CHAPTER 5: BIOLOGICAL ENVIRONMENT

5.1 Introduction to Marine Ecology

The University of Liverpool Centre for Marine and Coastal Studies (CMACS) has been commissioned to carry out an assessment of possible effects on marine ecology relating to the proposed Burbo Offshore Wind Farm.

The scope of the marine ecology assessment is to include:

- Marine benthic invertebrate communities
- Intertidal communities
- Fish species and communities
- Sea mammals

Tropho-dynamic interactions with bird populations are considered in Section 5.6. The marine ecology assessment also builds upon the coastal process assessment and an assessment of effects on commercial fisheries as detailed elsewhere in this Environmental Statement.

Initially, a literature review was undertaken to collect information on marine ecology within the Study Area (area of probable near-field and far-field effects), Liverpool Bay and the Irish Sea. Informed by this desk based review, the following work was undertaken:

- An analysis of field survey requirements
- Agreement of appropriate survey methodologies with statutory bodies (EN and CEFAS)
- Site specific surveys that would yield data sufficient for analysis of impacts, including seabed sediments, intertidal benthos and fish.
- An assessment of impacts of construction, operation and decommissioning on marine ecology; including an assessment of cumulative impacts in relation to other wind farm developments in Liverpool Bay
- Defining appropriate mitigation and/or monitoring
- Assessment of residual impacts taking any mitigation into account

5.1.1 Assessment Methodology

The significance of impacts on marine ecology has been evaluated by taking account of the status and level of importance of marine ecology ‘receptors’ and the magnitude of any impacts. Importance is defined in relation to Liverpool Bay, the Irish Sea and UK and North East Atlantic Waters, magnitude is determined on the basis of species vulnerability, spatial and temporal incidence of any impacts and ability of species or communities to recover.

In determining the significance of an impact, 'magnitude' is assessed against 'importance' to provide a range of significance from 'negligible' to 'major' as shown in Table 5.1 below.

Table 5.1: Matrix to assess significance of impacts

		Magnitude of impact			
		Negligible	**Low**	**Medium**	**High**
Level of importance of receptors	**Liverpool Bay**[1]	Negligible	Minor	Minor/Moderate	Major
	Irish Sea[2]	Minor	Minor/Moderate	Moderate/Major	Major
	UK / North East Atlantic Waters	Minor	Moderate	Major	Major

[1]***Liverpool Bay:*** *Rossall Point to Great Orme (an area of 2,500km^2)*
[2]***Irish Sea:*** *The limits of the Irish Sea are taken to be north of a line drawn west from St. Ann's Head in Wales to the Irish coast and from Rathlin Island (Northern Ireland) to the Mull of Kintyre in Scotland*

Determination of the magnitude of an impact is based on the commentary on the EIA.

A significant impact in terms of the EIA regulations is considered to be one of Major or Moderate/Major significance.

An outline of site-specific surveys, approaches and methodologies adopted are provided below. Further details are provided in the Marine Ecology Technical Appendix C.

5.1.2 Survey Methodology

Survey methodologies used in relation to subtidal and intertidal benthic invertebrates and fish are provided in the Marine Technical Appendix C.

The sections below consider, for each element of the marine ecosystem (benthic invertebrates, intertidal communities, fish and marine mammals) their current status, and importance; appropriate design measures implemented to avoid environmental impacts; the nature and significance of any impacts associated with the proposed Burbo Offshore Wind Farm (alone and in combination with other developments); and any appropriate mitigation and/or monitoring.

5.2 Marine Benthic Communities

5.2.1 Existing Environment

The results of previous surveys of benthic communities in Liverpool Bay (Mackie, 1990; Jones, 1950; Connor et al, 1996; Eagle, 1973 & 1975; Rees and Walker, 1983; Holt and Shalla, 2001) are summarised in the Marine Ecology Technical Appendix C. This Technical Appendix also considers factors influencing benthic distributions and relationships of benthic classifications of the Irish Sea to the Burbo Flats area.

As described in the Marine Ecology Technical Appendix C, substrate is an extremely important determining factor in the composition of benthic communities. Substrate conditions over the survey area are provided earlier in this E.S. and in the Coastal Process Technical Appendix A to the E.S. In general, however, the sandy nature of the substrate, with a very low content of stones, means that invertebrate infauna (rather than epifauna) are very much dominant over the whole survey area. Indeed, sessile epifauna such as hydroids, bryozoans, sponges, tunicates, barnacles and many of the anemones were almost completely absent from the Day grabs, with only trivial amounts found in the beam trawls. Full survey results are presented in the Marine Ecology Technical Appendix C and are summarised below.

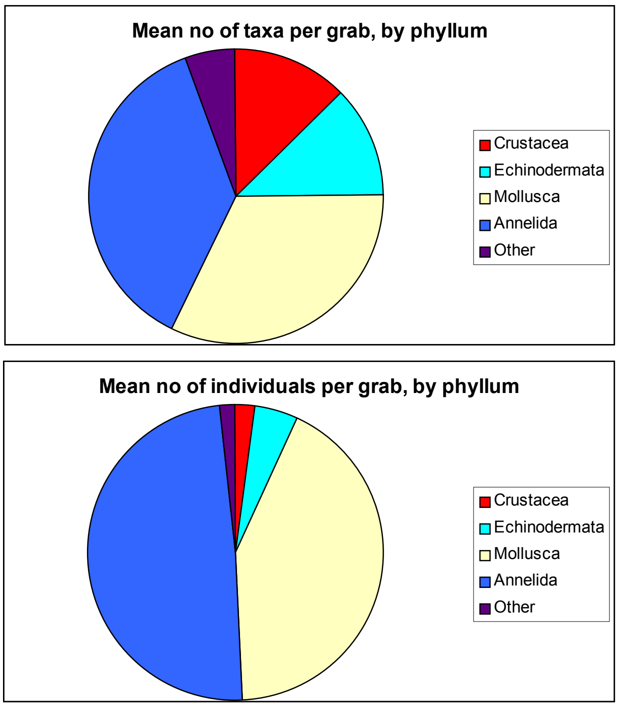

Figure 5.1: Numbers of taxa and individuals in Day Grab samples

A total of 91 taxa were recorded in the Day grab survey, of which 84 were identified to species. The infauna are strongly dominated, both taxonomically and numerically, by molluscs and polychaete worms (Figure 5.1). There are a number of crustacean species, mostly amphipods, all of which are present in only small numbers, usually in the cleaner sands.

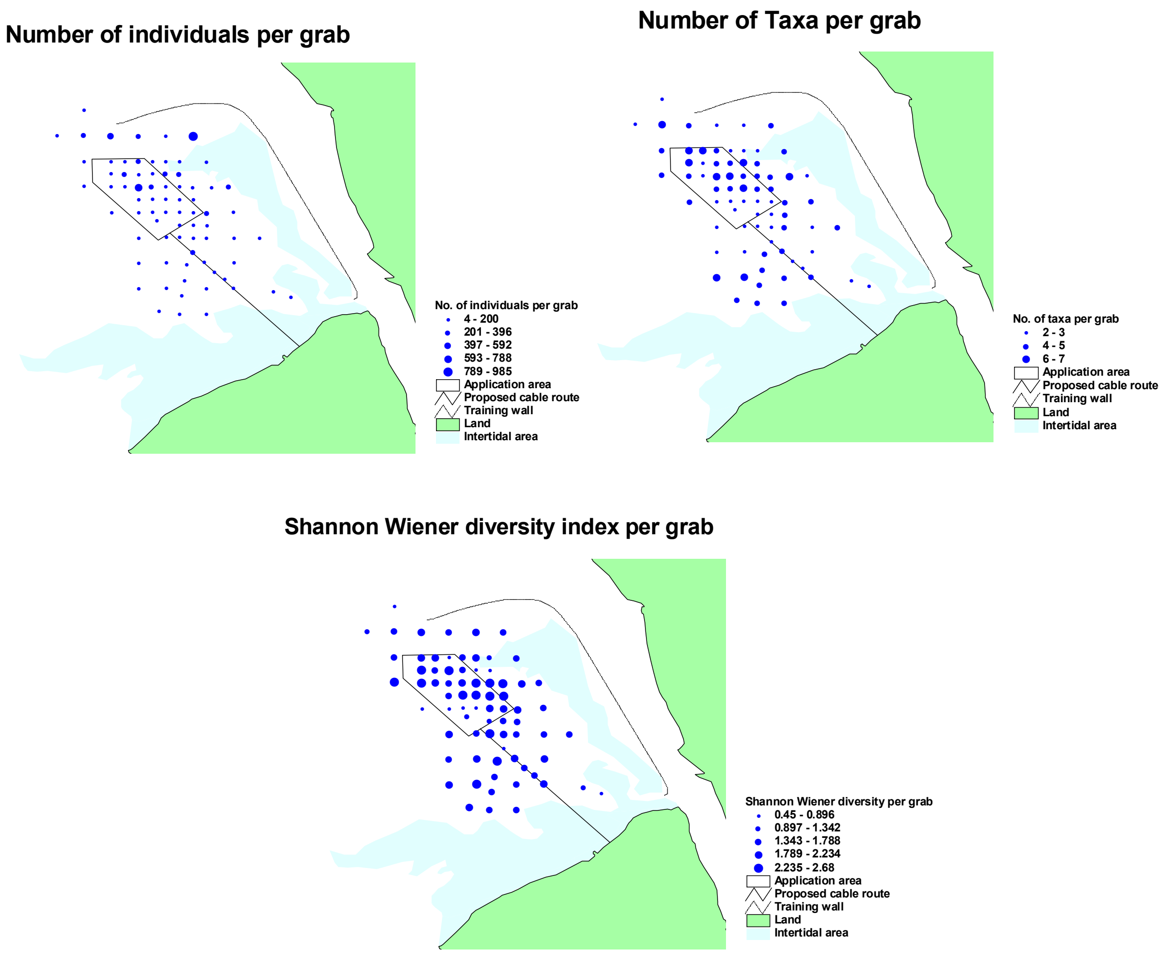

Figure 5.2: Numbers of taxa, individuals and Shannon Wiener diversity index in Day grab samples

In comparison with sites further offshore in Liverpool Bay (sampled and analysed using the same methods to this survey) the number of taxa found are consistently very low, at around 10 per grab, and with low standard deviations. Numbers of individuals are also low, but with larger standard deviations (although it is worth pointing out that the Burbo flats survey covers a relatively wide area). Shannon Wiener diversity index is again generally low (less than 2.5), as is usually the case in areas of shallow, moderately exposed sands. In contrast, Mackie et al. (1996) reported Shannon Wiener diversity indices well in excess of 6 in gravelly sites in the Southern Irish Sea (data from 2 pooled grabs, though diversity indices are relatively unaffected by sampling size) and relatively few sites with Shannon Wiener indices less than 3.5, though several of these were in shallow inshore areas. The richer site had an average of 145 taxa (pooled data from 2 grabs).

The number of taxa, number of individuals and diversity indices did not differ greatly between the application area and the proposed cable route. Analysis of replicate samples shows close similarities within specific sites throughout the study area.

There appears to be some relationship between sediment characteristics and taxonomic richness and diversity (Figure 5.2 below), although this is not a clear relationship. The slightly finer sands to the north of the application area appear to have increased richness and diversity, while the slightly muddier sands near the middle of the application area, where there was an enriched organic carbon content and in some cases also a increased stoniness, were of lower diversity. Correlation of invertebrate communities with environmental variables (see Marine Ecology Technical Appendix C) shows a strong influence of Total Organic Carbon (TOC) on community composition. TOC values recorded were very high, presumably due to the influence of the Mersey Estuary. However, TOC may be variable over time, which may explain the temporal variability in invertebrate communities reported previously (e.g. Eagle, 1973; 1975).

The eight most numerous taxa recorded account for 78% of the animals found. The dominant fauna are predominantly deposit feeders (the worms *Lagis koreni* and *Magelona johnstoni* – until recently always regarded as *Magelona mirabilis* - and bivalves *Abra* and *Fabulina*) or predatory worms (*Nephtys spp*, *Pholoe inornata, Eteone longa, Glycera tridactyla*). There are relatively few filter feeders in the area, though *Donax vittatus* probably relies mainly on filter feeding. There are at least two factors which could be influential in this regard; many filter feeding species, including many sponges, hydroids and bryozoans, might be affected by frequent episodes of high turbidity. Others (such as the soft coral *Alcyonium digitatum*, the dead man's fingers which was found occasionally in the beam trawls, barnacles, mussels and others) might be restricted by the lack of stable hard surfaces on which many filter feeders need to attach. It is worth noting that the filter feeding polychaete *Lanice conchilega* (sand mason), which is more tolerant of suspended sediments than many other filter feeders and does not require hard substrates, has been reported as being abundant slightly to the west of the survey area (Eagle, 1973) and was widespread on the lower shore near to the proposed cable route but was not found in offshore samples.

The distributions of eight of the most numerous taxa are variable but all of them were found in lower numbers in the muddier sands with the exception of the bivalve *Abra alba*, which is commonly associated with muddy sands. *Nephtys cirrosa* was widespread throughout but was more common in the shallower areas with clean sands. *Mysella bidentata* was also widespread but with a slightly deeper distribution. *Donax vittatus* appears to show a particularly clear preference for clean sands with low fines content.

Five individuals of the uncommon thumbnail crab *Thia scutellata* were found in very shallow water to the south of the survey area. These represent very low densities in comparison to areas further north in Liverpool Bay where densities can be at least twenty times higher (Holt and Shalla, 2001), but are comparable to the densities found in most other Irish sea populations (Rees, pers. com.). They were spread over a distance of at least 4km, outside of the Irish Sea distribution previously reported (Rees, 2000; Moore, 2001). The sediment with which they were associated seems to be somewhat finer than that which they are thought to prefer (Rees, 2000). Eagle (1975) who carried out surveys of this area in the 1970's did not record *Thia scutellata*. This raises the possibility that this species is subject to fluctuations in populations, as is found in many other species in these highly mobile sediments.

The information collected in the present survey was used to produce an indicative biotope map (Figure 5.3 below). The surveyed area, including much of the application area, is dominated largely by the IGS.FabMag biotope (*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, neither biotope is a particularly clear match with the relevant biotope descriptions. The northern edge of the survey area, together with a few other scattered stations, best matches the IGS.FabMag biotope (although it has finer sediment with very numerous *Mysella bidentata*, *Lagis koreni*, *Pholoe inornata*, *Amphiura brachiata* and some *Abra alba*, which give a poorer match with the biotope). Station 6 was species poor with a few *Macoma balthica*, and could arguably be described as IMS.MacAbr (*Macoma balthica* and *Abra alba* in infralittoral muddy sand).

The area of slightly muddy, organically enriched fine sand, sometimes with stones, in the south of the application area is characterised by the presence of quite high numbers of *Nephtys cirrosa* and *Nephtys hombergi, Phoronis muelleri, Pharus legumen, Mysella bidentata,* and *Pholoe inornata.* It arguably has some overlap with IGS.NcirBat but is much richer, and is best described as unclassified.

There is a small area in the deeper water to the west, outside of the application area, which equates roughly to CMS.AbrNucCor (*Abra alba*, *Nucula nitida* and *Corbula gibba* in circalittoral muddy sand or slightly mixed sediment), although this is based only on a single grab sample.

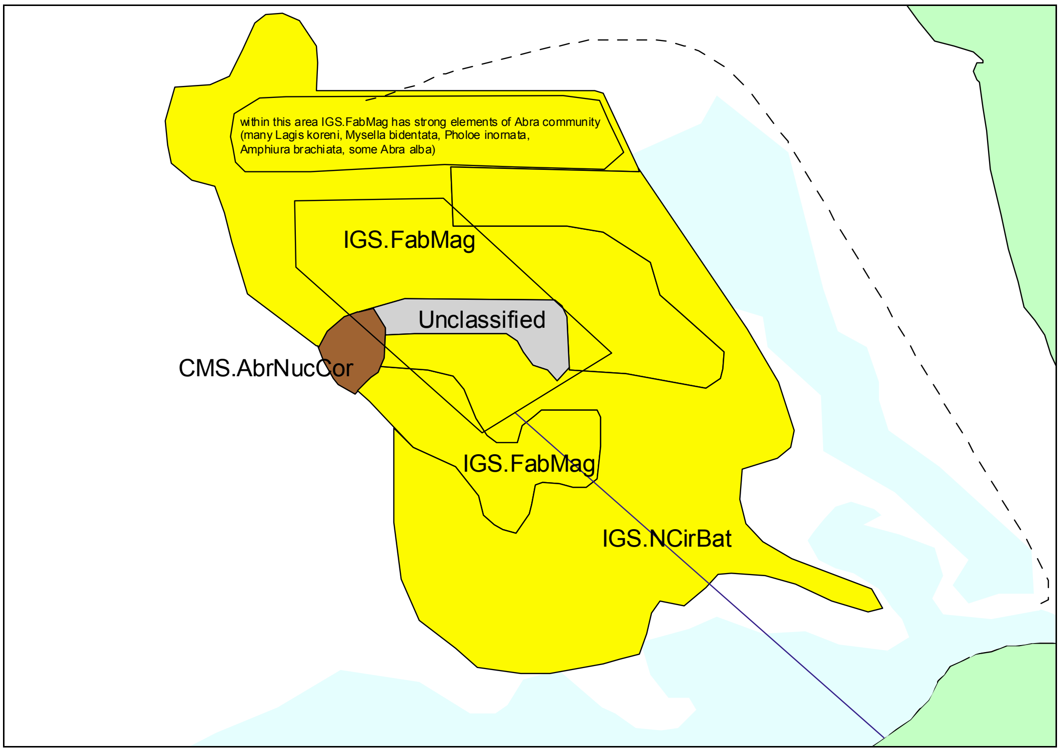

Figure 5.3: Indicative biotope map of the Burbo Flats area

IGS.FabMag	*Fabulina fabula* and *Magelona mirabilis* with venerid bivalves in infralittoral compacted fine sand
CMS.AbrNucCor	*Abra alba*, *Nucula nitida* and *Corbula gibba* in circalittoral muddy sand or slightly mixed sediment
IGS.NcirBat	*Nephtys cirrosa* and *Bathyporeia* spp in infralittoral sand
Unclassified	Some overlap with IGS.NcirBat but considerably richer, and characterised by the presence of quite high numbers of *Nephtys caeca* and *Nephtys hombergi, Phoronis muelleri, Pharus legumen, Mysella bidentata,* and *Pholoe inornata.*

5.2.1.1 Importance of Species and Communities found at Burbo Flats

The two main biotopes/communities described above as being representative of, or occurring within, the Burbo Flats area are important as a source of prey organisms for flatfish, and so are considered to be of at least Liverpool Bay level significance. The polychaete worms *Lagis koreni* and *Magelona mirabilis* (IGS.FabMag biotope) are known to be particularly important (Rees and Dare, 1993), while the siphons of bivalves are often nipped-off even if the whole bivalve is not eaten. Given the importance of Liverpool Bay as a flatfish nursery ground these communities are considered to be of importance at the level of the Irish Sea.

The thumbnail crab *Thia scutellata* is considered to be Nationally scarce. The population at Burbo Flats appears to be very small and localised in comparison with those further offshore in Liverpool Bay, but nevertheless it is considered potentially important at the level of UK waters. These levels of importance are summarised in Table 5.2.

Table 5.2: Importance of representative communities and selected benthic species from Burbo Flats.

Community/species	Level of importance	Justification and commentary
IGS.FabMag	Irish Sea	Provide important food items for fish, particularly juvenile flatfish
IGS.NCirBat	Liverpool Bay	Provide some important food items for fish, particularly juvenile flatfish.
Thumbnail crab *Thia scutellata*	UK waters	Nationally scarce.

5.2.1.2 Sensitivity of Species and Communities found at Burbo Flats

A number of workers including Rees et al., (1992) and Eagle, (1973; 1975) have shown that the muddy sand fauna (which they referred to as an *Abra* community) in the Burbo Bight area had dominant species that varied greatly between years. Factors such as the level of recruitment (especially of bivalves, which varies enormously from year to year), the degree of storminess and the level of bioturbation (reworking and loosening of the sediments by the infauna) and especially by high densities of *Lagis koreni* and *Abra alba*, are all probably very important factors affecting these changes. They are also capable of excavating themselves if lightly buried (Rees et al., 1993). Furthermore, in Liverpool Bay, *L. koreni* and *A. alba* in particular were thought to have been present at increased densities in the vicinity of large amounts of deposited dredged Mersey estuary sediments (Rees et al., 1993).

Also, many of the dominant species are known to be short lived. *Lagis* and *Abra* do not usually survive longer than one year, for example, and have other life history characteristics that are associated with species in unstable environments (Rees and Dare, 1993; Eagle, 1973; 1975).

Other important constituents of the IGS.FabMag biotope as found in the Burbo Flats surveys, including *Nephtys cirrosa*, *Magelona mirabilis*, and *Fabulina fabula* are also important in “infralittoral sands and gravels” as defined in Jones et al. (2000) and Elliot et al. (1998), which also includes biotopes such as IGS.NCir.Bat. It is widely accepted that these communities are also well adapted to high energy conditions and will tolerate changes such as sediment disturbance or increased turbidity relatively well (e.g. Kaiser and Spencer, 1996; Elliot et al., 1998; Jones et al., 2000).

Thus both the IGS.FabMag and the IGS.NcirBat would be expected to have a very low sensitivity to changes in sediment characteristics, light burial or increased suspended sediment due to sediment plumes.

The thumbnail crab *Thia scutellata* is known to have very specific requirements for sediment. It is therefore potentially sensitive to changes in sediment structure, including increases in fines sufficient to interfere with the free percolation of water through the sediment and hence interfere with its ability to respire.

5.2.2 Assessment of Environmental Impacts on Benthic Communities

5.2.2.1 Construction and Decommissioning

Habitat Disruption

Turbine Installation

The most immediate impact of construction on benthic communities would be habitat disturbance arising from the driving of piles (including disruption from the feet of jack-up barges used for piling operations), and any placement of scour protection around the bases of the turbines. Some additional minor effects may arise due, for example, to dropped construction materials and their recovery. The effects of cable laying operations, and permanent loss of seabed habitats, are discussed separately below**.**

The amount of total seabed, and extent of the individual invertebrate biotopes identified in the survey area, affected by these operations will be insignificant and all of the species found are common within the Liverpool Bay and wider Irish Sea, although the IGS.FabMag biotope is considered important as a fish feeding resource. The areas affected are presented in Table 5.3 below. The turbine supports are likely to be 4m in diameter, but for these calculations a 'worst case' value of 5m has been used. Scour protection is required over an area of 4-6 times the turbine support diameter, therefore a worst case of 30m diameter has been used in calculating the area covered by scour protection.

Table 5.3: Area of biotopes present that will be affected by construction activities (Km^2)

Activity	Biotope			Total
	IGS.FabMag	IGS.NcirBat	Unclassified	
Turbine Supports	0.0003	0.00008	0.00005	0.0004
Scour Protection	0.014	0.004	0.003	0.021
Jack-up Barge	0.002	0.0006	0.0003	0.0029
Total	**0.016**	**0.005**	**0.003**	**0.024**

The total area affected is in the order of less than 0.001% of Liverpool

Bay. The extent throughout Liverpool Bay of the biotopes identified within the survey area is not known. However, less than 0.7% of the **surveyed area** of each biotope would be directly affected by construction activities. Direct effects on habitat are therefore considered to be negligible and thus significance of impacts on the main communities will be negligible (IGS.NcirBat) or minor (IGS.FabMag).

The benthic communities present are all strongly dominated by infauna in sandy sediments with varying additional amounts of finer and coarser material. Some epifauna are also present, but these are a relatively minor component of the invertebrate communities found. Any fugitive arisings from piling operations (see Coastal Process Technical Appendix A) are expected to be rapidly dispersed by waves and tides. Moreover, the species present are adapted to high energy environments with mobile sediment conditions and the significance of these wider impacts would also be negligible (IGS.NcirBat) or minor (IGS.FabMag).

The uncommon thumbnail crab *Thia scutellata* was not found in the application area and will not be directly affected by windfarm construction activities. The significance of these potential impacts is therefore considered to be minor.

Cable Installation

The impact of cable laying will extend over ca. 14.5km of cable trenched into the turbine array area for interconnection of the turbines plus ca 3km of cable trenched (to include 3 cables) from the proposed wind farm to the lower shore, a total of around 17.5km.

It is expected that cables will be buried to a depth of 1m between the turbines and 1m from the wind farm to the landfall. Cable installation would principally be by plough (whereby a wedge of seabed is raised slightly, the cable inserted, and the sediment lowered back into place) or by jetting. Although the area of impact will be similar, localised invertebrate mortality along the proposed cable route will probably be higher with jetting, due to the greater amount of disturbance to the sediment, and in particular the likely exposure of many of the animals to predation. With burial by plough, impacts will arise from disturbance by the plough and from the skids upon which the plough will probably be carried (typically two skids, each 50 – 100 cm across). In the context of Liverpool Bay, only very small areas of seabed will be affected (estimated at less than $0.043km^2$ due to cable trenches and skids, or under 0.002% of the Liverpool Bay area; areas directly affected by jetting, if used, are assumed to be more or less similar). These impacts will also be a one off occurrence (in contrast to, for example, fishing by beam trawl, where impacts frequently recur in fished areas) and recovery of the fauna present is expected to be very rapid (possibly within a number of tides for some species which are able to migrate rapidly from adjacent sediments) Significance of the impacts is therefore negligible (IGS.NcirBat) or minor (IGS.FabMag).

There will be localised impacts on the thumbnail crab *Thia scutellata*, which lives buried just below the surface of the sand. In the case of plough burial, assuming a very unlikely worst case scenario in which all crabs over a 2 m swathe are killed, it is estimated that this would represent at most around 0.05% of the population present, which appears to be spread over a distance of at least 4km. This impact would therefore be of negligible magnitude, and significance of the impacts is therefore minor. In the case of jetting, it is possible that the sediment characteristics would locally (within a few metres) be changed sufficiently to impede re-colonisation. Nevertheless, the area affected would still be extremely small, the impacts negligible, and so the significance of the impacts would be minor.

Water Quality Changes

Suspended Sediment

Coastal process modelling has included the potential release of fine sediments into the water column with either drilling or piling of turbine supports and laying of cables. Some sediment is likely to be suspended in the water column as a result of the piling operations, but this is likely to be of very limited extent and of short duration (Coastal Processes Technical Appendix A). Similarly cable laying operations by plough are also likely to release only very small amounts of suspended sediments for a very limited duration (see Technical Appendix A). Given the relative insensitivity of the local benthos to such changes, impacts of these will be negligible.

Greater amounts of sediment would be released into the water column due to the scouring of sediments around the turbine support structures. Such release would occur until scour depressions had reached an equilibrium (up to a matter of days depending on current and wave conditions). This material would then settle out of suspension over high and low water periods.

Various scenarios for plume dispersion of the scoured material have been considered, with the most severe case being rapid scour across all the installed structures in response to a peak wave and tidal event. Under this scenario the largest amount of sediment is released in to the system in one go from each of the 30 turbine locations. This presents the upper limit of equilibrium scour development and the maximum quantity of sediment that could contribute to elevated levels of suspended sediments.

Result of this scenario indicate that fine sediments entering the River Mersey will make a marginal, short-term contribution, of around 30mg/l, to an already highly turbid environment (baseline conditions are generally in the region of 30-450mg/l at the surface and 70 to 1500mg/l near-bed). Fine sands would contribute a further 50mg/l to this environment, but this material will be dispersed closer to the seabed.

Outside of the Mersey Estuary, fine material (<63um) will be dispersed across the Burbo Flats area, with levels in the region of 18mg/l near surface and 50mg/l near-bed. These represent increases over 'average' baseline conditions of 55mg/l near surface and around 120mg/l near-bed. These elevations will occur over a matter of several days before deposition occurs. Deposition of material is predicted mainly to the north and west of the licence area and to the north of Hoylake. Levels of deposition of this fine material are up to 140g/m^2 in a few areas, and more usually less than 100g/m^2, this represents an average of under 1/10th mm depth of deposited material.

Transport of fine sand reaches levels approaching 50mg/l but only near-bed. Deposition of this material will occur rapidly and predictions indicate deposition of up to 140g/m^2 on the seabed, again equivalent to an average of less than 1/10th mm of deposition.

In relation to normal movement of sediments, this deposition of silt, clay and fine sand will represent a negligible increase in deposition over the area. However, deposition will not be uniform but will occur preferentially in depressions etc in the seabed. The significance of the impacts of increases in suspended sediments are therefore expected to be negligible (IGS.NcirBat) or minor (IGS.FabMag and Thumbnail crabs). Neither of these are therefore considered to be significant.

Remobilisation of Contaminants

The sediments on Burbo Flats are colonised by a faunal assemblage which, although possibly poorer in terms of species and individuals than sites further offshore, nevertheless supports communities typical of such habitats within shallower waters of Liverpool Bay. No groups were notably absent or impoverished as may be expected if contamination was having an adverse effects on invertebrate populations.

Corresponding with this, assessment of the likely effects of potential release of contaminants within the sediments has determined that there are no accumulations of persistent contaminants which were of concern in terms of remobilised sediments (Coastal Processes Technical Appendix A). A 'worst case' scenario assessment of dispersal of fine sediments (<63μm, which would contain the majority of contaminants present) shows that increases in suspended sediment levels would be low, and that these would be dispersed and deposited primarily in the Mersey Estuary and within the Burbo Flats area. These would not, therefore, in any way increase the levels of contaminants in areas of deposition or pose any significant risk to the invertebrate communities present.

Grouting (Chemicals)

The grout used will be cement which will have the effect of locally raising the pH. However, in view of the small amounts used, no effects on local benthic communities are envisaged.

Turnkey contractors will be appointed to carry out the installation of the turbines. Part of the contractor evaluation process will be the control exercised over environmental impacts during construction. With an appropriate Environmental Management Plan, there are expected to be no significant impacts from release of pollutants due to operation of plant and contractors activity.

Noise and Vibration

Evidence of noise and vibration related effects on invertebrates, fish eggs and larvae is restricted to the effects of very loud noise sources such as underwater explosions where the sound wave is of a destructive intensity. The only other noise sources of potentially harmful intensity are those produced by seismic investigations, which may have an impact within ten metres (McCauley, 1994; Brand and Wilson, 1996). This is a result of the fact that most invertebrates can only perceive the sound wave as a physical force.

Thus, apart from such seismic survey, and possibly extremely localised effects of pile driving, no adverse impacts on benthic invertebrates from construction-related noise and vibration are expected.

Scour and Sediment Redistribution

The turbine supports will inevitably cause local alterations of current velocity, which will result in increased erosional forces in certain areas around the structures, causing scour (if scour protection is not used). Studies of the likely scour surrounding the structures (including the effects of scour protection) indicate a probable area of impact of up to around 30 m in diameter. Finer sediments will be preferentially removed from these areas, leaving a much coarser sediment than previously, with a greater component of stones and shell fragments. This will affect the fauna able to colonise the sediment, but the exact nature of the faunal community will depend on both the composition of the sediment and its stability, as well as the suspended sediment regime.

Given the generally sandy nature of sediments in the area, areas subjected to scour would be dominated by assemblages of small numbers of crustaceans and polychaetes. In the event that the remaining substrate is quite stony, a relatively poor fauna, possibly dominated by scour tolerant encrusting organisms such as thin bryozoan crusts etc, would be expected to develop. However, if the sediment is more stable then there could be a richer and more diverse fauna. In the event that scour protection is used, then clearly a fauna different to that existing presently will develop. This is discussed below.

In either case, a good deal of uncertainty remains over the type of community which will occur, although it is likely that it will in at least some cases take weeks or months for the seabed to stabilise and probably considerably longer for the associated community to develop. It is possible that there will be zones of different physical and biological characteristics within a single scour depression, and that different scour depressions will have different characteristics. It is therefore possible that scour, with or without scour protection, will add slightly to the localised biodiversity of the area.

5.2.2.2 Operation

Permanent Loss of Seabed Habitat

The emplacement of the turbines will lead to the loss (subject to future decommissioning) of small areas of seabed habitat. As discussed below, additional hard-substrate habitat will be created by presence of turbine supports. The areas involved are summarised in Table 5.4 below (calculations of turbine support areas assume turbine supports of 5m diameter and scour protection over up to six times this area.

Table 5.4: Loss of seabed habitat (Km^2)

	Biotope			Hard substrate area
	IGS.FabMag	IGS.NcirBat	Unclassified	
Turbine Supports	0.0003	0.00008	0.00005	0.002
Scour Protection	0.014	0.004	0.003	0.02
Total	**0.014**	**0.004**	**0.003**	**0.022**

Total habitat areas are therefore largely unaffected. As discussed above, the effects of losses of existing habitat is considered negligible, and thus significance of impacts on the main communities will be negligible (IGS.NcirBat) or minor (IGS.FabMag).

Noise and Vibration

There is very little evidence to suggest that benthic invertebrates are able to perceive the noise and vibration produced by offshore wind farms (Vella et al., 2001) and, as discussed below, colonisation of turbines supports and other underwater structures by marine invertebrates and algae is a commonly observed phenomenon.

Colonisation of Structures

Colonisation of artificial structures by marine organisms is a widely reported phenomenon. Oil and gas drilling and production platforms in the Irish and North Seas, themselves subject to considerable levels of noise and vibration, are subject to colonisation by a diverse range of marine organisms including seaweeds, mussels, barnacles, tubeworms, hydroids, sponges, soft corals and other invertebrates (Vella et al., 2001). Monopiles at the Horn's Rev wind farm in Denmark were colonised by bryozoans, sea anemone, sea squirts, starfish and the common mussels *Mytilus edulis* within 5 months of its construction (Bio/consult, 2000 cited in Leonhard, 2000). More locally, studies of an anemometer mast off the North Wales coast have shown ready colonisation by large numbers of common mussel *Mytilus edulis,* dead-man's fingers *Alcyonium digitatum*, anemones of the family *Metridiidae*, seaweeds and barnacles, while the common starfish *Asterias rubens* was abundant on the seabed at the base of the mast.

Similar colonisation is expected to occur on the turbine support bases. However, as the turbines will also be physically scraped of encrusting organisms at intervals to reduce hydrodynamic drag, development of encrusting communities is likely to be arrested at the stage described above.

An epifaunal community is also likely to develop on the surface of any scour protection used. Furthermore the surface complexity, and the presence of nooks and crannies, etc. within scour protection (such as rock armour) will also greatly increase the attractiveness to colonising organisms (Pickering and Whitmarsh 1997; Hoffman et al. 2000). Highly complex structures provide a greater surface area and greater shelter from predators and from physical conditions such as water movement and light intensity. This allows a more diverse and dense assemblage, including organisms that are more fragile or light sensitive, to colonise an area from which they were previously absent. However, the nature of these communities will be influenced by, amongst other things, the size and stability of the rock armour, and is therefore difficult to predict. Smaller stones will presumably be turned more frequently during storms, and would be more likely to develop a scour tolerant fauna such as bryozoan crusts, while larger, more stable stones would probably support a greater diversity of organisms both on and between the rocks.

The overall effect of the turbines and scour protection will therefore be to replace the existing IGS.FabMag, IGS.NcirBat and unclassified biotopes with hard substrate communities. This will increase (albeit extremely locally) the overall species diversity. It is possible that there will also be a slight increase in the overall productivity of the area (Wickens and Barker, 1996; Grossman, et al*.* 1997) as the greater substrate area and colonising flora and fauna will attract various free-living invertebrates and small fish (such as pipefish and butterfish). Again though, these will be minor and localised effects.

Overall, each turbine would more than double the surface area available to invertebrate colonisation. The effect of the addition of the 30 proposed turbines would therefore be to slightly increase local species diversity and productivity.

Water Quality Changes

Changes to water quality could theoretically arise from abrasion of copper slip rings, erosion of anodes and any accidental spillages of material during maintenance.

Releases of copper from slip rings during operation of the windfarm on water quality are expected to be of negligible quantities, so that no significant changes to water quality is anticipated. Similarly, release of aluminium from sacrificial anodes is also expected to result in insignificant changes on water quality and consequently no impacts on benthos will occur.

As with construction activities, turnkey contractors will be appointed to carry out maintenance activities. The contractor evaluation process will again include the degree of control exercised over environmental impacts. An Environmental Management Plan will include specifications of measures to control slippage of material during maintenance activities.

If scour protection is used, changes to suspended sediments are unlikely to be significant, and impacts will be negligible. Significance of the impacts is therefore negligible (for the IGS.NcirBat biotope) or minor (for the IGS.FabMag biotope and for Thumbnail crabs).

5.2.2.3 Decommissioning

Should complete decommissioning of the wind farm be required, including removal of turbine supports and any scour protection material, then the support structures would either be physically pulled from the seabed or severed below the seabed. Scour protection may, or may not, need to be removed mechanically. Both activities would give rise to some noise and vibration impacts, but these would be significantly lower than those described above for construction-related impacts. The greatest effects of turbine and scour protection removal is likely to be the removal of colonising organisms, although, over time (given in-filling of turbine support holes, etc), a return to present conditions would occur without lasting impact.

The removal of scour protection material will also involve the removal of colonising organisms. The difficulty of recovering scattered rock material would also cause localised disturbance of the seabed. Given the localised increases in species diversity and possibly also productivity associated with the habitat provided by the scour protection, and the damage likely to result from its retrieval, removal of this is seen as a negative impact of medium magnitude. Although the significance of these impacts would be only minor, these would be easily avoided by leaving scour protection in place.

5.2.2.4 Cumulative Impacts

Cumulative effects are assessed here by combining the anticipated effects of all the known proposed wind farm developments in Liverpool Bay. These are Burbo (30 turbines), North Hoyle (30 turbines), Rhyl Flats (30 turbines), Shell Flats (90 turbines) and Southport (30 turbines).

As a result of the development of the above wind farms in Liverpool Bay, 0.17km^2 or 0.007% of available seabed habitat in Liverpool Bay would be lost. Because the Shallow Venus is widespread and common, the cumulative impact on benthos or loss of food resource are considered to be of ‘negligible’ magnitude and therefore not significant.

5.2.3 Mitigation Measures

No significant impacts on benthic communities in the Burbo Flats area are predicted as a result of construction or operation of the wind farm. No mitigation measures are therefore necessary. However, monitoring of benthic communities is proposed (see below).

On decommissioning, however, it is recommended that consideration be given to leaving any scour protection, if used, in place as a continuing habitat for colonising organisms and to prevent disturbance to the seabed if such material was removed. These issues would need to be balanced against possible benefits of removal such as increased ability to fish in the area subsequent to their removal.

5.2.4 Monitoring

Monitoring of benthic communities is proposed in order to confirm that any future changes in the communities are restricted to the immediate vicinity of the turbines. Monitoring of the populations of the thumbnail crab *Thia scutellata* will take place in the vicinity of the cable. Surveys of benthic invertebrate communities were carried out over a large area in April 2001 in order to describe and map these communities within and around the application area, including the proposed cable route. For this purpose single replicate samples at a high number of stations is the best survey method.

For future monitoring of these communities, however, it is more appropriate to take replicate samples at fewer sampling stations. This allows more accurate quantification of variability in the invertebrate communities present. As an indicative sampling protocol, around 20 stations would be chosen for future survey with three replicate grabs taken for analysis from each. Sites would be selected so as to provide information on:

- Changes in the vicinity of the turbines (as a result of changes to sediment composition and structure) and over the windfarm site.
- Changes in the major community types found, i.e. the IGS.NCirBat, IGS.FabMag and the presently unclassified muddier area in the survey area.
- Changes along the cable route including populations of the thumbnail crab *Thia scutellata*.
- Determination of far-field effects at control sites, as determined by the coastal process assessment.

The selection of suitable sites for ongoing monitoring would be based upon the information collected during the baseline survey carried out in 2001 and the precise wind farm layout and construction methodology (such as precise layout of scour protection, if required).

As wind farm construction is scheduled over the summer months, future monitoring would take place in late summer to coincide with the completion of construction. Monitoring would take place prior to construction, post-construction and for at least two years during the operational phase of the windfarm.

Colonisation of turbine support structures and scour protection would be determined by diver-operated video observations and analysis with some accompanying sample collection for verification of identification.

Monitoring work would be carried out in parallel with monitoring of sediments (as sediment structure and composition are critical in influencing benthic communities) and fish communities.

Monitoring of the cable route would extend into the intertidal zone and involve replication of the survey undertaken for this EIA.

5.3 Intertidal Ecology

5.3.1 Existing Environment

5.3.1.1 Coastal Habitats in the Study Area

Sandy Shores

Bassindale (1938) carried out surveys of the Mersey Estuary with several sample locations along the Wallasey foreshore. Within the North Bank area the shore was described as “sparsely inhabited sand”. Along the lower shore he noted a number of *Echinocardium cordatum* and *Lanice conchilega* although these were found to be more abundant to the west. The bivalve *Callista chione* was also found to be present, in some places alone, on the lower sand banks. Other species recorded on this stretch of shore included the bivalves *Macoma* sp., *Mactra corallina*, *Spisula solida* and the polychaete *Owenia* sp. *Corophium* were also noted in muddy areas towards East Hoyle Bank, although communities generally became less rich but more densely inhabited in this direction.

Bamber (1988) and Garwood and Foster-Smith (1991) investigated the sandy intertidal zone between Rhos-on-Sea and New Brigton (northern tip of the Wirral peninsula). Above the mid tide level on the open shore, the infauna was found to be dominated by the polychaete *Scolelepis squamata*, the amphipod *Bathyporeia pelagica* and the isopod *Eurydice pulchra*. Below the mid tide level, the shore was dominated by the polychaetes *Spio martinensis*, *Magelona mirabilis*, *Nephtys cirrosa*, *Lanice* *conchilega* and *Arenicola marina*. Artificial structures were encrusted by *Mytilus edulis*, *Elminius modestus* and *Semibalanus balanoides*. During August 2002, the BAP species *Sabellaria alveolata* was noted on some of the groynes off Wirral foreshore (Prof S J Hawkins, pers. com.).

Estuaries

The Eastern Irish Sea/Liverpool Bay coastline is characterised by a number of major estuaries, comprising over 1000km of the coastline north and east of the Great Orme. The main estuaries within Liverpool Bay are the Dee, Mersey and Ribble Estuaries (Davidson 1995). The saltmarshes in the Eastern Irish Sea are largely concentrated in the Dee and Ribble Estuaries, Morecambe Bay and the inner Solway Firth, with smaller pockets found in the Mersey, Clwyd and Duddon Estuaries (Hill, 1995). These comprise approximately 30% of the total British saltmarsh resource. Very small areas of saltmarsh are also present at the Alt Estuary.

The Dee, Mersey and Ribble Estuaries comprise much of the intertidal habitat (mudflat and sandflats exposed at low water) and almost all the saltmarsh within Liverpool Bay.

Mersey Estuary

The Mersey Estuary has been modified considerably by man’s activities. The estuary is retained within concrete banks at its mouth and enclosed on both sides by both industrial and urban development. There are numerous discharges of sewage and industrial waste into the estuary (Covey, 1988). Due to this extensive modification of the estuary a limited range of marine communities are present. The extensive mud flats of the inner estuary support faunal populations characterised by the estuary ragworm *Hediste diversicolor* and *oligochaete* worm communities, common to most estuaries in the region. At the mouth of the estuary, wave exposure and strong tidal streams have lead to the development of mobile banks of intertidal sediments that support burrowing amphipods such as *Bathyporeia pelagica* and *Nephtys cirrosa*, a polychaete worm.

Dee Estuary

The Dee estuary is one of the largest estuaries on the Eastern Irish Sea coastline. The intertidal habitats represented within the Dee estuary include sandy shores and mud flats, and saltmarsh. These habitats and associated species are discussed below.

Much of the Dee estuary is characterised by extensive intertidal flats of muddy fine sand with polychaetes such as the ragworm *Hediste diversicolor,* Baltic tellin *Macoma balthica*, peppery furrow shell *Scrobicularia plana* and the edible cockle *Cerastoderma edule.* Around the mouth of the estuary the biotope is of clean mobile sand with a sparse community of amphipods and polychaetes (LGS.S.AP.P). Sediments adjacent to Hilbre Island hold communities of the sand mason worm

Lanice conchilega (JNCC, 1998). There are also historical records of the honeycomb worm *Sabellaria alveolata* (a BAP species) at Hilbre although these have not been seen since early last century.

The intertidal rock of Hilbre Island and Little Hilbre supports the only littoral hard substratum communities within the estuary. Species include lichens, channelled wrack *Pelvetia canaliculata,* spiral wrack *Fucus spiralis,* bladder wrack *Fucus vesiculosus,* serrated wrack *Fucus serratus* and the edible mussel *Mytilus edilus* (JNCC, 1998).

Large areas of regionally significant saltmarsh have developed on the Dee Estuary, extending from Burton to Thurstaston with increasing populations of saltmarsh vegetation occupying the foreshores of Hoylake and West Kirby. There are also smaller salt marshes at Point of Ayr and Flint.

Alt Estuary

The Alt is a relatively small estuary, but is close to the application area. At the mouth of the Alt, small areas of freshwater marsh and saltmarsh are present, while the area south and east of the low water channel is characterised by muddier sand substrates than the Sefton coast area further to the north.

5.3.1.2 Survey Results and Community Classification

Intertidal Invertebrate Populations

Sediment Core Analysis

Intertidal sediments collected from the foreshore at Wallasey were analysed for invertebrate composition and particle size distributions. In general, species diversity was low. Eleven species were identified from the three shore heights, of which, a maximum of six were found together in any one sample. The amphipod *Bathyporeia pelagica* and the polychaete worm *Nephtys cirrosa* were the most commonly observed species on the upper and lower shores respectively. Another common species was the polychaete, *Scolelepis squamata,* which was observed in large numbers on the upper shore. Other species observed occasionally were the amphipod, *Haustorius arenarius*, the isopod *Eurydice pulchra*, the swimming crab *Liocarcinus depurator* and the sea potato *Echinocardium chordatum*. Three species of bivalve molluscs were also identified; the thin tellin *Angulus tenuis*, baltic tellin *Macoma bathica* and *Mysella bidenta*. Species diversity was patchy both from high to low water and across the shore.

The intertidal invertebrate species identified on the foreshore at Wallasey in May 2002 compare well with intertidal core analysis recorded by Bamber (1988) and Garwood and Foster-Smith (1991). These surveys highlighted 14 different species, of which, 11 species were the same as those identified in May 2002. Those species found in 1988/1991 that were absent from the foreshore in 2002 were only previously recorded in low numbers.

All the species identified are common in sand or muddy sand shores of the British Isles. Indeed, *Scolelepis squamata* and *Bathyporia pelagica* are characteristic of the upper and mid shore locally between Rhos-on-Sea and New Brighton whilst *Nephtys cirrosa* and sand mason worms, *Lanice conchilega* (not seen in cores but observed extensively on the lower shore) are characteristic of the lower shore in the area.

Habitat Mapping

Biotope mapping was carried out on the Wallasey foreshore in order to assess the distribution of biotope communities along the proposed cable route. Mapping was carried out in accordance with standard MNCR methodologies (Wyn et al., 2000). Full definitions of biotopes discussed in the text are also summarised below. Figure 5.4 below shows biotopes within the study area.

In general terms, the shore is dominated by fine, well-sorted sands that extend around 2km from the upper shore to low water. Some zonation is present, although the communities are quite patchy as a result of channels cutting into the shore and sandbanks creating raised, well-drained, areas.

In summary, biotopes (discussed in greater detail in the Marine Ecology Technical Appendix C) found during intertidal surveys of the Wallasey foreshore were typical of sandy shores along this section of coast. Species and communities found were similar to those described by Garwood and Foster-Smith (1991). Of the nine biotopes recorded, all except three were classed as Very Common or Common (see Table 5.5 and Figure 5.4 below). The three remaining biotopes are all classed as uncommon (LGS.S.Lan, LMS.BatCor and IMS.Ecor Ens).

Considering the highly mobile nature of intertidal sands in moderately exposed to exposed conditions, it is likely that the boundaries of the communities described above are constantly shifting. This was apparent from the differences in the distribution of channels as recorded on charts and as actually present on the shore during surveys.

Table 5.5: Summary of biotopes found in intertidal surveys

Shortcode	Longcode	Description	Frequency of occurrence in Britain
1	LR	Bare rock	N/A
2u	SLR.F.Fspi	*Fucus spiralis* on moderately exposed to very sheltered mid-eulittoral rock	Very common
4h	MLR.Eph.EntPor	*Porphyra purpurea* or *Enteromorpha* spp. on sand-scoured mid or lower eulittoral rock	Scarce
5e	ELR.MB.Bpat.Sem	*Semibalanus balanoides* on exposed or moderately exposed, or vertical sheltered, eulittoral rock	Very common
5g	ELR.MB.MytB	*Mytilus edulis* and *Fucus vesiculosus* on moderately exposed mid eulittoral rock	Common
13b	LGS.S.Bar.Snd	Barren coarse sand shores	Common
13c	LGS.S.Lan	Dense *Lanice conchilega* in tide-swept lower shore sand	Uncommon
13d	LGS.S.AEur	Burrowing amphipods and *Eurydice pulchra* in well-drained clean sand shores	Common
13g	LGS.S.AP.P	Burrowing amphipods and polychaetes (often *Arenicola marina*) in clean sand shores	Common
14a	IMS.EcorEns	*Echinocardium cordatum* and *Ensis* spp. in lower shore or shallow sublittoral muddy fine sand.	Uncommon
14c	LMS.BatCor	*Bathyporeia pilosa* and *Corophium* spp. in upper shore slightly muddy fine sand shores	Uncommon
15a	LMU.HedMac	*Hediste diversicolor*, *Macoma balthica* in sandy mud shores	Common

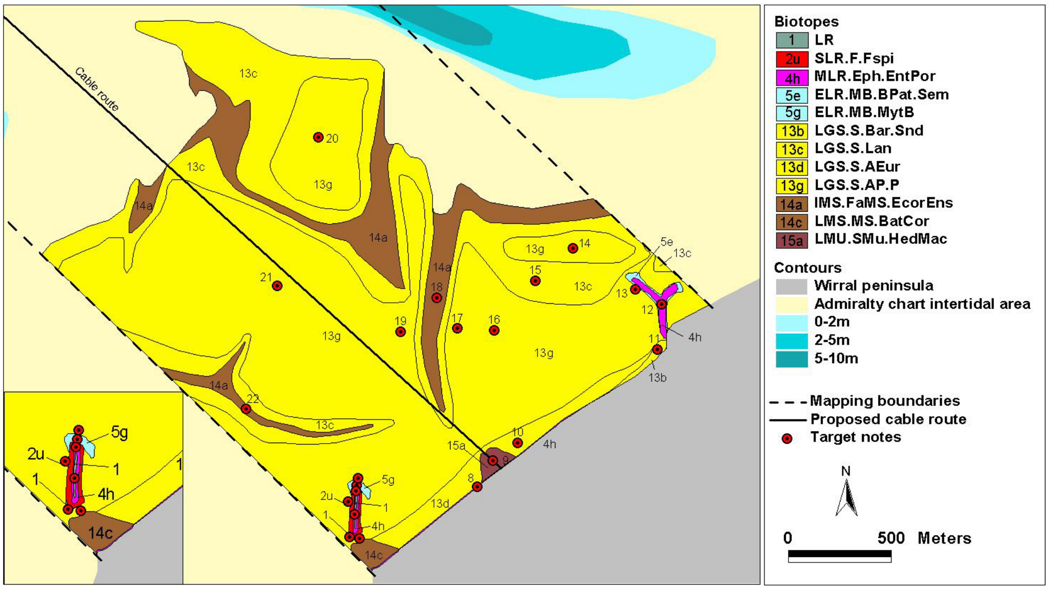

Figure 5.4: Distribution of biotopes on the Wallasey foreshore in vicinity of cable route.

5.3.2 Assessment of Environmental Impacts on Intertidal Ecology

5.3.2.1 Construction and Decommissioning

The New Brighton foreshore is a generally moderately exposed to exposed although some sheltered pockets of sediment do exist around the groyne structures on the mid-upper shore. Tidal currents are also strong in this region. The shore communities (generally well sorted fine sands dominated by amphipods and polychaetes) reflect this high degree of exposure.

The community types present tend to be widely distributed in the local area. This includes two of the uncommon biotopes, *Lanice conchilega* in tide-swept lower shore sand and *Echinocardium* and *Ensis* spp. in lower shore or shallow sublittoral muddy fine sand, which are both present over very large areas of the Wallasey foreshore and are known to occur along much of the coast from Wirral to Colwyn Bay (Mills, 1998). The other uncommon biotope, *Bathyporeia pilosa* and *Corophium spp.* in upper shore slightly muddy fine sand shores, is less widely distributed but does not lie in the direct route of the proposed cable.

The actual intertidal area that will be disturbed during trenching is around 0.005km^2. This is equal to 0.1% of the intertidal area surveyed on the Wallasey foreshore.

Following any disturbance to the shore that results in the depletion of populations it is likely that the area would be rapidly repopulated by polychaetes and amphipods many of which swim in high tides. Molluscs may take longer to re-colonise, although these do not appear to be present in high numbers in the area likely to be affected by trenching.

The shore is subject to frequent disturbance, reflected by the continual shifting of water channels and shore topography both through general tidal movements and storm conditions. It is therefore likely that the shore would recover rapidly from disturbance caused by trenching activities. This includes the scarce *Enteromorpha intestinalis* and *Porphyra purpurea* biotope, which favours habitats prone to significant disturbance.

The BAP species *Sabellaria alveolata*, a colonial tubeworm capable of forming reef like structures, although now present on some of the groynes on this foreshore, was not found on the groynes in the vicinity of the cable route. Moreover, this is a species which is dependent upon high levels of suspended sand in order to construct its tubes, and which can even tolerate short term burial. Cabling activities on the shore are not, therefore, expected to have any negative effects upon it, even if were to expand its range in future to include the groynes within the area of the cable route.

5.3.2.2 Operation

Change to Wave Dynamics (Exposure)

Changes to wave dynamics brought about by the presence of turbine structures may affect tidal streams and exposure on the New Brighton foreshore. Significant changes to tidal streams and/or exposure would have an effect on the sediment composition of the shore and consequently affect intertidal communities which are inherently linked to sediment composition. Coastal process modelling indicates a slight reduction (6% of baseline wave height) in a downwind direction of the wind farm. These impacts, however, do not extend to the adjacent coastline. No impacts would therefore arise.

Warming/Drying

Typically communities are representative of sediment type. This reflects the particle size composition, organic content and, in the case of the intertidal, water retention. Warming and drying of the sediment in the region of the cable may affect the nature of the sediment resulting in changes to the infauna communities.

The heating effect (at full usage) of the cable is expected to be around only 40 watts per m of cable, it seems unlikely therefore that any effect would extend more than a few tens of cm from the cable. As the cable will be buried to a depth of at least 1m, drying of surface sediments during low tide also seems extremely unlikely. The only possible exception to this might be at the very top of the shore in sand which may not be covered by the tide for periods of many days. However, here there tends to be very little life except when there has been a stranding of drift seaweed deposited on the surface of the beach. Even in this case, the heating and drying effect of the cable would be likely to be insignificant compared to a combination of wind and sun.

Significance of impacts from warming and drying effects of the cable is therefore expected to be insignificant.

Fish and Shellfish

5.3.3 Existing Environment

5.3.3.1 Abundance and Distribution

The Irish Sea in general, and Liverpool Bay in particular, support diverse marine communities including a number of ecologically and commercially important fish and shellfish species (Nash, 1990). Within Liverpool Bay, the Mersey, Dee and Ribble Estuaries also provide suitable conditions for estuarine and migratory (diadromous) species. The shallow inshore waters of Liverpool Bay are also important nursery grounds (and in some cases spawning grounds) for a number of species. Several rare and vagrant species are also reported in the area. These aspects of fish communities are considered here in terms of the Liverpool Bay area and Irish Sea.

The fish groups relevant to the report have been discussed under the following headings:

- Shellfish
- Demersal species (those associated with the seabed)
- Pelagic species (more free-swimming species)
- Elasmobranchs (sharks, skates and rays, particularly electrosensitive species)
- Migratory species (such as salmon, sea trout and eels)
- Rare and vagrant species

Shellfish

Of the shellfish species under consideration (cockle *Cerastoderma edule*, mussel *Mytilus edulis*, lobster *Homarus gammarus*, crab *Cancer pagurus* and whelk *Buccinum undatum*) only the brown shrimp *Crangon crangon* is considered to be of importance to the development. This species, although widespread throughout the Irish Sea, is abundant at the local scale and is likely to be important to the maintenance of trophic functioning.

Demersal Species

From general surveys of the Irish Sea, it is clear that habitats such as those found at Burbo Bank tend to be dominated by demersal species. Demersal fish include bottom-living and mid-water species that are closely associated with the seabed, such as flatfish species, whiting and cod.

Of the flatfish species, the most common within the Irish Sea are the plaice *Pleuronectes platessa* and dab *Limanda limanda* (Pawson and Robson, 1996). The Dover sole *Solea solea* is also generally widespread in the Irish Sea and has a similar lifestyle to plaice (Pawson and Robson, 1996). The flounder *Platichthys flesa* is more common in the eastern Irish Sea, but tend to be found in reduced salinity waters (Fox et al., 1997). A number of other flatfish such as the solenette *Buglossidium luteum*, scaldfish *Arnoglossus laterna* and lemon sole *Microtomus kitt* are commonly found in shallow waters around the Irish Sea.

Of the species discussed above, a number are commercially exploited in the eastern Irish Sea; cod, whiting, sole and plaice being the most important (see Commercial Fishery Technical Appendix D). All are subject to ICES Irish Sea Stock Assessments, but only plaice is considered to be within safe biological limits. Cod populations in particular have declined considerably over recent years, leading to the implementation of a cod recovery programme by the EU prohibiting cod fishing in the early part of the year in some areas of the Irish Sea. It is not thought that extensive exploitation of plaice, Dover sole, whiting or cod takes place in the proposed application area, although some fishing does take place off Rock Channel and Leasowe (Gray, 1995), mainly for sole, skate, plaice and brill. Demersal species taken as by-catch that are of commercial value are bib and dab.

A number of species that are of no direct commercial value also typically occur in the eastern Irish Sea, including the lesser weever *Echiichtys vipera*, the common goby *Pomatoschistus microps* and the sand goby *Pomatoschistus minutus*. These species, however, are important prey items to a number of directly valuable species including whiting, herring, codling, flatfish and bass (Potts and Swaby, 1993; Wheeler, 1969) and are of importance in the maintenance of trophic ecology. Both goby species are also protected under the Bern Convention Annex III.

To determine the fish communities present within the application and cable route area, a beam trawl survey was carried out at 15 sites in and around the application area using a 2m beam trawl as described in the Marine Ecology Technical Appendix C. This survey found the solenette *Buglossidium luteum* to be the most common demersal species, with a number of other flatfish species also present including (in order of abundance):

- dab *Limanda limanda*
- scaldfish *Arnoglossus laterna*

- Dover sole *Solea solea*
- plaice *Pleuronectes platessa*
- lemon sole *Microstomus kitt*
- flounder *Platichtys flesus*

As detailed above, many of these flatfish are important commercial species and are also significant in the functioning of the epibenthic community both as predators and prey (Rogers et al., 1998). Of the individuals caught only sole were regularly recorded as large specimens (some to 35 cm). Several dab were over 20 cm but all other fish caught were small specimens.

Other demersal species recorded included the lesser weever *Echiichtys vipera*, whiting *Merlangius merlangus*, pogge *Agonus cataphractus*, sand goby *Pomatoschistus minutus* and pipefish *Syngnathus* sp. Small numbers of the tub gurnard *Trigla lucerna*, red gurnard *Aspitrigla cuculus* and bib *Trisopterus luscus* were also present (a full species list is provided in the Marine Ecology Technical Appendix C).

Previous studies by Eagle (1973) and CEFAS indicate the presence of similar species to those found during the present study (September 2001 and April 2002), with varying proportions of dab, plaice, sole, whiting, lesser weever and dragonet. It is, however, apparent that there are fairly significant differences in the relative abundance of species between the different surveys, notably the solenette which was by far the most abundant species in April 2002 surveys but which was not noted in Eagle's surveys of 1971-1972. However, It is not unusual to find such differences in relative abundance of species between different surveys, especially when separated by several years and considering the highly mobile nature of fish, particularly non-flatfish species. These differences are further discussed in the Marine Ecology Technical Appendix C.

Pelagic Species

The most abundant pelagic species in the eastern Irish Sea are herring, sprat, mackerel, scad and sandeels. Pelagic species are free-swimming in the water column and are, therefore, less dependant on benthic habitats, although sandeels tend to bury themselves in coarse sand during the night and throughout the winter (Pawson and Robson, 1996). They also tend to be widely distributed.

Pelagic species, (including sandeels) tend to be severely under-represented in beam trawl surveys (tending to swim up and over the mouth of the net frame). Surveys did, however, show the lesser sandeel *Ammodytes tobianus* and the smooth sandeel *Hyperoplus lanceolatus* to be present in small numbers at a few sites within the proposed construction area (these all within the vicinity of the proposed cable route). Other pelagic species are also likely to be sporadically present in the area.

Community Characterisation

The demersal fish community present is typical of communities found throughout the eastern Irish Sea and Liverpool Bay and is classified as the Pleuronectes-Limanda assemblage according to Ellis et al. (2000). This community classification is dominated by flatfish including plaice *Pleuronectes platessa* and dab *Limanda limanda* along with the common starfish *Asterias rubens*, and discriminated from other assemblages by the presence of the hermit crab *Pagurus bernhardus*, the sand-star *Astropecten irregularis*, dab and the solenette *Buglossidium luteum*.

This community was found to be widely distributed throughout the inshore waters of the eastern Irish Sea by Ellis et al. (2000), including the Liverpool Bay area, generally grading to a community discriminated by the presence of *Microchirus* and *Pagurus* in deeper waters (waters of approximately >20m). The Pleuronectes-Limanda assemblage is also well represented in adjoining parts of the Irish Sea (Hillis and Grainger, 1990).

Elasmobranchs

Elasmobranchs are fish with a cartilaginous skeleton - sharks, skates and rays. Over the past few decades, elasmobranch species in general have suffered dramatic reductions in their numbers due to unregulated fishing and habitat degradation (Camhi et al., 1998). Low reproductive rates mean that populations cannot recruit individuals fast enough to replace those lost to fishing, pollution, etc. No elasmobranch species were found during the baseline surveys, although, thornback ray has been found in previous surveys (Eagle, 1973). One (unidentified) ray egg pouch was found during the April 2002 survey. Those species most likely to be present in the application area include the:

- lesser spotted dogfish *Scyliorhinus canicula*
- thornback ray *Raja clavata*
- spurdog *Squalus acanthias*
- tope *Galeorhinus galeus*

The basking shark *Cetorhinus maximus* is a seasonal visitor to the Irish Sea and is protected under National and International legislation. They are most commonly observed in the Irish Sea during the summer months when water temperatures increase. Most commonly, sightings are made in the inshore waters (<10km from the coast) to the south and south west of the Isle of Man. In these areas, sightings may number many hundreds per year (CMACS, 1998). Sightings of basking shark in the inshore waters to the east and south east of the Isle of Man are much fewer in number. For example, the Basking Shark Society holds records for four sightings in 1998, three in 1997, thirty three in 1996 and nine in 1995. The number of sightings in the eastern Irish Sea are very few indeed. The Basking Shark Society holds three records for sightings between 1996 and 1998, two of which are close to the Isle of Man, whilst the other record is for a sighting just north of the Ribble Estuary. There are no records for sightings in

Liverpool Bay.

Migratory Species

The migratory species that are likely to be present in the application area are the Atlantic salmon *Salmo salar*, the sea trout *Salmo trutta* and the European eel (*Anguilla anguilla*). Other migratory species are mainly associated with the Dee Estuary and are discussed under Rare and Vagrant Species below.

The Atlantic salmon *Salmo salar* is widely distributed throughout the UK and many of the rivers feeding the eastern Irish Sea, notably the River Dee. It is an anadramous species spending most of its life feeding at sea, migrating upstream to spawn (Mills, 1971). Salmon were reported by Potts and Swaby (1993) as only entering the Mersey occasionally as a stray and not surviving. However, salmon appear to be have been returning to the River Mersey recently with records of three salmon in 2001 and one so far in 2002, although there is no evidence of spawning taking place. It is hoped that improving environmental conditions will result in increasing numbers.

Salmon will drift back and forth on the tides within estuaries, waiting for appropriate conditions for upstream migrations, and are found throughout the year in lower parts of estuaries, but migrating upstream only from spring until early-winter. Although less is known of offshore movements of salmon, when offshore it is thought that smolt will stay close to the coast as they migrate west to Ireland and Greenland/Iceland (Moore et al., 1998; Moore and Potter, 1994).

The River Dee supports a significant salmon fishery with trammel and seine nets operating during the open season (June to August). A rod fishery also operates from March to October. Most significant net catches are made in July and August with high rod catches continuing in September after the net fishing season has closed. River Dee catches comprise over 50% net catches and around 9% of rod catches in the Welsh region (Environment Agency, 2000).

Information relating to salmon numbers is inferred from catch data, although these are inherently related to fishing effort. There were steady net catches from 1990-1999, although numbers dropped significantly in 2000. Rod catches are much lower and more variable, but recent catches have been generally low. Monitoring of the River Dee by a fish trap and fish counter shows particularly low returning stock levels in 1999 and 2000 (Environment Agency, 2000).

Declining Atlantic salmon numbers throughout the UK in recent years has not yet been related to specific factors. However, Aprahamian and Robson (1996) suggested that water abstraction resulting in the loss of habitat and spawning grounds, acid deposition, farming, forestry, waste water treatment and tidal barrages may result in the inability of migratory fish to pass through waters.

Salmo salar is protected under Annex III of the Bern Convention on the Conservation of European Wildlife and Natural Habitats (1979) but in freshwater only. A Final Salmon Action Plan has been completed for the River Dee (CEFAS and Environment Agency, 2002).

The sea trout *Salmo trutta* is present in rivers throughout the Irish Sea including the River Dee (Aprahamian and Robson, 1996). It was also recently introduced to a dock on the River Mersey (Potts and Swaby, 1993), although there are no reports of re-colonisation. The sea trout has a similar life-history to the salmon, spending most of its life feeding at sea and migrating upstream to spawn. Again, little is known of the movements of sea trout following downstream migration which are similar in timing to those of Atlantic salmon (Moore et al., 1998). However, although little information is available relating to sea trout occurrences in the River Mersey, sea trout are much more coastal than salmon, moving along the coast but not far from it (Moore and Potter, 1994; Mills, 1971) and are almost certain to remain in the Irish Sea to feed. It is possible, therefore, that Dee Estuary sea trout may feed in and around the application area.

No specific information relating to the catadramous European eel *Anguilla anguilla* is available, although they are likely to be present in all river systems in the area (Aprahamian and Robson, 1996). Eels have a complex life-history. Although never observed, it is thought that European eels spawn in the Sargasso Sea, the larvae drifting into the Gulf Stream and becoming widely distributed along the British coast. On reaching coastal waters an unknown proportion of elvers remain in estuarine and inshore waters while many migrate to freshwaters on increasing tides in April and May (Environment Agency, 2000b). Migration of adult eels between fresh and coastal marine waters is known to occur in both directions although the scale is unknown. Males mature after 7-12 years in freshwater, females between 9-16 years. Following maturity eels migrate west towards the Sargasso Sea, probably at depth.

The salmon, sea trout and European eel are all recognised under the UK Salmon and Freshwater Fishery Act (1975).

Rare and Vagrant Species

Species discussed here include migratory species associated with the River Dee that may pass through the application area but which will not be present in large numbers, and species that only rarely occur in the eastern Irish Sea and are outwith their normal range. These species include the:

- river lamprey or lampern *Lampetra fluviatilis*
- sea lamprey *Petromyzon marinus*
- smelt *Osmerus eperlanus*
- allis shad *Alosa alosa*
- twaite shad *Alosa fallax*

- sturgeon *Acipenser sturio*
- electric ray *Torpedo* sp.
- mako *Isurus oxyrincus*
- porbeagle *Lamna nasus*
- blue shark *Prionace glauca*
- thresher shark *Alopias vulpinus*
- pearlside *Maurolicus muelleri*
- opah *Lampris guttatus*
- trigger fish *Balistes carolinensis*
- sunfish *Mola mola*.

Further information on these species is provided in the Marine Ecology Technical Appendix C.

5.3.3.2 Fish Nursery and Spawning Grounds

Fox et al. (1997) provide general information on the distribution of main Irish Sea species with regard to spawning grounds and nursery areas. Although Fox et al. (1997) do not have a sampling site that directly coincides with the application area, the relative distribution in the main areas of the Irish Sea can be identified. Further information on juvenile fish grounds is available from juvenile fish surveys which were carried out specifically for the application area in 2001.

Spawning Grounds

The spawning grounds of fish species in the Liverpool Bay area (see Marine Ecology Technical Appendix C) appear to be widespread and not coincidental with the application area. However, for plaice the most prolific spawning ground appears to be in the eastern Irish Sea off the North Wales coast between Anglesey and Rhyl (Fox et al. 1997). This is of importance in terms of inshore nursery grounds in the Liverpool Bay area.

Nursery Grounds

The shallow sandy bays that exist around the inshore waters of the eastern Irish Sea are ideal nursery grounds for many species. As a result the Burbo Bank area may be more important as a nursery ground than for the adult species it supports.

In general terms, flatfish tend to have relatively well defined inshore nursery areas, while other species such as cod, mackerel and whiting spawn over wide areas offshore and have somewhat indistinct distributions of juvenile fish (Pawson and Robson, 1996). For this reason the Burbo Bank area is of greater relevance as a flatfish nursery ground.

Flatfish nursery grounds in the eastern Irish Sea are widely distributed, many flatfish species spending at least six months in coastal nursery grounds following metamorphosis, gradually moving offshore as they grow

(Amezcua, 2000). Adult fish generally live further offshore (Nash, 1990), although movement to and from spawning grounds can cause major changes in distribution during adult phase (Amezcua, 2000).

Following spawning, plaice juveniles aggregate on nursery grounds on suitable sandy stretches of coastline. This includes grounds throughout the eastern Irish Sea from the Mull of Galloway to the Anglesey (Pawson and Robson, 1996). Along the North Wales coast highest densities of 0-group plaice occur between Rhyl and Llandulas in water of around 2-10m depth (Rogers, 1993; Rogers, 1994). As plaice grow and move offshore distribution extends with 0-group, 1-group and 2-group plaice occurring in areas up to 20m and older fish coinciding with these areas and also extending to deeper waters (Symonds and Rogers, 1995). Highest densities of plaice larvae in this region were recorded in late May (Fox et al., 1997).

Dover sole and dab nursery grounds coincide with those used by plaice, and include much of the inshore sandy ground from the Anglesey to Morecambe Bay and the Solway Firth (Pawson and Robson, 1996). Riley et al. (1986) found higher densities of Dover sole around Colwyn Bay (between Great Orme and the River Dee) than areas to the north and east. Dab juveniles were found in Liverpool Bay from mid-March onwards, and throughout almost the whole of the eastern Irish Sea by late May, according to studies by Fox et al. (1997).

Flounder and bass juveniles are more closely associated with estuarine or riverine areas. In order to safeguard bass populations in UK waters, a number of restrictions are placed on fisheries, including minimum landing sizes, mesh size controls and prohibition of fishing in nursery areas for all or part of the year (MAFF and WOAD, 1990). In the River Dee restrictions cover all tidal waters enclosed by a line drawn 213^{o} true from Hilbre Point to Mostyn Quay.

Nursery grounds for some pelagic species are also present in inshore waters. Juveniles herring migrate from spawning grounds to the east of the Isle of Man to nursery grounds along the English coast from Great Orme Head to the Mull of Galloway, reaching them around November to February and onwards. Juvenile sprat (whitebait) are often found mixed with juvenile herring in inshore areas (Pawson and Robson, 1996).

Juvenile sandeel tend to be found inshore, including the intertidal and estuaries as well as offshore to a depth of 60m. Surveys of egg and larvae distributions in the Irish Sea by Fox et al. (1997) found larvae of sandeels close to the Irish Coast and Cardigan Bay during the early part to the year, with greater concentration found off County Down to Dublin, Cardigan Bay and the eastern Irish Sea in waters of <40m by mid-March. By May the concentration of larvae had declined off the Irish coast although numbers remained high throughout large areas of the eastern Irish Sea until the end of the surveys in June.

Juvenile fish surveys related to the Burbo Offshore Wind Farm development were carried out at New Brighton in September 2001. The species present were typical of sandy shores in the eastern Irish Sea and were dominated by juvenile plaice. The shrimp *Crangon crangon* (commonly found in similar environments to juvenile plaice) was also found in large numbers. The species present were typical of sandy shores in the eastern Irish Sea and were dominated by juvenile plaice. Plaice larvae settle from April onwards in such nursery grounds where they remain for a year or more before moving to deeper waters (Nash et al., 2001). The juvenile plaice captured were healthy and reasonably fast growing as would be expected during the early autumn, and generally in good condition. The results of the juvenile fish survey are provided in full in the Marine Ecology Technical Appendix C.

The results of the survey show the density of juvenile plaice at Wallasey to be particularly high compared to other sites in previous years. The Great Orme to Formby area is also seen to be important in terms of the eastern Irish Sea, but generally less so than Lynas Point to the Great Orme. Also, densities can change considerably on an inter-annual basis. In particular, a very strong recruitment is thought to have occurred in 2001. Nevertheless, the inshore area surrounding the application site appears to be a significant juvenile plaice nursery area.

In summary, Burbo Bank is not thought to be an area coinciding with significant spawning grounds, but is undoubtedly a highly important nursery ground for the plaice *Pleuronectes platessa* in a local and regional context, requiring careful consideration in this assessment. The area may also be used by other species including the dab *Limanda limanda*, flounder *Platichthys flesus*, sole *Solea solea* and solenette *Buglossidium luteum* although little information is available relating to the distribution of the latter. The whiting *Merlangius merlangus* may also use the area as a nursery ground to a lesser extent. Herring, sprat and sandeel nursery grounds are likely to coincide with the application area although grounds are widely distributed throughout the eastern Irish Sea.

5.3.3.3 Fish Feeding Resource

The application area is dominated by flatfish and demersal species. Distribution of these species is strongly correlated to seabed type, this determining the presence or absence of suitable prey species. The interrelationship between benthic invertebrates (studied by grab sampling in and around the application area) and fish communities is therefore important to the understanding of fish distributions.

Invertebrate species found in high densities during grab sampling included the trumpet work *Lagis koreni*, an important food-source for commercially important demersal fish, particularly dab and plaice to which it contributes 35% by weight to diet (seasonally averaged; Rees and Dare, 1993), and *Abra alba* a bivalve mollusc which was found to constitute 40% by weight of important food species of plaice (seasonally averaged) off the North

Wales coast (Basimi and Grove, 1985). *Asteria rubens* and *Echinocardium cordatum* are also known to be components of demersal fish diets including plaice (Rees and Dare, 1993) although their relative contribution is unknown. *Angulus tenuis,* found intertidally, is known to be an important food source to plaice in particular (Hayward et al., 1996) and is probably fed on by juvenile flatfish.

5.3.4 Description of Design Features to Avoid Environmental Impacts

The presence of cables and the electromagnetic fields that they generate, may produce responses in elasmobranchs. Electromagnetic fields effects will, however, be reduced through the insulation of cables. In addition, burial of electrical cables to a depth of 1-2m will reduce the potential for impacts on receptors.

5.3.5 Assessment of Environmental Impacts on Fish and Shellfish

This section details the potential effects of the construction, operation and decommissioning of the Burbo Bank wind farm in relation to the main groups of fish and shellfish and those key species present in the area.

Construction and Decommissioning

- Physiological and behavioural effects of underwater noise and vibration resulting from construction operations
- Changes to water quality through mobilisation and redistribution of sediment in the water column
- Changes to water quality through mobilisation of contaminants associated with surface sediments and other construction-related activities

Operational Effects

- Effects of electrical and magnetic fields in the vicinity of power cables on electrosensitive and migratory fish groups
- Physiological and behavioural effects of underwater noise and vibration resulting from turbine operation
- Indirect effects on fish of permanent changes in benthic habitat through changes in coastal processes

The evidence for impacts of offshore windfarm construction and operation is often relevant to groups of fish (with similar physiology), rather than being specific to all the sensitive species identified in the application area. For example, different groups of fish have different hearing capabilities. The assessments of each of the above potential effects therefore deals in many cases with impacts on such ‘groups’ of species.

5.3.5.1 Construction and Decommissioning

Noise and Vibration

The loudest noises produced during the construction period are likely to be associated with the installation of the turbine foundations by driven monopile. Pile driving will also be of most concern as it will be carried out fairly constantly over a three to four month period. This is, therefore, considered here in detail. All other noise produced during construction would be significantly lower than this. Intermittent noise associated with construction activities (vessel movements, seismic survey, piling etc) is generally low frequency in the range of several hertz (Hz) to 3000Hz (Vella et al. 2001). NB all sound levels given in this section are in decibels (dB) re: 1μPa -1m (units used in underwater sound) unless otherwise stated, whilst sound frequencies are given in hertz (Hz).

Available data on the noise generated during piling indicates a range of source sound levels from 135-145dB Moore et al. 1984 (cited in Richardson et al. 1995) to 225-236dB in the frequency range 130-150Hz (Ward and Healy, 2002). Taking the precautionary approach, and so a worst-case-scenario, the higher of these sound pressure levels will be used as an indication of noise levels generated by piling for the proposed Burbo Flats Wind Farm.

For comparison, the noises generated by other anthropogenic activities are given in Table 5.6 below.

Table 5.6: Noises generated by anthropogenic activities other than offshore wind farms

Anthropogenic noise source	Peak sound level at source (dB)	Dominant frequency(s) (Hz)
Seismic air-gun surveys	210 (average array)* 259 (large array)*	10-1000
5m Zodiac with an off-board motor	152 *	6300
Tug/barge travelling at 18km/hr	162 *	630
large tanker	177 *	100
Typical fishing vessel	150-160 **	-
Pile driving	135-145 * 225-236***	50-200 130-150

** Richardson* et al *(1995) ** Gulland and Walker (1998) *** Ward and Healy (2002)*

Noise Perception in Fish

Sound is perceived by fish through the ears and lateral line (the acoustico-lateralis system). The 'swimbladder', a gas filled sack located within the body of some species of fish, may also be utilised in the detection of sound. Groups that do not posses a swimbladder (and so, have lower hearing ability) include the flatfish and elasmobranchs (sharks and rays).

The acoustico-lateralis system is sensitive to the vibration, or particle displacement, component of a sound wave. The swimbladder however, is sensitive to the pressure component of a sound wave, which it resonates as a signal that stimulates the ears (Hawkins, 1983).

The vibration and pressure components of the sound signal both change with distance from the noise source. This is most apparent when fish move across the near-field:far-field boundary. In the near-field, vibration akin to hydrodynamic flows is the stimulus detected by fish (Jobling, 1995). This field extends one wavelength of the sound frequency from its source and is of particular importance to fish as it is used to detect the motion of predators and prey. Taking the pile driving example given above, noise generated at frequencies between 130-150Hz (Ward and Healy, 2002) would generate near-fields extending some 11-13m out from the noise source (13m refers to a sound frequency of 130Hz).

The far field extends from one wavelength outwards. Unlike the near-field, pressure is the prevailing component of the sound wave, and thus, fish species that can detect pressure and vibration stimuli are generally considered to be more sensitive to underwater noise. Noise sensitive species include the herring and cod fish (clupeids and gadoids respectively). However, there is a degree of variation in noise-sensitive species based on the degree of association between swimbladder and ears; the greater the association, the more noise-sensitive the species.

Fish are generally sensitive to noises within the frequency range of <1Hz to 3000Hz. Within this range, however, it is reported that fish only respond consistently to very low frequency, or very high frequency noises (Knudsen et al. 1992, 1994; Nestler et al. 1992). Sounds in the range of 50 to 2000Hz, such as the peak sound levels produced by many anthropogenic activities, only produce short-term startle response at the outset of sound production with subsequent habituation to noise (Knudsen et al. 1992, 1994; Westerberg, 1999).

Hearing thresholds are defined at three different levels (Knudsen, 1992):

- *Absolute hearing threshold* - are established under controlled laboratory conditions in the absence of any masking noises, the absolute threshold refers to the minimum sound levels required at a specific frequency for the sound to be heard.
- *Awareness reaction threshold* - the sound level, in the presence of masking sounds, at which there is a spontaneous, physiological response (such as an increase in heart beat or temporary threshold shift in hearing). The awareness threshold is usually considerably above the absolute threshold.
- *Avoidance response threshold* - the threshold at which a fish first shows an avoidance reaction. This is generally well above the absolute hearing threshold.

Thus, when assessing the potential effects of noise upon the hearing of fish, sound levels of between 75 and 85 dB above the absolute hearing threshold are generally required for a temporary threshold shift in a hearing sensitive species (where a temporary threshold shift is an elevation in the absolute auditory threshold) whilst received noise levels of approximately 180dB are required to produce a strong avoidance or alarm response in hearing sensitive species such cod (Chapman and Hawkins, 1969; Pearson et al. 1992).

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 there absolute hearing threshold to display a behavioural reaction (salmon are discussed in more detail below). However, noise levels at or above the awareness reaction thresholds have the potential to impact on fish. 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 in the minnow species *Pimephales promelas,* which has very sensitive hearing. Scholik and Yan further report that temporary threshold shifts vary by species, distance from a sound source, intensity of the sound source and frequency of the sound source. In addition, depth, water temperature and salinity also influence threshold shifts.

Noise-Sensitive Species

Several ‘hearing specialists’ such as whiting and the shore rockling *Gaidropsarus mediterraneus*, gadoids (cod family) and herring clupeids have been recorded in the Study Area. Other species such as the allis and twaite shad (herring-like fish) are reported to be present in the nearby Dee Estuary.

The absolute hearing threshold of the cod (for which data is available) between 100 to 200Hz is approximately 75dB. This is assumed to be indicative of other hearing sensitive species found in the area such as the whiting.

Sound levels of 223-236dB generated during pile driving will attenuate to levels of 180-185dB within tens of metres of piling activity as a result of multi-mode interference found at short ranges (Ward and Healy, 2002). This will stimulate an immediate startle reaction, as discussed above, in any fish that are close to the turbine being driven into the seabed. Following the startle reaction, fish are likely to increase swimming speeds away from the source of noise generation. In addition, a sound levels of 180dB is approximately 20 to 30dB above the awareness reaction threshold and thus, hearing-sensitive fish in close proximity to the piling may be subject to temporary threshold shifts. For example, at a distance of 10m from the pile and with source levels of 236dB fish would receive a temporary threshold shift within 3.5 seconds, whilst at a distance of 1000m (1km) there may be a temporary threshold shift if fish were to stay at that distance for 8 hours (ERM, 2002). A 'soft start-up' of piling activities would reduce the impact of potential shifts in hearing thresholds. This is considered in more detail under mitigation. However, it should be noted that source sound levels of 223-236dB will only be generated as the turbine foundations are driven into the top layers of the seabed - with increasing depth into the seabed, there will be a reduction in sound level generated as much of the sound energy produced through piling is directed downwards into the seabed.

The impact of noise generated from pile driving on hearing-sensitive fish is likely to be immediate startle-responses in fish that are close to the turbine. This will be followed by avoidance of the area over the duration of noise generation. The area fish will avoid is likely to be around 1000m. Within this area, fish may or may not be subject to temporary or permanent threshold shifts depending on species and individual tolerance, distance from the piling location and the depth of the turbine in the seabed. A 'soft start-up' of piling will help reduce impacts on fish in close proximity to the turbine being driven into the seabed at the start of each activity period. The magnitude of noise and vibration impacts is therefore considered to be ‘low’ as no important populations of hearing-sensitive species are present in the Burbo Flats area, and so, impacts would not be significant.

Less Noise-Sensitive Species

Flatfish such as the solenette *Buglossidium luteum,* plaice *Plueronectes platessa* and dab *Limanda limanda* are commercially important and occur in large numbers in and around the application area. This group of fish lack a swimbladder and thus, are only likely to be sensitive to sound in the near-field and the absolute hearing threshold of these species tends to be 20 to 30dB above that of more noise-sensitive species (Hawkins, 1993). Accordingly, any impacts on these species will be considerably lower than on hearing-specialists. Elasmobranchs such as the lesser spotted dogfish *Scyliorhinus caniculus* and commercially important (and declining) thornback ray, will show a similar reaction to flatfish. These species will show short-term changes in behaviour and avoidance of the relatively small near-field area (for example, 13m at 130Hz) around the turbine location(s) at which piling is taking place over the duration of noise generation. Whilst some species within these groups are considered to be of ‘high’ *sensitivity* as a result of their commercial and conservation interests, the *magnitude* of impacts is therefore ‘low’ as impacts are confined to a restricted area and are short-term. Impacts would therefore not be significant.

Migratory Species

The River Mersey, adjacent to the proposed wind farm, does not support significant salmon or sea trout populations. However, the Dee Estuary to the south west of the proposed wind farm is know to support significant populations of both salmonids. Thus, the construction of the proposed wind farm may impact on salmonids moving into or out of the Dee Estuary. These Salmonids are of commercial interest and are protected under

National and International legislation.

The impact of noise and vibration on salmonids will follow a similar pattern to that of flatfish. Salmon are sensitive to noise in the frequency range between <1 - 300Hz (Hawkins and Johnstone 1978). Maximum sensitivity is found at 150Hz with an absolute hearing threshold of 100dB.

Awareness reaction and avoidance response thresholds have been established for salmonids through investigation of the use of low-frequency sounds as a fish deterrent. 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 (some 70 to 80dB above the absolute threshold). Knudsen et al. (1992) further report that the avoidance response threshold in the marine/freshwater environment was not apparent at 150Hz, even at received sound levels of greater than 200dB. Sand et al. (2001) report similar results in the riverine environment where salmon showed no observable reaction to *received* sound levels of 214dB at 150Hz. These levels far exceed the noise that would be generated during piling.

Hawkins and Johnstone (1978) conclude that the swimbladder plays no part in the hearing of the salmon. On this basis, the noise generated during construction of the proposed Burbo Flats wind farm would not impinge on salmonids. Further evidence of this lack of reaction to noise includes Feist et al. (1996) who demonstrated that marine piling only affect the behaviour of salmonids within a radius of 600 meters of the sound source, and Anderson (1992) who reports similar results, but adds that apparent habituation to piling was observed almost immediately. While the sensitivity of salmonids is ‘high’ due to their protected status and commercial importance, the magnitude of these impacts would therefore be ‘negligible’, and so would not be significant.

Sea and river lamprey (also reported from the Dee Estuary) both lack a swimbladder and thus, will only be susceptible to noise and vibration in the near-field. Considering that this is such a small area (for example, 13m at 130Hz), the magnitude of impacts is considered to be ‘negligible’.

Studies of the impacts of an operating windfarm on the European eel *Anguila anguila* have shown it to be relatively insensitive to the noise generated by offshore wind farms (Westerberg, 1999) and so, the magnitude of impacts is considered to be ‘negligible’.

The noise generated during decommissioning is likely to be of similar frequency to that generated during construction. However, it is unlikely to contain sound pressure levels in the region produced by activities such as piling and thus, impacts would be less than during construction.

A further impact may be the disruption of fish which may have accumulated around the turbine foundations as fish aggregating devices. However, fish would redistribute themselves rapidly, and the magnitude of such impacts is considered to be ‘negligible’ and thus, not significant.

Changes in Water Quality

Suspended Sediments

During construction and decommissioning works increased sediment loading from pile driving and cable trenching may cause mobilisation of fine sediments. Sediment scour around the piles could also add to suspended sediment plumes, often over a relatively rapid period, if scour protection were not used. Surveys have shown that the seabed in the area of the proposed development is mainly composed of sand, with a relatively low fine particle component (the more easily transported fraction).

However, sediment loads in the application area are naturally high. Burbo Bank lies at the mouth of the River Mersey which has a high natural turbidity, particularly during storm conditions, when significant quantities of sediment are disturbed from the seabed and retained in the water column. In addition dredge and spoil disposal grounds have been used in Liverpool Bay for disposal of maintenance and capital dredgings since 1959 (sewage sludge disposal was phased out in 1998). The closest of these to the application area (IS 140) is approximately 10km to the west of the development area boundary. Large quantities of maintenance and capital dredgings have also been deposited at this site (2,425,000 wet tonnes – 1996; 2,090,000 wet tonnes – 1997) (BHP Billiton Petroleum Ltd., 2001).

Consequently sediment suspension is likely to be of minor importance in relation to existing, turbid, conditions in the area. Relative quantities of mobilised fine sediment will therefore, be insignificant.

The primary effect of increased sediment suspension appears to be an increased ability of prey species to avoid predators and a resulting reduction of food intake by predatory species (Cole et al., 1999; Blaber and Blaber, 1980). Different species of fish show considerable variation in their tolerance of suspended sediment loads, although it has been suggested that levels of 14g/l and higher have a physiological effect on fish (Cyrus and Blaber, 1987). As the levels of suspended sediment required to exert lethal impacts are several orders of magnitude higher than elevated levels likely around Burbo Flats, impacts will be negligible.

Re-Suspension of Pollutants

As detailed above for potential impacts on benthic invertebrate communities, it is not anticipated that there will be any significant impact resulting from re-suspension of pollutants (see Coastal Processes Technical Appendix A).

Grouting

Grouting, carried out in the placement of turbines on the seabed will raise pH of the surrounding water. However, considering the small quantities that are likely to be used and the extent of tidal flushing and seawater buffering, no significant impacts on water quality or fish species will arise.

Sediment Redistribution – Scour, Change to Currents and Suspended Sediment Settling

As described above, scour may take place surrounding the turbine support structures, resulting in winnowing of finer sediments with sediments becoming coarser, with a greater component of stones and shell fragments as a result. Sediment is an important factor in the distribution of demersal fish species, particularly juvenile nursery grounds. Plaice juveniles, which are the most common juvenile fish species in the inshore areas, and sand eels, an important prey species, have a preference for coarser, sandy substrate. Given this preference, and the extremely small areas affected by potential scouring (0.004% of available habitat on the coast between the Great Orme and Formby Point). Impacts will not be significant.

Loss of habitat for sole, which prefer finer sediments than are generally present in the survey area, would also not be significant, this species being found in deeper waters and towards the west of the application area in the region of Colwyn Bay.

Changes to Food Resource

A number of important prey species were identified in benthic invertebrate surveys, including *Lagis koreni*, *Abra alba*, *Asteria rubens* and *Echinocardium cordatum*. All of these species were widespread throughout the surveys. As detailed in the assessment of impacts on benthic invertebrates, it is not anticipated that construction will affect benthic food resources except on a very localised scale (e.g. directly below the turbines).

However, during construction it is predicted that avoidance of the area by some fish species, including species such as sandeels and gobies, will occur due to impacts of noise and vibration and possibly also suspended sediments. As these are important prey items for a number of pelagic fish, demersal fish and bird species, it is possible that predatory species may move to adjoining areas to feed. The nature of this impact is, however, temporary and highly localised (in the order of 1km around the piling operation), with fish species expected to redistribute in the application area and the proposed cable route following construction.

5.3.5.2 Operation

Electromagnetic Field (EMF) Effects

Electromagnetic fields, produced by electrical cabling both between turbines and from the wind farm to the shore, may affect fish species by:

- Influencing electrosensitive species such as sharks, skates and rays, via passive reception of low-frequency voltage gradients
- Interfering with the Earth's natural magnetic field, used in navigation by many migratory species such as salmon, eels, and elasmobranchs (Bullock, 1973; Kalmijn, 1982)

Although the electric fields produced by undersea cables are traditionally considered to be negligible, Gill and Taylor (2001) demonstrated that even relatively small emissions can be detected by benthic elasmobranchs species found in UK waters. Therefore, there exists the potential for electrosensitive species to detect and respond to the electromagnetic fields produced by offshore power installations.

Predicted Electromagnetic Fields (EMF)

The individual turbines will be connected together by 33kV triple core XPLE cable. The connection between the wind farm and the nearest suitable sub-station at Wallasey will be made by three separate 33kV cables. The Horns Rev wind farm in Denmark has been used as an example of the predicted EMF emissions (Gill and Taylor, 2001), although this used a single 150kV connection to land that would exert a greater effect. Finite element numerical analysis based on Maxwell's equations for electric fields and their mutual coupling was used to predict the electric fields emitted at Horns Rev. Based on this modelling, from which it is predicted that the 150Kv cable would produce an emission of 10μV/cm through an unburied 3-core cable.

However, cables used at Burbo Flats would be rated at a much lower voltage (33kV rather than 150kV) and would be buried between turbines and from the windfarm to shore at depths of approximately 1-2m.

Potential Impacts on Electrosensitive Species

The species most likely to detect electromagnetic fields are those electrosensitive species that typically inhabit the benthic zone, either throughout, or at some stage in their life history. Benthic species present in the area include the thornback ray *Raja clavata* and the lesser-spotted dogfish *Scyliorhinus caniculus.* Pelagic species which are found in deeper waters and at higher levels in the water column would be much less affected, if at all. The basking shark *Cetorhinus maximus* is known to visit shallow bays to feed on planktonic organisms in the upper water column, but records of the basking shark in the area of the Burbo Flats are few if any, and thus they are unlikely to be affected by electromagnetic fields generated by the wind farm cables.

With the cable specifications outlined above, electrical fields significantly lower than 10μV/cm would occur adjacent to the cable with significant dissipation either side over a distance of metres, to tens of metres, of seabed. The main impacts to be considered are as follows.

Firstly, some benthic elasmobranchs may avoid electric fields at 10μV/cm. Gill and Taylor (2001) suggest that benthic elasmobranchs may actively avoid the electric fields predicted to emanate from undersea cables at a distance of approximately 20cm from the source. With the lower rating of cables used, and burial of cables, such avoidance impacts would not arise along the cable routes.

Secondly, individuals may be attracted to electric fields of approximately 0.1μV/cm, which are similar to the bioelectric field emitted by prey species and so the electric field emitted may act as an attractant to some elasmobranchs over distances of possibly several metres. However, following initial attraction, individuals would be expected to move away when no prey species are found. There is, also, no evidence to suggest that attraction to electric fields would have a detrimental effect on fish at individual or population levels.

The sensitivity of benthic elasmobranchs is 'high' due to their commercial value and their declining populations. Impacts of EMF are expected to be of 'low' magnitude, and thus, moderate significance, which is not considered significant in terms of the EIA regulations.

Effects of Magnetic Fields

The current industry standard cable specifications will reduce the potential magnetic fields to very low levels. Although elasmobranchs and migratory teleosts, such as salmonids and anguillid eels navigate by geomagnetic fields, the localisation and low level of the magnetic fields emitted would be below naturally occurring fields. Furthermore, olfaction (smell) is the main sense used in migration once salmonids reach coastal waters. No adverse effects on migration due to magnetic fields would therefore occur. Thus, whilst sensitivity of migratory species is 'high' due to the commercial value and National/International protection afforded to salmonids, the magnitude of impacts is 'negligible', and so, impacts are not significant.

Noise and Vibration

Recently, measurement of underwater noise has been undertaken at three Scandinavian offshore wind farms (Henriksen et al. 2001) whilst the turbines were both operating and idle and whilst the turbines were operating under different wind speeds. The results obtained are presented in Table 5.7 below (for comparison, these sound levels are similar to offshore oil and gas drilling platforms and considerably less than the noise generated by most boats and ships).

Table 5.7 Underwater noise generated at Middlegrunden, Vindeby and Bockstigen-Valar: peak source levels and frequencies (Henriksen et al. 2001)

Turbine Type	Wind speed (m/s)	source level (dB re: 1 µPa^2/Hz)	* Noise frequency (Hz)
Middlegrunden, Denmark Twenty 2 MW 'Bonus' turbines concrete foundation	13 6 6	115 101 111	125 125 25
Bockstigen-Valar, Sweden Five 0.55 MW 'Windworld' turbines steel monopile turbine supports	8 8	108 108	160 16
Vindeby, Denmark Eleven 0.45 MW 'Bonus' turbine concrete foundation	13 13	113 130	125 25

** Noise frequencies given are the centre frequencies of 1/3-octave bands.*

These results are comparable, though slightly higher, than predicted noise levels from a proposed UK windfarm of between 2.5 to 5 MW turbines (ERM, 2002) for which, peak source sound levels of 98.5dB at 400Hz were predicted.

The proposed Burbo Flats wind farm will employ 2.5 MW turbines. In the absence of more monitoring data, and following the precautionary principle, we have therefore assumed that the noise produced by operating turbines at Burbo Flats would be in the range of 98-130dB at frequencies between 25-400Hz.

Impact of Noise and Vibration on Species Recorded in the Study Area

As described above, the hearing-specialist species present in the study area (such as whiting and shore rockling) are assumed to have maximum sensitivity between 100-150Hz and an absolute hearing threshold of 75-80dB (Hawkins, 1993). The noise generated by operating turbines immediately adjacent to the turbines will be 35-40dB above their absolute threshold in this range and, as discussed earlier, sound levels generally need to be 75-85dB above the absolute threshold for a temporary threshold shift. Therefore, it is very unlikely that there will be any impacts on hearing apparatus.

The hearing threshold at which fish show behavioural reactions is generally well above the absolute hearing threshold (as discussed above) and it is reported that received noise levels of 180dB are required to produce a strong avoidance or alarm response in herring and cod (Pearson et al. 1992). Noise levels of 180dB are considerably louder than the likely noise that will be generated by the proposed windfarm. Furthermore, gadoids have been documented to tolerate noisy underwater structures such as oil drilling platforms (Valdemarsen, 1979). Investigations at the Svante Wind Farm, Sweden, have shown numbers of cod in close vicinity to an operating turbine to be greater than in the surrounding open waters, although lower than when the turbines are not operating (Westerberg, 1999). This presumably reflects habituation to a continuous noise stimulus and/or tolerance in light of benefits provided by the turbine foundation. Therefore, whilst this suggests that hearing specialists such as the cod, whiting and shad may show some behavioural reaction to the noise generated by the proposed wind farm, such species have been shown to readily habituate to/tolerate, and accumulate around such structures.

Within the near-field, wind farm turbines will produce noise and vibration stimuli that will be perceived by fish as hydrodynamic motion. However, Hoffman et al. (2000) report that the low-frequency hydrodynamic/acoustic fields generated by turbines will be perceived very differently by fish from fields generated by other animals, and thus, fish in the near-field will not be impaired in their ability to detect and interpret fields from different sources such as predators or prey.

In summary, the immediate impact of noise and vibration from a 'starting-up' wind farm is likely to induce some startle responses in species with good hearing capabilities. This may be accompanied by short-term avoidance reactions followed by general habituation to the continuous noise generated by the operating turbines. The hydrodynamic/acoustic fields generated within the near-field would not impair the ability of fish to detect and interpret fields from different sources.

The presence of Nationally/Internationally protected and ecologically and commercially important species gives an overall ‘high’ sensitivity for fish species. However, the magnitude of noise and vibration impacts is considered to be ‘low’ and any impacts would not be significant.

Direct Loss of Benthic Habitat

The installation of turbines on the seabed, with a ‘worst case’ assumption of scour protection to a diameter of 30m, will result in the direct and permanent loss of habitat at a total area of around 0.02km^2.

As discussed under construction related impacts, the proportion of this area lost by the proposed development would, therefore, account for 0.004% of available fish nursery habitat on this section of coast, or 0.2% of the application area.

The impact to fish species is therefore considered negligible in terms of the regional and Burbo Flats area.

Creation of New Habitat

It has long been known that fish tend to aggregate around objects placed in the sea. As a result of this association, the phenomenon has been widely used in the development of fish aggregating devices (FADs). However, the attraction of fish to objects such as artificial reefs is poorly understood. It is postulated that fish are attracted to submerged objects because they provide shelter from currents and wave action, safety from predators and food resources associated with the invertebrate organisms that colonise submerged objects. Surface complexity is also considered to be a factor in the attractiveness of submerged artificial structures (Wickens and Baker, 1996) as its increase the number of available micro niches, and so, the use of scour protection is likely to increase the attractiveness of the turbine foundations.

Artificial reefs and FADs are currently being used in North America and extensively in the Far East as a fisheries technique for both fin and shell-fisheries (Hernkind et al., 1997, MSC, 2000). Several studies have demonstrated that biomass is greater on vertical artificial reefs than on natural reefs and it has been postulated that this difference is due to vertical structures being more attractive to fish for settlement and recruitment than moderately sloped natural reefs (Rilov and Benayahu, 2000). Such an effect would therefore occur with turbine support structures.

Increases in catch-per-unit-effort (CPUE) are documented for fish assemblages on artificial reefs in Southern California (Ambrose and Swarbrick, 1989). At present, no fishing exclusion zone is proposed for the Burbo Offshore Wind Farm, although for safety and practical reasons fishermen are not expected to trawl (the main fishing method used in the area) or gill-net close to the turbines. Fish attracted to the turbines are, therefore, unlikely to be more vulnerable to fishing practices.

Different fish species have different affinities to submarine structures and these affinities may change during their lifecycle. Whilst the majority of the fish species present in the Burbo Flats area are not true reef-dwelling species, some groups present are known to be attracted to such structures. These include the gadoids such as whiting (which are found in relatively large numbers in the baseline survey) and cod. Flatfish such as plaice are also attracted to artificial reefs although it is believed that they visit reefs primarily to forage (Hoffman et al., 2000). Some reef-dwelling species found in rocky substrate areas to the south of Burbo Flats around the mouth of the Dee Estuary may also colonise these new structures however, thereby increasing local population sizes.

Thus, it is likely that fish may be attracted to the proposed windfarm, although the actual size of the total fish populations in the area may not necessarily increase. Rather, the congregations of fish around the proposed wind farm would represent a small redistribution of the existing populations in the area. The attraction of the wind farm to fish may be most apparent during stormy conditions as the turbines and any scour depressions are likely to absorb and disperse the incident energy and create a relatively calm area within and immediately leeward of the windfarm.

The overall magnitude of such an impact would therefore be potentially beneficial, but low.

5.3.5.3 Cumulative Impacts

Combined Noise Effects on Fish Species

The use of similar technology by wind farm developers should mean that the noise generated by turbines of the five proposed wind farms would be similar to those discussed in this E.S. Given this assumption the following cumulative impacts are considered.

The noise generated by an operating wind farm will be below levels reported to produce a temporary threshold shift, or strong startle response in noise-sensitive species. Less noise-sensitive species may only be aware of the turbines within metres of them and, thus, two wind farms next to each other will not have a cumulative effect.

Whilst the noise generated by construction activities will cause short-term avoidance of wind farm sites, the impacts associated with the construction period are unlikely to have a cumulative affect as a result of the differing timescales under which construction of the sites will take place.

Combined Electromagnetic Field (EMF) Effects on Elasmobranchs

In relation to the Burbo Offshore Wind Farm, EMF effects are considered to be extremely localised and, with the adoption of mitigation measures such as cable burial and insulation, of ‘negligible’ magnitude. However, there is at present a lack of substantive quantifiable evidence related to the absolute impact of electric cables on elasmobranchs. There is therefore a degree of uncertainty in determining the combined effect that cabling associated with all five wind farm developments could have on elasmobranch populations in Liverpool Bay.

Assessment of EMF effects, however, is now the subject of a generic study coordinated by COWRIE (a research group set up by the Crown Estate). The initial phase of this study will seek to determine EMF associated with cables. Future stages are expected to look in more detail at EMF/elasmobranch interactions.

A summary of impacts on fish associated with development of the proposed wind farm is provided in Table 5.8 below.

Table 5.8: Summary of Environmental Impacts on Fish (assuming scour protection is used)

Species	Level of importance	Scale of impact				
		Construction				
		Suspended sediment	Noise and vibration	Resuspension of pollutants	Grouting	Changes to food resource
Brown shrimp	Liverpool Bay	Negligible	Negligible	Negligible	Negligible	Negligible
Plaice	Irish Sea	Low[1]	Low	Negligible	Negligible	Negligible
Dab	Irish Sea	Low[1]	Low	Negligible	Negligible	Negligible
Sole	Irish Sea	Low[1]	Low	Negligible	Negligible	Negligible
Solenette	Liverpool Bay	Negligible	Low	Negligible	Negligible	Negligible
Flounder	Liverpool Bay	Low[1]	Low	Negligible	Negligible	Negligible
Sprat	Liverpool Bay	Low[1]	Low	Negligible	Negligible	Negligible
Whiting	Liverpool Bay	Negligible	Low	Negligible	Negligible	Negligible
Sandeel	Liverpool Bay	Low[1]	Low	Negligible	Negligible	Negligible
Sand goby	Liverpool Bay	Negligible	Low	Negligible	Negligible	Negligible
Salmon	UK	Negligible	Negligible	Negligible	Negligible	Negligible
Sea Trout	UK	Negligible	Negligible	Negligible	Negligible	Negligible
Basking Shark	UK	Negligible	Negligible	Negligible	Negligible	Negligible
Lesser spotted dog fish	Liverpool Bay	Negligible	Negligible	Negligible	Negligible	Negligible
Thornback Ray	Irish Sea	Negligible	Negligible	Negligible	Negligible	Negligible

Species	Level of importance	Scale of impact					Magnitude of significance	Significance of impact
		Operation						
		Noise and vibration	Sediment redistribution	Direct loss of habitat	Direct loss of water column habitat	Creation of new habitat		
Brown shrimp	Liverpool Bay	Negligible	Negligible	Negligible	Negligible	Positive[3]	Negligible	Minor
Plaice	Irish Sea	Low	Positive[2]	Negligible	Negligible	Positive[3]	Low	Minor
Dab	Irish Sea	Low	Negligible	Negligible	Negligible	Positive[3]	Low	Minor
Sole	Irish Sea	Low	Negligible	Negligible	Negligible	Positive[3]	Low	Minor
Solenette	Liverpool Bay	Low	Negligible	Negligible	Negligible	Positive[3]	Negligible	Negligible
Flounder	Liverpool Bay	Low	Negligible	Negligible	Negligible	Positive[3]	Low	Minor
Sprat	Liverpool Bay	Low	Negligible	Negligible	Negligible	Positive[3]	Low	Minor
Whiting	Liverpool Bay	Low	Negligible	Negligible	Negligible	Positive[3]	Negligible	Negligible
Sandeel	Liverpool Bay	Low	Negligible	Negligible	Negligible	Positive[3]	Negligible	Negligible
Sand goby	Liverpool Bay	Low	Negligible	Negligible	Negligible	Positive[3]	Negligible	Negligible
Salmon	UK	Negligible	Negligible	Negligible	Negligible	Positive[3]	Negligible	Minor
Sea Trout	UK	Negligible	Negligible	Negligible	Negligible	Positive[3]	Negligible	Minor
Basking Shark	UK	Negligible	Negligible	Negligible	Negligible	Positive[3]	Negligible	Negligible
Lesser spotted dog fish	Liverpool Bay	Negligible	Negligible	Negligible	Negligible	Positive[3]	Negligible	Negligible
Thornback Ray	Irish Sea	Negligible	Negligible	Negligible	Negligible	Positive[3]	Negligible	Minor

[1] Relating specifically to juveniles.
[2] Possible that scour may provide additional habitat for plaice juveniles.
[3] A low positive impact

5.3.6 Mitigation

A soft-start procedure should be instigated during pile driving activities and defined by an Environmental Management Plan for the works. This will reduce the impact of the initial noise levels generated on any fish in very close proximity to piling at their start-up. If the hammering of the pile is slowly increased, fish will be able to move to a distance away from the activity at which noise levels are acceptable. This soft-start procedure should be carried out over a sufficient time period to allow fish to move away from the general area and should be carried out at the start of each activity period.

Furthermore, should piling involve the installation of more than one turbine foundation at a time, piling should be carried out in as restricted an area as is possible. This would reduce the area from which fish could be excluded. Again, this should be carried out as defined by an Environmental Management Plan.

Electromagnetic field effects will be reduced through the insulation of cables and secure earthing at both joints. In addition, burial of electrical cables to a depth of 1-2m will reduce the potential for impacts on fish.

5.3.7 Monitoring

5.3.7.1 Possible Changes to Sediment Composition and Distribution

Impacts to fish populations resulting from possible changes to sediment characteristics (by turbine construction and cable laying) would be monitored. Post-construction beam trawls would be carried out at the same time as grab sampling (for sediments and invertebrates) and results of these integrated in future monitoring reports. Monitoring proposals would be discussed with fishermen’s organisations prior to commencement.

5.3.7.2 The Role of Turbines as Fish Aggregating Devices (FADs)

Locations will be identified in order to assess fish densities at set distances and direction from the turbines. Consideration will be given to use of additional sampling methods such as fish traps or set nets as well as beam trawls.

5.3.7.3 Changes in Abundance of Noise Sensitive Species

Beam trawl and mid-water trawl surveys carried out to assess the role of turbines as FADs will be related to preliminary monitoring of noise levels to assess possible changes in distribution of noise-sensitive species. The windfarm site should also be made available, if required, for future generic studies on noise and vibration.

5.3.7.4 Changes in Abundance of Electrosensitive Species

Considering the limited availability of information relating to electrosensitive species in relation to cables, in particular the thornback ray, beam trawls surveys would be carried out in the vicinity of the cable route. Statistical analysis of fishery catches in the area over time should also be considered. A 'generic' industry-wide study should also be considered as discussed above. The windfarm site should also be made available, if required, for future generic studies on EMF emissions and impacts.

5.3.7.5 Predicted Impacts of Disturbance to Fish Species during Construction

Fish surveys carried out post construction would allow the assessment of disturbance to fish during installation of turbines and cable laying.

5.4 Marine Mammals

5.4.1 Existing Environment

Marine mammals present in UK waters comprise cetaceans (whales and dolphins), pinnipeds (true seals, eared seals and walrus) and the otter. Of these only certain species of cetaceans and pinnipeds are found within the general area of the proposed development. These are considered below.

The order Cetacea is divided into two sub-orders; the odontocetes and the mysticetes. The odontocete or toothed whales is the sub-order to which the dolphin and porpoise belong. These animals are generally smaller and have adapted the use of very high frequency sounds such as echolocation in communication, orientation and feeding. Odontocete cetaceans are more common in shallow coastal waters.

The mysticetes, or baleen whales, are large oceanic whales that have adapted to the use of low-frequency sounds to communicate over long distances. Members of this sub-order include the minke whale *Balaenoptera acutorostrata*.

The northern Irish Sea and Liverpool Bay is not rich in marine mammals compared with other areas of Britain. Indeed, the SCANS project, an International investigation co-ordinated by the Sea Mammal Research Unit (SMRU) in 1994 to estimate small cetacean abundance in the North Sea, Baltic and waters around the UK, did not survey the northern Irish Sea due to the fact that numbers are considered so low. As a result of this, there is very little data on population sizes of cetaceans that visit the Irish Sea. A similar picture exists for pinniped species in the Irish Sea.

Some qualitative, rather than quantitative data does exist for the general area of the north eastern Irish Sea in the form of sightings databases. Data from sightings programs is inevitably difficult to interpret, but does provide a good indication of the species that are present in, or visit, an area.

Sightings in Liverpool Bay and the northern Irish Sea are generally reported to the Sea Watch Foundation. This sightings program holds data between 1973 and 2002 with the majority of data relating to the last fifteen years when more dedicated searches have been carried out (Evans, 1998a). This data has been considered together with Sea Watch Foundation 'abundance' plots for the northern Irish Sea.

Species Recorded and Conservation Status

The cetacean and pinniped species recorded in Liverpool Bay and the northern Irish Sea, and their conservation status, are given below.

Cetaceans

Fifteen species of cetaceans have been recorded in the northern Irish Sea, within 60km of the coast, since 1975 (Evans, 1996, Sea Watch, unpublished data). Table 5.9 below shows the six species that are present throughout the year, or recorded annually as seasonal visitors.

Table 5.9: Cetacean species present throughout the year in the Northern Irish Sea or recorded annually as seasonal visitors

Odontocetes	Mysticetes
• harbour porpoise *Phocoena phocoena* • bottlenose dolphin *Tursiops truncatus* • common dolphin *Delphinus delphis* • Risso's dolphin *Grampus griseus*	• minke whale *Balaenoptera acutorostrata* • long-finned pilot whale *Globicephala melas*

The other nine species, listed in Table 5.10 below, have only been recorded casually in the region:

Table 5.10: Cetacean species recorded casually in the Northern Irish Sea

Odontocetes	Mysticetes
• 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* • sei whale *Balaenoptera borealis*

The harbour porpoise (odontocete cetaceans) is the most commonly observed species in Liverpool Bay. The ecology and distributions of the most common and/or representative of these species (habour porpoise, bottlenose dolphin, common dolphin and minke whale) is provided in the Marine Ecology Technical Appendix C.

Protection is given to all cetaceans species in UK waters through Section 9 of the Wildlife and Countryside Act 1981. This act prohibits the deliberate killing, injuring or disturbance of any cetacean species. Protection of cetaceans in European waters is also afforded to them through Article 12 of the EC Habitats Directive (92/43/EEC), implemented by The Conservation (Natural Habitats, etc.) Regulations 1994. In addition to this, 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. These include the requirement that the signatories "work towards....the prevention of...disturbance, especially of an acoustic nature".

All cetacean species found in UK waters are considered to be of high sensitivity due to the National and International protection afforded to each.

Pinnipeds

Two species of seal (pinnipeds) are found in the northern Irish Sea; the common/harbour seal *Phoca vitulina* and the grey seal *Halichoerus grypus.*

Both common and grey seals are protected under the UK's Conservation of Seals Act (1970) and Annex II of the E.C. Habitats Directive (1992/43/EEC).

Accordingly, common and grey seal are also considered to be of high sensitivity due to the National and International protection afforded to each.

The ecology and distributions of these species is provided in the Marine Ecology Technical Appendix C.

5.4.2 Assessment of Environmental Impacts on Marine Mammals

Due to their high degree of mobility and sensory awareness, impacts on marine mammals will be restricted to disturbance due to noise and human activity during construction, noise generated by operation of the wind farm and tropho-dynamic affects due to changes in prey populations.

5.4.2.1 Construction and Decommissioning

Due to the similarity of the processes involved, decommissioning being essentially construction in reverse, the effects of these are considered here together.

Noise Source Levels

The loudest noises produced during the construction period are likely to be associated with the installation of the turbine foundations by driven monopile. Pile driving will also be of most concern as it will be carried out fairly constantly over a three to four month period. This is, therefore, considered here in detail. All other noise produced during construction would be significantly lower than this.

The noise generated by construction activities is discussed under impacts on fish above. Briefly, the loudest noises generated during construction would be those associated with pile driving and seismic surveys. Pile driving may generate noise levels in the range of <150dB to approximately 236dB at source (i.e. in the location of the piling). Seismic survey produce low frequency sounds with source levels of 210dB to 259dB (Richardson et al*.* 1995). The majority of sound energy produced during both seismic surveys and pile driving is below 1,000Hz (Moore and Ljungblad, 1984, Richardson et al*.*, 1995, Ward and Healy, 2002). Note: all sound levels given in this section are levels at the source of sound generation and with reference to 1µPa -1m (the units used in underwater measurements) unless otherwise stated.

Noise and Vibration

The harbour porpoise is the most frequently observed cetacean species in Liverpool Bay. They are recorded throughout the year, with the largest number of sightings made between May and September. However, it should be noted that whilst this species is the most frequently observed, numbers are very low in the east of Liverpool Bay. As information on the auditory sensitivity is also available for this species, this is considered here in detail.

In general, small cetaceans have poor hearing at low frequencies (Vella et al*.* 2001). The hearing range of the harbour porpoise (the species most commonly sighted in Liverpool Bay), ranges from 1kHz (1,000Hz) to 150kHz with best sensitivity between 8kHz to 40kHz (Anderson, 1970). Theoretically, at 1kHz, a noise must be greater than 75dB to be audible to a porpoise - the absolute hearing threshold.

However, it should be noted that absolute hearing thresholds are developed under laboratory conditions in the absence of any background noise. Hearing thresholds in the relatively 'noisy' marine environment are, therefore, likely to be above those established in the laboratory for both cetaceans and seals. An example of this is given for the beluga, a small odontocete whale. Sound at frequencies below 1,000Hz must exceed the beluga’s absolute hearing threshold by approximately 17dB (the Critical Ratio) for it to be heard above background noise. Critical ratios for low frequency sounds have not been determined for many other small cetaceans However, it is assumed that the harbour porpoise will be similar to the beluga as the absolute hearing threshold of the two species is similar (Richardson et al., 1995).

If a noise is within the hearing threshold of an animal, the distance the animal is from the noise source dictates, to an extent, the effect. This is referred to as the 'zones of noise influence', of which there are four;

- Zone of audibility (the zone in which a noise is audible)
- Zone of responsiveness (startle/alarm response, increase in heart beat)
- Zone of masking (masking of sounds used in communication and echolocation)
- Zone of physiological effect (such as temporary hearing threshold shift)

Records of the effects of noise on cetaceans are primarily concerned with seismic surveys, which are somewhat noisier than pile driving. The general reaction of cetaceans to seismic surveys is avoidance. As a results of this, the National Marine Fisheries Service (NMFS) of the United States has adopted conservative safety distances for cetaceans around seismic surveys based on the sound level a cetacean would receive during survey activity. These received low-frequency sound pressure levels are 180dB for the large mysticetes such as the minke whale and 210dB for small cetaceans such as the harbour porpoise (NMFS, 1998). At received sound levels in excess of 180 and 210dB, cetaceans may be subject to temporary or permanent shifts in hearing thresholds.

Zone of Physiological Effect

The noise generated at source during the proposed piling may range from <150 to 236dB, as discussed above. A worst case scenario would assume that peak piling noise will be comparable to 236dB. This sound level is similar to levels generated by small seismic survey arrays and, thus, US seismic survey safety measures are relevant to the proposed piling. As noise generated in shallow waters spreads cylindrically with an attenuation of 3dB per doubling of distance from source (a very simple model), at 512m the received sound level for small cetaceans will be 209dB. This distance of 512m corresponds to the safety zone of 500m required under UK legislation around a seismic survey array to reduce the impact of the surveys on marine mammals species (Pierson et al. 1998).

Within 500m of the piling operation, small cetaceans such as the harbour porpoise may be subject to temporary or permanent shifts in their hearing thresholds depending on how close they are to the noise source and the length of time spent at that distance. Ridgeway et al. (1997, cited in Ward and Healy, 2002) have show that the bottlenose dolphin are subject to temporary shifts in hearing thresholds at sound levels of 78-85dB above their hearing thresholds over an eight hour exposure period. Considering that the masked hearing threshold at 130-150Hz (frequency range of peak piling energy) in the bottlenose dolphin (assumed to be comparable with harbour porpoise) is approximately 140dB (Richardson et al., 1995), a temporary threshold shift would occur at sound levels between 218 and

225dB over an eight hour period. Thus, these cetaceans would have to remain within close proximity of the piling location for a period of eight hours. Given the mobility of these species, such impacts would not arise.

It should be noted that peak sound pressures generated during piling occur when the object being hammered is close to the surface of the seabed. As depth increase, more of the sound energy generated is directed downwards into the earth and there is a corresponding decrease in sound levels radiated into the water column.

Zone of Masking

It is unlikely that there will be a 'zone of masking' as the sounds used most extensively in communication and echolocation are of much higher frequencies than those generated by construction.

Zone of Responsiveness

The 'zone of responsiveness' may lie at any point between the zone of audibility and the zone of physiological effect, i.e. anywhere between 0.5km (500m) and >20km. Within this zone, small cetaceans such as the harbour porpoise are likely to show a startle or alarm response and avoid the general construction area. As a result of this, it is unlikely that small cetaceans would move into the relatively small zone of physiological effect whilst piling is taking place. Mitigation is proposed to avoid any impacts during construction start-up.

Zone of Audibility

The most extensive of these conceptual zones is the 'zone of audibility', the area within which the animal might hear the noise. Depending on background noise levels in the sea, piling noise in the range of 225-236dB is likely to be audible over tens of kilometres.

In summary, the impact of construction work on small cetaceans is likely to be short-term avoidance of the local area of works over the period of sound generation. Cetaceans will only be at risk of physiological effects if within a small area close to the location of piling. Within this area, there is a risk of temporary shifts in hearing thresholds should they stay in the area over and extended period. Considering the sound level generated, this period may be as long as eight hours. However, small cetaceans are much more likely to avoid the area of works over the construction period. At the start of each activity period, any small cetaceans in the immediate area are likely to show startle or alarm response and move to a distance from the works at which noise levels are comfortable. The highest risk would be to any individuals in very close proximity to the works at their start-up, for which, appropriate mitigation is proposed. The magnitude of possible impacts associated with construction activities would, therefore be, 'low' and any impacts would not be significant.

The audible sensitivity of mysticete whales such as the minke whale has not been measured, but it has been suggested that hearing sensitivity may be centred in the vicinity of 100-200Hz (Potter and Delroy, 1998). These large whales are thought to be sensitive to low frequency noise over considerable distances, based on the assumption that they are sensitive to noises in the same low-frequency range that they use in communication. Should this be correct, the mysticetes would be very sensitive to the sound levels generated during piling. However, considering that so few mysticetes are observed in Liverpool Bay, it is unlikely that any will be affected other than to be deterred from this area. The magnitude of possible impacts associated with the fairly short term construction activities would, therefore be, 'negligible' to 'low' and any impacts would not be significant.

The impacts associated with decommissioning would be similar to those of construction and would arise from the generation of noise and vibration. Noise levels would, however, be lower than those associated with piling. Accordingly, the magnitude of the impact is considered to be 'negligible' to 'low' and would not be significant.

Pinnipeds

Hearing sensitivity of the common seal ranges from 1kHz to 50kHz with the absolute hearing threshold ranging from 60 to 82dB (Richardson et al. 1995). At frequencies below 1kHz, where the noise from most construction activities are found, data for the common seal showed an absolute hearing threshold at 100Hz of 96dB (Kastak and Schusterman, 1995). Absolute hearing thresholds have not been developed for behavioural responses in the grey seal. However, as the common and grey seal are both phocinid seals, their sensitivity is assumed to be similar.

Seals show both attraction to and avoidance of anthropogenic noise sources, but generally show 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 avoidance of the presence of humans, which is the most probable cue. Furthermore, grey seals (the species that hauls out on the sand banks and rocks of Hilbre Island and the mouth of the Dee Estuary) seem to readily habituate to most anthropogenic sounds and activities (Vella et al. 2001).

The most common reaction of seals hauled out on land to construction noise and activity will be alarm behaviour. If a disturbance is sufficient, seals will leave their haul out area and enter the water. However, this behaviour is usually triggered by a very close approach by humans and other predators (tens to hundreds of metres, depending on frequency of exposure to human activity).

The reaction of seals to construction activities when they are already in the water is generally avoidance but again, this may be a reaction to visual cues rather than noise. Certainly investigations of the impact of seismic surveys on grey seals showed that seals left an area where surveys producing source sounds of 214 to 224dB were being carried out, for the duration of the works. Following this, they returned soon after the survey ended (Thompson et al. 1998). Conservative safety distances for pinnipeds around seismic surveys are defined by received sound pressure levels of 210dB (NMFS, 1998), as for small cetaceans discussed above.

The sound levels generated during the investigation of Thompson et al. (1998), is comparable to the noise levels that will be generated during piling (assuming a worst-case-scenario that piling noise is of the order of 225-236dB at source). Thus, we can expect to see similar behaviour. At the start-up of activity, any seals in the general area will move to a distance at which sound levels are acceptable. Seals may also avoid the general area of the construction works due to the presence of human activity.

A possible result of this avoidance behaviour may be exclusion from some feeding grounds in the wind farm area over all or part of the construction period. However, it is more likely that some seals would avoid the area whilst others would be indifferent. Certainly, grey seal bulls (males) are known to approach fishing vessels in Liverpool Bay (Dobson, 2002 pers comm), which generally produce sound levels of 150-160dB at source (Gulland and Walker, 1998). Also, during construction of the Näsrevet Wind Farm, Sweden (situated approximately 5km from a grey seal colony), seals rapidly habituated to construction activities (Westerberg, 1999), which included piling. Monitoring of these seals showed that they only became alarmed when support vessels moved with hundreds of meters of them. The closest seal haul out area to the site of the proposed works, is approximately 12km to the south east (at the mouth of the Dee Estuary), and thus, seals hauled out at this location would not be affected by construction activity or the movements of support vessels within the site area.

In summary seals are likely to avoid the general area of works over the period of noise generation. Seals would only be at risk to temporary or permanent shifts in hearing thresholds within close proximity over an extended period of time. Within this relatively small area, which is likely to be less than 500m, seals may show startle and alarm reactions with increases in swimming speeds away from the noise source. Seals would be most at risk if they were in very close proximity to piling at its start-up, for which appropriate mitigation measures are proposed. However, seals are expected to quickly habituate to the day-to-day activities as has been demonstrated at Näsrevet and during other marine construction projects. The significance of any impact is considered to be 'low', and therefore, would not be significant.

Direct impacts on seal populations in the area during decommissioning would be restricted to disturbance of any individuals active in the area and their possible exclusion during decommissioning activity. Any such impacts would similarly be short-term and would simply lead to movement of seals to other nearby areas. The magnitude of the impact is considered 'negligible' to 'low' and would not be significant.

5.4.2.2 Operation

Noise and Vibration

Recently, measurements of underwater noise has been undertaken at three Scandinavian offshore wind farms (Henriksen et al. 2001), whilst turbines were both operating and idle and whilst turbines were operating under different wind speeds. Briefly, peak source sound levels were 130dB at 25Hz and 115 dB at 125Hz. These 'actual' measurements are slightly higher than predicted for another UK offshore wind farm 98.5dB at 400Hz (peak sound level/frequency at source). For comparison, these sound levels are similar to offshore oil and gas drilling platforms and considerably less than the received sound levels of 180 and 210dB, which define the safety zones around seismic surveys (mysticete and odontocete/pinnipeds respectively). However, unlike seismic survey and the majority of construction noises generated at sea, the noise generated by wind farms would be long-term in nature.

Cetaceans

Henriksen et al. (2001) compared the noise generated by an offshore wind farm with the audible sensitivity of the harbour porpoise. The frequency at which porpoise were most sensitive was 315Hz, where the noise generated by an offshore wind farm at source was 17dB above their hearing threshold of approximately 103dB. This data allows the zone of audibility to be determined.

Assuming the very simple sound propagation model of cylindrical spreading, where the noise generated by the turbines will attenuate at a rate of 3dB when the distance from the source is doubled, turbine noise from the proposed Burbo Offshore Wind Farm will be detected by porpoise within a distance of 50m. Within this area, there may or may not be a zone of responsiveness. Furthermore, as the closest distance between turbines is likely to be approximately 500m, porpoise would be able to move between turbines within the wind farm, without being adversely affected by noise generated.

Even assuming a worst-case-scenario, that the 'zone of audibility' is similar to a zone of exclusion, impacts on harbour porpoise (and by extrapolation, other odontocete cetaceans) are considered to insignificant due the very small area involved. Following familiarisation with the physical presence of the wind farm, it is expected that porpoise and other cetaceans, such as the bottlenose dolphin, may exploit wind farm sites as feeding areas. The magnitude of noise and vibration impacts is therefore, 'negligible' to 'low' and so impacts would not be significant.

The hearing sensitivity of the larger, mysticete cetaceans such as the minke whales is not known, but they are expected to be able to hear the low-frequency noise generated by the proposed wind farm. Their reactions to wind farm noise, however, cannot be predicted in the absence of their hearing threshold. However, there are several examples of mysticete whales continuing to migrate past oil and gas drilling platforms, which generate sound at frequencies and levels comparable to wind farms (Vella et al., 2001). Thus, as minke whales and other mysticete species are seldom seen in the shallow water of Liverpool Bay, and considering that the sound levels generated during operation would not be at a level to cause injury, any impacts on behaviour would be of little significance for individuals entering the Irish Sea.

Pinnipeds

The absolute hearing sensitivity of common seals to sounds below 1kHz has only been determined for a single individual. Henriksen et al. (2001) adopted a worse-case-scenario (as for harbour porpoise) and extended the absolute hearing threshold of the common seal below 1kHz and into the frequency range of offshore wind turbine noise production. The maximum overlap between the two was 30dB above the hearing threshold at 125Hz. With cylindrical spreading of sound and a 3dB loss per doubling of distance from source, this gives the common seal a detection range 'zone of audibility' for wind farm noise of 1,000m. Although common seals are not found in the general area of the proposed Burbo Flats Wind Farm, it is assumed that grey seals will have a similar zone of audibility.

Grey seals tend to forage over very large areas. Assuming that the home range of grey seals is 4,000km^2 and that the 'zone of audibility' (1,000m) is also a zone of exclusion, then grey seals would be excluded from an area of less than 24km^2 (area of proposed wind farm including a 1km boundary) or less than 1% of their home range. However, it is far more likely that whilst seals may be able to hear the turbines within 1km, the area they are excluded from would be far smaller and indeed, exclusion may not occur at all. Certainly, there are many examples of pinnipeds approaching and tolerating noisy environments such as airports and harbours (Vella et al. 2001).

The magnitude of noise and vibration impacts on the grey seal is therefore considered to be 'negligible' to 'low' as they are unlikely to show any reactions other than to the physical presence of the turbines. Following familiarisation with the structures, it is possible that seals may use the wind farm as a feeding ground should fish assemblages be higher around turbine foundations. Impacts would, therefore, not be significant.

Trophic Effects

Harbour porpoise, other small cetaceans and grey seals are opportunistic hunters that predate wide range of fish and invertebrates species 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. Over the operational life of the wind farm, turbines are likely to act as FADs and concentrate fish. This may lead to increased use of the wind farm, over time, as a foraging area. During decommissioning, the loss of such a FAD effect may present a short-term adverse effect, but both porpoise and seals would quickly adapt to any such changes. The magnitude of trophic effects are, therefore, considered to be 'negligible' and so are not considered to be significant.

5.4.2.3 Cumulative Impacts

Combined Noise Effects

The use of similar technology by wind farm developers should mean that the noise generated by turbines of the five proposed wind farms would be similar to those discussed in this E.S. Given this assumption the following cumulative impacts are considered.

Harbour porpoise are expected to be able to detect turbine noise within 50m of a turbine. Assuming a worst-case-scenario that porpoise are in fact excluded from wind farm sites, the cumulative impact on the available feeding area would be the potential exclusion of less than 5% of the available area in Liverpool Bay.

It is not expected that seals will be excluded from wind farms. A worst-case-scenario would, however, result in a loss of less than 5% of available feeding area in Liverpool Bay. Furthermore, as the average home range for the grey seals (the area in which they regularly feed) is approximately 4000km^2, exclusion from the Liverpool Bay wind farms would result in a loss of approximately 3.4% of their home range.

The impacts associated with the construction period are unlikely to have a cumulative affect as a result of the differing timescales under which construction will take place, as discussed for fish above.

The magnitude of cumulative effects of exclusion of marine mammals from Liverpool Bay wind farm sites is, therefore, considered to be 'negligible' and not significant. Furthermore, turbine foundations acting as FADs will only cause a redistribution of fish in the local area of a windfarm, and not reduce the quantity of prey items away from wind farms upon which porpoise and seals feed.

5.4.3 Mitigation

A soft-start approach as defined in the Section 5.3.6 above will mitigate impacts on cetaceans and pinnipeds for the same reasons as discussed for fish.

5.4.4 Monitoring

Seal numbers at the haul out site at Hilbre Island (at the mouth of the Dee Estuary) would continue to be collated from existing monitoring exercises.

It is also recommended that a generic study on behalf of the offshore wind farm industry be considered to investigate whether offshore wind farms affect the foraging behaviour of seals. This could be achieved by tagging (VHF/Satellite) investigations. Due to the large area over which seals forage for food, such an investigation could be undertaken to investigate the combined effects of the offshore wind farms proposed for Liverpool Bay.

5.5 Birds

This section presents the methodology adopted in the assessment of the ornithological issues, describes existing conditions, evaluates the significance of the site, and assesses likely impacts and recommends mitigation and monitoring.

The scope and methods of assessment were agreed in scoping meetings and correspondence with:

- English Nature (EN) (North West Region)
- Royal Society for the Protection of Birds (RSPB) (North West Regional Office)
- Lancashire Wildlife Trust (North Merseyside Office)

5.5.1 Existing Environment

5.5.1.1 Introduction

This section provides, for the application site in the context of Liverpool Bay (referred to as “the Bay”), an assessment of:

- The baseline population size, distribution and movement of bird species
- The importance of populations, in relation to criteria for European, national and county site designations

The application site lies within a sector of the Irish Sea known as Liverpool Bay, which is broadly defined as the area between Rossall Point, at the southern edge of Morecambe Bay, and Red Wharf Bay in Anglesey. This section introduces the current state of knowledge of the ornithological interest of the Bay, as it relates to the proposed Burbo Offshore Wind Farm. This introduction also provides a rationale for, and summary of, the more detailed bird studies reported on in later sections of the chapter and identifies gaps in existing data and discusses how they are met by studies specific to this assessment.

5.5.1.2 Context

The birdlife of the inter-tidal flats and saltmarsh bordering Liverpool Bay is relatively well studied and most of this habitat is statutorily protected within Natura 2000, the European network of protected sites, on account of populations of a number of waterbird species. With the exception of terns, these coastal sites are designated for species of waterfowl and waders, whose use of the offshore environment is confined to flight above it, into or between feeding and roosting areas.

Knowledge of offshore birdlife in the Bay, prior to a Countryside Council for Wales (CCW) research project during the winters of 2000/2001 and 2001/2002 (Oliver et al. 2001 and Robinson & Oliver *in prep*.) and studies for the proposed offshore wind farms, was less well known.

The following sections present the summary of the findings of site-specific surveys undertaken between February 2001 and the present day. Three recent seabird surveys (the CCW common scoter *Melanitta nigra* surveys of Liverpool Bay in 2000-2001 (Oliver et al. 2001) and 2001-2002 (Robinson & Oliver *in prep*.) and the seabird surveys commissioned by NWP Offshore Ltd in respect of the North Hoyle Environmental Statement (NWP Offshore Ltd, 2002a, 2002b and 2002c)) enable the site-specific offshore surveys at Burbo Bank to be placed in the context of the wider Liverpool Bay.

Data on inter-tidal waterfowl numbers and terrestrial roosts of seabirds were obtained from:

- British Trust for Ornithology
- Lancashire County Bird Recorder (Seaforth Nature Reserve and Lancashire annual bird report)
- Liverpool Bay Wader Studies Group
- Wildfowl and Wetlands Trust

5.5.1.3 Survey Methods and Rationales

(i) Aerial Surveys

Common scoter is a sea duck of conservation importance in Liverpool Bay, potentially qualifying parts of the Bay as a marine Special Protection Area under the Birds Directive (79/409/EEC). Surveys of common scoter were undertaken within a CCW research contract co-ordinated by Casella Science and Environment Ltd in 2000/2001. This survey was repeated for the winter of 2001/2002 jointly by Casella Stanger (the company's present name) and The Wildfowl and Wetlands Trust. Seascape Energy Ltd was a project partner for the CCW project in 2001/2002. Surveys covering Burbo were undertaken in February, November and December 2001 and January, February, March and April 2002.

A detailed description of the methodologies and analysis techniques employed for the aerial surveys is provided in Technical Appendix B.

(ii) Boat Surveys

Rationale

There is uncertainty about the efficiency of aerial surveys in providing robust data for all species, for the following reasons:

- Frequency of detection of some species, including divers, can be lower from aeroplanes than from boats, potentially resulting in errors as the result of small sample size
- A number of similar species cannot be separated from the air, for example auk species and diver species, which are could be relevant to the Burbo Bank site
- Information on behaviour, relevant to birds' use of a sea area, and flight height, utilised in assessment of risk of collision with turbine blades, require the longer observation of birds, from sea level, provided by boats

The recommendation for offshore bird survey work in both Germany (Ommo Huppop pers. com.) and the UK (A.Webb, JNCC pers. com.), for reasons stated above, is for a combination of aerial and boat surveys. Surveys should extend over a calendar year, to enable all populations of potential conservation interest to be assessed. This should ideally utilise both survey platforms, until the effectiveness of aerial and boat-based methods is better understood.

Boat Surveys of the Burbo Bank Area

For this assessment boat surveys of a study area of between 38.9km^2 and 45.5km^2 comprising the Burbo Bank site and a 2km buffer, were undertaken between December 2001 and February 2002. The Environment Agency research vessel "Coastal Guardian" was used allowing observers an eye height above water of 6m. A variation on the 180^o scan method (Komdeur et al., 1992) was followed, which involved an observer scanning on either side of the boat, including the vessel's front, to ensure no under-counting of divers. Transect lines were separated by 1km in the first December 2001 survey and then by 2km in the second December 2001 and February 2001 surveys, to allow greater survey coverage. All species, both in flight and individuals observed on the sea surface, were recorded other than gulls, with the exception of two oceanic gull species, kittiwake *Rissa tridactyla* and little gull *Larus minutus*.

A detailed description of the methodologies and analysis techniques employed for the aerial surveys is provided in the Technical Appendix B.

Common Tern Foraging Studies

The proposed wind farm area was the subject of a combined boat and land-based survey to investigate the number of common tern that are either using the application site for feeding or in transit. The methodology of the survey has been agreed with Lancashire Wildlife Trust and the RSPB. A detailed description of this methodology alongside the survey findings is provided in Technical Appendix B.

(iv) Desk-Based Study

The ornithological assessment of the cabling route was, due to the wealth of existing data, undertaken as a desk study. Wetland Bird Survey (WeBS) core count and low water data for the North Wirral Foreshore were acquired for 2001 and summarily for the five year period of 1997-2001. Consultation was undertaken on site with the WeBS recorder (Carl Clee) and RSPB representative for the Dee Estuary (Colin Wells).

5.5.1.4 Evaluation

The following definitions are used in the text to assign levels of importance to bird populations.

(i) European Importance

A population of European importance is one that qualifies a site for classification or potential classification as a Special Protection Area under Articles 4.1 or 4.2 of the European Directive on the conservation of wild birds (79/409/EEC), generally referred to as the Birds Directive. SPAs form a part of the Natura 2000 suite of sites to protect the rare and vulnerable flora and fauna of the European Community.

The criteria for selection of SPAs in Britain are agreed for terrestrial SPAs, extending to the mean low water mark, but not for marine SPAs. In the absence of agreed criteria, it is recognised that criteria are necessary for this Environmental Statement, as there is precedence for potential SPAs being treated as SPAs in the implementation of planning control.

The draft definition of a potential marine SPA is one that meets the draft Stage 1.1 or Stage 1.2 selections guidelines for marine SPAs (Johnston et al, 2002), that is respectively 1% of the national population of a species listed in Annex 1 of the Birds Directive and 1% of the biogeographic population of other regularly occurring migratory species. The concept of a biogeographic population is the range of a population over its breeding, migration and wintering grounds. The boundaries and hence the population size are set by the government’s advisors on nature conservation.

One example is given for clarification. Common scoter has a population that breeds from western Siberia west to Scotland and migrates through north western Europe to winter in north-west European and North African waters. Birds breeding further east have different migration routes and wintering grounds. Therefore the population selected for the setting of the 1% threshold is the Western Siberia/North West Europe/North Africa population, estimated to be 1,600,000 birds, which gives a SPA threshold of 16,000 birds. Whilst terrestrial SPAs are classified from five-year mean peak data, such a run of data is unlikely to be available for all marine SPA classification. Therefore for the purpose of this assessment a single years peak count is accepted as sufficient to consider a potential marine SPA.

(ii) National Importance

Populations of national importance are a qualifying feature for the notification of a Site of Special Scientific Interest (SSSI) (JNCC 1989). For the purpose of this evaluation, the qualifying feature is:

- 1% of the British breeding, passage or wintering population

There is no legislative provision for the designation of land beyond the low water mark as SSSIs. For the logically consistent purpose of this assessment, 1% of the British population of a seabird is evaluated as of national importance, although it would not bring into force the planning controls on developments that may impact on notified SSSIs.

In the terrestrial environment it is customary to consider populations of county or local importance which are the qualifying features of a designated or potential county or borough wildlife site. There is no equivalent system in the offshore environment. However, Liverpool Bay represents an identifiable geographic unit, itself of international and national importance in its entirety for a number of bird species. The regional or local importance of Burbo can be assessed in the context of Liverpool Bay populations.

5.5.1.5 Sites and Populations of Ornithological Importance

(i) Designated Sites of International (European) Importance

The following sites have been designated as either of international (European) or national importance for waterfowl in the vicinity of the Burbo Offshore Wind Farm application area. Each is designated for populations that may range over the Burbo site.

Mersey Narrows and North Wirral Foreshore Proposed SPA (pSPA)

The pSPA comprises the Mersey Narrows SSSI and North Wirral Foreshore SSSI. It qualifies under Article 4.1 of the Directive (79/409/EEC) as it is regularly used by 1% or more of the British population of two Annex 1 species: common tern and bar-tailed godwit.

The site qualifies under Article 4.2 of the Directive (79/409/EEC) by virtue of regularly supporting over-wintering populations exceeding 1% of the biogeographic population of knot, redshank (*Tringa totanus*) and turnstone (*Arenaria interpres*).

Additionally, it qualifies under Article 4.2 as it regularly supports more than 20,000 waterbirds. In the non-breeding season the site regularly supports 28,841 waterbirds (5 year peak mean 1994/5-1998/9). Species with nationally important wintering populations, in addition to those mentioned above, are cormorant, oystercatcher (*Haematopus ostralegus*), grey plover (*Pluvialis squatarola*), sanderling (*Calidris alba*) and dunlin (*Calidris alpina*).

The Mersey Narrows SSSI is additionally notified for its nationally important non-breeding population of cormorant, while the North Wirral Foreshore SSSI is additionally notified for its nationally important population of wintering dunlin, bar-tailed godwit and knot.

Ribble and Alt Estuaries SPA

The SPA comprises the Ribble Estuary SSSI and the Sefton Coast SSSI. It qualifies under Article 4.1 of the Directive (79/409/EEC) as it is regularly used by 1% or more of the British population of six Annex 1 species: common tern, ruff (*Philomachus pugnax*), bar-tailed godwit, Bewick's Swan (*Cygnus columbianus*), whooper Swan (*Cygnus cygnus*), and golden plover (*Pluvialis apricaria*).

The site qualifies under Article 4.2 of the Directive (79/409/EEC) by virtue of regularly supporting over-wintering populations exceeding 1% of the biogeographic population of pink-footed goose (*Anser brachyrhynchus*), shelduck (*Tadorna tadorna*), wigeon (*Anas penelope*), teal (*Anas crecca*), pintail (*Anas acuta*), oystercatcher, grey plover, knot, sanderling, dunlin, black-tailed godwit (*Limosa limosa*) and redshank and a breeding population exceeding 1% of the biogeographic population of lesser black-backed gull (*Larus fuscus*) .

Additionally, it qualifies under Article 4.2 as it regularly supports more than 20,000 waterbirds. In the five-year period 1985/86 to 1989/90 an average peak of 218,900 birds was recorded, comprising 161,500 waders and 57,400 wildfowl.

The Ribble Estuary SSSI qualifies for its internationally important population of Bewick’s swan, pink-footed goose, shelduck, wigeon, oystercatcher, knot, sanderling, dunlin, black-tailed and bar-tailed godwit. The Sefton Coast SSSI qualifies for its internationally important population of wintering grey plover, knot, sanderling and bar-tailed godwit and dunlin, and nationally important population of wintering oystercatcher and dunlin.

There is considerable interchange in the movements of wintering birds between this site and Morecambe Bay, the Mersey Estuary, the Dee Estuary and Martin Mere.

The Dee Estuary SPA and Proposed Extensions

The SPA spans the boundary between England and Wales. It comprises four SSSIs: Dee Estuary, Inner Marsh Farm, Shotton Lagoons and Reedbeds, and Gronant Dunes and Talacre Warren.

It qualifies under both Article 4.1 and Article 4.2 of the Directive (79/409/EEC).

Under Article 4.1, it is regularly used by four species listed in Annex 1 of the Directive: bar-tailed godwit, common tern, little tern and sandwich tern.

Under Article 4.2, the site qualifies by virtue of supporting more than 1% of the biogeographic population of redshank, shelduck, teal, pintail, oystercatcher, knot, dunlin, grey plover and black-tailed godwit. The Dee Estuary also qualifies under Article 4.2 by virtue of regularly supporting at least 20,000 waterfowl. The five-year mean peak (1991/2-1995/6) is 120726. Important component species mentioned in the citation, in addition to those tabulated above, are great crested grebe (*Podiceps cristatus*), cormorant, wigeon, lapwing and sanderling.

Mersey Estuary SPA

The SPA is coincident with the Mersey Estuary SSSI. It qualifies under Article 4.1 of the Directive (79/409/EEC) by virtue of supporting an over-wintering population of one Annex 1 species, namely golden plover.

Under Article 4,2, the Mersey Estuary qualifies by virtue of regularly supporting number exceeding 1% of the biogeographic population of redshank and ringed plover on passage and dunlin, pintail, redshank, shelduck and teal over winter.

Additionally, it qualifies under Article 4.2 through regularly supporting at least 20,000 waterfowl. The five-year mean peak for 1991/2-1995/6 was 99,467 birds. Species with important populations noted in the citation, in addition to those mentioned above, are curlew (*Numenius arquata*), black-tailed godwit, lapwing, grey plover, wigeon and great crested grebe.

The Mersey Estuary SSSI additionally qualifies through regularly supporting more than 1% of the British wintering population of wigeon and curlew.

(ii) Designated Sites of National Importance

There are no SSSIs, other than those that are components of the SPAs discussed above, which have birds that may range over Burbo. The nearest SSSIs for breeding seabirds are Great Orme’s Head SSSI and Little Orme’s Head SSSI.

(iii) Designated Sites of County or Local Importance

There are no designated, non-statutory sites qualifying for their ornithological interest relevant to this assessment.

(iv) Populations of International (European) Importance

The following three species have populations in Liverpool Bay that may justify marine SPA classification for parts of Liverpool Bay, under the draft marine SPA selection criteria.

Red-Throated Diver

Red-throated diver is listed on Annex 1 of the Birds Directive, which results in the provisional threshold for SPA designation being 1% of national population, rather this species' biogeographic population.

Red-throated diver is considered a species of the "inshore" waters, that is within 5km of land (although it can sometimes be seen further offshore), where it feeds on both bottom-dwelling fish and those within the water column. It is not known, for Liverpool Bay, the relative extent to which each of these two broad categories of fish features within the divers' diet. It is therefore not possible to comment upon the influence of water depth on diver distribution in Liverpool Bay other than to state that diving depths are reported to be limited to 2-9m.

The Liverpool Bay distribution is concentrated inshore in shallower waters, though less so than common scoter (see below). Boat-based surveys commissioned by NWP Offshore Ltd showed birds aggregated in November-December 2001 and March 2002 in Red Wharf Bay, Conwy Bay, Constable Bank and Colwyn Bay. The sample count from that study in March 2001 of 281 birds can be considered a minimum for the Welsh side of the Bay. This is 5.8% of the estimated British wintering population of 4,850 (Stone et al, 1997) and would, under the draft stage 1.1 criterion for selection of marine SPAs, qualify at least parts of Liverpool Bay as an SPA for this species. It should be noted however that the British wintering population of 4,850 is simply an estimate, the reliability of which is considered to be poor. The figure has been derived from land-based, rather than offshore, surveys, a methodology that would typically underestimate diver numbers.

Figure 5.5 shows the summed distribution for Liverpool Bay from monthly aerial survey during November 2001-April 2002. Unidentified divers, likely to be this species, are included in this figure, while the small number of observations of black-throated and great northern divers has been excluded. Species other than red-throated divers accounted for 10% or less of boat-based observations on the Welsh side of Liverpool Bay in 2001/2002 and probably fewer, given the relative frequency of observations of those species from land, on the English side of the Bay.

The breaks in the classes in Figure 5.5 are, as with all other figures, selected to give clarity to the distribution discussed in the text, for example the dispersed distribution of red-throated diver and aggregated distribution of common scoter

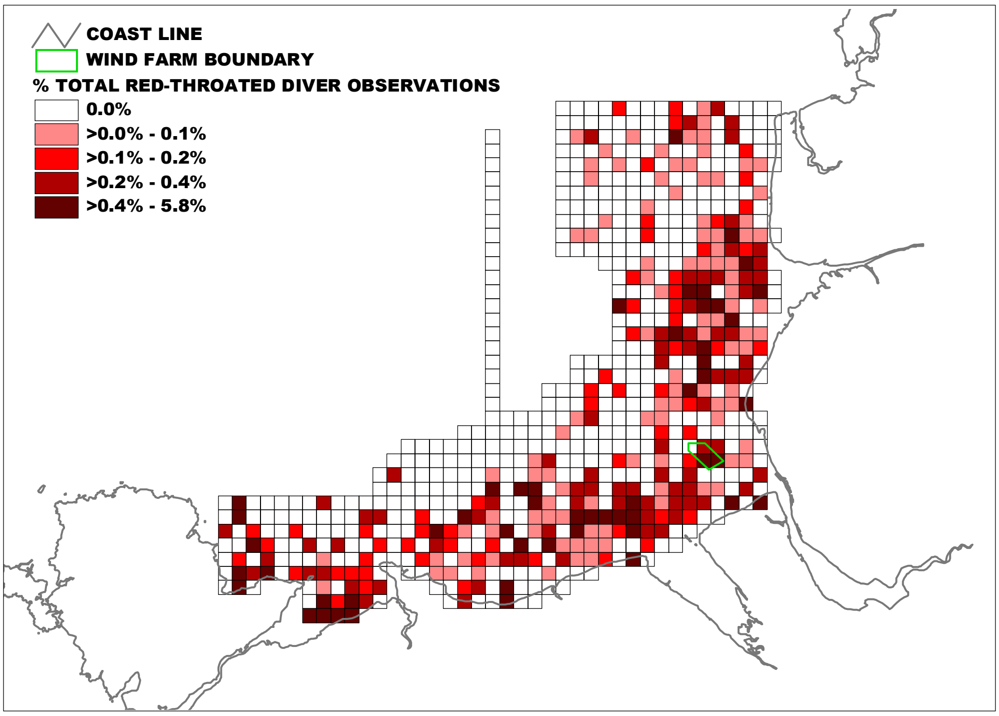

Figure 5.5: Red-throated diver distribution winter 2001-2002, based upon aerial surveys (total count, combined for all months=668)

Figure 5.5, from aerial survey data, shows a broad distribution in inshore waters, most within 10km of land, but probably hides aggregations. Analysis of aerial and boat-based survey data off the North Wales coast in 2001/2002 showed that numbers recorded from boat surveys are on average approximately seven times greater than from aerial survey (NWP Offshore Ltd, 2002). The data, cautiously interpreted with the caveat of low detection rates, show some preference on the English side of the Bay for the mouths of the Dee and Ribble Estuaries and a notable scarcity over the large expanse of Shell Flat, west of Blackpool.

The finer resolution of the boat survey data (Figure 5.6), which more accurately records numbers, as opposed to the broad distribution data given by aerial survey, gives a maximum count of 19 birds within Burbo and the 2km buffer. A comparison of the boat survey data for all of the North Wales section of Liverpool Bay for 2001/2002 with the Burbo data (NWP Offshore Ltd, 2002) shows that red-throated diver densities at Burbo are less than the average for the Bay. Therefore that Burbo is not preferentially selected by this species. There is presently no guidance on how to delineate a marine SPA for dispersed species such as red-throated diver. One approach proposed by the JNCC is to have a threshold density, below which sea areas would be excluded from an SPA (Johnston et al.

2002). No threshold numbers have been set. However, whilst the population of Liverpool Bay justifies consideration of a marine SPA for red-throated diver, if the density mapping approach to selecting the SPA boundary is pursued, Burbo would likely be excluded from the SPA.

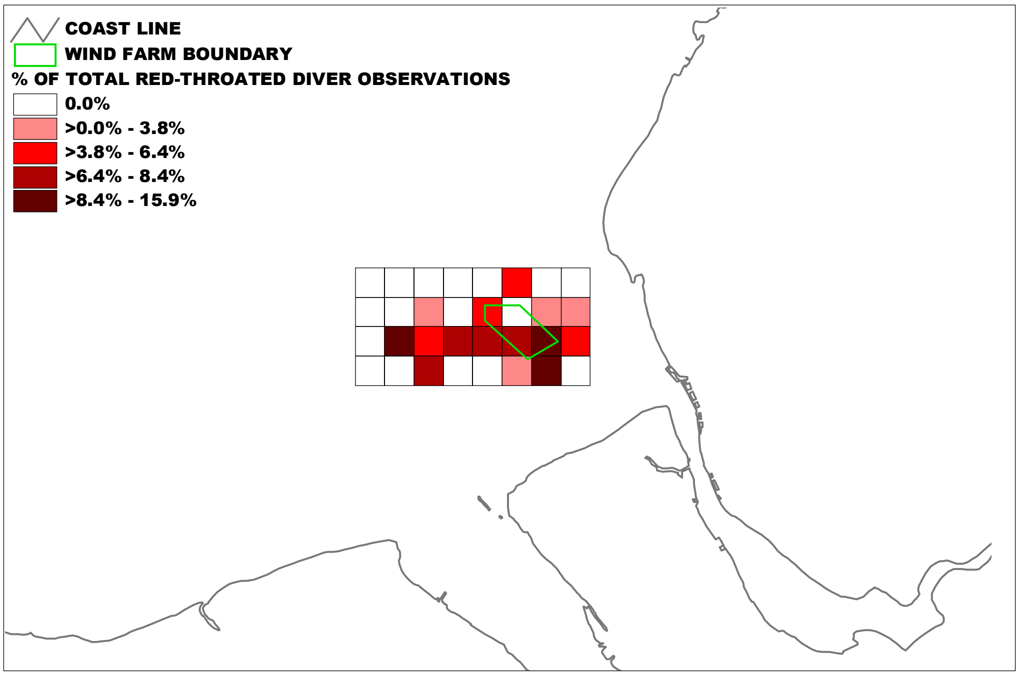

Figure 5.6: Red-throated diver distribution for December 2001 and February 2002 combined, based on boat surveys (total count summed for all surveys=38)

Common Scoter

Common scoter is a UK Biodiversity Action Plan Priority species. There is no statutory force behind the list of Priority species, though there is nevertheless a requirement to classify key wintering areas. Any potential marine SPAs for this species would be classified for areas holding greater than 1% of its biogeographic population.

Common scoter is a sea duck of inshore waters, which has a highly aggregated distribution in shallow waters of less than 10m depth. The distribution is probably determined by the localised abundance of accessible food supply, of which several mollusc species in the upper sediment of sandy sea beds are known to be important elsewhere in Europe. Food preference in Liverpool Bay is not known, but is the subject of an on-going study by the School of Ocean Sciences at the University of Wales, Bangor, within the CCW All Wales common scoter survey 2001/2002. Although data from the food preference study is not yet available, existing information is considered sufficient to be able to assess the likely effects of the development on common scoter.

The first complete aerial survey of common scoter in Liverpool Bay, in the winter of 2000/2001 (Figure 5.7), recorded a maximum of 16,604 birds (Oliver et al. 2001). This threshold exceeds 1% of the biogeographic population (Western Siberia/North-West Europe/North Africa; see Section 5.5.1.4 for a definition of this term) and would, if maintained, qualify at least parts of Liverpool Bay as a marine SPA under the Stage 2.2 criterion for terrestrial SPAs. Between 76% and 96% of the population occurred in 10% of the survey area. The six key locations at which significant concentrations of common scoter were recorded are, from the west, Red Wharf Bay, Conwy Bay, Colwyn Bay, Kinmel Bay, west of Formby Point and offshore of Blackpool.

The six key locations remained important in 2001/2002 (Figure 5.8) and two additional areas held birds; populations extending east of Kinmel Bay onto Chester Flats and south of Formby to Taylor's Bank. The latter area, 4km to the north and north-east of Burbo, is the nearest aggregation to the application site.

Common scoter may also moult in UK waters. Aerial surveys to determine whether there are moult sites in Liverpool Bay, undertaken for the first time in the second half of August 2002, recorded no common scoter form the Burbo study area. The nearest concentration of birds in flight, rather than moulting birds, was at the mouth of the Ribble.

On Burbo, no birds were recorded on the application site in either winter 2000/01 or 2001/02. Given the superficial suitability of the area, measured by water depths, this result is unexpected. However, proximity to the main shipping channel into Liverpool will be an additional determinant. Danish studies have shown that birds avoid suitable feeding areas near to regular boat activity (I.K. Petersen, unpublished data).

Patterns of movement of common scoter in Liverpool Bay, which would be expected to be in response to tide cycles and therefore food availability, are not known. Analysis of the 2000/2001 data shows that in the main feeding areas birds spaced themselves in proportion to the extent of presumed feeding grounds throughout the winter. This would suggest that, unless disturbance is persistent, there is no regular movement of birds between key feeding areas during the winter period. If bird movement between key feeding areas did occur then, assuming straight line flight, movement between the Welsh and English aggregations nearest to Burbo would be expected to pass to the north of, rather than through, Burbo.

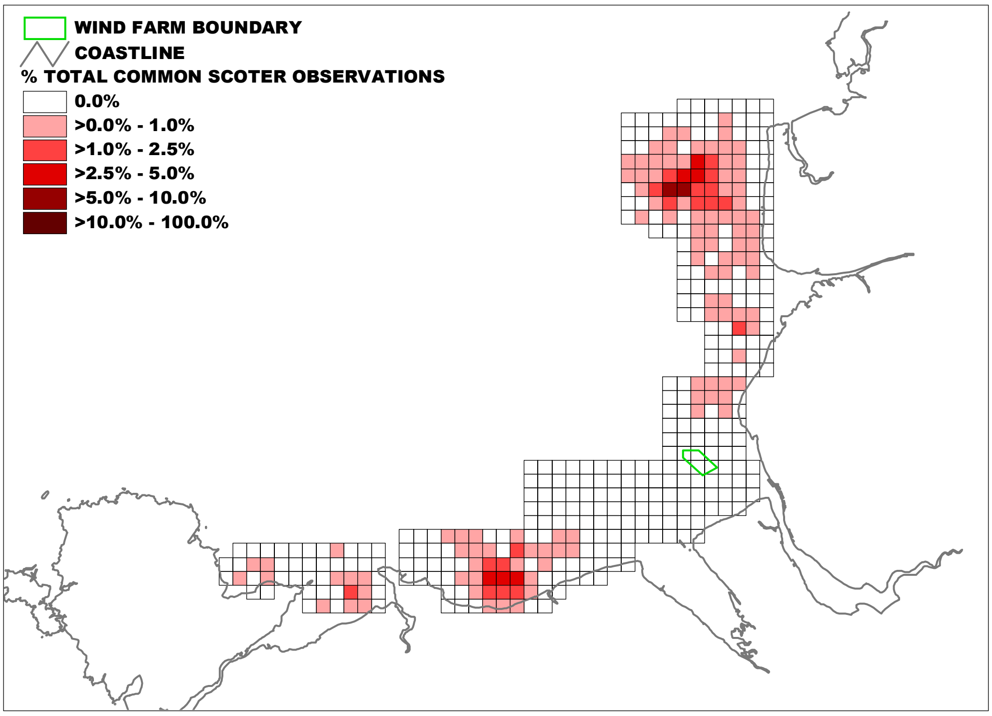

Figure 5.7: Common scoter distribution winter 2000-2001, combined from all aerial surveys (maximum monthly count =16,604)

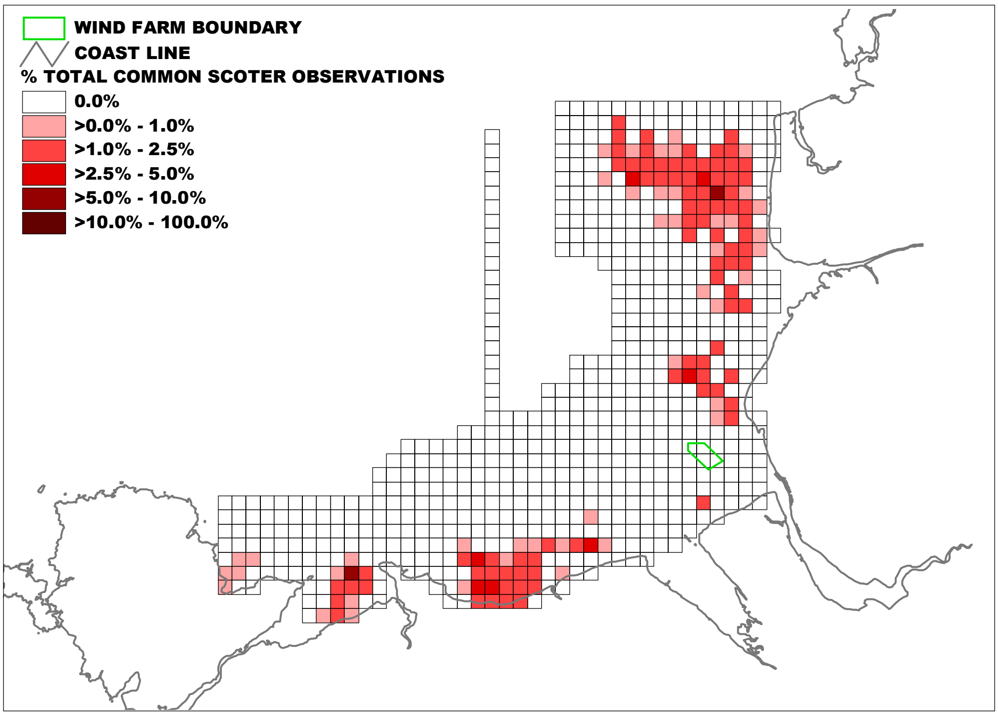

Figure 5.8: Common scoter distribution winter 2001-2002, combined from all aerial surveys (total count summed for all months=62,643)

Common Tern

Common tern is listed on Annex 1 of the Birds Directive, which results in the provisional threshold for SPA designation being 1% of national population, rather this species' biogeographic population.

The common tern breeding colonies at Seaforth Nature Reserve, Shotton Steelworks and the Ribble Marshes are the reasons for the qualification of the Mersey Narrows and North Wirral Foreshore pSPA, The Dee Estuary SPA and proposed extensions, and Ribble and Alt Estuaries SPA respectively.

Birds are present at the Seaforth colony between April and August with few birds remaining in September. The colony is supplemented by non-breeding birds in their second and third calendar year and, from July onwards, failed and successful breeders from other colonies and the offspring of the latter. Thus, although the pSPA qualifies for the number of pairs, no threshold set for qualifying non-breeding populations, but the Seaforth population certainly exceeds 1% of the British post-breeding population.

A common tern study was commissioned to inform the E.S. as to the use (both as a foraging area and in transit) of Burbo by common terns from the Seaforth colony, as well as the two next nearest colonies at Shotton Steelworks and the Ribble Marshes. The findings of the study suggest that the common terns recorded within the study area comprise birds from both the Seaforth and Shotton populations.

Based upon the observations made during this study, the wind farm application site does not constitute a significant foraging area for common terns. On average, for each of the eight surveys, the number of birds recorded foraging within the wind farm represented only 4.0% and 4.4% of total number of birds observed departing from and arriving at Seaforth respectively.

The principal direction of departure from and arrival at Seaforth was recorded to be from the west (45.9% and 43% of arrivals and departures respectively) and from a west-north-west direction (20.4% and 24.8% of arrivals and departures respectively). Both these flight lines evidently relate to birds moving between the colony and local foraging areas within the Mersey channel, immediately adjacent to the Seaforth colony, and at East Hoyle Bank, to the south of Burbo. Some of the birds heading out of the colony on a westerly bearing, however, were observed to continue further west to forage as far as the mouth of the Dee Estuary. An additional foraging area was identified in the vicinity of Formby Point, with birds taking a north-north-west course from Seaforth. Flight lines to and from Seaforth and these foraging areas in all cases did not pass through Burbo.

Despite not falling along the principal flight lines observed from Seaforth, some birds were nevertheless observed to pass through Burbo. Specifically, a number of birds were observed to cross the western part of the Burbo site, whilst apparently in transit between Formby Point and the Dee Estuary. However, on average for each of the eight surveys, the number of birds recorded to make direct flight through the wind farm represented only 14.2% and 17% of total number of birds observed departing from and arriving at Seaforth respectively.

Although common terns have therefore been shown to pass through the Burbo site, all observations of common tern flight height were recorded to be within approximately 5-10 metres of the sea surface and hence flight altitude is below the rotor blade height. This observation is supported by published studies which found that the flight height at which movement to feeding areas and diving takes place is below that of turbine height (Perrins, 1998) and decreases in stronger winds (P.Marsh, pers. com.).

Waders

In addition to the qualifying interest of the Mersey Narrows and North Wirral Foreshore SPA, which is based on high-tide roost data, the North Wirral foreshore is an important inter-tidal feeding ground. The five-year mean peak count of waterfowl at low tide is 494,469 birds. Numerically dominant in winter are dunlin and knot, in tens of thousands, with several thousand each of bar-tailed godwit, grey plover, redshank and oystercatcher. The main feeding grounds are (Carl Clee, pers. com.) the inter-tidal between Leasowe Lighthouse and Mockbeggar Wharf, the latter near to the chosen Burbo cable route. Densities of birds in Sector 10 of the Wetland Bird Survey (WeBS) low-tide counts, which encompasses the cable route, shows some preference around the cabling area, measured by a higher than average density, for cormorant, oystercatcher, redshank and ringed plover over the five-year period between 1997 and 2002 (no records were obtained in 2000). Additionally, curlew, dunlin, grey plover, knot and turnstone were each recorded in higher than average densities in Sector 10 for one year of the five-year survey period. All other species were either recorded at average or below average densities.

Within the cabling area there are no high tide roost sites. The nearest is on groynes to the west of the cabling route.

There is an interchange of birds between the North Wirral foreshore and the Mersey Narrows and Alt Estuary. Persistent movement of redshank and oystercatcher between the foreshore and Seaforth Nature Reserve does not impinge on the airspace of the Burbo development and so is not considered further. There is irregular movement, on spring tides, of several species of wader between a roost site on the Alt, within the Ribble and Alt Estuaries SPA, and low-tide feeding grounds on the North Wirral foreshore. The direct route between the two would involve an unknown fraction of the birds passing through the Burbo site.

Irregular incidents are normally un-recorded in the studies for environmental statements and require anecdotal evidence. This shows the main species to be bar-tailed godwit and knot, with probably some movement of dunlin. The frequency of movement, as a proportion of the number of days in which observations were made, is not known.

(v) Populations of National Importance

Cormorant

Cormorant is of national importance by virtue of the species being a qualifying feature of Mersey Narrows SSSI.

Cormorant feed mainly on bottom-dwelling fish and most feeding is confined to water depths of 1-3m. This shallow water distribution is clearly shown in Figure 5.9. The Seaforth roost is the largest in Liverpool Bay and peaks in strong winds, when temporary roosts such as buoys along the shipping channel are abandoned. A satellite tagged bird that spent 27 days at the Seaforth roost in 1996 carried out most movements within 10km of the colony, although the bird travelled up to 35km offshore. The distribution in Figure 5.9 reflects the multiple number of roost sites on the shore of Liverpool Bay. On the English side is a smaller roost at Formby Point, 12km to the north west of Seaforth, which likely is the origin of some of the birds at the mouth of the Ribble. The main cluster of observations in Liverpool Bay, between Formby Point and the North Wirral shore, may represent the main range of birds foraging from the Seaforth roost.

Burbo is within the main expected foraging range. The preference for shallow waters is shown by the easterly distribution within the area surveyed in detail by boat (Figure 5.10). As bird foraging is in part determined by tide, neither aerial nor boat survey data can be used to assign to Burbo a proportion of the total population of the SSSI, as an unknown fraction remain on the roost at any time. However, there is evidently preference for Burbo and the site and sea areas within 4km, in the context of Liverpool Bay.

Highest densities occur in the shallow waters to the east of Burbo, over Burbo Bank and Taylor’s Bank.

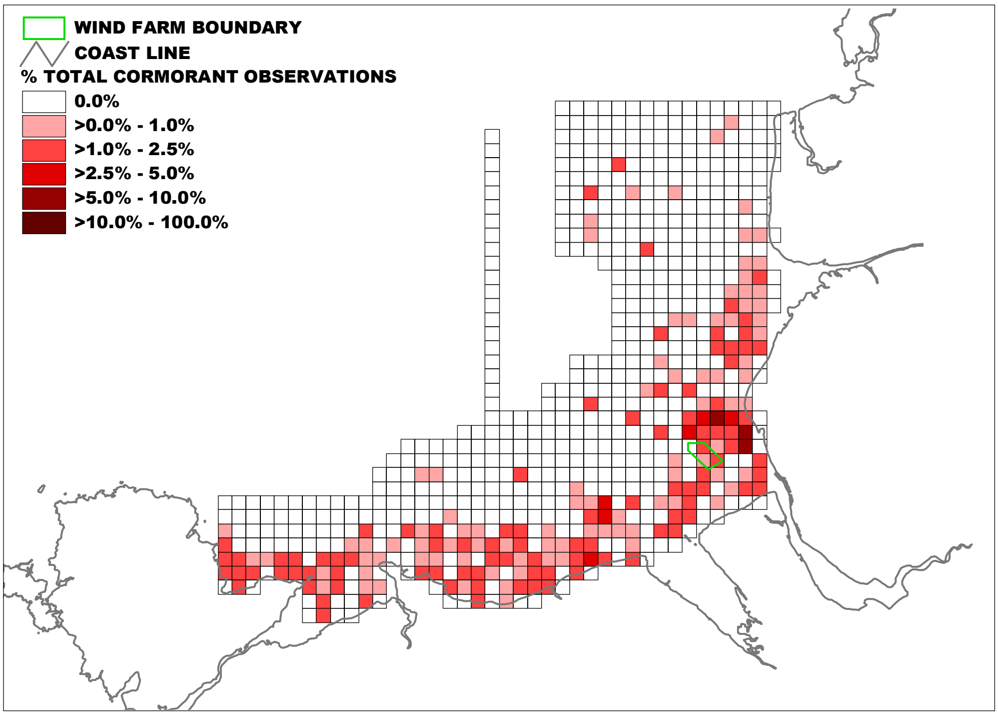

Figure 5.9: Cormorant distribution for winter 2001-2002 based on aerial surveys (total count summed for all months=1033)

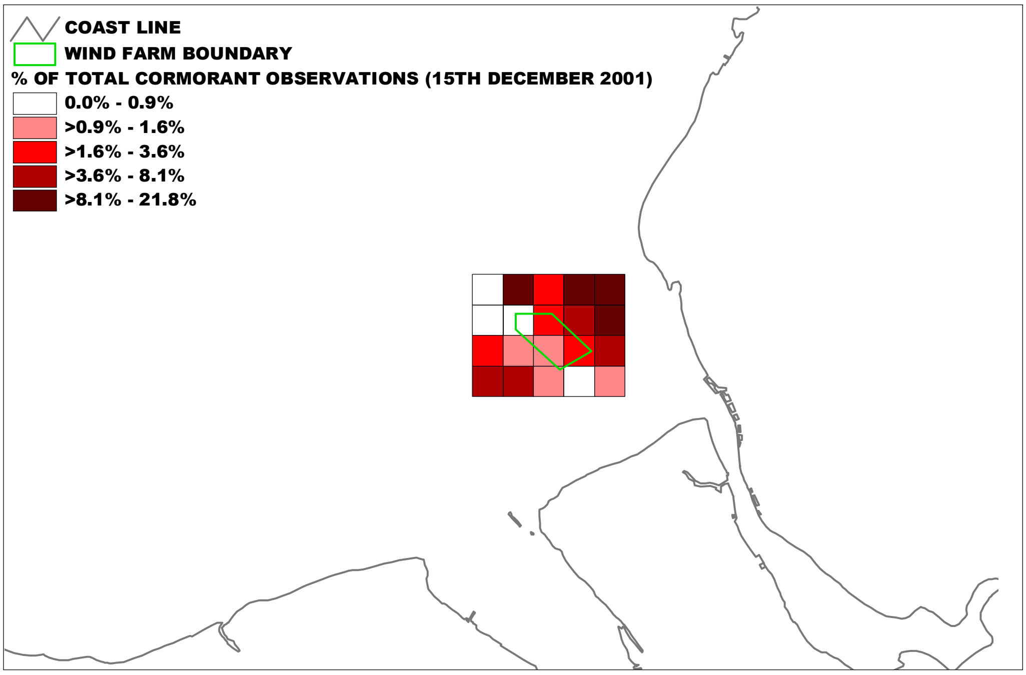

Figure 5.10: Cormorant distribution for 15th December 2001, based on boat surveys (total count summed for all months=232)

Scaup

Scaup is not afforded statutory protection within the UK.

Scaup is a seaduck of inshore waters, where it feeds on bottom fauna, mainly molluscs, and is found in water depths of less than 6m, mainly less than 3.5m. The species was formerly numerous at the mouth of the Dee and, until 1990, numbers inshore between Point of Ayr and Llandulas exceeded 1% of the British population (110 birds) in most years. However, in recent years the population has declined and its range contracted. In the 1980s high tens of birds were recorded most years at Seaforth Nature Reserve. This population disappeared until the winter of 2001/2002, when a maximum of 8 birds during November 2001 was recorded, six of which stayed until the end of the year, associating with the pochard (*Aythya ferina*) flock. Birds roost, not feeding, during the day at the reserve and by inference most feeding must be at night. The offshore feeding areas are not known.

Red-Breasted Merganser

The wintering population of red-breasted merganser in Liverpool Bay is of national importance.

Numbers recorded from boat surveys on the Welsh side of the Bay in November-December 2001 exceeded the 1% of the British wintering population, with a peak of 217 birds in December. Birds broadly follow the distribution of common scoter, though being more dispersed.

Only very low numbers occurred occasionally in the Burbo study area, with a maximum of 2. Outside of the Burbo site and 2km buffer, records became more frequent further west near the mouth of the Dee.

Guillemot and Razorbill (or Auks)

Both species are component features of Great Orme’s Head SSSI, notified for its breeding seabird assemblage, and occur at four further breeding colonies. Numbers are increasing and the combined population is of c2,500 pairs. There are no suitable breeding sites on the English side of the Bay.

Birds are more dispersed in winter, when the breeding population may be supplemented by immigrant birds from further north (Figure 5.11). The figure shows some avoidance of shallow waters, which is locally confirmed in the vicinity of Burbo, where both species are more frequent in the west of the study area (Figures 5.12-13), razorbill being absent from Burbo. The distribution supports that of land-based observations in Liverpool Bay, where both species are scarce. Burbo is well beyond the foraging range of birds from the breeding colonies.

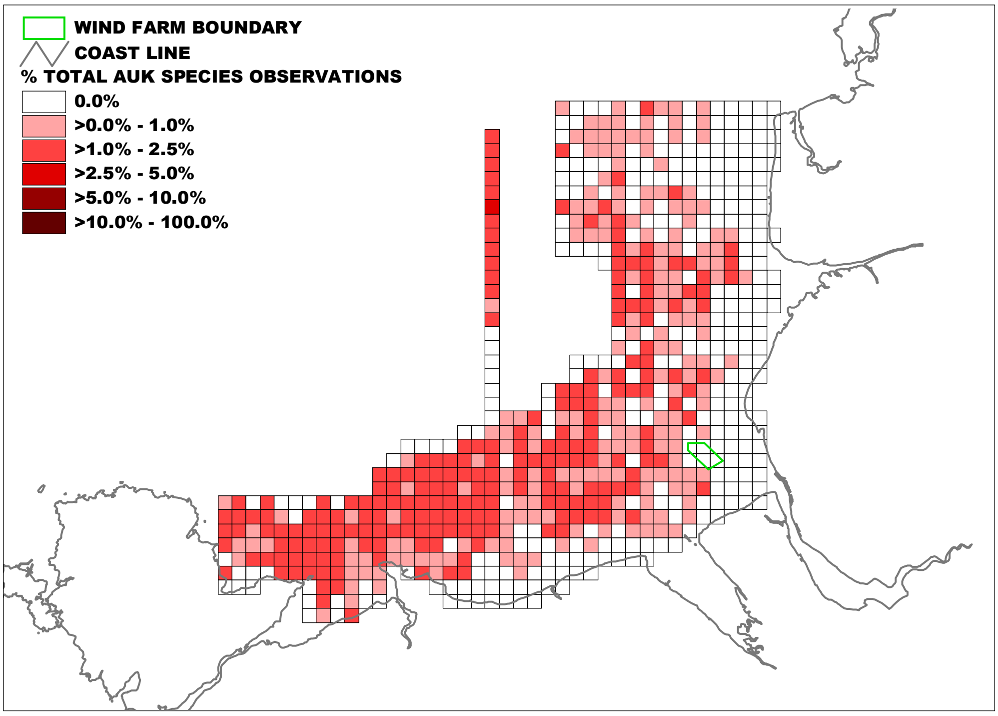

Figure 5.11: Auk distribution winter 2001-2002, based on aerial surveys (total count summed for all months=5249)

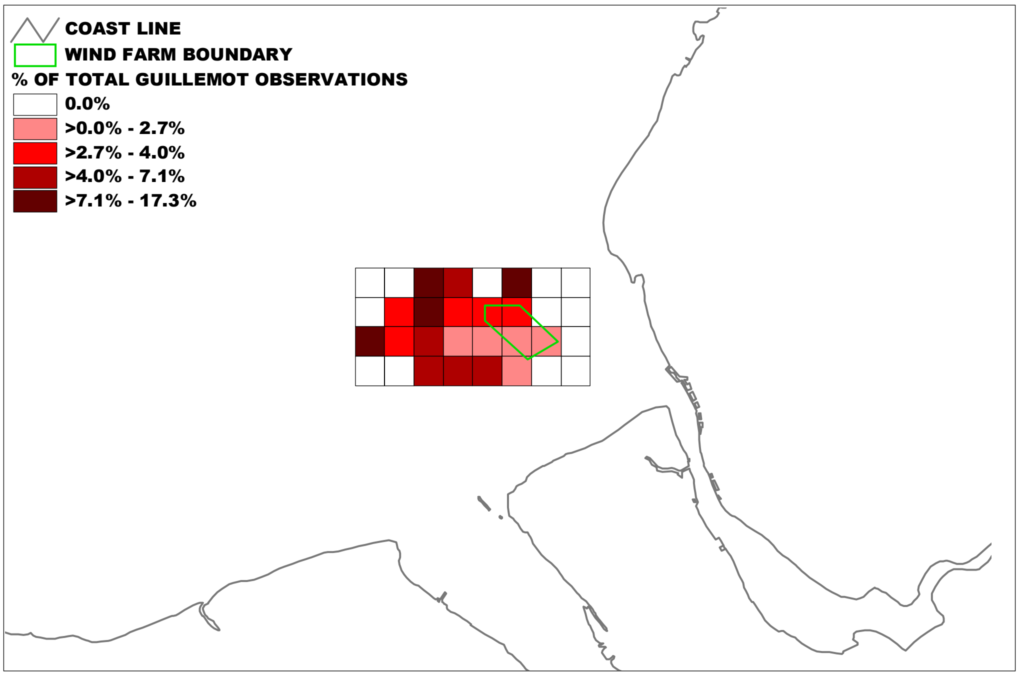

Figure 5.12: Guillemot distribution for December 2001 and February 2002 combined, based on boat surveys (total count summed for all months=65)

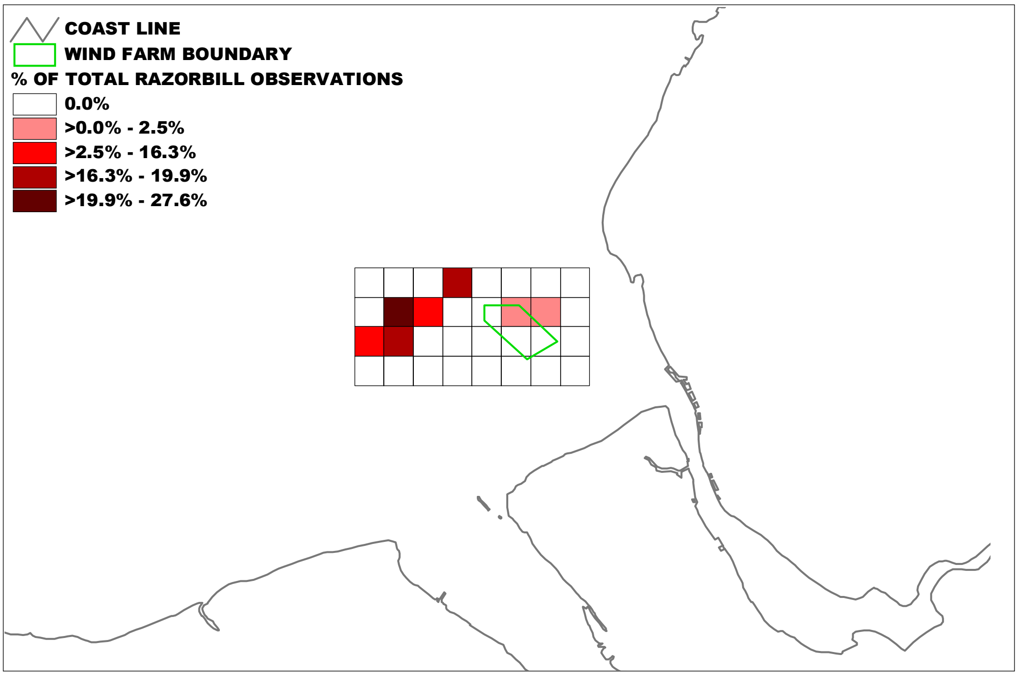

Figure 5.13: Razorbill distribution for December 2001 and February 2002 combined, based on boat surveys (total count=18)

Little Gull

There is no formal estimate of the British passage and wintering population of this species, therefore the species is not a qualifying feature of any SSSIs in the UK. However, it is known that the largest spring passage movement in UK occurs through Seaforth Nature Reserve. Passage occurs between late March and the first week of May, with peak numbers of 250-500 usually in the second half of April. Passage through the reserve is rapid and the total number passing through is not known but probably accounts for most of the wintering Irish Sea population. Recent studies suggest a population of the order of magnitude of 1,000 birds winters off south-east Ireland and is assumed to be the origin of the passage birds through Seaforth.

At Seaforth, the switch from marine to freshwater prey occurs, but there is a period early in the passage when birds occasionally visit the reserve, but presumably feed offshore. Birds also continue to roost offshore, whilst feeding on the reserve. In this period, the offshore feeding area is not known. Inclement weather and the very narrow survey window meant no data were gathered to provide information on baseline conditions at Burbo for this species. Published data is used to inform this Assessment.

Leach's Petrel

Leach's petrel, whilst not a reason for the notification of statutory sites, is probably on occasion present in populations of national importance in the vicinity of Burbo.

Leach's petrel is one of a number of seabird species which is recorded from land over the inshore waters of the eastern Irish Sea between August and October after persistent, strong north-west winds. Birds are assumed to be deflected from offshore migration, either through the west Atlantic or the centre of the Irish Sea, that would not bring them within sight of land. Leach's petrel is the one species that is on occasion recorded from Liverpool Bay in numbers that exceed at least the lower estimate of 1% of the UK breeding population, the size of which is uncertain due to the birds' nocturnal habits.

The total numbers and spatial dimensions of movement through the Irish Sea of Leach's petrel are not known. There is no practical method of gathering this data. The weather in which passage occurs precludes the use of survey boats and so no data were gathered to provide information on baseline conditions at Burbo for this species. Published data is used to inform this Assessment.

5.5.2 Environmental Impacts

5.5.2.1 Introduction to Impacts

The impact of offshore wind turbines on birds remains uncertain. Studies to date of terrestrial wind turbines have been published, though with very few adequate studies that can be confidently cited (e.g. Benner et al. 1993; Clausager & Noer 1995). Such studies show low numbers of collisions and some disturbance, effectively resulting from habitat loss, which is very variable between species. Monitoring at the Tuno Knob offshore wind farm in Denmark has demonstrated two "effects" which could be considered impacts (Guillemette et al., 1998; Tulp et al., 1999): avoidance of flying between turbines and decreased use of sea areas between turbines by one or more species. No studies in the UK have demonstrated effects that can be converted into impacts on populations.

In the light of this uncertainty, five potential impacts have been identified that can be assessed semi-quantitatively, as risks of impacts on birds rather than truly quantitative prediction of effects on populations: collision risk, disruption of flight paths, habitat loss, disturbance and lighting.

Impacts are considered for populations from notified SSSIs and classified or potential (p)SPAs.

For each population, impacts are considered for:

- Construction
- Operation
- Decommissioning

Each impact is uncertain in magnitude, but identified as a precaution, therefore meeting the requirements of both the Environmental Impact Assessment Regulations and the Conservation (Natural Habitats, etc.) Regulations 1994.

The impact assessment matrix developed to assess the significance of effects of offshore wind farm development, under contract to ETSU (Percival 2001) was considered and is used to assign significance of effect to impacts on each species, with a note of caution. Namely, the quantification in this study, due to unavoidable uncertainties about impacts as indicated above, is a quantification of the proportion of a population at risk. The matrix is acknowledged to be a working document. Also, it explicitly permits a level of effects on Natura 2000 populations as acceptable with mitigation. However, this decision can only be determined by a "competent authority".

(i) Collision Risk

Collision risk of birds with turbine blades can be calculated from an assessment of the numbers of birds flying through the wind farm area, flight height and the geometry and rotation of blades. A model, which assumes no avoidance behaviour and which should therefore be treated as conservative, has been developed by Scottish Natural Heritage (SNH) and requires field data for calibration for each species. The SNH model requires accurate flight height assessment of birds exhibiting normal flight behaviour. Offshore, the use of a boat as a platform for observations would reduce flight activity if the boat were moored near to a proposed turbine base. If the boat is moored at a distance sufficient to avoid disturbance then there is no practical method for flight height estimation. Therefore the data gathering offshore for the SNH is currently impractical.

An alternative approach to the SNH model was adopted. During surveys, flight heights for species of conservation concern were estimated for two bands: below turbine blade height and within or above turbine blade height. The level of risk of collision was assessed qualitatively as the proportion of observations within and above turbine flight height. This calculation will over-estimate the proportion of the population at risk, both because it considers birds flying above blade height and because it assumes birds take no avoidance action, which species evidently do. The assessment of the proportion of the population at risk of collision is therefore conservative.

As mentioned earlier in the text, the flight height data is necessarily limited to informing this assessment. It is acknowledged that the behaviour of bird species, including flight height, may differ under poor weather conditions. The safety restrictions on conducting boat-based bird surveys under poor weather conditions however have prevented such data from being collected as part of this assessment. The only species that is pushed into the Merseyside coast in significant numbers during storm conditions is Leach's petrel. This species, however, flies beneath rotor blade height and so would be expected to be at risk of collision.

A study of the flight altitude of coastal birds on the East Friesian island of Wangerooge, revealed a general tendency for bird species, including red-throated diver and common scoter, to fly at low altitude when orientated into a head wind and at an increased altitude for flights in tail winds (Kruger & Garthe, 2001).

(ii) Disruption of Flight Paths

Avoidance of flying between turbines could add to the energetic costs of daily movements of birds or dissuade birds from reaching regular feeding areas if the turbines effectively "closed the door" to the feeding area through the avoidance effect. This potential impact is assessed qualitatively from knowledge of species' ecology and information gathered on the movement of species in Liverpool Bay.

(iii) Habitat Loss

Direct loss of habitat through changes in the benthic fauna or fish populations is considered by reference to predicted impacts on these aspects in the relevant sections of the Marine Ecology Technical Appendix C.

(iv) Disturbance

Indirect habitat loss, through birds avoiding use of sea areas between or near a wind farm, is considered likely to be the most important potential effect on some bird populations. The measure of the risk of this is the proportion of the maximum total observations of important bird species within the Burbo site and within 2km and 4km envelopes around the site (refer to Figure 5.14). The 2km envelope is the maximum distance over which there is some evidence of changed behaviour of seabirds in response to offshore turbines. The 4km envelope gives context to the assessment, but is not used in this report to define the risk of impact, there being to date no empirical evidence of change in behaviour in response to turbines at distances greater than 2km.

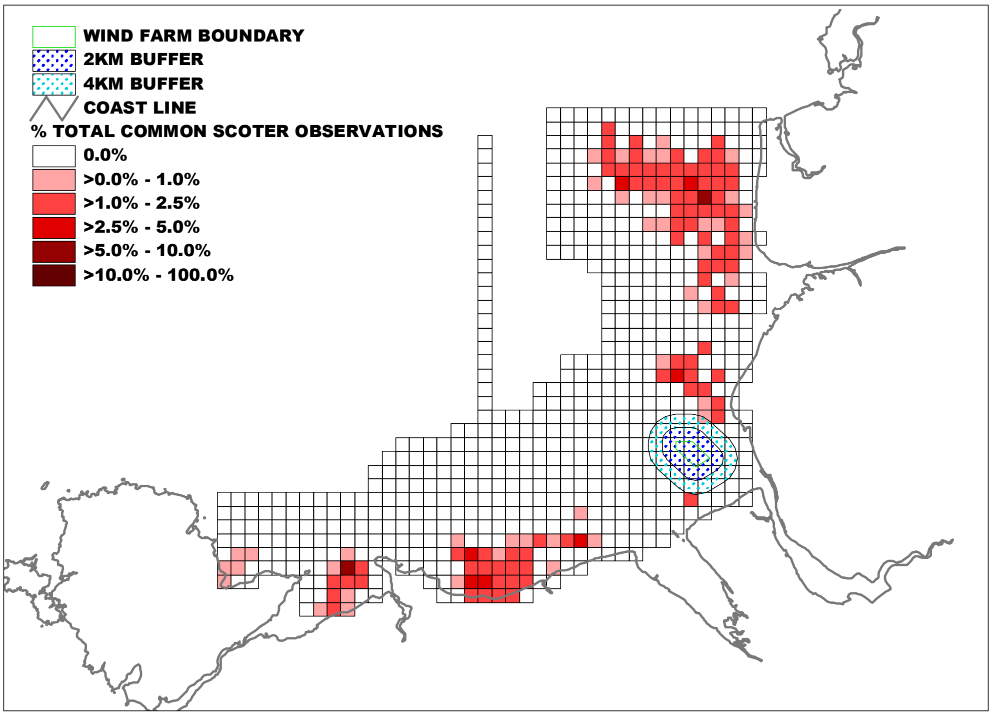

Figure 5.14: Common scoter distribution 2001-02 – showing buffers used in the assessment of disturbance effects

The risk of impact is based on the precautionary and conservative assumption of populations being limited by food resources and therefore birds being unable to relocate elsewhere into suitable habitat. However, although the proportion of the maximum total observations of important bird species within the 4km envelope around the site has been calculated, it is provided only to give a wider context to the figures obtained for the Burbo site itself and 2km buffer. It is the 2km buffer that has been used in this assessment to determine the significance of impacts, in the absence of any specific data for our species of interest. The 2km buffer is considered to be more realistic than the 4km buffer, though still conservative, since it is in excess of the maximum distance from which field studies have demonstrated some change in behaviour of seabirds in response to wind turbines (Tulp et al., 1999).

It should be emphasised that this is a measure of risk, not of impact, as responses will be variable between species and have not been studied for any of the seabird species relevant to this study. The semi-quantitative approach is therefore supplemented, in the assessment of significance of effects, with information on species' behaviour that may inform how they would respond near to turbines.

(v) Lighting

The effect of lighting from the turbines on nocturnal bird movement is discussed from a review of literature.

Substantial lighting on offshore structures such as oil platforms can attract seabirds, which appear to use the lighting to assist in locating prey at night (Wiese et al. 2001). Lighting on the turbines would not have this effect, being too removed from the water. From evidence of lighthouses, in certain weather conditions nocturnal migrants could be attracted to the lights, thus increasing the risk of collision with turbine blades for some species. The level of lighting for navigation and aviation that is proposed for the offshore wind farm, however, is of significantly reduced intensity and concentration in comparison to lighthouses. There is no evidence that lighting levels proposed would alter bird behaviour.

5.5.2.2 Impacts on Populations of International and National Importance

Table 5.11 presents the percentage of observations within the wind site, 2km and 4km buffers, from aerial surveys, and flight heights percentage at risk height, from boat surveys, for internationally and nationally important populations. The table has, however, only been completed for those species for which data are available in a form that lends itself to such analysis.

Table 5.11: Summary of risk of impacts from Burbo on populations of international and national importance

Species	**Percentage of total aerial survey observations within:**		**Flight height**
	Wind farm	**2km buffer**	**% at risk**
Populations of European importance			
Red-throated diver	1.2	1.3	3.2
Common scoter	0.0	0.0	0.0
Common tern			
Wader species			
Populations of national importance			
Cormorant	0.4	4.2	6.6
Red-breasted merganser	0.0	0.0	0.0
Little gull			
Auks	0.1	0.3	0.0

Notes:

- The observations within the wind farm derive from aerial survey data. Either single numbers only (red-breasted merganser) or no individuals (common tern, wader species, and little gull) were recorded; therefore no information is available for these species.
- The flight height data derives from the Burbo boat surveys and the percentage of the population at risk is the proportion of observation during those surveys of birds at or above turbine blade height.
- An assessment of any impact on common tern, waders species and little gull has been made by reference to species numbers and known behaviour of each species

(i) Impacts on populations of international importance

Red-Throated Diver

Aerial survey findings reveal that less than 2.5% of the total red-throated diver observations, equating to 8.7 individual birds, were recorded in Burbo and its 2km buffer.

3.2% of all observations of red-throated divers in flight that were recorded from the boat surveys, were flying at a height at or above blade height. These were apparently longer distance flights to and from inshore waters, not due to boat disturbance.

Construction of the turbines and cabling and decommissioning will take place during periods of no or low diver populations in Liverpool. Any effects of disturbance will be temporary.

Fish stock prey of divers is predicted not to alter post-construction.

Impacts are therefore: predicted disturbance within 2km of the Burbo, occupied by less than 3% of the Liverpool Bay population; less than 4% of the Liverpool Bay population at risk of collision; and no direct habitat loss. Therefore, the magnitude of **risk of impact** is predicted to be **low**. This impact is on a population of **very high sensitivity**, therefore of **medium significance**, albeit the risk of impact being on single figures of birds.

Common Scoter

No common scoter occurred on the Burbo site and less than 1% of the Liverpool Bay population occurred within 2km of the site in 2000/2001 and 2001/2002. The percentage of observations within 4km of the site were higher in 2001/2002, when the Formby population feeding grounds extended south over Taylor's Bank.

The reason for the absence of common scoters from Burbo, given the superficially suitable shallow water habitat with a rich benthos, is unclear. Mollusc recruitment is very variable and could determine future suitable years for common scoter on Burbo. Contrary to this is the historically low numbers of birds recorded from Seaforth, which would indicate that a population has not been overlooked. Regular boat movements are negatively correlated with scoter movement (I.K. Pedersen, unpublished data) and could on Burbo, with the proximity of the Queen's Channel and temporary mooring sites for ships entering the Mersey, be the principal explanatory factor.

Compared to most species, a high proportion of common scoter flight movement throughout Liverpool Bay (NWP Offshore Ltd 2002) was within or above turbine blade height. However, it is suspected that the higher flight movements are escape responses to the approaching survey boat, most observations without disturbance being below blade height. Even with this caveat, less than 0.001% of the population is at risk from collision.

No movement of birds through Burbo was observed or would be expected. Direct movement between common scoter aggregations in 2000/2001 and 2001/2002 would not pass through Burbo. Second, populations at each of the key sites remained static (corrected for survey effort) in the winter of 2000/2001 (Oliver et al, 2001).

No quantifiable effect, through change in the benthic fauna or release of toxins in suspended sediments, on scoter food at Taylor's Bank is predicted from construction of the wind farm.

Most construction and cabling work and decommissioning will take place when common scoter is absent from the Bay. Boat movements during maintenance occur through areas with no common scoter present.

Impacts are therefore: predicted disturbance within 2km of the Burbo, occupied by less than 1% of the common scoter population; less than 0.1% of the population at risk of collision; no direct habitat loss; and no disruption of flight paths. This would result in a predicted **risk of impact** of **negligible** magnitude on a population of **very high sensitivity**, therefore an impact of **low significance**.

Waders

Wader species are subject to potential impacts from:

- Disturbance and habitat loss during cabling
- Collision or disturbance to flight route from the operational wind farm

Cabling at the North Wirral Foreshore

Cabling construction will occur outside of the period in which bird numbers qualify the SPA, so to minimise any disturbance to waders. Impacts on the benthos are predicted to be of less than month's duration (refer to Marine Ecology Technical Appendix C). No impact on sediments, therefore benthos, is predicted from operation of the cabling. Therefore in the very short-term, defined as less than a one-month period, there will be a reversible **risk of impact** of **medium** magnitude on a population of **very high sensitivity**, therefore an impact of **very high significance**. In the *medium term*, defined as a period of longer than one month, there will be a **risk of impact** of **negligible** magnitude on a population of **very high sensitivity**, and therefore an impact of **low significance**.

Collision risk and disruption to flight paths from turbines

There is no data to quantify movement frequency and height of movement of waders through Burbo and therefore to inform the risk of collision. There are no studies on the response of waders to offshore turbines. A review of waders' behaviour in response to terrestrial turbines found low risk of collision. Radar studies have demonstrated avoidance of turbines during flight for a number of species groups, but not waders. The risk of impact of Burbo on movement of waders is therefore of uncertain significance. There exists the potential for an impact by virtue of the fact that waders are known to fly between Formby and Wirral in sizeable flocks and at a height which would place them at risk of collision.

However, a study on wader movement in relation to existing turbines at

Kreekrak, Netherlands, (Musters et al. 1995, 1996), tempers the magnitude of impact. Here, indirect observation of collision frequency through targeted search of corpses demonstrated low rates of collision, with estimates of mortality of 0.41-0.53% of the waterfowl population annually from a 20 turbine development. This would, extrapolating to 30 turbines at Burbo, result in estimates of less than 1% mortalities annually for the population flying through Burbo being killed per year. Therefore, as the Kreekrak study is considered the most relevant in the available literature, and with caveats on a number of the parameters for Burbo being unmeasured, a **risk of impact** of **negligible** magnitude on a population of **very high sensitivity**, therefore an impact of **low significance**.

Common Tern

Burbo is within the foraging range of the Mersey Narrows and North Wirral Foreshore SPA common tern population as well as common terns of the two next nearest colonies to Burbo, at Shotton Steelworks and the Ribble Marshes. The latter are qualifying features of the Ribble and Alt Estuaries SPA and The Dee Estuary SPA and proposed extensions, respectively.

The findings of the study investigating the use (both as a foraging area and as a flight path) of Burbo by common terns of these three mentioned colonies suggest that the majority of common terns recorded within the study area comprise birds from both the Seaforth and Shotton populations.

Based upon the observations made during this study, the wind farm application site does not evidently constitute a significant foraging area for common terns. Despite not falling along the principal flight lines observed from Seaforth, some birds were nevertheless observed to pass through Burbo. Specifically, a number of birds were observed to cross the western part of the Burbo site, whilst apparently in transit between Formby Point and the Dee Estuary.

Although common terns have therefore been shown to pass through the Burbo site, all observations of common tern flight height were recorded to be within approximately 5-10 metres of the sea surface and hence flight altitude is below the rotor blade height. This observation is supported by published studies which found that the flight height at which movement to feeding areas and diving takes place is below that of turbine height (Perrins, 1998) and decreases in stronger winds (P.Marsh, pers. com.). This and behavioural observations suggest a low risk of collision.

No change in the relevant fish stock prey, sand eels and herring sprat, is predicted within or outside Burbo.

There is no evidence of the feeding behaviour of terns near to turbines from which disturbance can be assessed. Monitoring of a single turbine at Lake Ijsselmeer in The Netherlands (Dirksen, et al, 1998), near to which birds flew from a roost, but did not forage, showed avoidance of the turbines by distances of 50-100m, this distance increasing with larger foraging parties and in the dark. The location of wind turbines at Seaforth Docks is not informative, as birds leave the reserve to forage offshore in a north-westerly direction, at some distance from the turbine string.

For common tern therefore, with no predicted loss of food resources and a low risk of collision, a **risk of impact** of **negligible** magnitude on populations of **very high sensitivity** is predicted, therefore an impact of **low significance**.

(ii) Impacts on Populations of National Importance

Cormorant

Burbo is probably within the core foraging range of the wintering cormorant population of the Mersey Narrows SSSI. This is reflected in the high proportion of observations within the site and buffers, though with birds occurring at higher densities inshore of Burbo. If cormorants are sensitive to disturbance from wind turbines, there is potentially a significant effect on the SSSI population. There is no literature to support the species' sensitivity to, or tolerance of, offshore turbines whilst feeding.

There is some evidence that cormorants should not be sensitive to wind turbines. The wintering population qualifying the Mersey Narrows SSSI as such occurs within 200 m of a string of wind turbines at Seaforth Docks. There has been no measurable change in the roost's location or size in the period subsequent to construction. Offshore structures such as anemometer masts and buoys are used as temporary roosts.

No impact on fish stock prey for cormorant is predicted.

Given a low percentage of the population at risk of collision, no habitat loss, predicted low levels of disturbance due to habituation and no disruption of flight paths, a **risk of impact** of negligible effect on a population of **high** sensitivity is anticipated, therefore an impact of **very low significance**. This conclusion accepts the uncertainty over the sensitivity of cormorant to disturbance from turbines.

Guillemot and Razorbill (or Auks)

Burbo is beyond the foraging range of birds from Little Orme's Head SSSI and Great Orme's Head SSSI during the breeding season. In winter, neither species preferentially selects Burbo. The species fly at low height, except when exiting and arriving at breeding cliffs. Response to wind turbines is not known, but auks are tolerant of offshore human activity.

No quantifiable change in fish prey species is predicted to occur as a consequence of the development.

For both species, predicted impacts are no habitat loss, low levels of disturbance and negligible risk of collision, for 1% of the population.

Therefore there is a predicted **risk of impact** effect of **negligible** magnitude on a population of **high sensitivity**, resulting in an impact of **very low significance**.

Red-Breasted Merganser

Birds were absent from Burbo and did not preferentially select the buffer zones. All observations of birds in flight elsewhere in Liverpool Bay were below turbine blade height. No effect on fish stock prey from the development is predicted.

There is therefore a predicted **risk of impact** of **negligible** magnitude on a population of **high sensitivity**, resulting in an impact of **very low significance**.

Little Gull

The feeding grounds of the Seaforth population are not known but could include Burbo. Flight height of little gulls offshore is low (Coveney & Phalan, 2001), except when moving between land and offshore feeding areas. Therefore collision risk is expected to be low. The Seaforth population, which uses a site near to industrial structures, would not be expected to be sensitive to disturbance. No impacts on marine fauna, therefore prey items, are predicted. The turbine bases may create turbulence that increases accessible prey. Therefore, despite uncertainty over the importance of Burbo for little gulls, the predicted **risk of impact** of the turbines is **low**, on a population of **high sensitivity**, therefore of **low significance**.

5.5.2.3 Cumulative Impact Assessment

(i) Introduction to Cumulative and “in Combination” Effects

Article 6(3) of the Habitats Directive (92/43/EEC) makes explicit, and guidance on the provisions of this Article (IAU 2001) reiterates, the need for assessment of effects on Natura 2000 sites to be considered in combination with other plans and projects that may affect that site. Cumulative effects of wind farm sites, potentially on nature conservation interest at a level of importance below that of European sites, is also required by the Environmental Impact Assessment Directive (97/11/EEC).

It is recognised that the meaning of the word “cumulative” and the required planning status of the ”…other plans and projects” is less clear and open to interpretation. Therefore, it has been considered that cumulative effects will be considered in relation to the other wind farms mooted to be proposed for development in Liverpool Bay.

For this assessment, information exists from which the predicted effects of the proposed Burbo Offshore Wind Farm site in combination with those at Rhyl Flats, North Hoyle, and Shell Flat can be made. Additional consideration is given to the Arklow Bank offshore wind farm where little gulls winter, passing through Seaforth Reserve. No useful baseline information exists from which the cumulative effects of other offshore activities can be made and none has been made available by the statutory agencies.

Existing activities, even if they have an effect on bird populations, form part of the background noise against which predicted change should be measured. It is, however, considered impossible to assess cumulative effects on the bird populations that might exist in the absence of all these activities. For potential SPAs, the “favourable status” that should be maintained pertains to the habitats that support the population level at which the SPA is classified, not that habitat which supports a hypothetical population that could exist in the absence of existing activities.

A semi-quantitative assessment of the cumulative effects of the four wind farm sites within the Bay, on each of the populations of European and national importance, can be made for disturbance. Information on benthos is available for Burbo, though such information is not available for other proposed wind farm sites. Similarly, behaviour of birds around all four of the wind farm sites is not available and therefore an assessment of disruption of flight paths and collision risk cannot be made. It has further been assumed that, excepting any habitat loss due to an accident or accidents, direct loss of feeding habitat is likely to be small for all sites and so the cumulative effect of habitat loss is not considered further.

(ii) Disturbance

The method used to assess cumulative effects of disturbance, identical to the impact assessment in relation to the Burbo site, is described below.

The significance of the “in combination” or cumulative effect is calculated from summing the known or estimated proportion of the population of interest within the area over which disturbance is predicted to occur. The summed percentage of the population potentially affected by the sites gives, using the impact assessment methodology used earlier in this report, a level of significance of effects.

In deciding on the size of the sea area over which disturbance might occur and the sensitivity to disturbance of individuals, the reasoning used earlier in this report for each species is, for consistency, repeated for this cumulative effects assessment.

5.5.2.4 Cumulative impacts on populations of international and national importance

(i) Cumulative Impacts on Populations of International Importance

Red-Throated Diver

The effects of disturbance on this dispersed species are uncertain, as it is at least likely, though not statistically proven, that the aerial survey data on which the assessment is based does not detect aggregations of this species. On the unproven assumption that disturbance takes place up to 2km from the wind farm site then the potential **cumulative risk of impact**, should turbines disturb divers, is therefore of **medium** magnitude, on a species of **very high sensitivity** and so of **very high significance**.

The contribution of Burbo (Table 5.12) to the cumulative effects on red-throated divers is **low**.

Table 5.12: Cumulative effects on Red-throated Diver

Wind farm	**% of total aerial survey observations within:**	
	wind farm	**2km buffer**
Burbo	1.2	1.3
Shell flats	0.8	0.8
Hoyle	1.2	2.8
Rhyl	0.9	3.0

Common Scoter

Common scoter distribution is highly aggregated in the Bay and a major aggregation occurs in the vicinity of the Shell Flat site. 30.3% of common scoter observations were within 2km of a proposed wind farm, of which 28.8% were within 2km of Shell Flat. This is a potentially **high cumulative risk of impact**, on a population of **very high sensitivity** and therefore of **very high significance**. The contribution of Burbo (Table 5.13) to the cumulative effect is nil at 2km.

Table 5.13: Cumulative effects on Common Scoter

Wind farm	**% of total aerial survey observations within:**	
	wind farm	**2km buffer**
Burbo	0.0	0.0
Shell flats	10.6	18.2
Hoyle	0.0	0.1
Rhyl	0.1	1.3

Table 5.14 summarises the predicted cumulative or “in combination” disturbance effect of the wind farm sites in Liverpool Bay on bird populations of European importance.

Table 5.14: Cumulative disturbance effects by proposed wind farms in Liverpool Bay

Species/ Species groups	Significance of effects				
	Burbo	North Hoyle	Rhyl Flats	Shell Flat	In combination
Population of European importance					
Red-throated diver	Medium	Medium	Medium	Medium	Very high
Common scoter	Low	Low	Medium	Very high	Very high

(ii) Cumulative Impacts on Populations of National Importance

Cormorant

The cormorant population of Seaforth cannot be distinguished from other populations, for which there would be expected to be overlap in the foraging ranges where other wind farm sites are considered. Cited literature on the foraging range of cormorants and satellite tagging data would suggest that most movement from Seaforth was only over Burbo. Therefore a cumulative effects assessment is not made.

Little Gull

Burbo wind farm site is the only proposed wind farm site within Liverpool Bay which could potentially impact upon the spring passage through Seaforth Reserve. Recent studies, however, appear to indicate that these birds originate from the little gull population of approximately 1,000 birds that winters off County Wicklow, south-east Ireland, at which location (specifically on the Arklow Bank) an offshore wind park is proposed to be built. Ornithological studies of the Arklow Bank wind farm site (Coveney & Phalan, 2001) have demonstrated that large numbers of little gull forage over the bank.

The Arklow Bank studies used a qualitative impact matrix, compared to a quantitative matrix as used in the Burbo assessment (Percival, 2001), to determine the significance of effects on little gulls. Despite their differences, however, the two impact matrices are considered sufficiently similar to allow a cumulative effect to be predicted. Using the qualitative matrix, Coveney & Phalan, 2001 concluded the significance of collision risk and disturbance effects of the Arklow Bank wind farm, to be moderate and major, respectively. It should be noted that the Arklow Bank impact assessment is risk-based, with magnitude of effects being determined primarily on the number of birds present per se, rather than considering the vulnerability of the birds present by taking into account how their behaviour may influence any impact.

Rather, in the Burbo impact assessment the magnitude of impact has been determined by taking both number of birds present and their likely vulnerability to disturbance and collision into account. Accordingly, despite the uncertainty over the importance of Burbo for little gulls, the predicted effect of the Burbo wind farm is considered to be **low magnitude**. Little gulls are known to typically fly low and, therefore, not be particularly vulnerable to collision. Additionally, the Seaforth birds feed within 100m to 200m of Seaforth's sea-wall turbines and so would not be expected to be sensitive to disturbance. Given that the population is of **high sensitivity**, an impact of **low significance** is predicted for Burbo.

In combination, Burbo and the Arklow Bank wind farms would, based upon the individual consultants' impact assessments, result in a predicted effect of high magnitude. For the reasons given above, however, this magnitude rating should be considered highly conservative, since little gulls' feeding behaviour offshore, for example the tendency to feed in the wake of boats and buoys, implies that this species is likely to show a low vulnerability to disturbance.

On the assumption that little gulls are not disturbed by wind turbines and are at low risk of collision, as evidenced by their behaviour at Seaforth Nature Reserve in the vicinity of turbines (for which there is anecdotal evidence, but no scientific study) then reasoning from the species' behaviour a **cumulative risk of impact** of **low significance** is predicted.

Guillemot and Razorbill (or Auks)

The wintering population of razorbills and guillemots is considered to be unlikely to be sensitive to disturbance, given these species' tolerances of other offshore structures. Negligible numbers occur within 2km of Burbo.

Other Species

For other species of conservation concern, populations are not known or expected to range over Burbo and one or more other wind farms, therefore no cumulative effects assessment is made.

5.5.3 Monitoring

5.5.3.1 Introduction to Monitoring

It is regarded as best practice to undertake pre-construction, during construction and post-construction monitoring, with the purpose of informing developers of any likely generic impacts of offshore wind farm development. To this end it is proposed to undertake monitoring at Burbo to investigate further the species for which an impact has been predicted within this Assessment and associated Environmental Statement. The precise monitoring will be formulated in consultation with English Nature, though is proposed to address the following:

- Effects on the red-throated diver population in Liverpool Bay
- Effects on the population(s) of common terns from the Mersey Narrows and North Wirral Foreshore SPA and, pending the results of

further surveys, the population from the Dee Estuary SPA
- Effects on wader movement between The Mersey Narrows and North Wirral Foreshore SPA and the Ribble and Alt SPA
- Effects on the cormorant population of the Mersey Narrows SSSI.

5.5.3.2 Monitoring Package

The monitoring programmes will require the following studies:

(i) Red-Throated Diver

Pending study into the relative effectiveness of boat and aerial survey methods for population estimation for red-throated diver, monitoring will be undertaken of disturbance effects from turbines on this species.

(ii) Common Tern

Boat-based monitoring will be carried out on the distribution and foraging behaviour of common terns in the vicinity of the turbines.

(iii) Waders

Studies will be undertaken to determine flight behaviour in the vicinity of turbines and, pending the results, consideration will be given to collision monitoring.

(iv) Cormorant

Boat-based monitoring will be carried out on the distribution and foraging behaviour of cormorant in the vicinity of the turbines.