Centre for Marine and Coastal Studies

The Impact of Construction Noise from the Robin Rigg Offshore Wind Farm Development on Cetaceans in the Solway Firth

An updated Environmental Assessment

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1 Introduction

The Robin Rigg Offshore wind farm is a consented development of 60 turbines located on a sub-tidal sand flat within Scottish waters in the mid area of the Solway Firth. In 2002 Centre for Marine and Coastal Studies, University of Liverpool undertook the Environmental Impact Assessment concerning cetaceans. During the assessment it was considered that the loudest noise levels occurring during the construction phase would arise from the installation of the turbine foundations through pile driving.

It was originally estimated that the maximum noise level generated by piling would be unlikely to exceed 150dB at source. This noise level estimate was based on a literature review as no specific information was available at the time regarding noise levels associated with offshore wind farm construction. It was consequently predicted that harbour porpoise (*Phocoena phocoena*), the only cetacean species which the Environmental Statement noted was regularly observed in the Solway Firth, would be able to detect noise from pile driving within a radius of up to 1-1.5km and therefore concluded that there would be no serious adverse impact of construction noise on harbour porpoise.

In 2003 COWRIE (Collaborative Offshore Wind Energy Research Into the Environment) commissioned research into the noise levels associated with offshore wind farms, including during construction by hammer piling of monopile foundations. This led to the production of the report: *'Measurements of underwater noise during construction of offshore windfarms, and comparisons with background noise'* (Nedwell *et al*, 2004). This study directly measured the noise levels associated with piling turbine foundations into the sea bed at the North Hoyle wind farm (Liverpool Bay, Irish Sea) and found that piling at 5m depth produced a source level of 260dB re 1 μPa @ 1 m and for 10 metres depth 262dB re 1 μPa @ 1 m.

In the light of this new information, and the fact that these levels were higher than those assessed in the original environmental statement for Robin Rigg, it was considered necessary to reassess the possible impacts of elevated construction noise levels upon cetaceans of the Solway Firth. E.ON UK Renewables Developments Limited have asked Centre for Marine and Coastal Studies Ltd (CMACS) to undertake this work.

Since the original Environmental Statement was produced in 2002 a 12 month baseline survey of marine mammal activity in and around the wind farm site in the Solway Firth has been completed (February 2004 to January 2005). This survey programme has been reported separately in a sightings report (CMACS 2005). The sightings report confirmed that the primary cetacean species present in the Solway Firth on a regular basis was harbour porpoise.

Data provided by the Solway Shark Watch Foundation[1] that was used in the original Environmental Statement supports this conclusion. Between 1975 and 2002 a total of fifteen species of cetaceans were recorded within 60km of the coast in the Irish Sea. However, the cetacean species most regularly observed in the Solway Firth are two odontocetes: Harbour porpoise and the Bottlenose dolphin (*Tursiops truncatus*).

[1] Data from the Solway Shark Watch Foundation was provided by Norman Hammond. The group records marine mammal sightings, in addition to sharks.

Bottlenose dolphin are seen in the northern Irish Sea during all months of the year, with most sightings from approximately April to September. Sightings are commonly of groups that vary between two and ten individuals including young. In the Solway Firth, bottlenose dolphins are only occasionally seen. When they are seen however, they are usually observed in large groups moving through the area over a period of a few days. This movement may describe a foraging migration from Cardigan Bay. This species feeds on a variety of benthic and pelagic fish including eels, flounder, dab, sole, salmon and trout, all of which are found in the Solway Firth. Due to the very low presence of mysticete cetaceans within the Solway firth it is unlikely that there will be any individuals in the general area during the construction period. If bottlenose dolphin or other cetaceans do occur it is considered that mitigation developed to protect harbour porpoise will also protect other species.

The present report therefore focuses on the reassessment of underwater noise impacts from offshore wind farm construction on harbour porpoise in the Solway Firth and suggests mitigation, where necessary, to ameliorate impacts which may arise from higher construction noise levels.

This report also provides a summary of harbour porpoise populations and ecology in UK waters and, to the best available current knowledge, the Solway. This summary is based primarily on the CMACS sightings report and a specialist report commissioned by CMACS from Dr Peter Evans of the Sea Watch Foundation, Oxford.

In UK waters, protection is given to all cetaceans species through Section 9 of the Wildlife and Countryside Act (1981), which prohibits the deliberate killing, injuring or disturbance of any cetacean. Protection is also afforded to cetaceans through Article 12 of the Habitats Directive (92/43/EEC), implemented by The Conservation (Natural Habitats, etc.) Regulations (1994). Furthermore, 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”.

The harbour porpoise is a UK BAP species and is listed under Annex II of the Habitats Directive (92/43/EEC).

2 Harbour Porpoise in UK Waters and the Solway Firth

2.1 HP Breeding Behaviour

In the British Isles, and adjacent seas, calves have been observed between February and September, particularly during May to August with a peak in June (Evans, 1997; Sea Watch, unpublished data), and this coincides with the findings from reproductive studies conducted upon stranded or by-caught animals (Møhl-Hansen, 1954; Fisher and Harrison, 1970; Sørensen and Kinze, 1994; Lockyer, 1995; Addink and Smeenk, 1999). The gestation period of the harbour porpoise is ten months so that peak mating occurs in August. Evidence for social and sexual activity in late summer has been widely reported (see, for example, Evans, 1997; Evans and Wang, 2003). Females are believed to nurse their calves for between eight and twelve months, although weaning is a gradual process, and young probably start taking solid food after a month or two (Mohl Hansen, 1954; Read, 1999).

In the Irish Sea, by far the most important area for breeding appears to be west of Pembrokeshire extending northwards to southern Cardigan Bay (Evans and Wang, 2003). However, harbour porpoise are believed to calve within the upper reaches of the Solway Firth, in particular the area between Southerness Point and Silloth, and there may be a peak in late summer. This information is based on regular findings of dead porpoise calves in the intertidal zone between Workington and Silloth each year in September (Hammond, pers. comm. 2002).

It is not clear whether individual harbour porpoise have favoured calving grounds. Comprehensive coverage of the region using effort-related surveys does not exist; however, sightings reports from those surveys that have been conducted, along with limited dedicated land-based observations and opportunistic sightings, together suggest that some areas are favoured over others (although not necessarily for calving).

Most of the Solway Firth is very shallow, and studies elsewhere indicate that during calf rearing, porpoises tend to favour coastal areas with depths between 10 and 40 metres, and in several areas particularly 20-30 metres (Evans, 1997; Read 1999). Sightings indicate that the species tends to occur all across the central and outer parts of the Firth (west of a line drawn from Silloth to Southerness Point) but including at least part of Moricambe Bay (North of Silloth). Beyond this region, there is a similar likelihood of sightings off the Galloway (e.g. Luce Bay) and Cumbria (off Maryport and Whitehaven) coasts.

2.2 Distribution of HP Populations

An important question is whether harbour porpoise in the Solway Firth can be considered to represent a distinct population. Prior to the use of molecular genetic techniques Harbour porpoise (HP) were considered to be divided into sub-populations based on the presence gaps in suitable habitat and assumed limited migration capacity.

Gaskin (1984) proposed that there were 14 sub-populations in the North Atlantic (in Britain this included Ireland/west Britain, North Sea and English channel.

More recently, metrical studies using skeletal material, along with studies of tooth ultra-structure and genetics have broadly supported this level of population division and together suggest that subpopulations of harbour porpoises may exist in the North Sea and adjacent waters, with possible separate populations occurring in the Irish Sea, northern North Sea, and southern North Sea (Netherlands) (Andersen, 2003; Lockyer, 2003). Genetic evidence from the UK and elsewhere also indicates that males disperse more widely than females (Walton 1997; Andersen *et al*., 1997; Tolley *et al*., 1999).

Within the Irish Sea, there is no evidence for sub-structuring although it should be borne in mind that very few porpoises have been sampled in the northern Irish Sea. However, bearing in mind the extensive individual movements revealed from recent satellite radio tagging studies from Danish waters (regularly from inner Danish waters into the northern and central North Sea – Jonas Teilmann, *pers. comm.*), this is thought to be unlikely. For the purposes of this reassessment, therefore, Solway Firth harbour porpoise are considered as part of the wider Irish Sea population.

Certain individuals are likely to be present in the Solway Firth throughout the year. The species has been recorded in the area every month of the year (Evans *et al*., 2003) and studies elsewhere (for example in Danish waters, Shetland, and Cardigan Bay) suggest that some porpoise individuals do remain in the same area for extended periods. Such residency is likely to be determined by the availability of potential prey. If there are seasonal gaps in the occurrence of suitable prey, then porpoises very likely move out of the region for that period. Most of the long-distance movements in the North Sea are thought to relate to seasonal variations in food availability. The same may occur in the Solway Firth although one can expect at least some individuals to be resident throughout the year.

2.3 Harbour Porpoise Population Size

No harbour porpoise population estimates exist for the Solway Firth or for the entire Irish Sea. A spatio-temporal analysis of combined effort-related sightings data from the SCANS survey, European Seabirds at Sea and Sea Watch Foundation's databases suggested that an area of the southern Irish Sea from southern Cardigan Bay (West Wales) south to the St George's Channel (west of Pembrokeshire) was one of particular importance for the species in the context of the rest of the British Isles (Evans and Wang, 2002). In the Cardigan Bay SAC, a population of 122 animals (95% CI 90-165) was recorded between May and October 2001, but with three times as many in August-September compared with May-July (Baines *et al*., 2002).

Between 2001 and 2004, summer population densities of harbour porpoises within the southern Cardigan Bay SAC have varied between 0.2 and 0.5 per km^2 (Sea Watch unpublished data). Based on knowledge of the Sea Watch sightings database it is likely that in the Solway Firth, population densities are towards the low end of this range. Assuming that the usable area of the Solway Firth for harbour porpoise includes all water west of a line drawn from Silloth to Southerness Point as far as the mouth between Workington and Abbey Head, but including Moricambe Bay (cf. Section 2.1) provides a figure of around 600 km^2. This equates to a peak porpoise population of around 120 individuals in the Firth. This compares to maximum sightings in 12 months of vessel based survey of 34 individuals in November 2004 (CMACS 2005). This seems reasonable given that only a proportion of Firth was covered by the survey and survey efficiency can never be 100%.

2.4 Harbour Porpoise Foraging

Prior to project specific surveys (see below), limited information has been available about which areas of the Solway Firth are used by harbour porpoise for foraging since observations had been made over only portions of the estuary, and watches had rarely extended over long periods. Our general knowledge of harbour porpoise habitat preferences would suggest that deeper water channels and particularly the edges of sand banks are likely to be amongst favoured locations, with depths typically varying between 10 and 40 metres (Evans and Wang 2003, Read 1999). As most of the Solway Firth is less than ten metres depth, this means that porpoises are unlikely to favour areas east of a line drawn from Silloth to Southerness.

This general assessment is supported by the sightings report (CMACS 2005), based on project specific surveys carried out over the area shown in Figure 1, Section 4.3. Most sightings were in deeper water channel areas to the east and west of the wind farm and there was a general scarcity of sightings in shallow waters (such as within the proposed wind farm area).

The sightings report also identified patterns in harbour porpoise movement that were related to tidal state. There was evidence that porpoise moved inshore towards high tide and were most active in the survey area (cf. Fig. 1, Section 4.3), presumed feeding, during the 3 hours when the tide was ebbing fastest and around low water.

3 Cetacean Hearing Physiology and Possible Impacts

3.1 Basic Hearing Physiology

Marine mammals utilise noise for a variety of purposes such as hunting, breeding and communicating. Generally, small cetaceans have poor hearing at low frequencies (Vella et al., 2001).

Physically, ears of marine mammals are similar to those of land mammals and therefore, since many forms of hearing loss are based on physical structure, it is likely that hearing damage occurs by similar mechanisms. The most dramatic differences in hearing between terrestrial mammals and cetaceans are that the ear canals may not be functional and odontocetes such as porpoises are able to channel sound from their environment to the middle ear through the lower jaw using fats in conjunction with a thin bony area called the pan bone.

3.2 Potential Impacts of Noise: Physical Damage

Noise, depending upon spectral characteristics, duration of exposure and magnitude can have several levels of effect. The sudden onset of very loud noise may cause lethal effects through the damage of sensitive tissues. Sub-lethal levels of noise may damage hearing by causing decreased auditory sensitivity. The extent of hearing damage from noise emitted from a point source depends upon a number of factors such as the physiological and physical behaviour of the mammal, the duration of the noise, the frequency of the noise, the level of the noise and the background environment. If exposure to the noise is short then hearing may be recoverable (Temporary threshold shift or TTS); if the noise is long in duration or has a sudden onset then hearing, particularly in the higher frequencies, can be permanently lost (Permanent Threshold Shift or PTS).

The extent of damage to the ear determines whether the resulting threshold is either a TTS or a PTS. If permanent hearing damage occurs this may have serious consequences for individuals affected through impaired foraging, predator detection, communication, or mating disruption.

Much of the data on the effects of loud noise on marine mammals has been extrapolated from human hearing systems due to the physiological similarities. Although it is sensible to assume that hearing damage will be similar in terms of the physiological damage caused it is not realistic to extrapolate hearing level as marine mammals have different sensitivities to sound levels. This is because marine mammals have evolved ears which function well within the context of the underwater environment with tougher inner ears adapted to the very much greater pressures occurring underwater and with depth (i.e. static pressure experienced in deep dives). Recent anatomical and behavioural studies do indeed suggest that cetaceans may be more resistant than many land animals to temporary threshold shifts (Ketten 1998).

3.2 Potential Impacts of Noise: Behavioural Effects

Noise present below levels that can cause physical damage to animals may still have ecological impacts. Increased noise levels may impede the mammals ability to navigate, find food or may mask communication signals which may be vital for social cohesion, mating, warning or individual identification. It may also mask the detection sounds of predators or prey. Such masking is considered to be biologically significant if the animal's biological fitness is reduced (i.e. a decline in the rate of reproduction). However, the extent to which masking can affect biological fitness is not yet fully understood (Erbe *et al* 2000). Elevated noise levels may also result in behavioural disturbances with a disruption of normal animal behaviour such as cessation of feeding, or onset avoidance of an area. This is not considered to be biologically significant if alterations in swimming path, breathing and heart rate are only temporary. However, if animals are scared away from critical habitats for an extended period or if foraging, mating or nursing are impeded then impacts are considered to be important.

For this re-assessment the relatively new concept of "the perceived level of sound for particular species (dBht)" has been applied in the analysis of behavioural effects on cetaceans. The dBht (Species) level is estimated by passing sound through a filter, which mimics the hearing ability of the species. If the level of sound is sufficiently high on the dBht (Species) scale it is likely that an avoidance reaction will occur (Nedwell *et al* 2004). Nedwell *et al* suggest that 90 dBht (*species*) and above will cause significant avoidance reaction, with strong avoidance by most individuals at 100 dBht (*species*). Mild avoidance reactions may occur in a minority of individuals at levels above about 75 dBht (*species*).

3.3 Piling Noise

3.3.1 Overview and Experience at Other Wind Farms

The marine environment is generally considered to be relatively noisy with ambient noise arising from wave action, bubble formation, action of wind and rain on the sea surface and noise from wildlife. This ambient noise combines with man made noise produced from, for example, shipping, offshore installations, sonar and pleasure craft to produce background noise which varies with different locations due to the influences of the existing sea bed geology and the local environment, including depth characteristics.

It is assumed that noise levels and transmission loss (with distance) during piling at Robin Rigg will be similar to those experienced during piling at the North Hoyle wind farm with an upper level of around 262 dB as this is the most representative data currently available. It is recognised that there will be some variation in the absolute noise level of pile driving at Robin Rigg and propagation with distance compared to North Hoyle due to differences in depth, substratum and bathymetry of the sea bed in addition to any differences in engineering practice. It is believed that an assumption that the source noise level and broad noise propagation characteristics will be similar to North Hoyle is reasonable provided that this information is used conservatively.

Experience at other wind farms provides some useful background for the present project, although it is recognised that no detailed noise monitoring has yet been undertaken in direct conjunction with monitoring of marine mammal activity. Horns reef (Denmark) is the largest marine wind farm to date with 80 turbines and came into operation in December 2002 (Dolman, 2003). It is also a known area for porpoise breeding though the exact location cannot be pinned down. Tougaard *et al* (2003) undertook a study of the effects of the windfarm construction (piling) upon the local harbour porpoise population. Acoustic data loggers (PODs[2]) and ship based visual surveys were used. Although piling source noise levels are not given it is assumed they were of a similar level to those measured for piling at North Hoyle and expected at Robin Rigg. This is a reasonable assumption because pile sizes and driving techniques are very similar to those used at North Hoyle and proposed for Robin Rigg. Results showed piling activity to have a short-term impact on the harbour porpoise with porpoise activity being reduced up to 15 km from the wind farm then returning to normal levels 3-4 hours after piling had ceased. No evidence has arisen of physical harm to harbour porpoise or other marine mammals as a result of offshore windfarm construction.

This suggests that porpoise will return to the area after the cessation of the piling noise within a few hours. Medium to long term impacts on harbour porpoise populations in the Solway Firth would therefore not be expected to arise.

3.3.2 Duration of Piling

Pile driving to the required depth is expected to require hammering to take place for typically 1 to 3 hours per pile. Allowing for vessel positioning, and other setting up activities including interruptions due to adverse weather, it is expected than on average 1 pile will be installed every 2 to 3 days (1 to 3 hours in 36 if two rigs operate) during the period March to October 2006. The precise timings will be subject to some variation depending on ground conditions at individual turbine locations.

It is therefore important to bear in mind that the activity giving rise to the noise levels in question is short duration and infrequent, accounting for between 2 and 6% of the time. The noise will not be continuous over this period but intermittent, i.e. pulsed sound as the hammer operates.

3.3.3 Distance over which harm could occur

Various estimates have been made of the noise level threshold at which marine mammals will be at risk of physical harm. It is important to take into account the time period over which noise will act on receptor organisms, for example, Richardson *et al* (1995) suggest that relatively low levels of noise (140 dB) can induce a hearing injury in marine mammals but need to be continuous over several hours[3].

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[2] PODs detect harbour porpoise vocalisations (‘clicks’) to provide a measure of animal activity.
[3] Piling at Robin Rigg will be taking place for a small time period, e.g. 3 hours within a 72 hour period (3 hours in 36 if two rigs operate) and will comprise pulsed, not continuous sound over this period.

Nedwell et al. 2004 cited the work of Yelverton *et al.* (1972) who estimated a threshold of 163 dB re 1 μP (at source) for a high incidence of moderately severe blast injuries to marine mammals. Using transmission loss estimates for North Hoyle, Nedwell et al. considered that injury might occur to marine mammals there within 77m (5 m water depth) of piling activity.

Overall, it is considered highly unlikely that any physical harm would result to harbour porpoise (or any other cetacean) at a distance of more than 200 m from piling activity. It is considered likely that hearing injury could occur if animals were present in close proximity to piling (especially within 100 m or so), but highly improbable that this would occur provided that mitigation recommended in Section 4 was followed to ensure that animals are displaced further than 200 m from the centre of piling activity.

3.3.4 Distance over which behavioural effects could occur

Based on the source level of 262 dB and transmission loss for North Hoyle a level of 90 dBht (*Phocoena phocoena*), which would be expected to evoke a significant avoidance reaction from most individuals, would be received at 7.5 km from piling. This assumes that the Robin Rigg site has the same transmission loss characteristics as North Hoyle. This equates to a zone of avoidance around the piling rig of diameter 15 km which would be approximately 58% of the width of the estuary. There is therefore a possibility that movement of porpoise into and out of the estuary could be affected by the works. However, it is considered that the infrequent nature of piling described in Section 3.3.2 coupled with the availability of significant water without a predicted avoidance impact means that this risk is small.

Between 75 and 90 dBht (*Phocoena phocoena*) less marked avoidance reactions would be expected extending over a wider area. The prediction of reaction at distances for all behavioural impacts is clearly non exact and effect ranges will vary between individuals and over time as background noise varies. Some individuals may show similar reactions at longer or indeed shorter range.

Overall, behavioural effects are not considered significant in terms of the Irish Sea harbour porpoise population of which Solway porpoise are a part (cf. Sections 2.2 and 2.3); however, it may be significant for animals in the vicinity at the time of works. The perceived risk, albeit for a limited proportion of the time when piling takes place, is that individual animals might become ‘trapped’ to the east (landward) of the wind farm during piling which could cause undue stress, especially on a falling tide. For this reason, monitoring has been recommended in Section 4 to identify if such problems arise. Additional mitigation is then suggested which could be invoked if required.

3.3.5 Conclusions on Noise Impacts on Harbour Porpoise

- It is unlikely that death of individuals or permanent damage to auditory systems will arise from the piling activity unless individuals are in close proximity to the works, which will be mitigated for (Section 4).
- Harbour porpoise are expected to avoid an area of approximately 15 km

diameter around the construction rig during piling.

- Given the evidence from other wind farms, such displacement as does occur is likely to take place over the duration of piling only with porpoise returning to the area several hours after cessation. As piling is expected to occur over a very short period of time (approximately 3 hours over a 72 hour period with one rig operating) the significance of displacement on harbour porpoise in the Solway Firth is considered to be low.
- The potential impact of noise from the construction of Robin Rigg offshore wind farm on the Irish Sea harbour porpoise population, of which Solway Firth porpoise are a part, is considered negligible.
- However, because of the potential for the works to have behavioural impacts affecting individual animals, monitoring and further mitigation that could be invoked at short notice is recommended in Section 4.

4 Mitigation & Monitoring

4.1 Overview of Mitigation and Monitoring

A multi-level approach is envisaged involving:

- basic mitigation to avoid physical harm to harbour porpoise;
- monitoring to check for longer range behavioural impacts;
- stand-by mitigation should adverse long range behavioural impacts be observed.

The above will be supported by specialist noise studies that will provide noise measurements *during* construction that will confirm whether the current harbour porpoise mitigation and monitoring is appropriate or requires adjustment. The noise studies should, as far as possible, be undertaken at the commencement of piling works and at the same time as harbour porpoise monitoring.

4.2 Mitigation to Avoid Physical Harm to Harbour Porpoise

The general advice given in the JNCC's guidelines on minimising acoustic disturbance to marine mammals (JNCC 2004) has been adapted to provide the following specific guidance for piling activities during the construction of Robin Rigg offshore wind farm. This mitigation seeks to ensure that no harbour porpoise (or other marine mammal) is within 200m when piling starts. Mitigation should thus include the following:

1. Noise generation should be kept to a minimum throughout the construction period with pile drivers and other noisy plant machinery only being activated when required. This advice does not include use of acoustic deterrent devices designed to reduce risk of damage to marine mammals.
2. Acoustic deterrent devices (ADTs: porpoise pingers and/or seal scrammers[4]) should be deployed from the jack up rig 7 minutes before soft start piling commences. This will allow time for a porpoise swimming at (conservatively) 0.5 m/s (Otani et al. 2001) to move more than 200 m away. It is recognised that use of ADTs may require licensing from the relevant authorities.
3. ADTs should be switched off after 7 minutes, immediately before **soft start** pile driving. Pile driving should be started in such a way that sound energy initially released is at a low level and increased gradually and uniformly over 5 minutes until operational levels are reached.
4. ADTs should not be operated outside periods of piling activity and never for more than 10 minutes at a time to avoid acclimation and also to reinforce the association between them and follow up piling noise. If piling is delayed for whatever reason the devices should be switched off and the process re-started from step 2 prior to the next piling operation.

[4] Harbour seal (*Phoca vitulina*) and grey seal (*Halichoerus grypus*) may be present in the Solway Firth. Scrammers would act to deter both seals and porpoise from the area.

NB If marine mammals are sighted within approximately 500m of the installation barge leading up to piling the (soft start) piling would not commence until mammals had not been observed within 500m for at least 15 minutes.

The following summary can be provided to site engineers:

Marine Mammal Mitigation Procedures

Time (min)	**Activity**
0	Activate acoustic deterrent devices
7	Turn off ADTs & begin soft-start piling
12	Commence full piling

Notes

ADTs should not be operated outside periods of piling activity and never for more than 10 minutes at a time. If piling is delayed for whatever reason the devices should be switched off and the process re-started prior to the next piling operation.

If marine mammals are sighted within approximately 500m of the installation barge leading up to piling (soft start) then piling shall not commence until no mammals have been observed within 500m for at least 15 minutes.

4.3 Monitoring and Mitigation to Address Long Range Avoidance

The primary purpose of the monitoring is to maximise the likelihood that adverse long range behavioural impacts are detected. The primary concern is that individual animals do not become effectively trapped to the east (landward) at a distance of 7.5 km or more from the wind farm in the shallower part of the estuary, especially on a falling tide.

A number of survey methods have been considered, including: continuation of previous vessel based surveys (CMACS 2005); acoustic detection devices (e.g. PODs) and land based observations. All methods have both advantages and disadvantages. Vessel based surveys are limited to daylight hours in good weather and visibility conditions; however, information is obtained instantly and an experienced observer can infer useful information from animal sightings such as direction of movement, type of surfacing (e.g. feeding, resting, alarm). PODs detect over a relatively limited range (several hundred metres), are prone to loss by entanglement with fishing gear, anchors etc., do not provide data until serviced and analysed in detail and would be difficult to deploy and interpret in the Solway where there are complex channels and banks that will affect sound propagation. Furthermore experience during the monitoring exercises in support of the Environmental Statement was that equipment permanently sited in the Solway was generally quickly lost or damaged due to wave/weather conditions, resulting in loss of data. PODs also have a further drawback in that negative results (no clicks detected) do not prove that porpoise were absent as they may simply not have vocalised while in range. Their advantage lies in excellent temporal resolution over limited spatial areas and ability to operate in all conditions. Land based observations have similar advantages and disadvantages to vessel based surveys except that they sacrifice improved temporal resolution for spatial discrimination.

Given the existing database of harbour porpoise sightings from previous vessel based surveys and the need to obtain information quickly so that mitigation can be applied in an appropriate timescale, the main thrust of monitoring should be by vessel based survey. The existing survey transects are shown in Fig. 1. It is proposed that these surveys be re-commenced and undertaken on a fortnightly basis over the construction period. This should include at least 3 surveys prior to commencement of the main construction activities. As far as tides and tide constraints allow, transects should be extended as far northeast towards a line between Southerness Point and Silloth as possible. Depending on tides this may restrict the number of transects that can be extended in this way; if so the extended transects should not be adjacent ones.

During piling operations surveys should initially be undertaken on a more frequent basis and it is suggested that surveys should be timed to coincide with driving of the first 3 to 6 piles. This is likely to result in 2 to 3 surveys per week for the first fortnight of piling. Once several surveys have been completed in favourable conditions during piling the frequency can be reduced back to fortnightly surveys.

Because of the shallow waters and shifting banks it may not be desirable to take a survey vessel east between an approximate line from Southerness Point to Silloth on a falling tide. The risk of harbour porpoise becoming trapped past this area must therefore be inferred from supporting observations.

Evidence *during piling* that there was no cause for concern would be as follows:

- porpoise behaving in a normal manner (e.g. foraging, resting);
- directional swimming towards the piling works.

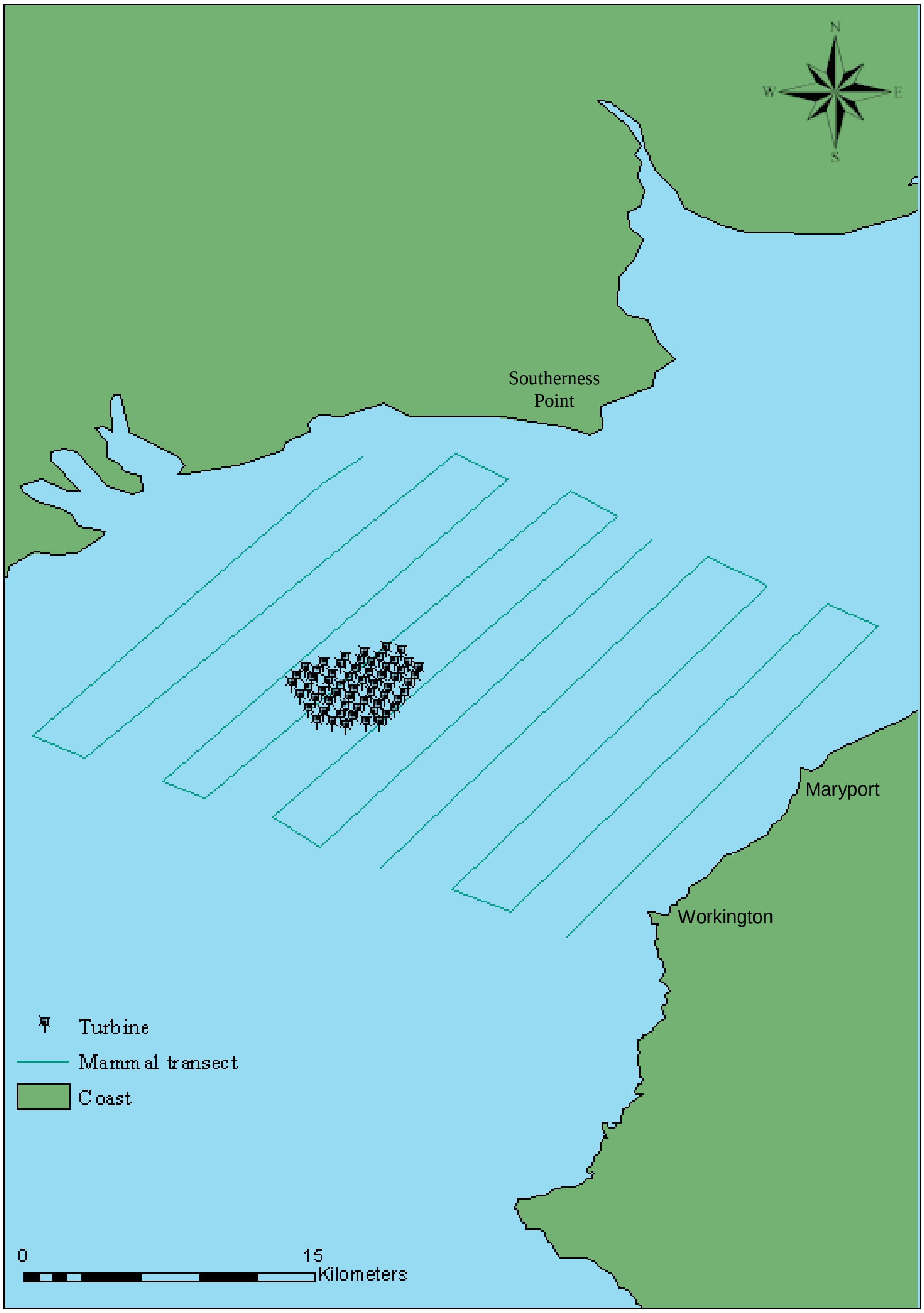

Figure 1. Existing vessel based transects.

Evidence *during piling* that there was cause for concern would be as follows:

- directional swimming away from the piling works on a falling tide (previous surveys (CMACS 2005) show that porpoise move towards the mouth of the Firth towards low water);
- observations of strandings (including reports from land based observers (see below) or reliable accounts from other parties).

Vessel based surveys could also be supported by land based surveys. The Solway Shark Watch and Sea Watch Foundation have recorders who provide data in the area and these, if necessary supplemented by consultants/volunteers, could provide valuable information by observing from strategic viewpoints. These could include: Silloth, Grune Point and Southerness Point to potentially provide coverage across several kilometres of the Firth where it is just over 10 km wide.

If a problem is detected and there is determined to be a risk of harbour porpoise becoming trapped in the shallower parts of the estuary by a falling tide the mitigation that can be invoked is to avoid piling during periods shown by the monitoring to be most sensitive. Based on results from behavioural monitoring over the 2004 season it is currently anticipated that the period 2 hours before low water will be the most sensitive, period during which piling may need to be suspended. The precise periods for avoidance of piling will be adjusted in response to monitoring observations if necessary.

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