ASSESSMENT OF THE EFFECTS OF OFFSHORE WIND FARMS ON BIRDS

ETSU W/13/00565/REP

DTI/Pub URN 01/1434

Contractor
Ecology Consulting

Prepared by
S M Percival

The work described in this report was carried out under contract as part of the DTI Sustainable Energy Programmes. The views and judgements expressed in this report are those of the contractor and do not necessarily reflect those of the DTI.

First published 2001

EXECUTIVE SUMMARY

This report seeks to review current knowledge of the effects that offshore wind farms have on birds and to identify sensitive offshore locations where bird conservation interests and wind energy development may conflict. It seeks to provide information for all stakeholders in the development of offshore wind farms. The specific objectives of the project were to; (i) produce a review of the available reports, data and information relating to the effects of offshore wind farms on birds, (ii) establish the locations of offshore sites and areas that hold important bird populations, (iii) identify the bird migratory routes that may encroach upon prime offshore wind energy development areas, (iv) identify gaps and uncertainties in the existing knowledge and recommend further studies that are needed to address these, and (v) provide an inventory of planned and ongoing studies.

There are currently only eight operational offshore wind farms, all within northern Europe. As a result, there are only a small number of studies of the effects of offshore wind farms on bird populations. At Lely, in the Netherlands, two diving duck species (pochard and tufted duck) have been studied to investigate their flight behaviour in the vicinity of wind turbines, mainly at night using radar tracking techniques. The main finding of this study was that these ducks were able to adjust their flight behaviour according to the ambient light levels, and as a result were able to fly around the turbines, even in conditions of darkness. The study also showed that most birds passed around the outer turbines rather than between turbines, and led the authors to suggest that lines of turbines may act as a barrier. Study of a single offshore turbine in Sweden showed a similar change in flight patterns to avoid flying in close proximity to the turbine, with lower numbers flying within 500m.

The most comprehensive studies have been carried out at Tunø Knob, where a small (10-turbine) offshore wind farm was developed in an area used by substantial wintering seaduck populations. The species studied were mainly eider (peak 5,800), with smaller number of common scoter (peak 700). The main focus of the work was the potential disturbance effect of the wind farm. No significant disturbance effect was attributable to the wind farm. Changes in bird numbers and distribution appeared to reflect changes in their food supply, and numbers in the wind farm area were highest after the wind farm had been constructed. The only detectable effect was that the eiders avoided flying and landing within 100m of turbines, but this had no impact on their feeding distribution. No significant effect was apparent on common scoter either, though the results were not so conclusive for this species as sample sizes were smaller. The close link between bird abundance/distribution and that of their food supply highlighted the importance of integrated ecological study if impacts are to be fully understood.

A further study at Tunø Knob using radar tracking showed that both eider and common scoter were also flying through the area at night. These birds did, however, modify their behaviour around the turbines, with less flights within 1500m of turbines at night (consistent with the Lely studies – the birds appear to maintain a greater distance from the turbines in conditions of poor

visibility). Eiders tended to avoid flying between closely spaced (<200m) turbines, suggesting, as in the Lely study, that rows of wind turbines could potentially act as flight barriers. This has implications for wind farm design; long lines of turbines should be avoided in order to reduce effects on flight lines. They also suggested keeping distance between turbines as small as possible to minimise the total area of the wind farm.

More studies have been undertaken on the effects of onshore wind farms on birds, and some of these can provide useful information in the assessment of the likely effects of offshore locations too. However, there are differences between the new proposed offshore wind farms in the UK and the wind farms at which such studies have been carried out, and the implications of these differences must be carefully considered. The new offshore sites are likely to use larger, quieter turbines, with slower rotational speed, and they are likely to be larger scale developments.

Studies at the onshore wind farm at Blyth Harbour in north-east England have covered a range of seabird/coastal species and are particularly relevant to offshore developments. A collision study here found that wind farm mortality was much less than the existing background mortality, including overhead wires (which resulted in double the collision rate in the study area compared with the wind farm). No evidence was found of any significant disturbance effects, other than during construction (when some species were temporarily displaced).

Other studies on birds at coastal wind farms have also generally found that collision rates have been low/ negligible, and well below any level that could give any significant population effect, even taking into account difficulties in measuring collision rate. It is still important, however, to consider the ecological consequences of any additional mortality – even a small level could be significant in some circumstances, eg on a species in decline. In terms of disturbance effects, there has been no evidence of any major adverse effects, with disturbance recorded up to 800m from wind turbines but often no effect has been detectable at all. Again, as for collision risk, it is important to consider the ecological consequences of disturbance in judging the significance of any impacts.

There has been an indication from existing offshore wind farms that they can result in an increase in fish and shellfish availability, and in marine diversity generally. Benefits have been noted through turbine foundations functioning as artificial reefs and through reduced fishing activity within wind farm areas. A range of potential adverse effects needs to be considered too, including changes to sedimentation patterns. No such problems have been reported at existing sites, but this issue has not been studied in detail in the context of offshore wind farm developments. They would need to be fully considered in an EIA and assessed on site-by-site basis.

Given the general lack of information about the specific impacts that offshore wind farms may have on birds, caution is clearly required if conflict between the developments and bird conservation interests is to be avoided. This is particularly true in novel situations where no relevant studies have been made of the species present, eg close to important seabird breeding colonies.

Birds on migration have only been a problem at existing wind farms when very large numbers have been moving through wind farms with very large numbers of turbines, or where particularly sensitive species are involved (where a small level of additional mortality could be significant). Landbird migrants generally move over the sea on a broad front, so, without any topographical features to concentrate them through the wind farm, would not be expected to pass through an offshore wind farm in particularly high numbers. As long as wind farms are located well offshore (>1km), this should not be a major problem.

Coastal waterfowl movements have the potential to be a more important issue. Only low collision rates have been recorded at existing wind farms, but if large numbers were moving regularly through a large wind farm, then such local movements could result in collision problems. It would be best to ensure that wind farms are located away from major local flight routes. Such flights are usually restricted within an estuary complex but regular tidal movements have been recorded between the Dee and Alt estuaries, and would also be likely to occur in close proximity to other important estuaries (1km has been suggested by RSPB as an appropriate minimum separation distance to reduce risk).

There is a wide range of ecological studies that provide further supplementary information of relevance to offshore wind farm EIA. Studies of seabird habitat selection and foraging behaviour studies (including foraging distances from breeding colonies) are useful to determine the likelihood that particular species will use a wind farm area, how important the area occupied by the wind farm may be in a local context, and what the consequences would be of displacement/habitat loss. Ecological models can provide a framework to integrate the various data on the birds' behaviour and habitat use. Such an integrated approach is essential to understand bird-wind farm interactions, as found at Tunø Knob. It is important to understand the factors affecting population change and how a wind farm may affect these. Studies have been made of how collision risk may be mitigated. Turbine design measures might reduce the risk of bird collision. These include slower rotational speed, and painting blades to make more visible (though the latter has been mostly laboratory-based work, with little field testing that has demonstrated any major benefit). Navigational lighting could potentially increase collision risk. Work on the behaviour of birds to different forms of light concluded that birds would generally be least affected by using flashing white lights of as low intensity as possible, rather than continuous or red light, or rotating beams.

The infrastructure associated with offshore wind farm development also needs full consideration. An overhead line to take the cable to the grid connection may pose a greater collision risk to birds than the wind farm itself, for example. It would be advisable to avoid high densities of birds/sensitive species and statutorily protected areas as much as possible. If crossing such areas is unavoidable, then the cable should be undergrounded.

There are currently only a small number of planned/ongoing studies of the effects of offshore wind farms on birds. In Denmark five planned demonstration sites all have bird monitoring programmes, with baseline work now approaching completion and comprehensive monitoring scheduled after construction in 2002-04. Work is also ongoing at Utgrunden in Sweden and on the two offshore turbines at Blyth. Apart from this, however, most of the current work is in relation to the preparation of EIAs for planned offshore wind farms in northern Europe.

The UK holds a considerable number of important offshore bird sites. The BirdLife International Important Bird Areas have been used to identify all the sites that support internationally or nationally important populations. The conservation designations of greatest importance are those European sites that are Special Protection Areas (for birds) or Special Areas for Conservation (for habitats and other wildlife interest). If an offshore wind farm may have a significant adverse effect on the conservation interest of these sites, an Appropriate Assessment must be carried out, whereby the onus is on the developer to show that it would not adversely affect the ecological integrity of the site. With the current state of knowledge, this may be difficult, particularly for species that have not been studied at existing wind farms. It is important to consider other protected areas too, including nationally important Sites of Special Scientifics Interest, Sensitive Marine Areas, and Marine Nature Reserves. These areas should be avoided as much as possible, as they would all be of high/very high sensitivity. Particular sensitivities include seabird breeding colonies, seabird concentrations outside the breeding season, and estuarine waterfowl flight routes.

English Nature have suggested guidance to help identify potentially vulnerable seabird areas in the context of offshore wind farms. In relation to breeding seabirds, they recommend avoiding siting wind farms within 1km of important gull or tern colonies, or within 20km of other seabirds. They have also identified likely important areas for common scoter as sites 5-15m deep and up to 2km offshore off the Northumberland and Durham coasts, the Wash/North Norfolk coast, and in the Thames Estuary, Liverpool Bay, Morecambe Bay and the Solway. They have produced a specific list of vulnerable areas for England, and CCW have produced the same for Wales.

With such a new industry, it is inevitable that there are considerable gaps and uncertainties in the existing knowledge. Further studies are needed to address these, but also it is important that an approach can be agreed with consultees to deal with these uncertainties until such studies are completed. It is important to make the best use of the data available, and at the same time facilitate the collection of impact data as wind farms are constructed. The main priority needs are (i) more data on the distribution and abundance of offshore birds and the factors affecting their site use, (ii) more data on the actual effects of existing wind farms on key species, (iii) population studies of key species, (iv) information on indirect impacts, and (v) development of standardised methodologies for baseline data collection, assessment of effects and appropriate monitoring programmes. The latter should include the data requirements for an EIA, guidance for the use of worst-case analysis to assess uncertainties, a clear definition of what constitutes an unacceptable effect, the mechanisms (including appropriate risk assessment) to minimise the possibility of any adverse effects occurring and to ensure that unacceptable impact does not occur, and a protocol for monitoring studies to collect data that will reduce uncertainties in future developments.

It is important for both nature conservation and for wind farm developers that offshore wind farms are not developed in inappropriate locations. An agreed assessment methodology, such as that developed by SNH and BWEA, should provide a framework by which these issues can be addressed in a transparent and objective process, to give a clear indication of where problems are likely to occur and what is likely to constitute an unacceptable effect.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

1. BACKGROUND

The UK's offshore wind resource is one of the largest in Europe. The development of offshore wind power is recognised as being one of the key means to meeting the UK Government's commitments to reducing greenhouse gases. Construction of offshore wind farms will be subject to individual projects obtaining the necessary consent. Environmental assessment of projects will be an element of the consent process and so pertinent environmental issues and concerns will need to be identified and understood.

The availability of data and knowledge (or lack of it) on these environmental issues needs to be established. The UK has some of the largest seabird concentrations in Europe and many locations hold internationally important populations. In addition some offshore regions are on the migratory routes of various bird species. It is therefore important to establish the effects that onshore wind farms have on birds and to identify sensitive offshore locations where bird activity and wind energy development may become an important issue for consideration. This report seeks to address these issues, to assist in the assessment of the effects of offshore wind farms on birds and identify priorities for further research. It seeks to provide information for all stakeholders in the development of offshore wind farms. The specific objectives of the project were to:

- Produce a review of the available reports, data and information relating to the effects of offshore wind farms on birds.

- Establish the locations of offshore sites and areas that hold important bird populations

- Identify the bird migratory routes that may encroach upon prime offshore wind energy development areas.

- Identify gaps and uncertainties in the existing knowledge and recommend further studies that are needed to address these.

- Provide an inventory of planned and ongoing studies.

2. REVIEW OF CURRENT KNOWLEDGE OF THE EFFECTS OF OFFSHORE WIND FARMS ON BIRDS

2.1. Introduction

There are currently only eight operational offshore wind farms. All of these are within northern Europe. Details of each are given in Table 1 and their locations are shown in Figure 1.

Table 1. Existing offshore wind farms

Map ref no.	Site	Country	Year built	Turbines	Bird monitoring studies
1.	Vindeby (Baltic)	Denmark	1991	11 x 450kW (4.95 MW)	None
2.	Lely (Ijsselmeer)	Netherlands	1994	4 x 500kW (2MW). Semi-offshore.	Post-construction flight activity
3.	Tunø Knob (Baltic)	Denmark	1995	10 x 500kW (5MW)	Pre- and post-construction disturbance/ flight activity study
4.	Dronten (Ijsselmeer)	Netherlands	1996	19 x 600kW (11.4MW). Semi-offshore.	None
5.	Bockstigen (Baltic)	Gotland, Sweden	1997	5 x 550kW (2.75MW)	None
6.	Blyth (North Sea)	England	2000	2 x 2MW (4MW)	Pre- construction and ongoing post-construction
7.	Middelgrunden (Baltic)	Denmark	2000	20 x 2MW (40MW)	None
8.	Utgrunden (Baltic)	Sweden	2000	7 x 1.5MW (10.5MW)	Pre- construction and ongoing post-construction

With so few offshore wind farms constructed, and many of those built only recently, relatively few studies have been carried out of their effects on bird populations.

The first offshore wind turbine was erected at Nogersund in southern Sweden. This was a small 220kW experimental machine, located only 250m from the coast. Coastal migratory bird movements were studied in the vicinity of this turbine, and it was found that the birds avoided flying close to the turbine, mainly by flying further offshore around it (Larsson 1994). Insufficient numbers of breeding or resting birds were found in order to come to any clear conclusions regarding any effects.

The first offshore wind farm was constructed in 1991 at Vindeby in the Baltic. This area supported few birds, so no ornithological studies were carried out.

Bird monitoring was undertaken at the second offshore site, Lely, in the Netherlands. This four-turbine wind farm is located 1km offshore, in the Ijsselmeer. The focus of this work was the study of bird movements around the wind turbines, primarily using radar-tracking techniques.

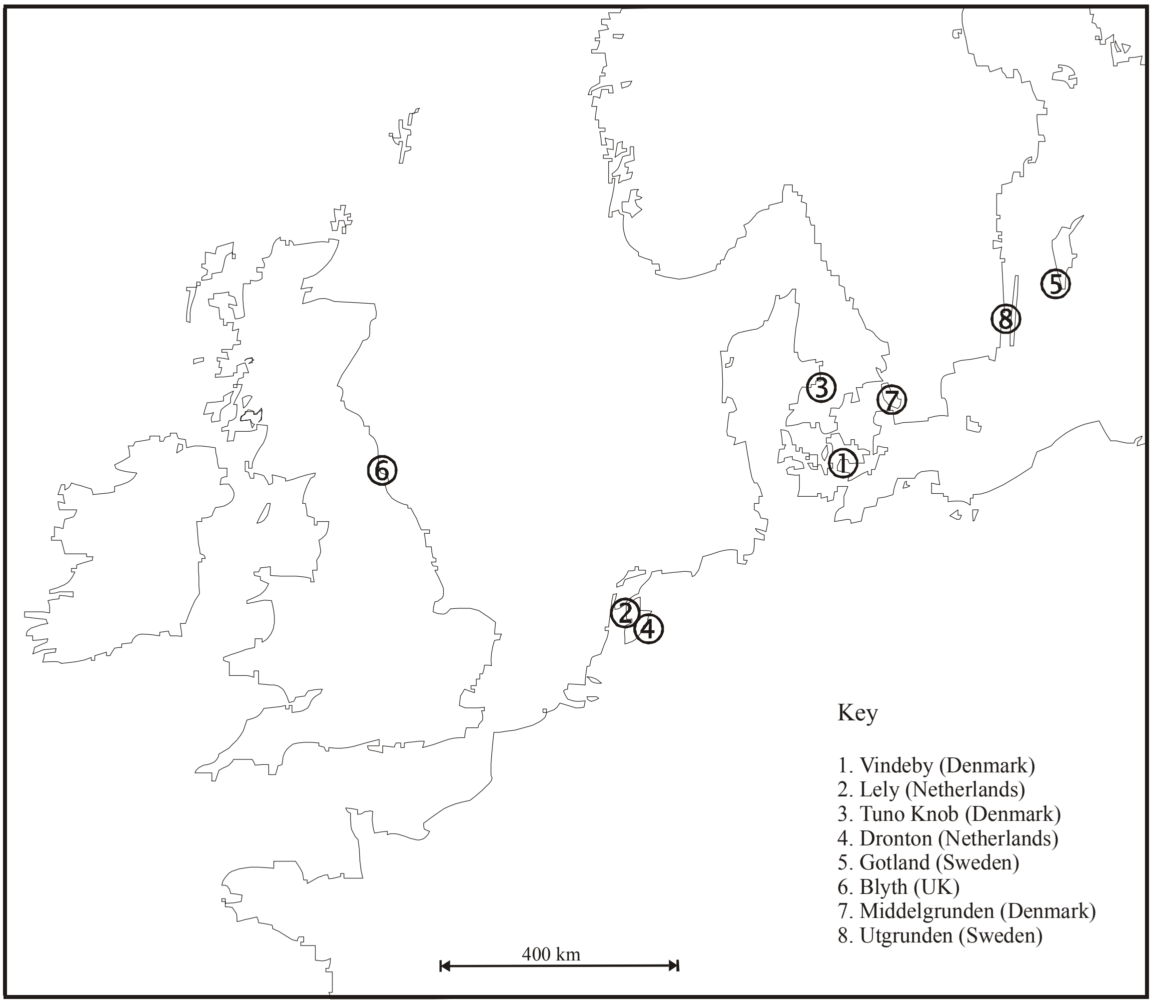

Figure 1. Locations of existing offshore wind farms, October 2001.

The third offshore wind farm was built at Tunø Knob, in the Danish Baltic, 7km offshore. As few birds were found at the first Danish offshore site, part of reason this site was chosen was to investigate the effects on birds. An area was selected that was known to support large numbers of seaduck but was not located within any protected internationally/nationally important nature conservation site (Madsen 1997). A very detailed study has been carried out, looking particularly at disturbance and flight behaviour of seaduck.

At both Dronten in the Netherlands (another semi-offshore site in the Ijsselmeer) and Bockstigen (a site off Gotland in the Swedish Baltic), no bird studies have been carried out.

Two of the three most recently constructed offshore wind farms, Blyth in the English North Sea and Utgrunden, in the Swedish Baltic, have bird monitoring programmes being undertaken. However, both were only commissioned in late 2000, so they have not yet provided any published data on effects. Detailed bird monitoring programmes are planned for the forthcoming Danish demonstration offshore wind farms but construction of these is not planned to commence until 2002.

Thus current information on the specific effects of offshore wind farms on birds is limited to two sites, Lely and Tunø Knob. The work and findings at each are summarised in the next section.

Significance is an important theme that recurs through much of the report and that requires careful use and definition. I have used the term consistently throughout to relate to the term in its EIA context, a definition that is intrinsically linked to biological significance. Thus all impacts described as significant indicate that they would be considered to be significant in the EIA process. Effects may be recorded but it is the ecological consequences of those effects that determine whether they are biologically significant.

The terminology used to describe each of the bird groups in the report also requires clear definition. Throughout I have used the term 'seabird' to include all the species that are covered under the JNCC Seabirds at Sea project (see for example Stone *et al*. 1995 for a full list). This essentially includes all bird species that make regular use of marine habitats (including divers, grebes, shearwaters, petrels, gannets, cormorants, seaduck, skuas, gulls, terns and auks). 'Waterfowl' includes all wildfowl (ducks, geese and swans), waders and other wetland species covered by the Wetland Bird Survey scheme (Pollitt *et al*. 2000).

2.2. Lely offshore studies

The studies at this site were conducted during the winter of 1995/96, and have been reported in a range of reports and papers (van der Winden *et al*. 1996, Dirksen *et al*. 1998).

2.2.1 Species present and numbers

The main species studied were two diving ducks, tufted duck and pochard. Between 400-600 were present in their study area during November 1995 and 600-800 during March 1996. These birds were roosting 500-1500m from the turbines (in sheltered waters close to shore in the lee of dykes). They fed on zebra mussels in open water up to 15km from the dykes. Feeding took place at night and the birds roosted during the day. Most of their flight movements were in darkness, flying to their feeding grounds after dusk and returning just before dawn.

2.2.2 Details of the study aims/objectives

The main aim of the project was to study the nocturnal flight behaviour of diving ducks approaching this semi-offshore wind farm. The wind farm comprised four 500kW turbines located between the birds' inshore resting and offshore feeding sites. The turbines are 800m offshore and in a line parallel to the shore, with 200m separations between each turbine. Each is on a 39m tower and has a rotor diameter of 40m. Most of the data in the study were collected using radar tracking techniques.

2.2.3 Summary of findings

The main finding of this study was that these ducks were able to adjust their flight behaviour according to the ambient light levels, and as a result were able to fly around the turbines, even in conditions of darkness. More flight movements close to turbines occurred during moonlit nights. On darker nights the birds avoided the turbines by a greater distance. It was concluded that during these nocturnal flights "*diving ducks either see or are otherwise aware of the turbines*."

The study also showed that most birds passed around the outer turbines rather than between turbines, and led the authors to suggest that lines of turbines may act as a barrier.

The study of the first offshore turbine in Sweden (Larsson 1994) showed a similar change in flight patterns to avoid flying in close proximity to the turbine, with lower numbers within 500m.

2.3. Tunø Knob offshore studies

These are the most comprehensive studies of the effects of offshore wind farms on birds that have been carried out to date. They were initiated because there was concern that populations of important seaduck species in the area, particularly eiders, could be displaced from their feeding areas through disturbance by the wind farm. Baseline monitoring was carried out in the year before the wind farm was constructed. During this period bird numbers and distribution were determined, together with that of their main food supply, blue mussels. Three further years' monitoring of both the birds and their food supply were carried out after the wind farm had been built. The wind farm comprised 10 500kW turbines in two rows, with a 200m separation distance within rows and 400m between rows. The turbines are on a 40.5m tower and have a rotor diameter of 39m.

2.3.1 Species present and numbers

The most abundant species at Tunø Knob was the eider duck, with peak numbers of 5,800 recorded during the work (in 1997/98). Common scoter were also present (peak 700, also in 1997/98), and smaller numbers of cormorants and gulls.

2.3.2 Details of the study aims/objectives

There are two main studies that have been undertaken, one reported by Guillemette *et al.* (1998 and 1999), and the other by Tulp *et al*. (1999).

(i) Guillemette et al. (1998 and 1999)

This work had four main aims:

- To test the effect of the offshore wind farm on bird numbers, distribution and behaviour.
- To carry out a before-after-control-impact (BACI) study, comparing Tunø Knob and nearby control area, before and after construction.
- To study the bird distribution in relation to the available food supply within Tunø Knob
- To carry out experimental studies of effects on local birds of turbine operation, food exploitation and flight behaviour using decoys.

Thus the main focus of the work was the potential disturbance effect of the wind farm rather than collision risk. The initial work (the baseline year plus two years post-construction) was reported in 1998. A third post-construction year's work was reported in 1999, where it was specifically aimed to test whether the sea duck returned to the site when food availability increased.

(ii) Tulp et al. (1999)

This work was carried out using a similar radar-tracking methodology to the Lely work, to study the nocturnal flight activity of seaducks around the wind farm. It was carried out during 1998/99. It sought specifically to determine whether seaduck showed nocturnal flight activity, how the wind farm affected their flight patterns at night, and how flying eiders responded to the wind turbines.

2.3.3 Summary of findings

(i) Guillemette et al. (1998 and 1999)

This study found no significant disturbance effect that was attributable to the wind farm. There was a decline in eider numbers following construction in 1995/6 and 1996/7 but a large increase was found in 1997/8, exceeding the baseline numbers. Studies of mussel availability suggested that the decline in eider numbers in 1995/6 and 1996/7 was attributable to a decline in the food supply rather than any effect of the wind farm. The increase in 1997/8 matched an increase in food availability in the area. The proportionate flock distribution in relation to the turbine locations was very similar in 1997/8 to the pre-construction distribution in 1994/5.

The main conclusions of this work are summarised in Table 2, which is quoted directly from Guillemette *et al* (1998).

Table 2. Summary of results of the Tunø Knob study (Guillemette et al 1998). Note: TK = wind farm site, RS = control site.

Investigation	Spatial scale (ha)	Design characteristics	Conclusion
Aerial surveys of the whole of Aarhus Bay comparing the abundance of eiders at TK and RS before and after the construction of the wind park.	88,000 to 5000	BACI controlling for the abundance of eiders in the whole of Aarhus Bay	Tendency to have fewer eiders at TK after the construction while it remained stable at RS. The results are suggestive of an impact (see ground surveys below).
Ground surveys comparing the abundance of eiders at TK and RS before and after the construction of the wind park	700 to 800	BACI 'controlling' for the abundance of food at both study sites.	Much lower number of eiders at TK after the construction while it was almost stable at RS. This was associated with qualitative and quantitative differences in the biomass of blue mussels between the two sites. The results suggest that the decrease in eider abundance was caused by food supplies and not by the wind park. This interpretation probably also applies to the results of aerial surveys
Ground surveys comparing the abundance and distribution of eiders within TK	160 to 245	BACI with three sister areas	Much lower number of eiders in the presumed impact sub-area (NW) after the construction of the wind park and similar fluctuations in the sister sub-areas. Large inter-annual and seasonal variations in the distribution of the eiders. The results suggest that fluctuations in eider numbers were caused by natural variation and not by the wind park. This interpretation also applies to their spatial distribution
On-off experiment comparing the abundance and distribution of eiders	40 to 230	Experiment randomising the effect of food supply	Similar number of eiders when controls and treatments are compared. The noise and the movements of the rotor do not affect negatively the abundance and the distribution of eiders.
Exploitation experiment comparing the proportion of eiders at different distances from the wind park on a winter basis	40 to 230	Manipulative experiment controlling for the influence of food supply	Similar proportion of eiders (corrected for food supply) at different distances of the wind park. Both, the standing towers and the revolving rotors did not influence the abundance of eiders on a winter basis.
The decoys experiment testing the impact of the wind park on flying eiders	40 to 230	Manipulative experiment 'attracting' eiders to land at different distances of the wind park.	Eiders avoided flying and landing within 100m of the wind park. This should decrease the probability of collision with the standing towers (in good weather conditions).

The results presented in Guillemette *et al* 1999 provided further evidence of a lack of any significant impact, with numbers of both eider and common scoter increased in response to an increased abundance of their food supply. Guillemette *et al*. concluded that "*the data pertaining to the abundance of common eiders at the scale of the whole study site are unequivocal. The total number of common eiders in 1997-98 was the highest number in four years of data, surpassing the baseline average by about 1,500 individuals. Even the fluctuations in abundance in 1997-98 were strikingly similar to the baseline year. In addition, there is no evidence that disturbance occurred in the vicinity of the park since the number and density of common eiders in 1997-98 were comparable to that of the baseline year, when there was no wind park*."

Thus this study suggested that numbers of eider ducks were not significantly affected by the presence of the offshore wind farm. The only detectable response by the birds was reduced flight activity within 100m of the turbines, and this did not result in reduced food resource utilisation in this area (and hence not any significant disturbance effect). Common scoters appeared to be similarly unaffected, though sample sizes were smaller as fewer birds occurred in the study area. This study also demonstrated the importance of looking at the birds' food supply in order to determine whether any disturbance effect took place. This is an important consideration for other studies monitoring the effects of offshore wind farms and for establishing baseline conditions for assessing the effects of offshore wind farms.

The limitations of the study should also be considered. In particular the work was carried out only during the winter, so effects of wind turbines on birds at other times of year may differ. The effects may also be different for larger-scale wind farms, where the area covered by the wind farm will be greater, turbines are likely to be larger and where associated human and boat activity may be increased. It should also be noted that no specific data were collected on the risk of collision. This study focussed rather on potential disturbance impacts.

(ii) Tulp et al. (1999)

Both eider and common scoter did show nocturnal flight activity, with flights between feeding areas and between feeding and roosting areas. Nocturnal flight activity was greater on brighter moonlit nights and less in mist and strong winds. The amount of seaduck flight activity in the vicinity of the wind farm (within 1500m) was reduced at night and to a lesser extent during dusk, but not during dawn. Within the wind farm and its immediate surrounds (within 500m) eiders appeared to prefer flying between turbines where there was a gap of 400m between them compared with 200m.

These results were generally in agreement with previous studies of the effects of wind turbines on bird flight behaviour on land. Species such as these seaduck, even though not used to finding obstacles in their flight path, actively avoided wind turbines whilst flying. As in the previous Lely study, it was suggested that rows of wind turbines could potentially act as flight barriers.

The authors made the following recommendations for wind farm design:

- *"Whether or not eiders will fly in between turbines, fly around them or choose a different feeding or roosting area altogether will be determined by a number of factors: the size of the corridor, the length of a possible detour and the availability of alternative feeding and roosting areas. To take the flight routes of seaducks into account, measures should be taken to enable them to follow their route with a small detour. Gaps in the arrangements of turbines can act as corridors. Based on the results of this study, these corridors need to be several kilometres wide in order to be effective.*
- *From the birds' point of view long line-shaped arrangements perpendicular to the main flight direction must be avoided as these can cut off or deteriorate flight routes or make areas inaccessible.*
- *Despite the fact that the locations of shellfish beds can vary from year to year, it is possible to take the location of favourable feeding areas into account by placing the turbines as deep as possible* (deeper water would be likely to be less favoured by seaduck as their food resource on the seabed would be more difficult for them to reach).
- *Since local birds will likely be familiar with the surroundings and obstacles, the collision risk for this group is smaller than for birds that are only passing through. In any case it is worthwhile to make the turbines as visible as possible (light colour).*
- *As it is difficult to predict whether and in what manner seaducks will fly through large windparks, it is preferable to keep the distance between turbines small and by doing so minimize the total surface area of the park."*

2.4. Studies at onshore wind farms

There are several studies of the effects of wind farms on birds at coastal onshore wind farms that can provide useful information about the likely extent of how bird populations may be affected by offshore wind farms. Though obviously, being onshore, there will be differences between these and offshore wind farms, the results can still be useful in the offshore context as long as the implications of such differences are fully considered. In particular consideration should be given to wind turbine design (with new offshore developments likely to be larger, quieter machines of slower rotational speed) and the scale of development (likely to be much larger for new offshore developments).

Onshore wind farm studies have been extensively reviewed by a number of authors, including SGS Environment (SGS 1996), commissioned by ETSU, Gill *et al*. (1996a), commissioned by SNH, and more recently by Percival (2000). I will not re-iterate their findings here but rather focus on issues and studies that have particular relevance to the assessment of offshore wind farms.

2.4.1 Blyth onshore wind farm

The Blyth onshore study has been looking at the effects of a nine-turbine (each 300kW) coastal wind farm since its construction in 1992. The wind farm is situated on a breakwater between an estuary and the sea, across a significant seabird flight route. This work has been reported by Still *et al*. (1996) and more recently by Painter *et al*. (1999).

The Blyth onshore wind farm is over-flown regularly by large numbers of seabirds (peak of about 5000 movements per day) including eiders (peak count 1300 in the study area), cormorant (peak 120) and a range of gull species (populations of 2500, 750 and 1000 for herring, great-black backed and black-headed gulls respectively), and a wader, purple sandpiper (peak 355). Also, being situated on the east coast of England, it is likely to be over-flown by large numbers of migrants.

The project looked at both collision and disturbance impacts from the wind farm. It sought to determine collision mortality, document flight lines around the wind turbines, and determine whether any species were affected by disturbance. The study started prior to construction, so it was possible to draw some before/after comparisons.

The collision risk was found to be variable between species. Cormorants were largely unaffected, with only a single collision of an immature bird recorded, even though they made regular flights through the wind farm. Eider duck collisions occurred more frequently. Initially following construction six collision victims were found in the first three months of operation, three in the next six months and a further three in the next 18 months. The reduced collision rate through time resulted from the birds adapting their behaviour to avoid flying in close proximity to the turbines. Overall the collision rate in the first 4½ years of the study, taking into account the fact that only about 40% of collisions were found (Still *et al*. 1996), was still considerably less that 0.01% of the bird flights through the wind farm. The study concluded that there had been no significant adverse effect on the local populations of this species. This collision rate has declined further during an additional two years' study (Painter *et al*. 1999).

Gulls were also recorded as collision victims, though, as for eiders, the collision rate was very low, with no significant adverse effect on the local populations of any of these species.

Overall the wind farm mortality was much less than the existing background mortality, including overhead wires (which resulted in double the collision rate in the study area compared with the wind farm).

In terms of disturbance effects, the only effect on cormorants was during construction, when the birds moved to an alternative roost site nearby. Once construction had been completed they returned and showed no subsequent effects at all during operation. There was no evidence of disturbance to purple sandpipers, eiders or gulls.

2.4.2 Other onshore wind farm studies

Data on collision rates from other coastal wind farm studies have been summarised in Table 3. Though difficult to determine accurately, collision rates estimated from these studies do give a reasonable indication of the levels of collision that have occurred at a range of different wind farms. Generally collision rates have been low/ negligible, and well below any level that could give any significant population effect. However, the significance of any additional mortality is likely to be linked to the population dynamics of the species colliding. Most populations may be unaffected by a small level of additional mortality, but there are some where even this could result in a significant population decline (Morrison *et al*. 1998). Species with high adult survival rate and low breeding rate may be more susceptible to population impacts, as they would be less able to replace any losses. Similarly species that were unable to compensate for any losses incurred, for example by increased survival or breeding rate (i.e. populations regulated in a density-independent way) would be more susceptible.

Table 3. Studies of collision rates of birds and wind turbines at existing onshore wind farms (from Percival 2000).

Site	Habitat	Species present	Number of turbines	Collision rate per turbine per year	Species colliding	Source
Altamont, California	Ranch land	Raptors	7000	0.06	Raptors, inc. Golden Eagle	Orloff and Flannery 1992, BioSystems Analysis Inc 1996
Tarifa, S. Spain	Coastal hills	Raptors, storks and many other migrants	90	0.34	Raptors, inc. Griffon Vulture	SEO/ BirdLife 1995
Burgar Hill, Orkney	Coastal moorland	Upland species inc. divers and raptors	3	0.15	Gulls, Peregrine (1)	Meek *et al.* 1993
Haverigg, Cumbria	Coastal grassland	Golden plover, gulls	5	0	None	SGS Environment 1994
Blyth, Northumb-erland	Coastal shoreline	Cormorant, eider, purple sandpiper, gulls, migrants	9	1.34	Mainly gulls, Eider	Still *et al.* 1995
Urk, Netherlands	Coastal – on dyke wall	Waterfowl, inc. geese, Bewick's swans, migrants	25	1.7	Gulls, waders, other waterfowl (no geese or Bewick's Swans), migrants	Winkelman 1989
Oosterbierum, Netherlands	Coastal – on dyke wall	Migrants, waterfowl	18	1.8	Waterfowl, kestrel, woodpigeon, passerines.	Winkelman 1992a, 1992b
Kreekrak, Netherlands	Coastal – on dyke wall	Waterfowl, inc. geese	5	3.4	Gulls, waders, Brent Goose (1), other waterfowl	Musters *et al.* 1996
Tjaereborg, Denmark	Coastal grassland	Waterfowl, mainly waders and gulls	1	3.0	Gulls, Mallard, Moorhen, passerines	Pedersen and Poulsen 1991
Näsudden, Gotland, Sweden	Coastal marsh and arable	Waterfowl inc. geese and breeding waders, migrants	70	0.7	Redshank (1)	Own data

Disturbance could potentially affect not only the wind farm itself but also a considerable surrounding area, displacing birds from feeding and/or roosting areas. Disturbance effects have been recorded as much as 800m from wind turbines (Pedersen and Poulsen 1991), a distance that is often used in wind farm assessments as a worst-case scenario. However, this study – and indeed several that have shown such relatively long-distance effects – were flawed in that they did not take into account confounding factors that could have resulted in the apparent disturbance, including changes in human disturbance and habitat differences. Details of disturbance studies relevant to coastal situations are summarised in Table 4. In an analysis of the overall disturbance question Percival (2000) concluded:

"Overall, it would seem that, while some studies have found some disturbance effects of wind farms, a large number have found no effect at all. The studies that have found the greatest effect also seem to be those that have other potentially confounding factors such as habitat differences or increased human disturbance. None of these have looked in detail at all the factors influencing bird distribution at the site, an approach necessary to determine whether the wind farm really is the prime cause of the observed displacement. In order to progress the evaluation of disturbance effects, disturbance itself needs to be carefully defined. It only has a real adverse effect if it reduces resource use by the birds (ie it directly causes resource under-utilisation and hence a reduction in carrying capacity) (Gill et al. 1996b). Any studies must therefore link the bird data to habitat and food availability and look at any effects in context of all factors potentially affecting bird numbers at the site. More studies at existing wind farms are clearly needed in order to understand whether wind farms do have any disturbing effects on birds. The bulk of the evidence at present is that they do not have any major adverse impact."

2.4.3 Indirect Effects of Offshore Wind Farms

As well as disturbance and collision, offshore wind farms also have the potential to result in a range of indirect effects on bird populations. These mainly involve changes that may occur to the birds' habitat/ ecological resources. The small number of studies that have been carried out so far on this issue have not found any significant adverse effects. At Vindeby in the Danish Baltic fish stocks actually increased following the construction of the wind farm, and it was considered that the turbine foundations provided an artificial reef habitat. Mussels were also found growing on the foundations, and the marine diversity generally increased (Lemming 1999). However, the number of studies is small and restricted to the waters of the Baltic. Careful consideration would need to be given to evaluate such indirect effects on habitats and ecological resources at UK sites, which may have very different ecological conditions. There are likely to be positive effects through the establishment of artificial reefs with some turbine foundations and in some offshore environments but not necessarily in all cases.

A further positive indirect effect of offshore wind farms on birds may be an increase in fish abundance through reduced fishing activity within the wind farm area. Some offshore developments are likely to exclude fishing from the wind farm altogether, others may result in a reduction of certain fishing activities such as bottom dredging.

There is a range of potential negative indirect effects on bird populations. Most notable amongst these are possible changes to sedimentation patterns. No such problems have been reported at existing sites, but this issue has not been studied in detail in the context of offshore wind farm developments. It would need to be fully considered in an EIA and assessed on site by site basis.

Thus, summarising the existing knowledge of the effects of wind farms on seabirds, there is some evidence of localised disturbance effects in some circumstances. The most comprehensive study to date, on seaduck at Tunø Knob, however, suggested no significant disturbance impact. Collision rates have generally been low/negligible, and there have been no documented impacts that were considered to be significant. Caution is required, however, in the interpretation of these results, as the overall number of studies has been small. Particular care is required with respect to novel situations, for example sites in proximity to seabird breeding colonies, where no such studies have been carried out.

In consultations RSPB and CCW both noted that a precautionary approach should be adopted where there are conservation concerns. There needs to be agreement between the wind industry and the conservation bodies over a practical way in which this can be applied. Each new development, particularly offshore, is by its very nature a new proposal in a new area. There needs to be an agreed mechanism for appropriate risk management to ensure that conservation interest is not adversely affected. At the same time, where there is not is a real risk of a significant effect, such issues should not unnecessarily restrict development.

Table 4. Studies of possible disturbance effects of onshore coastal wind farms on bird distribution (from Percival 2000)

Site	Habitat	Species present	Number of turbines	Species significantly affected	Distance affected	Source
Tjaereborg, Denmark	Coastal grassland	Waterfowl, mainly waders and gulls	1	Lapwing, Golden Plover, gulls	Max 800m. Breeding lapwing up to 300m	Pedersen and Poulsen 1991
Urk, Netherlands	Coastal – on dyke wall	Waterfowl, inc. geese, Bewick's and whooper swans	25	Whooper Swan, Pochard, Goldeneye.	Max 300m.	Winkelman 1989
Oosterbierum, Netherlands	Coastal – on dyke wall	Waterfowl	25	Waders, gulls and Mallard	Max 500m. No effect on breeding waders	Winkelman 1992d
Burgar Hill, Orkney	Coastal moorland	Upland species inc. divers and raptors	3	Red-throated Diver		Meek *et al*. 1993
Haverigg, Cumbria	Coastal grassland	Golden plover, gulls	5	None		SGS Environment 1994
Blyth, Northumb-erland	Coastal shoreline	Cormorant, eider, purple sandpiper, gulls	9	None		Still *et al*. 1995
Nasudden, Gotland, Sweden	Coastal marsh and arable	Waterfowl inc. geese and breeding waders	70	None		Percival 2000
Vejlerne, Denmark	Farmland and wetland	Pink-footed geese	61	Pink-footed geese	1-200m (no impact on SPA population)	Larsen and Madsen 2000

2.4.4 Studies of migrant birds at existing wind farms (a) land bird migrants

Land bird migrants could potentially by affected by offshore wind farms during their migratory journeys. The key concern with this group is the risk of collision with the wind turbines. The main reason for this concern results from Winkelman's work (1992a and 1992b) at a coastal onshore wind farm in the Netherlands. She recorded collision rates of 0.01-0.02% of birds passing through the wind farm, equivalent to 1 in 5-10,000 individuals. Thus such collisions would only result in a significant adverse effect if many tens of thousands of birds were regularly passing through the wind farm, even taking into account the problems associated with accurately determining collision rates.

There are two particular wind farm sites where major collision problems with migrant land birds have been encountered; Altamont Pass, California (Orloff and Flannery 1992, BioSystems Analysis 1996, Thelander and Rugge 2000) and Tarifa, in southern Spain (Barrios and Aguilar 1995, Janss 2000b). At both of these sites very large numbers of birds were passing through very large wind farms. The actual collision rate per turbine was low - considerably less than one bird per year, see Table 3 – but as a result of so many turbines being present, the overall total number of collision victims was significant. The problem was exacerbated because many of the species involved were birds of prey (both migrants and residents), including species likely to be sensitive to additional mortality and protected species such as Golden Eagle *Aquila chrysaetos* (Altamont) and Griffon Vulture *Gyps fulvus* (Tarifa). The problems resulted from a combination of sensitive species flying through the wind farm area in large numbers (as they were important migration and feeding areas), and turbine layout (very large numbers densely packed in sensitive locations where birds were very concentrated) and design (particularly many lattice towers attractive to birds of prey as perches, though recent research from Altamont has suggested this may not be a particularly important factor in collision risk, Thelander and Rugge 2000). Both sites also supported high densities of food resources, making the wind farm sites particularly attractive to foraging birds of prey.

It is clear from these examples that sites on main bird of prey migration routes and with high-density food resources attracting large numbers of foraging raptors should be avoided by wind farm developments. However, with regard to UK offshore wind farm development, numbers of birds of prey migrating along the UK coasts would be negligible in comparison, and the offshore sites would obviously not provide them with any feeding resource (other than perhaps ospreys).

The likelihood of large numbers of landbird migrants passing through an offshore wind farm would depend on two main factors: the regional location of the wind farm, and its distance offshore. It is unlikely large concentrations of susceptible migrants would occur offshore for a number of reasons:

- migration over the sea occurs over broad front (Alerstam 1990)
- there are no topographical features to concentrate birds through the wind farm
- the wind turbines themselves offshore would be more benign (in particular longer rotation period – and therefore slower rotor speed and reduced collision risk, with large gaps between turbines – potentially allowing birds to more readily fly between them with less risk of collision)

2.4.5 Studies of migrant birds at existing wind farms (b) coastal waterfowl

Many coastal habitats in the UK hold internationally important numbers of wintering waterfowl, so there is considerable potential for offshore wind farms to be proposed in areas in proximity to these habitats. Two main issues could arise as a result with regard to collisions, (a) long-distance coastal migration and (b) local daily movements between feeding and roosting areas.

Dirksen *et al*. (1998) carried out a detailed study of waterfowl movements at several sites around the Netherlands. Coastal migration was found to occur during both day and night, and birds generally flew at about the same height as wind turbines (below 100m). Movements were concentrated close inshore, with most occurring within 700m of the shore. Similar behaviour was observed for waders, gulls and migrant thrushes.

Local movements could potentially pose more of a problem with regard to collision risk than long-distance migrants, eg if a wind farm were located between important roosting and feeding areas. If a wind farm were located on a regularly used flight route, with thousands of waterfowl involved and flights on a tidal basis, there would be a potential for a very large number of flights through the wind farm. Therefore it would be advisable to avoid locating offshore wind farms in such areas. The studies carried out to date do suggest that the numbers of such birds that would need to be passing regularly through a wind farm would need to be very high in order for significant mortality to occur. At Kreekrak in the Netherlands, for example, a coastal wind farm immediately adjacent to the Oosterschelde SPA, with a local population of 2-6000 waterfowl only 1.9-4.6 collisions per turbine per year were estimated (Musters *et al*. 1995 and 1996). This study concluded that the level of mortality was not significant, and recommended that a further 15 turbines could be constructed without an adverse impact on the local bird populations.

Similar collision rates were reported from the Blyth Harbour wind farm, where 4500 waterfowl regularly occur (Still *et al.* 1995) and which falls within the Northumberland coast SPA. This study reported an average of 1.3 collisions per turbine per year, declining as birds habituated to the presence of the turbines (Painter *et al*. 1999).

Notwithstanding this, there are several potential offshore wind farm sites where very large-scale movements could potentially occur. The sub-tidal banks off the Wirral and the Mersey, in particular, are known to be over-flown very regularly by large numbers of waders making tidal roost flight movements between the Dee and the Alt estuaries (Mitchell *et al*. 1988). Similar large-scale movements would be expected in close proximity to other important estuaries, including the Wash and Morecambe Bay.

Overall therefore, the risk of collision of migrants with offshore wind turbines should be low/negligible, particularly when located several kilometres offshore (the further offshore, the less likely that concentrations of birds would be passing through). Avoiding close inshore waters will reduce likelihood of collisions occurring.

2.5. Other relevant ecological studies

Though relatively few studies have been carried out specifically on the effects of offshore wind farms on birds, there are a range of other published ecological studies that could be very useful in determining what effects may be likely to occur, and which species may be likely to be affected. The aim of this section of the report is to review such studies and highlight some of their key findings of relevance to predicting the effects of offshore wind farms on birds.

2.5.1 Collision risk of other relevant structures

There are a number of studies of the effects of other man-made structures that provide useful information about the possible effects of wind turbines on birds, and about ways in which such effects may be mitigated.

Much research has been undertaken on the collision risk posed by very high towers (>200m) to flying birds. High towers that are illuminated at night have been shown to cause large numbers of collisions under certain circumstances. Early work carried out by Cochran and Graber (1958) found that lights on such tall towers attracted migratory birds, which often resulted in collision. Subsequent studies similarly found strong positive link between lighting at night and collision rate (Evans and Manville 2000).

Offshore wind turbines, if lit at night, could potentially pose similar risk to communication towers. Therefore it is important to consider those risks and how they may be mitigated. Much can be learnt from the mitigation measures and guidelines established for communication towers (Evans and Manville 2000). The issue seems to centre on the type of illumination used, though collision rates with wind turbines would be expected to be rather lower than with the much taller communications towers at which much of the mortality has been reported.

Artificial lights at night have been well documented as being an attractant to migrant birds. Birds migrating at night can be attracted to sources of artificial light, particularly during periods of inclement weather (Weir 1976, Verheijen 1958, 1985). These birds can become disoriented and hence vulnerable to collisions with the structures themselves. Experimental trials have, however, shown that such risks can be considerably reduced. Trials carried out to reduce migrant mortality at Dungeness Lighthouse in Kent, for example, considerably reduced the level of bird mortality by changing the continuous rotating beam to a flashing light (Baldwin 1965). Further studies found similar results, with flashing/strobe lights being much less attractive to migrant birds. The colour of the light is also potentially important. Several studies have suggested that red lighting can in some circumstances reduce the level of bird mortality (Ogden 1996), though the reason behind this is likely to be the relatively weaker intensity of red lights rather than specifically their colour, as birds generally have a wide spectral sensitivity (Verheijen 1985). It should also be noted that red light may have an additional adverse effect by disrupting the magnetic orientation of migrating birds (Wiltschko *et al*. 1993), so it would probably be better to use white light on offshore wind farms if possible.

The general recommendations to come from these studies are firstly to avoid lighting where possible. Where structures such as offshore wind turbines have to be lit, flashing lights of as low intensity as possible should be used.

Flashing/ strobe white lights would be better than continuous or red light, or rotating beams (Ogden 1996).

Another collision issue relates to the vulnerability of birds to colliding with overhead lines. For UK offshore developments, the grid connection cable would be likely to be laid along the seabed to the shore, but there may be a considerable distance onshore that the cable needs to go in order to reach a suitable grid connection. Hence studies of the collision risk posed by overhead wires will be useful in assessing the effects that such grid links may have. The topic has been the subject of several recent reviews, particularly by Bevanger (1998) and Janss (2000a). The collision risk can, in some species at least, be quite substantial (and usually considerably higher than the risk posed by wind turbines, Winkelman 1992), so it would be advisable to avoid high densities of birds/sensitive species and statutorily protected areas as much as possible. If crossing such areas is unavoidable, then the cable should be undergrounded.

2.5.2 Measures to reduce collision risk

Several studies in the United States in particular have been undertaken to determine whether specific turbine design measures might reduce the risk of bird collision. This included work on raptor visual physiology, raptor flight behaviour, and their response to potential blade patterns. The results indicated that raptors were able to distinguish between several patterns painted on blades, but field tests are yet to be undertaken (Sinclair 1999). Work on the role of motion smear in bird collisions with wind turbines has recently been started, to determine further whether painting blades with a certain type of pattern would aid birds in seeing the blades and therefore provide a mitigation strategy and reduction in bird fatalities. This work, too, however, has been primarily laboratory based and has not been field tested (Sinclair 1999).

2.5.3 Migrant flight behaviour

If migrant birds are to be at risk of collision with offshore wind turbines, then obviously they must be flying at the same height as the turbine rotors. Therefore studies of the altitudes at which migrants fly can be useful in determining the magnitude of collision risk.

Generally birds fly at the altitude that enables them to complete their migratory journey with the minimum energy expenditure (Liechti *et al*. 2000). Higher altitude flights can deliver significantly lower energy demand, but studies have shown that heights of migration are highly variable (Alerstam 1990). They are dependent on numerous factors including species, location, geographic features, season, time of day and weather conditions (Cooper and Ritchie, 1995). Ogden (1996) provides a useful summary of current knowledge:

"(1) nocturnal migrants migrate at higher altitudes than diurnal migrants;

(2) very low migration close to the Earth's surface is almost completely non-existent at night;

(3) in head winds, birds withdraw to lower altitudes with lower wind velocities;

(4) lower altitudes are used over mainland and small bodies of water than during transoceanic migrations;

(5) marshes, lowlands, etc. are usually crossed at relatively high altitudes, whereas migrants often cross mountainous regions at relatively low height, sometimes using mountain passes;

(6) faster flyers may prefer higher altitudes than do slower species (Berthold, 1993: p. 82, and references therein);

(7) in North America, birds migrate at higher altitudes in fall than in spring (Richardson, personal communication; Cooper and Ritchie, 1995)."

Of these various factors, it is clear that wind conditions are particularly important. Birds generally seek to minimise head winds and maximise tail winds, and will alter their flight height in order to seek out the most favourable winds. As a result they usually fly at lower altitude in head winds than in tail winds (Alerstam 1990).

Most migratory flights take place at altitudes well above the height that wind turbines would reach. However, that is not to say that no significant movements occur at these lower altitudes. Winkelman (1992a-c) and Dirksen *et al* (1998) have both recorded substantial flights below 150m (ie at turbine height.

Another important factor influencing collision risk is the visibility conditions under which migration takes place. Birds would be likely to suffer a higher collision rate when flying in conditions of poor visibility. Migrants generally avoid flying in cloud, flying instead either above or below cloud level in overcast conditions (though generally lower altitude than clear conditions), and also usually stay above mist/fog banks (Alerstam 1990).

Whether birds migrate by day or night is also likely to affect their risk of collision. Many species, for example most waterfowl, are flexible, migrating during both day and night. Others migrate primarily by day, and hence would be less likely to collide with wind turbines. These tend to be either species that roost communally at night and use more patchily distributed food resources (eg swallows, wagtails, starlings) or species that soar/glide and are dependent on thermals (Alerstam 1990). Many species, including most small land birds, are primarily nocturnal migrants. They generally use more widespread/ uniform food resources and forage individually. After a night's migration they would be likely to be able to feed on arrival at a staging site straightaway in the morning.

Collision risk with wind turbines is likely to be highest when migrants (particularly nocturnal ones) meet unfavourable conditions (head winds and rain) during their journey. This usually results in the birds interrupting their migration and landing as soon as possible. In Britain, this can sometimes result in large ‘falls’ of migrants occurring on the coast, as birds make the first available landfall after crossing the sea. These are most frequent along the east coast of England in autumn, as migrants arrive across the North Sea from Scandinavia. This is the time at which migration is most likely to occur at lower altitudes and concentrated in coastal areas.

There is a widespread impression that migrant birds follow tightly defined flyways. Therefore if a wind farm were to be placed in such a flyway, the risk of collision would be much higher as many more birds would be likely to pass through it. However, the evidence for such distinct concentrations is weak. Reviewing the general pattern of migration routes, Ogden (1996) concluded that:

“A popular but perhaps misunderstood notion holds that bird migration occurs in a concentrated manner along specific routes, called “flyways.” The concept of the migratory flyway was introduced by F. C. Lincoln in the 1930s, and used mainly with reference to waterfowl (eg Lincoln, 1935; Ens et al., 1994). While the idea of flyways may indeed have some limited validity for waterfowl and shorebirds, there is much overlap among flyways, and most species use more than one flyway during migration. The term flyway is occasionally applied to other groups of birds, including songbirds. However, at least in continental areas, the application of such an idea is misleading, since songbird migration overland occurs along a broad front with little evidence of concentration along particular routes (J. Richardson, personal communication). During spring and fall migration, birds migrate to and from geographically diverse locations, and thus the visual perception of “highways of birds” is probably neither a useful nor a valid concept. The idea of a flyway for land birds is only appropriate in special geographic situations, such as along the narrow parts of Central America and Mexico.”

This is not to say that concentrations do not occasionally occur, and it is important to consider in UK terms where such ‘special geographic situations’ may occur. Coastal concentrations in particular do occur within Europe but are generally found in close proximity to the shore. Dirksen *et al* 1998, for example, found that most migrant concentrations were found within 700m of the shore. Overall with regard to the collision risk for migrants at offshore wind farms, there is no current evidence to suggest that this should be a major nature conservation problem. Studies at existing coastal wind farms have found the numbers of collisions of migrants to be insignificant, even when many hundreds of thousands of migrants have been passing through wind farms, (eg Winkelman 1992a and 1992b) and general studies of bird migration have shown that concentrations do not generally occur offshore. Neither English Nature (Appendix A) nor RSPB (R. Langston, in litt.) currently consider that migrant collision risk should be a principal concern with offshore wind farms, as long as turbines are located more than 1km from the shore. CCW (Appendix B) however urge a cautious approach on this issue, not because of a specific problem but rather because of lack of information about collision rates with offshore wind farms.

2.5.4 Seabird habitat selection and foraging behaviour studies (including foraging distances from breeding colonies)

Many of the seabird species that occur in British waters have not been studied at existing offshore wind farms, so the precise nature of their interaction is difficult to predict. However, there have been many studies of seabird ecology that can enable their likely susceptibility to impacts from offshore wind farms to be evaluated. Even with species that have been studied at other wind farms, an understanding of their ecology is necessary in order to fully determine the likely effects of a new offshore wind farm.

There is a substantial amount of background information available on the ecological characteristics of areas that are likely to support important seabird populations. Such information could be very useful in the identification of more sensitive areas likely to hold larger numbers of birds. It would also be useful in the assessment process to evaluate the importance of the wind farm site in relation to alternative feeding/roosting sites within the locality. In ecological terms, a greater impact would be likely where a wind farm occupies a large proportion of the birds' local resource from which they may be displaced. Potentially sensitive areas are likely to be related to a range of factors including:

- Proximity to breeding colonies
- Water depth
- Substrate type

One way in which this issue could be addressed is to use ecological models to provide a framework to integrate the various data on the birds' behaviour and habitat use. Model predictions could be used to give a long-term view to these variable and often complex marine systems, and to explore the possible impacts of a wind farm. The modelling approach adopted by Wanless *et al.* (1997) to study the distribution of shags in relation to their main food source, sand eels, provides an example of how such models might be constructed. Such an approach requires high quality ecological data but much of this already exists for many seabird species. The importance of an integrated ecological approach has already been clearly demonstrated in the Tunø Knob study (Guillemette *et al* 1999). Without data on the distribution and abundance of the birds' food supply, it would not have been possible to fully understand the effects of the wind farm on the local bird population.

The foraging distances of many seabirds from their breeding colonies has been well studied. It is particularly important in the context of offshore wind farms to indicate the likely use of the wind farm area in relation to its distance from breeding colonies. Some species, such as little tern and black guillemot (Lloyd *et al*. 1991), feed close inshore and usually in the close vicinity of their colony. Others forage over much greater distances. Gannets, for example were found to fly an average 232km on each foraging trip from a colony in the Bass Rock in the Firth of Forth, up to a maximum of 540km (Hamer *et al.* 2000).

Many seabirds have been shown to be highly flexible in their foraging distances in response to changes in the distribution and abundance of their food supply. Kittiwakes in Shetland fed within 5km of their colony when there was an adequate local food supply, but in other years foraged over 40km from their colony (Hamer *et al*. 1993). Guillemots showed a similar response, flying six times further to feed in years of poor local food supply (Monaghan *et al*. 1994). Shags switched their feeding area from less than 1km from their colony to over 10km when the local sand eel (their main food source) distribution changed (Wanless *et al*. 1991).

The consequences of a reduced food supply are readily observed. Many species do have a degree of compensation that they can employ. When guillemots experienced reduced food supplies they mitigated the effects on their reproductive output by shifting their time allocation so that more time was available for foraging (Uttley *et al*. 1994). There is obviously a limit to the extent that they can do this, and in some years total breeding failure resulted. Poor weather conditions (eg stormy weather) have also been shown to force this species to spend more time foraging and travel further (Finney *et al* 1999), with a consequent reduction in the food brought to the chicks. Arctic terns (Monaghan *et al*. 1989) showed a similar reduction in chick growth and higher chick mortality in years with poor food (sand eel) availability.

The close link between seabird breeding behaviour and the distribution and abundance of their food supply has prompted Monaghan (1996) to suggest that monitoring seabirds might be a more cost-effective way to monitor the distribution and age structure of fish populations than direct surveys of the fish themselves. Monitoring of local seabird breeding success could similarly be a useful component of an offshore wind farm monitoring programme (obviously taking into account all the factors that could influence seabird productivity).

Sea depth is another important factor affecting seabird distributions. Numerous species' preferences have been studied, particularly since the introduction of telemetry techniques that allow recording of dive depth and duration. Some species, such as guillemots, have the ability to forage in deep waters. This species usually dives to around 20m but can go as deep as 180m (Piatt and Nettleship 1985). Other species are more restricted, for example eider and common scoter both show preferences for shallow (<10m) water depths, similar to those suitable for offshore wind farms (Brager *et al*. 1995). Other species prefer even shallower water: for example, little tern feeding at Scroby Sands, off Great Yarmouth, was found to be concentrated over sand banks of 1-2m depth (Harris 1999). It may be possible in some circumstances to use such data to avoid particularly sensitive species at a site, by locating turbines away from their preferred depth of water.

The seabed substrate type has been shown in several studies to be linked to the habitat preferences of several seabirds' food supply. For example, sand eels, an important component of many seabird species' diet, are found primarily where there are sandy sediments (Reay 1986). Their seabird predators can therefore be expected to follow similar distributions (Wanless *et al.* 1997). Ecologically impoverished substrates, such as shifting sands, could be ideal sites for offshore wind farms (from an ecological perspective at least) as they may be less likely to support important bird populations.

2.5.5 Factors affecting seabird population changes

Many of Europe's seabird populations have been and are continuing to be adversely affected by human activities. Tasker and Canova (1997) identified the three key threat areas as:

- Loss/deterioration of nest sites
- Pollution
- Reduction in food resources through intensification of fisheries and other industries exploiting marine habitats.

In assessing the potential effects of offshore wind farms on seabirds, it is important to take into account the other factors that are influencing their population levels, and how the wind farm may interact with such factors. In an area with a limited and declining food supply, for example, the effect of a wind farm may be rather greater than in an area with a super-abundant food supply where birds could simply move away from the wind farm to an alternative feeding area.

Population declines are essentially driven by reduced breeding success, increased mortality or a combination of the two. Declines in common scoter, scaup and velvet scoter abundance in Britain (Kirby *et al.* 1993), for example, were suggested to result from oil pollution and the actions of commercial fisheries increasing mortality both directly (through contamination with oil) and indirectly (through a reduction in their food supply). Roseate tern in north-west Europe declined from 3812 nesting pairs in 1968 to 561 pairs in 1987, a reduction of 85% (Cabot 1996). This was attributed to increased mortality on the wintering grounds off west coast of Africa. High post-fledging mortality has also been shown to be important in studies of this species in the USA (Nisbet and Spendelow 1999). The assessment process needs to include careful consideration of the population dynamics of any species that could be adversely affected.

2.5.6 Information on additional potential impacts

In any EIA for an offshore wind farm development, consideration will need to be given to all of the aspects of the development that could potentially affect bird populations. This will include any associated infrastructure onshore and the cabling pipelines bringing the generated power ashore.

Though these additional potential impacts should be able to be designed to minimise any ornithological effects, it would be advisable to avoid protected nature conservation sites where there is any possibility of an adverse effect occurring. There is no specific published study on such impacts, so it would be useful to incorporate such work into bird monitoring programmes.

3. PLANNED AND ONGOING STUDIES OF THE EFFECTS OF OFFSHORE WIND FARMS ON BIRDS

The most extensive research into the effects of offshore wind farms on birds is being carried out in Denmark, where comprehensive projects have been initiated for their planned demonstration offshore sites. Several of these are in important bird areas, and should provide much extra information on the actual effects. The areas in which these new wind farms are sited hold particularly large numbers of seaduck, including common scoter. The Danish Natural Environmental Research Institute has initiated detailed research on this species but the work to date has only comprised pre-construction baseline data collection. Post-construction monitoring is scheduled from 2002 onwards.

Other studies in relation to birds and offshore wind farms are being carried out but are in the early planning stages of the wind farm, and construction is likely to be some years hence. Work has been carried out to establish ornithological baseline conditions for potential sites off the Dutch and German coasts to look at possible impacts.

Table 5. Planned and ongoing bird studies at offshore wind farms

Site	Country	Comments
Ongoing bird studies at existing offshore wind farms:		
Blyth (North Sea)	England	Extension of ongoing onshore study to cover the offshore turbines (pre- and post- construction), including collision victim searches, night watches using night vision equipment and video surveillance to monitor birds passing through/within rotor height.
Utgrunden (Baltic)	Sweden	Pre- and post-construction monitoring programme being undertaken, no results currently publicly available.
Bird studies being undertaken for potential offshore wind farms:		
Five sites in Baltic and North Sea	Denmark	Monitoring bird distribution and abundance by aerial surveys and migration routes and intensities using tracking radar pre- construction. EIA work completed. Bird monitoring programmes to be undertaken at each site during and after construction.
North Sea	Germany	Baseline work being undertaken for pilot wind farm to be constructed in 2003, and subsequent monitoring programme.
North Sea	Netherlands	No work currently being undertaken; awaiting construction consent.

4. LOCATIONS OF IMPORTANT OFFSHORE BIRD SITES, MIGRATORY ROUTES AND NATURE CONSERVATION PROTECTED AREAS

A key starting point in this section is the definition of an important offshore bird site. In this report BirdLife International's criteria for the identification of Important Bird Areas (Heath and Evans 2000) have been followed. Essentially this includes all sites that support internationally/ nationally important populations. In the context of this report all sites with any seabird or estuarine/coastal bird interest described within the Important Bird Areas (IBA) book have been included.

The important bird sites and nature conservation protection areas are obviously inter-linked. Within the UK, a large proportion of the Important Bird Areas are also protected nature conservation sites, and many are European protected sites under Special Protection Area (SPA) designation.

Each main international/ national designations is discussed briefly below:

4.1.1 Special Protection Area (SPA)

The EU Birds Directive (79/409/EEC) was adopted in April 1979 to protect all wild birds and their habitats, and to designate SPAs to protect rare or vulnerable species and all migratory birds. It was implemented into UK legislation by the 'Conservation (natural habitats and of wild flora and fauna) Regulations 1994.' SPAs and SACs together form network of areas termed '*Natura 2000'*, designated to conserve natural habitats and rare, endangered or vulnerable wildlife species. In the marine environment they are often referred to as 'European Marine Sites'. The Birds Directive specifically lists rare and vulnerable species that should be afforded special protection on Annex 1.

JNCC are currently carrying out a review of the SPA designations in the UK. This process is likely to result in the designation of further areas, including offshore sites, though no specific areas have been identified to date (D. Stroud, pers. comm.).

The protection afforded by a SPA covers not just the site itself but also the surrounding areas that those important bird populations use. Thus, for example, the waters around a SPA breeding seabird colony, would be protected as well as the breeding colony itself.

Where offshore developments may be likely to have a significant effect on a SPA (or a SAC – see below) an Appropriate Assessment will be needed under the 1994 Conservation (Natural Habitats and of Wild Flora And Fauna) Regulations. This process puts a clear onus on the developer to demonstrate that there will not be an adverse effect on the ecological integrity of the site due to a development within or close to it. If there is likely to be an adverse impact on the integrity of the site then consent would normally only be given in circumstances of over-riding national public interest.

4.1.2 Ramsar

The convention on wetlands of international importance was agreed at Ramsar in Iran in 1971 and was ratified by the UK government in 1976. It gives a government commitment to promoting the conservation of important wetlands. All Ramsar sites are also SSSIs and many have additionally been designated as SPAs.

4.1.3 Special Area for Conservation (SAC)

These are areas that have been proposed for designation under the EU Habitats Directive 92/43/EEC (1992). This legislation forms a major contribution by the EU to the Biodiversity Convention agreed at the 1992 Rio Earth Summit. The details of the qualifying criteria for designation are given on the proposal schedule for each site. These sites do include marine areas below mean low water mark as well as terrestrial habitats, and are legislated through the 'Conservation (Natural Habitats and of Wild Flora And Fauna) Regulations 1994.'

The Habitats Directive has two specific lists of priority habitats (Annex 1) and priority species (Annex 2), for which countries are obligated to take special protection measures to ensure their conservation.

4.1.4 Site of Special Scientific Interest (SSSI)

These areas have been notified under the Wildlife and Countryside Act 1981 for their special interest by reason of any of their flora, fauna, or geological or physiographical features. They are the main statutory national conservation designation to protect sites of nature conservation importance. The reasons for designation are given on each site's SSSI schedule, together with potentially damaging operations that are not permitted without consent from the statutory government conservation agency. SSSIs do not currently cover land below the mean low water mark.

The Wildlife and Countryside Act 1981 also gives special protection to rare bird species listed on its Schedule 1. It is illegal to disturb any of these at their breeding site.

4.1.5 Marine Nature Reserves (MNR)

Marine Nature Reserves are created by statute (under the Wildlife and Countryside Act 1981) to conserve marine flora and fauna. They also may be established within 3 nautical miles of the coast under the Territorial Seas Act 1987, or, by an Order of Council, to the limits of UK territorial waters. They include both the sea and the sea bed.

4.1.6 Sensitive Marine Areas (SMA)

This is a non-statutory designation but still identifies important areas for conservation. Sensitive Marine Areas are nationally important sites, notable for their marine animal and plant communities, or which provide ecological support to adjacent statutory sites. In several cases (eg the Wash and north Norfolk coast), they have been the precursors for marine SACs.

In terms of sensitivities, all of these areas would be likely to be considered of at least as high sensitivity, and the internationally important protected areas very high sensitivity. Any wind farm development that could affect such areas would need to be able to show that it would not significantly affect the nature conservation interest for which the site was designated. Particular sensitivities may include:

Seabird breeding colonies – the effect of an offshore wind farm will depend on its distance from breeding colonies and on the species involved. As discussed above, different seabirds have very different foraging behaviour, some ranging only a few hundred metres from their colony to feed (eg little terns), and others many hundreds of kilometres (eg gannets, Manx shearwaters).

Seabirds concentrations outside breeding season – concentrations of seabirds may also occur outside the breeding season. Several species, particularly terns, gather together in large post-breeding flocks prior to autumn migration, and concentrations may also occur in winter.

Estuarine waterfowl flight routes – there are some potential offshore wind farm sites that may impinge on the intertidal or on important regularly used flight routes between feeding sites or between feeding and roosting sites.

Migrant land birds – if large concentrations of migrants passed through offshore wind farms they could be at risk of collision. However, if offshore wind farms are located away from the immediate vicinity of the coast, where such concentrations would be likely to occur, then the risk of collision would be likely to be much lower. The turbines should ideally be unlit, but if this is unavoidable then appropriate lighting, as discussed above, should be used.

The locations of the important seabird sites (i.e. those identified as Important Bird Areas on the basis of the seabird populations that they support) in the UK are shown in Figure 2. Each site is numbered, with that number cross-referencing the site details in Appendix E. The zone of potential ornithological sensitivity around each of these sites will be highly variable, dependent primarily on the species of importance that they support, though English Nature have suggested a potentially vulnerable zone of 1km around gull and tern colonies and 20km around other seabird colonies (Appendix A). JNCC have a forthcoming project to identify site- and species-specific distances around seabird colonies, which will in the future provide a more precise indication of the distances involved. The Figure also indicates the UK offshore wind farm interest areas in which the current round of proposed sites are located (Crown Estates, 2001).

Figure 3 shows the locations of important estuarine bird sites (i.e. those identified as Important Bird Areas on the basis of the estuarine bird populations that they support). As with the important seabird sites, each is numbered to cross-reference the site details in Appendix F.

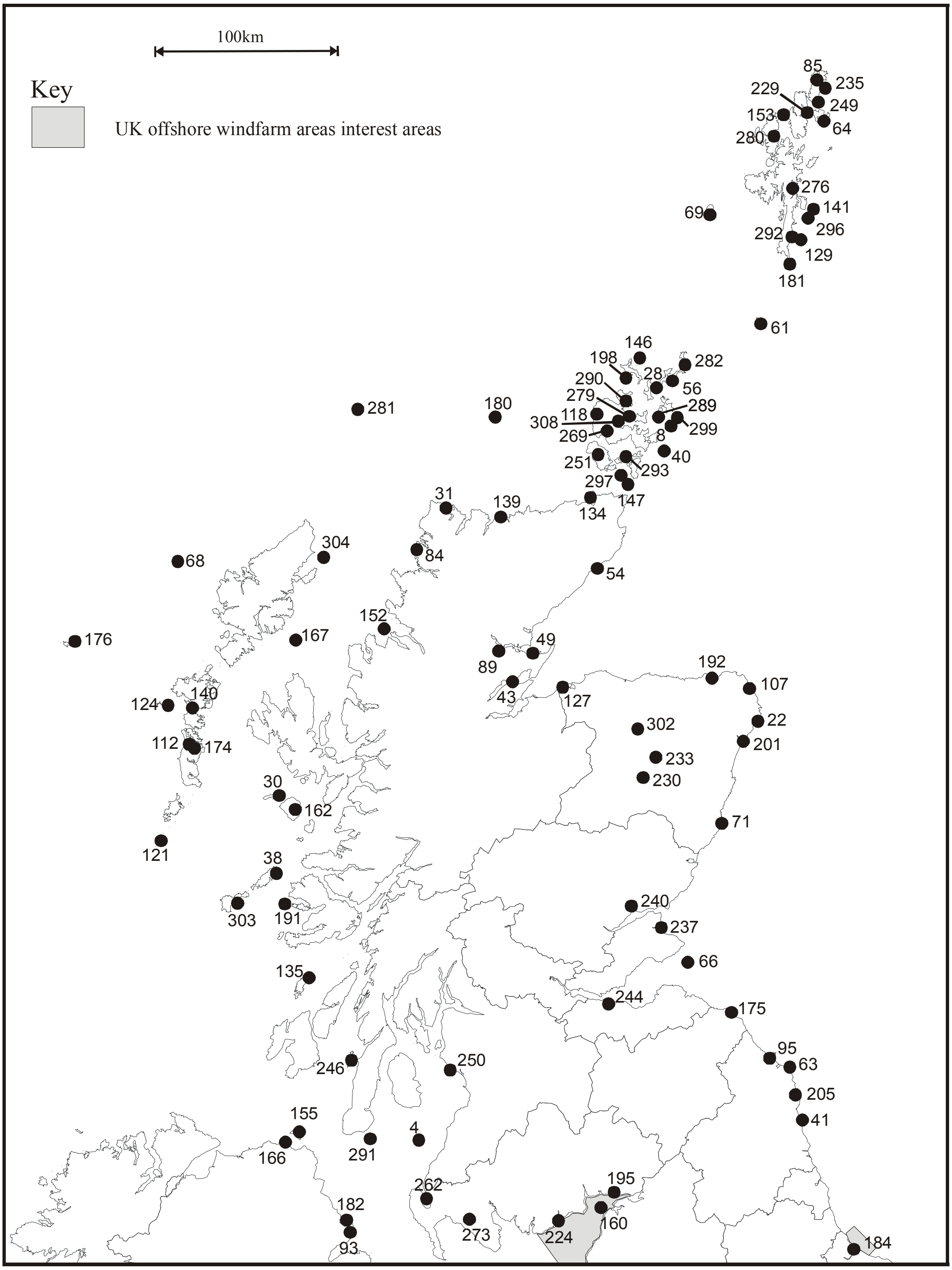

Figure 2 (a). Seabird sites in the northern UK identified as Important Bird Areas (Heath and Evans 2000). Site numbers cross-reference the site details in Appendix E.

Key

UK offshore windfarm areas interest areas

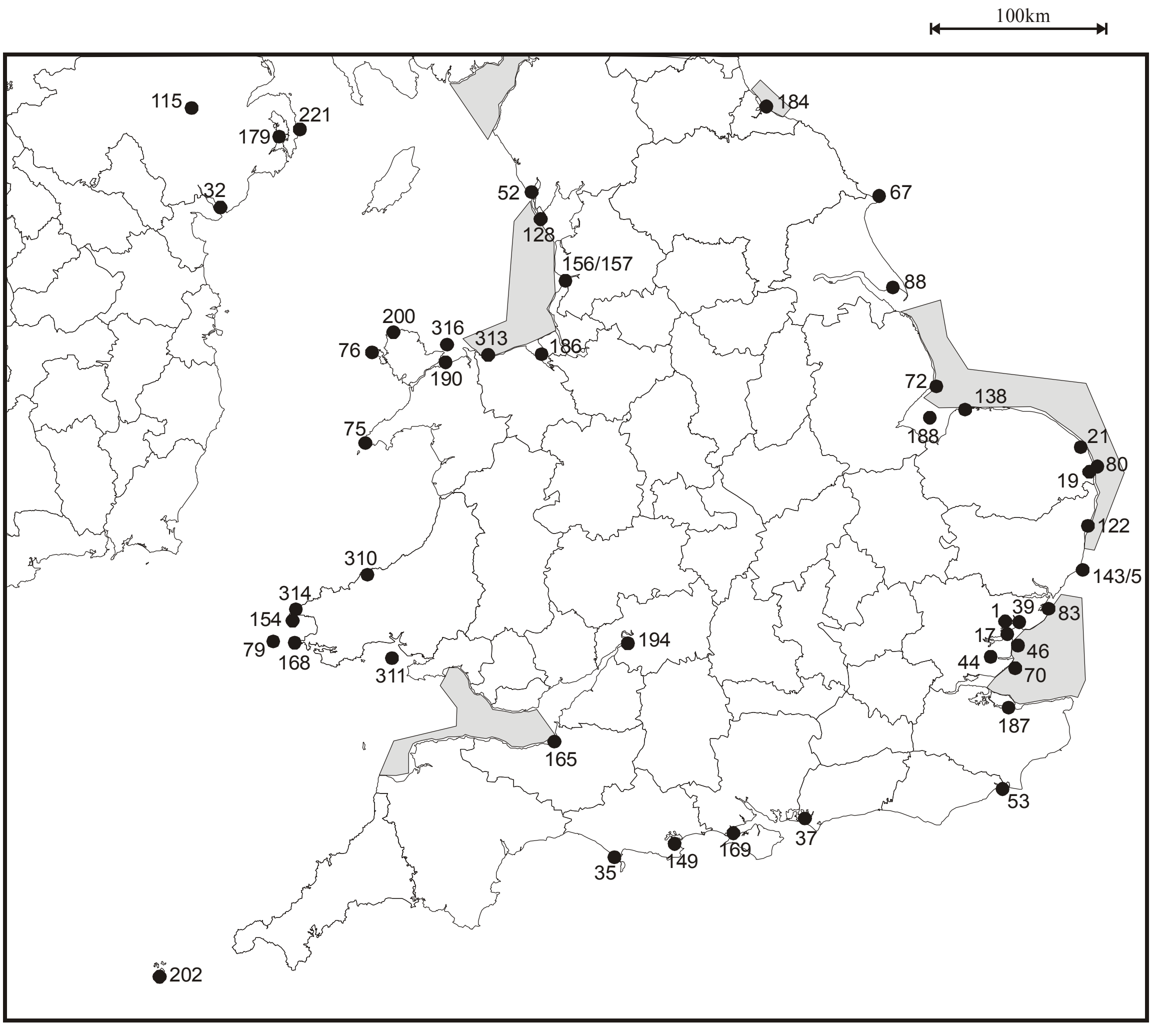

Figure 2 (b). Seabird sites in the southern UK identified as Important Bird Areas (Heath and Evans 2000). Site numbers cross-reference the site details in Appendix E.

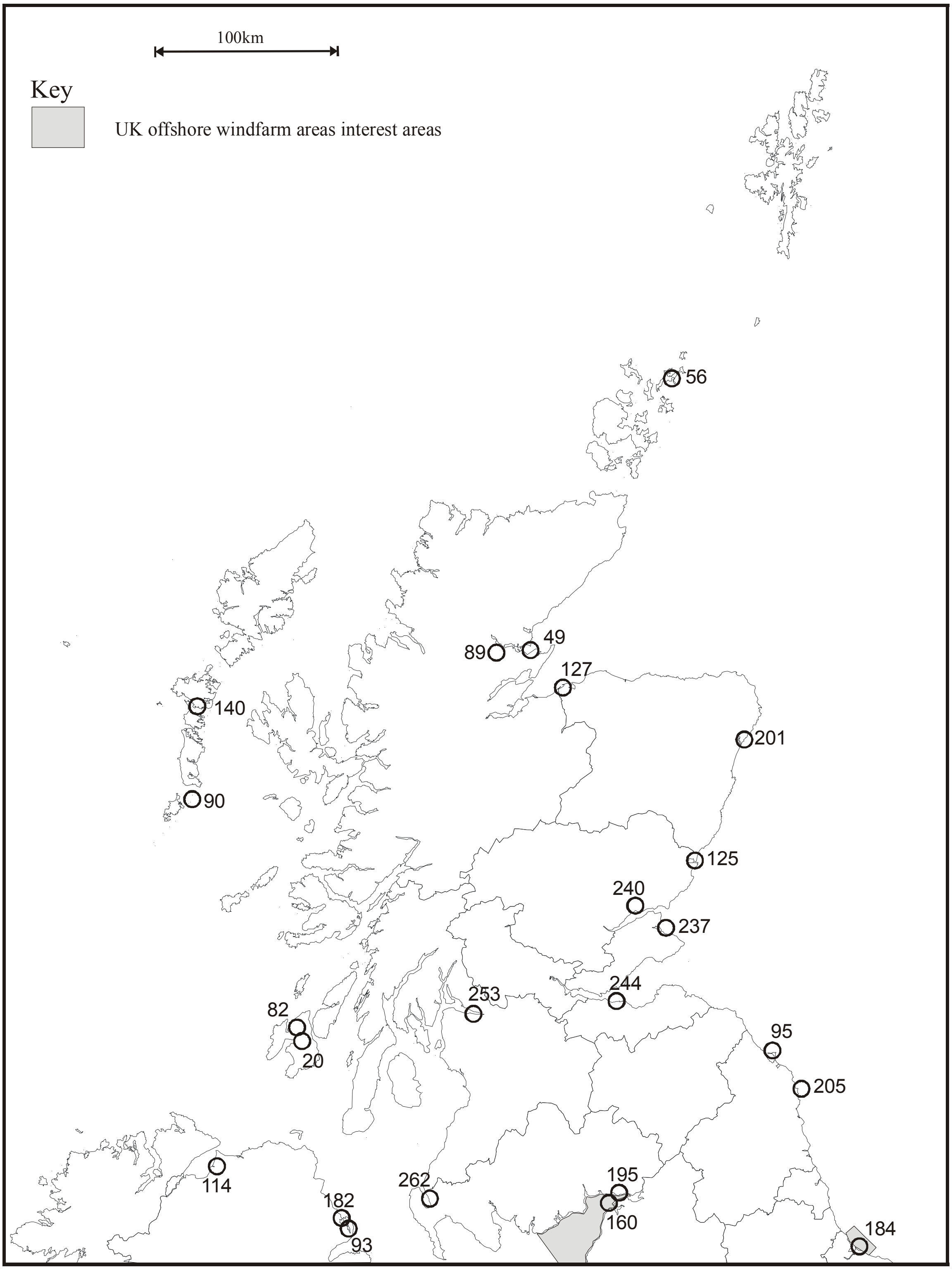

Figure 3 (a). Estuarine bird sites in the northern UK identified as Important Bird Areas (Heath and Evans 2000). Site numbers cross-reference the site details in Appendix F.

Key

UK offshore windfarm areas interest areas

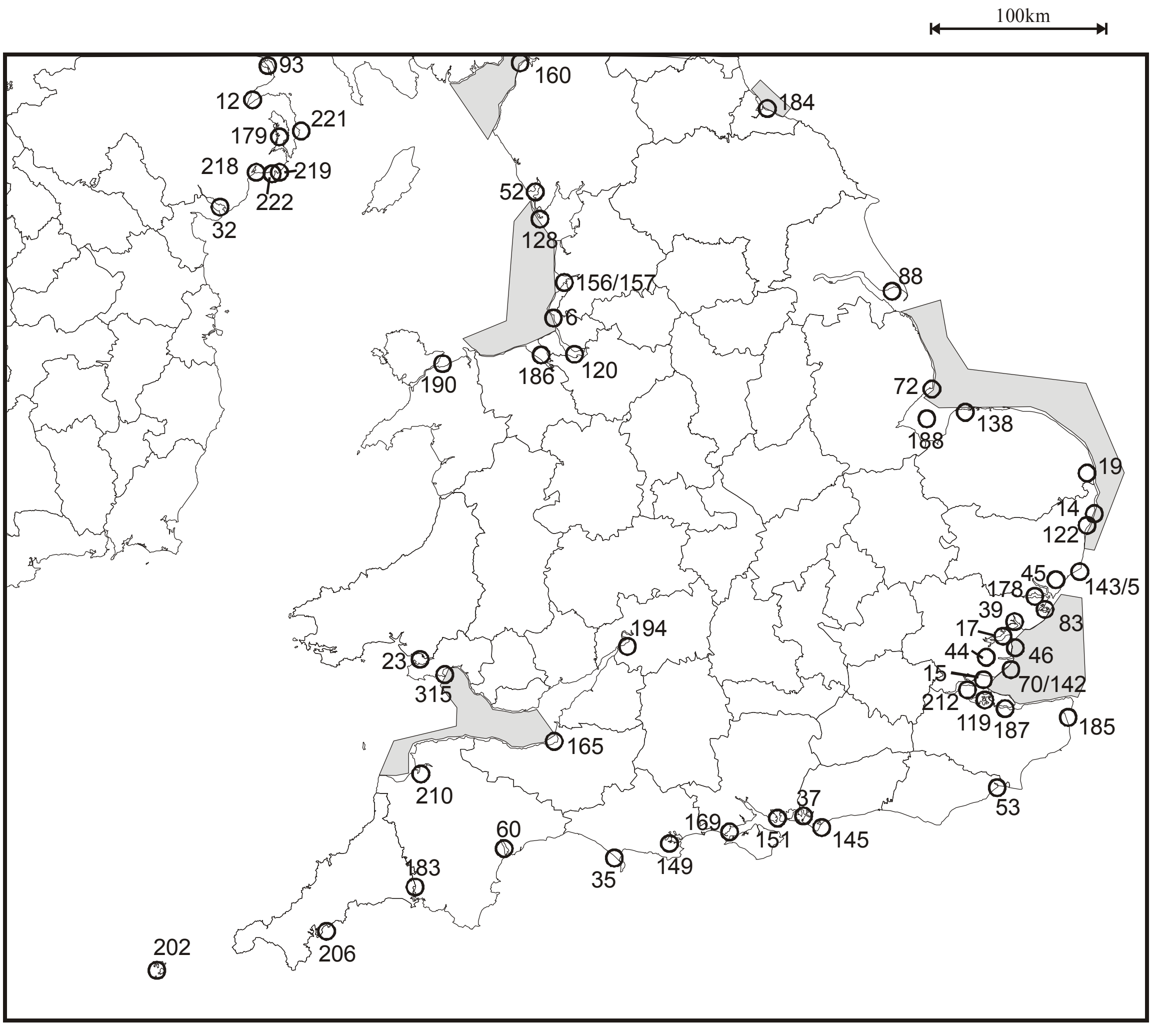

Figure 3 (b). Estuarine bird sites in the southern UK. identified as Important Bird Areas (Heath and Evans 2000). Site numbers cross-reference the site details in Appendix F.

English Nature (Allan Drewitt) and CCW (Sian Whitehead) have both identified potentially vulnerable areas for seabirds in the context of offshore wind farms. The details are given in Tables 6 (England) and 7 (Wales) and the locations are shown on Figure 4. They are both taken directly from the EN and CCW consultation responses (see Appendix A and B for full details). All of these sites are also listed as important seabird areas on Figure 2 and in Appendix E.

English Nature have further identified the likely extent of the important seabird areas, according to whether the breeding colony supports just gulls/terns or other seabirds. In the case of the gulls and terns a distance of 1km from the colony is regarded as a vulnerable area, for the other species 20km from the colony. These vulnerable areas are shown on Figure 4. The same criteria have been used to identify such areas in Wales and Scotland, though it should be noted that neither CCW nor SNH have suggested or agreed such guidance distances.

In addition to these sites, English Nature has also identified particular offshore areas that regularly support important concentrations of seabirds. These comprise: Liverpool Bay, the South-west Approaches, the Yorkshire-Northumberland coast and the North Sea sandbanks (including The Hills, North- East Bank, Brown Ridge and Dogger Bank). English Nature also suggested that the following areas (5-15m deep and up to 2km offshore) are of known importance for Common Scoter: Northumberland and Durham coasts, the Wash/North Norfolk coast, and in the Thames Estuary, Liverpool Bay, Morecambe Bay and the Solway.

Table 6. Offshore wind farms - potentially vulnerable areas for seabirds in England. Source: English Nature (Allan Drewitt).

Map No.	Existing or Proposed SPA	Important seabird species (italics - potentially important, ? = possibly important)	Within 1km of shore?	Within 20km of shore?
5	Alde-Ore	Sandwich Tern, Little Tern, Lesser Black-backed Gull, Seabird assemblage (Lesser black-backed gulls and terns) >20,000 seabirds	✓	?
14	Benacre to Easton Bavents	Little Tern *Red-throated Diver*	✓	
35	Chesil Beach and the Fleet	Little Tern	✓	
37	Chichester and Langstone Harbours	Sandwich Tern, Little Tern	✓	
39	Colne Estuary	Little Tern	✓	
41	Coquet Island	Sandwich, Roseate, Common and Arctic Terns, Puffin, Seabird assemblage (Black-headed Gull)	✓	✓
52	Duddon Estuary	Sandwich Tern	✓	
53	Dungeness to Pett	Common and Little Tern,	✓	

	Level	Mediterranean Gull		
60	Exe Estuary	Little Tern	✓	
63	Farne Islands	Sandwich, Roseate, Common and Arctic Terns, Guillemot, Puffin, Seabird assemblage (Shag, Cormorant, Kittiwake)	✓	✓
70	Foulness	Sandwich, Common and Little Terns	✓	
67	Flamborough Head	Kittiwake, Seabird assemblage (Puffin, Razorbill, Gannet, Herring Gull)	✓	✓
80	Great Yarmouth North Denes	Little Tern	✓	
83	Hamford Water	Little Tern	✓	
88	Humber Flats and Marshes	Little Tern	✓	
202	Isles of Scilly	Storm Petrel, Lesser Black-backed Gull, Seabird assemblage (Shag, Great Black-backed Gull)	✓	✓
95	Lindisfarne	Little Tern, *Common Scoter?*	✓	
119	Medway	Little Tern	✓	
122	Minsmere-Walberswick	Little Tern *Red-throated Diver*	✓	
128	Morecambe Bay	Sandwich and Little Tern, Herring and Lesser Black-backed Gull, Seabird assemblage (gulls and terns), >20,000 seabirds, *Common Scoter?*	✓	?
138	North Norfolk Coast	Little, Sandwich, Common and Roseate Terns, Mediterranean Gull, *Common Scoter?*	✓	
205	Northumberland Coast	Little Tern, *Eider, Common Scoter?*	✓	
149	Poole Harbour	Common Tern, Mediterranean Gull	✓	
156	Ribble and Alt Estuaries	Common Tern, Lesser Black-backed Gull, Seabird assemblage (Lesser Black-backed and Black-headed Gull, terns) >20,000 seabirds	✓	?
169	Southampton Water and the Solent	Sandwich, Common, Little and Roseate Terns, Mediterranean Gull	✓	
184	Teesmouth and Cleveland Coast	Sandwich Tern, Little Tern	✓	
187	Swale	Mediterranean Gull	✓	
188	The Wash (incl. Gibraltar Point)	Common and Little Terns	✓	
186	The Dee	Common and Little Tern	✓	

Table 7. Offshore wind farms - potentially vulnerable areas for seabirds in Wales. Source: CCW (Sian Whitehead).

Map No.	Site	SPA (existing or proposed)	Important species
186	The Dee	Yes	Common and Little tern, waders and wildfowl
190	Traeth Lafan	Yes	Waders and wildfowl (esp. Great Crested grebes)
312	Dyfi	Yes	Waders and wildfowl (esp. Greenland White-fronted geese)
23	Burry Inlet	Yes	Waders and Wildfowl
165	Severn Estuary	Yes	Waders and Wildfowl
75	Glannau Aberdaron and Ynys Enlli	Yes	Breeding seabirds, esp. Manx Shearwater.
79	Grassholm	Yes	Gannet
168	Skomer, Skokholm and Middleholm	Yes	Breeding seabirds, esp. Storm Petrel, Manx Shearwater
200	Ynys Feurig, Cemlyn Bay and the Skerries	Yes	Sandwich, Roseate, Common and Arctic Terns
316	Ynys Seiriol	Yes	Cormorant
311	Carmarthen Bay	Yes	Divers and seaducks (esp. Common Scoter)
313	Liverpool Bay	No	Divers and seaducks (esp. Common Scoter)
310	Cardigan Bay	No	Divers and seaducks (esp. Common Scoter)

Note: this table excludes the many smaller sites that are important nationally or regionally for birds (for example SSSIs at Great Orme, Little Orme, Swansea Bay and Blackpill, Crymlyn Burrows, Milford Haven and Fedw Fawr).

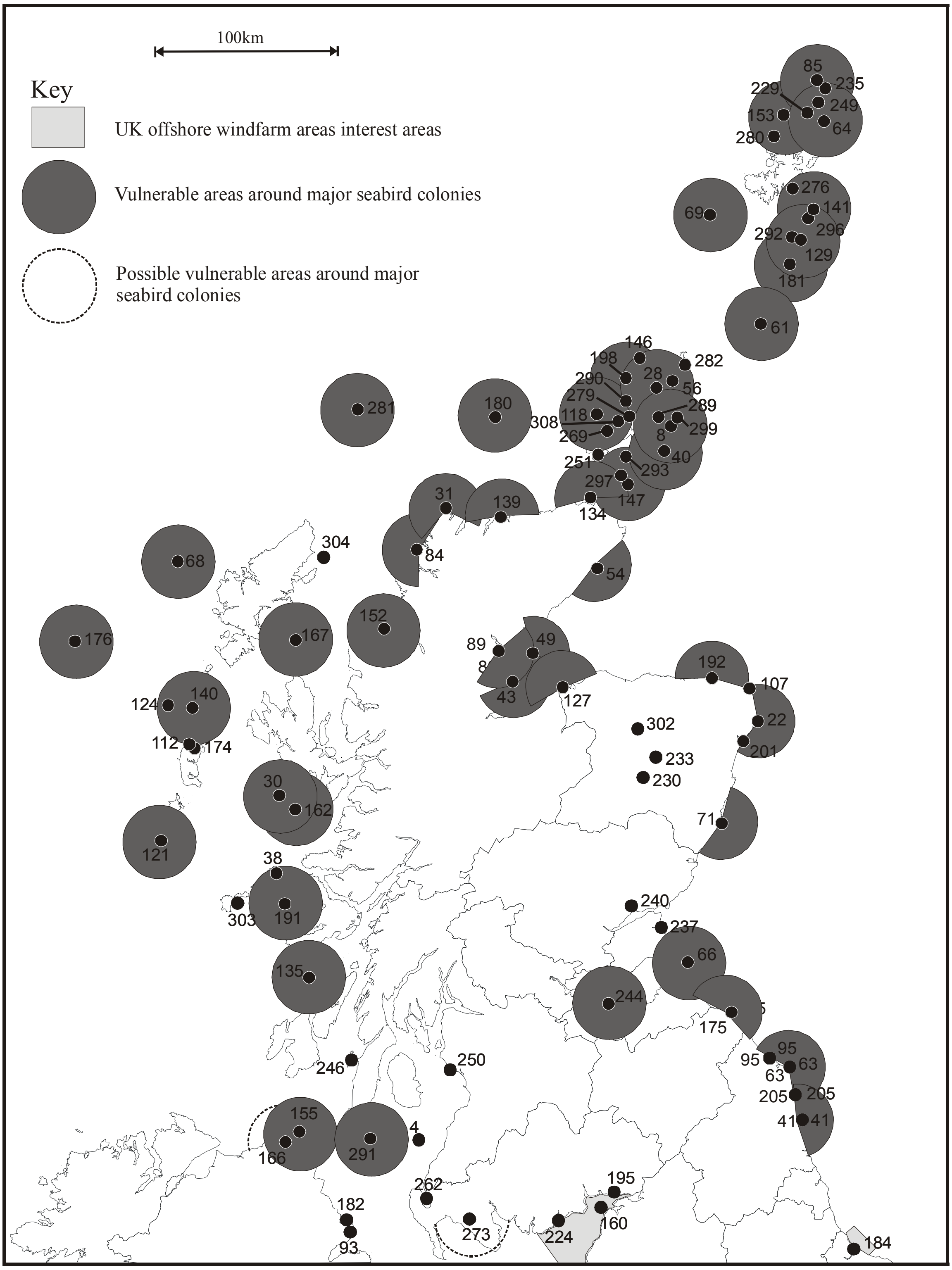

Figure 4 (a). Offshore wind farms – potentially vulnerable areas for seabirds in the northern UK. Note potentially vulnerable areas follow the suggestion of English Nature (20km radius) but actual vulnerable areas will vary on a site-specific basis. Major colonies are those designated as SPAs for seabird species that feed offshore. Possible vulnerable areas indicate a 20km radius around SPAs designated for near-shore species.

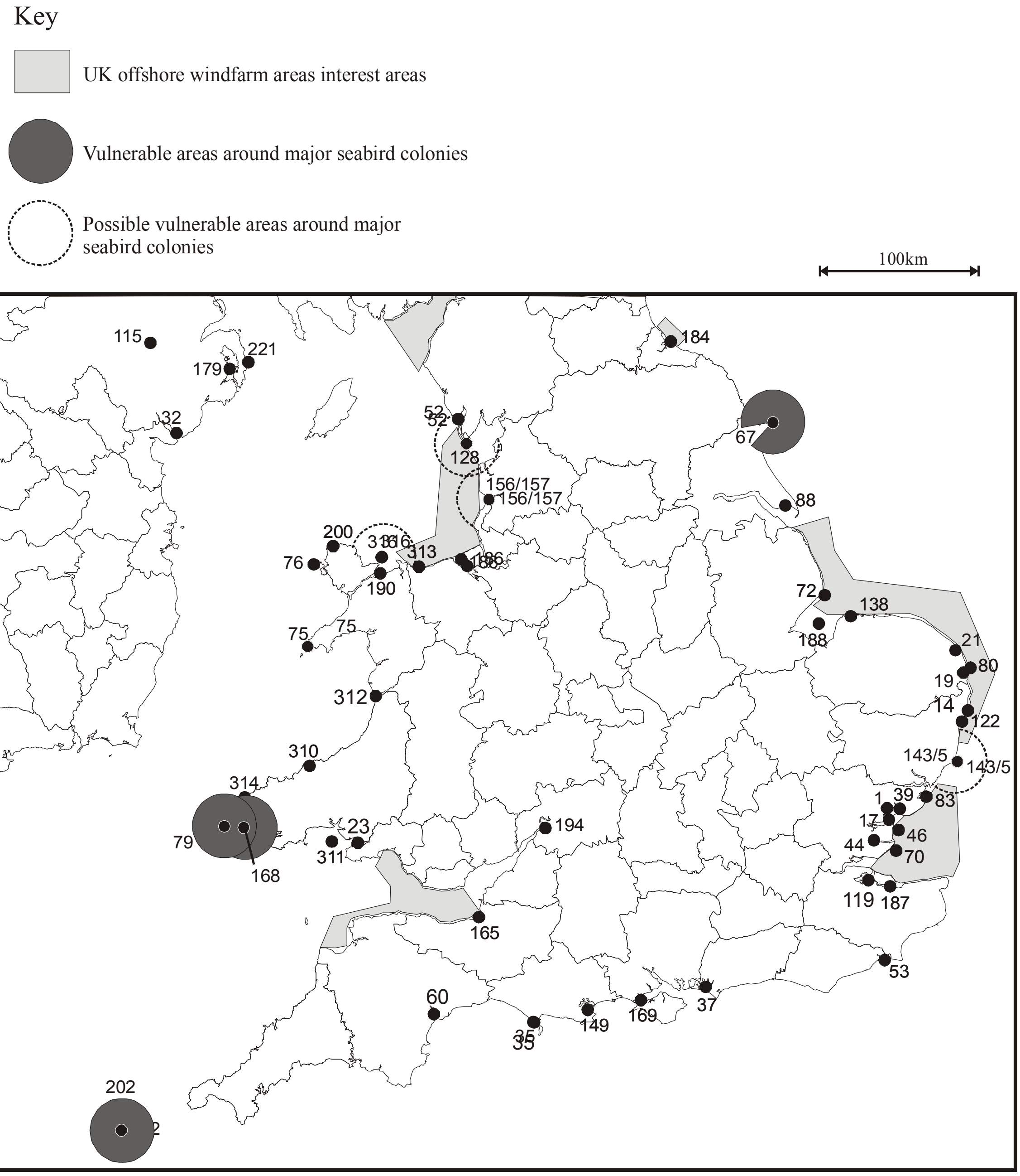

Figure 4 (b). Offshore wind farms – potentially vulnerable areas for seabirds in the southern UK. Note potentially vulnerable areas follow the suggestion of English Nature (20km radius) but actual vulnerable areas will vary on a site-specific basis. Major colonies are those designated as SPAs for seabird species that feed offshore. Possible vulnerable areas indicate a 20km radius around SPAs designated for near-shore species.

4.1.7 Migratory bird routes

Defining precise migratory routes in the UK is difficult. Despite the widespread impression that migrant birds follow tightly defined flyways, it is now generally agreed that most migration occurs over a broad front (Alerstam 1990, Ogden 1996), rather than along discrete migratory corridors. Ogden (1996) concluded that the idea of flyways is probably neither a useful nor a valid concept for landbirds, and that it has only limited validity for waterfowl.

Coastal concentrations of migrants do occur under certain weather conditions, however, though these can occur in any coastal areas. Generally such concentrations are found in close proximity to the shore. Dirksen *et al* 1998, for example, found that most migrant concentrations were found within 700m of the shore. RSPB (R. Langston, in litt.) have identified the zone within 1km of the shore as the main potential for concern regarding migrants. In terms of generalising migrant abundance in different coastal/offshore regions, numbers tend to be greatest on east coast of Britain (particularly England), with usually less recorded along the west coast of Britain.

Though not strictly speaking migratory routes, local flight routes used by coastal waterfowl moving between feeding areas and between feeding and roosting sites do have the potential for conflict with offshore wind farm development. Most such movements are close inshore and within an estuary complex, but there is a well-documented case of regular longer-distance movements between estuaries, which lead to large numbers of waterfowl passing regularly through potential offshore wind farm sites. This link is between the Dee and the Alt Estuaries in north Wales/ north-west England. Kirby *et al*. (1988) reported large numbers of waders moving from feeding areas in the Dee Estuary to roost on the Alt on each tidal cycle. All consultees raised this as a potential issue, particularly in relation to these sites (both of which are internationally important SPAs. If a potential offshore wind farm site lay between (or in close proximity to; <1km) any major waterfowl roosting and feeding areas, then it would be important that this issue was addressed in any EIA, appropriate field data collected and the collision risk (and risk of flight line disruption) fully assessed.

5. GAPS AND LIMITATIONS OF THE CURRENT KNOWLEDGE OF THE EFFECTS OF OFFSHORE WIND FARMS ON BIRDS

As relatively few studies have been carried out on the effects of offshore wind farms on birds, assessments of the effects of new developments will often need to be made without detailed information on the precise effects that will occur. In such a situation it is important that the best use is made of the data that are available, and that data on the effects of new offshore wind farms are collected through appropriate monitoring programmes to inform future developments.

There are inevitably considerable limitations in the current knowledge of the effects of offshore wind farms on birds, given that there are so few existing offshore wind farms and only a small range of species that have been studied. Though no significant impacts have been reported to date at offshore or at coastal wind farms, this does not mean that new offshore sites do not have the potential to cause such effects. The new proposed offshore wind farms in the UK for example, are of a larger scale and will use larger turbines than those wind farms where these studies have been carried out.

There are a number of areas that could considerably add to the current knowledge and enable more detailed assessments of effects to be made. These include:

- More data on the distribution and abundance of offshore birds and the factors affecting their site use. The use of standard data collection methodologies (eg Komdeur 1992) will enable the data to be comparable across different sites. This work should include determination of the densities at which populations occur through the year, and the study of bird-habitat relationships (eg foraging areas and water depth) to predict likely sensitive areas (so that they can be avoided) for key species. Standardisation of the way in which data are collected for baseline studies for offshore wind farm development (though agreed methodologies between developers and conservation agencies) would be a way in which this could be achieved, together with an extension of the wide-scale surveys carried out by the JNCC Seabirds at Sea team in 1980s/90s.

- More data on the actual effects of existing wind farms on key species, including generic studies on behavioural responses of different species to wind farms. In some cases this may only be obtained by collaboration at an international level. It is particularly important for a new industry such as offshore wind that every opportunity is taken to obtain data on the ornithological effects of developments. Agreeing appropriate monitoring methodologies is essential in achieving such an objective.

- Information on offshore wind farm layout design to provide clear guidance for developers to minimise ornithological impacts. Published studies do not provide clear recommendations. Spacing wind turbines widely, for example, may reduce the likelihood of blocking flight lines but at the same time may increase the area from which birds are displaced by disturbance. Turbines located close together may also reduce the likelihood of birds trying to pass between them, hence increasing the collision risk. Recent work on wintering geese (Larsen and Madsen 2000) has suggested that some species at least may be more disturbed by clusters of turbines than by lines, adding further to the optimal layout debate. Studies should be conducted to determine the relative importance of these issues and the optimal solution to minimising impacts.

- Population studies to determine the ecological characteristics of species that may be more sensitive to (i) small increases in mortality rates through collisions, and (ii) effects of habitat loss through disturbance. Consultations between nature conservation bodies and the wind industry should be undertaken to identify the key species that are likely to be affected, and generic studies should be undertaken to further our understanding of these ecological issues. Common scoter is one such species that is widespread and likely to be an issue at several potential offshore wind farm sites.

- Development of standardised agreed methodologies for the assessment of effects for EIA work and for the monitoring of the effects when offshore wind farms are constructed. These methodologies should include the collection of baseline data, the use of those data and other available information in the assessment process, the determination of the significance of effects and the design of appropriate monitoring programmes.

- Information on additional potential impacts including effects of seabed grid connection cabling, effects of navigational lighting and changes to the geomorphological processes that may occur. Again, following the principle that as much data as possible should be collected on potential effects as offshore wind farms are developed, all aspects of possible impacts should be investigated.

- Identification of potential cumulative impacts of offshore wind farms, and how these should be assessed.

- The need to assess and control for any disturbance effects during construction (e.g. seasonal restrictions).

- The need for the results of all studies (onshore and offshore) to be readily accessible so that future wind farm proposals and studies can benefit. ETSU could perhaps play a role in maintaining a common library of reports and publishing summaries and access details on their web site.

- Development of methodologies to quantify local bird movements and flight lines, to determine collision mortality and to carry out nocturnal studies.

- Site-specific information on vulnerable locations.

With any new development there will always be a degree of uncertainty as to its precise effects. With an offshore wind farm, this uncertainty is likely to be high, though, given the experiences of onshore wind farms, such effects are generally likely to be fairly small as long as the turbines are appropriately located. An agreed methodology to enable both developers and conservationists to identify such appropriate locations (and avoid locations that pose an unacceptable risk) would be a key tool in facilitating the development of offshore wind farms. Such a methodology should include:

- Data requirements for EIA.

- Guidance for the use of worst-case analysis to assess uncertainties.

- A clear definition of what constitutes an unacceptable effect.

- Mechanisms (including appropriate risk assessment) to minimise the possibility of any adverse effects occurring and to ensure that unacceptable impact does not occur.

- Protocol for monitoring studies to collect data that will reduce uncertainties in future developments.

5.1. Data requirements for EIA

The first phase of any ornithological assessment for an offshore wind farm should be a desk study to collate existing data and identify the main issues. This should then enable the second phase, the field study to focus on these main issues and ensure that it provides the required data in order to be able to assess the likely effects and to provide a baseline for the monitoring of effects.

The methods for surveying seabirds at sea are well established (see particularly Komdeur *et al*. 1992) and should be followed for offshore wind farm surveys. The frequency of survey and type of survey (plane and/or boat-based) will be dependent on the species likely to be present and the sensitivity of the site. Details of the methodology to be used for specific proposals should be agreed with appropriate consultees. It is likely that some fine-tuning of the standard methods will be required, for example more closely-spaced transects, more frequent surveys and perhaps supplementary observations from strategic points overlooking the wind farm area. Consideration should also be given to appropriate software for data analysis, eg the DISTANCE package (Buckland *et al*. 1993).

The major gap here is not the field methods but rather the precise data requirements and particularly the process of the use of those data in carrying out the assessment. Agreement should be sought with consultees regarding general principles and the specific details that each proposal site raises at the earliest opportunity. The requirements will be related to the bird interest on the site, though all sites are likely to require at least a full year's data. As RSPB state in their position statement on offshore wind energy and birds (Appendix

D), "*the appropriate sampling design and duration of research and monitoring will depend on the location, species present, their sensitivity and conservation importance and the size of the proposed wind farm development. Year-round studies are essential, over a minimum of one year, to collect baseline data for the proposed wind farm location plus surrounding area*."

The recent guidance on studying bird- wind farm interactions published in the USA (Anderson *et al*. 1999) provides a very useful reference source on the design of impact studies. Further specific suggestions from consultees include:

- The need for the development of efficient field methods to measure collision mortality.
- Impacts of statutory lighting requirements.
- Need for an adequate baseline of information (including control sites) to give a meaningful comparison with future monitoring studies.
- Potential for cumulative impacts
- Nocturnal study methodologies.
- The benefits of potential mitigation measures or, at least, mitigation principles.
- Generic sensitivities of different species based on life history traits, population dynamics, ecology and abundance.
- Site-specific information on abundance, distribution, seasonal patterns of occurrence of all relevant bird species.
- Site-specific information on migratory routes and flight lines involving local movements.
- Site-specific information on bird habitat and resource use and availability.

5.2. Monitoring

It is very important that developers should take opportunities to improve knowledge of effects of offshore wind farms on birds through appropriate monitoring of the birds using the area. As stated by RSPB (R. Langston, in litt.) research and monitoring should be seen as an essential component of offshore wind farm development. More detailed monitoring would usually be required where larger numbers of more sensitive species are present. Clearly monitoring should only be undertaken at sites where there are sufficient birds present to be likely to yield useful and meaningful information. As concluded by Guillemette *et al*. 1999 in their Tunø Knob study, much more useful and conclusive results will be obtained from integrated studies to look at birds, the wind farm and the other ecological factors influencing the birds' distribution and abundance.

Monitoring should be linked with pre-construction baseline data in order to maximise its scientific value. This should be taken into account when determining study areas for baseline studies, so that a sufficient area is surveyed to include both areas that could potentially be affected by the wind farm and ecologically similar areas that would not. From the information available it is very unlikely that any effects would be detected over 2km from the wind turbines, so baseline surveys should include, as a minimum, an equal area to the wind farm that lies more than 2km from the proposed turbine positions. This would enable both before-after-control-impact and gradient-response (i.e. determining the relationship between bird abundance and distance from the turbines) studies to be carried out to investigate the effects of the wind farm.

As with the EIA data requirements, the main gap with regard to monitoring is agreement for a monitoring programme protocol. This should be agreed with key consultees at the earliest possible opportunity.

6. IDENTIFICATION OF AREAS INAPPROPRIATE FOR OFFSHORE WIND FARM DEVELOPMENT DUE TO THEIR BIRD POPULATIONS

There are several stages in the identification of these areas. Determination that bird issues should not be a significant problem could result from two positions, either (i) where no important bird populations occur in the vicinity of the proposed development, or (ii) where important bird populations occur but where there is good evidence that a significant impact will not occur. Given the general lack of information about how bird populations are affected by offshore wind farms, achieving the second of these positions is likely to currently be very difficult.

From a legislative point of view, it is clear that any offshore wind farm would be very unlikely to be permitted anywhere that it threatened the ecological integrity of a European protected site (SPA or SAC) or where it could damage the interest of a SSSI. The Birds and Habitats Directives put the onus on the developer to show that any proposed development in the vicinity of an SPA or SAC would not adversely affect its conservation interest.

The best option would therefore be to avoid areas with important bird populations altogether. The problem then lies in defining such areas. As discussed above, all new developments inevitably involve a degree of uncertainty as to the effects that they will have. When important protected areas or populations could potentially be affected, the precautionary principle should be applied. This is explicit in much recent conservation legislation. In order to ensure that bird issues are assessed fully (and appropriate sites are not blocked unnecessarily), the circumstances under which a precautionary approach is appropriate and how it should be undertaken need to be clarified. With regard to offshore wind farms, it should generally need both important bird population(s) to be present in the development area and a reasonable likelihood that a significant impact may occur, though in the context of any possible impact on a SPA or SAC, the onus would be on the developer to demonstrate that a significant impact would not occur.

The ornithological assessment methodology that has been developed by Scottish Natural Heritage (SNH) and the Scottish branch of the British Wind Energy Association (BWEA) provides a framework by which these issues can be addressed in a transparent and objective process (Percival *et al*. 1999). The guidance recently published in the USA (Anderson *et al*. 1999) is also very useful. One of the key advantages of this type of approach is that it gives a clear indication of where problems are likely to occur, and what is likely to constitute an unacceptable effect.

The SNH/BWEA methodology involves three stages in judging acceptability:

i. Determination of the sensitivity of the population(s) that could potentially be affected (Table 8):

Table 8. Definitions of ornithological sensitivity

SENSITIVITY	DETERMINING FACTOR
VERY HIGH	Cited interest of SPAs and SSSIs. Cited means mentioned in the citation text for the site as a species for which the site is designated (SPAs) or notified (SSSIs).
HIGH	Other species that contribute to the integrity of an SPA or SSSI. Local population of more than 1% of the national population of a species. Ecologically sensitive species, eg large birds of prey or rare birds (<300 breeding pairs in the UK).
MEDIUM	Regionally important population of a species, either because of population size or distributional context. EU Birds Directive Annex 1 and/or W&C Act Schedule 1 species (if not covered above). UK Biodiversity Action Plan (BAP) priority species (if not covered above).
LOW	Any other species of conservation interest, eg species listed on the Birds of Conservation Concern (9) not covered above.

ii. Determination of the magnitude of the likely effect(s) (Table 9):

Table 9. Definitions of magnitude of effect on bird populations. Note: percentage values are for guidance only.

MAGNITUDE	DEFINITION
VERY HIGH	Total loss or very major alteration to key elements/ features of the baseline conditions such that post development character/ composition/ attributes will be fundamentally changed and may be lost from the site altogether. Guide: >80% of population/habitat lost
HIGH	Major alteration to key elements/ features of the baseline (pre-development) conditions such that post development character/composition/attributes will be fundamentally changed. Guide: 20-80% of population/habitat lost
MEDIUM	Loss or alteration to one or more key elements/features of the baseline conditions such that post development character/ composition/ attributes of baseline will be partially changed. Guide: 5-20% of population/habitat lost
LOW	Minor shift away from baseline conditions. Change arising from the loss/ alteration will be discernible but underlying character/ composition/ attributes of baseline condition will be similar to pre-development circumstances/patterns. Guide: 1-5% of population/habitat lost
NEGLIGIBLE	Very slight change from baseline condition. Change barely distinguishable, approximating to the "no change" situation. Guide: <1% of population/habitat lost

iii. Cross-tabulation of the sensitivity and magnitude to give the significance of the impact (Table 10). High and very high significance impacts would be unacceptable, medium ones borderline (which could, for example, be mitigated by careful wind farm design and layout), and low/very low would be acceptable.

Table 10. Matrix of magnitude and sensitivity used to determine the significance of effects.

		SENSITIVITY			
MAGNITUDE		**Very high**	**High**	**Medium**	**Low**
	Very high	Very high	Very high	High	Medium
	High	Very high	Very high	Medium	Low
	Medium	Very high	High	Low	Very low
	Low	Medium	Low	Low	Very low
	Negligible	Low	Very low	Very low	Very low

This methodology has been developed during 1998-2001, and is currently being published on the SNH and BWEA web sites. It has not been designed as a fixed methodology but rather one that will be developed and improved through use. As this process of refinement is ongoing it is important to consider borderline cases (medium and low significance) particularly carefully when applying the methodology in any ornithological assessment.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1. Consultee responses

English Nature (Appendix A) stated that their main concern with regard to birds and offshore wind farms is the potential for disturbance. They noted that a cautious approach to offshore wind farm development and its possible effects on birds is required as there is currently a lack of specific data on impacts available.

CCW (Appendix B) consider there to be a wider potential for negative impacts, through both collision and disturbance. They accepted that direct habitat loss was not an issue for most species but suggested that it may be in some circumstances for common scoter through an impact on benthic faunal communities. CCW recommend that a precautionary approach should be taken, and advise avoiding areas used by significant numbers of birds (migration flyways, or within or in the immediate vicinity of SPAs or other important bird areas). They have also highlighted what they consider to be priorities for further information on bird numbers: (i) seabirds (aerial surveys of common scoter in Liverpool, Carmarthen and Cardigan Bays are ongoing, though their longer-term continuation is not guaranteed), and (ii) flyway routes (particularly whether there may be any other sites where regular large-scale movements may occur across potential offshore wind farm sites, as in the Dee-Alt estuary link).

The Wildlife Trusts and WWF (Appendix C) note that potential interactions between offshore wind farms and avian species should be investigated and evaluated as part of the environmental assessment, and that monitoring should be undertaken after construction and the results should be available to the public.

RSPB (Appendix D), whilst supportive of renewable energy in general, consider that there should be a presumption against offshore wind farms that may affect wildlife on international and national sites, or on other areas with large concentrations of birds. They state that a precautionary approach should be adopted where a risk is identified. The species of most concern to them are seabirds, waterbirds (notably waders and wildfowl) and seaducks.

7.2. Overall evaluation and conclusions

The main problem regarding the assessment of the effects of offshore wind farms on birds is not so much that major impacts are likely to occur but rather a lack of information on such effects. There have only been a very small number of studies carried out to date on offshore wind farms.

The most likely issue is that of disturbance. Wind farms could potentially displace birds from the vicinity of the wind turbines, resulting in loss of feeding and/or roosting habitat. Studies at existing offshore wind farms have not found any significant impacts, with only small behavioural changes observed. Birds exhibited slight alterations to their flight paths, which could result in lines of closely spaced turbines being a block to flight lines but also reduces collision risk. However, this conclusion relates to only a small number of studies from relatively small developments. Evidence from onshore wind farm sites indicates that there may be some displacement but this would be likely to be relatively small scale. It could, however, become important with larger wind farms, where the total area affected could be quite large, or where the wind farm occupies a locally scarce habitat, eg on the only local sandbank in otherwise deep water.

Some concerns have been raised regarding the collision risk that an offshore wind farm may pose to local and migrating bird populations. Collision rates have not been studied at existing offshore wind farms, though it is not generally considered (based primarily on experience from onshore wind farm studies) to be a major problem (see, for example, Appendix A). Evidence from existing onshore wind farms suggests that collisions are very unlikely to be important unless large numbers of particularly sensitive species (such as birds of prey) are flying through very large wind farms (with many hundreds of turbines). However there have been no direct measurements made of collision rates at offshore wind farms. Studies to determine these would need a novel approach to quantify collisions (as it would not be possible to recover collision victims) but should be carried out as a priority at appropriate sites where sufficient numbers of birds may be at risk of collision for meaningful results to be obtained. Such an approach is planned for some of the Danish offshore demonstration wind farms, where baseline monitoring has indicated very large numbers of migrants pass through the proposed wind farm area. In terms of minimising the possibility of collision impacts occurring, the measures adopted to minimise disturbance (ie locating offshore wind farms away from important offshore bird areas) will at the same time reduce collision risk.

Thus the main problem seems to be not so much that a significant impact of offshore wind farms on birds is likely (indeed the limited available evidence suggests that this would not be the case) but rather that the lack of specific evidence to be able to demonstrate that a significant impact would not occur. There are some species for which there is little or no information about how they may respond to wind farms, eg auks, gannet, shearwaters and terns. For other species, eg common scoter, there are some sparse data but there are relatively few species, eg eider, that have been studied in detail.

The UK supports many important seabird populations, and many of these occur in sites with international and national statutory protection status. In terms of breeding seabirds, English Nature have suggested defining areas potentially vulnerable to offshore wind farm development as 1km around important gull and tern colonies, and 20km around other important seabird colonies (though 20km may be less applicable to cormorant and black guillemot which feed primarily close inshore and close to their colony). It would be advisable to avoid these areas as much as possible, if only to avoid the issue of the current lack of knowledge about how particular bird species may respond to the presence of a wind farm. It should be noted though that

CCW expressly stated in consultations that they did not wish Welsh vulnerable areas to be so tightly defined.

It would be advisable to avoid important seabird concentrations outside the breeding season as well. Whilst the evidence suggests that eider ducks are not significantly affected, data on most other species are currently sparse or non-existent.

There are some potential offshore wind farm sites that may impinge on the intertidal or on important regularly used waterfowl flight routes between feeding sites or between feeding and roosting sites. This would be most likely to be an issue if the wind farm were located in close proximity to an intertidal area, so maintaining as much distance as possible from important estuarine bird sites is recommended.

Migrant land birds could be an issue if large concentrations of migrants passed through offshore wind farms, through risk of collision. However, if offshore wind farms are located away from the immediate vicinity of the coast where such concentrations would be likely to occur (i.e. more than 1km offshore), then the risk of collision would be likely to be much lower. The turbines should ideally be unlit, but if this is unavoidable then appropriate lighting, as discussed above, should be used.

With such a new industry, it is inevitable that there are considerable gaps and uncertainties in the existing knowledge. Further studies are needed to address these, but also it is important that an approach can be agreed with consultees to deal with these uncertainties until such studies are completed.

More data are required on the actual effects of existing wind farms on key species. These will need to be collected from new offshore wind farms as they are constructed. It will be important to ensure that robust scientific monitoring of effects is carried out where appropriate. Studies of potential cumulative effects should also be considered where appropriate.

More data are also required on the distribution and abundance of offshore birds and the factors affecting their site use. These will be needed for most offshore wind farm EIAs and should include the study of bird-habitat relationships to predict likely sensitive areas for key species.

Population studies are required to determine the ecological characteristics of species that may be more sensitive to (i) small increases in mortality rates through collisions, and (ii) effects of habitat loss through disturbance.

Standardised methodologies for the assessment of effects for EIA work and for the monitoring of the effects when offshore wind farms are constructed should be agreed with consultees. The SNH/BWEA ornithological assessment methodology for wind farms provides a way in which this could be addressed.

8. REFERENCES

Alerstam, T. (1990) *Bird Migration*. Cambridge University Press, Cambridge.

Anderson, R.L., Morrison, M., Sinclair, K, and Strickland, D. with Davis, H. and Kendall, W. (1999) Studying Wind Energy/Bird Interactions: A Guidance Document. National Wind Coordinating Committee, c/o RESOLVE, Washington DC.

Baldwin, D.H. (1965) Enquiry into the mass mortality of nocturnal migrants in Ontario. *The Ontario Naturalist* 3: 3-11.

Barrios, L. and Aguilar, E. (1995) Incidencia de las plantas de aerogeneradores sobre la avifauna en la comarca del campo de gibraltar. Draft report. R. Marti (ed). Sociedad Española de Ornitología (SEO/ BirdLife), Madrid. 110 p.

Berthold, P. (1993) *Bird migration – a general survey*. Oxford University Press, Oxford, U.K.

Bevanger, K. (1998). Biological and conservation aspects of bird mortality caused by electricity power lines: a review. *Biological Conservation* 86: 67-76.

BioSystems Analysis Inc. (1996) A continued examination of avian mortality in the Altamont Pass Wind Resource Area. Report to California Energy Commission 56 pp

Brager, S., Meissner, J. and Thiel, M. (1995) Temporal and spatial abundance of wintering common eider, long-tailed duck and common scoter in shallow water areas of the southwestern Baltic Sea. *Ornis Fennica* 72:19-28.

Buckland, S.T., Anderson, D.R., Burnham, K.P. and Laake, J.L. (1993). Distance sampling: estimating abundance of biological populations. Chapman and Hall.

Cabot, D. (1996) Performance of the Roseate Tern population breeding in North-West Europe - Ireland, Britain and France, 1960-1994. *Biology and Environment - Proceedings of the Royal Irish Academy* 96: 55-68.

Crown Estates (2001). UK offshore wind farm interest areas. <www.crownestate.co.uk>.

Cochran, W.W. and Graber R.R. (1958) Attraction of nocturnal migrants by lights on a television tower. *Wilson Bulletin* 70:378-380.

Cooper, B.A. and Ritchie, R.J. (1995) The altitude of bird migration in east-central Alaska: a radar and visual study. *Journal of Field Ornithology* 66: 590-608.

Dirksen, S., Spaans, A.L. and Winden, van der J. (1998) Nocturnal collision risks with wind turbines in tidal and semi-offshore areas. In *Wind Energy and Landscape*. Proc. 2nd European and African Conference on Wind Engineering, 1997. pp. 99-108.

Ens, B.J., Piersma, T. and Drent, R.H. (1994) The dependence of waders and waterfowl migrating along the East Atlantic Flyway on their coastal food supplies: What is the most profitable research programme? *Ophelia Supplement* 6: 127-151.

Evans, W.R., and Manville, A.M. (eds.). (2000) Avian mortality at communication towers. Transcripts of Proceedings of the Workshop on Avian Mortality at Communication Towers, August 11, 1999, Cornell University, Ithaca, NY.

Finney, S.K., Wanless, S. and Harris, M.P. (1999) The effect of weather conditions on the feeding behaviour of a diving bird, the Common Guillemot. *Journal of Avian Biology* 30: 23-30.

Gill, J.P., Townsley, M. and Mudge, G.P. (1996a) Review of the impacts of wind farms and other aerial structures upon birds. Scottish Natural Heritage Review 21 68 pp

Gill, J., Sutherland, W.J. and Watkinson, A.R. (1996b) A method to quantify the effects of human disturbance on animal populations. *Journal of Applied Ecology* 33: 786-792.

Guillemette, M., Larsen, J. and Clausager, I. (1998) Impact assessment of an off-shore wind park on sea ducks. NERI Technical Report 27 63pp

Guillemette, M., Larsen, J.K. and Clausager, I. (1999) Assessing the impact of the Tuno Knob wind park on sea ducks: the influence of food resources. NERI Technical Report No 263 21pp

Hamer, K.C., Monaghan, P., Uttley, J.D., Walton, P. and Burns, M.D. (1993) The influence of food-supply on the breeding ecology of Kittiwakes in Shetland. *Ibis* 135: 255-263.

Hamer, K.C., Phillips, R.A., Wanless, S., Harris, M.P. and Wood, A.G. (2000) Foraging ranges, diets and feeding locations of gannets in the North Sea: evidence from satellite telemetry. *Marine Ecology - Progress Series* 200:257-264.

Harris, R. (1999) A further field survey of the Little Terns of the Scroby Sands area, Great Yarmouth. Unpublished Econet Ltd Report 43pp

Heath, M.F. and Evans, M.I. (eds) (2000). Important bird areas in Europe: priority sites for conservation. Volume 1. Northern Europe. Cambridge, UK: Birdlife International (BirdLife Conservation Series No. 8).

Hunt, W.G., Jackman, R.E., Hunt, T.L., Driscoll, D.E. and Culp, L. (1998) A population study of golden eagles in the Altamont Pass Wind Resource Area:

population trend analysis 1997. Report to National Renewable Energy Laboratory. 33pp

Janss, G.F.E. (2000a). Avian mortality from power lines: a morphologic approach of a species-specific mortality. *Biological Conservation* 95: 353-359

Janss, G.F.E. (2000b). Bird Behavior In and Near a Wind Farm at Tarifa, Spain: Management Considerations. Proceedings of the National Avian-Wind Power Planning Meeting III, San Diego, CA, May 1998, pp. 110-114. NWCC c/o RESOLVE Inc., Washington, DC and LGL Ltd., King City, Ontario.

Kirby, J.S., Evans, R.J. and Fox, A.D. (1993) Wintering seaducks in Britain and Ireland - populations, threats, conservation and research priorities. *Aquatic Conservation-Marine and Freshwater Ecosystems* 3: 105-137.

Komdeur, J., Bertelsen, J. and Cracknell, G. (1992) *Manual for Aeroplane and Ship Surveys of Waterfowl and Seabirds.* IWRB Special Publication No 19: 37pp. NERI, Kalø, Denmark.

Larsen, J.K. and Madsen, J. (2000) Effects of wind turbines and other physical elements on field utilization by pink-footed geese: a landscape perspective. *Landscape Ecology* 15: 755-764

Larsson, A-K. (1994) The environmental impact from an offshore plant. *Wind Engineering* 18: 213-219

Lemming, J. (1999). A Danish perspective on offshore wind farms. In *Irish Sea Renewable Energy Resources*, pp. 33-42. Irish Sea Forum Report No. 23.

Liechti, F., Klaassen, M. and Bruderer, B. (2000) Predicting migratory flight altitudes by physiological migration models. *Auk* 117: 205-214.

Lincoln, F.C. (1935) The waterfowl flyways of North America. (Circular 342) U.S. Department of Agriculture, Washington, DC. 12 pages.

Lloyd, C., Tasker, M.L. and Partridge, K. (1991) *The status of seabirds in Britain and Ireland.* T. and A.D. Poyser, London.

Lowther, S. (2000) The European perspective: some lessons from case studies. Proceedings of the National Avian-Wind Power Planning Meeting III, San Diego, CA, May 1998, pp. 115-124. NWCC c/o RESOLVE Inc., Washington, DC and LGL Ltd., King City, Ontario.

Madsen, P.S. (1997). Tuno Knob off-shore wind farm. Proceedings of The European Union Wind Energy Conference, Goteborg, 1996. pp.4-7.

Meek, E.R., Ribbands, J.B., Christer, W.B., Davy, P.R. and Higginson, I. (1993) The effects of aero-generators on moorland bird populations in the Orkney Islands, Scotland. *Bird Study* 40: 140-143

Mitchell, J.R., Moser, M.E. and Kirby, J.S. (1988) Declines in midwinter counts of waders roosting on the Dee Estuary. *Bird Study* 35: 191-198

Monaghan, P. (1996) Relevance of the behaviour of seabirds to the conservation of marine environments. *Oikos* 77: 227-237.

Monaghan, P., Uttley, J.D., Burns, M.D., Thaine, C. and Blackwood, J. (1989) The relationship between food-supply, reproductive effort and breeding success in Arctic Terns. *Journal of Animal Ecology* 58: 261-274.

Monaghan, P., Walton, P., Wanless, S., Uttley, J.D. and Burns, M.D. (1994) Effects of prey abundance on the foraging behaviour, diving efficiency and time allocation of breeding Guillemots. *Ibis* 136: 214-222.

Morrison, M.L., Pollack, K.H., Oberg, A.L. and Sinclair, K.C. (1998) Predicting the response of bird populations to wind energy-related deaths. Presented at 1998 ASME/AIAA Wind Energy Symposium Reno, NV. January 1998 8pp

Musters, C.J.M., Noordervliet, M.A.W. and Ter Keurs, W.J. (1995) Bird casualties and wind turbines near the Kreekrak sluices of Zeeland. Report 28 pp

Musters, C.J.M., Noordervliet, M.A.W. and Ter Keurs, W.J. (1996) Bird casualties caused by a wind energy project in an estuary. *Bird Study* 43: 124-126

Nisbet, I.C.T. and Spendelow, J.A. (1999) Contribution of research to management and recovery of the Roseate Tern: review of a twelve year project. *Waterbirds* 22: 239-252.

Ogden, L.J.E. (1996) Collision Course: The Hazards of Lighted Structures and Windows to Migrating Birds. World Wildlife Fund Canada and the Fatal Light Awareness Program report, 52 pp.

Orloff, S. and Flannery, A. (1992) Wind turbine effects on Avian activity, habitat use, and mortality in Altamont Pass and Solano County Wind Resource Areas 1989-1991. Biosystems Analysis Inc. California Energy Commission 160 pp

Painter, A., Little, B. and Lawrence, S (1999) Continuation of bird studies at Blyth Harbour wind farm and the implications for offshore wind farms. DTI ETSU report no W/13/00485/00/00.

Piatt, J.F. and Nettleship, D.N. (1985) Diving depths of four alcids. *Auk* 102: 293-297.

Pedersen, M.B. and Poulsen, E. (1991) Impact of a 90m/2MW wind turbine on birds: Avian responses to the implementation of the Tjaereborg Wind Turbine at the Danish Wadden Sea. Danske Vildtundersogelser Haefte 47: 34-44 pp

Percival, S.M. (2000) Birds and wind turbines in Britain. *British Wildlife* 12: 8-15.

Percival, S.M., Band, B. and Leeming, T. (1999) Assessing the ornithological effects of wind farms: developing a standard methodology. Proceedings of the 21st British Wind Energy Association Conference 161-166.

Pollitt, M., Cranswick, P.A., Musgrove, A., Hall, C., Hearn, R., Robinson, J. and Holloway, S. (2000) *The wetland bird survey 1998-99: wildfowl and wader counts.* BTO/WWT/RSPB/JNCC, Slimbridge.

Reay, P. J. (1986) Ammodytidae. In Fishes of the North-Eastern Atlantic and the Mediterranean, Vol. 2, pp. 945–950. Ed. By P. J. P. Whitehead, M. L. Bauchot, J. C. Hureau, J. Nielsen, and E. Tortonese. UNESCO. 1007 pp.

SGS Environment (1994) Haverigg Windfarm ornithological monitoring programme. Report to Windcluster Ltd.

SGS Environment (1996) A review of the impacts of wind farms on birds in the UK. Report to Energy Technology Support Unit (E.T.S.U.) 27 pp

Sinclair, K. (1999). Status of the U.S. Department of Energy/National Renewable Energy Laboratory Avian Research Program. National Renewable Energy Laboratory report, 11pp.

Still, D., Little, B. and Lawrence, S. (1996) The effect of wind turbines on the bird population at Blyth Harbour. Report to Border Wind Limited. 34 pp

Stone, C.J., Webb, A., Barton, C., Ratcliffe, N., Reed, T.C., Tasker, M.L., Camphuysen, C.J. and Pienkowski, M.W. (1995) *An atlas of seabird distribution in north-east European waters*. Peterborough, Joint Nature Conservation Committee.

Tasker, M. and Canova, L. (1997) Marine Habitats. In *Habitats for Birds in Europe: a conservation strategy for the wider environment*, Tucker, G.M. and Evans, M.I (eds). BirdLife Conservation Series No. 6. BirdLife International, Cambridge.

Thelander, C.G. and Rugge, L. (2000) *Avian risk behavior and fatalities at the Altamont wind Resource Area.* National Renewable Energy Laboratory Report 28pp.

Tulp, I., Schekkerman, H., Larsen, J.K., van der Winden, J., van de Haterd, R.J.W., van Horssen, P., Dirksen, S. and Spaans, A.L. (1999) Noctural flight activity of sea ducks near the windfarm Tunø Knob in the Kattegat. IBN-DLO Report No. 99.30

Uttley, J.D., Walton, P., Monaghan, P. and Austin, G. (1994) The effects of food abundance on breeding performance and adult time budgets of guillemots. *Ibis* 136: 205-213.

Verheijen, F.J. (1958) The mechanisms of the trapping effect of artificial light sources upon animals. *Netherlands Journal of Zoology* 13: 1-107.

Verheijen, F.J. (1985). Photopollution: Artificial light optic spatial control systems fail to cope with. Incidents, causations, remedies. *Experimental Biology* 44: 1-18.

Wanless, S., Bacon, P.J., Harris, M.P., Webb, A.D., Greenstreet, S.P.R. and Webb, A. (1997) Modelling environmental and energetic effects on feeding performance and distribution of shags: integrating telemetry, geographical information systems, and modelling techniques. *ICES Journal of Marine Science* 54: 524-544.

Wanless, S., Harris, M. P., and Morris, J. A. (1991) Foraging range and feeding locations of shags Phalacrocorax aristotelis during chick rearing. *Ibis* 133: 30–36.

Weir, R.D. (1976) Annotated bibliography of bird kills at man-made obstacles: a review of the state of the art and solutions. Department of Fisheries and the Environment. Canadian Wildlife Service, Ontario Region.

Wiltschko, W., U. Munro, H. Ford, and R. Wiltschko. (1993) Red light disrupts magnetic orientation of migratory birds. *Nature* 364: 525-526.

Winden, J, van der., Dirksen, S., Bergh, L.M.J. van den, and Spaans, A.L. (1996) Nachtelijke vliegbewegingen van duikeenden bij het Windpark Lely in het Ijsselmeer. Report 32pp

Winkelman, J.E. (1989) Birds and the wind park near Urk: collision victims and disturbance of ducks, geese and swans. RIN Rep 89/15. Rijkinstituut voor Natuurbeheer, Arnhem. 117-121 pp

Winkelman, J.E. (1992a) Impact of the Sep wind park near Oosterbierum (Fr.), the Netherlands, on birds, 1: Collision victims. DLO-Institut voor Bos-en Natuuronderzoek, Arnehem, RIN rapport 92/2.

Winkelman, J.E. (1992b) The impact of the Sep Wind park near Oosterbierum, The Netherlands, on birds, 2: nocturnal collision risks. RIN Report 92/3

Winkelman, J.E. (1992c) The impact of the Sep wind park near Oosterbierum (Fr.), The Netherland, on birds, 3: flight behaviour during daylight. DLO-Institut voor Bos-en Natuuronderzoek, Arnhem, RIN rapport 92/4.

Winkelman, J.E. (1992d) The impact of the Sep wind park near Oosterbierum (Fr.), the Netherlands, on birds, 4: Disturbance. DLO-Institut voor Bos-en Natuuronderzoek, Arnehem RIN rapprt 92/5

Appendix A. Offshore wind farms - potentially vulnerable areas for seabirds in England

Allan Drewitt, English Nature

Introduction

There is little published work on the potential impacts of offshore wind farm development on birds. The limited material available suggests that there is some effect on flight lines, with birds shifting flight paths to avoid turbines, and probably some disturbance effect on feeding birds within 100m of turbines. Given the nature of bird movements over the sea, which are generally across a broad front rather than along specific ‘corridors’, along with observations that most seabirds fly close to the sea surface and thus below rotor height, it seems unlikely that collision with rotors will be a significant nature conservation issue. Impacts resulting from disturbance (both visual and acoustic) and direct loss and damage to foraging areas are likely to be more important.

The seabird areas that are potentially vulnerable to offshore wind farm development are listed in the table below. These areas are largely adjacent to important seabird colonies within existing SPAs, extending up to 20km from the coast depending on the size and species composition of the colony. Offshore areas that may be important for seaduck, divers and grebes are also listed, although there is no comprehensive survey data for these groups. Finally, the wholly offshore areas of known importance for seabird concentrations are listed, although reference to the Seabirds at Sea dataset will be required when assessing the potential impact of specific proposals. Further explanation of each category is provided below.

Gull and tern colonies

This category relates to offshore waters within 1km of SPAs that support breeding terns and gulls. Most terns and gulls feed within this range and many seabirds congregate to loaf and roost within this distance from their colonies. The relevant SPAs are listed, along with their important seabird species, in the table below.

Large seabird colonies

This includes offshore waters up to 20km from SPAs supporting large numbers of seabirds, especially the more pelagic species such as Gannets, Kittiwakes, Auks and Petrels which usually feed more distantly from their colonies. The distance that such birds occur offshore varies both with species and within species and between colonies. Some birds may also use non-contiguous areas, overflying large expanses of sea to distant foraging grounds. Defining an area of up to 20km offshore as vulnerable might therefore encompass much ‘dead ground’ where birds do not occur in significant numbers. The best approach may be to establish the specific use made of sea areas around each of the colonies used by such seabirds to more accurately identify the important areas. Relevant SPAs, together with their important seabird species, are listed in the table below.

Offshore areas supporting seaduck, diver and grebe concentrations

Seaduck, diver and grebe concentrations may also be particularly vulnerable to disturbance and habitat loss affecting the coastal waters where they feed and roost. Although there is currently no comprehensive survey coverage of these groups, and numbers are very variable from one year to the next, areas of known importance for Common Scoter in particular include shallow waters (5-15m deep and up to 2km offshore) off the Northumberland and Durham coasts, the Wash/North Norfolk coast, and in the Thames Estuary, Liverpool Bay, Morecambe Bay and the Solway. Species likely to occur in important numbers adjacent to SPAs are indicated in italics in the table. However, such concentrations have not been identified by any objective comparison of standardised data and thus their relative importance is unknown. In addition, the Greater Thames, from North Foreland to the north Essex coast may support internationally important concentrations of divers, grebes and seaduck and the greater Liverpool Bay area is currently being investigated by CCW/EN NW Team.

Offshore seabird concentrations

There has been no recent attempt to identify important concentrations of seabirds which lie wholly offshore. The Seabirds at Sea Team at JNCC (under contract from DETR/DTI) has a dataset which may be analysed to identify important concentrations (Contact Andy Webb 01224 655702). Notwithstanding these comments, the following areas predictably support important concentrations of seabirds at sea: Liverpool Bay, the south-west approaches, the Yorkshire-Northumberland coast and the North Sea sandbanks (including The Hills, North- East Bank, Brown Ridge and Dogger Bank).

Offshore wind farms - potentially vulnerable areas for seabirds

Existing or Proposed SPA	Important seabird species (italics - potentially important)	within 1km of shore	within 20km of shore
Alde-Ore	Sandwich Tern, Little Tern, Lesser Black-backed Gull, Seabird assemblage (Lesser black-backed gulls and terns) >20,000 seabirds	✓	?
Benacre to Easton Bavents	Little Tern Red-throated Diver	✓	
Chesil Beach and the Fleet	Little Tern	✓	
Chichester & Langstone Harbours	Sandwich Tern, Little Tern	✓	
Colne Estuary	Little Tern	✓	
Coquet Island	Sandwich, Roseate, Common and Arctic Terns, Puffin, Seabird assemblage (Black-headed Gull)	✓	✓

Duddon Estuary	Sandwich Tern	✓	
Dungeness to Pett Level	Common & Little Tern, Mediterranean Gull	✓	
Exe Estuary	Little Tern	✓	
Farne Islands	Sandwich, Roseate, Common & Arctic Terns, Guillemot, Puffin, Seabird assemblage (Shag, Cormorant, Kittiwake)	✓	✓
Foulness	Sandwich, Common & Little Terns	✓	
Flamborough Head	Kittiwake, Seabird assemblage (Puffin, Razorbill, Gannet, Herring Gull)	✓	✓
Great Yarmouth North Denes	Little Tern	✓	
Hamford Water	Little Tern	✓	
Humber Flats and Marshes	Little Tern	✓	
Isles of Scilly	Storm Petrel, Lesser Black-backed Gull, Seabird assemblage (Shag, Great Black-backed Gull)	✓	✓
Lindisfarne	Little Tern, Common Scoter?	✓	
Medway	Little Tern	✓	
Minsmere-Walberswick	Little Tern Red-throated Diver	✓	
Morecambe Bay	Sandwich & Little Tern, Herring and Lesser Black-backed Gull, Seabird assemblage (gulls and terns), >20,000 seabirds, Common Scoter?	✓	?
North Norfolk Coast	Little, Sandwich, Common and Roseate Terns, Mediterranean Gull, Common Scoter?	✓	
Northumberland Coast	Little Tern, Eider, Common Scoter?	✓	
Poole Harbour	Common Tern, Mediterranean Gull	✓	
Ribble and Alt Estuaries	Common Tern, Lesser Black-backed Gull, Seabird assemblage (Lesser Black-backed and Black-headed Gull, terns) >20,000 seabirds	✓	?
Southampton Water and the Solent	Sandwich, Common, Little and Roseate Terns, Mediterranean Gull	✓	
Teesmouth and Cleveland Coast	Sandwich Tern, Little Tern	✓	
Swale	Mediterranean Gull	✓	

The Wash (incl. Gibraltar Point)	Common & Little Terns	✓
The Dee	Common & Little Tern	✓

Allan Drewitt
18 January 2001

Appendix B. Ornithological issues affecting the development of offshore windfarms in Wales

CCW's approach to the potential development of offshore wind farms is based on support for renewable energy. However, this must not be to the detriment of wildlife and the scenic beauty of seas, coast or countryside. This means that we must deal with each proposal on a case-by-case basis.

At present, our knowledge of the impacts of offshore windfarms on bird populations is very limited, due to the paucity of research. There is a small, but slowly growing, body of information relating to onshore windfarms, and some of the findings from these studies, particularly from coastal developments, can be extended in principle to marine bird species.

We feel that there are three main potential negative impacts that offshore windfarms can have on bird populations:

- Direct impact - it is very difficult to collect accurate bird collision data. In the absence of evidence to demonstrate the extent of any impact, we would advise a precautionary approach, and that offshore windfarms are not located in any areas that are known to be used by significant numbers of birds (for example across migration flyways, or within or in the immediate vicinity of SPAs or other important bird areas).

- Loss of habitat - for some seabird species, this is unlikely to be a significant factor. However, we would be concerned about the impact of wind turbine construction in areas known to be used by feeding common scoter. In addition to the potential disturbance effects (see below), the construction process may have a significant impact on the benthic faunal communities on which common scoter feed.

- Disturbance, and behavioural changes - there are little data available at present on the disturbance effects of offshore wind turbines. The effect of lighting and provision of potential perching and roosting structures is also not known. As with direct impacts we would therefore advise a precautionary approach, and that developments are avoided within or adjacent to SPAs or other important bird areas.

We have indicated in the table below those sites that we consider to be the most sensitive. Some of those sites listed (for example Liverpool Bay) comprise huge areas, and it is likely that only sections within the site will be deemed to be particularly vulnerable for birds, but in the absence of more detailed information, we have to indicate the potential importance of the site as a whole.

Please also note that all the sites we have identified are on or adjacent to the Welsh coast. Colleagues in JNCC are currently undertaking a project to identify further sites, which may qualify under the Birds and Habitats

Directives as Natura sites in the offshore environment - the first phase of this project will identify suitable sites in waters beyond 12 nautical miles (NM) from land. In undertaking this review of waters beyond 12NM, it is possible that further suitable sites may be identified within 12NM from the shore. Until the current project is completed, we will treat all potentially suitable habitat for such sites with care, to ensure that they are not damaged or altered in such a way that might prejudice against their selections as Natura 2000 sites.

The sites that we have listed also exclude the many smaller sites that are important nationally or regionally for birds. Therefore this list should not be regarded as comprehensive, and there are other sites, some of which are notified as Sites of Special Scientific Interest (for example Great Orme, Little Orme, Swansea Bay and Blackpill, Crymlyn Burrows, Milford Haven and Fedw Fawr) which may be impacted by particular developments. We would expect these to be dealt with on a case-by-case basis, through the usual scoping and consultation processes.

Offshore wind farms – potentially vulnerable areas for seabirds in Wales

Site	SPA (existing or proposed)	Important species
The Dee	Yes	Common and Little tern, waders and wildfowl
Traeth Lafan	Yes	Waders and wildfowl (esp. Great Crested grebes)
Dyfi	Yes	Waders and wildfowl (esp. Greenland White-fronted geese)
Burry Inlet	Yes	Waders and Wildfowl
Severn Estuary	Yes	Waders and Wildfowl
Glannau Aberdaron and Ynys Enlli	Yes	Breeding seabirds, esp. Manx Shearwater.
Grassholm	Yes	Gannet
Skomer, Skokholm and Middleholm	Yes	Breeding seabirds, esp. Storm Petrel, Manx Shearwater
Ynys Feurig, Cemlyn Bay and the Skerries	Yes	Sandwich, Roseate, Common and Arctic Terns
Ynys Seiriol	Yes	Cormorant
Carmarthen Bay	Yes	Divers and seaducks (esp. Common Scoter)
Liverpool Bay	No	Divers and seaducks (esp. Common Scoter)
Cardigan Bay	No	Divers and seaducks (esp. Common Scoter)

As we have already indicated, there is currently very little information available on the impacts of offshore windfarms. Although there are more studies arising from terrestrial developments, extrapolation of findings from these studies to the marine environment is limited, and any interpretations should be made with caution. We would highlight the following as priority areas for research:

Better knowledge of bird numbers and distributions

JNCC Seabirds at Sea have an ongoing programme of offshore survey work. However, this can only provide a snapshot view of bird populations, and does not take account of within season and diurnal movements. CCW are currently funding aerial and shore- based surveys of Common Scoter in Carmarthen, Cardigan and Liverpool Bays (the latter in partnership with the oil and wind industries) and these are providing the level of detail that we feel is necessary in order to make informed decisions about offshore developments.

Information about flyway routes

We would be particularly concerned about how birds are moving along the Welsh coast. It is already known, for example, that waders move between the Alt and Dee Estuaries – do they follow the coastline, or are they flying a more direct route that would take them out over the sea, and so through a potential development area?

Disturbance effects, and behavioural changes

There is a need to review and consolidate the studies that have been done, but which are mostly reported in the grey literature, or in other languages. It would also be useful to examine the impacts of other offshore structures on birds – for example, studies have been done of the effects of oil rigs, and their associated lighting, on birds.

Mitigation measures

Of the development already in place, how effective have any measures been to mitigate or reduce any potential impacts?

Dr Sian Whitehead
Ornithologist

Appendix C. The Wildlife Trusts and Worldwide Fund for Nature-UK Position Statement on the Development of Offshore Wind Farms (extract relating to birds)

Mick Green

From the Joint Marine Programme of The Wildlife Trusts and WWF-UK "Position Statement on the Development of Offshore Wind Farms".

Interactions with Birds

Given that wind turbines are fundamentally tall structures, possessing large parts which rotate at relatively speed, there would appear an obvious potential for negative interaction with bird populations, resulting from birds being struck by rotor blades. Such interactions could be potentially serious in the case of offshore wind farms within the UK, given its importance for wading and seabird populations, and the fact that the British Isles forms is covered by migration routes for many other bird species.

These concerns have also been a high priority in Denmark, where specific research has been undertaken to assesses the impact that a substantial pilot offshore wind farm – Tunø Knob – had upon internationally important populations of scoter and eider seaducks, which are resident within the area of the project. A three-year study commissioned by the Danish Government, revealed that the wind farm did not appear to have an effect upon either the abundance or distribution of these species in the general area of the project. Results, indicated that the ducks exhibited avoidance behaviour, with rates of flying and landing being significantly lower within 100m of the turbines, compared to areas 300m and 1000m from the turbines. This behaviour was exhibited by the ducks irrespective of whether the rotor blades were turning or stationary.

While the results of the above study are important, it is obvious in the case of offshore wind farms proposed within the UK that:

- potential interactions between offshore wind farms and avian species should be investigated and evaluated as part of the environmental assessment, and
- monitoring should be undertaken after construction, and results should be available to the public.

Appendix D. RSPB position statement on offshore wind energy and birds

The RSPB's policy is to support renewable sources of energy, provided that adverse impacts on wildlife are avoided by appropriate siting and design. Renewables offer an opportunity to modify or reverse the deleterious changes associated with climate change, arising from over-reliance on fossil fuels. There should be a presumption against developments affecting wildlife on designated or qualifying international and national sites (eg. SPAs, SACs) or other areas with large concentrations of birds such as migratory flight paths. The precautionary approach should apply in these situations, where a risk is identified.

The main potential hazards to birds from offshore wind farms are:
- Disturbance
- Collision risk
- Loss of habitat (eg sandbanks)

The species groups of most concern to RSPB are seabirds, waterbirds (notably waders and wildfowl) and seaducks.

A key point is the distance offshore that offshore wind farms are sited. Generally, siting them closer inshore, i.e. within 1km, depending on the location, is likely to increase the potential for intercepting flight paths by birds moving between feeding areas, feeding and roosting or breeding areas (eg seabird colonies) and larger-scale movements along the coast or migration landfall.

Sandbanks that are important feeding locations may present points of conflict, especially where large numbers of turbines are proposed such that much/all the area is likely to be occupied by a wind farm. Shallow water areas are potential fish spawning grounds, favoured by sandeels and locations of mussel beds etc and so can be important to both feeding seabirds and seaducks and to fisheries. The hydrological and geomorphological implications of siting fixed structures on these substrates need to be assessed as well as the ecology of these areas.

Further offshore, large concentrations of birds are most likely in response to food availability, e.g. at tidal upwellings which concentrate plankton and shoals of fish, and around fishing vessels, and when rafting during moult etc. Pinpointing key locations offshore will be necessary to understand the possible links between seabird nesting colonies and their feeding areas. There is some documentation on foraging distances around the UK by breeding seabirds to assist in determining potentially sensitive areas further offshore. Otherwise, most movement is likely to be fairly dispersed and many birds fly low over the sea, below the height of turbine blades.

The appropriate sampling design and duration of research and monitoring will depend on the location, species present, their sensitivity and conservation importance and the size of the proposed wind farm development. Year-round studies are essential, over a minimum of one year, to collect baseline data for the proposed wind farm location plus surrounding area. A single year may not be representative, owing to weather conditions or other factors and site-specific issues may limit the extent to which results from elsewhere can be applied. Nonetheless, the use of standard methods will enable maximum comparability with studies on other sites and enable contextual evaluation against national datasets. In reality, there will be a spectrum of scales of study, with more data needed for locations with considerable bird interest but where there are uncertainties as to likely impacts. These studies need to take into account diurnal, tidal-cycle, weather-related and seasonal variations in site use, as appropriate.

Appendix E. Important seabird sites in the UK

Note: map reference numbers refer to site locations on the maps in Figures 2-4.

Map ref.	Country	Name	SPA	Notes
1	England	Abberton Reservoir	Yes	Inland breeding cormorant
4	Scotland	Ailsa Craig	Yes	Breeding gannet and Lesser black-backed gull. Herring gull.
5	England	Alde-Ore Estuary	Yes	Sandwich, common and little terns. Lesser black-backed gull. Wintering waders (avocet, redshank).
8	Scotland	Auskerry	Yes	Breeding storm petrel. Arctic tern.
17	England	Blackwater Estuary (Mid-Essex Coast Phase 4)	Yes	Wintering brent geese and waders. Breeding Sandwich, common and little terns.
19	England	Breydon Water	Yes	Breeding common tern. Wintering waterfowl.
21	England	Broadland	Yes	Breeding common tern.
22	Scotland	Buchan Ness to Collieston Coast	Yes	Breeding razorbill. Herring gull, kittiwake and guillemot.
28	Scotland	Calf of Eday	Yes	Breeding Great black-backed gull. Red-throated diver, cormorant, whimbrel, arctic skua, guillemot.
30	Scotland	Canna and Sanday	Yes	Breeding shag. Corncrake.
31	Scotland	Cape Wrath	Yes	Breeding razorbill. Kittiwake and guillemot.
32	Northern Ireland	Carlingford Lough	Yes	Breeding Sandwich and common tern. Wintering waterfowl.
35	England	Chesil Beach and The Fleet	Yes	Breeding little tern. Wintering wildfowl.
37	England	Chichester and Langstone Harbours	Yes	Breeding little tern. Wintering waterfowl.
38	Scotland	Coll	Yes	Breeding little tern and corncrake. Red-throated diver, arctic skua, common and arctic terns.
39	England	Colne Estuary (Mid-Essex Coast Phase 2)	Yes	Wintering waterfowl. Breeding Sandwich, common and little terns.
40	Scotland	Copinsay	Yes	Breeding Great black-backed gull. Guillemot.
41	England	Coquet Island	Yes	Breeding Sandwich, roseate, common and arctic terns, and puffin. Eider and black-headed gull
43	Scotland	Cromarty Firth	Yes	Breeding common tern. Cormorant. Wintering waterfowl, including seaduck - common and velvet scoter, long-tailed duck, scaup and eider.
44	England	Crouch and Roach Estuaries (Mid-Essex Coast Phase 3)	Yes	Wintering waterfowl. Breeding Sandwich, common and little terns.
46	England	Dengie (Mid-Essex Coast Phase 1)	Yes	Wintering waterfowl. Breeding Sandwich, common and little terns.
49	Scotland	Dornoch Firth and Loch Fleet	Yes	Breeding common tern. Cormorant. Wintering waterfowl, including seaduck - common and velvet scoter, long-tailed duck, scaup and eider.
52	England	Duddon Estuary	Yes	Wintering waterfowl. Breeding Sandwich and little tern.

53	England	Dungeness to Pett Level	Yes	Wintering waterfowl. Breeding Sandwich, common and little terns.
54	Scotland	East Caithness Cliffs	Yes	Breeding shag, herring and Great black-backed gull, kittiwake, guillemot, razorbill and black guillemot. Fulmar and cormorant.
56	Scotland	East Sanday Coast	Yes	Breeding Sandwich tern. Arctic tern. Wintering waterfowl.
61	Scotland	Fair Isle	Yes	Breeding shag, great skua, arctic tern, guillemot, razorbill and puffin. Fulmar, arctic skua and kittiwake. Migrants.
63	England	Farne Islands	Yes	Breeding shag, Lesser black-backed gull, Sandwich, roseate, common and arctic terns, puffin. Also cormorant, eider, kittiwake and guillemot.
64	Scotland	Fetlar	Yes	Breeding red-necked phalarope. Fulmar and whimbrel.
66	Scotland	Firth of Forth Islands	Yes	Breeding gannet, cormorant, shag, Lesser black-backed gull, herring gull, Sandwich, roseate and common tern, guillemot, razorbill and puffin. Eider, kittiwake, arctic tern.
67	England	Flamborough Head and Bempton Cliffs	Yes	Breeding kittiwake, guillemot, razorbill and puffin.
68	Scotland	Flannan Isles	Yes	Breeding storm and Leach's petrel and razorbill. Guillemot.
69	Scotland	Foula	Yes	Breeding fulmar, Leach's petrel, shag, great skua, arctic tern, guillemot, razorbill and puffin. Red-throated diver, arctic skua.
70	England	Foulness (Mid-Essex Coast Phase 5)	Yes	Wintering waterfowl. Breeding Sandwich, common and little terns.
71	Scotland	Fowlsheugh	Yes	Breeding herring gull, kittiwake, guillemot and razorbill.
72	England	Gibraltar Point	Yes	Breeding common and little tern. Black-headed gull. Wintering waterfowl.
75	Wales	Glannau Aberdaron and Ynys Enlli/Aberdaron Coast and Bardsey Island	Yes	Breeding Manx shearwater. Resident peregrine and chough.
76	Wales	Glannau Ynys Gybi /Holy Island Coast	Yes	Resident chough.
79	Wales	Grassholm	Yes	Breeding gannet.
80	England	Great Yarmouth North Denes	Yes	Breeding little tern.
83	England	Hamford Water	Yes	Breeding little tern. Wintering waterfowl.
84	Scotland	Handa	Yes	Breeding great skua, guillemot and razorbill. Kittiwake.
85	Scotland	Hermaness and Saxa Vord	Yes	Breeding gannet, great skua, black guillemot and puffin. Red-throated diver, fulmar, whimbrel, arctic skua and guillemot.
88	England	Humber Flats, Marshes and Coast (Phase 1)	Yes	Breeding little tern. Wintering waterfowl.
89	Scotland	Inner Moray Firth	Yes	Breeding common tern. Cormorant. Wintering waterfowl, including seaduck - common and velvet scoter, long-tailed duck, scaup and eider.
93	Northern Ireland	Larne Lough	Yes	Breeding Sandwich, roseate and common tern. Wintering brent geese.
95	England	Lindisfarne	Yes	Breeding little tern. Wintering waterfowl.

107	Scotland	Loch of Strathbeg	Yes	Breeding Sandwich tern. Wintering wildfowl.
112	Scotland	Lochs Druidibeg, a` Machair	Yes	Breeding little tern, spotted crake and corncrake.
115	Northern Ireland	Lough Neagh and Lough Beg	Yes	Breeding common tern. Wintering waterfowl.
118	Scotland	Marwick Head	Yes	Breeding guillemot. Kittiwake.
121	Scotland	Mingulay and Berneray	Yes	Breeding shag, guillemot and razorbill. Fulmar and kittiwake.
122	England	Minsmere - Walberswick	Yes	Breeding little tern. Wintering waterfowl.
124	Scotland	Monach Isles	Yes	Breeding black guillemot. Wintering barnacle geese.
127	Scotland	Moray and Nairn Coast	Yes	Breeding common tern. Cormorant. Wintering waterfowl, including seaduck - common and velvet scoter, long-tailed duck, scaup and eider.
128	England	Morecambe Bay	Yes	Breeding Lesser black-backed gull, herring gull and Sandwich tern. Wintering waterfowl.
129	Scotland	Mousa	Yes	Breeding storm petrel. Arctic tern.
134	Scotland	North Caithness Cliffs	Yes	Breeding shag, herring and Great black-backed gull, kittiwake, guillemot, razorbill and black guillemot. Fulmar and cormorant.
135	Scotland	North Colonsay and Western Cliffs	Yes	Breeding chough. Wintering barnacle geese. Kittiwake and guillemot.
138	England	North Norfolk Coast	Yes	Breeding Sandwich, common and little tern. Wintering waterfowl.
139	Scotland	North Sutherland Coastal Islands	Yes	Breeding Leach's petrel. Wintering barnacle geese.
140	Scotland	North Uist Machair and Islands Phase 1	Yes	Breeding storm petrel, corncrake and little tern. Wintering waders and barnacle geese.
141	Scotland	Noss	Yes	Breeding gannet, great skua and guillemot. Fulmar.
143	England	Orfordness-Havergate (part of Alde-Ore Estuary)	Yes	Breeding Lesser black-backed gull, Sandwich, common and little tern.
146	Scotland	Papa Westray (North Hill and Holm)	Yes	Breeding arctic tern and black guillemot. Arctic skua.
147	Scotland	Pentland Firth Islands	Yes	Breeding Great black-backed gull and arctic tern. Guillemot.
149	England	Poole Harbour	Yes	Breeding Mediterranean gull, Sandwich and common tern. Wintering waterfowl.
152	Scotland	Priest Island (Summer Isles)	Yes	Breeding storm petrel.
153	Scotland	Ramna Stacks and Gruney	Yes	Breeding Leach's petrel.
154	Wales	Ramsey and St David`s Peninsula Coast	Yes	
155	Northern Ireland	Rathlin Island	Yes	Breeding guillemot and razorbill. Herring gull and kittiwake.
156	England	Ribble and Alt Estuaries (Phase 2)	Yes	Breeding Lesser black-backed gull and common tern. Wintering waterfowl.
157	England	Ribble Estuary	Yes	Breeding Lesser black-backed gull and common tern. Wintering waterfowl.
160	England	Rockcliffe Marsh (part of Upper Solway Flats and Marshes)	Yes	Breeding Lesser black-backed gull. Wintering waterfowl.
162	Scotland	Rum	Yes	Breeding Manx shearwater. Golden eagle.
165	England/ Wales	Severn Estuary	Yes	Breeding Lesser black-backed gull. Wintering waterfowl.

166	Northern Ireland	Sheep Island	Yes	Breeding cormorant.
167	Scotland	Shiant Isles	Yes	Breeding shag, razorbill and puffin. Wintering barnacle geese. Fulmar and guillemot.
168	Wales	Skomer, Skokholm and Middleholm	Yes	Breeding Manx shearwater, storm petrel, Lesser black-backed gull, razorbill. Resident short-eared owl and chough. Puffin.
169	England	Solent and Southampton Water	Yes	Breeding Sandwich, common and little terns. Black-headed gull. Wintering waterfowl.
174	Scotland	South Uist Machair and Lochs	Yes	Breeding spotted crake, corncrake and little tern. Wintering whooper swan.
175	Scotland	St Abb`s Head to Fast Castle	Yes	Breeding shag, guillemot and razorbill. Cormorant, kittiwake and eider.
176	Scotland	St Kilda	Yes	Breeding fulmar, Leach's petrel, gannet, great skua, razorbill and puffin. Kittiwake, guillemot.
179	Northern Ireland	Strangford Lough	Yes	Breeding Sandwich, common and arctic terns. Wintering waterfowl.
180	Scotland	Sule Skerry and Sule Stack	Yes	Breeding storm petrel, gannet, shag and puffin. Guillemot.
181	Scotland	Sumburgh Head	Yes	Seabird colonies.
182	Northern Ireland	Swan Island	Yes	Breeding Sandwich, roseate and common terns. Wintering brent geese.
184	England	Teesmouth and Cleveland Coast	Yes	Breeding little tern. Wintering waterfowl.
186	England/ Wales	The Dee Estuary	Yes	Breeding little and common tern. Wintering waterfowl.
187	England	The Swale	Yes	Breeding Mediterranean gull. Wintering waterfowl.
188	England	The Wash	Yes	Breeding common and little tern. Black-headed gull. Wintering waterfowl.
190	Wales	Traeth Lafan/Lavan Sands, Conway Bay	Yes	Breeding cormorant. Wintering waterfowl.
191	Scotland	Treshnish Isles	Yes	Breeding storm petrel and Great black-backed gull. Wintering barnacle geese. Guillemot.
192	Scotland	Troup, Pennan and Lion`s Heads	Yes	Breeding kittiwake, guillemot and razorbill. Herring gull, gannet.
194	England	Upper Severn Estuary (part of Severn Estuary)	Yes	Breeding Lesser black-backed gull. Wintering waterfowl.
195	England/ Scotland	Upper Solway Flats and Marshes	Yes	Breeding Lesser black-backed gull. Wintering waterfowl.
198	Scotland	West Westray	Yes	Breeding kittiwake, arctic tern and guillemot. Arctic skua and razorbill.
200	Wales	Ynys Feurig, Cemlyn Bay and The Skerries	Yes	Breeding Sandwich, roseate, common and arctic terns.
201	Scotland	Ythan Estuary, Sands of Forvie and Meikle Loch	Yes	Breeding Sandwich and little tern. Wintering pink-footed geese. Eider and common tern.
202	England	Isles of Scilly	No	Breeding storm petrel, shag, Lesser black-backed gull, Great black-backed gull, roseate and common tern. Wintering waders.
205	England	Northumberland Coast	Yes	Breeding arctic and little tern. Wintering waterfowl.

221	Northern Ireland	Outer Ards Peninsula	Yes	Breeding arctic tern. Cormorant. Wintering waterfowl.
224	Scotland	Almorness Point and Hestan Island	No	Breeding Lesser black-backed gull. Herring gull.
229	Scotland	Blackpark and Gutcher, Yell	No	Breeding red-throated diver, whimbrel and arctic skua.
230	Scotland	Bluemill	No	Breeding common gull.
233	Scotland	Correen Hills	No	Breeding common gull.
235	Scotland	Crussa Field and the Heogs	No	Breeding whimbrel and arctic skua
237	Scotland	Eden Estuary, Tentsmuir Point and Abertay Sands	Yes	Breeding little tern. Eider, common scoter, red-breasted merganser. Wintering waterfowl.
240	Scotland	Firth of Tay	Yes	Wintering black-tailed godwit. Eider.
244	Scotland	Firth of Forth	Yes	Breeding Lesser black-backed gull and common tern. Wintering waterfowl. Eider, cormorant and common scoter.
246	Scotland	Gigha Island and Islets	No	Breeding black guillemot.
249	Scotland	Hill of Colvadale and Sobul	No	Breeding arctic skua and whimbrel
250	Scotland	Horse Island	No	Breeding Lesser black-backed gull. Eider.
251	Scotland	Hoy	Yes	Breeding red-throated diver, great skua and Great black-backed gull. Fulmar, arctic skua, arctic tern and guillemot.
262	Scotland	Loch Ryan	No	Wintering scaup. Eider.
269	Scotland	Lochs of Harray and Stenness	No	Wintering whooper swan, greylag and scaup.
273	Scotland	Mochrum and Castle Lochs	No	Resident cormorant.
276	Scotland	Moorland areas, central Shetland	Yes	Breeding whimbrel and arctic skua. Red-throated diver.
279	Scotland	North Mainland Coast	No	Wintering waders. Long-tailed duck.
280	Scotland	North Roe and Tingon, mainland Shetland	Yes	Breeding red-throated diver and great skua. Whimbrel and arctic skua.
281	Scotland	North Rona and Sula Sgeir	Yes	Breeding Leach's petrel, gannet, Great black-backed gull, guillemot and razorbill. Fulmar, kittiwake and puffin.
282	Scotland	North Ronaldsay coast	No	Breeding black guillemot.
289	Scotland	Rothiesholm peninsula, Stronsay	No	Breeding Great black-backed gull.
290	Scotland	Rousay (part)	Yes	Breeding arctic tern. Arctic skua.
291	Scotland	Sanda Island	No	Breeding shag and razorbill.
292	Scotland	Sandwick and Clift Hills	No	Breeding great skua. Arctic skua and whimbrel.
293	Scotland	Scapa Flow	No	Breeding black guillemot. Wintering great northern diver, Slavonian grebe, shag, velvet scoter. Eider and long-tailed duck.
296	Scotland	South Bressay	No	Breeding great skua. Arctic skua.
297	Scotland	South Walls and Switha	No	Wintering barnacle geese.
299	Scotland	South-eastern Stronsay	No	Breeding black guillemot.
302	Scotland	Tips of Corsemaul and Mortlach	No	Breeding common gull.
303	Scotland	Tiree	Yes	Breeding corncrake and little tern. Wintering waders and geese.
304	Scotland	Tolsta Head, Lewis	No	Breeding Great black-backed gull.
308	Scotland	West Mainland Moors, Orkney	Yes	Breeding red-throated diver. Resident hen harrier, merlin and short-eared owl. Arctic skua.
310	Wales	Cardigan Island	No	Breeding Lesser black-backed gull.

311	Wales	Carmarthen Bay	No	Wintering waterfowl. Breeding cormorant. Common scoter.
313	Wales	North Wales coast	No	Wintering common scoter.
314	Wales	Pembrokeshire cliffs	Yes	Breeding razorbill. Resident peregrine and chough.
316	Wales	Ynys Seiriol	Yes	Breeding cormorant

Appendix F. Important estuarine bird sites in the UK

Map ref.	Country	Name	SPA	Notes
5	England	Alde-Ore Estuary	Yes	Sandwich, common and little terns. Lesser black backed gull. Wintering waders (avocet, redshank).
6	England	Alt Estuary	Yes	Wintering waders and pink-footed geese.
12	Northern Ireland	Belfast Lough	Yes	Wintering waterfowl.
14	England	Benacre to Easton Bavents	Yes	
15	England	Benfleet and Southend Marshes	Yes	Wintering brent geese and waders
17	England	Blackwater Estuary (Mid-Essex Coast Phase 4)	Yes	Wintering brent geese and waders. Breeding Sandwich, common and little terns.
19	England	Breydon Water	Yes	Breeding common tern. Wintering waterfowl.
20	Scotland	Bridgend Flats, Islay	Yes	Wintering waterfowl, inc. barnacle geese and scaup.
23	Wales	Burry Inlet	Yes	Wintering waterfowl.
32	Northern Ireland	Carlingford Lough	Yes	Breeding Sandwich and common terns. Wintering waterfowl.
35	England	Chesil Beach and The Fleet	Yes	Breeding little tern. Wintering wildfowl.
37	England	Chichester and Langstone Harbours	Yes	Breeding little tern. Wintering waterfowl.
39	England	Colne Estuary (Mid-Essex Coast Phase 2)	Yes	Wintering waterfowl. Breeding Sandwich, common and little terns.
44	England	Crouch and Roach Estuaries (Mid-Essex Coast Phase 3)	Yes	Wintering waterfowl. Breeding Sandwich, common and little terns.
45	England	Deben Estuary	Yes	Breeding and wintering waders.
46	England	Dengie (Mid-Essex Coast Phase 1)	Yes	Wintering waterfowl. Breeding Sandwich, common and little terns.
49	Scotland	Dornoch Firth and Loch Fleet	Yes	Breeding common tern. Cormorant. Wintering waterfowl, including seaduck - common and velvet scoter, long-tailed duck, scaup and eider.
52	England	Duddon Estuary	Yes	Wintering waterfowl. Breeding Sandwich and little tern.
53	England	Dungeness to Pett Level	Yes	Wintering waterfowl. Breeding Sandwich, common and little terns.
56	Scotland	East Sanday Coast	Yes	Breeding Sandwich tern. Arctic tern. Wintering waterfowl.
60	England	Exe Estuary	Yes	Wintering waterfowl
70	England	Foulness (Mid-Essex Coast Phase 5)	Yes	Wintering waterfowl. Breeding Sandwich, common and little terns.
72	England	Gibraltar Point	Yes	Breeding common and little tern. Black-headed gull. Wintering waterfowl.
82	Scotland	Gruinart Flats, Islay	Yes	Wintering barnacle and white-fronted goose and whooper swan. Corncrake.
83	England	Hamford Water	Yes	Breeding little tern. Wintering waterfowl.

88	England	Humber Flats, Marshes and Coast (Phase 1)	Yes	Breeding little tern. Wintering waterfowl.
89	Scotland	Inner Moray Firth	Yes	Breeding common tern. Cormorant. Wintering waterfowl, including seaduck - common and velvet scoter, long-tailed duck, scaup and eider.
90	Scotland	Kilpheder to Smerclate, South Uist	Yes	Breeding little tern, spotted crake and corncrake. Wintering waterfowl.
93	Northern Ireland	Larne Lough	Yes	Breeding Sandwich, roseate and common tern. Wintering brent geese.
95	England	Lindisfarne	Yes	Breeding little tern. Wintering waterfowl.
114	Northern Ireland	Lough Foyle	Yes	Wintering waterfowl.
119	England	Medway Estuary and Marshes	Yes	Wintering waterfowl.
120	England	Mersey Estuary	Yes	Wintering waterfowl.
122	England	Minsmere - Walberswick	Yes	Breeding little tern. Wintering waterfowl.
125	Scotland	Montrose Basin	Yes	Wintering whooper swan and pink-footed goose. Eider.
127	Scotland	Moray and Nairn Coast	Yes	Breeding common tern. Cormorant. Wintering waterfowl, including seaduck - common and velvet scoter, long-tailed duck, scaup and eider.
128	England	Morecambe Bay	Yes	Breeding Lesser black-backed gull, herring gull and Sandwich tern. Wintering waterfowl.
138	England	North Norfolk Coast	Yes	Breeding Sandwich, common and little tern. Wintering waterfowl.
140	Scotland	North Uist Machair and Islands Phase 1	Yes	Breeding storm petrel, corncrake and little tern. Wintering waders and barnacle geese.
142	England	Old Hall Marshes (part of Blackwater Estuary)	Yes	Wintering waterfowl.
143	England	Orfordness-Havergate (part of Alde-Ore Estuary)	Yes	Breeding Lesser black-backed gull, Sandwich, common and little tern.
145	England	Pagham Harbour	Yes	Wintering waterfowl.
149	England	Poole Harbour	Yes	Breeding Mediterranean gull, Sandwich and common tern. Wintering waterfowl.
151	England	Portsmouth Harbour	Yes	Wintering waterfowl.
156	England	Ribble and Alt Estuaries (Phase 2)	Yes	Breeding Lesser black-backed gull and common tern. Wintering waterfowl.
157	England	Ribble Estuary	Yes	Breeding Lesser black-backed gull and common tern. Wintering waterfowl.
160	England	Rockcliffe Marsh (part of Upper Solway Flats and Marshes)	Yes	Breeding Lesser black-backed gull. Wintering waterfowl.
165	England/ Wales	Severn Estuary	Yes	Breeding Lesser black-backed gull. Wintering waterfowl.
169	England	Solent and Southampton Water	Yes	Breeding Sandwich, common and little terns. Black-headed gull. Wintering waterfowl.
178	England	Stour and Orwell Estuaries	Yes	Wintering waterfowl.
179	Northern Ireland	Strangford Lough	Yes	Breeding Sandwich, common and arctic terns. Wintering waterfowl.

182	Northern Ireland	Swan Island	Yes	Breeding Sandwich, roseate and common terns. Wintering brent geese.
183	England	Tamar Estuaries Complex	Yes	Wintering waterfowl.
184	England	Teesmouth and Cleveland Coast	Yes	Breeding little tern. Wintering waterfowl.
185	England	Thanet Coast and Sandwich Bay	Yes	Wintering waterfowl.
186	England/ Wales	The Dee Estuary	Yes	Breeding little and common tern. Wintering waterfowl.
187	England	The Swale	Yes	Breeding Mediterranean gull. Wintering waterfowl.
188	England	The Wash	Yes	Breeding common and little tern. Black-headed gull. Wintering waterfowl.
190	Wales	Traeth Lafan/Lavan Sands, Conway Bay	Yes	Breeding cormorant. Wintering waterfowl.
194	England	Upper Severn Estuary (part of Severn Estuary)	Yes	Breeding Lesser black-backed gull. Wintering waterfowl.
195	England/ Scotland	Upper Solway Flats and Marshes	Yes	Breeding Lesser black-backed gull. Wintering waterfowl.
201	Scotland	Ythan Estuary, Sands of Forvie and Meikle Loch	Yes	Breeding Sandwich and little tern. Wintering pink-footed geese. Eider and common tern.
202	England	Isles of Scilly	No	Breeding storm petrel, shag, Lesser black-backed gull, Great black-backed gull, roseate and common tern. Wintering waders.
205	England	Northumberland Coast	Yes	Breeding arctic and little tern. Wintering waterfowl.
206	England	South Cornwall Coast	No	Wintering divers and grebes
210	England	Taw and Torridge Estuary	No	Wintering waterfowl.
212	England	Thames Estuary and Marshes	Yes	Wintering waterfowl. Breeding waterfowl.
218	Northern Ireland	Dundrum Inner Bay	Yes	Wintering brent geese.
219	Northern Ireland	Killough Harbour and Coney Island Bay	No	Wintering waterfowl.
221	Northern Ireland	Outer Ards Peninsula	Yes	Breeding arctic tern. Cormorant. Wintering waterfowl.
222	Northern Ireland	South Down Coast	No	Wintering waterfowl.
237	Scotland	Eden Estuary, Tentsmuir Point and Abertay Sands	Yes	Breeding little tern. Eider, common scoter and red-breasted merganser. Wintering waterfowl.
240	Scotland	Firth of Tay	Yes	Wintering black-tailed godwit. Eider.
244	Scotland	Firth of Forth	Yes	Breeding Lesser black-backed gull and common tern. Wintering waterfowl. Eider, cormorant and common scoter.
253	Scotland	Inner Clyde Estuary	Yes	Wintering redshank. Cormorant.
262	Scotland	Loch Ryan	No	Wintering scaup. Eider.
312	Wales	Cors Fochno and Dyfi	Yes	Wintering white-fronted geese.
315	Wales	Swansea Bay - Blackpill	No	Wintering ringed plover and sanderling.