and are designed to protect locally important plants, animals and other wildlife.

Within the area under consideration there are sixteen Wildlife Trust reserves and these are further described in Table 3.6.6 and Figure 3.6.8.

Ministry of Defence (MoD) Sites

MoD areas including PEXAs and radar installations in relation to the Gwynt y Môr Offshore Wind Farm project area have been considered separately as part of the EIA process and are not included as part of this report. However, some MoD owned sites around the UK coastline also occur within designated sites of nature conservation value. The MoD gives high priority to nature conservation on the Defence estate and these sites often have very limited public access resulting in good examples of habitat.

The closest MoD estate site to the project area is located at the Sealand ranges within the Dee Estuary (already a designated RAMSAR, SAC, SSSI and SPA area) and covers an area of approximately 477ha of primarily saltmarsh habitat. There is an additional MoD site located at Altcar (Merseyside) covering a 250ha area of saltmarsh and dune habitat (Keddie, 1996).

3.6.4 Rare, Endangered and Protected Species

Benthic invertebrate species

The Marine Nature Conservation Review (MNCR) has identified rare benthic species within this area and records show that the following may be found in the eastern Irish Sea (Nationally rare species are classified as those that occur in eight or fewer of the Ordnance Survey 10 km grid squares found within 3nm of the coast, while nationally scarce species are those that occur in 9 to 55 grid squares (Sanderson, 1996a)):

- *Ophelia bicornis* is a rare benthic worm. This is most probably due to its very specific habitat requirements of lose mobile sand, and it is most likely to be found in areas of the lower shore. Within the eastern Irish Sea it has been recorded from the outer Ribble Estuary.

- *Stryphnus ponderosus* is a nationally rare sponge recorded from areas around Ynys Seriol (Puffin Island-located off the east coast of the Isle of Anglesey), however this sponge is known to have a wide depth range and so therefore may only be rare within inshore areas.

- Two other nationally rare sponges are also recorded from the Menai Straits (in proximity to Puffin Island) and these are *Tethyspira spinosa* and *Plocamilla coriacea.*

- The nationally rare amphipod *Nannonyx spinimanus* is also present within the Menai Straits.

None of these species were recorded from the characterisation surveys undertaken at the Gwynt y Môr Offshore Wind Farm and surrounding area. No protected benthic invertebrate species were recorded from the benthic characterisation surveys, however the following rare species were recorded:

***Thia scutellata* (thumbnail crab):** This species is considered to be nationally scarce within UK waters and is listed in the "Atlas of marine Biodiversity Action Plan Species and Habitats and Species of Conservation Concern in Wales" although it is not a Biodiversity Action Plan (BAP) species (Clark, 1986; Rees 2001; Moore, 2002). It has narrow habitat requirements, which are limited to loose well sorted medium sands of a medium phi between 1.1 and 1.3 with a low fine sand/silt or clay content so that water infiltrates freely allowing the crab to respire (Rees, 2001). Suitable sediment locations are thus fairly limited.

Thia scutellata was present at a total of 41 sites during the Gwynt y Môr Offshore Wind Farm benthic characterisation surveys with a maximum abundance of 3 individuals at site 125. The main distributions of *Thia scutellata* within the Irish Sea are considered to be 6-12 miles off the North Wales coastline with a smaller population off the east coast of Anglesey and limited areas within Cardigan Bay and Camarthern Bay. Older records also exist for Constable Bank and the Menai Straits (Rees, 2001). *Thia scutellata* was found in and around the site of the North Hoyle Offshore Wind Farm (Innogy, 2002). Baseline surveys for offshore developments in the outer Liverpool Bay area have also yielded records of this species further North than described by Rees (2001) (Shalla *et al*., 1997; Holt and Shalla, 2001) and small numbers were found in similar areas during surveys in support of proposals for aggregate extraction (ERM, 2002). Small numbers have also been found in a limited shallow area near proposed offshore wind farm development at Burbo Bank (SeaScape Energy, 2002) and Rhyl Flats (COWL, 2002). The species has also been reported at the entrance to the Dee Estuary (Dee Estuary Phase 1 survey, unpublished) and to the north west of the Great Orme (Barne *et al.,* 1996). In almost all cases numbers found are small, typically averaging much less than 10 per m^2. However, in the area of the Hamilton East development some 30km North of Prestatyn a survey using 39 grab samples found an average of 2.3 crabs per grab, equivalent to an average of 23 crabs per m^2 over an area of several km^2 (Holt and Shalla, 2001). The wider distribution of *Thia scutellata* as determined from all of these sources is given in Figure 3.6.9.

***Acheus cranchii* (Cranch's spidercrab)**: This species was recorded on three occasions during the benthic characterisation survey: a single individual from each of grab sites 31 and 87 (both located within the eastern section of the survey area) and a single individual from trawl location 3 (at the north of the site) during the beam trawl survey of December 2003 (see section 3.3 for locations). The grab locations were both classified as having poorly sorted coarse gravel/sand sediments. Although this species is listed as being scarce it is considered possible that it may have been under-recorded within Welsh waters due to its similarity to other species (CCW, 2004).

Sabellaria spinulosa (Ross worm): Although this species is an extremely common and widespread species found in much of the north-eastern Atlantic and the Mediterranean. It can, under certain circumstances, be considered to be a species of importance due to its ability to form extensive, relatively stable aggregations, which can support rich and diverse communities and can, when particularly dense and stable, be regarded as "biogenic reefs" (Holt *et al.,* 1998). However, it is more usually encountered in relatively small numbers, attached to stones, rocks, shells, algae and other suitable substrata as an encrusting form. Foster-Smith and Hendrick (2003) suggest a figure of 375 individuals per $0.1m^2$ grab could be a useful indicator of *Sabellaria* reefs. During the characterisation survey of the project area only extremely low numbers of this species were encountered –a total of only 37 individuals from all 325 grabs and not a single record from the beam trawl surveys, indicating that the presence of a *Sabellaria* biogenic reef located either within or adjacent to Gwynt y Môr Offshore Wind Farm project area is unlikely.

Fish species

In addition to the European and national legislation that covers the exploitation of marine fish (e.g. Common Fisheries Policy) and migratory species (e.g. UK *Salmon and Freshwater Fisheries Act*, 1975), a number of fish species are also subject to a range of national and international conservation measures. Rare fish are defined as those species afforded protection under such national or international conventions, other than fishery legislation. Rare marine and estuarine fish species previously recorded within Liverpool Bay and the wider eastern Irish Sea are displayed in Table 3.6.7 alongside the specific legislative protection afforded to them.

Basking shark

The basking shark (*Cetorhinus maximus*) is the second largest fish in the world; it is a regular summer migrant to the coastal waters of the Isle of Man and the western Irish Sea but neither a numerous nor regular visitor to Liverpool Bay. It is a plankton filter-feeder that is most frequently associated with hydro-thermal fronts or other areas of high plankton production.

Little detail is known about its annual life cycle but recent data-logging tag studies (www.cefas.co.uk/sharks) indicate that it overwinters in shelf waters rather than migrating to the off-shelf abyss as had previously been thought possible. In common with other large sharks, the basking shark is ovo-viviparous, i.e. eggs are gestated internally and live young are born. The Basking shark is a rare visitor to Liverpool Bay and is more common in other parts of the Irish Sea such as to the west of the Isle of Man.

Common and sand gobies

Although the common (*Pomatoschistus microps*) and sand (*Pomatoschistus minutes*) gobies are both scheduled species in the Bern Convention, they are not subject to any specific UK conservation measures; they are ubiquitous and abundant in shallow sandy habitats less than 2-5 m in depth. During spring and early summer they lay demersal eggs, often on the inside of an empty bivalve mollusc shell. The eggs are guarded by the male until they hatch.

The Sand Goby, *Pomatoschistus minutes,* which is protected due its importance at the trophic level, was one of the most abundant fish species recorded during the Gwynt y Môr characterisation beam trawl surveys.

Allis and twaite shad

The allis (*Alosa alosa*) and twaite (*Alosa fallax*) shad are members of the herring family that spend most of their late juvenile and adult life in coastal waters (see, for example, Maitland & Campbell, 1992). In spring, the mature adults enter estuaries and move upstream to the lower reaches of freshwater where they lay their eggs before returning (May-June) to the sea. The post-larval fish drift downstream in late summer and young-of-the-year reach the estuaries in autumn where they probably remain over winter. Neither species is abundant nor a regularly recorded species in the Irish Sea but there are records of their capture in all of the major estuaries draining into Liverpool Bay (Potts & Swaby, 1999). It is more than 70 years since there was any positive record of the allis shad spawning in UK rivers but twaite shad are known to spawn in rivers of the south-west of England and south Wales (Apprahamian & Apprahamian, 1990). The spawning status in rivers draining into Liverpool Bay is not certain but relatively regular catches made in salmon nets in and around the Solway Firth suggest that twaite shad may spawn in one or more of the rivers draining into the Solway Firth.

River and sea lamprey

The distribution and life history of lampreys is not dissimilar to that of the shads (see, for example, Maitland & Campbell, 1992); most of their life is spent in coastal waters and they enter estuaries to spawn in the spring. Sea lampreys (*Petromyzon marinus*) spawn in the lower reaches of rivers before returning to sea in early summer, followed by young-of-the-year in the autumn. River lampreys (*Lampetra fluviatilis*) migrate further upstream and the juveniles remain in the river until spring when they emigrate to the lower estuaries or coastal waters where they remain for 1-2 years before returning to spawn.

Smelt

The European smelt (*Osmerus eperlanus*) is a member of the salmon family that, like shad and lamprey, spends most of its adult life in coastal waters but enters estuaries to spawn in the spring (see, for example, Maitland & Campbell, 1992). The adults return to sea once they have spawned; the post-larvae drift downstream and the young-of-the-year reach the lower estuary in autumn. Their distribution and status in Liverpool Bay is not known with any certainty but a small spawning population does run into the River Conwy.

Salmon
Atlantic salmon spend a year or more at sea feeding before returning to the specific river of their birth (natal river) to spawn between November and January in the river's headwaters (see, for example, Mills, 1989 or Maitland & Campbell, 1992 for reviews of salmon biology, behaviour and life histories). Once they have spawned the majority die but a few survive to spawn a second or even a third time (multi-sea-winter fish – MSW). Once hatched, the young fish (parr) spend 2-4 years in the river system before developing into smolts that swim downstream and migrate to sea between late April and early June.

The route by which they return through the Irish Sea in search of their natal river is not known but it is generally acknowledged that they swim along the coast seeking olfactory clues that help identify the correct river. Assuming that this pattern of migration is followed, it suggests that salmon seeking North Wales rivers are unlikely to make direct contact with Gwynt y Môr or even the inshore Round 1 site at Rhyl Flats. At present, however, it is still a matter of conjecture whether fish seeking the River Dee or Ribble, for example, come through the Menai Strait or approach from another direction, possibly across the Gwynt y Môr project area.

Sturgeon
The common sturgeon (*Acipenser sturio*) ranges from the Atlantic coast of France to the Severn Estuary and Pembrokeshire in western Britain, and up to the Firth of Forth on the Scottish east coast and the Limfjord on the west coast of Denmark in the North Sea. There are now few catches in these waters and the only location where a spawning stock is known to remain in this range is the Gironde basin in France.

The adults migrate into estuarine and brackish waters to spawn and juveniles move between estuaries and the sea. The causes of its decline in Europe have been a directed fishery, pollution of the lower reaches of rivers, damage to spawning grounds and manmade obstacles restricting migration. There have also been reports of accidental catches in trawls and nets at sea and in estuaries when fishing other species, which add another pressure on stock. The sturgeon is only occasionally reported in UK waters and is considered unlikely to be present within Liverpool Bay, although historic data does record this species within the Dee Estuary (Potts and Swaby, 1993), however, it is only likely to be a very rare visitor and is unlikely to be found moving into estuaries to spawn.

Marine mammal species
Marine mammal species present within Liverpool Bay and the wider eastern Irish Sea have been identified and discussed previously within Section 3.5. Within UK waters all marine mammal species are protected under both national and international legislation.

Cetaceans are protected under Section 9 of the Wildlife and Countryside Act (1981). This act prohibits the deliberate killing, injuring or disturbance of any cetacean species. Cetaceans are also protected under Article 12 of the EC Habitats Directive (92/43/EEC), listed on the Bonn and Bern convention Appendices, and in addition, the UK is a signatory to the

Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS) and has applied its provisions in all UK waters, including the Irish Sea. All cetaceans are also designated UKBAP (Biodiversity Action Plan) species.

Pinnipeds are protected under the UK's Conservation of Seals Act (1970), in addition to Annex II and V of the EU Habitats Directive (1992/43/EEC), and are also listed as Appendix III species of the Bern convention.

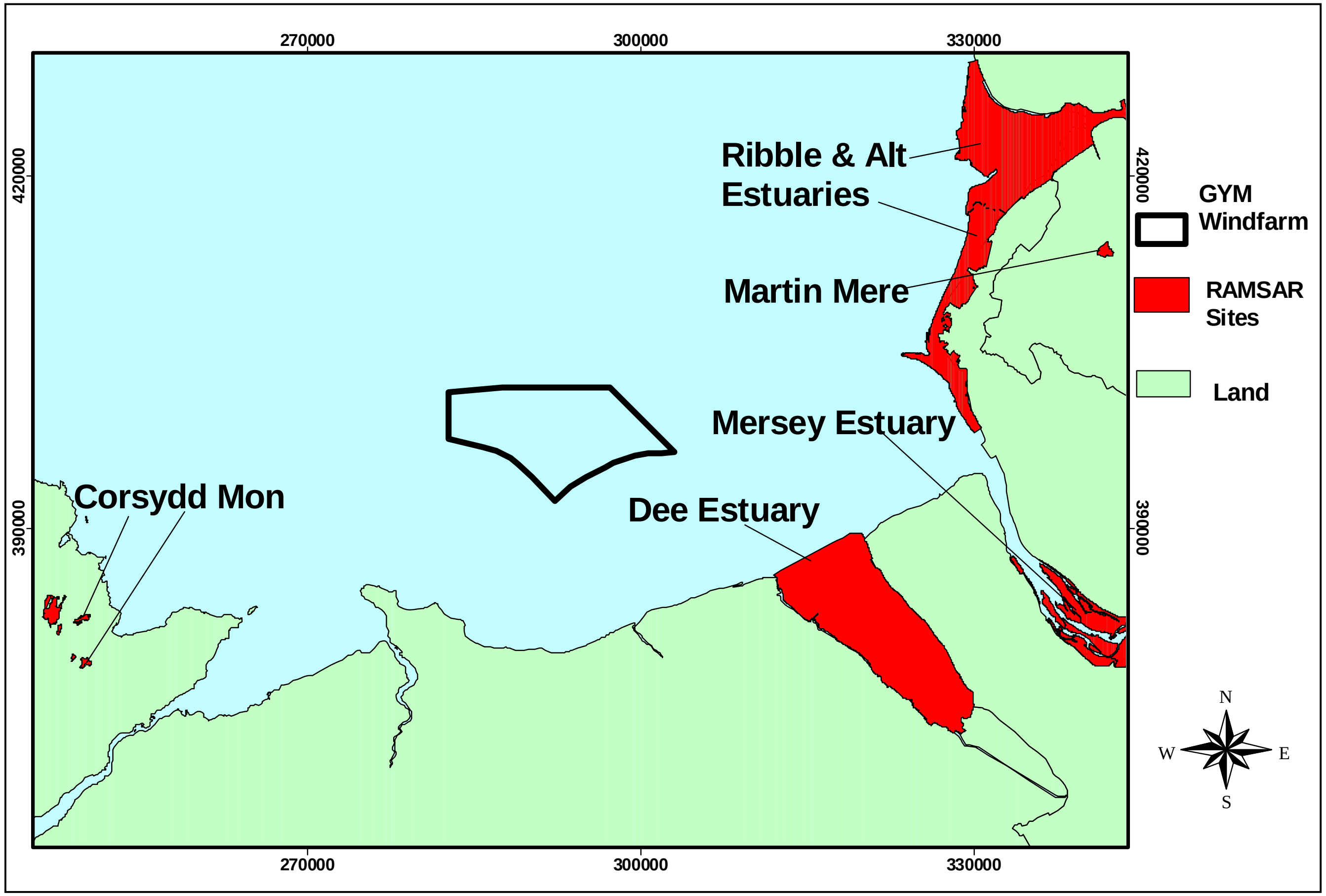


Figure 3.6.1: Designated Ramsar sites within Liverpool Bay

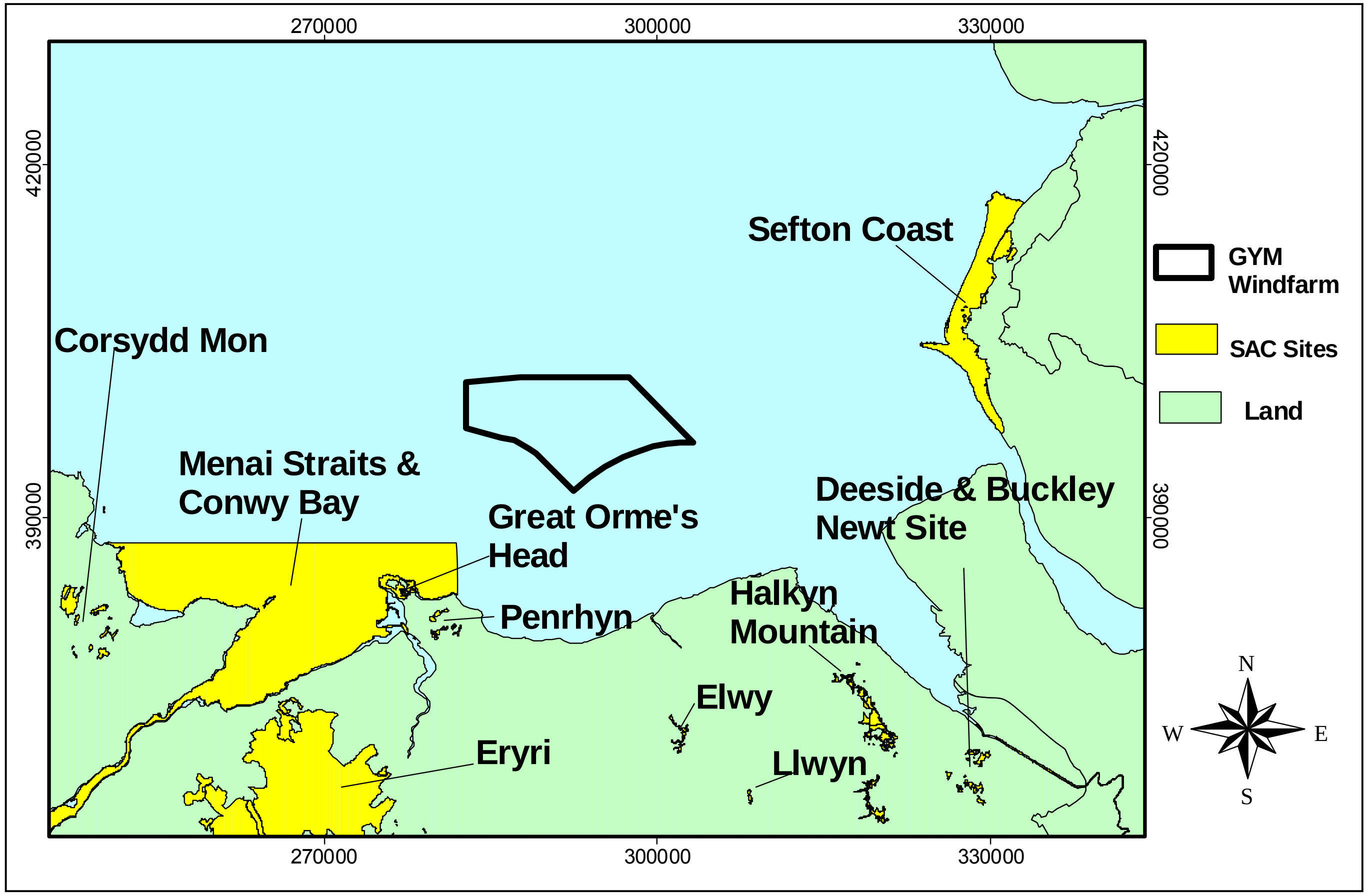


Figure 3.6.2: Designated SAC sites within and around Liverpool Bay

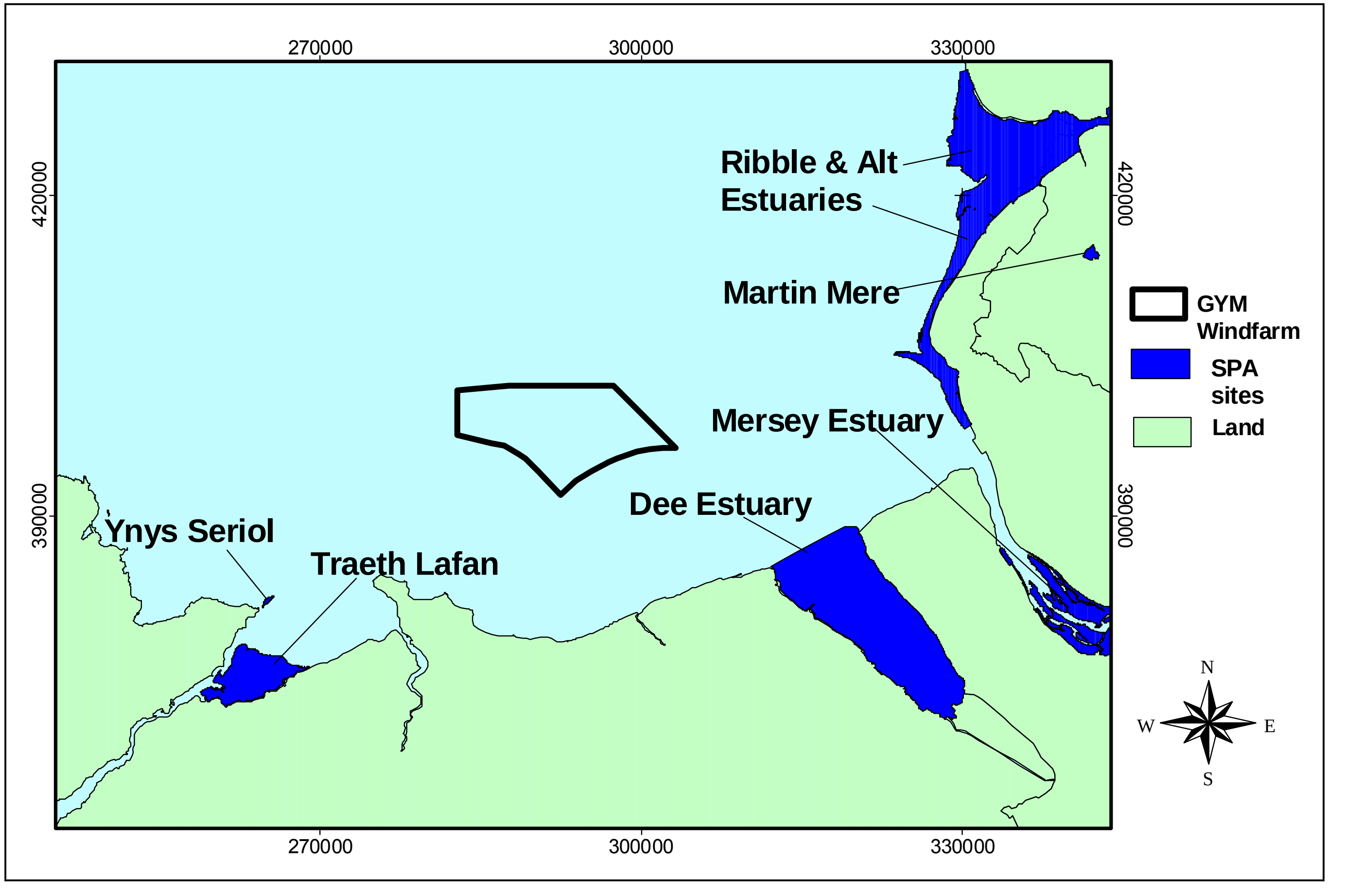


Figure 3.6.3: Designated SPA sites within Liverpool Bay

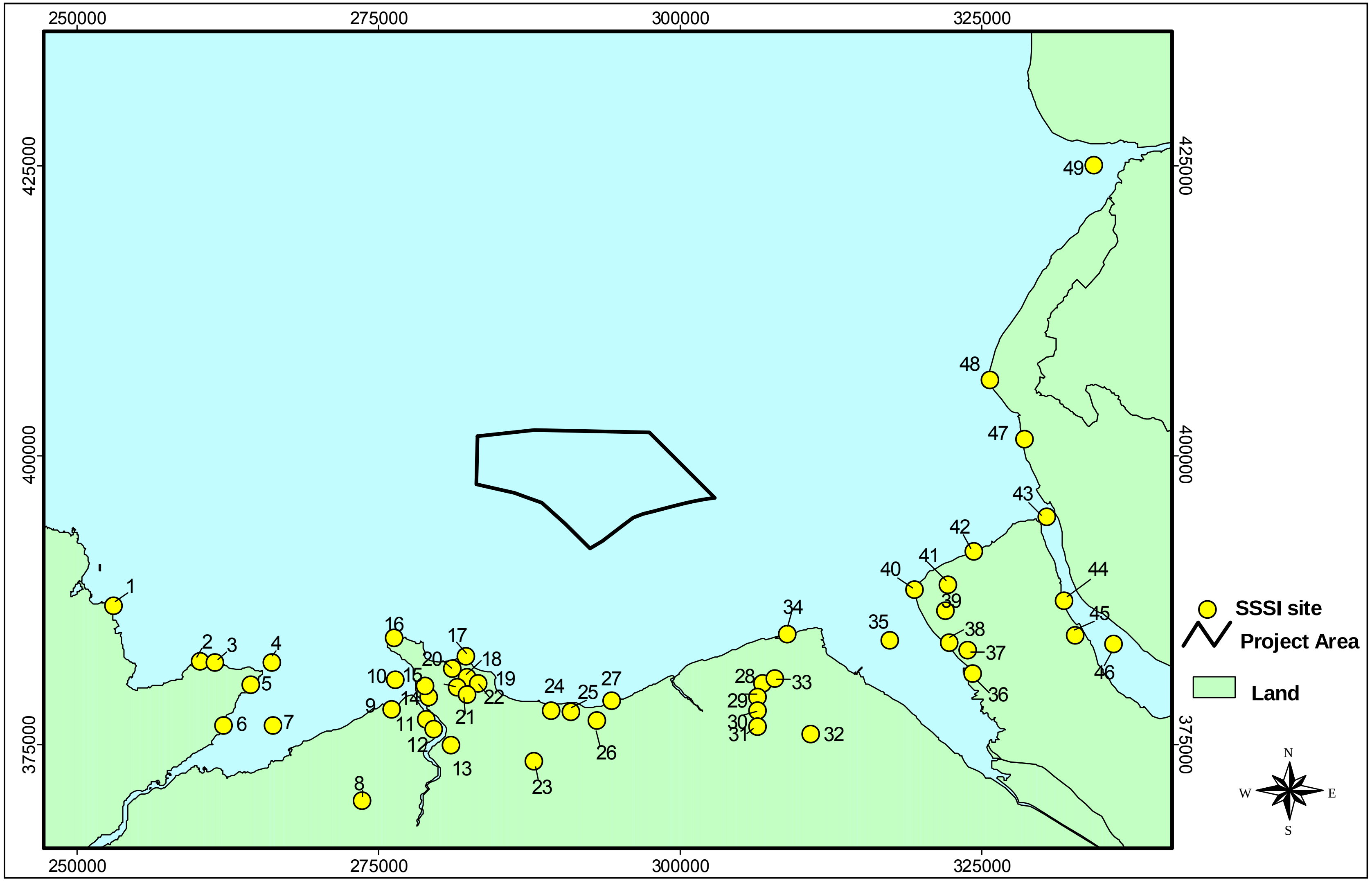


Figure 3.6.4: Location of SSSIs within and around Liverpool Bay (see Table 3.6.3 for site identification).

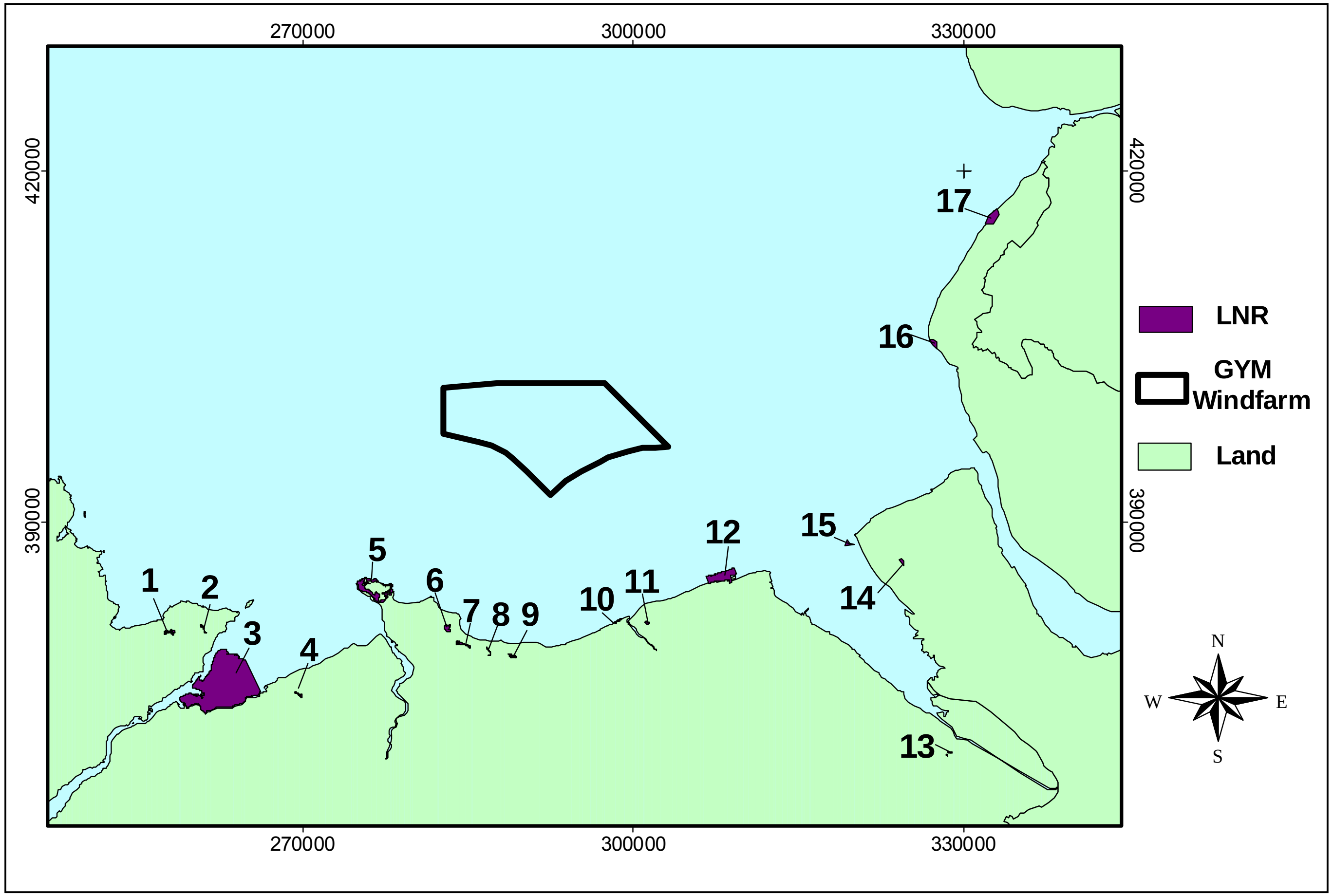


Figure 3.6.5 Designated Local Nature Reserves (LNRs) within the coastal regions of Liverpool Bay (see Table 3.6.4 for descriptions).

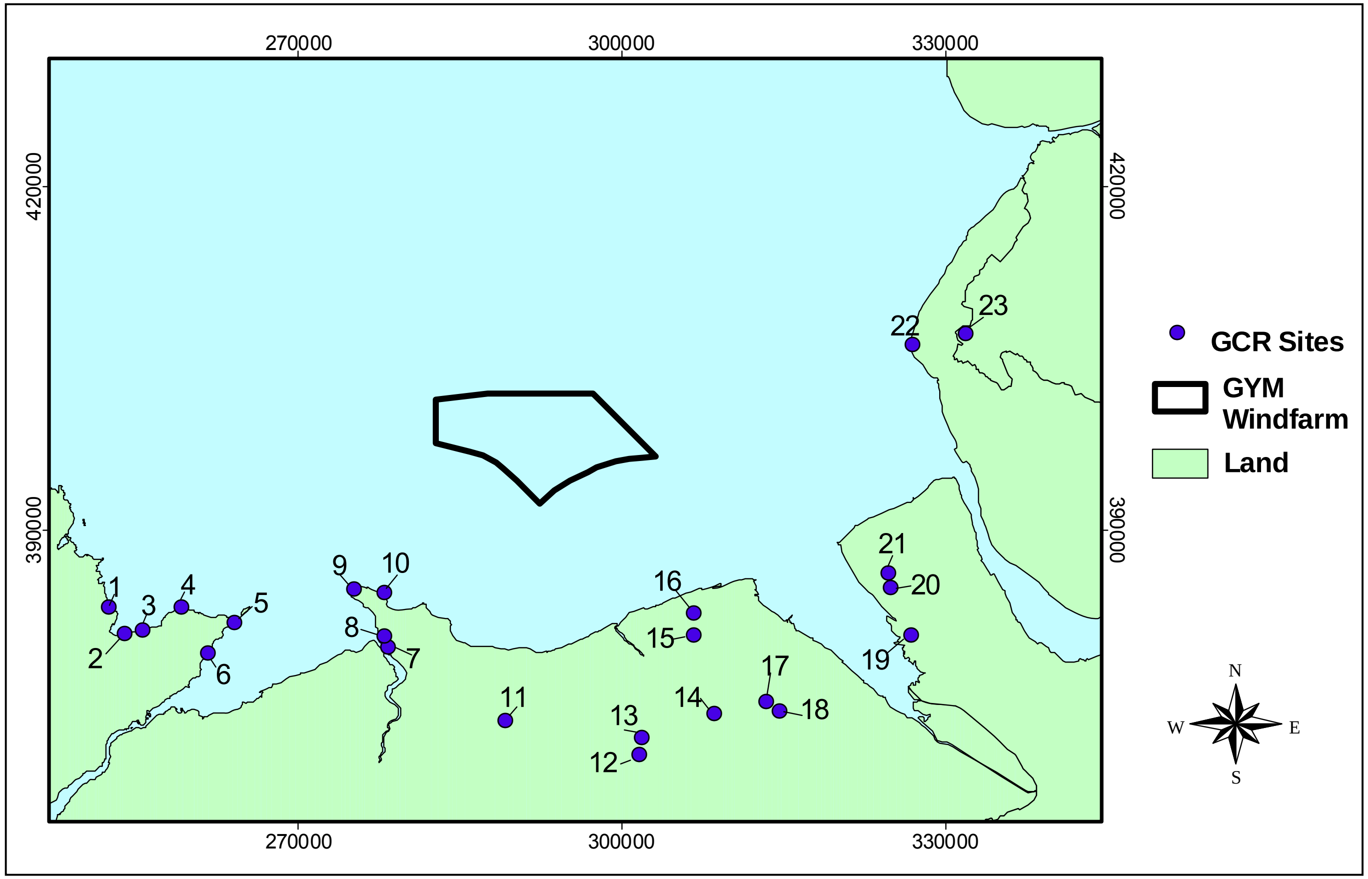


Figure 3.6.6: GCR sites located within the area in relation to the Gwynt y Môr project area (see Table 3.6.5 for descriptions)

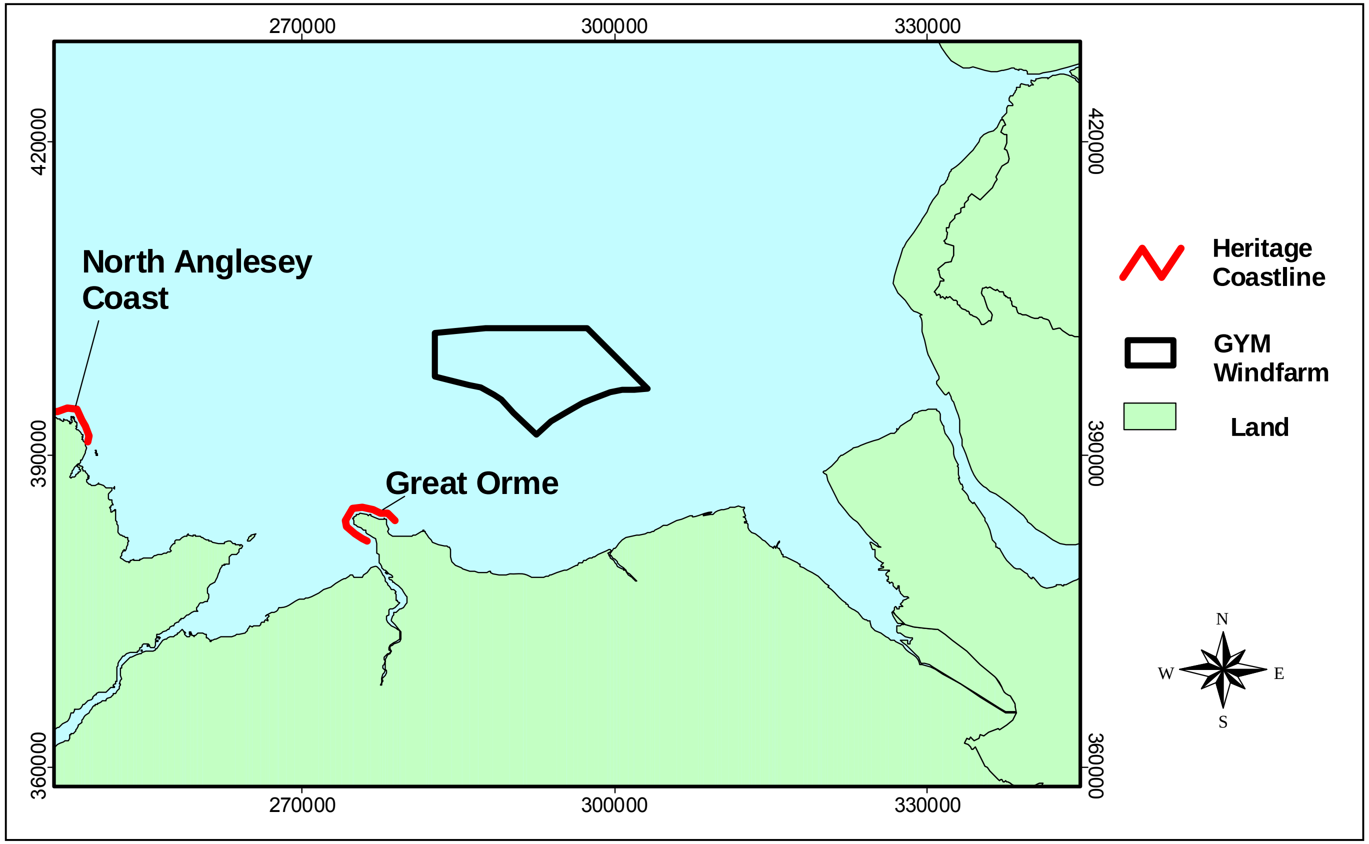


Figure 3.6.7: Designated heritage coastlines within Liverpool Bay and in proximity to the Gwynt y Môr Offshore Wind Farm project area.

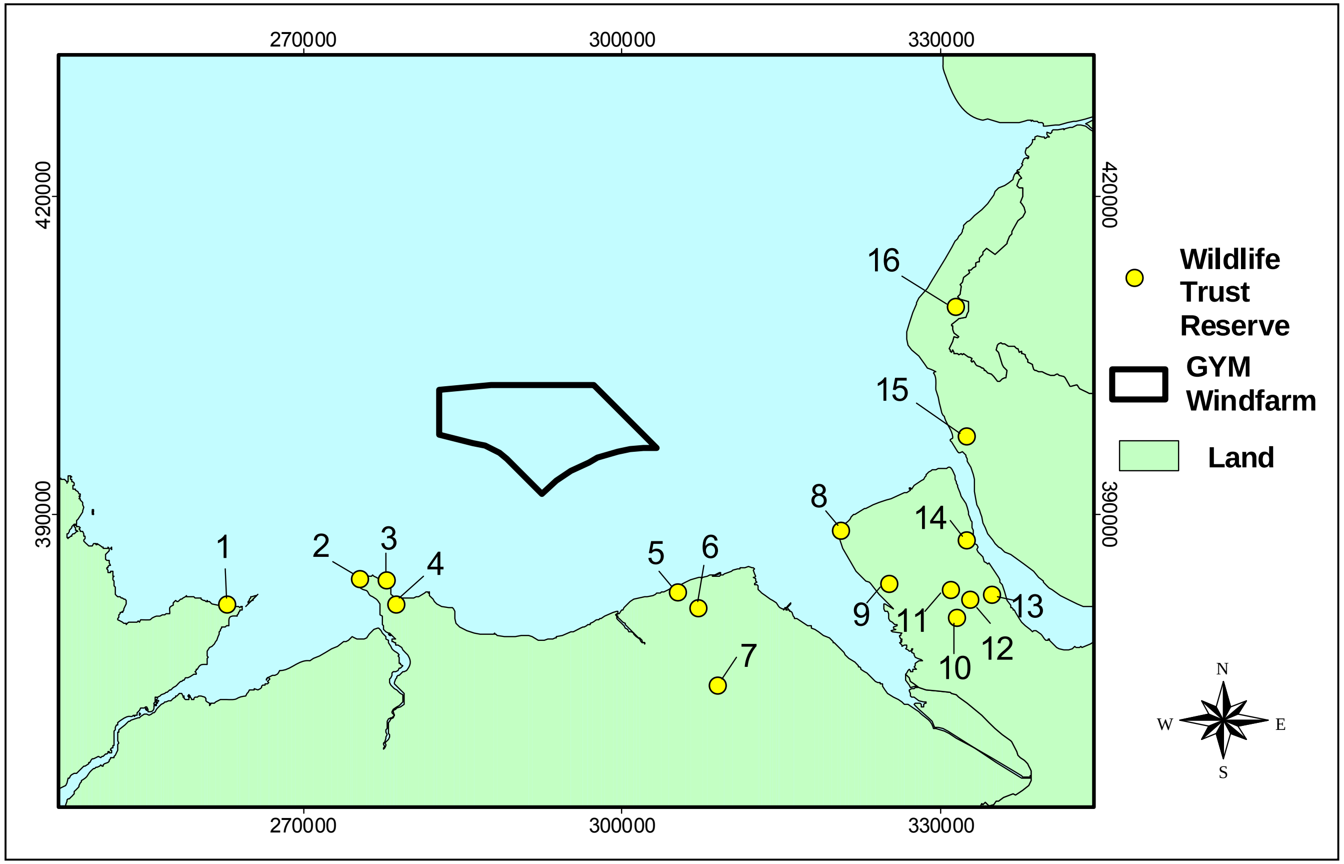


Figure 3.6.8: Wildlife Trust Sites within Liverpool Bay (see Table 3.6.6 for descriptions).

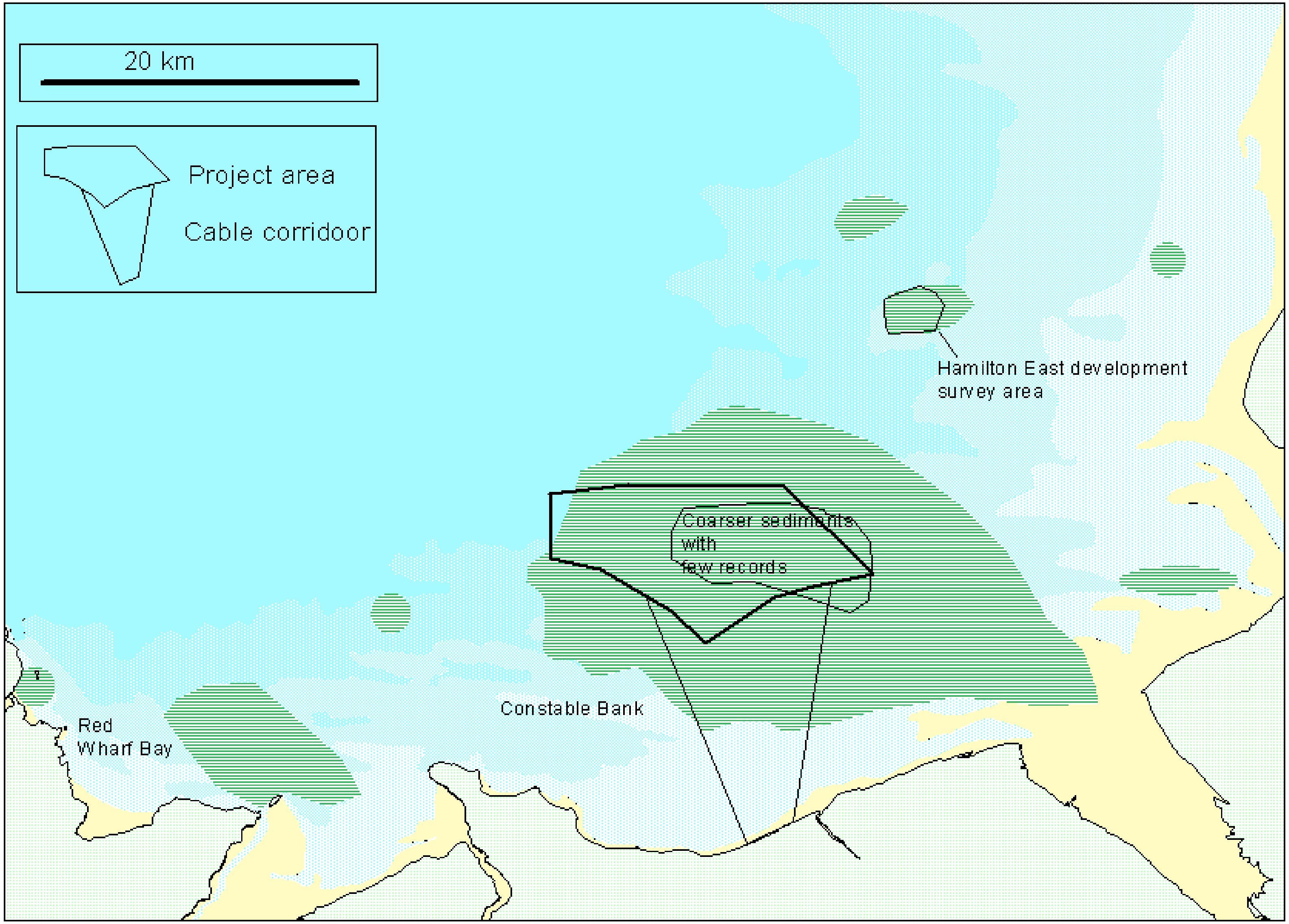


Figure 3.6.9: Distribution of the crab *Thia scutellata* off the coast of North Wales (from a variety of sources; see section 3.6.4 text for references).

Table 3.6.1: Designated RAMSAR sites within Liverpool Bay and reasons for designation (source: JNCC, CCW, EN and Keddie, 1996).

Name of Ramsar Site	Distance from Project Area (km)	Reasons for designation
Dee Estuary	14.2 SE	The Dee Estuary covers an estimated area of 13,055 ha and contains extensive areas of intertidal mud and sand flats, with large expanses of saltmarsh towards the head of the estuary. The estuary is considered to be extremely important for wintering and passage waterbird populations supporting an average of 90,518 waterbirds. On the upper shore of the estuary the site also includes the three sandstone islands of Hilbre considered to be important for cliff vegetation and maritime heath and grassland. The site also includes an assemblage of nationally scarce plants in addition to the Sandhill rustic moth *Luperina nickerlii leechi* which is a British Red Data Book species.
Ribble and Alt estuaries (Sefton coastline)	35km E	The Ribble and Alt Estuaries including the Sefton coastline (which was included within the Ribble and Alt estuaries designated site as part of the Phase 2 Ramsar Site (7UK083)) is a designated site as it regularly supports more than 20,000 waterbirds. These feed on a rich invertebrate fauna and *Enteromorpha* beds and, in addition, the saltmarsh supports a limited range of vegetation communities typical of the area, with *Spartina anglica* being the dominant species.
Martin Mere	43km NE	This site is located 10 miles inland from Southport and supports internationally important numbers of wintering waterbirds (average of 46,244). Nationally important wintering waterbird species include *Aythya ferina*, *Philomachus pugnax*, *Tringa erythropus* and *Ana crecca*. There are also a number of botanically important species including the whorled caraway (found at only very few sites in northern England), higher plants such as *Carum verticillatum*, *Rumex maritimus*, *Oenanthe fistulosa*, *O. aquatica* and *Lemna gibba*, and the lower plant *Leucoagaricus serenus*.
Mersey Estuary	34km SE	The estuary consists of large areas of intertidal sand and mudflats and saltmarsh. These provide feeding and roosting sites for large populations of waterbirds and this site was designated in recognition of its importance for migratory wading birds during spring and autumn (including internationally important numbers of *Charadrius hiaticula)*. In addition, over winter, the site regularly supports an average of 99,676 waterbirds, including shelduck *Tadorna tadorna*, redshank *Tringa totanus*, dunlin *Calidris alpina alpina*, pintail *Anas acuta* teal *Anas crecca* and ringed plover *Charadrius hiaticula.* Some parts of the northern shoreline of the estuary are composed of boulder clay cliffs. Below these cliffs are rocky shores with transitional areas with *Phragmites australis.* Other plant species found at the site include *Spartina anglica, Puccinellia maritima, Salicornia* spp.,

Name of Ramsar Site	Distance from Project Area (km)	Reasons for designation
		Suaeda maritime and *Typha latifolia.*
Corsydd Mon/Anglesey Fens	36km SW	This site covers an area of calcareous fens, which is a rare habitat type within the United Kingdom. Calcareous springs, predominantly from limestone aquifers, irrigate the fen and result in distinctive vegetation. The site supports a diverse flora and fauna with associated rare species and is notable as the best site in Wales for stoneworts *Nitella tenuissima.* Another nationally important plant species is *Dactylorhiza traunsteineri.* In addition the site also supports the nationally important bird species *Circus aeruginosus, C. cyaneus* and *Vanellus vanellus* as well as the Otter, *Lutra lutra* and the invertebrates *Coenagrion mercuriale, Eurodryas aurinia, Stratiomys chamaeleon* and *Acrometopia wahlbergi.*

Table 3.6.2: Local BAP marine and coastal habitat and species plans in existence for the counties bordering Liverpool Bay (source: UKBAP, 2005).

County	BAP Habitat/ Species
Gwynedd	Sea and River Lampreys Maritime Cliffs and Slopes
Conwy	Skate and Rays Coastal Sand Dunes Coastal Vegetated Shingle
Denbighshire	Harbour porpoise
Flintshire	None
Cheshire	Allis and Twaite Shad Harbour porpoise Mudflats Coastal Saltmarsh Coastal Sand dunes Coastal and Flood plain grazing marsh
Merseyside	Coastal Saltmarsh Coastal sand dunes

Table 3.6.3: SSSI sites located within the area under consideration (for locations see Figure 3.6.4) (source: CCW and EN, 2005).

Name of SSSI	Distance and Direction from Project Area	Reasons for designation
1. Traeth Lligwy	34.4km SW	Selected for 3 features of geological interest: rare example of deformed Old Red Sandstone rocks north of the Hercynian Front, outcrops of the Devonian Forth Mor Formation and the Lligwy Bay Conglomerate which is a diachronous basal unit to the carboniferous Limestaone.
2. Arfordir gogledd Penmon (incorporating Fedw Fawr-Caeau Ty-Cydwys, Penmon and Red Wharf Bay SSSIs)	27.4km SW	Important for wet heath, maritime grassland, base-rich flushes and associated species with these habitats.
3. Bwrdd Arthur	25.2km SW	One of the larger limestone sites in West Gwynedd designated for its botanical interest.
4. Puffin Island	23km SW	Nesting seabirds breeding both on its sea-cliffs and open grassland areas.
5. Glannau Penmon-Beaumaris (incorporating Lleiniog SSSI)	25.1km SW	Some of the finest exposures of Late Pleistocene deposits of Irish Sea origin found in North Wales. The succession comprises a series of current bedded sands and gravels overlain by Irish Sea till. The coastal cliffs also reveal a submerged forest and marine sediment.
6. Baron Hill Park	29.8km SW	Parkland containing ancient trees supporting diverse epiphytic lichen flora.
7. Traeth Lafan (Lavan Sands)	26.8km SW	The sands are nationally important for their assemblies of moulting great-crested grebes and wintering populations of oystercatcher and curlew. The site is also regionally important for shell duck.
8. Snowdonia (Eryri)	28.2km SW	Snowdonia contains many examples of plants and habitats of interest including llyn Idwal representing oligotrophic waters of high water quality. In addition Snowdonia has the best developed most extensive areas of Siliceous alpine and boreal grasslands in Wales.
9. Sychnant Pass	21.2km SW	Large area of heath with smaller patches of bracken and acid grassland.
10. Aber Afon Conwy/Conwy Estuary	18.8km SW	PSSSI. Specialised and nationally scarce biotopes. Most species rich with good examples and large extent of complete zonation and estuarine intertidal biotopes. Nationally scarce population of the belted beauty moth
11. Cadnant	20.5km SW	Special interest for its geology showing a biostratigraphically important section in the Caradoc of north Wales.
12.Benarth Wood	20.4km S	Mixed deciduous woodland on Silurian rocks adjacent to the Conwy Estuary and

Name of SSSI	Distance and Direction from Project Area	Reasons for designation
		receiving low rainfall. The wood is ungrazed and has a diverse ground flora and adequate tree regeneration.
13.Coed Ffordd-Las	21km SW	Biological site selected to represent a type of broadleaved woodland that is uncommon in North Wales. Soil is predominantly acid in nature with a tree canopy dominated by sessile oak and sycamore
14. Deganwy Quarries and grassland	18.8km SW	Geological interest with exposures of the Deganwy mudstones and overlying Conwy Grits. Exposed quarry faces are bedding plane faces and grassland in the immediate vicinity has a range of plants found on light calcareous soil including common rockrose and Lady's bedstraw.
15. Bwlch Mine	18.6km S	Only recorded Welsh locality for the lead-antimony-sulphides semseyite, zinkenite and heteromorphite along with stibnite, galena, pyrites and blende.
16. Great Ormes Head	14.7km SW	Geological, botanical, entomological, ornithological and marine biological features of interest.
17. Little Ormes Head	14.6km SW	Geological, botanical, entomological, ornithological and marine biological features of interest.
18. Gloddaeth	16.3km SW	Carboniferous limestone ridge with a large area of well developed, mixed woodland, limestone grassland and heath, in addition to small areas of scrub.
19. Pydew	17.7km S	Series of species-rich grassland and scrub located on the Pydew Carboniferous limestone ridge. Wide range of flowering plants with a range of less common species including Pyramidalorchid, Kidney vetch and Green-winged orchid while several nationally rare species, including Spiked Speedwell and Hoary Rocrose are present.
20. Marle Hall Woods	18.5km SW	Structurally diverse, mixed deciduous woodland, partly located on steep carboniferous limestone slopes.
21. Coed Bron Garth	18.1km S	Mixed deciduous woodland exhibiting good structural diversity and located predominantly on a steep east-facing Carboniferous Limestone scarpe slope.
22. Bryn Euryn	15.4km S	Species rich grassland developed on a prominent hill formed mainly of carboniferous limestone.
23. Llyn y Fawnog	19km S	Former lake basin now restricted to a small area near the centre. Good example of the advanced stages of a hydrosere under oligotrophic conditions. Around the lake is a floating mat of Bottle Sedge, Water Horsetail and Cotton-grass. Outer zones of Bog mosses and other plants characteristic of acid bogs, is being colonized at the margins of the basin by birch.
24. Mynydd Marian	14.2km S	Limestone grassland communities and

Name of SSSI	Distance and Direction from Project Area	Reasons for designation
		population of the dwarf race of silver studded blue butterfly.
24. Llandulas Limestone and Gwrych castle woods	14km S	Limestone grassland, heath and woodland communities and associated flora and fauna.
26. Coed y Gopa	14.7km S	This site is noted for its species interest, as it is a winter roosting site for the lesser horseshoe bat, *Rhinolophus hipposideros*.
27. Llandulas beach	13.6km S	Shingle bank mainly above the high water mark on the foreshore west of Abergele. It represents the best example of a vegetated shingle bank in the former county of Clwyd.
28. Graig Fawr	17.5km SE	Limestone grassland communities supporting populations of vascular plants and butterflies and moths.
29. Prestatyn Hillside	17.5km SE	Carboniferous limestone supporting a range of semi-natural plant communities including calcareous and acidic grassland; calcareous heath and scrub and broadleaved woodland.
30. Maes Hiraddug	18.2km SE	Unimproved neutral grassland vegetation, which occurs in association with some small patches of woodland and scrub.
31. Moel Hirradug Quarries	19.1km SE	The best locality in Britain for the study of fossil plants contained within the Lower Brown Limestone.
32. Hendre Bach	23.2km SE	Fen-meadow, associated soligenous mire vegetation and the population of black bog-rush Schoenus nigricans which it supports. The site represents rare and uncommon vegetation types within the former county of Clwyd.
33. Teilia Quarry	18.6km SE	Internationally important for the study of fossil plants which lived during Lower Carboniferous times (330 million years ago). No other site in the UK contains any comparable flora and the most similar assemblage known is in Czechoslovakia.
34. Gronant Dunes & Talacre Warren	12km SE	Dunes and other associated habitat which are the only remnant of a once extensive dune system along the North Wales coastline.
35. Dee Estuary	14.2km	One of the most important estuaries in Britain and amongst the most important in Europe for its populations of waders and wildfowl.
36. Heswall Dales	25.9km SE	Dry lowland heath, with developing birch-oak woodland and areas of acidic marshy grassland along the natural valleys
37. The Dungeon	25km SE	Wooded ravine with a natural stream section through the Tarporly Siltstone Formation of the Mercia Mudstone Group, of Triassic age.
38. Dee Cliffs	24km SE	Clay cliff and bank habitat with some marl pits which have a rich flora and fauna and an area of herb-rich neutral grassland

Name of SSSI	Distance and Direction from Project Area	Reasons for designation
39. Thurstaston common	17km SE	Largest and best remaining example of a lowland heath in Merseyside
40. Red Rocks	15km SE	Typical example of a sand dune system and includes a brackish dune slack and reedbed.
41. Meols Meadow	16km SE	Best example of the Crested Dog's-tail/Common Knapweed type of grassland known in Greater Manchester and Merseyside.
42. North Wirral foreshore	16.9km E	Intertidal sand and mudflats and embryonic saltmarsh which is of considerable importance as a feeding and roosting site for passage and wintering flocks of waders, wildfowl, terns and gulls.
43. Mersey Narrows	28.9km E	Large areas of intertidal sand and mudflats supporting internationally important populations of Turnstone (*Arenaria interpres)*, Redshank (*Tringa totanus)* and nationally important populations of Cormorant (*Phalacrocorax carbo)*.
44. New Ferry	33km SE	Pioneer saltmarsh community and intertidal sand and mudflats.
45. Dibbinsdale	33.3km SE	Largest area of semi-natural woodland of its type in Merseyside, containing typical examples of Ash and valley Alder woodland, each of which supports a rich flora and fauna.
46. Mersey Estuary	34km SE	Internationally important site for wildfowl consisting of large areas of intertidal sand and mudflats.
47. Formby point	27.6km E	Large dune system supporting large natterjack toad population- a nationally rare species.
48. Sefton coastline	35km E	Largest sand dune system in England.
49. Ribble and Alt estuaries	43.6km NE	Extensive area of intertidal sand-silt flats with one of the largest areas of grazed saltmarsh in UK.

Table 3.6.4: Location of coastal LNR sites within Liverpool Bay (see Figure 3.6.5 for locations) (source: English Nature (1998), Countryside Council for Wales (2005) and JNCC (2005)).

LNR	Distance and Direction	Reasons for designation
1.Llanddona Commons	29km SW	Common land supporting four habitat types: dry heathland, scrub, bracken bramble underscrub and neutral grassland. Species include common heather; bell heather, western gorse, tormentil, heath, milkwort and sedges.
2. Llangoed Common	27km SW	Common land supporting natural vegetation.
3. Traeth Llafan (Lavan Sands)	26.8km SW	Large intertidal area of sand and mudflats important for wintering birds.
4. Nant y Coed	23km SW	Ancient oak woodland.
5. Great Orme headland	14.7km SW	Presence of nationally rare plants- only place in the UK for wild cotoneaster as well as dwarf forms of grayling and silver-studded blue butterflies. Cliff-nesting seabirds including guillemot, kittiwake, fulmar and cormorant.
6. Bryn Euryn	15.4km S	Prominent carboniferous limestone hill covered with species rich grassland dominated by hairy oat grass, meadow oat grass, crested hair grass, quaking grass, and common rock rose and lesser meadow rue.
7. Pwllycrochan Woods	15.7km S	Deciduous woodland with a variety of native trees
8. Fairy Glen	15km S	Oak, sycamore and ash tree woodland with associated wildflowers
9. Mynydd Marian	15km S	Limestone grassland community with populations of the dwarf race of silver studded blue butterfly.
10. Kinmel dunes	12.9km S	Remnants of a much larger stretch of dunes that originally ran along this part of the North Wales coast. Important for the characteristic semi-natural vegetation present.
11. Brickfield ponds	14.3km S	Freshwater flooded clay pit surrounded by tall grassland and scrub which is important for wildfowl and waders.
12. Gronant dunes	12km SE	Largely unmodified remnant of the dune system which previously ran along the North Wales coastline. Only breeding colony of little tern (one of UKs rarest seabirds) in Wales.
13. Llwyni pond	34km SE	Series of ponds home to a range of amphibians including the Great crested Newt.
14.Thurstaston common	22km SE	Semi-natural and planted woodland, heathland and open parkland.
15. Hilbre Island	14.2km SE	Maritime grassland/heathland, vegetated cliff and rocky intertidal habitats supporting varied species of heath dominated flora and waders, wildfowl and grey seals.
16. Ravenmeols Hills	35km NE	Dune habitat important for Natterjack toad species.
17. Ainsdale and Birkdale Sandhills	35km NE	One of the largest areas of wild dune left in the UK. Reserve is 268ha of open dunes and is rich in flora and fauna with dune slacks providing breeding pools for Natterjack toads.

Table 3.6.5: Designated GCR sites within proximity to the Gwynt y Môr Offshore Wind Farm and the surrounding region (source: CCW, EN, 2005).

Number on map (see Figure 3.6.6)	Distance and Direction from Project Area	Name of GCR site designated for the importance of its earth science
1	35km SW	Lligwy Bay
2	33.8km SW	Red Wharf Bay
3	31km SW	Trwyn Dwlban
4	26.2kmSW	Tandinas quarry
5	24km SW	Flagstaff quarry
6	25.1km SW	Lleiniog
7	19km SW	Deganwy Quarry
8	19km SW	Bwlch mine
9	14.7km SW	Great Orme Headland
10	13.4km SW	Little Orme Headland
11	19km S	Ty yn Ffodd quarry
12	27km S	Cefn caves
13	25km S	Pont newydd caves
14	22km SE	Beuno Caves
15	18km S	Dyserth Quarry
16	17km S	Teilia Quarry
17	23km SE	Caerwys
18	24km SE	Ddol
19	26km SE	The Dungeon
20	22km SE	Thurstaston
21	20km SE	Thurstaton Road cutting
22	33km E	Ainsdale
23	35km E	Downholland moss

Table 3.6.6: Wildlife Trust Sites identified within the area under consideration (see Figure 3.6.7 for locations) (source: Wildlife Trusts of Cheshire, Merseyside and North Wales, 2005).

Name of Site (No corresponds with Fig 3.6.7)	Distance and Direction from Project Area	Site Description
1. Mariandrys	16km SW	Carboniferous limestone providing unique soil habitat for a characteristic group of plants.
2. Great Ormes Head	14.7km SW	Area of carboniferous limestone with associated groups of plants.
3. Rhiwleddyn	11km SW	Site of 12acres of which the eastern section forms part of the Little Orme SSSI. Predominantly limestone habitat with associated grassland habitat.
4. Bryn Pydew	17km SW	Excellent example of limestone pavements and grassland.
6. Maes Hirradug	16km S	Wildflower meadow forming part of the Maes Hirradug SSSI.
7. Y Craig	18km S	Small limestone escarpment with grassland haven for butterflies.
5. Big pool wood	9km SE	Wood and scrubland totalling area of 10 acres.
9.Cleaver heath	26km SE	Heathland supporting varied populations of insects, birds and reptiles such as the common lizard (also designated SSSI)
8. Red Rocks Marsh	14.2km SE	Sand dunes, reedbeds and marsh important for many species of wintering birds as well as the rare natterjack toad.
10. Foxes wood	31km SE	Part of ancient semi-natural woodland (also a designated SSSI)
12. Intake Wood	31km SE	Part of ancient semi-natural woodland (also a designated SSSI)
13. Patricks Wood	31km SE	Part of ancient semi-natural woodland (also a designated SSSI)
11. Thornton Wood	33km SE	Part of ancient semi-natural woodland (also a designated SSSI)
14. New Ferry Butterfly Park	29km SE	Grass and scrubland supporting birds, insects and butterflies
15. Seaforth	31km E	Fresh water and saltwater lagoon within Liverpool Docks at the mouth of the River Mersey. Important as a roosting site for waders, sea birds and large numbers of wintering ducks.
16. Haskayne cutting	37km E	Marsh, scrub and grassland supporting butterflies and common toads, frogs and lizards

Table 3.6.7: Species of fish recorded within Liverpool Bay and the eastern Irish Sea (Potts & Swaby, 1999) that are protected by national and international legislation**.**

Species	Protection
Allis Shad, *Alosa alosa*	Appendix II & Appendix III of the Bern convention Annexes II and V of the Habitats directive UK BAP species
Twaite Shad, *Alosa fallax*	Appendix III of the Bern convention Recommended for addition to Schedule 5 of the Wildlife and countryside act 1981 under section 9-(4) (a). Annexes II and V of the Habitats directive UK BAP species
Sea Lamprey, *Petromyzon marinus*	Appendix III of the Bern convention Annex II species of the EC species directive
River Lamprey, *Lampetra fluviatilis*	Appendix III of the Bern convention Annex II species of the EC species directive
Sturgeon, *Acipenser sturio* (records from the Dee Estuary)	Appendix III of the Bern convention CITES species Schedule 5 of the Wildlife and countryside act 1981 Annex II species of the EC species directive
Smelt*, Osmerus eperlanus*	Appendix III of the Bern convention Annexes II and V of the Habitats directive
Salmon, *Salmo salar*	Appendix III of the Bern convention but only protected under Annex II of the EC species directive when in freshwater.
Common goby, *Pomatoschistus microps*	Appendix III of the Bern convention
Sand goby, *Pomatoschistus minutus*	Appendix III of the Bern convention
Basking Shark, *Cetorhinus maximus*	Appendix III of the Bern convention Wildlife and Countryside Act (1981) Appendix II of the Convention on International Trade in Endangered Species (CITES). UK BAP species

3.7 Subsea Noise Background

3.7.1 Underwater noise sources within Liverpool Bay

Natural underwater noise can be generated by a number of processes such as waves, currents, bubble formation arising from breaking waves or precipitation such as rain or hail, and impact noise generated during the act of precipitation upon the sea surface. Turbulence associated with surface disturbance or turbulent tidal flow and the movement of sediments on the seabed will also contribute to ambient noise levels. Subsea noise is also generated by marine organisms including crustacea such as snapping shrimps, fish which produce a variety of grunts and other noises and marine mammals which produce a range of clicks, pops and whistles. Source levels for tonal sounds made by cetaceans have been recorded as; around 170-180 dB re 1μPa@1m while echolocation clicks range from a source level of 170 dB re 1μPa@1m for the harbour porpoise (*Phocoena phocoena*) up to 226 dB re 1μPa@1m for the bottlenose dolphin (*Tursiops truncatus*) (QinetiQ, 2005).

Man made noise within the marine environment of Liverpool Bay may arise from industry such as the operation of the oil and gas rigs and aggregate extraction at the licensed areas within the Bay. Noise will also be generated during the maintenance dredging of the shipping channels at the mouths of the Dee and Mersey Estuaries causing mechanical noise from the operation of the dredge and a noise similar to sediment transport resulting from the disturbance of the gravel on the seabed, to be generated.

Shipping occurring in the main shipping lanes of Liverpool Bay is another man made source contributing to noise levels in areas close to the shipping lanes. Large shipping will generate noise of a low frequency and leisure craft such as motorboats will generate noise of a higher frequency. In addition to noise levels generated from the machinery of shipping craft noise will also be created by the disturbance of the water.

Other sources of man made noise include onshore industrial adjacent to the coastline which can contribute to underwater noise by coupling through the substrate. Noise levels are only significant if the noise is intense e.g. quarry blasting, or if there are a number of noise sources e.g. an area of heavy industry. Transport systems close to the coastline such as the A55 expressway and the main line railway line to Holyhead may also couple noise into the underwater environment via the substrate. The coupling through the substrate will generally only occur at very low frequencies.

Sonar including echosounders and fish-finding sonars are further sources of man made noise within this area. Activities of the fishing industry and leisure craft will all contribute to noise from this activity as most vessels from small leisure craft up to the largest commercial ships have at least one echosounder. These work on frequencies from 26 Khz to 300 kHz with source levels up to 220 dB re 1μPa@1m. These sonars direct their energy downwards into the seabed but there is significant energy travelling horizontally.

In addition, the operational wind farm at North Hoyle and the construction and subsequent operation of the wind farms at Rhyl Flats and Burbo Bank will also contribute to the man made noise levels of the area.

The background noise levels generated by these ambient and man made sounds will also be affected by the subsea environment of Liverpool Bay as sound levels are heavily influenced by depth, bathymetry, seabed type and salinity. The variations of water depth as a result of tidal flow can also make a significant difference to the background noise levels in the shallow areas of the North Wales coastline.

For the noise radiated by a wind farm to have an environmental impact, its energy must significantly add to the background noise levels. It is necessary therefore to have an understanding of the noise levels around the proposed site before the wind farm is constructed.

Offshore wind farms are often located in areas of locally shallow water where noise can be increased naturally by the effects of locally enhanced tidal flow over sand/shingle banks, which results in increased noise generated by sediment transport processes. This may be combined with the impact of sea state, especially in sites chosen for high levels of exposure to strong winds, and the proximity of a site to anthropogenic sources such as shipping lanes. Furthermore, complex seabed topography in shallow coastal waters can focus noise to produce higher than expected noise levels (Urick, 1983). Many sites may be naturally noisy.

There is no literature concerning the background noise levels within the Gwynt y Môr project area or surrounding marine environment. It was therefore deemed necessary to undertake a site-specific survey to predetermine the existing background noise levels at the site. This would allow the predictions for the noise levels likely to be experienced at the Gwynt y Môr project area during the different phases of the wind farm (construction, operation and decommissioning) and could then be used to assess the potential impacts of wind farm generated noise upon the marine fauna of Liverpool Bay (detailed within section 4). In addition, measurements of the noise levels at the nearby operating North Hoyle Offshore Wind Farm have also been measured as part of the monitoring phase of this wind farm. The results from these measurements were used to predict the noise levels likely to be experienced at Gwynt y Môr during its operational phase.

3.7.2 Site-specific Background Noise Levels

A site-specific survey was designed to predetermine the existing background noise levels at the Gwynt y Môr Offshore Wind Farm project area (CMACS & QinetiQ, 2005- Appendix 3). Measurements were taken using three hydrophones deployed from a survey vessel at 37 predetermined measurements stations across the project area (see Appendix 3 for a comprehensive list of all trials equipment deployed and the locations of the measuring sites). The hydrophones were lowered to a depth of approximately half the water column or 5 m where the water depth was less than 10 m. At each measurement station, a total of around 10 minutes of data were acquired using each of the high frequency (HF), medium frequency (MF) and low frequency (LF) hydrophones. In addition to the acoustic data, the latitude and longitude of the station was determined by GPS and the prevailing wind direction and strength and sea state were also noted. The number and approximate distance to any noise sources such as passing vessels and gas or oil installations was also noted, in addition, for those stations within close visual proximity to the operational North Hoyle Offshore Wind Farm, the number of turbines in operation was recorded, as was the typical rotational speed.

Data acquisition from the hydrophones was controlled through two onboard computers operating independently of each other. The LF and MF hydrophones were controlled through a computer running the computer program Ishmael® (Mellinger, 2002). For the second computer, which controlled the HF hydrophone, data acquisition was controlled by a QinetiQ proprietary program called SeaProDaq. Following data acquisition, both programs stored the data files in .wav format ready for subsequent data processing. Each of the data files obtained were processed using the Fast Fourier Transform (FFT) in order to provide estimates of power spectral density across 1/3 octave bands. Power spectral densities were averaged over the time taken to acquire the data samples. The LF and MF data sets were processed using the mathematical matrix computing language, MATLAB, developed by The Mathworks, USA. The HF data sets were processed using the QinetiQ proprietary processor Nereus running on a PC with the Linux operating system.

The results of the ambient noise data that were acquired over the whole of the Gwynt y Môr project area are displayed in Figure 7.1. Background noise levels are given in 1/3 octave bands for each data set and it can be seen that, for a given frequency, there is considerable variation across the Gwynt y Môr project area.

Overall, the background noise levels for the area were highly variable between sites with (at a frequency of 10 Hz) noise levels varying from below 120 dB re 1 uPa per band level to 147 dB re 1 uPa per band level. Such a variation of nearly 30 dB appears typical up to a frequency around 20 kHz beyond which, the variation reduces to 10 dB or less. In addition, it will be seen that there is a large spike centred at 20 kHz and a smaller one at 40 kHz. The reason for this is unknown but it is speculated that it was an artefact of the HF hydrophone and data acquisition system. Noise levels over the frequency range 10 Hz to 150 Hz have been recorded and the results show a characteristic fall in level with increasing frequency. Although considerable variation was seen from location to location, this was attributed to a number of factors including wind noise, wave slap, flow noise, industrial noise such as shipping and the noise from the nearby North Hoyle Offshore Wind Farm. Such variations were also attributable to water depth due to bathymetric variation and state of tide.

3.7.3 Predicted Wind Farm Offshore Underwater Noise Levels

The different phases of the windfarm will generate underwater noise. Noise predictions for the construction and decommissioning phases of the project are discussed within section 2. However, to predict the operational noise levels at Gwynt y Môr the underwater noise levels at the operational North Hoyle Offshore Wind Farm were assessed and these data used to predict noise levels by uplifting over the measured baseline noise levels at the Gwnyt y Môr project area. To measure the noise levels at North Hoyle the same equipment as detailed above was used at predetermined measurement stations located along transects which bisected the wind farm (see Appendix 3 for locations). This data was then used to determine sound pressure levels across third octave bands for the 30 turbines that comprise the wind farm to provide data that could be uplifted in order to provide an estimate of the underwater noise levels likely at Gwynt y Môr during its operational phase.

At North Hoyle the highest sound levels were recorded in the frequency range 100-200 Hz, where they exceed 140 dB re 1 uPa. Such sound levels were recorded at a number of sites where the measurement station was as close as 500 m from a wind turbine. The spectra fall in level as frequency increases until the level reaches 50-60 dB re 1 uPa at frequencies over 100 kHz. This data was then uplifted to take into account the larger turbine class and number at Gwynt y Môr and was applied over the background noise levels obtained during the site-specific survey to gain an estimate of the operational noise levels for Gwynt y Môr. The results of which are displayed in Figure 7.2. It can be seen that the maximum sound pressure levels are found generally over the frequency range 100 Hz to 200 Hz. There is also seen to be considerable variation over all sites for a given frequency. For instance, over the above frequency band, the maximum sound pressure levels vary between 120 dB re 1 uPa/band level and 155 dB re 1uPa/band level. In order to provide an estimate of the total power emitted by the wind farm, total noise levels at each measurement site and over the frequency range 10 Hz to 150 kHz were plotted as a function of range using the uplifted Gwynt y Môr data set and the results are shown in Figure 7.3.

Both Transmission Loss (TL) and Source Level (SL) models have been fitted to the measured RMS power levels from the uplifted source as a function of range. These are essentially a best fit line through the data; the SL is effectively the level at a range of 1 m and the TL represents the gradient of the line. The source level for the operational wind farm at Gwynt y Môr was estimated at 159.1 dB re 1uPa/band level while the transmission loss was found to be weakly dependent on range at $0.53\log_{10}R$ where R is the range from the centre of the wind farm. The weak dependence on R suggests that most of the measured sound is in fact existing background noise levels and not operational wind farm noise.

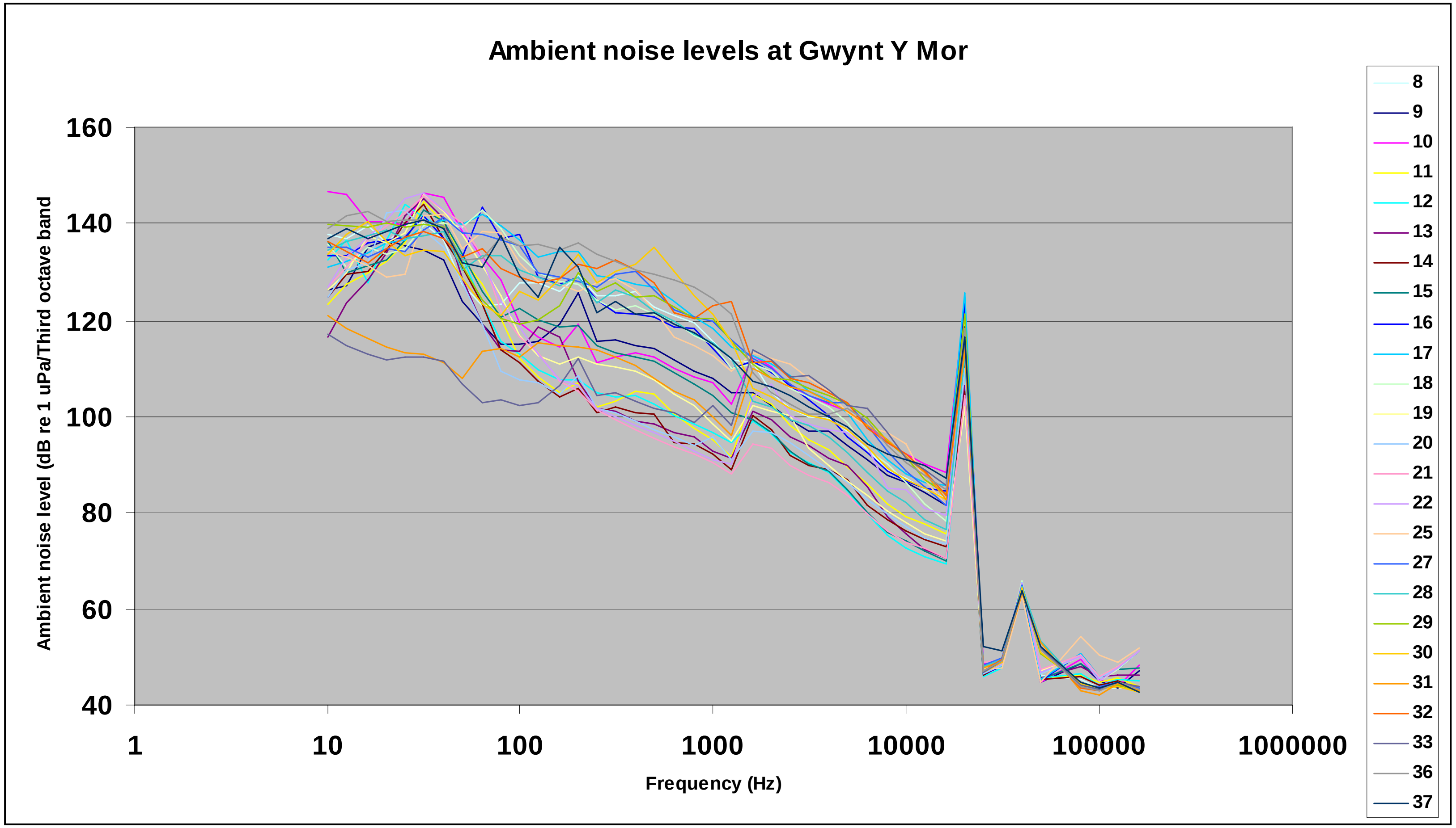


Figure 7.1: Ambient noise levels recorded from the 25 usuable data sets from the 37 stations across the Gwynt y Môr project area.

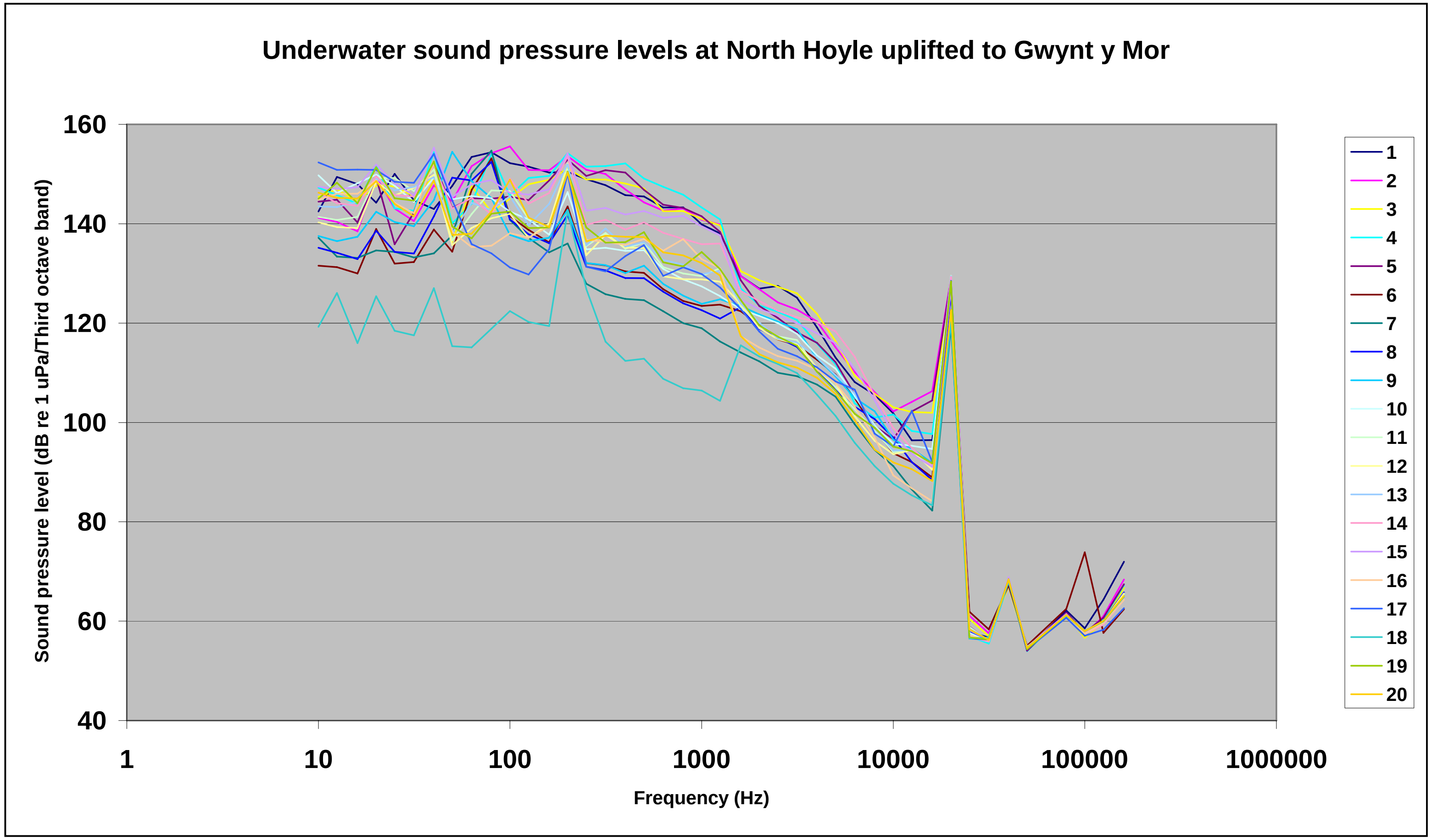


Figure 7.2: Uplifted noise data from the North Hoyle operational wind farm to Gwynt y Môr.

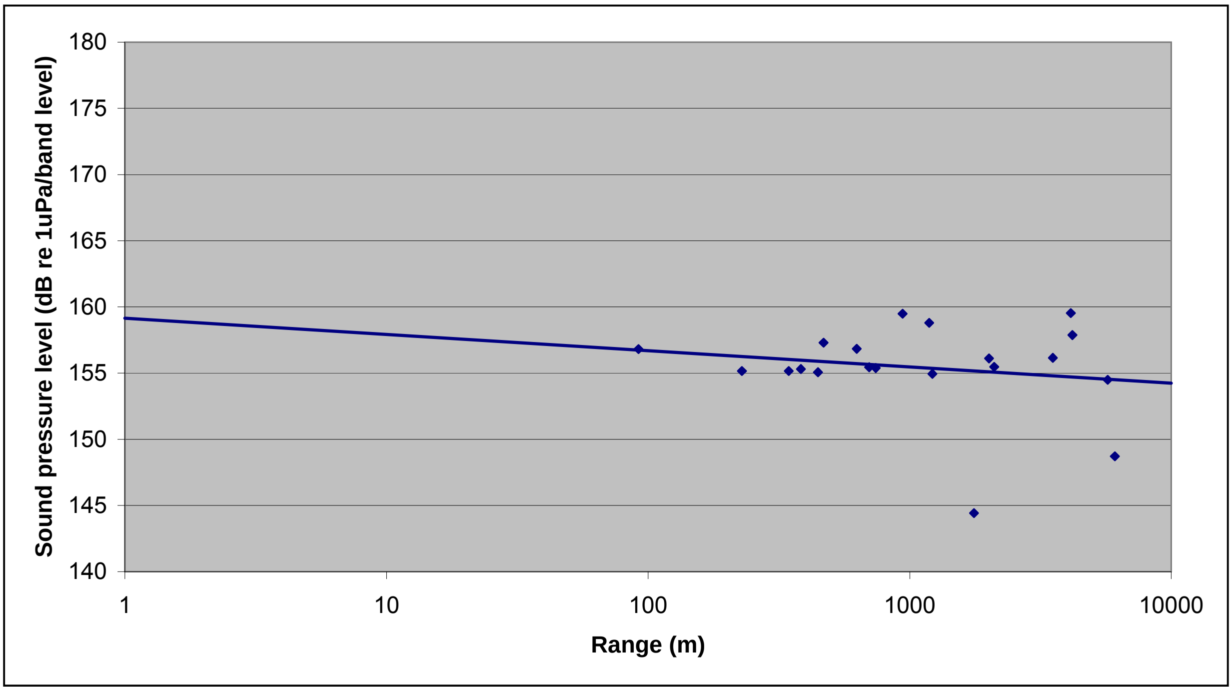


Figure 7.11: RMS sound pressure levels as a function of range and transmission loss model for estimates of noise at the Gwynt y Môr Offshore Wind Farm.

3.8 Electromagnetic Field Background

Three-phase cables are widely employed for high-voltage electric power transmissions since they are more efficient to transmit power than the two wires of a single-phase system. They therefore find wide application in offshore power transmission. Within a three-phase cable, there are three separate cores, each of which is shielded by an insulation screen. The use of insulation screens enables the confinement of the electric field within the cable and reduces the risk of shock, both achieved by earthing the screens. However, the screens do not shield the electromagnetic (EM) fields. As a result, there are EM fields outside the cable, radiating into the surrounding medium in which the cable is located. The EM field has two components, an Electric (E) field which is effectively retained within the cable by the shielding and a magnetic (B) field which is detectable outside the cable.

It was shown by CMACS (2003) that for industry standard AC offshore cables (three-core XLPE) the B fields induce another E-field (the iE-field) in the surrounding medium. If marine organisms can detect either the B or iE fields emitted by sub-sea cables there is potential for disturbance of their normal behaviour which could result in an adverse effect. This potential is considered separately for organisms that may be sensitive to magnetic and electrical fields. The majority of information is drawn from a recent study by CMACS and Cranfield University for COWRIE (Cranfield & CMACS, 2005).

3.8.1 Magnetic Fields

A relatively large number of marine species are believed to be sensitive to magnetic fields. This sensitivity is based either on detection of the induced electric field resultant from the interaction of water currents with, or the animal's own movement through, the earth's magnetic field or magnetite based detection of geomagnetic fields. The former requires electroreceptive ability (cf. the following section) and relates principally to elasmobranchs while magnetite based detected is associated with other species noted below.

Certain teleost (bony) fish species, including salmonids, eels, mackerel and plaice are believed to be magnetically sensitive. Other marine species understood to be magnetically sensitive that need to be considered in the environmental assessment for the Gwynt y Môr Offshore Wind Farm include: marine mammals (Cetacea, including harbour porpoise, common and bottlenose dolphin but not seals (pinnipeds)); Crustacea (including crabs, shrimp and prawns) and Mollusca (including snails and bivalves) (All from Cranfield & CMACS, 2005). It should be noted that all examples of magnetic response for Crustacea and Mollusca have been demonstrated outside UK waters (but including species found inside UK waters); it is therefore *speculated* that certain Crustacea and Mollusca present within the Gwynt y Môr project area will be magnetically sensitive); it is currently unknown which species could be affected but magnetic sensitivity has been demonstrated outside the UK for Decapoda (*Crangon crangon*); Isopoda (*Idotea baltica) and Amphipoda (Talorchestia martensii* and *Talitrus saltator)*.

In all cases, magnetic sensitivity is understood to be associated with orientation and direction finding ability. If animals perceive a different magnetic field to the earth's there is potential for them to become disorientated; depending on the magnitude and persistence of the confounding magnetic field the impact could be a trivial temporary change in swimming direction or a more serious impact on migration.

Any B field produced by offshore power cables will be superimposed onto existing magnetic fields, for example the earth's geomagnetic field which has a strength of approximately 50 µT (CMACS, 2003). The CMACS study suggested that although the B field from sub-sea AC power cables would likely be significantly smaller than the earth's field (up to 1.7 µT) it would vary over time and may therefore be perceived differently from the constant earth field. It was also calculated that B fields from subsea power cables used at offshore wind farms would fall away rapidly with distance from the cable, dropping to less that 1/50th of the earth's field after 2.5m. These calculations were made for a 33 kV XLPE tri-phased, 50 Hz AC cable carrying 641 A.

Westerberg & Begout-Anras (1999) investigated the orientation of eels (*Anguilla anguilla*) in a disturbed geomagnetic field created by the presence of a submarine high voltage direct current (HVDC) power cable. HVDC power cables pass a current in a single-conductor cable with the return current via the water. It should be noted that this type of cable is not characteristic of the AC cables currently proposed for UK offshore wind farms. In the Westerberg & Begout-Anras study, the B-field generated by the cable was of the same order of magnitude as the Earth's geomagnetic field at a distance of 10m. Of twenty-five female eels tracked, approximately 60% crossed the cable. Westerberg & Begout-Anras concluded that the cable did not act as a barrier to the eel's migration path in any major way. In a more recent publication, Westerberg (2000) reported similar results after investigating elver movement under laboratory conditions.

The Bio/consult (2002) study at the Vindeby offshore wind farm in Denmark cited evidence of the sensitivity of certain teleost (bony) fish to B fields, including salmonids, plaice and eels. Here the conclusion was that magnetic fields around the submarine power cables may be of sufficient magnitude to affect sensitive fish but only up to around one metre from the cable (when the field was 33.1 µT), after which the field was predicted to be indistinguishable from the earth's field[1]. These conclusions were based on desktop assessment for 10 kV tri-phased, 50 Hz AC cables with maximum current in each of the three phases of the cable of 260 A.

Bio/consult AS also conducted a study of fish response to the presence of the main power cable to shore at the Nysted offshore wind farm in the southern Baltic Sea. The study only considered the magnetic component of the EM-Field. The electrical component was assumed to be contained within the cable shielding and there was no consideration of induced E-fields. The project status report (Hvidt *et al.* 2003) details the investigation of changes in populations of six bony fish species around the cable route. The study utilised passive fishing gear on both sides of the cable and was designed to test whether fish would cross the cable. The species chosen for analysis included herring *Clupea harengus*, common eel *Anguilla anguilla*, Atlantic cod *Gadus morhua* and flounder *Platichthyes flesus*.

The methods used in the study did not reveal any effect of the cable on the species investigated. However, the authors expressed doubts over the methods used. They considered the nets to have been employed at too great a distance from the cable to detect

[1] Note that this is in contrast to the suggestions made in the report by CMACS (2003). Here it was suggested that anthropogenically derived magnetic fields could be perceived differently from the earth's geomagnetic field even if they were smaller in magnitude.

whether the electro-magnetic field had repelled or attracted fish. In addition, the nets either side of the cable were parallel and could have shadowed one another. Nevertheless, no significant differences in catch numbers of fish were found either side of the net and it is believed likely that a serious blocking effect on eel migration in particular should have been detectable. Unfortunately, a gap in this study is that no measurements were made of the in situ B fields (iE fields were not considered at all) and the timing of the experiment was not related to wind farm generating status.

3.8 2 Induced Electrical Fields

In the UK the elasmobranchs (sharks, skates and rays) represent the major group of electrosensitive fish species. Elasmobranchs have specialised electroreceptors and use electric fields passively for the detection of bioelectric emissions from their prey, conspecifics and potential predators/competitors (the latter being more likely for early life history stages). The electroreceptive sense is only used in close proximity to the source and other senses (such as hearing or smell) are used at distances of more than approximately 30cm. This means that the electroreceptive sense is highly tuned for the final stages of feeding or detecting other animals and elasmobranchs are able to detect very weak voltage gradients (down to 0.5µV/m) in the environment around them (Kalmijn 1971; Murray 1974; Boord & Campbell 1997- all cited in Cranfield & CMACS, 2005).

Gill and Taylor (2002) suggested through a review of the literature and subsequent experimentation that elasmobranchs would be attracted to electric fields of 0.5 to 100 µV/m; above this value they would be expected to exhibit an avoidance response.

Other UK fish species that may be sensitive to electric fields are identified in Table 3.8.1. These species do not possess specialised electroreceptors but are able to detect induced voltage gradients associated with water movement and geomagnetic emissions. They are likely to be less sensitive to electric fields than elasmobranchs (Bullock 1973). The actual sensory mechanism of detection is not yet properly understood; however, it is likely that the E-fields that these species respond to are associated with peak tidal movements which can create fields in the range of 8-25µv/m (Barber & Longuet-Higgins 1948; Pals et al. 1982 (all cited in Cranfield University & CMACS, 2005).

The species listed in Table 3.8.1 all occur at the Gwynt y Môr project area. Cod and plaice were recorded in characterisation surveys while salmon and eel will migrate past the site between their marine and freshwater stages. Both European river and sea lamprey may occur in Liverpool Bay, although the status of these stocks is unknown (see section 3.4).

It was shown by CMACS (2003) that the very highest induced current densities (91.25 µV/m for a 132 kV XLPE submarine cable with perfect shielding) were effectively the same on the skin of the cable and on the seabed when the cable was buried to a depth of 1 metre, i.e. burial did not diminish the magnitude of the induced electric field. However, recent work (CMACS *in progress*) has demonstrated that for submarine power cables with different specifications burial to 1m can reduce the induced electrical field at the sediment-water interface by an order of magnitude.

Current densities produced by industry standard submarine power cables used for offshore wind farms are likely to lie within the theoretical range of detection by electrosensitive fish species and may occur either side of the theoretical boundary between attractive and repulsive effects for elasmobranchs (100 μV/m), depending on the generating status of the wind farm. Smaller current densities, but still within the theoretical range of detection, are expected to be propagated through the water for a distance of tens of metres.

Although CMACS (2003) highlighted that offshore cables could result in an iE field of a magnitude within the theoretical range of detection of elasmobranchs and certain other fish species, no information exists on the range of frequencies that species can detect. Thus it is uncertain whether the 50 Hz carried by sub-sea power cables for offshore wind farms is detectable by electrosensitive fish and, if detectable, whether such fields would be of any significance to the fish.

If anthropogenic electrical fields from submarine power cables are detected by electrosensitive fish species the following impacts are believed possible:

An artificial field that was attractive could result in individual animals investigating the seabed for food and wasting energy doing so.

A repulsive field that repelled animals would interrupt normal behaviour and potentially exclude habitat from use.

3.8.3 Likely Electromagnetic Fields at the Gwynt y Môr Offshore Wind Farm.

Existing Electric and Magnetic fields

Natural fields comprise the earth's magnetic field (approximately 50 μT) which will be detectable by magnetically sensitive species (Section 3.8.2) and certain fish species such as eel, cod, plaice and salmon will be able to detect electric fields in the range of 8-25μv/m caused by water movement through the geomagnetic field (cf. Section 3.8.3).

Certain electric and magnetic fields of anthropogenic origin are likely to be present within the development area prior to construction and will persist during the life of the Gwynt y Môr Offshore Wind Farm. The Cranfield & CMACS (2005) study identified that fibre optic and coaxial telecommunication cables; electrically heated pipelines and other (non-wind farm) power cables will have associated EM fields. The magnitude of such fields is unknown and the Cranfield & CMACS study identified the need for wider research to quantify such fields so that environmental effects, and possible interactions with offshore wind farm power cables, could be assessed.

Field studies prior to the construction of the North Hoyle Offshore Wind Farm (CMACS, 2003) identified the presence of a relatively large electrical field near the Clwyd estuary at Rhyl. This field was in excess of 70 μv/m at a distance of more than 1km from two existing (non-wind farm related) cables (11kV and 33kV) known to cross the estuary which were being studied; suggesting the presence of a pervasive field throughout the area which was not necessarily associated with the cables in the Clwyd estuary. Subsequent measurements using equipment with higher detection limits have identified electric fields of up to 2,500μv/m near the Clwyd Estuary (CMACS *in progress*). These fields mask the EM fields from the North Hoyle Offshore Wind Farm export cables but are not present at all times; when they have been absent it has been possible to measure iE fields of around 80-90μv/m above the North Hoyle export cables on the beach at Rhyl. These values are in line with the predictions of the Environmental Statement for the North Hoyle Offshore Wind Farm (CMACS 2002). The cause of these high E fields is still under investigation but is thought most likely to be associated with an earthing fault of local shore-based electrical equipment and therefore not related to the wind farm.

EM Fields Associated with the Wind Farm Development

The highest magnetic (B) and hence induced electrical (iE) fields will be produced when the Gwynt y Môr Offshore Wind Farm is generating at maximum capacity under optimal wind conditions. It is not clear what the exact size of the B and iE fields will be but they are likely to be of a comparable magnitude to those predicted for generic wind farm cabling. For example, CMACS (2003) showed that a B field of 1.6 μT and an iE field of 91.25 μV/m would be produced by a 132 kV XLPE tri-core cable under full load. It is therefore likely that B fields will be detectable by magnetically sensitive species and that, depending on generating status, iE fields will lie in the range that may be attractive or repulsive to electrically sensitive species.

No modelling has been undertaken at this stage to predict the B or iE fields that would be produced by the higher voltage cables that may be used at the Gwynt y Môr Offshore Wind Farm. In general, lower EM fields would be expected if the same power is delivered using a higher voltage. For example, an increase in voltage from 132kV to 245kV (the two possible export cable specifications) would mean a reduction in current by a factor of 1.86, assuming that cable properties were otherwise equivalent. Because the EM field is related to the cable current this means that the iE and B fields would also be 1.86 times less – circa 49 μV/m and 0.86 μT respectively.

There is the additional possibility that EM fields in close proximity to each other (e.g. where cables are laid close together such as may be the case at sub-station gathering points where cable may be laid less than 10 m apart) may be additive. Normally, the magnitude of the EM field at any given point is inversely proportional to the distance from the power cable. Since the frequency will be 50 Hz and wavelengths long, when cables are closely placed the fields may be combined constructively (in phase) which could result in larger fields in these areas.
For independently located cables, i.e. cables 10m or more apart, both B and iE fields are expected to be detectable within tens of metres (i.e. 10 to 90 m) on the seabed above each buried cable and a similar distance up into the water column. No estimate can yet be made for instances where cables are in close proximity.

For a proportion of time Gwynt y Môr will tend to be generating at below the maximum output levels due to variations in wind speed and the need to take turbines off-line for servicing etc. There will also be periods when no power is generated as a result of very high or low wind speeds leading to turbine shut down. Current estimates indicate that the Gwynt y Môr will have an annual capacity factor of circa 35.8% (based on on-site wind measurements) which includes an allowance for planned servicing and other maintenance and repair operations.

The capacity factor does not, however, identify how frequently the wind farm will be operating; it is currently estimated that Gwynt y Môr will be operating and generating electricity for 70-85% of the time, allowing for the periods of time when the wind speed will be above or below the operating limits of the chosen wind turbines.

It should therefore be considered that the wind farm will not produce steady iE and B fields over time. There will be periods when sub-maximal fields are produced and periods when no such fields are present. These fields will also vary spatially as a result of differing cable specifications between the array and export cable routes.

Table 3.8.1: Non elasmobranch fish species that are believed to be electrosensitive

Fish Species	Common name
Agnatha (Jawless fish)	
Lampetra fluviatilis	European river lamprey
Petromyzon marinus	Sea lamprey
Teleostei (Bony fish)	
Anguilla anguilla	European eel
Gadus morhhua	Cod
Pleuronectes platessa	Plaice
Salmo salar	Atlantic salmon

4. Potential Impacts of the Gwynt y Môr Offshore Wind Farm on the Marine Ecological Environment.

4.1 Introduction

Environmental Impact Assessment (EIA) is a core requirement for major development projects such as offshore wind farms. The main aim of the EIA legislation is to ensure that the authority responsible for giving the primary consent for a particular project makes its decision in the knowledge of any likely significant effects on the environment. This ensures that the importance of the predicted effects, and the scope for reducing them, are fully understood by the public and the relevant authority before a decision is taken.

This section (section 4) details the site-specific Environmental Impact Assessment (EIA), which has then been used to produce the summary Environmental Statement (ES) sections (detailed in npower renewables, 2005), for the impacts of the proposed Gwynt y Môr Offshore Wind Farm upon the following:

- *Sediment and Water Quality*
- *Marine benthic and planktonic communities*
- *Fish and Shellfish*
- *Marine mammals*
- *Sites or species of nature conservation interest (Marine and Coastal only).*

The project components and details outlined in Section 2 have been assessed for their potential to cause impacts on the marine environmental aspects listed above (using the information collated within Section 3) with potential impacts from each phase of the project (construction, operation and decommissioning) being considered separately within each assessment section. The assessment of these impacts has been rated against the criteria outlined in Table 4.1 to allow a considered and full assessment of the identified potential impacts to be made. Where appropriate, mitigation measures to ameliorate the intensity of the potential impacts have been suggested, in addition to recommendations for monitoring.

Thoughout this EIA, specific statutory and/or non-statutory guidance applicable to each of the sections listed above has been considered. Further consideration for the effects on species of key significance such as those of a high sensitivity or high importance e.g. species of a commercial value, those afforded legislative protection or those considered to be important at the trophic level, has also been made.

For the purpose of this assessment, a worst-case scenario approach has been undertaken which assesses the maximum likely impacts to the marine environment of the Gwynt y Môr Offshore Wind Farm. In addition, consideration is also given to the cumulative impacts of Gwynt y Môr with other developments and offshore activities, either currently occurring or planned within Liverpool Bay. These include the oil and gas platforms, marine aggregate extraction from licensed areas, channel maintenance dredging occurring at the Rivers Mersey and Dee, shipping and the offshore wind farms of North Hoyle (operational wind farm of 30 turbines offshore from Rhyl), Burbo Bank (Round 1 wind farm with consent, offshore from north Wirral coast) and Rhyl Flats (pre-construction, Round 1 wind farm with consent offshore from Abergele).

Table 4.1.1: Criteria against which identified potential impacts are assessed.

Impact rating	Spatial	Duration	Intensity	Significance	Cumulative effects
Permanent	-	Permanent or beyond decommissioning	-	-	-
High	National or international	Long term- greater than 15 years or for life span of the project (50yrs)	Large scale loss of biodiversity, loss of rare or endangered species or critical habitat.	Significant effects with no possible mitigation.	Significant effects with no possible mitigation.
Medium	Regional (Within Liverpool Bay/eastern Irish Sea)	Medium term (5-15 yrs)	Disturbance of areas or species that have conservation value or are of use as a commercial resource.	Significant effect but with potential for effective mitigation.	Significant effect but with potential for effective mitigation.
Low	Within a few km of wind farm project area.	Short term (1-5 years)	Loss or disturbance of non-threatened species or habitats; emissions demonstrably less than capacity of receiving environment.	Non-significant effects for which mitigation is simple or not required.	Non-significant effects for which mitigation is simple or not required.
Negligible	Within wind farm project area.	Quickly Reversible or less than 1 year.	No measurable or recognised sensitivity.	No measurable effect.	No measurable effect.

4.2 Potential Impacts on Water & Sediment Quality

The following section assesses the potential impacts of the construction, operation and decommissioning phases of the Gwynt y Môr Offshore Wind Farm on the sediment and water quality of Liverpool Bay. The assessment draws on the information provided in the baseline section detailed in 3.3.1, which includes a site-specific detailed assessment completed in support of the Gwynt y Môr EIA (CMACS, 2005).

4.2.1 Potential Impacts From The Construction Phase

Potential impact: The construction of the Gwynt y Môr Offshore Wind Farm may disturb contaminated sediments which could act to reduce water quality.

The surface sediments at the Gwynt y Môr project area were tested for a range of contaminants as part of the benthic characterisation survey (detailed in Appendix 1 and discussed in section 3.3.1). The overall impression was that the levels of contaminants within sediments at Gwynt y Môr were found to be consistently low. However, levels of Arsenic were raised in certain areas of the Gwynt y Môr project area but these concentrations were all found to be below the probable effects levels suggested by sediment quality guidelines. Increased arsenic levels are common throughout Liverpool Bay and are attributed to natural weathering processes of minerals in the North Wales area. Elevated levels of a small number of hydrocarbons (PAH) were found at two locations across the entire survey area however; the total hydrocarbon values at these sites were below the level considered to cause adverse biological effects and the overall hydrocarbon levels from the area were mostly below detection limits. In addition, because of the nature of the sedimentary environment within Liverpool Bay, it is not considered probable that contamination of sediments at depth will be incurred due to the constant sediment movement resulting from the high-energy environment (see section 3.3.1).

For the period of the construction phase, sediments would be disturbed during the turbine and sub station foundation installation, cable trenching and the movement of jack-up rig feet on and off the seabed. The greatest amount of sediment disturbed would arise from the installation of 150 gravity base foundations as part of Illustrative layout scenario 3 (see section 2). The worst-case scenario for cable laying would be the installation of all cables through the use of trenching by water jetting, as the sediments disturbed are not reinstated immediately. However, the physical process assessment conducted for Gwynt y Môr (RWE npower, 2005) has demonstrated that most of the sediments disturbed would be sands and gravels and would settle out of the water column over a very short distance. It is the suspension of potentially contaminated fine material, which has the greater risk of reducing water quality by increasing the contaminant concentration within the water column. These would then become dispersed as fine particles would tend to remain in suspension for longer periods and may be transported further afield. However, the modelling work in relation to the generation of suspended sediments has demonstrated that this will be at low concentrations and will be temporary, intermittent and transient in nature (see RWE npower, 2005).

Disturbance of the sediments, which may be a possible source of contaminants, will arise in the locality of the construction procedure rather than across the entire area. Dispersal of the sediments would likely to occur in the direction of tidal flow with most of the particles settling out of suspension within a few hundred metres of the construction activity. The spatial extent of this impact is therefore considered to be **Low**.

The surface sediments of Liverpool Bay are in a continuous cycle of re-suspension and deposition according to variations in the physical processes responsible for sediment transport within the Bay, particularly tidal and wave induced flows. Elevated levels of sediments within the water column are likely to be transported within a tidal cycle of the disturbance and would be expected to resettle out of the water column over a relatively short period of time, in keeping with the natural state of the surface sediments in Liverpool Bay. The impact would be relatively short in duration but would continue intermittently during the 2-3 years of construction. The duration of the impact is considered to be **Negligible.**

Due to the low level of sediment contamination across the site, the intermittent removal of sediment and the small amounts of disturbed sediments, which are at risk of dispersal in addition to the dilution effect of the receiving waters, the intensity of the impact is thought to be **Negligible**. This is the case even in relation to the worst-case in terms of volumes of disturbed sediment arising from gravity foundations or water jetting of cables. Other activities during construction or decommissioning, such as the use of alternative foundation solutions, ploughing of cables, or removal of offshore structures would result in significantly less disturbance of the low levels of contaminants present and therefore even less measurable effects on water quality. This effect is not considered to be sensitive to the numbers or layout of the Gwynt y Môr turbines or other offshore structures due to the low levels of contaminants recorded. The overall significance of this impact is therefore judged as being **Negligible**.

Mitigation: To minimise the disturbance of sediments, thus reducing any contaminants from entering the water column and thereby potentially affecting water quality during construction activities, it is proposed that the delineation and minimisation of working areas should be implemented prior to construction to restrict the area of disturbance to sediments. In addition, where multiple jack-up vessels are to be used, these should be located at sufficient distance from each other so as to avoid the potential for the combination of sediment contaminants to occur. Best practice methods should also be instigated on site to minimise the generation of spoil material and plumes generated.

Monitoring: no monitoring is considered to be necessary due to the negligible significance of this impact.

Cumulative impacts: Other activities within Liverpool Bay, which may release contaminated sediments into the water column, include aggregate extraction from the license area located to the North East of the Gwynt y Môr project area, in addition to the maintenance dredging occurring within the shipping channels at the entrances to the Dee and Mersey Estuaries. Dispersal of contaminated sediments may also occur during the construction of the Burbo Bank Offshore Wind Farm (located offshore from the Wirral at the entrance to the Mersey) and Rhyl Flats (inshore from the Gwynt y Môr project area). However, the construction of these wind farms is not anticipated to occur at the same time as for Gwynt y Môr.

Effects of the release of chemical contaminants from sediments at these locations upon the pre-existing water quality is also considered to be intermittent and transport of any contaminants released would be expected to travel within a specific area of the source defined by the tidal excursion.

Due to the intermittent nature of the impact, in addition to the overall low amount of contaminants within the sediments of the project area the overall cumulative impact upon water quality by contaminated sediment dispersal is considered to be of **Negligible-Low** significance.

Potential impact: Discharge of contaminants from construction vessels or plant may lead to a reduction in water quality.

Vessels associated with the construction phase of the Gwynt y Môr Offshore Wind Farm are detailed in section 2. These vessels, in addition to plant used to undertake construction, may incur potential spillages of small quantities of fuel, oil and lubricants onto decks which may then be washed into the marine environment by deck spray. Litter generated by vessels may also be discarded into the sea by accident or carelessness, all of which may act to reduce water quality.

The spatial extent of this impact is likely to be limited to the area of the Gwynt y Môr project area, where the construction activity is occurring. However, there is potential for impacts to arise when vessels are in transit between the site and port. A number of ports are being considered for use during the construction phase and these are located not only within Liverpool Bay but also throughout the eastern Irish Sea (see section 2). However, the potential for this impact to occur is considered to be limited to the specific times when vessels are not in transit and are being used to perform construction procedures and as a result this is expected to be limited to the Gwynt y Môr project area and because of this the spatial impact is identified as being **Negligible.**

Any discharge to the marine environment would be expected to be quickly dispersed due to the high-energy environment, the mixing properties of the receiving waters and the relatively small quantities of materials which could be spilt. The duration of this impact is therefore considered to be **Negligible**.

The discharge of contaminants into the marine environment from vessels or plant is not an intentional part of the construction phase. Any such discharge would be accidental and is not considered to be of sufficient quantity to be of detriment to the surrounding water quality, the intensity of the impact is therefore considered to be **Low,** which would then be reduced to **Negligible** if mitigated procedures were followed.

Mitigation: It is recommended that all plant be fully serviced and inspected before use to limit any potential discharges to the marine environment. Standard waste generated by vessels must be treated according to MARPOL 73/78, the UK Merchant Shipping (prevention of pollution) Regulations 1983 and the Merchant Shipping (Prevention of Pollution by Garbage) Regulations (1988). In addition, adequate systems must also be in place when refuelling so as to ensure minimum loss to the environment.

A Pollution Control Plan (PCP) must be prepared setting out the procedures to be implemented prior to the construction phase with regard to the control and treatment of any accidental spillages or disposal of waste that may occur. The PCP should be made a condition of contract.

A Site Environmental Management Plan (SEMP) must also be prepared and should be managed and controlled by an appropriately qualified Environmental Manager. This should detail methods for the recording and control of all wastes or spillages and should include provision for the training of all construction personnel in the proper control and disposal of waste material. Adherence to the provisions of the SEMP must be made a condition of contract.

Monitoring: the proper reporting and control of all wastes and spillages through all phases of the project should be subject to compliance monitoring.

Cumulative impacts: There is a potential for similar discharges to occur within Liverpool Bay from the current shipping, oil and gas industry, maintenance vessels at the North Hoyle Offshore Wind Farm and during the construction of the Burbo Bank and Rhyl Flats wind farms. However, because of the low levels of contaminants involved and the dilution and mixing properties of the receiving waters, any potential cumulative impacts upon water quality are considered to be of **Negligible** significance.

Potential impact: Discharge of contaminants from the construction process may result in water or sediment contamination.

The major components of the sub stations and turbines will be manufactured and painted with anti-corrosion and anti-fouling paint mostly on land so the potential for release of contaminants within the marine environment are limited to the jointing of the prefabricated sections (possibly using grout), attachment of access platforms, ladders and j-tubes by welding and the use of grouting during piling procedures. Grouting (using a strong liquid cement) is also utilised during piling operations (see Section 2). Any grout entering the marine environment may have the possible effect of increasing pH levels in the immediate receiving waters.

The spatial scale of this impact is considered to be limited to within the boundaries of the project area and is therefore considered to be **Negligible.**

Due to the dispersal capacity at the site being relatively high, any incidences of contaminant discharge will be quickly dissipated through mixing and the duration of the impact is therefore considered to be **Negligible.**

Inputs into the marine environment are not a planned part of the project and any releases would be accidental. The quantity of the discharge is therefore likely to be small and dispersed quickly as a result of tidal flow, having potentially very little effect on overall water and sediment quality. The intensity of this impact is therefore considered to be **Low**. With the mitigation proposed to implement sufficient environmental management systems for installation operations to minimise any such discharge, the intensity of this impact would be reduced further to **Negligible.** The assessment of this effect is not dependent on any particular foundation option, turbine layout or operational and decommissioning process, provided that the mitigation provided is properly adhered to, principally through proper design of the offshore structures

Mitigation: The SEMP must be implemented for all significant operational maintenance undertaken within the marine environment and should include provision to ensure that no significant discharges of contaminants arise during the construction phase as detailed above.

Monitoring: The proper reporting and control of all wastes and spillages through all phases of the project should be subject to compliance monitoring. In particular, processes such as grouting should be subject to careful design and monitoring in order to attempt to minimise any accidental spillages.

Cumulative impacts: Similar discharges may arise during the development of the Rhyl Flats and Burbo Bank offshore wind farms. However, the effects would be highly localised and therefore the cumulative effects of this impact are considered to be **Negligible**.

Potential impact: The release of suspended solids during the construction of Gwynt y Môr could lead to increased turbidity and a resulting decrease in dissolved oxygen in the surrounding waters.

The disturbance of finer marine sediments during the construction phase will enhance suspended sediment levels within the water column. Such increases of suspended sediments will elevate the turbidity of the water column causing a reduction in ultra-violet light penetration. Ultra-violet light from sunlight kills bacteria within the water column and as a result of reduced light penetration; bacteria levels would be expected to increase.

Suspended sediments may also contain high levels of organic matter. Such increased levels of organic matter and bacteria will increase the biological oxygen demand (BOD) and chemical oxygen demand (COD) within the water column. This is more likely to occur in inshore waters which are stratified and not well mixed especially during summer months when temperatures are increased. Such increase in oxygen demand will result in an overall diminishment in dissolved oxygen. If suspended sediment levels are elevated in proximity to the designated bathing waters located along the coastline there is a risk that the reduction in light penetration would reduce microbial kill-off affecting the bathing water quality standards (tested for between May-September by the Environment Agency).

The generation of suspended sediments would arise during the construction process from the installation of foundations for the wind farm components, cable laying and the movement of jack-up rig feet on and off the seabed. The worst-case scenario for the generation of spoil would from illustrative layout scenario 3 (150 gravity base turbines) (see section 2) and cable laying by the method of water jetting (see section 2).

The fines disturbed during construction would remain in the water column for a longer period of time than heavier particles such as gravel or coarse sands and will travel over a wider area before settling out of the water column. Dispersion of these sediments will also depend upon the prevailing hydrodynamic conditions. In periods of calm weather and at slack tides dispersion of the sediments will be slower and will persist over a longer period of time. This may be more significant in summer months when the sea temperature is warmer and the water column stratified causing the potential for reduced dissolved oxygen in the water column to be at its greatest.

The generation of suspended sediment associated with turbine installation will be intermittent over the duration of the 2-3 year construction period. The larger particles of the generated suspended sediments will resettle out of suspension very quickly- within 100s of metres from the source. Fines, however, would persist longer within the water column and would be carried up and downtide of the wind farm depending upon tidal flow at the time of construction. However, the modelling work undertaken as part of the physical process assessment has demonstrated that suspended sediments generated from construction work would generally be at low concentrations and would be temporary, intermittent and transient in nature (see RWE npower, 2005). In addition, the surface sediments of Liverpool Bay are in a continuous cycle of re-suspension and it is expected that the suspended sediments generated would quickly become absorbed into the background levels. Also, suspended sediment monitoring using recording sediment loggers undertaken during the vibropiling of a met mast at the North Hoyle Offshore Wind Farm showed no detection of any change in suspended sediment concentrations at a distance of 168m from the piling operation (CMACS, 2004). The overall spatial impact is therefore considered to be **Negligible**.

Cable laying procedures are extremely quick and any associated suspended sediments would be expected to disperse rapidly over the course of a tidal cycle. During the cable installation process for the North Hoyle Offshore Wind Farm measurements of bathing water quality were undertaken at Rhyl using the same procedures and tests as are utilised by the Environment Agency for EU bathing water quality standards tests. The results of this survey showed no measurable effects of the cable laying activities on the water quality (CMACS, 2003). The overall duration of impact is therefore considered to be **Low.**

Given the intermittent nature of construction activities and the relatively low amount of fines and organic matter found to be contained within the sediments at the Gwynt y Môr Offshore Wind Farm project area the intensity of the effect on water quality is given as being **Negligible**.

Overall, it is concluded that the significance of the impact of fines produced during construction increasing turbidity and reducing dissolved oxygen concentration and overall water quality would be **Negligible,** even allowing for the worst-case scenario associated with gravity base foundations and water jetting for cable laying.

Monitoring: None considered necessary.

Mitigation: None proposed.

Cumulative impacts: The elevated suspended sediment levels generated as a result of the construction activities of Gwynt y Môr have been assessed as being **Negligible** significance due to the short time scales of sediment generating activities, the very localised increase in suspended sediment concentration and the wide dispersal of very minimal sediment concentrations. It is not considered that suspended sediments generated during the construction phase of Gwynt y Môr will have a cumulative effect with other sediment generating activities occurring within Liverpool Bay, most notably aggregate extraction (construction of other offshore wind farms will not be occurring simultaneously) on the water quality of Liverpool Bay.

4.2.2 Potential Impacts From The Operational Phase

Potential impact: Release of chemicals during the operational phase may result in a reduction of water quality.

During operation of the wind turbines there will be no direct releases into the marine environment. Routine maintenance of the turbines will generate waste products such as gear oil and hydraulic fluids and these are to be disposed of by means of controlled disposal methods on land (Section 2). However, there is a small risk that spillage may occur which may impact upon the water quality. The limitations of which will be accounted for by suitable mitigation.

Turbines are protected by a corrosion protection system which is a paint system in addition to a cathodic protection system likely to be the standard system currently used for offshore structures. Although some corrosion may occur over the lifetime of the turbines this is likely to be at a very low level, which will be readily diluted within the marine environment and similar in extent to other offshore installations.

The spatial impact is therefore considered to be **Negligible** limited to the boundaries of the wind farm.

The duration of the impact is considered as being **Negligible** and the significance of the impact is also considered to be **Negligible** due to the low amount of leachate and the highly dispersive characteristics of the marine environment.

The overall significance of this impact is therefore also assessed as being **Negligible**. The assessment of this effect is not dependent on any particular foundation option, turbine layout provided that the mitigation provided is properly adhered to, principally through proper design of the offshore structures.

Mitigation: Environmental management systems will be implemented for all significant operational maintenance undertaken within the marine environment to ensure that no significant discharges of contaminants arise during the operational phase.

Monitoring: The proper reporting and control of all wastes and spillages through all phases of the project should be subject to compliance monitoring.

Cumulative impacts: none predicted.

Potential impact: Discharge of contaminants from vessels associated with the operational phase may lead to a reduction in water quality.

Vessels associated with the operational phase are detailed in Section 2 and are likely to be similar to those used during the construction phase. The impacts are therefore identified as being similar to those identified during the construction phase and are therefore assessed as being: Spatial: **Negligible**, Duration: **Negligible**, Intensity: **Low**. The overall significance is assessed as being **Low** but is reduced to **Negligible** with the mitigating measure of suitable environmental management plans being in place throughout the duration of the operating phase with regard to the control and treatment of any accidental spillages or disposal of waste that may occur. This should be made a condition of contract. No monitoring is suggested and no cumulative impacts are identified.

Potential Impact: Scour of the operating turbines may increase sediment concentrations within the water column acting to reduce water quality

The presence of artificial structures on the sea bed may cause variations in the local current velocity potentially increasing erosion forces around the base of these structures resulting in scour. This may cause an increase in suspended sediments to occur which may reduce water quality as a result of increased turbidity. However, the modelling concerning elevated sediment concentrations resulting from scour of the operating turbines at Gwynt y Môr revealed that the overall pattern of sediment movement and suspended load were relatively unchanged (npower renewables, 2005). Studies at the operational North Hoyle Offshore Wind Farm have also revealed that the extent of the predicted scour has not arisen and that no detectable increases in suspended sediments has arisen as a result of the operational phase of the Wind Farm (ABPmer, 2005). It can therefore be postulated that impacts on the water quality of Liverpool Bay arising from increased suspended sediments will not be incurred during the operational phase of the Gwynt y Môr Wind Farm.

Mitigation: none specific to this impact identified.

Monitoring: none specific to this impact deemed necessary.

Cumulative Impact: The results of the modelling at Gwynt y Môr in addition to the studies at North Hoyle indicate that cumulative impacts with the other three wind farms of Liverpool Bay and the other sediment generating activities of aggregate extraction would not be incurred.

4.2.3 Potential Impacts From The Decommissioning Phase

Potential impact: Discharge of contaminants from decommissioning vessels or plant may lead to a reduction in water quality.

The impacts are considered as being the same as those identified for the construction phase. The spatial scale of the impact is therefore considered to be **Negligible**, the duration **Negligible** and the Intensity **Low**. The overall significance of the impact was identified as **Low** but falling to **Negligible** with the mitigation proposed as for the construction phase. This mitigation must include a Pollution Control Plan (PCP) which must be prepared setting out the procedures to be implemented throughout the decommissioning phase with regard to the control and treatment of any accidental spillages or disposal of waste that may occur. The PCP should be made a condition of contract. Monitoring should include the proper reporting and control of all wastes and spillages through all phases of the project should be subject to compliance monitoring.

Cumulative impacts: There is a potential for similar discharges to occur within Liverpool Bay from the current shipping, oil and gas industry (decommissioning of the other wind farms within Liverpool Bay would not occur at the same time). However, because of the low levels of contaminants involved the dilution and mixing by the receiving waters any potential cumulative impacts upon water quality are considered to be of **Negligible** significance.

Potential impact: Discharge of contaminants from the decommissioning process may result in water or sediment contamination.

The impacts are considered to be similar to those identified during the construction phase.
These are: Spatial impact: **Negligible**, Duration of impact: **Negligible**, Intensity of impact: **Low** reducing to **Negligible** with the proposed mitigation. The overall significance of this impact is therefore designated as being **Negligible**. The mitigating procedures previously described for this impact within the construction section above will also be suitable for the decommissioning phase. Monitoring should include the proper reporting and control of all wastes and spillages throughout the decommissioning phase of the project. No cumulative impacts are identified, as other wind farms in proximity to Gwynt y Môr would not be decommissioned at the same time.

Potential impact: The release of suspended solids during the decommissioning of the Gwynt y Môr project could lead to increased turbidity and a resulting decrease in dissolved oxygen in the surrounding waters.

The impacts are considered to be similar to those identified during the construction phase which, due to the intermittent production of suspended sediments and the low amount of fines found within sediments, in addition to the high energy dispersal environment of Liverpool Bay are assessed as being: Spatial: **Negligible**, Duration: **Low**, Intensity: **Negligible** and the overall impact significance is therefore deemed to be **Negligible.**

Monitoring: none considered necessary.

Mitigation: none proposed.

Cumulative impacts: The elevated suspended sediment levels generated as a result of decommissioning activities at Gwynt y Môr have been assessed as being of **Negligible** significance due to the short time scales of sediment generating activities, the very localised increase in suspended sediment concentration and the wide dispersal of very minimal sediment concentrations. It is not considered that suspended sediments generated during the decommissioning phase of the Gwynt y Môr project will have a cumulative effect with other sediment generating activities occurring within Liverpool Bay, most notably aggregate extraction (decommissioning of other wind farms will not be occurring simultaneously) on the water quality of Liverpool Bay.

4.3 Potential Impacts on Benthic Ecology

This section assesses any potential environmental impact of the Gwynt y Môr Offshore Wind Farm on the benthic, plankton and intertidal communities of Liverpool Bay and the eastern Irish Sea.

4.3.1 Relevant Guidance for Assessment

Statutory guidance is in place regarding impact assessment of offshore wind farm developments within United Kingdom waters upon marine benthic communities. These have been duly considered for the assessment of impacts from the Gwynt y Môr Offshore Wind Farm and are summarised below.

- **CEFAS (2002). Guidance notes for Environmental Impact Assessment in respect of FEPA/CPA requirements**.

This identifies the range of foreseeable effects arising from wind farm development as being:

- Those arising from construction activities (especially the installation of foundations and cable laying) causing direct effects due to physical disturbance of seabed substrata and alterations to the local habitat, and indirect effects arising from the re-distribution of fines.
- Those arising from scour around turbines following installation. Importance of effects will depend upon the extent of scour, if any, and the necessity for ameliorative action.
- Colonisation of structures and associated events which may locally enhance biodiversity and increase food availability or shelter for commercial fish/shellfish although, clearly, local circumstances must be considered in evaluating the net environmental benefits and costs.
- Cumulative effects with other man-made activities causing an impingement upon the benthic biota.

- **Defra (2005) Nature Conservation Guidance on Offshore Wind Farm Development. Version R1.9.**

This identifies the potential impacts from offshore wind farm developments on the sub-tidal communities as being:

- habitat loss: from placement of the base of each turbine and scour protection, if present;
- smothering: increase in suspended sediments and consequent deposition of sediments with possible smothering;
- scour: causing habitat alteration, altered tidal flow patterns and altered wave exposure; and;
- vibration: considered unlikely to cause significant impacts unless the physical composition of the seabed changes (e.g. through liquefaction).

4.3.2 Potential Impacts From The Construction Phase

As identified above, the potential impacts of the construction phase are: loss of habitat, increased suspended sediment concentrations, changes to seabed structure and profile and noise and vibration.

Potential impact: The construction of the Gwynt y Môr offshore structures could directly affect benthic habitat.

The placement of structures on the seabed such as turbine and offshore substation foundations and scour protection (where required) will directly affect benthic habitat. The worst-case scenario for benthic habitat loss would result from the use of the gravity base foundation solution at all of the turbine and the sub station locations and for the illustrative layout scenario 3 with a total of up to 154 structures (although there are fewer turbines for scenario 3, the gravity foundation bases would in fact cover a larger area than the structures under scenarios 1 or 2) (Section 2). A predicted maximum area of 0.44km^2 for the gravity-based turbine and substation foundations of scenario 3 would be occupied under this worst-case scenario, with a predicted minimum of 0.007km^2 for multipile foundations for the 250 turbines and up to 4 substations described by the illustrative layout scenario 1.

An additional area of seabed could be occupied by scour protection, where this is considered necessary. Initial engineering design work combined with the results of the physical process assessment indicated that as a worst case circa 50% of the offshore structures might require scour protection. The total area that could be occupied by scour protection is currently estimated to be a maximum of circa 0.078km^2 for illustrative layout scenario 1 and using either monopile, suction caisson or gravity base solutions, falling to an estimated area of circa 0.017km^2 for multipile foundations combined with turbine illustrative layout scenario 3.

Therefore, it is currently estimated that the worst realistic case for the loss of seabed habitat resulting from the placement of offshore structure foundations and associated scour protection is predicted to be circa 1.22km^2, reducing to an estimated minimum of circa 0.024km^2. All of the other foundation options and illustrative layout scenarios will fall within these two areas of effect and therefore these areas can be considered to represent the likely envelope of effect for seabed habitat loss. As a proportion of the whole Gwynt y Môr project area, this represents approximately between 0.02 and 0.98% of the project area or an estimated maximum of approximately 0.03% of the total area of Liverpool Bay (based on the total area of Liverpool Bay being 4,870 km^2).

The existing biotopes at the Gwynt y Môr project area, identified during the site-specific benthic characterisation surveys are all previously described from Liverpool Bay and they are considered to be relatively common throughout the wider Irish Sea.

The installations will be in place throughout the Gwynt y Môr project life span (up to a fifty year period) and as a result the duration of impact is assessed as being **High.** However, the installations themselves will provide new habitat for colonisation by benthic species which is thought to offset the loss of original habitat (the addition of habitat for colonisation by benthic fauna has been assessed within the operational effects section below) because of this the duration of impact is therefore considered to be short-term and overall is assessed as being **Low**.

Although the areas of seabed that are finally affected would be lost for the life-time of the wind farm, the area affected is considered to be small, the benthic habitats across the project area are considered to be relatively common throughout the Irish Sea and the impacts are ultimately reversible following decommissioning. Therefore, the significance of effects of direct benthic habitat loss are considered to be **Negligible.**

Mitigation: none considered necessary.

Monitoring:

A programme of benthic monitoring will be undertaken. The details of the monitoring will be agreed with the relevant statutory authorities, notably CCW and CEFAS. The following approach is currently considered appropriate.

The surveys will be conducted using grab sampling, using suitable sampling equipment for the prevailing sedimentary conditions, to provide information concerning infaunal species and using beam trawling to provide data on epifaunal species. An array of sampling sites, including a suitable number of replicate sampling stations to establish variability, will be designed to provide a representative description of the range of biotopes identified. The sampling area will cover a single tidal ellipse around the project area including the export cable route. Samples for infauna, epifauna, particle size distribution and total organic carbon analysis will be collected. The benthic monitoring will adhere to the BACI (Before-After-Control-Impact) approach. Results will be compared with the data gathered from any monitoring of the physical environment (such as side scan sonar, swathe bathymetry etc).

Sampling will be conducted prior to construction, in order to establish a baseline; immediately after the completion of the construction phase; and subsequently at annual intervals and for at least 5 years post-construction. A programme of monitoring may also be required to monitor the effects of the decommissioning process. This will be discussed with the relevant regulatory bodies at an appropriate time.

Cumulative assessment: A number of other activities within Liverpool Bay may remove sea bed habitat including the extraction of marine aggregates, maintenance dredging, pre-existing offshore installations such as oil and gas rigs and the North Hoyle Offshore Wind Farm and the planned offshore wind farms at Rhyl Flats and Burbo Bank.

There is a current licensed marine aggregate extraction site immediately to the east of the Gwynt y Môr project area and a further application to dredge aggregates to the north east. The existing licensed area (Areas 392/393) supports a relatively low level of activity (compared to that seen on sites off the south or east coasts of England for example) with dredging for fine to coarse sand deposits. The nature of the resource means that while this activity is physically removing seabed habitat and associated fauna, a comparable layer of seabed will remain following dredging and the generally mobile fauna are anticipated to rapidly recolonise the affected areas. A similar situation is anticipated for the proposed dredging at Area 457. The active dredge area for Areas 392/393 totals between 1-2.5 km^2 (Crown estates 2005 & Oakwood environmental 2002). In combination with the worst-case scenario for habitat loss at Gwynt y Môr (1.22km^2) this translates as approximately 0.08% of Liverpool Bay. This represents a very small area of Liverpool Bay which will be affected and cumulative impacts for the existence of the Gwynt y Môr Offshore Wind Farm in combination with the aggregate extraction operations are not therefore anticipated when compared to the wider area of Liverpool Bay.

The disposal of maintenance dredging spoil occurs over a very limited area with relatively small quantities deposited at most of the Liverpool Bay sites meaning that broader scale cumulative effects when combined with the relatively small area of habitat lost to the Gwynt y Môr development must be considered unlikely to be significant.

Most offshore gas and oil installations in Liverpool Bay and the eastern Irish Sea were built 10-20 years ago and, at present, it seems unlikely that there will be any significant change. These structures do currently occupy seabed area and represent an historic loss of seabed habitat which act in-combination with Gwynt y Môr and the various other activities in the region. However, as with the Liverpool Bay wind farms, the areas of seabed affected are small when considered on a regional scale and these structures also offer additional surfaces for colonisation by benthic species.

The other wind farms of Liverpool Bay (namely North Hoyle, Burbo Bank and Rhyl Flats) will also contribute to habitat loss. The North Hoyle Offshore Wind Farm was assessed as occupying habitat equivalent to 0.0008% of Liverpool Bay (Innogy, 2002). Given that Burbo Bank and Rhyl Flats are also Round 1 consented wind farms they will have a similar number of turbines as North Hoyle and will therefore occupy a similar area of habitat. When combined with Gwynt y Môr this equates to a worst case of <0.5% of the seabed habitat of Liverpool Bay. Additional areas may be affected by scour protection, whilst other areas will be temporarily affected by cable installation, but nonetheless, a very small proportion of the Liverpool Bay area will be affected. This is, of course, a simplistic argument since it takes no account of the nature of the habitat lost. Consideration of the seabed at North Hoyle, Gwynt y Môr and Rhyl Flats indicates a consistent habitat which is recorded as common and characteristic of the wider Irish Sea region suggesting that cumulative impacts on particularly sensitive or rare habitats will not occur.

As a result the net loss of benthic habitat as a result of Gwynt y Môr and in-combination with the range of other activities in the region is considered to be of negligible significance on the scale of the wider Liverpool Bay region. These effects are also reversible in the longer term, following decommissioning when the habitats at the wind farm sites will need to be returned to their pre-existing condition. It should also be noted that Gwynt y Môr, in-combination with the other offshore structures of Liverpool Bay, do offer new vertical surfaces for colonisation by benthic species which may be considered to be somewhat beneficial to hard substratum favouring species within Liverpool Bay.

Potential impact: The feet of jack-up rigs during the construction phase will physically disturb the seabed habitats.

When installing the turbines and offshore substations it is necessary for the jack-up rigs to make contact with the seabed. This will cause a temporary disturbance on the sea bed at the point of contact which could potentially impact upon macrofaunal species by disturbing sensitive habitats or where features of conservation interest are known to occur.

The estimated total area of seabed disturbed by the jack-up rigs at the Gwynt y Môr Offshore Wind Farm location has been calculated as 0.12km^2 for illustrative layout scenario 1, 0.10km^2 for illustrative layout scenario 2 and 0.07km^2 for illustrative layout scenario 3 (Section 2).

Illustrative layout scenario 1 is therefore considered as being the worst-case scenario with 0.09% of the total seabed within the development area being affected. Due to this being only a small proportion of the development area the spatial impact is considered to be **Negligible**. However, it should also be noted that jack-up rigs might also be used during the operational phase for maintenance of major turbine and sub station components, representing an ongoing impact on the seabed throughout the operational phase.

The benthic communities recorded from across the Gwynt y Môr project area are relatively well known throughout the Irish Sea so that the recovery of impacted areas through recruitment from adjacent non-affected areas would be expected to occur.
The recoverability of the habitats recorded and the relatively small areas affected tend to mitigate the significance of any impacts resulting from jack-up operations, although the ongoing use of jack-ups through the operational phase means that the significance is assessed to be **Low.**

Mitigation: none considered necessary.

Monitoring: The results of the physical process monitoring, notably side scan sonar and swathe bathymetry records should be reviewed for evidence of jack-up deformation of the seabed and if deemed necessary should be investigated as part of the benthic sampling regime in discussion with the relevant statutory authorities, notably CCW and CEFAS.

Cumulative impacts: Because of the temporary nature and the very small area over which this impact occurs no cumulative impacts are predicted.

Potential impact: Cable laying activities could adversely affect subtidal and intertidal habitats.
A network of inter-turbine cables are required to link the turbines to each other, which in turn will be connected to the offshore substation with subsequent inter-substation connection cables. Transmission cables will then run to shore from the offshore substations and it is estimated that there will be between 3 (minimum) and 6 (maximum) of these required for the Gwynt y Môr project.

Installation may be via the use of a cable plough, trenching tool or through high pressure water jetting with target burial to between 0.5-1.0 metres below the seabed surface. Installation of the cable within the lower intertidal/shallow subtidal zone may be undertaken using a cable plough landed at the beach landfall or through directional drilling/trenching, or a combination of these techniques. For the installation of the cables through the intertidal zone an area of approximately 100m width is considered to be required.

The impacts of the suspended sediments generated during cabling installation upon the macrobenthic communities have been assessed within the next impact statement and are therefore not included within this assessment, which focuses on the disturbance generated to both subtidal and intertidal habitats as a result of burying the cable.

Following the disturbance of the sediments from the cable laying process, the subtidal habitats would be expected to recover with recolonisation of the disturbed sediments occurring from recruitment of macrofaunal species from the adjacent undisturbed biotopes. Initial colonisers are likely to be nematode worms such as *Nephtys hombergii* in addition to the tube building worms such as *Pomatoceros triqueter* which were identified as being common during the characterisation survey (see section 3.3). Once the sediment stabilises, further species would then be expected to colonise allowing the eventual recovery of the initial biotope. Because the width of the area associated with cable laying is small (300mm) the recovery of these subtidal areas by recruitment from the surrounding biotopes would be expected to be relatively rapid.

The existing intertidal biotopes identified at the proposed cable landfall sites (section 3.3) are previously described all along this stretch of coastline from the Wirral to Colwyn Bay (Mills, 1998) and no rare or unusual intertidal habitats were identified within the proposed cable landfall corridor. Disturbance from cable trenching would be temporary to the intertidal habitats with the sediments being immediately replaced following the cable laying process. Following this disturbance to the sandy intertidal area, it is likely that there will be a highly localised reduction in species diversity and biomass; however, the area would become rapidly recolonised by polychaete and amphipod species from the neighbouring unaffected sediments, which contain the same biotopes as the affected areas. Molluscs may take longer to recolonise, although these do not appear to be present in high numbers in the areas likely to be affected by cable laying activities. The upper shore shingle and pebble areas are relatively barren in species and it is likely that this barren habitat would remain following the cable laying activity.

Additional impacts from the laying of cables include the possible heating effects of the cables causing the warming and drying of the sediment within the immediate vicinity of the cable which may affect the nature of the sediment resulting in possible changes to the infaunal benthic and intertidal communities. However, the heating from both the inter-turbine and shore transmission cables will be both extremely small, and extremely localised, and would be impossible to detect against natural fluctuations in temperatures. For any species to be affected, in even a small and very localised way, they would presumably have to be extraordinarily sensitive to increases in temperature. As the marine species identified at the Gwynt y Môr project area are present throughout the UK and much of European waters, including warmer waters to the south within the Bay of Biscay, and the colder waters associated with more northern regions, they are not considered to be highly sensitive to fluctuations in temperature.

The monitoring phase of the North Hoyle Offshore Wind Farm is still underway and although is not possible to formulate any definite conclusions with regard to construction impacts until further monitoring has been undertaken, initial findings have shown that the dominant species still remain common post-construction of the wind farm with sites along the wind farm cable route being very similar to inshore control areas indicating that, at this stage, little impact to the benthic habitats from the cabling has been identified.

The impact of cable laying activities is limited to the Gwynt y Môr project area and along the cable corridor to the shore cable landfall point, the spatial impact is therefore assessed as being **Low.**

The duration of this impact is expected to be short-term in nature with subtidal sediments disturbed by water jetting expected to refill within a year and the temporary disturbance of the intertidal habitats by trenching as a result the duration of impact is assessed as being **Low**.

The impact of cable laying activities is considered to be temporary due to the rapid installation methods, the small area of sea bed affected and the rapid recovery of biotopes (both subtidal and intertidal) as a result of recolonisation of fauna from the adjacent unaffected areas of biotope. Given the limited area affected by cable laying and the ease of recolonisation the intensity of this impact is assessed as being **Low.**

The overall significance of this impact is therefore considered to also be **Low.**

Mitigation: In order to ensure rapid recovery of the intertidal areas affected, specifically where trenching is employed, surface sediments will be side cast and subsequently re-instated in order to ensure an appropriate habitat remains. The area of beach used for installation, including the movement of plant, will be minimised as far as practical.

Monitoring: Monitoring of the impacts and recovery of cable installation will be included as part of the benthic monitoring plan detailed within the preceding sections. Post-construction monitoring of the intertidal habitats (one-off survey only)willl also be undertaken. These surveys must be developed using statutory guidance and after consultation with the relevant statutory authorities notably CCW and CEFAS.

Cumulative impacts: no cumulative impacts are predicted as the construction of the Rhyl Flats and Burbo Bank offshore wind farms would not be occurring at the same time as the Gwynt y Môr development.

Potential impact: Construction activities will raise suspended sediment levels within the water column potentially affecting subtidal macrobenthos and plankton growth.

Activities associated with the construction phases of the Gwynt y Môr project have the potential to disturb sediments and increase the turbidity of the surrounding waters. This may then affect plankton and benthic invertebrate communities. Impacts could include increased light attenuation, which may cause an impact upon species dependant upon this light source for photosynthesis (e.g. plankton and algae). Suspended sediments will also affect filter feeding organisms such as anemones (e.g. *Metridium senile*) and shellfish such as mussels (e.g. *Mytilus edulis*) thereby affecting growth, and may also smother sessile organisms when they settle out of the water thereby affecting the macrobenthic communities of the area.

For the purposes of this assessment, the likely worst case for increases in suspended solids during either construction or decommissioning have been calculated. The greatest volume of disturbed sediment is likely to result from the installation of gravity foundations and under illustrative layout scenario 3, where it is calculated that a maximum of circa 212,100m^3 of seabed sediments might be disturbed. By contrast the use of suction caisson foundations, for any turbine layout, would produce almost no noticeable increase in suspended solids. Spoil generated by foundation placement, be it through dredging for gravity bases or the disposal of drill cuttings from drill/driving of monopile foundations, will be disposed of around each offshore structure (section 2).

Additional volumes of suspended sediments may be disturbed by cable installation, particularly where the water jetting method is used for installation. Water jetting of all of the subsea cables (considered here to be the worst-case scenario) could result in the displacement of as much as 113,750m^3 of seabed sediments. By contrast the use of the plough technique is considered to result in very low levels of sediment disturbance.

Much of the disturbed sediment arising from gravity foundation placement or cable installation will be of a relatively coarse nature, such as gravels and sands, and will resettle out of suspension within a few hundred metres of the construction (or indeed decommissioning) activity. Finer material however would be expected to remain in suspension for a somewhat longer period of time and will travel on prevailing currents over a wider area.

The modelling of suspended solids suggests that sediment plumes would be relatively localised to the areas of construction activity, even under worst-case conditions, before dilution reduces the sediment plumes to levels not distinguishable from normal background levels (RWE npower, 2005). The spoil disposed of around each turbine location will be subjected to erosion and dispersal, which will also act to increase the levels of suspended sediments within the water column. The spatial extent of this impact is therefore assessed as being **Low**.

Increased suspended sediments would be generated intermittently throughout the construction phase and the disposal of spoil (associated with certain foundation installation methods) would also occur during the 2-3 year phase as each installation is placed into the sea bed rather than representing a single major disposal event. The duration of this impact is therefore assessed as being **Low**.

The surface sediments of Liverpool Bay are in a continuous cycle of re-suspension and deposition according to variations in the physical processes responsible for sediment transport within the Bay, particularly tidal and wave induced flows. Benthic species present are all well adapted to such high-energy environments and therefore tolerant of intermittent disturbance or smothering (e.g. Kaiser & Spencer, 1996; Elliot *et al*., 1998; Jones *et al*., 2000). The deposition of intermittently released sediments such as sand and silt will likely be tolerated by the resident infauna. This is because the faunal communities consist of species which naturally burrow through sediments, a reflection of the normal environment within which they exist. The impact of smothering is therefore considered to be low. However, it is possible that filter feeding organisms such as the plumose anemone *Metridium senile* which was found on areas of hard substratum during the characterisation surveys and the soft coral *Alcyonium digitatum* which was also present within these areas, may be more susceptible to elevated levels of suspended sediments. However, information summarised in Hartnoll (1998) suggests that many such species, including *A. digitatum*, are also quite tolerant to such changes. The absorption of the suspended levels into the background concentrations of the Liverpool Bay turbid environment over a relatively short distance means that it is unlikely that this impact will have an affect on the planktonic communities of Liverpool Bay.

The process of dumping spoil around the turbines was also undertaken at North Hoyle and although the monitoring phase is still underway, the initial findings have shown that the dominant species still remain common post-construction of the wind farm and that biotopes also remain broadly similar to those identified pre-construction indicating that the broad scale habitats of the wind farm area have not been altered as a result of spoil disposal across the site.

In summary, the intermittent and temporary nature of the increases in suspended solids across the project area resulting from the construction operations, the relatively rapid dispersion of sediment plumes to natural background levels and the natural tolerance of the fauna in the area to such events means that the impacts on benthic and planktonic communities are assessed to be of **Negligible** significance, even when considering the worst-case scenario. This impact is further reduced with the proposed mitigation. Notably, the other foundation and cable installation options are anticipated to produce much lower quantities of suspended sediment or spoil and the effects would be expected to be even less as a result.

Mitigation: None proposed.

Monitoring: The consideration of the effects of spoil and suspended sediments should be incorporated into the benthic monitoring programme previously described. However, the low levels of suspended solids predicted and the intermittent nature of their generation, together with the experience gained from the monitoring of the North Hoyle operations and other Round 1 sites strongly suggests that monitoring of suspended solids during the construction phase is not justified at the Gwynt y Môr project area.

Cumulative impacts: impacts on plankton and benthic communities arising from increases in suspended solids from the construction of Gwynt y Môr or other activities such as aggregate dredging or spoil disposal are considered unlikely given the temporary and intermittent nature of such effects and the naturally high ambient turbidity of the Liverpool Bay region to which the existing fauna will be naturally adapted. It is not envisaged that the construction of the Rhyl Flats and Burbo Bank wind farms will be occurring at the same time as for Gwynt y Môr therefore in-combination effects with the other wind farms of Liverpool Bay are not expected.

Potential effect: Discharge of contaminants during the construction, phase may adversely affect plankton or benthic faunal communities.

Contaminants potentially released into the marine environment may include diesel, oil, lubricants, antifouling paint and grout arising from the vessels and plant associated with the construction phase of Gwynt y Môr. Such contaminants have the potential to be toxic to macrobenthic communities should they occur in high enough quantities.

During the construction period any accidental release of contaminants would be limited to the immediacy of each turbine or offshore sub station installation area and as a result would be highly localised. The spatial impact is therefore assessed as being **Negligible**.

Any discharge to the marine environment would be expected to be quickly dispersed due to the high-energy environment and mixing of the receiving waters. The duration of this impact is therefore considered to be **Negligible**.

The discharge of contaminants into the marine environment from vessels or plant would not be an intentional part of the construction phase. Any such discharge would be accidental and mitigating procedures such as appropriate environmental management plans would be in place to reduce such impact from occurring, because of this and the highly localised area which may be affected the intensity of impacts on the macrofauna is assessed as being **Negligible** and the overall significance of the impact is also considered to be **Negligible**.

Mitigation: The control of contaminants from the construction phase has been detailed in relation to potential impacts on water quality as laid out in the previous section.

Monitoring: none proposed

Cumulative impacts: Because of the highly localised nature of this impact no cumulative impacts are identified.

Potential effect: Release of seabed contaminants disturbed as part of the construction, phase could affect plankton and macrobenthic populations.

The nature, distribution and effects of seabed contamination disturbed by the construction phase of the Gwynt y Môr project on water quality have been assessed under Section 4.2.1, above. It has been concluded that the very low levels of contaminants recorded, the dispersive nature of the Liverpool Bay area and the temporary and intermittent nature of the disturbance that may result is unlikely to lead to significant effects.

Disturbance of the sediments, which may be a possible source of contaminants, will arise in the locality of the construction procedure rather than across the entire area. The spatial extent of this impact is therefore considered to be **Low**.

The surface sediments of Liverpool Bay are in a continuous cycle of re-suspension and deposition according to variations in the physical processes responsible for sediment transport within the Bay, particularly tidal and wave induced flows. Elevated levels of sediments within the water column are likely to be transported within a tidal cycle of the disturbance and would be expected to resettle out of the water column over a relatively short period of time, in keeping with the natural state of the surface sediments in Liverpool Bay. The impact would be relatively short in duration but would continue intermittently between the 2-3 years of construction. The duration of the impact is considered to be **Negligible.**

Due to the low level of sediment contamination across the site, the intermittent disturbance of sediment and the small amounts disturbed in addition to the dilution effect of the receiving waters, the potential for the release of contaminants during the construction phase is not predicted to adversely affect plankton or benthic communities. The assessment of the effect of such release of contaminants on the water quality was found to be negligible (see section 4.2.2) and as a result of this, the intensity of this impact on the plankton and benthic communities is also assessed as being **Negligible** .

The overall significance of this impact is judged as being **Negligible**.

Mitigation: The control of contaminants from the construction phase has been detailed in relation to potential impacts on water quality as laid out in the previous section

Monitoring: none proposed.

Cumulative impacts: none identified.

Potential effect: Noise generated during the construction, decommissioning or operational phases could affect macrobenthic communities and plankton.

Underwater noise will be generated during each of phases of the Gwynt y Môr project. Construction noise could arise from foundation installation (particularly where piling is used); increased vessel traffic, cable installation and the installation of scour protection. The worst-case scenario for noise is considered to arise from the installation of offshore foundations using pile driving. The predicted subsea noise levels arising from the piling of the 5MW class turbines at Gwynt y Môr have been estimated to be at a level of 273 db re 1μ Pa (QinetiQ, 2005) (Section 2). This figure has been used to assess the impact of underwater piling noise on marine benthos based upon a worst-case scenario. Other sources of noise arising from other forms of foundation installation and vessel traffic are thought to have little affect on the overall background noise levels and are therefore assessed as having no impact.

In general, marine invertebrates do not possess air filled spaces so they will perceive sound as a physical force, detecting the vibration and water particle movement using both external and internal sensory structures such as hairs and statocysts. In relation to the potential effects of noise on benthic invertebrates it is generally assumed that sound has few behavioural or physiological effects unless the organisms are very close (within metres) to a powerful noise source.

Seismic exploration levels are known to be in the order of 250dB at 10-120Hz (Richardson *et al.,* 1995) and it has been previously observed that noise sources of this intensity may have an impact upon marine invertebrates within ten metres of the source (McCauley, 1994; Brand & Wilson, 1996). Examples of these impacts include polychaete species withdrawing to the bottom of their burrows or retracting their palps into their tubes, and bivalve species withdrawing siphons. It is predicted therefore that close proximity to pile driving at noise levels of 273 db re 1μ Pa is here assumed to be able to cause physical damage to organisms present due to the effects of the high-pressure wave generated and the sessile nature or slow motility of these organisms, but if so this will be limited to a distance of a few metres. The spatial impact is therefore assessed as being **Negligible**.

Piling at Gwynt y Môr is expected to be a drive and drill approach and as a result the noise levels generated from piling will be intermittent in nature. Piling is expected to occur throughout the 2-3 year construction phase but as impacts will be localised to the immediate area of piling operation the duration of this impact is assessed as being **Negligible**.

The impacts of noise generated during the construction phase are considered to be highly localised disturbance on a temporary basis, which is not thought to be detrimental to the overall marine community structure of the development area. The intensity of the impact is therefore considered to be **Negligible** and the overall significance of the impact is assessed as being **Negligible.**

Mitigation: none considered necessary.

Monitoring: none specific to noise is proposed but the programme of benthic monitoring may be used to confirm the conclusions of this assessment.

Cumulative impacts: due to the highly localised nature of this impact no cumulative impacts are identified.

4.3.3 Potential Impacts From The Operational Phase

Potential impact: Discharge of contaminants during the operational phase may adversely affect macrofaunal communities.

As detailed within section 2, during the operational phase all turbines will be subject to a six monthly routine service on all mechanical components such as gearboxes, transformers, switch gear and generators. This will involve the routine changing of lubricants and hydraulic oils which will be subsequently disposed of via licensed recycling contractors on land. Annual maintenance will be required for the offshore substations and any wastes generated would be similar as for the turbines and would be disposed of in the same manner. Any exceptional maintenance of wind farm installations such as rotor blade removal will require the mobilisation of jack-up rigs which themselves may generate contaminants such as spilt lubricants or fuel being deck washed into the marine environment.

Contaminants potentially released into the marine environment are therefore likely to be diesel, oil, lubricants, antifouling paint and grout arising from maintenance vessels and plant required for servicing or the repair of installations. Any accidental spillage of these contaminants into the marine environment may have the potential, if they are in sufficient quantities, to be toxic to the macrofaunal communities within the immediate vicinity.

As identified in the assessment of the impacts of Gwynt y Môr upon water quality (section 4.2.1) any release of contaminants during the operational phase into the marine environment would be entirely accidental and would be highly localised to the immediacy of each turbine or sub station installation area undergoing maintenance. The spatial impact of this effect on the macrofaunal communities is therefore assessed as being **Negligible**.

Any discharge to the marine environment would be expected to be quickly dispersed due to the high-energy environment and mixing of the receiving waters. The duration of this impact is therefore considered to be **Negligible**.

The release of contaminants into the marine environment from vessels, plant or installations is not an intentional part of the operational phase. Any such discharge would be accidental and mitigating procedures such as appropriate environmental management plans would be in place to reduce such impact from occurring, because of this and the highly localised area which may be affected the intensity of impacts on the macrofauna is assessed as being **Negligible** and the overall significance of the impact is also considered to be **Negligible**.

Mitigation: The control of contaminants from the operational phase have been detailed in relation to potential impacts on water quality as laid out under Section 4.2.1.

Monitoring: none proposed

Cumulative impacts: Because of the highly localised nature of this impact no cumulative impacts are identified.

Potential impact: The presence of the offshore wind turbines and sub stations may change tidal and residual currents altering water fronts and affecting benthic and plankton communities.

The installation of turbines and offshore substations at the Gwynt y Môr project area may potentially alter the prevailing hydrodynamics of the immediate area which may also affect sediment processes. Such alterations could affect the water fronts which are important for plankton and may also increase current speed at the sea bed which will cause an impact of scour affecting macrofaunal habitats and communities (this is considered in further detail below).

The impacts of the Gwynt y Môr project on the prevailing hydrodynamic conditions of the area have been assessed separately (see RWE npower, 2005) and it has been concluded that the development will have only very small scale effects on tidal flows. **No impacts** to the water fronts and therefore plankton productivity of Liverpool Bay are considered likely to occur.

Mitigation: none considered necessary.

Monitoring: none proposed

Cumulative impacts: none identified.

Potential impact: The installation of the offshore structures could alter seabed sedimentological processes affecting macrobenthic communities as a result of scour.

The presence of artificial structures on the sea bed may cause variations in the local current velocity potentially increasing erosion forces around the base of these structures resulting in scour. This is likely to lead to the displacement of surface sediments (especially finer sediment material) changing the original sediment environment to a coarser substratum than previous with a greater component of cobbles, stones, gravel and shell fragments.

The potential for scour to occur has been assessed as part of the physical processes assessment presented elsewhere in RWE npower (2005). It has been concluded that small localised scour may occur around monopile foundations as has been observed at the North Hoyle Offshore Wind Farm scouring around the monopile foundations has remained low and of the order of 0.5m and scour has not been observed at all of the structures (ABPmer, 2005). The seabed sediments are of similar grading to those found at Gwynt y Môr and, therefore, it is considered that the likely risk of scouring around the foundation structures at the present study site is low (RWE npower, 2005). Because of the similarity of sediment types between North Hoyle and Gwynt y Môr it is considered that the risk of scour around monopile foundations is low. However, it has been assessed that the worst-case scenario is generated by gravity base turbines which may result in a scour depth local to the foundation of 5.4-13.5m. The smallest scour pit would be generated from monopile foundations where a pit of depth 2.2 - 2.6m might theoretically occur. All other turbine options fall between these two estimates.

The sedimentary environment heavily influences marine benthic communities and any changes to sediment habitat are likely to affect the fauna able to colonise the sediment. Burrowing marine invertebrate infauna such as molluscs, worms and crustacea will be the greatest affected by the loss of finer sediments and if disturbance of the remaining sediment is a frequent occurrence then a relatively poor fauna, likely to be dominated by scour tolerant encrusting organisms such as thin bryozoan crusts etc, would be expected to develop (assuming the sediments are dominated by cobble and small boulders); or by small numbers of crustaceans and polychaetes if the remaining sediment is more granular. It is therefore considered that within the area affected by scour there will be a reduction in species diversity, abundance and biomass.

In contrast, where scour protection is deployed, sediment stability will tend to increase and will provide additional stable substratum to be colonised by benthic invertebrate species leading to a richer, diverse fauna. Ultimately the benthic communities that occur in those areas subject to scour will depend on the extent and magnitude of the scour that develops, the degree of scour protection deployed and the degree to which the seabed eventually stabilises. It is considered that there will be zones of different physical and biological characteristics within the scour depression and it is therefore considered that scour, with or without scour protection, will alter the localised biodiversity of the area.

Although the installations associated with the Gwynt y Môr project will be in place for a period of up to 50 years the affects of scour are predicted to be limited to the short term as stabilisation of seabed conditions will occur (or if scour protection is used). The duration of this impact is therefore assessed as being **Low**.

It is predicted that when seabed conditions stabilise the benthic communities would recover some degree of their species diversity, abundance and biomass although within scour pits this may remain suppressed. However, it should be noted that scour has occurred at very few of the North Hoyle installations and the total area affected by scour at the Gwynt y Môr project area is in reality predicted to be relatively low. In addition, the colonisation of any scour protection used at the base of the turbines and offshore sub stations by hard substratum favouring benthic species of the area is likely to occur. The intensity of this impact is therefore assessed as being **Low** and the overall impact significance **Negligible**.

Mitigation: The use of scour protection will be considered for areas where significant scour is recorded and this will act to prevent any further erosion and associated release of suspended sediments from occurring.

Monitoring: As part of the benthic monitoring programme (detailed previously) some sampling within the immediate proximity of turbines will be attempted to assess the impacts of scour on benthic communities. This will be combined with the results from the physical monitoring of the seabed around the turbines using side scan sonar and swathe bathymetry.

Cumulative Impacts: none identified.

Potential impact: The introduction of new subtidal substratum, such as turbine and sub station support structures and surrounding scour protection may provide new surfaces for colonisation promoting habitat and species diversity.

Artificial structures placed into the marine environment provide a hard and stable substratum available for colonisation by a diverse range of benthic organisms such as seaweeds, mussels, barnacles, tubeworms, hydroids, sponges, soft corals and other invertebrates (Vella *et al.*, 2001) allowing the formation of an artificial reef. Studies at the Horns Rev Offshore Wind Farm (Denmark) noted colonisation of the turbine structures by bryozoans, sea anemone, sea squirts, starfish and the common mussels *Mytilus edulis* within 5 months of the wind farm construction (Bio/consult, 2000 cited in Leonhard, 2000). Studies at the North Hoyle Offshore Wind Farm 12 months after construction found the turbine structures to be colonised by a total of 59 faunal species with the most common being the barnacle *Balanus crenatus*, the mussel *Mytilus edulis* and the amphipod *Jassa falcata*. The common starfish *Asterias rubens* and the sea anemones *Metridium senile, Sagartia elegans* and *Sagartia troglodytes* were also conspicuous, in addition to many small invertebrate worms and crustacea as well as the commercially important edible crab *Cancer pagurus* which was observed feeding on the colonised species. All the species observed are known to occur on hard substrata near to the area and have most likely been recruited from nearby locations (CMACS & Marineseen, 2004).

The final project layout of the Gwynt y Môr Offshore Wind Farm will provide additional subtidal surfaces for example the illustrative layout scenario 1, which has the highest indicative number of turbines, provides an example of the greatest potential for new habitat with up to 0.08km^2 available for colonisation were monopole foundations to be installed. Use of gravity base structures would offer an even greater surface area for colonisation. Additional habitat may also be created by the placement of scour protection around the offshore structures and at the site of the pipeline crossings. Such scour protection will also provide a greater degree of complexity than the vertical habitats offered by the turbine and sub station surfaces, which is considered to be a beneficial factor in the attractiveness of artificial marine structures for colonisation (e.g. Wickens and Baker, 1996, Hoffman *et al.,* 2000). It is highly probable that the fauna observed colonising the installation structures at the North Hoyle Offshore Wind Farm would also colonise those present at Gwynt y Môr increasing the diversity of the habitat within the Gwynt y Môr area allowing hard substratum habitat favouring benthic species to colonise the structures and any associated scour protection.

The provision of new habitat for colonisation would only occur within the Gwynt y Môr project area and the spatial extent of this impact is therefore expected to be **Negligible**.

The Gwynt y Môr structures available for colonisation by benthic species are expected to be in place throughout the operational phase of the wind farm over a period of 50 years. However, during this time it may be necessary to periodically “clean” these structures to ensure structural integrity. This process would probably involve the scraping of the biofouling from the structures. Whilst this would obviously affect any encrusting communities that have established, it will not remove all of the biofouling and in any case would simply expose new surfaces for further colonisation. However, such a cleaning process may prevent the establishment of longer term climax communities on these structures that might otherwise have occurred. As a result the duration of this impact is assessed as being **Medium** but beneficial.

The provision of new substrata for colonisation at the wind farm site will offset, to some extent, the habitat lost from the construction of the wind farm. The intensity of this impact is therefore assessed as being somewhat beneficial to the benthic communities and the overall impact intensity is assessed as being **Low** beneficial.

This effect will be relatively limited in extent but will last for the duration of the wind farm and, as stated, will tend to offset the loss of habitat occurring during wind farm construction and operational phase. The significance of this positive effect is assessed to be **Low.**

Mitigation: none considered necessary.

Monitoring: It is recommended that a single, post-construction survey of a proportion of the underwater structures be undertaken using appropriate techniques such as diver or ROV observations to identify the extent and diversity of species colonisation. Such surveys should be discussed and agreed with the relevant statutory authorities, notably CCW and CEFAS.

Cumulative impacts: Within Liverpool Bay, in addition to the Gwynt y Môr, habitat available for colonisation by benthic fauna is provided by the oil and gas platforms and the wind farms of North Hoyle, Burbo Bank and Rhyl Flats (once the latter two are constructed). Although these structures will act to increase species diversity and possibly productivity this will be limited to the immediate area of each development and as such are not considered to alter the overall productivity or species diversity of benthic species within Liverpool Bay. Any cumulative impacts are therefore considered to be **Negligible**.

Potential impact: Noise and vibration generated from the operating turbines and offshore sub stations may affect macrobenthic communities.

There is very little evidence available that macro fauna are able to perceive the noise and vibration emitted from operating turbines. In addition, the colonisation of noisy artificial underwater structures such as oil and gas platforms and other offshore wind farms by a wide variety of benthic organisms is well documented (see above) suggesting that marine invertebrates are unlikely to be sensitive to the noise and vibration generated by operational offshore wind farms (Vella *et al.,* 2001). As a result of this, the impacts of noise generated by the operating installations are assessed as being: Spatial- **Negligible**, Duration- **High** as noise will be generated throughout the lifespan of Gwynt y Môr. Intensity- **no impact** upon benthic macrofauna species is anticipated. Overall impact significance is therefore deemed as being **Negligible.**

Mitigation: none considered necessary.

Monitoring: none specifically proposed but the benthic monitoring survey should highlight the conclusions formulated here.

Cumulative impacts: none identified.

Potential impact: Electromagnetic fields from the Gwynt y Môr Offshore Wind Farm subsea cables could adversely affect benthic invertebrate communities.

It is possible that certain benthic invertebrate species, particularly Crustacea and Mollusca, could be magnetically sensitive. The magnetic field component of EM-Fields produced by the subsea cables could theoretically interfere with the behaviour of these species. However, there is no evidence to date from ongoing benthic ecological monitoring at the North Hoyle Offshore Wind Farm that potentially magnetically sensitive species of crustaceans and molluscs have been adversely affected by the presence of submarine power cables and associated magnetic fields.

In view of the lack of any firm evidence of effects on benthic invertebrates, and the relatively limited spatial extent of the predicted EM-Fields arising from cables, the potential effects are assessed to be of **Negligible** significance.

Mitigation: None considered necessary.

Monitoring: As part of the benthic monitoring programme set out previously, it is recommended that some sampling within the immediate proximity of offshore sub-stations and cables is attempted to assess the effects. This would comprise placing a proportion of sample sites within approximately 10m of cables and sub-stations.

4.3.4 Potential Impacts From The Decommissioning Phase

Decommissioning activities would overall not be dissimilar to those employed during the construction phase. Impacts upon the marine benthic and planktonic communities of Liverpool Bay are therefore considered as being similar to those highlighted for the construction phase in section 4.3.3.

Potential impact: The removal of underwater structures such as turbine and sub station support structures and surrounding scour protection may affect seabed habitat.

As previously identified within this assessment the operational phase of Gwynt y Môr will provide additional habitat from the installations for colonisation by benthic fauna. As part of the decommissioning phase the turbine and offshore substation supports will be removed at the seabed. The removal of the foundations and supports will result in the loss of vertical habitat previously available for colonisation. Illustrative layout scenario 1 has the highest number of turbines and therefore the largest amount of vertical habitat available as artificial reef substratum (250 turbines and 4 sub stations) and is therefore considered to be the worst-case scenario for the greatest loss of habitat from decommissioning estimated to be 0.08km^2.

The removal of these structures will represent the loss of the communities present on the structures themselves which are likely to represent hard substrate communities uncommon to the surrounding seabed and limited to the Gwynt y Môr Offshore Wind Farm project area. The spatial impact is therefore identified as being **Negligible.**

The removal of the installations is likely to occur over the 2-3 year decommissioning phase so the duration of impact is considered to be **Low**.

The removal of the artificial reef substratum will result in a gradual change to the benthic communities over the duration of the decommissioning phase reverting to the biotopes previously established at the site prior to construction. The overall species diversity and possibly productivity may well be reduced as a result of the loss of the increased habitat however, the species identified as colonisers of the installation structures are all common to hard substratum areas of Liverpool Bay and the intensity of this impact upon the benthic ecology of the Gwynt y Môr project area and the surrounding area of Liverpool Bay is considered to be **Negligible.**

The overall significance of this impact is considered to be **Negligible.**

Mitigation: none considered necessary

Monitoring: It is recommended that a post-decommissioning survey be implemented to monitor the affects of the removal of installation structures upon the benthic communities of Gwynt y Môr. The specification of this survey will be developed and agreed with the relevant statutory authorities e.g. CCW.

Cumulative impacts: Additional habitat within Liverpool Bay available for colonisation by benthic invertebrate species arises from the offshore wind farms of North Hoyle, Burbo Bank and Rhyl Flats and the oil and gas platforms. The removal of habitat is considered to be a localised impact and it is unlikely that all structures will be removed simultaneously due to differences between project life spans. Because of this, and in the light that no effects would arise to the benthic communities of Liverpool Bay as a result of the decommissioning of the proposed Gwynt y Môr Offshore Wind Farm no cumulative impacts are identified.

Potential impact: The feet of jack-up rigs during decommissioning phase will physically disturb the seabed habitats.

During removal of the offshore wind farm installations such as turbines and substations as part of the decommissioning phase it will be necessary for the jack-up rigs to make contact with the sea bed. The duration and the number of rigs is likely to be the same as for the construction phase and any impacts are therefore assessed as being the same as those identified in section 4.3.2. The assessment of this impact is therefore as follows: Spatial-**Negligible**, Duration-**Low**, Intensity-**Low**, Significance-**Low**.

Mitigation: none considered necessary.

Monitoring: As stated above, it is recommended that a post-decommissioning survey be implemented to monitor the affects of decommissioning upon the benthic communities of Gwynt y Môr. The specification of this survey will be developed and agreed with the relevant statutory authorities.

Cumulative impacts: No cumulative impacts are identified due to the limited area and duration over which the impact occurs in relation to Liverpool Bay.

Potential Impact: Removal of cables may affect subtidal and intertidal macrofaunal communities.

As part of the decommissioning phase the inter-turbine and export cabling would be removed and the current methods identified for this cable removal would be through either peel-out-using a grapnel to pull the cable out of the seabed, pulling an under-runner by a steel cable to push the cable from the sea bed or by jetting the sea bed to remove sediment from the cable. These methods will cause similar impacts to the methods utilised to bury the cable during the construction period and as a result the impacts are identified as follows: Spatial-**Low**, Duration-**Low**, Intensity-**Low**, Significance-**Low**.

Mitigation: as identified for the construction phase in section 4.3.2: to minimise impacts upon intertidal communities the area over which plant operates during the process of cable removal should be delineated to restrict the area over which the impact occurs. In addition, to ensure the rapid recovery of the intertidal areas affected, specifically where trenches are excavated across the intertidal areas, surface sediments will be side-cast and subsequently re-instated in order to ensure an appropriate habitat remains.

Monitoring: It is recommended that a post-decommissioning survey is implemented to monitor the impacts and recovery of benthic communities and habitats as a result of cable removal. The specification of this survey will be developed and agreed with the relevant statutory authorities.

Cumulative impacts: The disturbance of habitat in a similar way will also occur during the decommissioning of the Burbo Bank and Rhyl Flats wind farms. However, it is not expected for the decommissioning of these wind farms to coincide with the decommissioning of Gwynt y Môr due to the large variations in timescales for the life spans of these different projects.

Potential impact: Decommissioning activities will raise suspended sediment levels within the water column potentially affecting subtidal macrobenthos via smothering and plankton growth via increased turbidity and light attenuation for photosynthesis.
During the decommissioning phase of Gwynt y Môr it is anticipated that the removal of wind farm installations and inter-turbine and shore cabling will generate an increase in suspended sediments in much the same way as identified for the construction phase. As installations will be removed at the sea bed and because drilling will not be required the generation of spoil is not anticipated. However, as a worst-case scenario the effects of increased sediment levels upon the macrofaunal and plankton communities for the decommissioning phase have been assessed as being similar as those assessed for during construction in section 4.3.2. Impacts are therefore considered to be: Spatial- **Low**, Duration-**Low**, Intensity-**Negligible** and overall impact significance-**Negligible**.

Mitigation: None proposed.

Monitoring: It is recommended that a post-decommissioning survey be implemented to monitor the affects of the increased suspended sediment levels generated during the decommissioning phase upon the benthic communities of Gwynt y Môr. The specification of this survey should be developed and agreed with the relevant statutory authorities.

Cumulative impacts: impacts on planktonic and benthic communities arising from increases in suspended solids from Gwynt y Môr or other activities such as aggregate dredging or spoil disposal are considered unlikely given the temporary and intermittent nature of such effects and the naturally high ambient turbidity of the Liverpool Bay region to which the existing fauna will be naturally adapted.

Potential impact: Potential discharge of contaminants during the decommissioning phase may adversely affect macrofaunal communities.
Potential contaminants, which may be released into the marine environment during the decommissioning phase, are assessed as being similar to those identified during construction activity in section 4.3.2 as: Spatial- **Negligible**, Duration-**Negligible**, Intensity-**Negligible** and overall significance-**Negligible**.

Mitigation: The control of contaminants from the construction phase has been detailed in relation to potential impacts on water quality as laid out in section 4.2.2. It is strongly recommended that this mitigation also be adhered to for the decommissioning phase of the project.

Monitoring: none proposed.

Cumulative impacts: none identified.

Potential impact: Release of seabed contaminants disturbed during decommissioning could affect plankton and macrobenthic populations.
The surface sediments at the Gwynt y Môr project area were tested for a range of contaminants (see section 3.1) and the overall impression was that the levels of contaminants within sediments at the Gwynt y Môr project area were found to be consistently low. Sediments would be disturbed during the decommissioning phase by the same methods as those identified during the phase of construction and the impacts are therefore assessed as

follows: Spatial- **Negligible**, Duration- **Negligible**, Intensity- **Negligible**, Significance- **Negligible**.

Mitigation: none considered necessary.

Monitoring**: none proposed**

Cumulative impacts: none identified.

Potential impact: The noise generated by the removal of the Gwynt y Môr Offshore Wind Farm installations during the decommissioning phase may affect macrobenthic communities.

The decommissioning phase of Gwynt y Môr will produce noise from turbine and sub station dismantling, any removal of scour and an increase in vessel traffic. As detailed in section 2 it is anticipated that foundation monopiles be cut away at the sea bed rather than being dismantled through the use of explosives. If this is the case then impacts concerning the effects of noise upon the marine benthos are considered to be lower than assessed for the high-energy levels generated during the construction phase.

There is little data available regarding the noise levels generated during decommissioning especially from the noise generated removing turbine foundations by cutting and the impact this has upon marine benthic invertebrate species and plankton. As a result of this and as best practice it has been considered that noise generated from decommissioning would be the same as for construction as a worst-case scenario. Therefore the effects would be: Spatial- **Negligible**, Duration-**Negligible**, Intensity-**Negligible**, Significance-**Negligible**. No mitigation or specific monitoring is proposed.

Mitigation: none considered necessary.

Monitoring: none proposed.

Cumulative impacts: As stated previously, the wind farms of Liverpool Bay will not be decommissioned simultaneously. Noise levels generated during decommissioning will also be intermittent and are not thought to create a significant overlap with other intermittent noise generating activities within the area such as aggregate extraction, dredging, shipping and the oil and gas industry. Given this intermittent nature, and the highly localised nature for this impact and the lack of behavioural of physiological response of benthic invertebrates and plankton species to noise levels no cumulative impacts on the benthic and plankton populations are identified.

4.4 Potential Impacts on Fish & Shellfish Ecology

This section assesses the potential effects of the Gwynt y Môr Offshore Wind Farm project on the fish and shellfish species of Liverpool Bay and the eastern Irish Sea.

4.4.1 Relevant guidance for the potential impacts of offshore wind farms on Fish and Shellfish.

Statutory guidance is in place regarding the environmental impact assessment of offshore wind farm developments within United Kingdom waters upon fish and shellfish species and habitats. These have been duly considered for the assessment of impacts of Gwynt y Môr and are summarised below.

- **CEFAS (2002). Guidance notes for Environmental Impact Assessment in respect of FEPA/CPA requirements**.

This lists the following aspects for consideration:

- Feeding areas
- Spawning grounds
- Nursery grounds for fish and over-wintering areas for crustaceans
- Migration routes for shellfish and fish, including elasmobranchs.

Specific wind farm issues include noise and vibration, EMF effects on elasmobranches, loss of habitat, loss of prey and productivity, positive impacts from the placement of the turbines and impacts on shellfish species.

The Environment Agency also highlights the need to assess impacts on 'migratory' fish species such as salmon.

- **Defra(2005) Nature Conservation Guidance on Offshore Wind Farm Development. Version R1.9.**

This identifies the potential impacts from offshore wind farm developments on the fish and shellfish species as being:

- loss or alteration of habitat for feeding and nursery areas; and
- disruption of normal behaviour including feeding and migration due to generation of electro-magnetic fields as well as effects of noise and vibration effects.

For shellfish, the main impacts are likely to result from loss or alteration of habitats as a result of construction activities. The potential for generation of artificial reefs may provide a benefit to some shellfish species. However, the impacts on fish and shellfish, which are prey species for birds and marine mammals, must also be taken into account when appraising the impacts to those groups.

4.5.2 Potential Impacts From The Construction Phase

Potential Impact: Gwynt y Môr turbine and offshore substation foundations will lead to a direct loss of fish and/or shellfish habitat.

Habitat will be directly lost as a result of the placement of turbine and offshore substation foundations on the sea bed in addition to any scour protection which is deemed necessary. In addition, temporary habitat disturbance will also be experienced from the jack-up rigs which are used during all phases of the project (previously described under Section 3.3.2 in relation to effects on benthic habitats). Under the worst realistic case scenario for the various options being considered and based on the illustrative layout scenarios provided such loss equates to a maximum area of circa 1.22km^2, reducing to an estimated minimum of circa 0.024km^2. All of the other foundation options and illustrative layout scenarios will fall within these two areas of effect and therefore these estimated figures can be considered to represent the likely envelope of effect for seabed habitat loss. As a proportion of the whole Gwynt y Môr project area, this represents approximately between 0.02 and 0.98% of the project area or a maximum of approximately 0.03% of the total area of Liverpool Bay (based on the total area of Liverpool Bay being 4,870 km^2).

The loss of this area of habitat does not represent a significant environmental effect spatially, its real environmental effect with respect to fish populations is the extent to which it results in a loss of essential fish (or shellfish) habitat such as spawning, nursery or feeding grounds where benthic prey species upon which fish feed are lost.

The spawning and nursery areas within Liverpool Bay and the eastern Irish Sea are highlighted in section 3.4. This identified that some commercial species spawn more or less ubiquitously throughout the eastern Irish Sea, including Liverpool Bay but others have more defined centres of spawning e.g. Plaice and Dover sole spawn between the Great Orme and Isle of Man. Herring spawn off the east coast of the Isle of Man in August and September (Hillis & Grainger, 1990; Coull *et al.,* 1998; Figure 3.4.5), well away from Gwynt y Môr. Whiting (*Merlangius merlangus*, April-May) and dab (*Limanda limanda*, April-May) do not have such clearly defined spawning areas but cod spawn (March-April) in the northern half of Liverpool Bay and flounder (*Platichthys flesus*) spawn (April-May) off all the major estuaries but most notably off the Dee and Solway Firth (Figure 3.4.5). The elasmobranchs, rays and dogfish, will deposit eggs in shallow areas of rough ground. And spawning is considered to be widespread throughout Liverpool Bay for the lesser spotted dogfish. However, thornback ray (*Raja clavata*) are most likely to be found in proximity to the major river estuaries. Hence, the area of rough ground in the vicinity of the North Hoyle Offshore Wind Farm, off the Dee Estuary, is one area where thornback ray may congregate to spawn (see section 3.4).

Nursery grounds for juvenile flatfish such as plaice, dab and sole are found within the sandier coastal areas of the Bay but especially along the North Wales coastline from the surf zone up to 10m in depth (Rogers, 1993, 1994; Innogy, 2002). The juveniles of these species are therefore likely to be encountered at the Gwynt y Môr project area. Any species that has a close association with a particular seabed type could be affected by any changes induced by construction work.

From the moment the first foundation is put in place, there is a loss of natural habitat supporting a variety of bottom-dwelling, benthic organisms, many of which provide the prey upon which commercial species of fish and crustacean shellfish feed. Hence, if a particular species of benthic prey is crucial to the diet of a fish and is restricted in its distribution, there is the potential to decrease the biomass of the prey species and the well being and long-term sustainability of the predator. This effect may be limited locally or, if the prey is of limited distribution but an essential component of a predator's diet, the Irish Sea stock of the predator might, theoretically, be affected. However, very few demersal fish in UK waters have a highly specialised diet, and none of those identified in the CEFAS trawl-survey data from within or around the Gwynt y Môr project area were specialised species in relation to their prey preferences (see section 3.4).

All habitat loss would be experienced within the Gwynt y Môr Offshore Wind Farm project area and as a result the spatial extent of this impact is considered to be **Negligible**.

The loss of habitat available for fish and shellfish species will be for the duration of the Gwynt y Môr Offshore Wind Farm life span and as a result the duration of this impact is assessed as being **High**.

The benthic habitats identified as part of the characterisation surveys (section 3.3) revealed biotopes at the Gwynt y Môr project area to be common across Liverpool Bay and the eastern Irish Sea. The loss of habitat used by fish as feeding grounds is therefore not anticipated due to the widespread nature of these biotopes outside the Gwynt y Môr Offshore Wind Farm project area which will not be affected (see section 3.3). Spawning and nursery grounds for a variety of fish species occur throughout Liverpool Bay and the eastern Irish Sea. It is therefore probable that the installation of Gwynt y Môr will affect some of this habitat. However, due to the widespread nature of such grounds and the substratum found at the wind farm site being common throughout Liverpool Bay and the wider Irish Sea the impact of loss of fish habitat to the wind farm structures is considered to be **Negligible**.

The inshore coastal areas are considered to be the key habitats for shellfish populations such as cockle and mussels stocks, and commercial crustaceans such as lobster and crab (see section 3.4). However, the Gwynt y Môr project area does support populations of King and Queen scallops which have a preferred habitat type of gravel or gravely sand. However, both these species are abundant in the waters beyond the 12 mile limit and their distribution extends throughout the greater part of the eastern Irish Sea (section 3.4). The foundation installation will, therefore, result in some loss of habitat used by these species, but it will be a very small proportion of the total available. Therefore the Intensity of this effect is considered to be **Low.**

The loss of habitat would be for the duration of the Gwynt y Môr project lifespan and would therefore represent an adverse effect; the loss represents a very small part of the total habitat available to the fish and shellfish species within Liverpool Bay. The overall significance of this impact upon the fish and shellfish species is therefore assessed as being **Low**.

Mitigation: none considered necessary.

Monitoring: A post-construction monitoring program is recommended to monitor the effects of the Gwynt y Môr Offshore Wind Farm construction on the fish and shellfish species of the area. It is suggested that these surveys will be developed using statutory guidance and after consultation with the relevant statutory authorities e.g. CCW and CEFAS. These surveys must utilise fisheries equipment which is suitable for manoeuvring amongst the turbine structures and should ideally reflect the fishing practices currently undertaken in the locality e.g. tangle nets.

Cumulative impacts: Within Liverpool Bay habitat loss also occurs as a result of the marine aggregate extraction and channel maintenance operations and the presence of the Hamilton and Douglas oil and gas platforms and the North Hoyle Offshore Wind Farm. In addition the proposed wind farms at Burbo Bank and Rhyl Flats will also result in a net loss of habitat available.

Most offshore gas and oil installations in Liverpool Bay and the eastern Irish Sea were built 10-20 years ago and, at present, it seems unlikely that there will be any significant change. However, as with the Liverpool Bay wind farms (see below) these structures do offer alternative surfaces for colonisation which offer some degree of mitigation for the initial loss of benthic habitat.

There is a licensed marine aggregate extraction site immediately to the east of the Gwynt y Môr project area and a further application to dredge aggregates to the north east. The existing licensed area (Areas 392/393) supports a relatively low level of activity (compared to that seen on sites off the south or east coasts of England for example). While this activity is physically removing seabed, with its indigenous fauna, a comparable layer of seabed is always left in place. Once dredging has ceased it will become recolonised by species from neighbouring unaffected areas, and since the resource dredged at these sites is of fine to coarse sand it may be anticipate that recolonisation would be relatively rapid when compared to the recolonisation at more stable gravel sites off the south or east coasts.

Waste disposal at sea is limited almost exclusively to the disposal of capital or maintenance dredging spoil. National policy is to use spoil ‘constructively’ and only if this is not possible is it disposed of at a licensed disposal site at sea. All such sites have been in use for many decades and any adverse effect they may have had on the abundance and distribution of benthos has probably stabilised although they may nonetheless have resulted in a change in the nature of the benthic habitats and associated fish fauna over that time. However, the area affected by spoil dumping and the relatively small quantities deposited at most of the Liverpool Bay sites means that broader scale cumulative effects when combined with the relatively small area of habitat lost to the Gwynt y Môr development must be considered unlikely to be significant.

The spawning, nursery and feeding grounds identified during the baseline assessment in section 3.4 are not limited solely to Liverpool Bay, indeed they are found throughout the Irish Sea and as a result when the net loss of habitat at Gwynt y Môr is considered in combination with these other habitat loss activities in the context of the eastern Irish Sea and the homogeneous occurrence of such habitat the overall cumulative impact is considered as being **Negligible**. Equally, any effects from Gwynt y Môr and the other wind farms will, ultimately, be reversible following decommissioning.

Potential impact: Construction activities will disrupt or disturb habitat that may be important for fish & shellfish species.

During construction activities seabed will be disturbed by the placement of installations into the seabed and the laying of the inter-turbine and shore cables. Specifically, the use of a drill/drive method for the installation of the monopile or multipile foundations will give rise to the disposal and dispersion of drill cuttings within the development site whilst the use of gravity foundations will necessitate the use of bed levelling or dredging to prepare the seabed for foundation placement. By comparison, the use of suction caissons is unlikely to result in any significant release of sediment or alteration of habitat. In addition, the placement of structures on the sea bed may result in very localised changes to tidal currents and waves around each foundation, which could result in the scouring of sediment away from the base of each structure, resulting in localised changes to the seabed and the release of sediment disturbed by such scour effects.

All cables will be buried using one of several methods (see section 2). All methods cause physical disturbance to the seabed potentially altering benthic communities utilised by fish as prey species or directly impacting key habitat such as spawning or nursery areas. The actual cable-laying procedure is rapid, almost instantaneous, as it progresses along the cable route but where water jetting is used the re-instatement of the cable trench will not occur immediately. The time taken for the disturbed sediments to stabilise and resume their pre-treatment characteristics is directly dependent upon the prevailing sedimentary and hydrodynamic regimes, however it is likely that significant re-instatement would occur within several months but probably less than one year.

The impacts of the suspended sediments generated by these construction activities on fish and shellfish species and habitats have been assessed within the next statement and are therefore not considered further within this impact statement which only considers the physical alteration of habitat by construction activities.

It is calculated that the maximum area of seabed directly affected by cable laying activities including all of the inter-turbine and export cables is between 0.063 – 0.105km^2. This area is a small fraction of Liverpool Bay, representing a maximum of circa 0.002% of the Liverpool Bay area (as previously defined). The worst-case scenario would be the use of water jetting for all cable laying activities as, unlike ploughing, the seabed is not re-instated immediately with sediments being left to settle (an estimated maximum of up to 113,750m^3) and eventually backfill cable trenches.

The winnowing of finer sediments from the seabed as a result of changes to currents or wave activity around each turbine or sub station structure will contribute to suspended sediment concentrations within the project area (see below). The sediment that remains following placement of these structures will potentially have a different composition that may make the substrate less attractive for some seabed-dwelling species to colonise which may affect prey species for fish or may influence the local appeal to a range of fish and shellfish for feeding, spawning and nursery areas. Changes to sediments as a result of scour would be highly localised limited to a small area around the base of each installation and entirely within the boundary of the wind farm area. The deposition of drill deposits from piling of the turbine and offshore substation foundations would also be localised to around each installation. The overall spatial extent of this impact (including cable laying) is therefore assessed as being **Low**.

Where the development of scour around the turbine and substation structures is predicted to occur, this effect will become apparent relatively quickly following their placement but would subsequently be expected to stabilise. Drill spoil deposition around each installation would occur over the duration of the construction phase and would represent a one off deposition impact. Such material would also be subjected to constant erosion and dispersal. In addition no long term alteration of the wider sediment processes of the area as a result of the Gwynt y Môr Offshore Wind Farm installations has been predicted (see RWE npower, 2005). The duration of this impact is therefore assessed as being **Low.**

Changes to seabed sediment structure is likely to influence the composition of the benthic community inhabiting the area of seabed affected which may affect the distribution of important fish prey items. Such changes, however, are likely to be localised (see section 4.3.2), so that it is difficult to envisage that they would have any discernible effect on the composition of associated local fish populations. Changes in seabed topography associated primarily with scour pits and the deposition of spoil arising from drilling will alter the habitat for fish spawning and will disturb shellfish especially in the north-west of the Gwynt y Môr project area where scallops are known to occur (see section 3.4). However, such disturbances will be localised to the vicinity of the installations and will not impact upon the fish and shellfish populations of Liverpool Bay due to the wide distribution of spawning grounds and shellfish habitat throughout Liverpool Bay and the eastern Irish Sea.

As the export cables leave the wind farm and approach the coast their track will cross the largest sole and plaice nursery area in Liverpool Bay (Rogers, 1993, 1994), and possibly the largest of the sole nurseries in the eastern Irish Sea (see section 3.4). To the east of the proposed cable route is also area of potential importance as a ray spawning-nursery area (see section 3.4). Due to the narrow area of sea bed affected by cable laying activities it is anticipated that juvenile species, including juvenile sole and plaice would move away from the line of operation to adjacent unaffected areas potentially even moving in behind the cable laying activities to prey on the disturbed or damaged benthic fauna. The intensity of this impact is therefore considered to be **Low**.

Construction activities will have the potential to alter seabed habitat potentially affecting fish and shellfish either by changing the behaviour of fish or making the seabed less suitable for shellfish settlement or as fish habitat. However, these effects are predicted to occur over highly localised areas and are not considered to significantly affect the populations of Liverpool Bay. The overall significance of the impact of construction activities on the fish and shellfish populations through the disturbance of habitat is therefore assessed as being **Low**.

Mitigation: Where significant scour is identified, there may be a need to place scour protection, for example rock armouring. This would prevent any further erosion and release of sediments with the concomitant benefit of enhancing the wind farms artificial reef characteristics.

Monitoring: The post-construction monitoring programmes for benthos will be used to monitor the recovery of fish or shellfish habitats following cable installation or removal. These surveys will be developed using statutory guidance and after consultation with the relevant statutory authorities e.g. CCW and CEFAS.

Cumulative impacts: As described previously, other habitat disturbances within Liverpool Bay will also occur as a result of channel maintenance dredging in addition to aggregate extraction. Due to the very small proportion of Liverpool Bay over which these operations occur, in addition to the key fish and shellfish habitats identified as part of the baseline assessment being found throughout the wider Irish Sea the cumulative impact is considered to be **Negligible.**

The timing of the construction of the Burbo Bank and Rhyl Flats Offshore Wind Farms would not overlap with the proposed Gwynt y Môr construction period so no in-combination impacts to fish and shellfish as a result of a disturbance to habitat from the construction of Gwynt y Môr are predicted.

Potential impact: Construction activities may generate spoil and result in increases in suspended sediment levels which may affect fish and shellfish habitats and behaviour.
During the construction phase of Gwynt y Môr increased levels of suspended sediments may arise from the spoil generated by the installation of the turbine and offshore sub station foundations (under some of the foundation options), cable laying and through the disturbance of sediment through scour.

The installation of foundations using gravity base foundations for the 150 5MW class turbines under illustrative layout scenario 3 represents the worst-case scenario in terms of the generation of increased suspended sediment with a maximum of circa 212,100m^3 of spoil potentially generated (section 2). Note that these volumes are for all of the turbines and as such would occur over a the 2 – 3 year installation program but in fact would occur intermittently through that period and therefore any effects would be transient and temporary in nature. For the process of cable laying the worst-case scenario represents the laying of all cables through the method of water jetting which would displace approximately 68,250-113,750m^3 of the surface sediments. However, most of the sediments disturbed would be sands and gravels which are likely to resettle out of the water column over a reasonably short distance. Fine particles will remain for longer in suspension and may be transported over a larger distance once in suspension. Other sources of suspended sediments are the action of scour around the base of the installation structures and the erosion of deposited drill cuttings which may cause the winnowing of finer sediments into suspension.

The effects on fish and shellfish species of the potential worst-case increases in suspended sediments are considered to have the potential to result in some small-scale avoidance by fish. The disposal of spoil might also act to smother any shellfish species within the immediate area of construction activities, including foundation placement (particularly in the case of gravity foundation or drill/drive piling where significant volumes of spoil may be generated) and cable installation (particularly where water jetting is used).

Any avoidance by fish species is predicted to be greatest around of the areas of highest concentrations of suspended solids. The modelling of suspended solids suggests that this would be relatively localised to the areas of construction activity, even under worst case conditions, before dilution reduces the sediment plumes to levels not distinguishable from normal background levels (RWE npower, 2005). The extent to which fish are affected by suspended and redistributed sediments depends very much on the nature and quantity of the sediment and the period of exposure. Any marine fish that were affected by the plume might be expected to do no more than redistribute themselves locally, relative to the sediment plume and thereby suffer no significant impact. However, such avoidance of construction activity generated sediment plumes may impact upon migratory species such as salmon and sea trout.

The dispersion of spoil material, where this is generated, and the highest concentrations of suspended sediments might act to deter fish spawning activity but this is likely to be a small-scale and temporary effect and no longer term effects on spawning or nursery habitats or behaviour are anticipated due to the rapid dilution and dispersion of this material.

Similar avoidance responses are predicted for for species such as salmon and sea trout and would be related to the concentration and persistence of the sediment plume. The effects would be localised to the vicinity of specific construction or decommissioning activity rather than across the whole project area. However, such avoidance of any activity generating sediment plumes may nonetheless impact upon the migratory behaviour of these species, particularly where it occurs close to their natal rivers. Specifically, the installation of the export cables were it to occur in close proximity to the River Clwyd (and specifically where water jetting is employed) may potentially deter pre-spawning salmon or sea trout from entering the estuary. However, the proposed export cable installation areas for Gwynt y Môr would occur over 2km away from the Clwyd Estuary and given the spatial and temporal limitations of the generated sediment plume (see RWE npower, 2005) and the rapid time for export cable laying operations within this area, it is not considered likely that such impacts would arise. Impacts on other sensitive areas such as the Dee and Conwy Estuaries are also not anticipated given their distance from the proposed cable laying operations.

Bivalve shellfish species, such as the scallop populations identified to the north west of the Gwynt y Môr project area, are filter feeders and their feeding mechanism as well as their gills can be clogged by high concentrations of suspended sediments. A persistent increase in suspended sediments above normal maximum levels may impact upon these species especially the scallop populations located principally to the north west of the project area. However, any such effects will be intermittent and temporary in nature and the spatial area affected will be limited in comparison to the distribution of the scallop populations in the wider Liverpool Bay region.

Effects on more remote shellfish habitats, particularly the estuarine environments around Liverpool Bay are considered unlikely given the distance of the Gwynt y Môr site from such environments and the very large quantities of naturally occurring mobile sediment in Liverpool Bay. Some crustacean species such as crab and lobster are also sensitive to excessively high suspended sediment concentrations since it tends to clog their gills and affects respiration although, generally, they tend to be less vulnerable than molluscan species because they are rather more mobile and will tend to move away from the source. As the main Gwynt y Môr project area is not an area recognised for crustacean fishing, and the nearest area is located around the Great Ormes Head, significant impacts on the key crustacean habitats as a result of elevated levels of suspended sediments are not anticipated. Similarly, the *Nephrops* habitat to the north of Liverpool Bay are too remote to be affected by the Gwynt y Môr construction activities.

In conclusion, given the relatively small scale, temporary and intermittent nature of the predicted increase in suspended sediments resulting from construction activities, the effects of increased suspended sediment concentrations and spoil disposal on the fish and shellfish populations and key habitats of Liverpool Bay is assessed as being of **Low** significance. This conclusion is drawn on the basis of considering the worst-case scenario in terms of the volume of spoil generated by foundation installation and the use of water jetting for cable installation. It is concluded that the use of other options such as suction caisson foundations or the use of a plough for cable installation are predicted to result in very low levels of suspended sediments and any effects will be negligible.

Mitigation: None proposed.

Monitoring: The low levels of suspended solids predicted and the intermittent nature of their generation, together with the experience gained from the monitoring of the North Hoyle operations and other Round 1 sites strongly suggests that monitoring of suspended solids during the construction or decommissioning phases is not justified at the Gwynt y Môr project area.

The disposal and dispersal of spoil generated specifically by gravity base or drill/drive pile foundation options and its effect on the seabed environment should be monitored as part of the physical and biological monitoring regime as detailed within section 4.3.

Cumulative impacts: Activities routinely undertaken in Liverpool Bay that contribute to suspended sediment concentrations are marine aggregate dredging, navigational maintenance dredging and spoil disposal and trawling. In addition, the construction activities at the Burbo Bank and Rhyl Flats wind farms will also generate suspended sediments. However, as the construction periods for these wind farms will not overlap with the Gwynt y Môr construction phase, in-combination effects will not arise.

Licensed aggregate dredging is limited to an area immediately to the east of Gwynt y Môr, although an additional application area exists to the north of the project area. Navigational dredging occurs in the approaches to Liverpool and Mostyn Dock (Dee Estuary) with spoil disposal at sites within Liverpool Bay and in close proximity to Gwynt y Môr s, whilst trawling is widespread through the wider Liverpool Bay area with some activity within the Gwynt y Môr project area (RWE npower, 2005).

All forms of towed fishing gear (beam trawls, otter trawls and dredges) disturb the seabed creating small-scale, ephemeral sediment plumes and winnow the surface sediments. The initial response of fish to a plume is to move away from the source (Harden Jones *et al.,* 1977) but many (scavenging) fish rapidly return, apparently to scavenge disturbed bio-detritus and damaged benthos (see papers in: Kaiser & de Groot, 2000). This behaviour is likely to remain during any construction activity although the construction exclusion zone is likely to exclude trawling activity from around the main construction site limiting the potential for cumulative effects to occur with any trawling activity in the area.

Maintenance dredge spoil must be disposed of at licensed disposal sites some of which may have been in use for some considerable time. Consequently, any periodic increase in suspended sediment concentrations associated with these activities are, effectively, contributing to the seasonal ambient conditions to which the indigenous fauna are adapted either because effects are negligible or because any adverse effects have become part of the norm. The potential exists for spoil disposal at sites surrounding the Gwynt y Môr site to interact with plumes generated by the foundation installation activity but any such interaction is highly likely to be temporary, intermittent and spatially limited such that any such cumulative interaction is likely to be of negligible significance.

Marine aggregate dredging in Liverpool Bay is a low-level activity compared to, for example, the eastern English Channel and the coastal waters of East Anglia. Depending on the source material being dredged, sediment plumes can be extensive, if transient, as a result of aggregate dredging. In the case of the Liverpool Bay dredging, the target resource is described as clean fine to coarse sand with very low levels of fine silty sediments such that the resulting plumes tend to be of low concentration and duration. When combined with the natural turbidity of the area, sediment plumes generated by dredging are not considered to be significant being temporary, intermittent and of low magnitude so that cumulative interactions with the Gwynt y Môr construction activities where they occur are predicted to be of negligible significance.

Thus, although the Gwynt y Môr foundation installation activity might act in-combination with some of the other existing activities in the Liverpool Bay area, such effects are unlikely to be extensive or result in persistent elevations of levels of turbidity in comparison to the existing, naturally occurring levels. Thus, the cumulative effects of the construction of Gwynt y Môr with other suspended sediment generating activities of Liverpool Bay are considered to be **Negligible.**

Potential Impact: Construction activities at Gwynt y Môr may release contaminants from disturbed sediments which could have an effect on fish and shellfish species.

The nature, distribution and effects of seabed contamination disturbed by the construction phase of the Gwynt y Môr project on water quality have been assessed under Section 4.2.1, above. It has been concluded that the very low levels of contaminants recorded, the dispersive nature of the Liverpool Bay area and the temporary and intermittent nature of the disturbance that may result is unlikely to lead to significant effects.

Disturbance of the sediments, which may be a possible source of contaminants, will arise in the locality of the construction procedure rather than across the entire area. The spatial extent of this impact is therefore considered to be **Low**.

The surface sediments of Liverpool Bay are in a continuous cycle of re-suspension and deposition according to variations in the physical processes responsible for sediment transport within the Bay, particularly tidal and wave induced flows. Elevated levels of sediments within the water column are likely to be transported within a tidal cycle of the disturbance and would be expected to resettle out of the water column over a relatively short period of time, in keeping with the natural state of the surface sediments in Liverpool Bay. The impact would be relatively short in duration but would continue intermittently between the 2-3 years of construction. The duration of the impact is considered to be **Negligible.**

Due to the low level of sediment contamination across the site, the intermittent removal of sediment and the small amounts of disturbed sediments, which are at risk of dispersal in addition to the dilution effect of the receiving waters, the potential for the release of contaminants during the construction phase is not predicted to adversely affect fish or shellfish communities. The assessment for the effect of such release of contaminants on the water quality was found to be negligible (see section 4.2.2) and as a result of this, the intensity of this impact on the fish and shellfish communities is assessed as being **Negligible**.

The overall significance of this impact is judged as being **Negligible**.

Mitigation: none proposed.

Monitoring: none proposed.

Cumulative impacts: none identified.

Potential effect: the noise or vibration generated during construction activities at Gwynt y Môr may disturb, harm or potentially kill fish species.

The marine environment is generally considered to be relatively noisy with ambient noise arising from wave action, bubble formation, action of wind and rain on the sea surface and noise from wildlife. This ambient noise combines with man made noise produced from shipping, offshore installations, fishing sonar and pleasure craft to produce background noise which varies with different locations due to the influences of the existing sea bed geology and the activity of the local environment. Any noise emitted from the offshore wind farm during the construction phase will act to increase the noise levels above the background noise levels within the vicinity of the Gwynt y Môr project area and the wider area of Liverpool Bay.

Fish are receptive to noise with hearing and the detection of vibrations being one of their most developed senses; making use of the good propagation of low frequency sounds which is approximately five times faster than in water than air. They receive the sound through the acoustico-lateralis system, which is the collective term for their ears and lateral line (a line of sensory organs running down the side of the body). The lateral-line detects low-frequency (<100 Hz) particle motion in the water as particle displacement caused by the pressure waves of sound contact the flanks of the fish, and the inner ear (within the skull) is sensitive to frequencies of between 1Hz -3 kHz (depending upon species) and is more sensitive to vibration rather than sound pressure.

Different species of fish have different hearing abilities and the main reason for this is differences in physiology. Teleost (bony) species of fish possess a gas-filled swimbladder and receive sound through this organ, which is sensitive to the pressure component of a sound wave converting the pressure waves to vibrations, thus allowing the fish to detect sound as well as vibration (Hawkins, 1993). The sensitivity to noise and vibration differs among fish species, especially according to the anatomy of the swimbladder and its proximity to the inner ear. Some species have a close coupling between the swimbladder and the inner ear allowing vibrations received by the swim bladder to be carried to the inner ear thus increasing hearing sensitivity. Those species having a fully functional swimbladder tend to be much more sensitive and are referred to as hearing-specialists. Within this group those species, which have some form of close coupling between the swim bladder and the inner ear e.g., Clupeids (herring family), have a high-sensitivity to noise. Hearing specialist identified as being present within the Gwynt y Môr project area and Liverpool Bay are herring (*Clupea harengus*) and sprat (*Sprattus sprattus*). Such hearing specialists will have a broader hearing band width and greater sensitivity than non-hearing specialists.

Other species found within Liverpool Bay, and therefore likely to occur within Gwynt y Môr project area which possess a swim bladder (but without the inner ear coupling) and are thus considered to be hearing specialists with medium sensitivity to noise include gadoids such as cod (*Gadus morhua*) and whiting (*Merlangius merlangus*), shad (e.g. *Allosa allosa* and *Allosa fallax*), Mackerel (*Scomber scombrus*) and Salmon (*Salmo salar*).

Those species lacking a swim bladder altogether such as elasmobranchs (sharks and rays) and flatfish tend to be of relatively low auditory sensitivity and are classed as being non-hearing specialists relying instead on the detection of particle displacement from sound waves (Turnpenny & Nedwell, 1994).

Many fish also produce sounds of their own usually crunches, grunts and popping sounds, which are low frequency in nature. These biological sounds are used by individuals to communicate with one another especially during activities such as spawning (Hawkins & Rasmussen, 1978) Fish also utilise sound to detect predators and prey and the presence of high level sounds from extraneous sources such as construction activities may mask the much weaker sounds of biological significance and may impair the behaviour and survival of the fish.

The number of fish species examined in detail for their responses to sound is relatively few and little work has been done regarding hearing damage to fish. However the hearing thresholds for fish are defined as follows (largely taken from Knudsen *et al*., 1992):

Absolute hearing threshold - the minimum sound levels required at a specific frequency for the sound to be heard. These thresholds are established under controlled laboratory conditions in the absence of any masking noises (Knudsen *et al*., 1992).
Awareness reaction threshold - the sound level at which there is a spontaneous, physiological response (such as an increase in heart rate). This threshold is usually considerably above the absolute hearing threshold.
Avoidance response threshold - the threshold at which a fish first shows an avoidance reaction. Again, this is generally well above the absolute hearing threshold and above the awareness reaction threshold.
Hearing damage threshold- the sound level at which damage to the auditory system occurs. This can occur after long exposure times to sound levels above the absolute hearing threshold and may be either temporary or permanent in nature.
Mortality threshold- the sound level at which mortality will occur.

When sound becomes greater than the absolute hearing threshold it has the potential to alter fish behaviour. This may arise from the masking of biologically important sounds such as those produced by predators or prey or it may impede communication within species thus affecting reproductive behaviour e.g. cod will make low frequency calls during spawning (approximately 20dB at 1m) which is readily masked by loud noise. Fish are well able to detect the direction from which noise is coming and take necessary avoiding reaction. High noise levels may therefore cause deflection from migratory routes and may also act to drive fish away from feeding and/or breeding grounds thus having an ecological impact upon local fish populations.

In species with less sensitive hearing abilities, the margin between the absolute hearing threshold and awareness reaction threshold is greater. For example, salmon are reported to require sounds of between 70 and 114dB over their absolute hearing threshold to display a behavioural reaction. However, noise levels at or above the awareness reaction thresholds have the potential to damage hearing. Scholik and Yan (2001) report that sound levels that are 75dB above the absolute threshold for 2 - 24 hours can cause a temporary threshold shift (TTS) (an alteration in hearing level after exposure to noise returning to normal over time) in the minnow species *Pimephales promela* (a hearing specialist). TTS vary by species, distance, intensity and frequency of the sound source in addition to depth, water temperature and salinity. A permanent threshold shift (PTS) (permanent damage to the hearing) is likely to be experienced after increased exposure time or to very loud noises. Enger (1981) found that when cod is exposed to sounds of 180dB (about 100-110dB above absolute threshold) at low frequencies for 1-5 hours then permanent hearing damage occurred as a result of the loss of ciliary bundles. It has also been documented that very loud noises are capable of killing fish as sensitive tissues are irreversibly damaged leading to mortality.

Construction activities such as foundation installation by piling (including any drilling which may be required), cable trenching, placement of rock armour for scour protection and the increased vessel activity required for the construction phase will all generate noise at the Gwynt y Môr Offshore Wind Farm. Of these noise sources the most likely noise impact will occur from foundation installation using pile driving and the impacts of this high energy noise has been identified as the worst-case scenario in this assessment for the identification of noise impacts to fish. Notably the installation of the alternative foundation options (the gravity base or suction caisson) will not result in such high energy noise and as such the noise impacts of these options would be even less than predicted for the driven pile solutions.

It is considered that the larger the pile diameter the louder the noise generated during pile driving (Nedwell, 2004). The 5MW turbines, which are the largest class of turbines under consideration for Gwynt y Môr, have a diameter of up to 6 metres. Therefore, as a worst-case scenario, the maximum pile diameter considered for the assessment is 6m. No current noise data exists for the underwater noise generated from the installation of piles of this diameter, however, measurements of pile driving 4m diameter steel mono-piles at the North Hoyle Offshore Wind Farm are available and demonstrate a source level of 260dB re 1 uPa @ 1metre for 5 metres depth for a pile 4m in diameter (Nedwell, 2004). In addition, assessments for other offshore wind farms have predicted that the noise levels for pile driving 6m piles to be 266 dB re 1 μPa with a depth uncertainty of +/-5dB. To predict the piling noise levels at the Gwynt y Môr Offshore Wind Farm these data have been extrapolated to an estimated source level of 273 db re 1 μPa @1m for the piling of 6m piles.. This figure has been used for this assessment as it represents the worst-case scenario for noise levels, which will be experienced by the fish populations of Liverpool Bay.

There is a potential for the high-energy low frequency sound generated by piling at this sound level to induce physiological damage, provoke strong avoidance reactions or even cause mortality to fish within close proximity to the source noise level generated by the piling activity.

As the low frequency sound generated from piling has the potential to cause mortality, induce hearing damage or provoke strong avoidance reactions it is important to recognise that effects from this construction operation will impact upon sensitive species in local fish populations. Such impacts have been considered for the hearing specialist and non-specialist species found within the development area:

An impact model based upon the audiograms of different noise sensitive and insensitive fish species has been used to assess the impacts of such noise levels upon fish species present within Liverpool Bay.

The impact model indicates that because of the low frequency of piling generated noise cod is the most sensitive fish species to this sound followed by the hearing specialist species herring. At a source noise level of 273 dB the impact model suggests that cod may suffer permanent hearing damage if present at a distance of approximately less than 800m from the centre of the piling operation. For herring this is estimated to be approximately 300m from the source noise level. At a swimming speed of 2.2m/s (National Marine Research Institute (NMRI), 2005) it would take cod in the proximity of the piling activity 6 minutes to retreat beyond 800m and the zone of permanent hearing damage. For herring, at a swimming speed of 1.67m/s (NMRI, 2005), it would take three minutes to travel 300m and retreat beyond the zone of permanent hearing damage. As the noise levels generated from piling are so much greater than these species hearing thresholds it would be expected that for fish within close proximity to the piling source severe damage would occur to sensitive tissues and it would be likely for mortalities to occur

Received noise levels of 180dB are reported to induce avoidance reactions in hearing specialists (Pearson *et al.,* 1992) The sudden onset of noise at this sound level will stimulate an immediate startle reaction and, as fish are well able to perceive which direction sound is coming from, following this initial startle reaction fish are likely to increase swimming speeds away from the source of noise generation. For piling with a source level of 273 dB a noise level of 180 dB would be received at an approximate distance of 11km for hearing specialists such as herring and cod.

Impacts on non-hearing specialists fish species such as flatfish and elasmobranchs are considered to be far lower than for hearing specialist species. Hastings *et al.* (1996) suggest that for hearing damage in non-hearing specialists sound levels would have to be of a magnitude of 200dB and over a continuous exposure through a long period (many hours). Although, at 273dB, the piling source noise level is greater than 200dB it is certainly not continuous in nature and will only be occurring over short-term periods (estimated to be circa 12 hours in the case of monopile foundations and approximately 24 hours for multipile foundations, out of an estimated total of 7 days to complete each foundation) so that hearing damage in non-hearing specialists is therefore not expected. The most likely impact would be one of avoidance of the area for the duration of the piling activity with normal behaviour of these species resuming on cessation of piling operations.

It is also necessary to consider the impact of the construction noise levels on the migratory species of Liverpool Bay such as salmon, eel and sea trout, and the anadramous species shad due to national and international protected legislation afforded to them. These species all possess swim bladders and are considered to be hearing specialist species. Sudden elevated noise levels may cause physiological damage or possibly deflect these species from their migratory routes as a consequence of an avoidance reaction initiated through the sudden onset of loud piling noise levels.

Salmonids are thought to be more sensitive to the vibration stimulus of a sound wave (near-field effects) rather than the pressure component (Hawkins, 1993) and are sensitive to noise between several hertz and approximately 300Hz (Hawkins and Johnstone, 1978). The hearing threshold of salmon in the range of peak sound levels generated by piling (50 to

200Hz) is 100 to 110dB (Hawkins and Johnstone, 1978) with best sensitivity of 100dB at 150Hz. This represents the absolute hearing threshold, the lowest levels at which pure-tone sounds can be detected by the salmon in the absence of any other noise.

Investigations into the use of low-frequency sounds as a fish deterrent for species such as the salmon and trout, have established awareness reaction and avoidance response thresholds. In investigating the awareness reaction threshold under laboratory conditions, Knudsen *et al,* (1992, 1997) and Mueller *et al*. (1998) found that at 150Hz, sounds of 170-180dB were required to obtain a behavioural response in both salmon and trout (*Salmo trutta*). This is approximately 70 to 80dB above the absolute hearing threshold of the salmon at 150Hz. Knudsen *et al*. (1992) further report that the avoidance response threshold for salmon and trout investigated in the marine/freshwater environment, was not apparent at 150Hz, even at sound levels of greater than 200dB. Sand *et al*. (2001) report similar results in the riverine environment where salmon showed no observable reaction to sound levels of 214dB at 150Hz. These levels of noise would be experienced at approximately 1km from the source level of piling based upon the impact model. This distance is not expected to alter migratory movements within Liverpool Bay and it is therefore not expected that piling operations will interfere with fish migration. Eels are considered to be hearing specialists of a medium sensitivity so the effects of noise from piling would be similar to those for hearing specialists and would therefore be expected to temporarily avoid the piling area to a similar degree. It is not expected that piling operations will interfere with fish migration in either case.

Pile driving noise clearly has the potential to cause an impact upon the fish species of the area with hearing specialist species such as cod and herring being the species with the greatest potential to be disturbed. Pile driving may drive fish some kilometres from the source of propagation for at least the duration of the operation. However, piling noise is discontinuous in nature (estimated to be circa 12 hours in the case of monopile foundations and approximately 24 hours for multipile foundations, out of an estimated total of 7 days to complete each foundation) and within hours of the pile driving noise ceasing it is expected that fish will begin to move back into the affected area allowing normal fish behaviour and distribution to resume. Closer to the piling activity, within a few metres, there is the potential for physical harm or fish mortality.

Noise levels generated from other construction activities such as cable trenching are not considered to be of a high enough intensity to cause major impacts to fish species e.g. cable trenching was found to be in the region of 178 dB re 1uPa @1m at the North Hoyle Offshore Wind Farm (Nedwell *et al.,* 2004). This noise level is below that necessary to provoke an avoidance reaction in hearing specialist species and major impacts are therefore not predicted for this construction activity.

In addition to the potential for physical damage or behavioural responses to the noise generated by piling, it is also important to consider particular sensitivities, notably effects on spawning activity (Vella *et al.,* 2001). Under very extreme cases, high levels of noise produced over a prolonged period could affect the spawning success of some species. If this occurred over a large enough area, or in an area of particular spawning activity, then a subsequent effect on the strength of year classes produced by spawning might occur. A review of the spawning activity in and around the Gwynt y Môr project area has been conducted and has identified that sole, plaice, cod and whiting may spawn around the project area. Equally, information on spawning suggests that these species may also spawn across much of the eastern Irish Sea. Notably, no spatially restricted spawners such as herring occur in the vicinity of Gwynt y Môr, the closest such spawning area being off the coast of the Isle of Man.

Cod (and whiting) are hearing sensitive species as has been noted above. These species are pelagic spawners and where they are disturbed by noise, would be expected to avoid that area with a consequent short delay in spawning. Such effects are possible as a result of piling operations at Gwynt y Môr and within several kilometres of the active construction site. However, consideration of the anticipated distribution of cod spawning in the eastern Irish Sea seems to suggest that the greatest spawning activity is seen further to the north (Coull *et al.,* 1998). In addition, their pelagic spawning nature means that they are not thought to be highly spatially restricted in their spawning habitat such that once the disturbance from piling noise had ceased or they had moved far enough from the disturbance, spawning could reasonably be expected to continue. Therefore, significant effects on cod or whiting spawning should not be anticipated. Cod do produce vocalisations when they are spawning, mostly in the form of low frequency grunts. It may be possible that the high-energy low frequency noise generated as a result of piling operations will mask these sounds. Research undertaken by Finstad & Nordeide (2004) has shown that these vocalisations take place at the rate of one per hour. Given the intermittent nature of drill-drive piling (12 hours over a seven day period for one pile), significant masking of communication noise by cod is not therefore anticipated.

Plaice and sole have been shown to exhibit spawning area fidelity with reports of some plaice returning to within 20km of a previous years spawning site (Hunter *et al.,* 2003). These species are non-hearing specialists and as a result would not be expected to be as sensitive to piling noise, experiencing avoidance reactions within kilometres of the piling noise activity. Small-scale avoidance would not be expected to impinge upon spawning activity given that the literature suggests the nearest distance returned to the previous years spawning site is 20km. Nonetheless, some disturbance of these species perhaps within a few kilometres could occur but would be temporary and intermittent so that long term effects on the spawning success of these species seems less likely. Equally, it is understood that in fact the greatest spawning aggregations of these species may occur further north and west of the Gwynt y Môr project area. Beam trawlers will target these spawning aggregations during the 1st quarter of the year. Consideration of the seasonal distribution of beam trawling in the eastern Irish Sea suggests that the focus of the beam trawl fishery during the sole and plaice spawning season occurs further north than Gwynt y Môr suggesting that the main spawning aggregations would be unaffected by the noise generated during the Gwynt y Môr construction phase.

As described above noise impacts to benthic species are not predicted to occur unless within very close proximity to the high-energy noise levels of piling activity, in addition other prey items such as sandeels and gobies are expected to be displaced by elevated noise levels in much the same way as predatory species. Impacts to feeding grounds are therefore also considered to be unlikely with displaced species moving to adjoining unaffected areas to feed.

In summary, there is the potential for physiological damage and displacement to be incurred by some fish species as a result of the sudden onset of the noise that might be generated by certain construction operations (specifically piling operations). However, because of the intermittent nature of the construction activities and the reversible nature of the impact (with species expected to return to affected areas upon cessation of piling activity) this impact is assessed as being of **Moderate** significance. However, the mitigation set out below will reduce the residual significance of this effect on fish species to **Low-Moderate**.

Impacts associated with other activities, including the installation of the alternative foundation solutions, cabling and vessel movements are considered likely to cause only small scale avoidance responses and are considered to be of **Negligible** significance.

Mitigation: In order to ensure that any effects on fish species are reduced to the minimum, a soft-start up procedure for piling operations will be initiated. Under a soft-start procedure, the pile hammer is only lifted gradually at the outset getting stronger each time until full impact is reached.. This will allow any noise sensitive species which could be affected by piling noise to vacate the area. This soft start procedure will be adopted for all piling plant associated with the construction phase and should construction cease for a period of more than six minutes soft start will be instigated before construction continues. This procedure will form part of the Site Environmental Management Plan, and all construction personnel will be made aware of the need for this mitigation through appropriate training.

Monitoring: the monitoring proposed for fish populations will seek to evaluate the distribution of fish species following the completion of the construction phase.

In addition, monitoring of the actual noise generated by monopile installation, using either piling or drill-driving be undertaken.

Cumulative impacts: Noise generated as part of the construction phase of the proposed Gwynt y Môr Offshore Wind Farm could also act cumulatively to affect fish and shellfish species. Other noise generating activities within Liverpool Bay include shipping, oil and gas platforms, maintenance dredging, aggregate extraction and the existing North Hoyle Offshore Wind Farm and the proposed wind farms of Rhyl Flats and Burbo Bank. Of these, the greatest potential cumulative effect might arise where two wind farms were being constructed simultaneously, particularly where piling was being used for foundation installation. Consideration of the construction programmes for Burbo Bank and Rhyl Flats suggest that both will be constructed before Gwynt y Môr so that such cumulative effects can not occur. Other noise generating activities associated with the construction of the wind farm are unlikely to cause cumulative affects.

4.4.3 Potential Impacts From The Operational Phase

Once the Gwynt y Môr Offshore Wind Farm is operational many of the effects will be similar to, or variations of, those that occur during the construction phase. Other potential effects are unique to the operational phase, most obviously the fact that electricity is being generated and its transmission along the cables may have an effect on fish or shellfish. Each of these potential impacts upon the fish and shellfish of Liverpool Bay and the wider eastern Irish Sea region are considered below.

Potential impact: The installations of the Gwynt y Môr Offshore Wind Farm could create a new habitat for fish and shellfish species.

Aggregation of fish around marine structures and man-made objects placed in the sea is a well known phenomenon which has been widely used in the development of fish aggregating devices (FAD's) and artificial reefs (e.g. Olsen & Valdermarsen, 1977, Valdermarsen, 1979, Ogawa, 1986). Possible reasons for this attraction include the provision of shelter from currents and wave action, safety from predators, and food resources associated with the colonising invertebrate organisms, which is often very dense (see section 4.3.2).

Research at oil and gas platforms within the North Sea have revealed particularly noticeable aggregations of gadoids such as whiting, cod and saithe in addition to large shoals of Norway pout (*Trisopterus esmarkeii*) (Cripps & Aabel, 1995). Surveys around an offshore turbine at Svante (Sweden) found numbers of cod within two hundred metres of an operating turbine to be greater than in the surrounding open waters (Westerberg, 1999). Initial monitoring of the North Hoyle Offshore Wind Farm foundations has already demonstrated that a faunal turf community of benthic and demersal species is rapidly established. Within 12 months of construction work commencing on the North Hoyle Offshore Wind Farm, dense shoals of juvenile whiting were recorded browsing over this turf community (Figure 4.4.1). There is therefore strong evidence that installation structures associated with offshore wind farms do indeed act as fish aggregation devices.

Some fish species are more attracted to underwater structures than others, and these affinities may change during their lifecycle. Some of the fish species identified during the characterisation surveys at Gwynt y Môr are known to be attracted to such structures e.g. gadoids such as whiting and cod. The generation of new habitat is less likely to be suitable for species such as flatfish and rays, however, Hoffman *et al.* (2000) states that flatfish species such as plaice are also reportedly attracted to artificial reefs, probably primarily to forage on the adjacent seabed.

Figure 4.4.1: Juvenile whiting browsing over a mat of common (blue) mussels settled on the sub-surface mono-piles of North Hoyle Offshore Wind Farm (Fig. 23) within 12 months of construction (CMACS & Marineseen, 2004).

The Gwynt y Môr project will provide new habitat available for colonisation by benthic species from the turbines, offshore substations and met masts in addition to any scour protection. The maximum area of vertical underwater habitat provided by turbines and offshore substations for colonisation by benthic organisms and available as would be 0.08km^2 (250 turbines plus 4 sub stations) from illustrative layout scenario 1. Any scour protection is likely to be rock (as was used at the North Hoyle Offshore Wind Farm) this is estimated to cover a maximum area of 78.9km^2 of sea bed (for Illustrative layout scenario 1). Additional scour protection for the cable crossing of the BHP pipeline which bisects the Gwynt y Môr project area will add an additional 360m^2 of new habitat. Such scour protection will provide a greater degree of complexity than the vertical habitats offered by the turbine and sub station surfaces. Increasing surface complexity, with its associated increase in the number of available micro niches, is also considered to be a factor in the attractiveness of artificial marine structures (Wickens and Baker, 1996), and so the use of scour protection is likely to increase the attractiveness of the turbine foundations, at least for small benthic fish including trophically important species and commercially important crustacea such as lobster and crabs.

Although the attractiveness of artificial structures to fish is not disputed, it is not yet clear to what degree artificial structures result in the mere aggregation of existing fish resources from the surrounding area, or a significant increase in fish biomass. It is possible that these structures merely act to concentrate fish species from the wider area (Grossman *et al.,* 1997). It is, however, reasonable to assume that the fish will aggregate from within a relatively small radius around the Gwynt y Môr project area relative to the species' total distribution in

Liverpool Bay and the Irish Sea. The spatial extent of this impact is considered to be **Low** as a result of the concentration of fish species within the wind farm, probably attracted from an area of a few kilometres away.

The components of the Gwynt y Môr Offshore Wind Farm are expected to be in place throughout the operational phase of the wind farm over a period of 50 years. However, during this time it may be necessary to periodically “clean” these structures to ensure structural integrity. This process would probably involve the scraping of the biofouling from the structures. Whilst this would obviously affect any encrusting communities that have established, it will not remove all of the biofouling and in any case would simply expose new surfaces for further colonisation. However, such a cleaning process may prevent the establishment of longer term climax communities on these structures that might otherwise have occurred. As not all of the biofouling would be removed at this time and because the structures would remain attractive to fish species e.g. through shelter from currents etc the duration of this impact is assessed as being **High** beneficial.

The provision of new habitat, which is readily colonised by benthic species (as assessed in section 4.3.2), which are prey items for many fish species, is seen as beneficial to fish species offsetting habitat loss from the installation of the wind farm. Although initially it is thought that fish species will become concentrated from the surrounding area it is likely over time that there will be an increase in fish biomass as a result of potentially enhanced growth rates due to new feeding opportunities. The intensity of this impact is therefore assessed as being **Low** beneficial.

The provision of new habitat for fish species as a result of the wind farm is considered to be potentially beneficial in the local area, and long term, but probably of minor overall significance to the fish populations of Liverpool Bay. The overall significance of this impact is therefore considered to be **Negligible.**

Mitigation: none considered necessary.

Monitoring: It is recommended that a single, post-construction survey of a proportion of the underwater structures be undertaken using appropriate techniques such as diver or ROV observation to identify the presence of any shellfish or fish species in the immediate vicinity of the turbines. This should also aide the identification of fish species aggregating around the turbines.

Cumulative impacts: Within Liverpool Bay, in addition to Gwynt y Môr, further habitat available for fish and shellfish populations is provided by the oil and gas platforms and the wind farms of North Hoyle, Burbo Bank and Rhyl Flats (once the latter two are constructed). Fish will aggregate around these structures but it is anticipated that they will be concentrated from within the immediate areas of these structures having no affect upon the overall population distribution of Liverpool Bay. No cumulative impacts are therefore identified.

Potential Impact: Noise generated as part of the operational phase of the Gwynt y Môr Offshore Wind Farm may affect fish species either through the masking of biologically important sounds and the displacement from habitat such as feeding or breeding grounds.

During the operational phase of the Gwynt y Môr project, underwater noise will be generated by the operating turbines and offshore substations as well as the vessels visiting the project area for maintenance purposes. This noise will generally be of a low frequency nature and will not be at high energy levels. Vessels engaged in maintenance operations are not considered to be a significant source of noise due to the vessel activity already experienced within the Liverpool Bay area.

The noise levels produced by operating offshore wind farms have generally been poorly studied although some measurements of underwater noise levels do exist from some Scandinavian wind farms and are detailed in Table 4.4.1. These sound levels are generally similar in level and frequency to sound levels produced by other offshore installations such as platforms and are lower in level than sound generated by most vessel activity.

To predict the operational noise levels for the Gwynt y Môr turbines, the underwater noise measurements taken at the existing North Hoyle site have been reviewed. The data acquired at North Hoyle has been modified to take into account the increased number of turbines and the larger turbine sizes at Gwynt y Môr and to allow a prediction of the noise levels for each of the three illustrative layout scenarios. No substantial difference was identified for the overall operational noise levels for the three different illustrative layout scenarios. In developing the predicted noise levels, based on the North Hoyle data, it has been assumed that the operational noise levels scale linearly with total generating power, that all the turbines would be operating at the same time, turning at the same rate and that the underwater propagation conditions at Gwynt y Môr would be similar to those experienced at North Hoyle.

This noise data has been applied to the existing measurements of background noise at the Gwynt y Môr project area and an impact model has been developed, based upon the audiograms of several fish species found within Liverpool Bay. This model has been used to provide an indication of operational noise levels which would be received by these species.

Table 4.4.1: Noise levels generated by operating offshore wind turbines

Offshore Turbine Structure	Wind Speed (m/s)	Source level (dB re: 1 μPa)	Frequency (Hz)
Middelgrunden (Denmark) 20 x 2MW 'Bonus' Turbines (Concrete foundation)	13 6 6	115 101 111	125 125 25
Bockstigen-Valar (Sweden) 5x 0.55MW 'Windworld' turbines (Steel monopile)	8 8	108 108	160 16
Vindeby (Denmark) 11x 0.45MW 'Bonus' turbine (Concrete foundation)	13 13	113 130	125 25

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Noise will be generated by the Gwynt y Môr installations and vessel activity throughout the 50year life span of the wind farm and as a result the duration of this impact is assessed as being **High.**

As described within the construction assessment, noise has the ability to provoke certain responses in fish depending upon the frequency, intensity and the duration of the sound. The threshold at which fish will show a behavioural response (such as avoidance) tends to be well above the absolute hearing threshold for instance; it is reported that received noise levels of 180dB are required to produce an avoidance response in herring and cod (Pearson *et al*., 1992). Noise levels of 180dB are considered to be greater than noise which would be generated by Gwynt y Môr Offshore Wind Farm. It has also been documented that gadoid species e.g. cod will aggregate around noisy underwater structures such as operational oil and gas rigs (Valdemarsen, 1979). Westerberg (1999) found cod to aggregate in greater numbers in the close vicinity of the operating turbine at Svante than in the surrounding open waters. This suggests that either the cod are able to habituate to the operational turbine noise or that they are able to tolerate it in light of the benefits provided by the turbines e.g. shelter from currents or an increase in food source due to the artificial reef effects of the turbine structures.

The distance that the tonal noise of the wind farm falls below the existing background noise levels (and theoretically becomes undetectable by fish species) was assessed and found to be a distance of 4m for hearing specialist fish species such as cod, herring and salmon. The levels of the predicted operational noise were found to insufficient to cause avoidance reactions or permanent hearing damage to fish species of Liverpool Bay (Appendix 3).

The noise levels generated during the wind farm operation are not considered to be loud enough to cause a deflection away from migration routes for species occurring in the area such as the anadramous shad and the migratories salmon, sea trout and European eel. Research undertaken by Westerberg (1999) of the effects of an operating turbine at Svante (Sweden) on the migrating eels found there to be no reaction to the noise generated. Furthermore, the near-fields of sound (<15m at 125Hz) generated around each turbine, are sufficiently small that fish will be able to move through the wind farm, and thus, any migratory species moving through the wind farm will not be restricted (Vella *et al.,* 1999). Given the spacing of the turbines at the Gwynt y Môr Offshore Wind Farm (see section 2) and in light of this information from Westerberg (1999) it is not considered that migratory routes for fish species will be impaired as a result of noise generated during the operational phase.

The operating turbines will produce noise and vibration in the near field, which fish will detect as hydrodynamic motion as the pressure wave displaces particles. As both hearing specialist and non-hearing specialist species utilise particle displacement for the detection of prey and predators it is possible that the operating turbines will mask this hydrodynamic motion. However, Hoffman (2000) states that the low frequency hydrodynamic fields generated by operating turbines will be perceived very differently by fish from fields generated by other animals. Noise from operating turbines should not therefore, impair fish in their ability to detect and interpret fields from different sources such as predators or prey within the near field. The sound generated by operating turbines is also considered to be harmonic in nature as well as operating at a constant level above background noise. It is possible that fish will show adaptation and habituation to the operating turbines at Gwynt y Môr and will accumulate around such structures for the beneficial reasons as identified in the impact statement above and has been shown to occur at other offshore installations such as North Hoyle and oil and gas installations.

Furthermore evidence of fish aggregation around current operating offshore wind farms such as Horns Rev, Svante and North Hoyle indicate that the benefits of the wind farm structures acting as artificial reefs out weigh any effects of noise and suggest that such noise levels do not act to drive fish away or impair biological activities. Taking this evidence into account it is not considered that the operational noise produced by the Gwynt y Môr Offshore Wind Farm will not impact upon the fish populations of Liverpool Bay and the intensity of this impact is assessed as being **Negligible**.

The overall significance of the impact of operational noise on the fish communities at Gwynt y Môr and within Liverpool Bay is assessed as being **Negligible**.

Mitigation: none considered necessary.

Monitoring: The recommended visual surveys of some of the Gwynt y Môr marine structures using either ROV or divers to examine benthic colonisation should also be used to demonstrate if fish and shellfish are affected by turbine operating noise. This information should be used in conjunction with the proposed fish monitoring previously suggested to support the conclusions formulated here as part of this assessment.

In addition, further assumptions were made regarding the turbines at the Gwynt y Môr project area these assumptions were that all turbines would be operational at the same time, turning at the same rate and that the underwater propagation conditions at the Gwynt y Môr site would be similar to those experienced at North Hoyle. It would be prudent to actively measure the operational noise levels of the operating turbines at Gwynt y Môr to verify this model.

Cumulative effects: Liverpool Bay is considered to be a relatively noisy environment with noise generation arising from the oil and gas platforms, shipping, aggregate extraction, channel maintenance dredging and the wind farms of North Hoyle, Burbo Bank and Rhyl Flats (when the latter two come online). The results from noise monitoring undertaken at North Hoyle and the predicted model for Gwynt y Môr (see Appendix 3) indicate that the low frequency noise level of the wind farms quickly dissipate into the background noise levels of Liverpool Bay within a very short distance from the wind farm boundary. In addition, evidence from North Hoyle (and indeed other offshore structures such as oil and gas rigs) suggest that noise effects on fish or shellfish during this phase will not be significant and would not act in-combination with other activities.

Electromagnetic Field Effects

Any EM field impacts are expected to be limited to within tens of metres of individual cables. It is currently anticipated that the additive EM fields from sub stations or cables in close proximity would only be detectable at relatively close range (within circa one km) and would not extend far beyond the wind farm boundary. The spatial extent of any impacts is therefore considered **Low**. Any EM field impacts will be long term since they will occur over the lifetime of the project (i.e. 50 years).

The severity and significance of potential impacts, which are all considered to be adverse, has been evaluated in relation to the following electromagnetic field specific impact statements:

Potential Impact: Magnetic fields produced by the Gwynt y Môr Offshore Wind Farm will disorientate anadromous and/or catadromous fish species.

This statement refers to the possibility that anthropogenic magnetic fields will disorientate salmonids (anadromous salmon and sea trout migrating from freshwater to the sea as smolts and back to freshwater to spawn as adults) and/or eels (catadromous fish entering freshwaters as elvers to grow and migrating to the sea to spawn). Current understanding is that the effect of such disorientation could range from a trivial temporary change in swimming direction through to unsuccessful migration with population level effects.

There is, however, no available evidence which shows that encounters with EM-Fields of a magnitude produced by the Gwynt y Môr buried cabling or electrical infrastructure will have detrimental effects on the normal navigation behaviour of these species. Salmon returning to their natal rivers are believed to use olfactory cues in navigation once in coastal waters. As a result, the detection of magnetic fields from the Gwynt y Môr buried cables in coastal waters by salmonids or eels during their migrational phase between the sea and local rivers such as the Clwyd and Dee would result at most in localised and temporary effects.

Overall impact significance: depending on whether any effect occurs there is a possibility of a negligible to medium severity impact of **negligible to low significance**.

Potential Impact: Magnetic fields produced by the Gwynt y Môr Offshore Wind Farm will adversely affect other fish species, including mackerel and plaice.

Other teleost species, for example mackerel and plaice, are also thought to be sensitive to EM-Fields (Cranfield and CMACS, 2005). However, it is reasonable to assume that, as a pelagic species, mackerel will be less likely to encounter the highest fields produced by the Gwynt y Môr subsea cables. Furthermore, there are no known reports which suggest that existing submarine cables, pipelines etc. have influenced the behaviour or distribution of any of these species. This, combined with the very limited spatial extent of the predicted EM-Fields (considered likely to be tens of metres around each cable), means that significant effects on the behaviour of these species are not anticipated.

Overall impact significance: depending on whether any effect occurs there is a possibility of a negligible to low severity impact but even a low severity impact would be of **negligible significance.**

Potential Impact: Induced electrical fields produced by the Gwynt y Môr Offshore Wind Farm will adversely affect elasmobranch (shark, skate and ray) fish species.

During the Gwynt y Môr scoping process, the greatest degree of concern expressed with regard to EM-Field effects related to the potential for adverse impacts on the behaviour of electrosensitive species, particularly, elasmobranch species such as thornback ray and tope; spurdog, smoothound or dogfish.

Both rays and smoothhound are benthic species that rely on electric fields to detect their prey and would therefore encounter E-fields whilst feeding at the seabed. It is considered likely that tope and spurdog would encounter the E-fields near the seabed as well as in the water column where both species spend a significant time hunting pelagically.

The E-fields arising from the subsea cabling have the potential to elicit either attraction or repulsion responses in sensitive species such as rays. Theoretically, attraction could reduce their encounter with natural bioelectric fields emitted by prey whilst repulsion could reduce the area of seabed habitat available to these species. It is noted that any effects will be variable over time and dependent on the generating status of the wind farm. However, there is no current evidence to indicate that either attraction or repulsion will have a detrimental effect on sensitive species. Generic research into the effects of EM-Fields on fish, including elasmobranch species is anticipated to continue as part of the COWRIE programme.

It is also the case that the current research into E-Fields has considered the effects of subsea cables in isolation. It will be the case for Gwynt y Môr that in some cases, for example around the offshore substations, cables may be laid in sufficient proximity for E-Fields to be additive. This could result in larger fields in these areas. No further information is available on the ecological significance of this effect but it is considered likely that the resultant fields would be within the range that could be repulsive to sensitive species (i.e. > 100 µV/m).

Overall impact significance: In view of the ongoing research into this issue and the conservation status of some elasmobranch species, a precautionary approach to the assessment of significance has been adopted. Potential effects on these species are therefore, currently adjudged to be of up to **Moderate** significance. .

Potential Impact: Induced electrical fields produced by the Gwynt y Môr Offshore Wind Farm will adversely affect electrosensitive teleost fish species.

Eel, cod, plaice and salmon occur within the development area and may be sensitive to electric fields (although less so than elasmobranchs). The Gwynt y Môr cabling could, therefore, potentially affect these species through interference with normal orientation in relation to water (tidal) movements. Such effects are however believed to be trivial, particularly for migratory species (salmon and eel) that would spend very little time within the wind farm area.

Overall impact significance: depending on whether any effect occurs there is a possibility of a negligible to medium severity impact of **negligible to low significance**.

Cumulative impacts: The following other offshore wind farm developments have been considered: North Hoyle, Rhyl Flats and Burbo Bank. It is expected that the EM fields produced by the Round 1 wind farms (Rhyl Flats and Burbo Bank) will be of similar magnitude to North Hoyle. The Gwynt y Môr Offshore Wind Farm will differ primarily in its use of offshore substations and, therefore, in the possible additive effects of cables in close proximity.

CMACS & Cranfield (2005) noted that certain telecommunication cables and underwater pipelines could also generate EM fields. The BHP gas pipeline which runs through the Gwynt y Môr Offshore Wind Farm and comes ashore just west of Point of Ayr is not believed to be heated and will therefore not have any associated EM field. There are power and telecommunication cables running across the Clwyd Estuary at Rhyl, which have measurable EM fields, but these fields will only propagate for short distances away from the coast (probably less than 100m). The offshore wind farm developments will therefore be the primary source of anthropogenic EM fields in the offshore environment.

Because any effects of EM fields from each wind farm development are not expected to overlap it is considered that the assessments outlined above will also apply to the cumulative impact assessment. In addition, we must consider the following additional impact statements specifically for the cumulative effects of Liverpool Bay offshore wind farms.

Potential impact: The multiple cables to shore will create a barrier effect that will interfere with the normal migratory movement of elasmobranch (shark, skate and ray) fish species through Liverpool Bay.

The power cables to shore represent extensive linear features between offshore wind farms and the North Wales/Wirral coastlines. As a precautionary basis for this assessment, it is assumed that, whereas induced electrical fields within wind farms could be avoided, fish would have to cross cables to shore on multiple occasions or undertake extended diversion routes around the wind farms if they were repelled by electrical fields. Migratory movements could include foraging and spawning excursions.

Overall impact significance: there is a possibility of a negligible to medium severity impact of **negligible to moderate significance**.

Mitigation: Depending on the cable specifications, burying cables to approximately 1m may reduce the magnitude of induced electrical field present at the sediment-water interface compared to the skin of the cable. There are other reasons why submarine power cables are buried (e.g. to avoid entanglement with fishing gear etc.); this may also have the additional benefit of reducing induced electrical fields.

Use of higher voltage cabling (e.g. 245kV as opposed to 132kV) would reduce the resultant EM-fields. In theory this might result in iE fields dropping below 100µV/m (the potential threshold below which repulsive effects are replaced by an attractive effect for elasmobranchs) for a higher proportion of wind farm operating time; however, the relative risks of attraction versus repulsion are unclear.

Other possible mitigation approaches involve application of novel technologies to increase the conductivity and permeability of cable armouring. These are not likely to be a commercially viable proposition at the time of writing.

Further Work and Monitoring in consideration to EM-Field effects:

Given the potential significance of EM field effects at Gwynt y Môr it is recommended that the progress of the anticipated continuing COWRIE research programme on EM-Field effects arising from offshore wind farms is kept under close review.

Should the results of the COWRIE research indicate the potential for significant ecological effects on electro-sensitive species, a fuller understanding of the likely magnitude of EM fields that will be produced by Gwynt y Môr would be required. For example, the influence of the final electrical design of the Gwynt y Môr project, specifically the subsea cabling, or the potential use of higher voltage (245kV) cables for power export to shore and the offshore sub stations where EM fields from adjacent cables may be additive may be adjudged to be of significance following the completion of the COWRIE work. In this case, modelling of EM fields, for example using Maxwell 3D software applied in the COWRIE stage 1 study (CMACS 2003), and based on the final detailed design of the electrical infrastructure of the Gwynt y Môr Offshore Wind Farm, may be appropriate in reviewing the significance of the ecological response to the EM-Fields produced by the project. It may be that EM fields are substantially lower and propagate for smaller distances than assumed in this impact assessment, especially if higher voltage cable options are selected. Modelling will shed light on this matter. Following on from the modelling and verification of the final electrical design, it may also be appropriate to verify the predicted EM fields by in situ measurement.

In addition, it is anticipated that the continuing COWRIE research will incorporate appropriate field monitoring of fish species in seeking to understand the spatial and behavioural response of potentially sensitive species to the EM-Fields produced by offshore wind farms. Currently it is anticipated that this generic research would be sufficient to provide a fuller understanding of the likely ecological response of sensitive fish species to the Gwynt y Môr project.

However, where the continuing COWRIE research highlights specific ecological concerns, monitoring at Gwynt y Môr in the future may be considered appropriate. Under those circumstances an appropriate monitoring programme at Gwynt y Môr would most likely be focused on ray species and could, for example involve sampling on a seasonal basis and with appropriate baseline and control data sets. Any data generated by field sampling could also be compared to the catches from the surrounding commercial fishery and indeed the CEFAS Irish Sea surveys undertaken with GOV (Grande Overture Vertical) gear.

In any case, be it for the COWRIE research programme or any subsequent site specific work, field monitoring data will always need to be related to the generating status of the offshore wind farm in question (and hence to EM field magnitude).

4.4.4 Potential Impacts From The Decommissioning Phase

Decommissioning activities would overall not be dissimilar to those utilised during the construction phase. Impacts are therefore likely to be similar to those for the construction phase of the Gwynt y Môr Offshore Wind Farm and are identified as being: major changes in habitat, elevated suspended sediment concentrations, changes to seabed structure and profile, and noise and vibration.

Potential impact: The removal of the Gwynt y Môr Offshore Wind Farm installations such as turbine and offshore substation support structures will remove habitat available to fish and shell fish as an artificial reef.

As previously identified within this assessment the operational phase of Gwynt y Môr will provide additional habitat generating greater habitat diversity within the area from the installation foundations, cable mattresses and any associated scour protection. This is deemed as being beneficial to the fish and shellfish populations of the area (see above). As part of the decommissioning phase all installations will be removed resulting in a loss of habitat previously available for fish and shellfish. Illustrative layout scenario 1 has the highest number of turbines and therefore the largest amount of vertical habitat available as artificial reef substratum (250 turbines and 4 sub stations) and is therefore considered to be the worst-case scenario for the greatest loss of linear habitat estimated to be a total of 0.08km^2.

The removal of turbines and offshore substation foundations would occur at the seabed and any spatial effects of this impact would be limited to the immediate area of the decommissioning activity and therefore by definition would be contained within the wind farm boundary. The spatial extent of this impact is therefore considered as **Negligible**.

The removal of the installations is expected to be spread out evenly over the duration of the Gwynt y Môr decommissioning phase which is expected to occur over a 2-3 year period. During this period, because the removal of structures will be a gradual process it is expected that fish and shellfish will be able to readjust during this gradual change and any effects directly attributable to removal should last no longer than the decommissioning period. The duration of impact is therefore deemed as being **Low.**

The removal of substratum previously available as artificial reef habitat to fish species providing feeding areas and shelter will result in a dispersal of fish and a potential localised fall in fish productivity. However, all the habitat will not be removed at once as structures will be removed one at a time throughout the duration of the 2-3 year decommissioning phase. Species are therefore given time over which they can readjust over the duration of the decommissioning phase. The intensity of the impact is therefore identified as being **Negligible**.

Any effect of wind farms on fish and shellfish distributions will be highly localised and decommissioning is unlikely to have any detectable effect on populations in Liverpool Bay. Assuming all structures would be removed at least to seabed level, the overall significance of this impact is assessed as being **Negligible**.

Mitigation: none considered necessary.

Monitoring: It is recommended that a post-decommissioning survey programme be implemented to monitor the affects of the removal of the offshore structures upon the fish and shellfish communities of Gwynt y Môr. The specification of this survey should be developed and agreed with the relevant statutory authorities, particularly CCW and CEFAS.

Cumulative Impacts: It is improbable that all Liverpool Bay wind farms (or other offshore structures) would be decommissioned concurrently so any possible in-combination effects would be extremely limited. The localised nature of the impact within the boundaries of the Gwynt y Môr Offshore Wind Farm means that any cumulative impacts are unlikely to occur.

Potential impact: The removal of cables may affect important fish and shellfish habitats such as feeding, spawning and or nursery grounds.

The impacts for the removal of the inter-turbine, offshore sub station and export cables are considered to be similar to those identified for the cable laying activities of the construction phase. The assessment of this impact upon the fish and shellfish species and habitats of Liverpool Bay are therefore considered as being the same as for construction and are therefore identified as follows: Spatial- **Negligible**, Duration- **Negligible**, Intensity-**Negligible** and overall impact significance- **Negligible**.

Mitigation: none considered necessary.

Monitoring: The post-decommissioning survey programme implemented to monitor the affects of the removal of the offshore structures upon the fish and shellfish communities of Gwynt y Môr should also be used to identify and monitor any impacts to fish and/or shellfish habitat resulting from cable removal. The specification of this survey will be developed and agreed with the relevant statutory authorities, particularly CCW and CEFAS.

Cumulative impacts: none identified.

Potential impact: Elevated concentrations of suspended sediments generated from decommissioning activities may impact upon the fish and shellfish communities of the area.

The generation of suspended sediments during the decommissioning phase is likely to be in the same way as for construction i.e. placement and removal of jack-up rig feet on and off sea bed, removal of cables, removal of installations especially scour protection which may be done by dredging. Key concerns will be for raising suspended sediment concentrations in the vicinity of potentially sensitive species such as filter-feeding bivalve molluscs and creating visually dense sediment clouds in the vicinity of river mouths at times when salmon or sea trout may be on their spawning migrations. Any impacts on the fish and shellfish are therefore assessed as being the same as for construction and are therefore deemed as being: Spatial **– Low,** Duration **– Low,** Intensity **– Low,** Significance **– Low**, In-combination **– Low**.

Mitigation: none proposed.

Monitoring: none considered necessary.

Cumulative impacts: Other activities within Liverpool Bay, which generate suspended sediments, are aggregate dredging, channel maintenance and the construction/decommissioning of other wind farms in the area, namely North Hoyle, Burbo Bank and Rhyl Flats. Due to the differences in project timescales decommissioning of the other wind farms within Liverpool Bay will not overlap with the Gwynt y Môr project. As the suspended sediment levels identified as being generated during decommissioning will be localised and are expected to settle out of suspension relatively rapidly over a short distance in-combination effects are unlikely to be extensive or result in persistent elevations of levels of turbidity in comparison to the existing, naturally occurring levels. Thus, the suspended sediment cumulative effects of the construction of the Gwynt y Môr Offshore Wind Farm with other suspended sediment generating activities of Liverpool Bay are considered to be **Negligible.**

Potential Impact: Decommissioning activities may release bed contaminants which could affect fish and shellfish populations.

The surface sediments at the Gwynt y Môr Offshore Wind Farm were tested for a range of contaminants (see section 3.1) and the overall impression was that the levels of contaminants within sediments at the Gwynt y Môr Offshore Wind Farm were found to be consistently low. Sediments would be disturbed during the decommissioning phase by the same methods as those identified during the construction phase. Impacts to the fish and shellfish populations of Liverpool Bay are therefore assessed as follows: Spatial- **Negligible**, Duration- **Negligible**, Intensity- **Negligible**, Significance- **Negligible**. No mitigation or monitoring is proposed and no cumulative impacts identified.

Mitigation: none proposed

Monitoring: none proposed

Cumulative impacts: none identified.

Potential impact: Noise and vibration associated with the activities necessary as part of the decommissioning phase may disturb, harm and/or kill fish and shellfish.

Noise and vibration arising from the decommissioning phase is likely to be generated in the same way as for the construction phase e.g. increased vessel activity, use of plant to remove structures etc. There would of course be no extreme noise sources such as piling as was the case for foundation installation using monopile or multipile options and in that sense the removal of foundations will similar to the installation process for suction caissons or gravity foundations. This effect would be limited in duration to the period of decommissioning after which noise would return to background, ambient levels. Overall the levels of sensitivity would be: Spatial **– Low,** Duration **– Negligible,** Intensity**- Low,** Significance **– Negligible.**

Mitigation: It is recommended that, in order to ensure that any effects on fish species are reduced to the minimum, a soft-start up procedure for all high-energy generating plant associated with the decommissioning phase. This will allow any noise sensitive species which would be affected by high noise levels to vacate the area. This procedure should form part of the Site Environmental Management Plan, with all decommissioning personnel made aware of this mitigation through appropriate training.

Monitoring: The monitoring of fish populations suggested above for the construction phase should also be implemented during decommissioning to evaluate the distribution of fish species following the completion of the decommissioning phase.

Cumulative impacts: As stated previously, the wind farms of Liverpool Bay will not be decommissioned simultaneously. Noise levels generated during decommissioning will also be intermittent and are not thought to create a significant overlap with other intermittent noise generating activities within the area such as aggregate extraction, dredging, shipping and the oil and gas industry. Cumulative impacts are not therefore identified.

4.5 Potential Impacts on Marine Mammals

This section assesses the potential effects of the Gwynt y Môr Offshore Wind Farm on the marine mammals of Liverpool Bay and the eastern Irish Sea. The assessment process has taken into consideration the conservation value of marine mammals and the protection afforded to them through the relevant legislation (both National and International). The following sections are based upon site-specific surveys of marine mammals at the Gwynt y Môr Offshore Wind Farm site and surrounding areas (Goold *et al.,* 2005) and in conjunction with information from available literature and evidence from other offshore wind farms.

4.5.1 Relevant Guidance for Assessment

Statutory guidance is in place regarding the assessment of the potential effects of offshore wind farm developments within United Kingdom waters upon marine mammals. These have been duly considered for the assessment of impacts from the Gwynt y Môr Offshore Wind Farm project area and are summarised below.

- **CEFAS (2002). Guidance notes for Environmental Impact Assessment in respect of FEPA/CPA requirements**.

  This lists the following aspects that need to be considered:

  - Species in the area;
  - Number, distribution and/or location of sightings;
  - Known routes and movements in/around or through the site;
  - Relative importance of the site to each species;
  - Specific uses of the site including temporal and spatial use. For example: haul out areas, pupping areas, feeding and breeding grounds.

The specific potential effects caused by offshore wind farms are highlighted as: disturbance caused by noise, vibration, physical intrusion and visual intrusion; interruption of known used routes, disturbance due to maintenance access during operation and potential barrier effects.

- **Defra (2005, draft) Nature Conservation Guidance on Offshore Wind Farm Development. Version R1.9.**

This identifies the potential effects of offshore wind farm developments on marine mammals as being:

- Physiological impacts such as hearing damage as a direct result of noise produced;
- Loss of foodstock (i.e. fish stocks or invertebrates) can result from damage, disturbance, or scouring of the sites during the development's construction or maintenance (i.e. operational) phases.
- Behavioural impacts as a result of noise produced such as avoidance of a breeding, nursery or feeding area; and
- Indirect effects such as noise impacts to a food source.

In determining the likely significance of any impacts, the following issues need to be considered:

- presence of marine mammals in the area of concern;
- sensitivity of the marine mammals;
- information on the level, type and frequency of noise emitted;
- information on the likely attenuation of noise along the propagation path;
- and ambient noise levels reaching/near to the marine mammals.

Where a potential adverse effect is identified the guidance suggests that mitigation measures should be considered to remove that effect before any consent is given. Mitigation measures fall into two broad categories: best practice measures which should be adopted by any offshore wind farm and should be an industry standard; and mitigation measures for adverse effects which is aimed at reducing an impact specific to a particular development.

Examples of possible best practice measures include:

- adequate briefing of construction and maintenance personnel and, in particularly sensitive locations, the presence of an on-site construction ecologist;
- ‘soft’ start procedure to construction (specifically related to piling used in installation of foundations); and
- sensitive timing and routing of maintenance trips to reduce potential disturbance from boats.

Monitoring of marine mammal activity during the construction and operational phase of the wind farm is considered as essential by the draft guidance for two reasons where significant potential sensitivity is identified:

- to assess the impacts of a particular development with regard to the need for further mitigation of those impacts, including whether a sterile area is created while the turbines are in operation; and;

- to provide general information on effects on marine mammals to help future developers minimise potential impacts.

4.5.2 Potential Impacts From The Construction Phase

Potential Impact: Noise generated during wind farm construction may cause physiological damage to marine mammals.

As detailed within section 3.7, ambient noise in the marine environment arises from wave action, bubble formation, the action of wind and rain on the sea surface and noise from wildlife. This ambient noise combines with man made noise produced from shipping, offshore installations, fishing sonar and pleasure craft to produce background noise which varies with different locations due to the influences of the existing sea bed geology and water depth. Noise generated during offshore wind farm construction will be superimposed onto the existing background noise and has the potential to disturb marine mammals by provoking an avoidance reaction or may even cause physiological damage to sensitive tissues. Impacts to marine mammal populations through avoidance reactions are considered separately in the following section whilst the potential for physiological damage is considered here.

Noise can have several levels of physiological effect on marine mammals. The sudden onset of very loud noise may cause lethal effects through the damage of sensitive tissues. Sub-lethal levels of noise may damage hearing by causing decreased auditory sensitivity. If exposure to the noise is short then hearing may be recoverable (Temporary Threshold Shift or TTS); if the noise is long in duration or has a sudden onset then hearing, particularly in the higher frequencies, can be permanently lost (Permanent Threshold Shift or PTS). If permanent hearing damage occurs this may have serious consequences for individuals affected through impaired foraging, predator detection, communication, or mating disruption.

Elevated noise levels associated with the construction phase of the Gwynt y Môr project could arise from several sources such as foundation installation or removal, cabling, placement or removal of scour protection and increased vessel activity. However, it is the high-energy noise levels produced during turbine foundation installation where piling is used (notably under the mono or multipile solutions) which has the potential to generate the highest noise levels which may be of sufficient intensity to cause harm to marine mammals in the absence of appropriate mitigation. It is considered that the larger the pile diameter the louder the noise produced. For this reason it is considered that the piling of mono-piles for the foundations of the 5MW class turbines (up to 6m in diameter) at Gwynt y Môr will represent the worst-case scenario for the generation of underwater noise levels. Because other turbine foundation solutions will produce lower sound levels, pile driving for mono-piles has been considered for the assessment of physical harm to marine mammals as the worst-case scenario for construction noise with subsequent comment on the range of other activities.

The high-energy sound pressure waves generated by driving piles of large diameter are potentially damaging to marine mammals, particularly where they occur in close proximity to the piling activity. The noise of pile driving 5MW class turbine foundations at the Gwynt y Môr Offshore Wind Farm has been estimated at 273 db re 1 μPa @1m (section 2). This noise level has been used to assess the physiological impacts upon the marine mammals found to be present at the Gwynt y Môr project area. It should be noted that although the audiograms available for marine mammals indicate that whilst marine mammals are most sensitive to sound of a higher frequency than that generated during piling operations, there is still sufficient power in the piling impulse to cause physiological impacts to marine mammals. Equally, in considering the potential impacts it is acknowledged that much of the data relating to the effects of noise on marine mammals has been extrapolated from human hearing systems and land mammals (NATO, 2002). In line with the precautionary principle, it is assumed that hearing damage will be similar in terms of physiological damage to that observed in humans or land mammals. However, this is not altogether realistic as marine mammals will have different sensitivities since they have evolved ears which function well within the context of the underwater environment with potentially 'tougher' inner ears adapted to greater pressures.

From the acoustic impact model (Appendix 3) it is predicted that a source level of 273 db generated from piling would induce hearing damage at a conservative estimate of approximately less than 4km for harbour porpoise and 1km for grey seals. At these noise levels it is considered that mortality may occur within a few hundred metres from the source level of piling operations. Harbour porpoise have been recorded swimming between speeds of 0.5-4.2m/s (Otani *et al.*, 2001), although they have been recorded at much greater speeds when chasing prey or fleeing. However, as a worst-case scenario, it has been calculated that it would take 7 minutes for a harbour porpoise to swim beyond 200m and thus the zone of mortality at a speed of 0.5m/s and 16 minutes for a harbour porpoise to travel 4km and thus beyond the zone of physiological injury (hearing damage) at a speed of 4.2m/s.
As pile driving produces sound at a level which is of a potential level to induce mortality for marine mammals at close proximity and may induce hearing damage at much greater distances and because of the conservation status of marine mammal species and the length of construction period over a 2-3 year phase the significance of this impact is considered to be **High**. Impacts from the installation of alternative foundation options, such as the gravity or suction caisson solutions, cable laying and scour protection are considered to be of a much lower intensity and therefore much lower impact significance.

However, it should be noted that piling operations would be intermittent, between 12 and 24 hours for each offshore structure, out of a total circa 7 day installation period, although more than one piling vessel might be operational and the construction period could extend over a two or three year period.

Suitable mitigation measures (discussed below) will, however, allow marine mammals to retreat beyond the zone of potential physical damage. As a result and, bearing in mind the intermittent nature of pile driving activity, the residual impact for the physiological damage to marine mammals as a result of piling noise is assessed as being of **Low-Moderate** significance. In considering the potential significance, the relatively low numbers of marine mammals recorded from the general Liverpool Bay area, including Gwynt y Môr is of relevance.

In reaching these conclusions, it should be noted that the monitoring of marine mammals at existing offshore wind farms (such as Horns Rev in Denmark) indicate an avoidance of the site during construction (using piling techniques) by marine mammals. However, the monitoring confirms that marine mammals quickly returned to the site upon cessation of these activities. Physical damage or mortality of marine mammals at these sites was not reported.

Mitigation:

In view of the potential significance of this impact, the length of the construction period and the conservation status of marine mammal species, the following mitigation measures will be implemented specifically where piling is the chosen foundation installation method. For all other construction activities this mitigation is not considered necessary. Similar mitigation would be appropriate for the decommissioning stage but is considered to be dependent on the methods used and the noise levels generated.

The general advice given in the JNCC's guidelines on minimising acoustic disturbance to marine mammals (JNCC, 2004) has been adapted to inform the following mitigation. The following programme of mitigation is also compliant with recommendations made by Defra (draft, 2005) in controlling effects from offshore wind farms on marine mammals.

This mitigation will seek to ensure that no harbour porpoise (or other marine mammal) is within 200 m of the construction vessel when piling starts, thus minimising any risk of mortality. Mitigation will include the following:

noise generation will be kept to a practical minimum throughout the construction period with pile drivers and other noisy plant machinery only being activated when required. This advice does not include use of acoustic deterrent devices designed to reduce risk of damage to marine mammals.

acoustic deterrent devices (ADTs, such as porpoise pingers and/or seal scrammers) will be deployed from the installation vessels for 7 minutes before soft-start piling commences. This will allow time for marine mammals to move more than 200m away from the intended activity. It is recognised that use of ADTs may require licensing from the relevant authorities.

ADTs will be switched off after 7 minutes, immediately before soft start pile driving. Pile driving will be started in such a way that sound energy initially released is at a low level and increased gradually and uniformly over a minimum of 16 minutes until operational levels are reached. Although the ADTs will ensure that marine mammals are beyond the zone of mortality, the additional mitigation of soft-start up over this length of time will ensure that marine mammals have plenty of time to retreat beyond the zone of physiological injury.

ADTs will not be operated outside periods of piling activity and never for more than 10 minutes at a time to avoid acclimation and also to reinforce the association between them and follow up piling noise. If piling is delayed for whatever reason the devices will be switched off and the process re-started prior to the next piling operation.

The SEMP will ensure that all offshore construction personnel are appropriately trained with regard to the proper implementation of these mitigation measures. These measures and evidence of their implementation will be clearly set out in the Site Environmental Management Plan.

Additional potential mitigation measures are identified by Defra (draft, 2005). These include the following:

Bubble curtains: These distribute air bubbles around the pile driving operation which dissipate the acoustic noise energy within the water column. Bubble curtains can be difficult to manoeuvre, or to maintain in position especially when they are used in areas of strong tides or currents. Vagle (2003) also states that bubble curtains have very small effects on the overall pressure levels of high-energy noise. Given the relatively low importance of the

Gwynt y Môr area for marine mammal species (with the possible, seasonal exception of grey seals) it is not felt that bubble curtains are required in this case, given the mitigation programme set out above.

Timing of piling operations: Because the Gwynt y Môr project area is not a significant area for marine mammals and because harbour porpoise have been recorded as being present throughout the year to some extent, together with the distance of the site from the known, key calving or pupping sites, the implementation of specific seasonal timing for piling operations is not considered to be effective when compared to the mitigation set out above.

Monitoring: None proposed

Cumulative impacts: Other noise generating influences within Liverpool Bay such as from shipping, the oil and gas industry and aggregate extraction are not considered to produce sudden onsets of loud noise capable of causing physical harm to marine mammals.

Significant in-combination effects might be experienced particularly where more than one offshore wind farm was under construction giving rise to multiple piling operations occurring within Liverpool Bay. However, as previously noted, the construction timetables for Rhyl Flats and the Burbo Bank offshore wind farms means that such cumulative effects can not occur. However, if all wind farms were to be constructed by piling operations there is a potential for extended impacts to marine mammals as a result of generated high energy noise to occur over a 4-5 year period as a result of construction at the Burbo Bank, Rhyl Flats and Gwynt y Môr wind farms respectively.

Both Burbo Bank and Rhyl Flats wind farms will be of a similar size to the existing North Hoyle Offshore Wind Farm and it is anticipated that construction noise levels will be of a lower magnitude than anticipated for the larger piles at Gwynt y Môr. Suitable mitigation measures must be implemented at each wind farm so as to prevent injury from occurring to marine mammals over this period but behavioural responses brought on by elevated high-energy noise over this time period will be incurred. The intermittent nature of piling operations, consideration of the wider area of Liverpool Bay available, in addition to the consideration that piling will not be occurring simultaneously at the different wind farm locations within the area and the absence of biologically significant areas (e.g. calving and pupping grounds) within the Bay implies that such effects will not greatly impact upon the marine mammal populations of the area.

Lower intensity noise levels produced during construction such as cable installation and rock armour installation will not be occurring at the same time as the other wind farms and are not therefore considered to give rise to cumulative impacts for marine mammals.

Potential impact: marine mammals will become displaced from the area due to avoidance from noise/visual disturbances arising during construction activity.

Elevated noise levels, but below those potentially causing physical damage, may cause behavioural disturbances with a disruption of normal marine mammal behaviour such as cessation of feeding, or an avoidance of the area. This is not considered to be biologically significant if alterations in swimming path or physiology are only temporary. However, if animals are displaced from critical habitats for an extended period or if foraging, mating or nursing are impeded then impacts are considered to be important at an individual level.

Grey seals show both attraction to (e.g. approaching fishing vessels) and avoidance of anthropogenic noise sources, but generally exhibit avoidance responses when sources of noise or activity are close and may be perceived as a threat. However, it is difficult to discriminate between a seal's avoidance of a noise source and visual cues. Evidence from the Horns Rev offshore wind farm indicated that seals left the area during the piling activity but returned after the cessation of piling (seal scaring devices were employed prior to piling activity). Due to the temporary nature of the displacement and no clear evidence found for a large-scale displacement of the seals from the wind farm area or the Horns Rev area as a whole during the months of construction, Tougaard *et al.* (2003) concluded that there was no reason to believe that the construction (piling of monopiles) had any large-scale influence over the seal population of the area. However, monitoring of the seals at haul out areas in proximity to the wind farm during the period of construction recorded higher numbers hauling out of the water during pile driving activities than was the case when pile driving was not occurring. Tougaard *et al.* (2003) also investigated the effects of the Horns Rev construction on the harbour porpoise population. The studies indicated that when piling was occurring, porpoise activity was reduced within an area of 15km but activity was seen to return to normal levels within a few hours of the cessation of piling works.

Noise will be generated during the construction phase from a variety of sources including turbine foundation and sub station installation, cable laying and increased vessel activity. However, as has been described in the preceding sections, the worst case in terms of noise generated by the Gwynt y Môr project will arise from piling operations where these are used for foundation installation. However, it is also acknowledged that marine mammals may elicit behavioural responses to, but to a lesser extent, by the visual disturbance from construction or decommissioning activity/vessels and also noise generated from other activities operating at lower noise intensities than piling. Comment on the effects of these other activities is, therefore, also provided as part of the following assessment.

Although marine mammals, particularly seals and porpoise have been recorded from the Gwynt y Môr project area throughout much of the year (particularly early spring through to autumn), the data suggests that they pass through the area on migration to other key, distant habitats (in the case of porpoise) or use the area as part of their wider feeding grounds (in the case of grey seals). Porpoise calving areas are known to exist much further south, off Cardigan Bay, whilst there are no known grey seal pupping habitats close to the Gwynt y Môr project area.

There is a potential for the loud noise levels associated with piling (273dB) to elicit a behavioural response in harbour porpoise up to an approximate distance of over 15km away from the source of the noise, although the precise distance and behaviour will vary between individuals of the same species. Such responses may include the cessation of feeding or the movement away from the area. Avoidance responses of grey seals are expected to be far less than this occurring within a few kilometres of the source noise.

The conclusions of this assessment are supported by the monitoring of marine mammals at other existing offshore wind farms. Evidence from the Horns Rev Offshore Wind Farm in Denmark indicates that seals left the wind farm area during piling activity but returned after the cessation of piling (seal scaring devices were employed prior to piling activity). An example of this temporary displacement was shown by the monitoring of the seals at haul out areas in proximity to the Horns Rev site. During the period of construction, higher numbers of seals were recorded hauling out of the water during pile driving activities than was the case when pile driving was not occurring. However, no clear evidence was found for a large-scale or longer term displacement of seals from the wind farm area or the Horns Rev area as a whole during the months of construction. Tougaard *et al.* (2003), therefore, concluded that there was no reason to believe that the construction (piling of monopiles) had any large-scale influence over the seal population of the area.

Tougaard *et al.* (2003) also investigated the effects of the Horns Rev construction on the harbour porpoise population. These studies indicated that when piling was occurring, porpoise activity was reduced within circa 15 km. However, porpoise activity was seen to return to normal levels within a few hours of the cessation of piling works.

The available evidence from other offshore wind farms indicates that marine mammal activity at Gwynt y Môr would be reduced during piling operations but on cessation of piling activities mammals would be expected to resume their normal distribution patterns. It is also anticipated that fish will become displaced from these construction activities in the same way as for marine mammals. This effect on fish may lead to marine mammals foraging outside the areas most affected by noise in response to the re-distribution of their favoured prey items.

The effect of noise disturbance on marine mammals is considered to be of **Low-Moderate** significance. This is because of the wide range over which marine mammals will forage, the intermittent nature of the piling activity, the low importance of the project area for key marine mammal behaviour (particularly reproduction) and the reversible nature of any impact as suggested by the Horns Rev experience.

For other construction, including other foundation installation options, the noise generated will be of a significantly lower magnitude and therefore, although some small-scale disturbance to marine mammals may still occur, it is considered to be of **Low** significance.

Mitigation: None proposed.

Monitoring: Monitoring of marine mammals will be carried out during the construction period and during the immediate post-construction period. The details of the monitoring will be agreed through consultation with CEFAS and the Countryside Council for Wales (CCW). It is anticipated that monitoring would comprise visual or hydrophone/TPOD surveys undertaken in parallel with ornithological monitoring during the main marine mammal season defined as March to October/November.

Cumulative impacts: Significant in-combination effects might be experienced particularly where more than one offshore wind farm was under construction giving rise to multiple piling operations occurring within Liverpool Bay. However, as previously noted, the construction timetables for Rhyl Flats and Burbo Bank means that such cumulative effects will not occur. However, if all wind farms were to be constructed by piling operations there is a potential for extended impacts to marine mammals as a result of generated high-energy noise to occur over a 4-5 year period as a result of construction at the Burbo Bank, Rhyl Flats and Gwynt y Môr wind farms respectively. It is therefore likely that marine mammals will incur behavioural responses over this time period.

The intermittent nature of piling operations, consideration of the wider area of Liverpool Bay available, in addition to the consideration that piling will not be occurring simultaneously at the different wind farm locations within the area and the absence of biologically significant areas (e.g. calving and pupping grounds) within the Bay implies that such effects will not greatly impact upon the marine mammal populations of the area.

Other noise generating activities occurring within Liverpool Bay include shipping, dredging and aggregate extraction and the oil and gas industry. These do not produce high-energy noise levels as for piling, and it is unlikely that in-combination effects of the construction phase of Gwynt y Môr will occur. However, this is an uncertainty due to a lack of specific information concerning the noise levels and occurrence of these noise-generating activities within Liverpool Bay, in addition to the varying responses shown by marine mammal species and individuals.

Potential impact: Noise generated by construction activities may interfere with the use of sound by marine mammals.

Marine mammals produce a variety of noises that have been described as clicks, pops, and whistles used during hunting, breeding and communicating. Odontocetes (toothed cetaceans) such as harbour porpoise also use echolocation for navigating and feeding (Richardson *et al.,* 1995). Increased levels of background noise may act to impede the ability of marine mammals to navigate, may mask sounds of prey or communication signals which may be vital for social cohesion, mating, warning or individual identification. Noise generated during construction activity at the Gwynt y Môr Offshore Wind Farm will arise from increased vessel activity and activities such as the installation of foundations, trenching of cables and placement of scour protection. Mostly such activities will generate low frequency noise; generally small cetaceans and pinnipeds have poor hearings at these lower frequencies.

The noise frequencies generated by construction vessels would be unlikely to interfere with communications and echolocation of harbour porpoise and dolphins in the area due to the small overlap of sound frequencies. Minke whales could be affected to a greater degree than these species due to their use of lower sound frequencies, although this species is noted as only occasional visitors to this part of the Irish Sea. Seals are less likely to be affected than cetaceans by sounds generated by the additional vessel activity due to their lack of echolocation and reliance on visual means for hunting.

The large area over which marine mammals range combined with the likely intermittent and temporary nature of the most significant noise generated by construction and the general lack of overlap with the key frequencies used by the most common marine mammals recorded from the area means that any such effects are considered to be of **Low** significance.

Mitigation: none considered necessary.

Monitoring: To provide information on any effects it is suggested that monitoring of marine mammals would be carried out during the construction period. This would be through the use of visual and/or hydrophone surveys after consultation with CEFAS and Countryside Council for Wales (CCW).

Cumulative impacts: As stated previously significant in-combination effects as a result of noise generated by construction activity are not considered likely to occur. However, noise generated from construction activities may take place over a 4-5 year period as a result of construction at the Burbo Bank, Rhyl Flats and Gwynt y Môr wind farms respectively (assuming all are constructed by piling). It is therefore possible that marine mammals will incur extended impacts. However, given the intermittent nature of piling operations, the differences in frequencies, consideration of the wider area of Liverpool Bay available, in addition to the consideration that piling will not be occurring simultaneously at the different wind farm locations within the area and the absence of biologically significant areas (e.g. calving and pupping grounds) within the Bay implies that such effects will not greatly impact upon the marine mammal populations of the area.

Potential impact: loss of prey species from displacement due to noise generated from construction activity.

Noise generated during the construction phases of the Gwynt y Môr Offshore Wind Farm (most notably from piling of foundations where this is employed) will cause temporary displacement of fish species from the immediate area of construction operations. This is especially significant for noise sensitive species such as herring which are an important prey item for marine mammals. Harbour porpoise, other small cetaceans and grey seals are opportunistic hunters that predate on a wide range of fish species and over very wide areas. The proposed construction works are not expected to change overall population densities of fish or invertebrates in Liverpool Bay, but they may produce short-term changes in distributions. Any displacement of important prey items from the area, particularly during piling, is also likely to be intermittent in nature and of a temporary nature, given that piling will occur only intermittently.

It is also notable that marine mammals forage over a very wide area and the site-specific marine mammal field study did not suggest that the Gwynt y Môr Offshore Wind Farm project area had a specific significance for marine mammal foraging.. In addition, important prey items such herring or mackerel are highly motile and although likely to be displaced in the same way, will be displaced to a lesser extent than marine mammals would by the high energy noise levels that may be generated during construction (see section 4.4).

The small-scale of likely displacement, the intermittent and temporary nature of the most significant sources of disturbance and the ubiquitous nature of prey distribution means that any effect on marine mammal prey and feeding is assessed to be of **Low** significance.

Mitigation: none considered necessary.

Monitoring: None proposed specifically for this potential effect although the marine mammal monitoring undertaken during the construction period should also seek to record behavioural information relating to any foraging behaviour.

Cumulative impacts: none identified given that prey items such as fish species will be displaced to a lesser extent than marine mammals as a result of construction noise.

Potential impact: increased vessel activity may either disturb or cause physical harm to marine mammals.

There would be an increase in vessel traffic at the Gwynt y Môr Offshore Wind Farm during the construction phase associated with turbine and sub station installation, cable laying and personnel transfer. Such vessels include: barges, Jack-up rigs and tugs which are mostly slow moving vessels producing sound of a low frequency which may travel for long distances (see section 2 for further detail of vessel movements). Marine mammals can exhibit an attraction to vessels e.g. seals to certain fishing vessels, however the usual response by marine mammals, especially timid cetaceans such as harbour porpoise is usually one of avoidance either by diving or moving away.

Liverpool Bay contains significant amounts of shipping particularly along the northern boundary of the Gwynt y Môr project area and it is expected that cetaceans will avoid ships detected by the noise travelling over a wider area. Also, the slow moving nature of the vessels will allow cetaceans sufficient time to move away and avoid any collision impacts. Seals spend a significant amount of time looking out from the surface of the water (to detect predators) as they are more affected by visual stimulants rather than noise. They are also considered to have sufficient time to take avoiding action from approaching vessels.

As increased vessel activity would be mostly concentrated on site during the construction phase and because marine mammals were observed in relatively low numbers here the spatial impact is assessed as being **Low.**

Vessels will be required for the entire construction phase estimated to last between 2-3 years and as a result the duration of the impact is considered to be **Low**.

Due to the various responses of marine mammals to approaching vessels and the relatively low number to be found in the area as well as they are well able to move out of the way the significance of this impact is deemed to be **Low.**

The significance of this impact is assessed as being **Low**.

Mitigation: none considered necessary.

Monitoring: None proposed specifically for this potential effect although monitoring undertaken during the construction period to investigate the displacement of marine mammals should also seek to record behavioural responses to vessels operating in the area.

Cumulative impacts: Liverpool Bay is a relatively noisy environment with oil and gas platforms service vessels, aggregate extraction vessels and a sizeable amount of shipping. It is also necessary to consider the consequences of this potential impact in combination with other wind farms located within Liverpool Bay such as North Hoyle Offshore Wind Farm maintenance vessels and the proposed Rhyl Flats and Burbo Bank construction and subsequent maintenance vessels. However, because marine mammals are able to take avoiding reactions and vessels will be mainly slow moving and audible over a large distance the in-combination effects of this impact are considered to be **Low.**

4.5.3 Potential Impacts From The Operational Phase

Potential impacts that may be generated during the operational phase of Gwynt y Môr are considered here, although some are considered as being similar to the construction phase.

Potential impact: The noise generated by the operation of the Gwynt y Môr Offshore Wind Farm may cause a disturbance to marine mammals.

During the operational phase of Gwynt y Môr, the operating turbines and offshore sub stations will generate underwater noise. This noise will generally be of a low frequency and will not be at high energy levels as might be experienced during the construction phase where piling is employed. Marine mammals are more sensitive to sound at higher frequencies where their communication sounds such as echolocation are also based. However, the noise generated by the wind farm may be at a level which will disturb marine mammals and as a result the operational noise levels of the wind farm have been predicted and assessed for the effects on marine mammals.

To predict the operational noise levels for the Gwynt y Môr turbines, the underwater noise measurements taken at the existing North Hoyle site have been reviewed. The data acquired at North Hoyle has been modified to take into account the increased number of turbines and the larger turbine sizes at Gwynt y Môr and to allow an estimate of the noise levels for each of the three illustrative layout scenarios for the project. No substantial difference was identified for the overall operational noise levels for the three different illustrative layout scenarios. In developing the predicted noise levels, based on the North Hoyle data, it has been assumed that the operational noise levels scale linearly with total generating power, that all the turbines would be operating at the same time, turning at the same rate and that the underwater propagation conditions at Gwynt y Môr would be similar to those experienced at North Hoyle.

The model to predict the operational noise levels at the Gwynt y Môr project area was based upon the assumption that the operational noise levels scale linearly with total wind farm generating power.

The distance that the tonal noise of the entire operational wind farm falls below the existing background noise levels (and theoretically becomes undetectable by marine mammals) was assessed and found to be a distance of 3m for both harbour porpoise and grey seals. The noise levels of the operating turbines within the wind farm are not considered to be loud enough or of the same frequency so as to impair the foraging, movement or communication of the marine mammals present. This sound will be of a low frequency and marine mammals are considered to be more sensitive to noise at the high frequency range of the spectrum. At this level it is not expected that the operating turbines will cause an effect upon the behaviour of marine mammals nor mask feeding or communication sounds

Evidence from other offshore wind farms such as Horns Rev and Nysted report marine mammals to be present within and around the wind turbines either foraging or passing through on their way to other areas. In addition, harbour porpoise have been observed actively foraging within the North Hoyle Offshore Wind Farm (CMACS field observation, 2005) and grey seals have also been observed within proximity to the North Hoyle Offshore Wind Farm area.

The overall significance of the operational affects of the operational noise upon marine mammal species is considered to be **Negligible**.

In addition further assumptions were made regarding the turbines at the Gwynt y Môr site these assumptions were that all turbines would be operational at the same time, turning at the same rate and that the underwater propagation conditions at the Gwynt y Môr site would be similar to those experienced at North Hoyle. It would be prudent to actively measure the operational noise levels of the operating turbines at Gwynt y Môr to verify this model.

Mitigation: none considered necessary

Monitoring: None specifically proposed. However, the marine mammal monitoring proposed during the immediate post-construction period will seek to evaluate the response of porpoise and grey seals to the operational turbines

Cumulative effects: The potential for the noise levels generated from the four operating wind farms within Liverpool Bay is not considered to cause a disturbance to the marine mammal species of the region due to the short distances from the wind farm boundary that the noise is detectable by marine mammals before it dissipates into the background noise levels. No cumulative impacts of the Gwynt y Môr operational wind farm in combination with other existing or proposed wind farms within Liverpool Bay upon marine mammals are therefore identified.

Potential impact: Long-term changes in habitat may impact upon marine mammal food resources.

During the operational phase the turbine foundations, scour protection and offshore sub stations will provide additional habitat available for colonisation by benthic fauna (see section 4.3.2) and are likely to also aggregate fish species due to the increased food source available and the provision of shelter from currents (see fish impact section 4.4.2). As identified previously, illustrative layout scenario 1 provides the greatest available area for colonisation by benthic invertebrate species and is therefore considered as an indicative example of the best-case scenario in terms of increased habitat availability.

Harbour porpoise, other small cetaceans and grey seals are opportunistic hunters predating a wide range of fish and invertebrates species over very wide areas. Investigations of seal foraging behaviour at the Rødsand Offshore Wind Farm (Denmark), established average home ranges (area in which seals forage) as 3,980km^2 for grey seals (Dietz *et al.*, 2001). Grey seals present at the haul outs identified at the mouth of the Dee Estuary could therefore forage throughout the whole of Liverpool Bay and a large proportion of the Irish Sea. Harbour porpoise and grey seals have been reported exhibiting foraging behaviour within the Gwynt y Môr Offshore Wind Farm project area during the site-specific surveys undertaken as part of the baseline (Goold *et al.,* 2005).

The likely increases in the population densities of invertebrate and fish species due to the increase in habitat from wind farm installations may be of beneficial impact to the marine mammals which are likely to continue foraging within the area. Indeed, anecdotal evidence from the North Hoyle Offshore Wind Farm suggests that harbour porpoise do utilise wind farm areas for foraging (CMACS field observation, 2005). Grey seals are also reported to regularly forage within the Horns Rev offshore wind farm.

Increased concentrations of marine mammal prey species would only occur around the installations of the wind farm. The expected spatial extent of this impact would not occur beyond the boundaries of the wind farm and is therefore considered to be **Negligible**.

During the operational phase it may be necessary to periodically “clean” the under water structures to protect structural integrity. However, during this process not all biofouling would be removed from the structures and this is not thought to affect marine mammal foraging. The duration of this impact is therefore considered to occur throughout the operational phase of Gwynt y Môr and is therefore assessed as being **High**.

Marine mammals have been observed foraging within the Gwynt y Môr Offshore Wind Farm project area however, due to the high mobility of marine mammals they will forage over a wide area throughout Liverpool Bay and the eastern Irish Sea. The intensity of this impact is therefore described as being **Negligible** and the overall impact significance is considered to be **Negligible (**but beneficial).

Mitigation none considered necessary.

Monitoring: None proposed specifically for this potential effect although monitoring undertaken during the immediate post-construction period will seek to identify mammal behavioural responses such as foraging.
Cumulative Impacts: The other offshore wind farms and installations such as oil and gas platforms within Liverpool Bay will also provide additional substratum for colonisation or shelter from currents for the prey species of marine mammals. As stated as part of the fish assessment section this may act to concentrate fish species from the area specifically in relation to the North Hoyle and Rhyl Flats Offshore Wind Farms due to their proximity to the Gwynt y Môr project area. However, because of the large foraging ranges exhibited by marine mammals and the wide distribution of their prey species across the Irish Sea the in-combination effects are considered to be **Negligible**.

Potential impact: increased vessel activity may either disturb or cause physical harm to marine mammals.
During the operational phase a number of maintenance vessels will be required at the Gwynt y Môr Offshore Wind Farm (see section 2). Impacts are considered as being similar to those assessed for the construction phase. The effects are therefore assessed as being: Spatial-**Low**, Duration-**High** (potential to occur over the duration of the operational phase although the number of vessels required on site at any one time is expected to be lower than during the construction period), Intensity-**Low**, Significance-**Low**, and Cumulative impacts-**Low**.

Mitigation: none proposed

Monitoring: monitoring of marine mammals undertaken during the post-construction period should also seek to observe any responses to maintenance vessels associated with the operational phase of the wind farm.

Potential impact: Electromagnetic fields (EM-Fields) produced by the Gwynt y Môr Offshore Wind Farm cables will adversely affect marine mammals.

The most frequently recorded marine mammals in the vicinity of the Gwynt y Môr project area are harbour porpoise and grey seals (CMACS, 2005). Each of these species is understood to be able to detect magnetic fields and most likely use the earth's magnetic field for orientation and navigation. The magnetic field component of EM-Fields produced by the Gwynt y Môr subsea cables could theoretically result in the disruption of this behaviour which could result in an attraction to or repulsion from the area of EM-Fields or more subtle impacts on the animal's behaviour.

There is no evidence from existing offshore wind farms, such as Horns Rev in Denmark or North Hoyle in the UK of either unusual increases or decreases in marine mammal activity which would suggest attraction or repulsion by magnetic fields (or other factors associated with these offshore wind farms). Additionally, there are no known studies that suggest magnetic fields produced by submarine power cables, electrically heated pipelines or telecommunication cables have impacts on marine mammals.

Overall impact significance: Even assuming that some small scale effects occur as a result of the EM-Fields, the small areas affected together with the lack of any existing evidence for significant effects on marine mammals means that this potential effect is considered to be of **Negligible to Low** significance.

Mitigation: Although cable burial may reduce the magnitude of EM-fields, selection of cable operating voltage is considered the primary available mitigation. However, there is a significant degree of uncertainty associated with this option and a greater understanding of the ecological effects, if any, of EM-Fields is required before definitive recommendations can be made.

Monitoring: None proposed specifically for this potential effect although monitoring undertaken during the immediate post-construction period will seek to elicit an behavioural response of marine mammal to EM-fields. This will require knowledge of cable positions and EM-fields in relation to monitoring data.

Cumulative impacts: The following other offshore wind farm developments have been considered: North Hoyle, Rhyl Flats and Burbo Bank. It is expected that the EM fields produced by the Round 1 wind farms (Rhyl Flats and Burbo Bank) will be of similar magnitude to North Hoyle. The Gwynt y Môr Offshore Wind Farm will differ primarily in its use of offshore sub stations and, therefore, in the possible additive effects of cables in close proximity. CMACS & Cranfield (in prep.) noted that certain telecommunication cables and underwater pipelines could also generate EM fields. The BHP gas pipeline which runs through the Gwynt y Môr Offshore Wind Farm and comes ashore just west of Point of Ayr is not believed to be heated and will therefore not have any associated EM field. There are power and telecommunication cables running across the Clwyd estuary at Rhyl, which have measurable EM fields, but these fields will only propagate for short distances away from the coast (probably less than 100m). The offshore wind farm developments will therefore be the primary source of anthropogenic EM fields in the offshore environment.

Because any effects of EM fields from each wind farm development are not expected to overlap it is considered that the assessments outlined above will also apply to the cumulative impact assessment. Depending on whether any effect occurs there is a possibility of a negligible to medium severity impact of **negligible to moderate significance**.

4.6.4 Potential Impacts From The Decommissioning Phase

Potential Impact: The decommissioning phase of the Gwynt y Môr Offshore Wind Farm may generate noise levels capable of causing physical harm or displacing marine mammals.

Noise levels generated from the decommissioning of the wind farm are at present uncertain (with the exception that explosives will not be used) in line with the precautionary principle, it has been assumed that noise levels may be similar order of magnitude as the noise generated by construction and is therefore assessed to be: Spatial –**High**, Duration-**High** Intensity**- Medium,** Significance**- High.** Residual impacts as a result of suitable proposed mitigation proposed below would be **Low-Moderate s**ignificance**.**

Mitigation: Mitigation will be similar to that proposed for pile driving construction. Any loud activities should have a soft start approach and ADTs should be used if any activity has the potential to cause physiological damage.

Monitoring: marine mammal monitoring is proposed during the decommissioning phase (and this should be equivalent to that undertaken during construction) to identify any effects on the marine mammal populations.

Cumulative impacts: It is highly unlikely that the decommissioning of the Gwynt y Môr Offshore Wind Farm will coincide with the decommissioning of other wind farms in the area, due to the differences in the Crown Estate Lease terms for Round 1 and Round 2 sites. Other noise activities in Liverpool Bay such as aggregate extraction; shipping and the oil and gas industry are unlikely to produce noise levels at an intensity of causing physical harm to marine mammals. Any cumulative impacts are therefore considered to be **Negligible**.

Potential Impact: Noise generated from decommissioning of the Gwynt y Môr Offshore Wind Farm may interfere with the use of sound by marine mammals.

This is considered to be similar to the impacts identified for the construction phase and, because of the large area over which marine mammals range combined with the likely intermittent and temporary nature of the most significant noise generated by decommissioning and the general lack of overlap with the key frequencies used by the most common marine mammals recorded from the area means that any such effects are considered to be of **Low** significance.

Mitigation: none considered necessary.

Monitoring: To provide information on any effects it is suggested that monitoring of marine mammals would be carried out during the decommissioning phase. This would be through the use of visual and/or hydrophone surveys after consultation with CEFAS and Countryside Council for Wales (CCW).

Cumulative impacts: As stated previously, the wind farms of Liverpool Bay will not be decommissioned simultaneously. Noise levels generated during decommissioning will also be intermittent and are not thought to create a significant overlap with other intermittent noise generating activities within the area such as aggregate extraction, dredging, shipping and the oil and gas industry. Given this intermittent nature, the differences in frequencies used by marine mammals compared with low frequency decommissioning noise, and the absence of biologically significant areas (e.g. calving and pupping grounds) within the Bay indicates that cumulative impacts will not be incurred.

Potential impact: increased vessel activity may disturb marine mammals or cause physical harm resulting from a direct collision.

During the decommissioning period vessels will be similar in number and type as for the construction phase and as a result the impacts will be similar. The effects are therefore assessed as being: Spatial-**Low**, Duration-**Low**, Intensity-**Low**, Significance-**Low**, and Cumulative impacts-**Low**.

Mitigation: none considered necessary.

Monitoring: None proposed specifically for this potential effect although monitoring undertaken during the decommissioning phase to investigate the displacement of marine mammals should also seek to record behavioural responses to vessels operating in the area.

Cumulative impacts: Liverpool Bay is a relatively noisy environment with oil and gas platforms service vessels, aggregate extraction vessels and a sizeable amount of shipping it is also necessary to consider the consequences of this potential impact in combination with other wind farms located within Liverpool Bay such as North Hoyle Offshore Wind Farm maintenance vessels and the proposed Rhyl Flats and Burbo Bank maintenance vessels. However, because marine mammals are able to take avoiding reactions and vessels will be mainly slow moving and audible over a large distance the in-combination effects are considered to be **Low.**

Potential impact: The decommissioning of the turbine installations may result in a loss of habitat used by marine mammals for foraging.

As identified in section 4.4 the operational phase of the Gwynt y Môr Offshore Wind Farm will generate greater habitat diversity within the area from the turbine foundations and associated scour protection which are assessed as being beneficial to marine mammals for foraging. The decommissioning phase of the wind farm will remove the sub station supports and the turbines at the level of the sea bed, together with any scour protection, which will result in a net loss of habitat previously available as artificial reef substratum.

The use of the 3MW class turbines, as indicated by Illustrative layout scenario 1, will tend to provide the highest number of vertical surfaces available for colonisation and is therefore considered to be the worst-case scenario for the greatest loss of linear habitat (estimated to be a total of circa $0.08km^2$). In addition, the removal of any scour protection will remove additional artificial reef habitat.

The spatial extent of this impact is confined within the boundaries of the Gwynt y Môr Offshore Wind Farm project area and is therefore considered to be **Negligible**.

Decommissioning would occur over a similar timescale to that of the construction phase which is expected to last between 2-3 years. Any effects caused by the removal of the Gwynt y Môr Offshore Wind Farm components will therefore last throughout the period of decommissioning and the duration effects are therefore assessed as being **Low**.

The removal of the Gwynt y Môr Offshore Wind Farm components over the 2-3 year decommissioning phase will allow fish time to redistribute over the area and is thought will have no significant effect upon the fish populations of Liverpool Bay (see section 4.4). Marine mammals will also forage for food over a very wide area and the intensity of the impact is therefore considered to be **Negligible.**

The impact significance is judged to be **Negligible** due to the highly localised nature of the impact and the large distances used by marine mammals for foraging.

Mitigation: none considered necessary.

Monitoring: none considered necessary.

Cumulative effects: The loss of some habitat from the decommissioning phase of the Gwynt y Môr Offshore Wind Farm is considered to have little cumulative impact, as it is highly unlikely that all the wind farms will be decommissioned at the same time due to the differences in the Crown Estate lease conditions for Round 1 and Round 2 sites. Also the decommissioning phase over 2-3 years is considered to be sufficient amount of time for prey items to redistribute themselves over the area.

4.6 Potential Impacts on Marine & Coastal Sites and Species of Conservation Interest

This section considers the impacts of the proposed Gwynt y Môr Offshore Wind Farm upon the marine and coastal nature conservation sites of Liverpool Bay and includes reference to the impacts upon rare or protected species. It should be noted that although some reference has been made to ornithological species and habitats here, the full impact assessment has been produced within ERM (2005). In addition, this section does not consider the potential impacts upon terrestrial species and designated nature conservation sites, these being assessed for elsewhere (see ERM, 2005).

4.6.1 Relevant Guidance for Assessment

Statutory and non-statutory guidance is in place regarding the environmental impact assessment of offshore wind farm developments within United Kingdom waters upon protected habitats and species. These have been duly considered for the assessment of impacts from the Gwynt y Môr Offshore Wind Farm and are summarised below.

- **Defra (2005) Nature Conservation Guidance on Offshore Wind Farm Development. Version R1.9.**

This gives the following advice with regard to the consideration of impacts on coastal and terrestrial habitats:

Important intertidal designated habitats to consider include:
• SAC, SSSI and Ramsar designations and can include almost any feature on the shore from rockpools to whole shores;

• intertidal SAC Annex 1 habitats, including reefs, mudflats and sandflats, estuaries, large shallow inlets and bays, lagoons and caves, and Annex 2 species associated with the intertidal habitats, including seals and otters;

• SSSI intertidal features including all nationally important and specialised biotopes, several whole shore designations, and nationally rare and scarce species listed in the Guidelines for selection of biological SSSIs: intertidal marine habitats and saline lagoons (JNCC 1996); and

• Ramsar intertidal features which can include estuaries and coastal areas out to a depth of 6m.

Important BAP habitats and species to consider include:

• maritime cliff and slope, *Sabellaria alveolata* reefs, littoral chalk, *Ascophyllum nodosum* ecad *mackii* beds, seagrass beds, mudflats and sheltered muddy gravels, tidal rapids and saline lagoons; and

• all those species listed in Annex 3 of the UK Biodiversity Group Tranche 2 Action Plans, Volume V – maritime species and habitats.

In addition, consideration of the impact of any damage or disturbance of the habitat utilised by species for which SACs or SPAs are designated will be paramount during impacts on the intertidal areas (mostly from cable laying). The severity of these impacts will depend on the shore types present, and their importance to designated species. As a general rule clean mobile exposed sandy shores recover more quickly than other sediment shore types. Bedrock, biogenic reef and muddy gravel shores are the most sensitive. The sensitivity (recoverability and vulnerability) of designated and BAP habitats and species need special consideration when assessing potential impacts.

- **Hiscock *et al.* 2002. High Level Environmental Screening Study for Offshore Wind Farm Developments – Marine Habitats and Species Project. Report to The Department of Trade and Industry New & Renewable Energy Program. (AEA Technology, Environment Contract: W/35/00632/00/00.))**

Where wind farms are proposed, their development should not adversely affect the conservation objectives and/or reasons for identification and notification or designation of sites of national wildlife importance.

• Where a proposed wind farm development is likely to have a significant adverse effect on a site of regional or local nature conservation importance, it should only be permitted if it can be clearly demonstrated that there are reasons for the proposal which outweigh the need to safeguard the nature conservation value of the site.

• Where wind farms are proposed, their development should not cause significant disturbance to, or deterioration or destruction of, key habitats of species listed in Annex IV of the Habitats Directive.

• Where wind farms are proposed, their development should not contravene the protective measures that apply to Schedule 1 birds, Schedule 5 animals and Schedule 8 plants [of the Wildlife and Countryside Act 1981].

• Where wind farms are proposed, their development should respect, and where possible further, the objectives and targets for priority habitats and species listed in the UK Biodiversity Action Plan.

• Consideration must be given to the potential impacts of wind farm development on rare and scarce species found in the marine environment.

- **English Nature *et al.* (2001)- Wind farm developments and nature conservation.**

From the point-of view of protection of marine natural heritage importance and marine wildlife resources, it will 'matter' if offshore wind farm developments cause:

• rare or scarce species or habitats to be lost from an area;
• protected or rare or scarce migratory species to be adversely affected;
• charismatic or 'public-interest' species to be lost or damaged;
• keystone species to be lost from an area;
• spawning areas to be lost;
• aggressive non-native species to be introduced or encouraged;

4.6.2 Potential Impacts From The Construction Phase

Potential impact: The installation of the export cables during the construction phase may affect designated conservation sites within the coastal area in the vicinity of the cable landfall.

There are currently four proposed cable landing sites for the export cables from the Gwynt y Môr Offshore Wind Farm. These are located along the North Wales coastline within the county of Conwy between the towns of Pensarn and Towyn. The installation of the export cable within the coastal zone will involve the physical disturbance of existing habitat, as the cable is trenched up the beach and onward into the terrestrial environment. Such disturbance may impact upon designated conservation sites or UKBAP species present within the coastal zone.

The closest identified designated conservation areas to the proposed cable landfall locations are the Llandulas and Traeth Pensarn SSSI (approximately 850m to the west of cable landfall option 1 at Pensarn) and the Kinmel Bay LNR (approximately 1.5km to the east of cable landfall option 4 Towyn East). The Traeth Pensarn and Llandulas SSSI is designated for the presence of a vegetated shingle bank which exisits above the high water mark (a UKBAP habitat) whilst coastal dunes and associated semi-natural vegetation are present at the Kinmel Bay LNR (also a UKBAP habitat). In addition there is also a local biodiversity action plan (LBAP) in place for these two habitats within the county of Conwy where these two sites are located. There are no UKBAP species or habitats present at any of the proposed cable landfall sites, with all habitats and species identified as present at these sites being considered as relatively common along this stretch of the North Wales coastline.

The small spatial area of habitat which will be disturbed during cable installation at the proposed cable landfall sites, in consideration with the distance of the closest designated coastal conservation sites being over 850m away from the site of disturbance, in addition to the lack of identified UKBAP habitats and species at the landfall sites means that **no impacts** to designated conservation sites within the coastal zone as a result of cable installation or removal are considered likely to be incurred.

Mitigation: none proposed.

Monitoring: none proposed.

Cumulative impacts: none identified.

Potential Impact: The installation of the Gwynt y Môr Offshore Wind Farm will impact upon sites currently designated for their conservation interest or those of potential future designation.

There are no designated sites of conservation interest within the Gwynt y Môr project area or export cable corridor, with the exception of the potential Liverpool Bay SPA (which is considered separately within ERM (2005). The Gwynt y Môr project cannot, therefore have any direct effects on sites designated for their conservation interest. The Gwynt y Môr project could, however, have indirect effects on areas of nature conservation interest through, for example, the alteration of coastal processes through effects on tidal currents or waves or may have direct effects upon offshore areas which could be potentially designated as protected sites for their conservation status in the future.

The assessment of physical processes (RWE npower, 2005) has concluded that the use of certain turbine structures, most notably gravity based turbines are likely to reduce wave heights down wind of the wind farm within the inshore environment. This effect is noticeable to the extent of the adjacent coastline. The use of gravity based turbines may also have some effect on the flow circulation within the inshore area. These alterations of flow patterns and the overall hydrodynamic regime of the inshore areas may disrupt the coastal zone environment dynamic by disrupting the erosional and depositional characteristics of the coastline. This may have indirect effects upon the coastal designated conservation areas located down wind and on shore from the Gwynt y Môr project area most notably the Dee Estuary (Ramsar, pSAC, SPA, SSSI), Gronant and Talacre dunes (SSSI, LNR), Kinmel Bay (LNR) and the Llandulas SSSI. Potential impacts include increased deposition of sediments as a result of reduced wave energy or a shift in coastal processes altering the prevailing sedimentary environment that may, over time, alter the characteristics of the coastal environment with an effect upon the species which inhabit these conservation areas. However, this dissipation of wave energy and reduction in wave height for the inshore areas has been shown by the model to be very small and as a result the significance of the effect upon the overall hydrodynamic regime of Liverpool Bay was assessed as being of Low significance (see RWE npower, 2005). Significant effects to the coastal areas inshore from the wind farm are not expected to arise (RWE npower, 2005) and given this, any indirect impacts to designated conservation areas inshore from Gwynt y Môr are also considered to be of **Low** significance.

The potential impacts of more complex wind farm structures such as gravity based turbines upon the prevailing hydrodynamic regime and the effects this has upon the coastline is poorly understood and cannot be modelled without uncertainty (see RWE npower, 2005) as a result the indirect impacts to coastal designated conservation sites also has an element of uncertainty.

It is also possible that wind farm construction may impact upon marine habitats of conservation interest where these occur within the Gwynt y Môr project area (for example Annex II habitats listed under the Habitats Directive or BAP habitats) which may be subject to future conservation status. The predominant benthic habitats at the Gwynt y Môr project area were identified during the benthic characterisation survey as being dominated by sublittoral sand and gravel habitats (CMACS, 2005). These are UK BAP habitats and sublittoral sand habitats in less than 20m depth are also listed as Annex II habitats. These sediments are also the most common habitats found below the level of the lowest low tide around the coast of the United Kingdom and are occur in a wide variety of environments, from sheltered (sea lochs, enclosed bays and estuaries) to highly exposed conditions (open coast). Such habitats are also important as they can support populations of commercial fish species and include areas of feeding, spawning and nursery grounds for commercially important fish species such as sole and plaice (these species are included under the grouped UKBAP for commercial fish species) and potentially could represent possible sites for designation as marine SACs.

The selection of sand and gravel habitats for marine SACs aims to protect the quality and extent of a representative range of sublittoral sand and gravel habitats and communities. The variation in sediment structure and extensive range of this key habitat type means that it is included in a total of 17 sublittoral biotopes as identified under the marine nature conservation review (MNCR). The characterisation survey of the Gwynt y Môr project area identified three existing biotopes within the site of the proposed wind farm (section 3.3) however, substantial variation was identified within these biotopes and the main community relationships were relatively broad and variable, but overall most communities were a reasonable match to sublittoral biotopes as defined by Connor *et al.* (2004). The actual extent of the biotopes found at the Gwynt y Môr project area throughout Liverpool Bay is unknown, however, all would appear to be common outside the project areas and have previously been described throughout the wider Irish Sea and British waters. The status of these habitats as possible areas for SAC designation is not therefore considered to be likely.

However, even under the worst realistic case scenario, the loss of seabed habitats as a result of the construction of Gwynt y Môr has been assessed to be of **Negligible** significance. Habitat loss would occur solely within the wind farm area and as a result the spatial extent of this wind farm is assessed as being **Negligible**. The loss of habitat would be incurred for the lifespan of the wind farm, which is 50 years, and the duration of impact is therefore assessed as being **High**. Due to the widespread nature of the biotopes identified at the Gwynt y Môr project area throughout the Irish Sea and UK waters and because of the substantial variability occurring within these biotopes at the Gwynt y Môr project area any impacts upon BAP habitats and potential future designated habitats is identified as being **Negligible**. The overall significance of this impact is therefore also assessed as **Negligible.**

Mitgation: none proposed.

Monitoring: none proposed.

Cumulative impacts: Habitat loss within Liverpool Bay arises from the oil and gas industry, the North Hoyle, Rhyl Flats and Burbo Bank offshore wind farms (when the latter two are constructed), channel maintenance dredging and aggregate extraction. As stated previously the biotopes found at the Gwynt y Môr project area and within Liverpool Bay are common throughout the Irish Sea and are previously described throughout the UK coastline. As a result it is generally not considered that these areas represent habitats likely to be designated for fututre conservation interest. Cumulative impacts of habitat loss within Liverpool Bay as a result of the construction of the Gwynt y Môr Offshore Wind Farm upon habitats for potential future designation are therefore not anticipated.

Cumulative impacts to coastal sites of a nature conservation interest may be incurred in conjunction with the other wind farms as a result of the alteration of the prevailing hydrodynamic regime. However, all the other wind farms within Liverpool Bay are/will have monopile foundations and as such are not anticipated to alter the prevailing hydrodynamic regime and a s a result in-combination effects upon the designated nature conservation coastal sites are not predicted.

Potential impact: The loss of habitat as a result of the construction of the Gwynt y Môr Offshore Wind Farm may impact upon rare and protected marine species.

A number of rare or protected species have been described from the area of the Gwynt y Môr Offshore Wind Farm including benthic invertebrate species, fish and marine mammals. The construction phase of the Gwynt y Môr project may disturb the essential habitat of these species or act to disturb their normal behaviour, and subsequently affect their integrity in relation to their conservation status.

Impacts on benthic sand and gravel habitats and key fish species such as plaice, sole, whiting and cod (all of which are listed under the UKBAP) have been assessed as being of Negligible significance so that any effect on their conservation status is equally considered to be unlikely.

The thumbnail crab, *Thia scutellata* was found to be present at sites within and around the Gwynt y Môr project area and is considered to be rare within UK waters but is not a UKBAP species and has no protection afforded to it. The assessment of the potential effects on this species, given the limited area affected by construction and the area over which it has been recorded means that it has been concluded that any impacts from the wind farm are not thought likely to diminish the presence of this species within Liverpool Bay.

Marine mammals, which are afforded both international and national legislative protection and are also UKBAP species, are seasonally present within Liverpool Bay but also forage over extremely large areas and have identified breeding grounds well away from the Gwynt y Môr project area, outside the Liverpool Bay area. The loss of habitat resulting from the installation of the Gwynt y Môr Offshore Wind Farm is not therefore considered to be significant on these species or their conservation status. Other impacts could occur, however, through collision with construction vessels and particularly from noise generated by the installation or removal of offshore structures. The assessment of these potential effects on marine mammals has concluded that only short term and temporary effects may occur but that, given the appropriate mitigation is in place, these effects will be of Low significance and the overall impacts on the e conservation status of these species, therefore, is assessed to be of **Low** significance.

In summary, given the small areas of seabed habitat affected, the short term and temporary nature of construction works and the relative unimportance of the project area for species such as marine mammals, impacts on the conservation status of these species are assessed to be of **Low to Negligible** significance.

Mitigation: none further than previously identified within relation to benthos, fish and marine mammals.

Monitoring: none further than previously identified within relation to benthos, fish and marine mammals.

Cumulative impacts: none further identified than previously highlighted within sections 4.3, 4.4 and 4.5 in relation to benthos, fish and marine mammals.

Potential impact: Construction activities may impact upon rare and protected marine species causing these species to be adversely affected at the population level or permanently excluded from the area.

Potential impacts arising from the activities associated with the construction of Gwynt y Môr on marine species have been highlighted as loss of available habitat, potential smothering of benthic species by elevated suspended sediment levels, collision risk from increased vessel activity within the area for species such as marine mammals and impacts of noise from structure foundation installation for species such as fish and marine mammals (see sections 4.3, 4.4 and 4.5). Rare and protected species occurring within Liverpool Bay and which may be affected by such construction activities have been identified as marine mammals and certain commercial UKBAP fish species such as plaice, sole, whiting and cod and other protected migratory fish species such as salmon.

Overall no long-term effects were identified for the populations of these species within Liverpool Bay as a result of Gwynt y Môr construction activity with any identified impacts being mostly temporary or short-term in nature confined to the construction period. The only long-term effect is generated through the loss of habitat at the wind farm site previously available for some of these species as foraging, spawning and nursery grounds which has been assessed separately within the previous impact statement.

No major changes at the population level for rare or protected species are expected to occur as a result of construction activities and as a result The spatial extent of this impact is assessed as being **Low-moderate**, the duration of this impact would occur during the 2-3 year construction period and is therefore considered to be **Low**. The intensity of this impact is considered to be **Low** and the overall significance of this impact is also assessed as being **Low.**

Mitigation: none further than previously identified within sections 4.3, 4.4 and 4.5.

Monitoring: none further than already proposed sections 4.3, 4.4 and 4.5 (benthos, fish and mammals).

Cumulative impacts: the cumulative impacts on marine species (including rare and protected species) generated by the Gwynt y Môr construction period in combination with other developments and activities within Liverpool Bay have been previously assessed within sections 4.3, 4.4 and 4.5.

4.6.3 Potential Impacts From The Operational Phase

Potential impact: the presence of the operational Gwynt y Môr Offshore Wind Farm may disturb rare or protected marine species

Potential disturbance to rare or protected species may arise from the noise levels or electromagnetic fields generated by the operating turbines or the physical presence and/or visual disturbance of the wind farm structures. This may act to disturb protected species during key behaviour such as migration, feeding or reproduction thereby affecting their conservation status.

The assessment of operational effects on marine mammals has concluded the physical presence of the turbines within the water column, the noise generated by the wind turbines and their visual presence above the water are unlikely to adversely affect these species and indeed evidence from other offshore wind farms such as Horns Rev have reported the presence of seals and harbour porpoise foraging within wind farm arrays. Anecdotal evidence also exists from the North Hoyle Offshore Wind Farm of Harbour porpoise actively foraging within the wind turbine array.

Fish species such whiting (Grouped UKBAP species under commercial fish) have also been recorded around the North Hoyle turbines, indicating that the positive effects of the turbines acting as fish attracting devices (FADs) negates any possible negative impacts of the turbine structures such as operational noise. Impacts on protected migratory fish species such as salmon, lampreys and shad are also predicted to be negligible.

Protected fish species which are electro-sensitive include skate and rays (UKBAP and Local BAP species for Conwy), salmon (Appendix III of the Bern convention and Annex II species of the EC species directive (freshwater only)), sea lampreys (Appendix III of the Bern convention and Annex II species of the EC species directive) and plaice and cod (listed under Grouped BAP for marine commercial fish). The assessment of the impacts of electromagnetic fields on these species has identified no current evidence of a likely detrimental effect on these fish species.

Overall, it is considered that the operational phase of the Gwynt y Môr Offshore Wind Farm will not have a detrimental impact upon the conservation status of these protected species within Liverpool Bay and effects are therefore assessed to be of **Negligible** significance.

Mitigation: none proposed.

Monitoring: The specific monitoring proposed for benthos, fish and marine mammals should be used to confirm the predicted level of effect on these designated marine species.

Cumulative impacts: the cumulative impacts on marine species (including rare and protected species) generated by the Gwynt y Môr structures in combination with other developments and activities within Liverpool Bay have been previously assessed within sections 4.3, 4.4 and 4.5.

Potential impact: the presence of the turbines may provide additional habitat for rare and protected marine species.

It is considered that the offshore structures associated with the Gwynt y Môr Offshore Wind Farm will provide areas of new habitat which will become readily colonised by hard substratum dwelling benthic organisms. These structures will then provide feeding opportunities for marine species (as has been seen at the North Hoyle Offshore Wind Farm) and may offer some form of shelter from currents or predators. This may be somewhat beneficial to protected marine species occurring within Liverpool Bay.

Species that are known to aggregate around such offshore structures include the gadoids cod and whiting which are UKBAP species under the Grouped Action Plan for marine commercial fish. In addition, the concentration of fish species within the vicinity of the wind farm area as a result of aggregation may also attract foraging marine mammal species of conservation interest such as grey seals and harbour porpoise. The new habitat provided by the offshore structures may also act to negate the effect of the loss of the existing seabed habitat resulting from wind farm construction and may indeed provide new feeding opportunities for rare and protected species occurring within Liverpool Bay. In addition the presence of the offshore structures at Gwynt y Môr may also reduce commercial fishing effort within the wind farm area which will also benefit the species present. However, such effect is considered to be small and only occurring within the Gwynt y Môr Offshore Wind Farm site. The spatial extent of this impact is therefore assessed as being **Negligible**. The duration of this impact would occur as long as the wind farm structures are in place which would be for the fifty year lifespan of the project. The duration of impact is therefore assessed as being **High**. The intensity of impact is assessed as being **Negligible** and the overall impact significance **Negligible**.

Mitigation: none proposed.

Monitoring: The specific monitoring currently proposed for benthos, fish and marine mammals at the Gwynt y Môr Offshore Wind Farm may act to identify potential benefits for these protected marine species

Cumulative impacts: the cumulative impacts on marine species (including rare and protected species) generated by the additional habitat associated with the Gwynt y Môr Offshore Wind Farm in combination with other developments within Liverpool Bay have been previously assessed within sections 4.3, 4.4 and 4.5 (benthos, fish and mammals).

4.6.4 Potential Impacts From The Decommissioning Phase

Potential impact: The removal of the landfall cables during the decommissioning period of Gwynt y Môr may impact upon designated conservation sites within the coastal area of the cable landfall site.

The removal of the landfall cables during the decommissioning phase of the Gwynt y Môr Offshore Wind Farm will have a similar impact on protected habitats and species as those identified for construction. Because of the distance to the closest protected areas of the proposed cable landfalls and the intertidal habitats being common throughout the Liverpool Bay coastline the impacts are identified as:

Spatial extent of impact **Low**, Duration of impact- **Low**, Intensity of impact- **Negligible** and the overall significance of this impact is also assessed as being **Negligible**.

Mitigation: none proposed.

Monitoring: none proposed.

Cumulative impacts: none identified.

Potential impact: The process of wind farm structure removal may harm protected or rare species altering their population levels or presence within Liverpool Bay.

The potential impacts arising from the activities associated with the decommissioning of the Gwynt y Môr Offshore Wind Farm on marine species are considered to be similar to those for the construction phase with any identified impacts being mostly temporary or short-term in nature confined to the decommissioning phase.

No major changes at the population level for rare or protected species are expected to occur as a result of decommissioning activities and as a result: the spatial extent of this impact is assessed as being **Low-moderate**, the duration of this impact would occur throughout the decommissioning phase and is therefore considered to be **Low**. The intensity of this impact is considered to be **Negligible** and significance of impact- **Negligible**.

Mitigation: none further than previously identified for benthos, fish and marine mammals.

Monitoring: none further than previously identified for benthos, fish and marine mammals.

Cumulative impacts: the cumulative impacts on marine species (including rare and protected species) generated by the Gwynt y Môr construction period in combination with other developments and activities within Liverpool Bay have been previously assessed within sections 4.3, 4.4 and 4.5.

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