10 EFFECTS OF THE DEMONSTRATOR PROJECT ON BIRDS

10.1 INTRODUCTION

There is extensive literature on the potential and actual effects that wind farms have on birds (e.g. *Birdlife International* 2003; Percival 2003). The construction and operation of commercial scale wind farms onshore or offshore has been found to produce a variety of effects including:

- *presenting a barrier to bird movement*
- *displacing birds from the area*
- *adversely affecting birds' feeding grounds or food sources*
- *presenting a collision risk to birds.*

The installation and operation of the two WTG units in the Beatrice field may give rise, in varying degrees, to some or all of these effects. This section therefore presents:

- *a review of site-specific data on use that birds make of the site throughout the year*
- *a quantitative assessment of the potential collision risk for birds*
- *a qualitative or quantitative assessment of the other potential sources of impact to birds*
- *an assessment of the significance of each of these potential sources of impact for birds.*

Site-specific information about the use that birds make of the Demonstrator site is presented in Section 4.7, based on the results of 12 months of observation from the Beatrice platform.

10.2 ASSESSMENT OF POTENTIAL EFFECTS OF THE DEMONSTRATOR WIND TURBINE GENERATORS ON BIRDS

10.2.1 BARRIER EFFECTS

Nature of potential effect

There is some indication that wind turbines may act as offshore barriers to bird movement (*BirdLife International*, 2003; Percival, 2001; OSPAR 2003), with birds flying around groups of turbines rather than through them. Several studies have shown that some bird species alter their flight routes to avoid flying through wind farms. For example, tufted duck and pochard at Lely in the Netherlands (Dirksen *et al.,* 1998); eiders at Tuno Knob in the Danish Baltic (Tulp *et al.,* 1999); and eiders at Utgrunden in the Swedish Baltic (Petterson and Stalin, 2003). In general, it is believed that birds will tend to avoid passing through wind farms, even when the total number of turbines is only 20 or 30 (Percival, 2001).

The consequence of such a response by birds will be dependent on the species in question, the physical condition of the individuals and the magnitude of the displacement that the wind farm causes. Issues of spacing between individual turbines and between clusters of turbines may be important and may offer the potential for mitigation. Generally, the closer turbines are sited to the shore, the greater the potential for interception of bird movements associated with feeding, roosting, breeding and migration (Desholm and Kahlert, 2005).

Assessment of barrier effect at Demonstrator site

The two WTGs are spaced about 900m apart, and WTG 1 is located about 1.6km from the Beatrice Alpha complex. They would present a small additional physical feature in the offshore environment close to the Beatrice field. Each WTG would occupy about 58,612m^3, of airspace ($C*\pi*r^2$, where C = blade maximum chord of 4.7m and r = blade length of 63m) (length of blade).

On the basis of the 12 months of observation, there do not appear to be marked diurnal or seasonal movements of birds across the proposed site of the two Demonstrator WTGs.

It is concluded that the presence of the two WTGs, spaced about 900m apart at the offshore location in the Beatrice field, is not likely to create a significant barrier to those species of birds that use the area.

10.2.2 DISPLACEMENT AND DISTURBANCE EFFECTS

Nature of potential effect

Generally speaking, birds will be sensitive to disturbance from offshore activities during all phases of the wind farm life-cycle. Birds will depart from the area of influence to avoid the source of disturbance and consequently will be excluded from that location for the duration of the disturbance. The risk of a potentially significant impact from displacement is dependent on:

- *the availability of alternative localities, such as other feeding areas*
- *the scale of the disturbance, including the distance from the disturbance within which the bird reacts to the disturbance*
- *the frequency and duration of the disturbance*
- *the sensitivity of the species to the disturbance*
- *the degree to which each species might habituate to the disturbance.*

The extent to which birds avoid turbines has variously been estimated as ranging from 100m to 1,500m, with a typical range of 400m to 800m (Percival, 2001, Guillemette *et al.,* 1998, Painter *et al.,* 1999). There is generally more evidence of displacement of birds around wind farms located in coastal habitats; most of the examples of such disturbance relate to waterfowl (Percival, 2003).

Assessment of displacement and disturbance effects at Demonstrator site

The operations to install the WTGs will be completed in a relatively short period of time (a total of about 20 days in May and 30 days in June or July), and would affect a small area of the sea adjacent to an existing offshore structure, the Beatrice field. The operations and equipment that would be used would be very similar to those employed for other activities associated with offshore oil and gas activities.

Once in place, the substructures would occupy a tiny area of the sea surface (about 900m^2 each) and the airspace that could be swept by the blades would be about 58,612m^3. If the Demonstrator site is represented as a rectangle 126m wide (blade diameter) by 900m long (separation of WTGs), around which it is assumed that there is a zone of 800m, from which birds may be displaced as a result of the presence of the WTGs, then the Demonstrator site could affect birds using an area of some 4.3km^2. This is a very small proportion of the available area within the Beatrice field determination boundary around Beatrice.

Periodic monitoring and maintenance of the WTGs will be carried out by the deployment of the emergency rapid intervention craft (ERIC) from the nearby Beatrice platform. Birds in the Beatrice field are well-used to the frequent presence and activities of supply boats and other offshore support vessels, and it is unlikely that the additional use of the ERIC and other small vessels for maintenance visits would result in significant additional disturbance or displacement effects.

It is, therefore, concluded on the basis of the existing literature on birds in the Moray Firth (Section 4.7), and the year-long sequence of observational data from the Beatrice platform, that the operations to install the WTGs, and their presence at the Demonstrator site, is not likely to result in the significant disturbance of species for which the Demonstrator site is an important area; or the displacement of birds from an area of the sea, or an area of airspace, that is important to them. Birds flying close to the WTGs will tend to avoid them (Section 10.2.3), and birds may not use the immediate area (within perhaps 400-800m) of the Demonstrator site. This area (about 4.3km^2), is small in relation to both the area within the field determination boundary and the area of the Smith Bank, and similar habitat is available beyond the very local influence of either the proposed WTGs or the existing Beatrice platforms.

10.2.3 LOSS OF OR CHANGES TO FOOD HABITATS

Nature of potential effect

Habitat loss occurs mainly through displacement of birds from an area around the wind turbines and includes reduced access to feeding areas and other important locations for specific activities, such as moulting. Physical changes to the habitat include the loss of the area of seabed covered by the turbine foundations, and the creation of new underwater substrate, in the form of the submerged parts of the WTGs, for the settlement of marine organisms (Noer *et al.,* 2000).

Existing studies (e.g. ABPmer, 2002) on the effects on bird populations of the loss of feeding habitat through the physical loss of seabed habitat indicate that changes to sediment character and physical processes are of small scale and restricted to the wind farm site. It is important that any proposed site should avoid important areas of suitable feeding habitat for particular species of interest.

In addition to the physical loss of habitat, there is also a potential “zone of avoidance” around turbines and wind farms where foraging birds are displaced. The probability of this effect occurring is high for at least some species which are sensitive to disturbance (DTI, 2003). Research carried out in Denmark on small wind farm developments, noted that both eider and common scoter were more abundant in the wind farm area immediately after construction was completed (reviewed by Percival, 2001). It was concluded that their distribution was more strongly mediated by food availability than any turbine avoidance behaviour. This suggests that exclusion may not affect all bird species, and some species and individuals are likely to forage amongst turbines. The consequence of exclusion on bird populations would be dependent on the extent of the exclusion and the availability of an alternative habitat. One of the important issues associated with the loss of, or change to, habitat is that of cumulative impacts, in particular those that potentially affect limited habitats that are important feeding areas (DTI, 2003).

A range of prey species for seabirds and sea ducks may be attracted to turbine structures following colonisation by shellfish (DTI, 2003). Increased abundance of fish species around the structures may potentially attract divers, auks, terns and gulls (DTI, 2003).

Assessment of this effect at the Demonstrator site

As stated above, it is postulated that the presence of the two WTGs could affect the use that birds may make of an area of about 4.3km^2 centred on the Demonstrator site. This is a very small proportion of the available habitat within the Beatrice field determination boundary, and of the Smith Bank.

Bird behaviour at the site was recorded in all months from August to December. Four species were observed feeding at the site, and the total numbers of observations of feeding for each species (of a total of 2,185 observations of behaviour) were as follows: tern sp., nine observations (0.4% of total); kittiwake, eight observations (0.4%); auk sp., one observation (0.05%); and Arctic skua one observation (0.05%). In addition, the site-specific benthic survey did not indicate that there were dense populations of sandeels on the seabed at the Demonstrator site (Section 4).

It is, therefore, concluded that the presence of the two WTGs will not result in any significant change to, or loss of, any offshore habitat that is used by birds for feeding.

10.3 ASSESSMENT OF POTENTIAL COLLISION RISK FOR BIRDS

10.3.1 INTRODUCTION

Wind turbines can pose a potential collision risk in relation to several types of bird movements (Noer *et al.,* 2000; Christensen *et al.,* 2003) including:

- *annual migration between breeding and wintering areas*
- *daily flights between roosting sites and foraging areas*
- *evasion or avoidance flights following disturbance by humans*
- *flights towards turbines, as a result of attraction to the wind farm area*
- *active foraging flights.*

Overall, it is clear that birds are generally able to avoid collisions (Percival, 2003) and the majority of studies to date have demonstrated low rates of collision mortality per turbine (Percival, 2001; *BirdLife International*, 2003). The risk of collision, however, will vary considerably depending on several factors such as species, flock size, normal flight behaviour (speed, direction, altitude), migration and local inter-site routes, weather conditions, population of birds adjacent to the wind farm, feeding habitats and seasonal variability in flight capability (as affected by, for example, moulting) (Noer *et al.,* 2000; Christensen *et al.,* 2003).

Data from the ornithological observations carried out at Beatrice were, therefore, used to estimate the collision risks for birds found at the Demonstrator site. The aim was to determine if the presence of the two WTGs would be likely to pose a "significant" risk to any species. In line with the definitions employed by SNH, a significant collision risk was defined as one that would be likely to represent additional mortality to the species equal to >1% of that species' natural mortality.

10.3.2 METHODS USED TO CALCULATE COLLISION RISK

Assessing collision risks

The effects of collisions with turbines can be determined by:

- *calculating the potential risk that a bird flying though the turbines would be struck by the blades*
- *multiplying this by the number of "bird transits" that would be made by each species in the year*
- *applying an avoidance factor to take account of the fact that a large proportion of the birds encountering the turbines would take some form of avoidance action and not be struck.*

The resultant estimate of additional annual mortality is then compared with natural mortality levels in order to assess the significance of mortality associated with the proposed wind farm.

A collision model provides a probability of collision given that a single bird flies through the swept area of a turbine once, assuming that the bird takes no avoiding action. The probability of collision is dependent on several variables such as the diameter, chord (width) and rotation speed of the turbine blades; and the length, wingspan and flying speed of the species of bird (Band, 2000).

The SNH model does not fully take account, however, of two variables, which may be important in obtaining a more accurate estimate of collision risk. For large-diameter blades, the flying height of the bird within the zone swept by the blades is important because birds flying near the centre of the blades are more likely to be struck than those flying near the tips of the blades (McAdam *et al.*, 2005). Secondly, the speed of the bird across the ground (and hence its transit time through the blades) also influences the collision risk (Brookes *et al.,* 2005). Both these factors were assessed in the collision risk models that were applied to the Beatrice data.

Models used for Demonstrator site

Four models were applied to assess collision risk for birds at the Demonstrator site, and as described later in the results (Section 10.3.3) these different models may be more or less applicable to some of the species observed at the Demonstrator site.

Model A: Uniform height distribution and constant speed. Bird speeds through the turbine are constant and birds are distributed uniformly in height. The collision probabilities are found for birds flying upwind and downwind, and the mean of these two probabilities is used to find the number of collisions. This is the approach taken in most wind farm EIAs (Band, 2000).

Model B: Skewed height distribution and constant speed. Bird speeds through the turbine are constant, and birds are distributed towards the lower part of the turbine. The use of this model is intended to reflect the fact that most sea birds fly close to the water, especially in relation to turbines of the size proposed for the Demonstrator Project. Lower flight reduces the probability of collision.

In the skewed height distribution, the calculations of individual collision probabilities depending on the radius at which a bird passes through the turbine are exactly the same as in the standard SNH model (Band, 2000).

Model C: Uniform height distribution, speed is affected by wind. Bird speeds and direction are affected by wind conditions, and birds are distributed uniformly in height. The use of this model is intended to capture the fact that bird speed through the turbine can be extremely low if the bird approaches the turbine obliquely or is flying into a headwind. These low speeds substantially increase the probability of collision.

A large data set for wind conditions in the Moray Firth (approximately 1.3 million records sampled at one-minute intervals from 2003 to 2005) was used to inform this model. The data set was reduced to contain only records where the turbine would be operational (10 minute average wind speed is between 3.5m.s^{-1} and 30m.s^{-1}). The model randomly sampled wind conditions from the data set. For each sample of wind velocity, bird direction was randomly sampled (uniform distribution 0-360^{o}), and bird height was randomly sampled (uniform distribution from the bottom to top of the turbine). Every probability quoted is the mean of 5,000 samples.

Model D: Skewed height distribution and constant speed. Bird speeds and direction are affected by wind conditions, and birds are distributed towards the lower part of the turbine. This combines features of models B and C.

Characteristics of key bird species

Table 10.1 shows the data used for the sizes of each species and their flight speeds.

Table 10.1 Sizes and flight speeds for key species at risk from collision (Pennycuick, 1997, 2001; Mularney et al., 1999).

CHARACTERISTIC	VALUE
	KITTIWAKE
Body length	42cm
Wingspan	105cm
Flight speed	13.1m.s^{-1}
	GREAT BLACK-BACKED GULL
Body length	74cm
Wingspan	166cm
Flight speed	12.8m.s^{-1}
	FULMAR
Body length	52cm
Wingspan	117cm
Flight speed	13m.s^{-1}
	GANNET
Body length	97cm
Wingspan	192cm
Flight speed*	10m.s^{-1}
	AUK sp.
Body length**	46cm
Wingspan**	73cm
Flight speed	16m.s^{-1}

Table 10.1 (cont) Sizes and flight speeds for key species at risk from collision (Pennycuick, 1997, 2002; Mularney et al., 1999).

CHARACTERISTIC	VALUE
	HERRING GULL
Body length	60cm
Wingspan	148cm
Flight speed	$12m.s^{-1}$
	TERN SP.
Body length***	37cm
Wingspan***	80cm
Flight speed***	$12m.s^{-1}$

* *No published data for gannet, speed is for herring gull which is the lowest speed for any comparatively sized bird. Using a low speed is a conservative assumption.*

** *Size is for guillemot.*

*** *Size and speed is for common tern.*

Calculating the number of transits

The number of transits through the turbines was calculated in a similar manner to that described by Band (2005) for foraging birds, using the estimates of density for each species (Section 4.8.3). The calculations were simplified slightly by using the density of birds per square metre of sea surface rather than per cubic metre of air. The area of distance Band D is $2,400,000m^2$, and the combined area of all distance bands is $3,100,000m^2$.

For the purposes of collision modelling a transit is considered to be when a bird passes through the square containing the turbine blades, i.e. a bird must be in the risk height band and must cross the plane of the turbine within a horizontal displacement of the turbine radius or less. Viewed from overhead, the turbine occupies a rectangle of sea surface with an area of $A=2RT$, where R is the turbine radius and T is the thickness of the disc. If d is the density of birds occupying the turbine, then the mean number of birds in the turbine at any one time, $n=Ad$. Each bird takes time $t=T/v$ to cross the turbine, where v is the speed of the bird through the turbine. So the rate at which birds must enter the turbine, $r = Ad$, which can be expressed as $2Rdv$. (It should be noted that other studies only count as transits the birds which pass through the smaller area of the turbine circle; this requires higher collision probabilities but does not alter the resulting number of collisions.)

It was assumed that the birds were active for half the year (mean activity per day of 12 hours). The data for the turbines indicate that they would be operational when wind speeds are in the range $3.5m.s^{-1}$ to $30m.s^{-1}$, and the weather data set indicated that these conditions would be obtained for 89% of the time. The total number of transits per year was thus calculated by multiplying the transit rate by half the number of seconds times 89%.

Turbine characteristics

Table 10.2 shows the input data used for the turbine characteristics. The blade profile (variation in blade chord width with radius) was modelled as varying linearly between four points. The variation in blade pitch was modelled as varying linearly between three points.

Table 10.2 Turbine characteristics used in collision risk modelling.

CHARACTERISTIC	VALUE
Radius	63m
Angular velocity	12.1 rpm
Hub height	88m
CHORD WIDTH	
• at 0m	3.32m
• at 3.5m	3.32m
• at 15.5m	4.73m
• at 63.0m	1.28m
BLADE PITCH	
• at 0m	10°
• at 3.5m	10°
• at 63m	0°

Applying a factor for avoidance

It is known that birds avoid collision with turbine blades, both by keeping at a distance from turbine sites, and by dodging blades if they pass through the plane of the turbines (Christensen *et al.,* 2003). To obtain a realistic estimate of the potential increase in mortality caused by birds colliding with the blades of wind turbines, an estimate of avoidance rate has to be factored in. SNH guidelines suggest the use of a 95% avoidance rate for preliminary assessment of risk, but this is acknowledged as a conservative value.

In the absence of quantitative data on the likely avoidance rates for the species that frequent the Demonstrator site, the collision risk assessment has used the conservative value of 95% avoidance for all species.

Calculating number of collisions and impact on population

For birds with large populations, the expected number of deaths per year is the product of the expected number of transits through the turbine, the collision probability and the inverse of the avoidance rate. The relative effect of the Demonstrator WTGs can then be assessed if the total size of the population in the Moray Firth is known.

10.3.3 RESULTS

Collision risk

In this section the estimated collision risk from the two WTGs are presented for seven species (section 4.8.2) at the Demonstrator site, namely kittiwake, gannet, fulmar, great black-backed gull, herring gull, tern sp. and auk sp.

Kittiwake

Kittiwakes were the most numerous bird in all the surveys, particularly flying at turbine height. Only birds flying at turbine height have been considered in this analysis. The densities in August, September, October, November and December were 1.33×10^{-7}, 3.18×10^{-7}, 9.73×10^{-8}, 1.011×10^{-7} and 0.0 birds.m^{-2} respectively. This gives an average density of 1.30×10^{-7} birds.m^{-2}.

Based on this density, and a flight speed of 13.1m.s^{-1}, it is estimated that there would be a total of 6,754 transits each year through the area swept by the blades of the two WTGs.

Collision Model A gives a collision probability of 4.6% if the bird is flying downwind or 6.3% if flying upwind. The mean collision probability is, therefore, 5.5%. This is for birds passing through the circle described by the turbine blades. Model B gives a probability of 2.8% for birds flying downwind and 3.8% for birds flying upwind, with a mean of 3.3%. Model C gives a probability of 7.8%, and Model D gives 5.5%.

Because kittiwakes are relatively high fliers, the most applicable model is Model C (uniform height distribution and speed affected by wind). Table 10.3 gives the expected mortality for kittiwakes for a range of avoidance rates.

Table 10.3 Estimated additional mortality for kittiwakes caused by two WTGs at the Demonstrator site.

Additional mortality	Avoidance Rate				
	90%	**95%**	**98%**	**99%**	**99.5%**
Model A	33	17	7	3	2
Model B	20	10	4	2	1
Model C	**47**	**23**	**9**	**5**	**2**
Model D	31	16	6	3	2

All values round to the nearest whole number.

Average hourly counts for kittiwake varied widely throughout the year (Section 4.8.2), from two per hour of observation in January to more than 70 per hour in July.

The total population of kittiwakes in the Moray Firth is around 75,675 (data from period 1998-2002, Mitchell *et al.*, 2004). The annual adult survival rate is 0.81 (Garthe and Hoppop, 2004), so in a population of this size about 14,378 natural deaths would be expected each year, and a 1% increase in mortality would be 144 individuals. The 33 extra deaths per year estimated using a 95% avoidance factor in Model C thus equates to an increase in mortality of 0.2%.

Great black-backed gull

The density survey only detected birds in October, November and December, with a density of 1.3×10^{-8} , 1.84×10^{-7} and 2.07×10^{-7} birds.m^{-2} respectively. This gives an average density over the five month period of 1.3×10^{-8} birds.m^{-2}.

Based on the density and a flight speed of 13.1m.s^{-1}, it is estimated that there would be a total of 4,114 transits each year through the area swept by the blades of the two WTGs.

Model A gives a collision probability of 7.7% for birds which pass through the turbine flying upwind and 5.9% for birds which pass through downwind. This gives is a mean of 6.8%.

Model B gives probabilities of 3.9% and 4.9% for downwind and upwind flight respectively, with a mean of 4.4%. Models C and D give probabilities of 10.2% and 7.8% respectively.

Great black-backed gulls are a manoeuvrable bird, so it is proposed that the most relevant model is Model D. Table 10.4 gives the expected mortality for great black-backed gulls for a range of avoidance rates.

Table 10.4 Estimated additional mortality for great black-backed gulls caused by two WTGs at the Demonstrator site.

Additional mortality	Avoidance Rate				
	90%	**95%**	**98%**	**99%**	**99.5%**
Model A	25	12	5	2	1
Model B	16	8	3	2	1
Model C	37	19	7	4	2
Model D	**28**	**14**	**6**	**3**	**1**

All values round to the nearest 0.1.

Average hourly counts for great black-backed gull varied widely throughout the year (Section 4.8.2), from 0.2 per hour of observation in August to almost eight per hour in December.

The breeding population of great black-backed gulls in the Moray Firth is around 850 (at East Caithness cliffs SPA), but the individuals found in the Moray Firth, and observed at the Demonstrator site, will have come from other sites. The numbers of great black-backed gulls in the Moray Firth vary greatly with season (Skov *et al*., 1995), and the increase in monthly average density observed at the Demonstrator site from October to December reflects the movement of birds into the area in autumn. Skov *et al*., 1995 estimated that over the period 1980-1994 there were on average 8,000 birds in the Moray Firth area during November to February, 100 in March to April, 1,900 in May to July (including Orkney) and 22,000 (excluding Orkney) in August to October.

Clearly, the birds in the Moray Firth, and those observed at the Demonstrator site particularly in autumn, do not originate only from the breeding colony at Troup Head, and it would not be justifiable to express additional mortality that may be caused by the WTGs solely in terms of this breeding population. The average population size given in Skov *et al.*, 1995 is 8,000.

The annual adult survival rate is 0.93 (Garthe and Hoppop, 2004), so in a population of 8,000 about 560 natural deaths would be expected each year. A 1% increase in mortality would be six individuals, and the results from the model show that such an increase might occur if the gulls' avoidance rate was 98%. This assessment should be treated with caution, however, in view of the considerable seasonal variations in numbers in the Moray Firth, and the observed seasonal variations in numbers per hour of observation at the Demonstrator site.

Herring gulls

Herring gulls were seen particularly in late autumn and winter. Only birds flying at turbine height have been considered in this analysis. No birds were seen at turbine height during surveys in August to September. The densities in November and December were 3.35×10^{-8}, and 1.27×10^{-7} birds.m^{-2} respectively. This gives an average density over the five month period of 3.22×10^{-8} birds.m^{-2}.

Based on the density, and a flight speed of 12m.s^{-1}, it is estimated that there would be a total of 1,534 transits each year through the area swept by the blades of the two WTGs.

Collision Model A gives a collision probability of 5.5% if the bird is flying downwind or 7.4% if flying upwind. The mean collision probability is therefore 6.4%. This is for birds passing through the circle described by the turbine blades. Model B gives a probability of 3.5% for birds flying downwind and 4.5% for birds flying upwind, with a mean of 4.0%. Model C gives a probability of 9.4%, and Model D gives 7.6%.

The most applicable model is Model D, because the birds generally fly below blade height (and so have a skewed distribution) and may fly into headwinds. Table 10.5 gives the expected mortality for herring gulls for a range of avoidance rates.

Table 10.5 Estimated additional mortality for herring gull caused by two WTGs at the Demonstrator site.

Additional mortality	**Avoidance Rate**				
	90%	**95%**	**98%**	**99%**	**99.5%**
Model A	9	4	2	1	0
Model B	6	3	1	1	0
Model C	13	6	3	1	1
Model D	**10**	**5**	**2**	**1**	**1**

All values round to the nearest whole number.

The total breeding population of herring gulls in the Moray Firth is about 13,570 pairs (27,140 individuals) (JNCC). The annual adult survival rate is 0.93 (Garthe and Hoppop, 2004), so in a population of this size about 1,900 natural deaths would be expected each year, and a 1% increase in mortality would be 19 individuals. The five extra deaths per year estimated using a 95% avoidance factor in Model D thus equates to an increase in mortality of about 0.3%.

Fulmar

The average density of fulmar for the period August to December was of 5.45 x 10^{-9} birds.m^{-2}. The total number of transits for this species was estimated to be 250 per year.

Model A gives a collision probability of 6.8% for birds which pass through the turbine flying upwind and 5.0% for birds which pass through flying downwind. This gives a mean of 5.9%.

Model B gives probabilities of 3.1% and 4.1% for downwind and upwind flight respectively, with a mean of 3.6%. Models C and D give probabilities of 8.4% and 6.4% respectively.

It is proposed that the most relevant model for fulmar is Model D. Table 10.6 gives the expected mortality for fulmar for a range of avoidance rates.

Table 10.6. Estimated additional mortality for fulmar caused by two WTGs at the Demonstrator site

Additional mortality	Avoidance Rate				
	90%	**95%**	**98%**	**99%**	**99.5%**
Model A	1.5	0.7	0.3	0.1	0.1
Model B	0.9	0.5	0.2	0.1	0.0
Model C	2.1	1.1	0.4	0.2	0.1
Model D	**1.6**	**0.8**	**0.3**	**0.2**	**0.1**

All values round to the nearest 0.1.

Average hourly counts for fulmar varied from between six and 16 birds per hour of observation over the period January to August (Section 4.8.2), to less than four per hour of observation for the period September to December.

The total population of fulmar in the Moray Firth is around 55,516 (Mitchell *et al.*, 2004). The annual adult survival rate is 0.986 (Garthe and Hoppop, 2004), so in a population this size about 777 natural deaths would be expected each year, and a 1% increase in mortality would be eight individuals. The 0.8 extra deaths per year estimated using a 95% avoidance factor in Model D thus equates to an increase in mortality of around 0.1%.

Gannet

Gannets were the second most abundant bird flying at turbine height, but they generally flew lower than kittiwakes. The density survey revealed densities in the period August to October of 2.65 x 10^{-7}, 0, and 6.19 x 10^{-8} birds.m^{-2}, which gave a mean of 1.09 x 10^{-7} birds.m^{-2}. The total number of transits for this species was estimated to be 2,314 per year.

Model A gives a collision probability of 9.7% for birds which pass through the turbine flying upwind and 7.4% for birds which pass through flying downwind. This gives a mean of 8.6%.

Model B gives probabilities of 5.2% and 6.5% for downwind and upwind flight respectively, with a mean of 5.9%. Models C and D give probabilities of 13.0% and 10.4% respectively.

It is proposed that the most relevant model for gannets is Model D. Table 10.7 gives the expected mortality for gannet for a range of avoidance rates.

Table 10.7 Estimated additional mortality for gannet caused by two WTGs at the Demonstrator site.

Additional mortality	**Avoidance Rate**				
	90%	**95%**	**98%**	**99%**	**99.5%**
Model A	20	10	4	2	1
Model B	14	7	3	1	1
Model C	30	15	6	3	1
Model D	**24**	**12**	**5**	**2**	**1**

All values round to the nearest whole number.

Average hourly counts for gannet varied considerably throughout the year (Section 4.8.2), from zero per hour of observation in January to nearly 10 per hour in October.

The average number of gannets in the Moray Firth ranges from 1,500 (November to February) to 4,000 (September to October) (Skov *et al*., 1995). This increase in numbers during the latter part of the summer and autumn seems to have been reflected in the numbers observed at the Demonstrator site, where elevated numbers per hour were observed over the period July to November. Gannets range widely during the breeding season, with many birds being found at considerable distances from their colonies. In September to October, Gannets are widely distributed over the western part of the North Sea, from the Humber to the Shetland Islands.

The total breeding population of gannet in the Moray Firth is around 3,094 (Mavor *et al.,* 2004), but the total numbers of individuals that may use the Moray Firth may be much higher. The Troup Head gannet colony on the eastern edge of the Moray Firth is the nearest one to the proposed WTGs, and the next nearest ones are in Shetland, and are much larger than the Troup Head colony. The Centre for Ecology and Hydrology at Banchory has carried out tracking studies, and found that gannets have very large foraging ranges; in addition there is evidence that birds from larger colonies forage further than those from smaller colonies. It is therefore likely that the Troup Head gannets will be feeding in the Beatrice area, and there is also a high chance that birds from other colonies (eg. Shetland) may also be present (Matt Parsons, *pers. com.,* 2006).

The annual adult survival rate is 0.93 (Garthe and Hoppop, 2004). If the total population using the Moray Firth were some 35,000 (Table 10.18) about 2,450 natural deaths would be expected each year, and a 1% increase in mortality would be 25 individuals. The results from the model indicate that this level of additional mortality might be obtained if gannets had an avoidance rate of 90%.

Auk sp.

Auks generally fly below the level of the turbine blades and only 11 (0.2% of all individuals seen) were detected at the relevant height band during the density surveys. Model A gives a collision probability of 5.3% for guillemots.

Tern sp.

Few terns were seen during the density surveys. Birds were only seen at turbine height during September, giving a density of 4.55 x 10^{-8} birds m^{-2} for this month. This gives an average density for the five month period of 9.09 x 10-9 birds m^{-2}. The total number of transits for this species through the two WTGs would therefore be 434 transits per year.

Collision Model A gives a collision probability of 4.4% if the bird is flying downwind and 6.3% if the bird is flying upwind. The mean collision probability is therefore 5.4%. Model B gives a probability of 2.7% for birds flying downwind and 3.8% for birds flying upwind, with a mean of 3.3%. Model C gives a probability of 7.6%, and Model D gives a probability of 5.1%.

The most applicable Model for tern sp. is Model D, because the birds generally fly below blade height (and so have a skewed distribution) and may fly into headwinds. Table 10.8 gives the expected mortality for tern sp. for a range of avoidance rates.

Table 10.8 Estimated additional mortality for tern sp. caused by two WTGs at the Demonstrator site.

Additional mortality	**Avoidance Rate**				
	90%	**95%**	**98%**	**99%**	**99.5%**
Model A	2.1	1.0	0.4	0.2	0.1
Model B	1.3	0.6	0.3	0.1	0.1
Model C	2.9	1.5	0.6	0.3	0.1
Model D	**2.0**	**1.0**	**0.4**	**0.2**	**0.1**

All values round to the nearest 0.1.

The total breeding population of tern sp. in the Moray Firth is about 604 pairs (1,208 individuals) (JNCC). The annual adult survival rate is 0.88 (Garthe and Hoppop, 2004), so in a population of this size about 144 natural deaths would be expected each year, and a 1% increase in mortality would be one to two individuals. The one extra death per year estimated using a 95% avoidance factor in Model D thus equates to an increase in mortality of about 0.7%.

10.4 ASSESSMENT OF SEVERITY OF IMPACTS ON BIRDS

10.4.1 INTRODUCTION AND METHOD

An assessment of the severity or significance of potential impacts on birds was made using the methodology developed by SNH and the British Wind Energy Association (Percival *et al.*, 1999). This takes into account the sensitivity (Table 10.9) of each species and an assessment of the magnitude of effects (Table 10.10), in order to present an assessment of the potential significance of effects on birds (Table 10.11). This type of approach is useful when seeking to assess the potential impact of new developments in new locations; it gives a clear indication of where problems are likely to occur, and what is likely to constitute an unacceptable effect (Percival, 2001).

Table 10.9 Definitions of the sensitivity categories describing the ornithological features of a site (Modified from Percival et al., 1999).

SENSITIVITY	DEFINITION
Very High	Bird species for which an SPA or SAC is designated or a SSSI notified.
High	Other bird species that contribute to the integrity of an SPA or SSSI. Ecologically sensitive species, e.g. large birds of prey or nationally rare species (<300 breeding pairs in the UK).
Medium	EU Birds Directive Annex I species, EU Habitats Directive priority habitat/species and WCA Schedule 1 species (if not covered above). UK BAP species (if not covered above).
Low	Any other species of conservation interest, such as those birds of Conservation Concern lists (if not covered above).

Table 10.10 Definitions of the categories used to assess the magnitude of effects on birds (Percival et al., 1999).

MAGNITUDE	DEFINITION
Very High	Total loss or very major alteration of key elements/features of the baseline (pre-development) conditions such that post-development character/composition/attributes of baseline condition will be fundamentally changed and may be lost from the site altogether. Guide: >80% of population/habitat lost.
High	Major alteration of key elements/features of the baseline condition such that post-development character/composition/attributes of baseline condition 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 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 the 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.

Table 10.11 The impact matrix showing the significance of the combined effects of different levels of "sensitivity" and "magnitude of effect" (Percival et al., 1999).

Magnitude of effect	**Sensitivity**			
	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

Effects categorised as being of "very high" or "high" significance would be unacceptable, effects rated as "medium" would be borderline (ones which could be amenable to mitigation by altering the design and lay-out of a wind farm), and effects categorised as "low" or "very low" would be acceptable (Percival, 2001).

10.4.2 ASSESSMENT OF SENSITIVITY

Table 10.12 shows the conservation status for each species recorded during observations from the Beatrice platform. The national status of a species takes account of whether it is listed on Schedule 1 of the Wildlife & Countryside Act 1981 (WCA 1981); all wild birds in the UK are protected under the WCA 1981. It is an offence to kill, injure or take any wild bird, egg or nest. Rare, endangered, declining or vulnerable bird species in need of special protection in the UK are listed under Schedule 1 of the WCA and are afforded additional protection from disturbance at the nest. A species' national status is also determined by whether it is amber-listed or red-listed as a Bird of Conservation Concern (RSPB *et al.*, 2002) or if it is subject to a UK Biodiversity Action Plan.

The international status of a species takes account of whether it is listed on Annex I of the EU Birds Directive 1979. Bird species protected under European legislation are listed under Annex I of the Birds Directive, which is translated into UK legislation under the Conservation (Natural Habitats, etc.) Regulations 1994. It is an offence to capture, kill or disturb any Annex I species, or to damage or destroy its breeding site. A species' international status is also determined by whether it is a qualifying interest for a neighbouring Special Protection Area (SPA) or Site of Special Scientific Interest (SSSI), or whether it is listed as a species that contributes to the integrity of an SPA or SSSI.

Table 10.12 The conservation status of all the species recorded at Beatrice. (Sources: RSPB et al., 2002; UK BAP; WCA, 1981; EC 1979).

SPECIES	NATIONAL STATUS				INTERNATIONAL STATUS		
	AMBER LIST	RED LIST	UK BAP	WCA 1981 SCHEDULE I	EU ANNEX I	QUALIFYING INTEREST FOR NEIGHBOURING SPA OR SSSI (numerical code shown)	SPECIES CONTRIBUTING TO INTEGRITY OF SPA OR SSSI (numerical code shown)
Arctic skua	–	–	–	–	–	–	–
Auk sp.	YES	–	–	–	–	YES (*) (1,9,54)	YES (1,9,54)
Blackbird	–	–	–	–	–	–	–
Black-headed gull	YES	–	–	–	–	–	–
Brambling	–	–	–	YES	–	–	–
Cormorant	YES	–	–	–	–	YES (9)	YES (9)
Collared dove	–	–	–	–	–	–	–
Common gull	YES	–	–	–	–	–	–
Common scoter	–	YES	YES	YES	–	YES (45)	YES (45)
Dunlin	YES	–	–	–	–	YES (23,33,45)	YES (23,33,45)
Eider	YES	–	–	–	–	–	–
Fulmar	YES	–	–	–	–	YES (1,9,54)	YES (1,9,54)
Great black-backed gull	–	–	–	–	–	YES (9)	YES (9)
Grey goose	YES	–	–	–	–	–	–
Northern gannet	YES	–	–	–	–	–	–
Herring gull	YES	–	–	–	–	YES (9,54)	YES (9,54)
Kittiwake	YES	–	–	–	–	YES (1,9,54)	YES (1,9,54)
Little gull	–	–	–	YES	YES	–	–
Meadow pipit	YES	–	–	–	–	–	–
Manx shearwater	YES	–	–	–	–	–	–
Great skua	YES	–	–	–	–	–	–
Sooty shearwater	–	–	–	–	–	–	–
Pied wagtail	–	–	–	–	–	–	–
Robin	–	–	–	–	–	–	–
Redwing	YES	–	–	YES	–	–	–
Red-throated diver	YES	–	–	YES	YES	–	–
Shag	YES	–	–	–	–	YES (9)	YES (9)
Teal	YES	–	–	–	–	–	YES (23,33,45)
Tern sp.	YES**	–	–	–	YES	YES (***) (9,33,39)	YES (9,33,39)
Wheatear	–	–	–	–	–	–	–
Woodpigeon	–	–	–	–	–	–	–
Whooper swan	YES	–	–	YES	YES	YES (32,33)	–

Auk sp. = black guillemot, guillemot, little auk, puffin, razorbill
Tern sp. = Arctic tern, common tern, Sandwich tern
(*): For guillemot and auk assemblage
Grey goose = greylag goose or pink-footed goose
(**): For Arctic tern and Sandwich tern
(***): For common tern

Table 10.13 SPA codes as shown in Table 10.13.

NUMBER	SPA NAME
1	North Caithness Cliffs
9	East Caithness Cliffs
23	Dornoch Firth and Loch Fleet
32	Loch Eye
33	Cromarty Firth
39	Inner Moray Firth
45	Moray and Nairn Cost
54	Troup, Pennan and Lion's Head

Based on the above information and status of bird species in the Beatrice area, the sensitivity of each species recorded in the area of the Demonstrator Project is shown in Table 10.14.

Table 10.14 The sensitivity of each bird species recorded at Beatrice.

SENSITIVITY	DEFINITION
Very High	Auk sp. (black guillemot, guillemot, little auk, puffin, razorbill) Common scoter Cormorant Dunlin Fulmar Great black-backed gull Herring gull Kittiwake Shag Tern sp. (Arctic tern, common tern, Sandwich tern)
High	Teal
Medium	Brambling Little gull Red-throated diver Redwing Whooper swan
Low	Black-headed gull Common gull Eider Gannet Great skua Grey goose Manx shearwater Meadow pipit
Negligible	Arctic skua Blackbird Collared dove Pied wagtail Robin Sooty shearwater Wheatear Woodpigeon

All species present that are qualifying interests or that contribute to the integrity of any neighbouring SPAs or SSSIs are considered to belong specifically to these designated areas, and the significance of any potential impact is judged accordingly.

All species of medium sensitivity may become high sensitivity if it is found that they are present in the wind farm area in numbers that surpass 1% of international or national populations. All species of low sensitivity may become medium sensitivity if it is found that they are present in numbers that are regionally important.

10.4.3 ASSESSMENT OF POTENTIAL MAGNITUDE OF THE EFFECTS OF THE TWO WIND TURBINE GENERATORS AT THE DEMONSTRATOR SITE

For the purposes of the environmental statement for the Demonstrator Project, the magnitude of possible effects on birds was assessed in relation to the populations of birds using the wider Moray Firth region. This is a conservative approach, and does not take into account the fact that the individuals observed from time to time at the Demonstrator site may originate from colonies or sites outside the area of the Moray Firth.

The potential for the Demonstrator WTGs to present a barrier to bird movement, to displace birds away from the area, or to give rise to habitat loss or loss of access to food sources, is addressed in Section 10.2. On the basis of the fact that only two WTGs will be installed, and that the area around the WTGs in which bird behaviour might be affected is small (about 4.3km^2), it is believed that after installation the presence of the two WTGs at the Demonstrator site is not likely to make a discernible difference to the pre-development baseline conditions, to exclude any species of bird from a significant part of the available offshore habitat, or to damage or degrade that habitat. The focus of attention for judging the potential magnitude of any effects from the Demonstrator Project, therefore, falls on the potential collision risk that the WTGs represent.

The quantitative assessments given in Section 10.3 show that, using conservative assumptions regarding average annual density at the site, and conservative values for the degree of avoidance (95%), no species is likely to suffer additional mortality that would exceed 1% of the population of that species in the Moray Firth. Table 10.15 summarises this evaluation for the five most numerous species observed at the Demonstrator site.

Table 10.15 Moray Firth populations of key species observed at the Demonstrator site, and estimates of total annual fatalities from the two WTGs.

	MF population			Estimated annual mortality from WTGs		
	Total number	**1% of MF population**	**Natural mortality**	**Total number**	**1% of MF population**	**As % of natural mortality in MF population**
Kittiwake	75,675	757	14,378	23	0.03	0.16
Great black-backed gull (1)	8,000	80	560	14	0.18	2.5
Fulmar	55,516	555	777	0.8	0.001	0.1
Gannet (2)	35,000	350	2,450	12	0.04	0.49
Herring gull	27,140	271	1,900	5	0.018	0.26
Tern sp.	1,208	12	144	1	0.08	0.69
Auk sp.	Not observed flying at blade height.					

All estimated numbers of mortality are made using the avoidance rate stated in the text.
(1) Estimated average number of birds in the Moray Firth, derived from Skov et al., 1995.
(2) See discussion, 10.5.

10.4.4 ASSESSMENT OF POTENTIAL SIGNIFICANCE OF THE EFFECTS OF THE TWO WIND TURBINE GENERATORS AT THE DEMONSTRATOR SITE

On the basis of these data, an assessment of the significance of potential effects on birds was made and is shown in Table 10.16.

Table 10.16 Assessment of the significance of potential effects on birds caused by the presence and operation of the two WTGs at the Demonstrator site in the Beatrice field.

SENSITIVITY	SPECIES	MAGNITUDE OF EFFECTS	SIGNIFICANCE
Very High	Auk sp.	Negligible	Low
	Common scoter	Negligible	Low
	Cormorant	Negligible	Low
	Dunlin	Negligible	Low
	Fulmar	Negligible	Low
	Great black-backed gull	Negligible	Low
	Herring gull	Negligible	Low
	Kittiwake	Negligible	Low
	Shag	Negligible	Low
	Tern sp.	Negligible	Low
High	Teal	Negligible	Very Low
Medium	Brambling	Negligible	Very Low
	Little gull	Negligible	Very Low
	Red-throated diver	Negligible	Very Low
	Redwing	Negligible	Very Low
	Whooper swan	Negligible	Very Low
Low	Black-headed gull	Negligible	Very Low
	Common gull	Negligible	Very Low
	Eider	Negligible	Very Low
	Gannet	Low	Very Low
	Great skua	Negligible	Very Low
	Grey goose	Negligible	Very Low
	Manx shearwater	Negligible	Very Low
	Meadow pipit	Negligible	Very Low
	Arctic skua	Negligible	Very Low
	Blackbird	Negligible	Very Low
	Collared dove	Negligible	Very Low
	Pied wagtail	Negligible	Very Low
	Robin	Negligible	Very Low
	Sooty shearwater	Negligible	Very Low
	Wheatear	Negligible	Very Low
	Woodpigeon	Negligible	Very Low

10.5 DISCUSSION

The coastline and waters of the Moray Firth together represent an internationally important area for several bird species (Section 10.7) there are resident populations, over-wintering populations, and birds on passage. The coast provides sites for breeding, and the coastal and offshore areas offer important feeding grounds. With respect to the two Demonstrator turbines in the Beatrice field, it is likely that the species that might be affected to the greatest extent would include those that:

- *use the area for feeding*
- *congregate in the area during moulting*
- *traverse the area at relatively low level on feeding excursions or during passage.*

The Smith Bank, on which the Demonstrator turbines are located, is an important feeding ground for seabirds (Mudge and Crooke, 1986). This area is particularly important in spring and autumn for guillemots, razorbills, kittiwakes, gannets and sooty shearwaters, but bird numbers are low in winter. Data for the Moray Firth indicate a predominantly coastal distribution for sea duck and coastal waterfowl (Dean *et al.*, 2003), with nationally important numbers of common scoter, long-tailed duck and eider.

There is concern that offshore wind farms may have a significant effect on sea ducks and waterfowl through collision and habitat exclusion. Although swans and geese are present in this region and migrate to nearby locations (Barton and Pollock, 2004), reports have shown that these birds are generally able to detect the presence of turbines and avoid them (Larsen and Madsen, 2000; Percival 1998; Koop, 1997 reported in *BirdLife International*, 2003). Though the Moray Firth is an important area for sea ducks (Lloyd *et al.*, 1991), eiders and common scoters are generally confined to areas within 5km of the shore and are, therefore, unlikely to be influenced by the Demonstrator Project.

Razorbills forage up to 55km from the coast, although most are likely to forage much closer to colonies and the highest densities occur close to coasts (Leaper *et al.*, 1988; Stone *et al.*, 1995). Webb *et al.* (unpublished) studied auks off Bempton Cliffs and reported few breeding adults foraging beyond 30km, but noted important concentrations of guillemots between 26km and 30km from Bempton. With respect to collision risk, guillemots and razorbills are thought generally to fly below the level of turbine blades, but are likely to fly higher when arriving and exiting breeding sites on cliffs, and in conditions of tail wind (A. Webb, *pers. comm.*).

Observations of red-throated divers suggest that the frequency of bird strike is low (Cramp and Simmonds, 1977), but the conservation importance of the species means that the effects of any mortality caused by collisions could have an effect on population size at a national scale. Observational data on the average flying heights of cormorants is limited, but studies in the Netherlands (Dirksen *et al.*, 1998) provide some evidence that cormorants may actively avoid turbines when flying between roosts and feeding areas.

Ten of the species observed during the 2005 monitoring programme at the Demonstrator site are considered to be of very high sensitivity and one of high sensitivity. Five species are judged to be of medium sensitivity and 16 of low sensitivity (Table 10.14).

The most frequently recorded species were, in descending order, kittiwake, auk sp., fulmar, gannet, great black-backed gull and herring gull. All other species were observed on fewer than 50 occasions. The most numerous species, again in descending order, were auk sp., kittiwake, fulmar, gannet, great black-backed gull, herring gull and tern sp. All other species counts recorded fewer than 100 individuals (Section 4.8.2). Since tern sp. were observed on fewer than 50 occasions, it is considered that the six species listed in Table 10.17 are more likely to be affected by the proposed development, and to a greater extent, than the other species recorded.

Table 10.17 Sensitivity and percentage of flights in the risk zone for the most common species recorded at the Demonstrator site.

SPECIES	SENSITIVITY	% FLIGHTS IN RISK ZONE
Herring gull	Very High	24.0
Great black-backed gull	Very High	21.1
Kittiwake	Very High	17.3
Gannet	Low	11.4
Auk sp	Very High	0.3
Fulmar	Very High	0

Of the four species most commonly found within the risk zone the herring gull, great black-backed gull and kittiwake are of high sensitivity, whereas the gannet is of low sensitivity.

A quantitative assessment of the potential effects of the proposed development has been carried out using the SNH collision risk model, with various stated assumptions, and where appropriate modifications to account for the specific size of the proposed turbines or differences in the flying behaviour of certain species. For herring gull, it was estimated that about five individuals might collide each year as a result of collisions with the WTGs, assuming that the species exhibited an avoidance rate of 95%. This would represent about 0.02% of the local population of this species. In the case of the kittiwake, it was estimated that there might be 23 collisions each year, if the species' avoidance rate was 95%. This would represent about 0.03% of the local population for this species.

For the great black-backed gull, it was estimated that perhaps 14 individuals from the local Moray Firth population of some 850 individuals might collide each year with the WTGs, assuming that the species exhibited an avoidance rate of 95%. This would represent about 1.6% of the local population of this species.

The great black-backed gull is a "very sensitive" species, but its numbers in the Moray Firth vary widely with the season (Skov *et al.,* 1995). Birds move offshore at the end of the breeding season and this was reflected in the data from observations at the Demonstrator site, where numbers seen rose from 0.2 birds per hour in August to nearly eight birds per hour in December. The additional mortalities that might arise from collisions with the WTGs offshore therefore need to be considered in the context of a wider population, which, based on data in Skov *et al.,* 1995 may average about 8,000. If this value is more representative of the sub-population that may be exposed to additional risk as a result of the WTGs, then the increase in mortality of about 14 individuals each year would represent about 0.2% of the population.

Although the gannet is not regarded as a "sensitive" species in the Moray Firth (Table 10.16), the estimated additional mortality through collision reflects concerns expressed in earlier appraisals of the effects of offshore wind farms on certain long-lived species with relatively low rates of productivity (*BirdLife International* 2003). At a 95% avoidance rate, the WTGs might cause an additional 12 fatalities each year, equivalent to about 0.4% of the population present at Troup Head. Gannet numbers were seen to rise significantly in the later part of the year, and this was probably a reflection of the fact that adults and juveniles were leaving nesting sites and foraging more widely. Gannets travel more widely after the breeding period, and it is therefore very likely that the individuals seen around the Demonstrator site in the late summer and autumn originated from a number of sites, not just Troup Head. For example, it is likely that gannets from colonies in Shetland will be found foraging in the Moray Firth after the breeding season.

The collision risk mortality for gannets from the two WTGs can, therefore, be put in context by considering the larger gannet population of northern Britain. Table 10.18 lists selected gannet colonies of northern Scotland and the North Sea, with estimates of their population size (Mitchell *et al.*, 2004).

Table 10.18 Sizes of selected gannet colonies of northern Scotland (Mavor et al., 2004) (Numbers derived by doubling the number of apparently occuped nests or sites).

COLONY	ESTIMATED POPULATION SIZE 2003-2004
1. Hermaness	31,266
2. Noss	17,304
3. Foula	1,836
4. Fair Isle	3,750
5. Sule Stack	9,236
9. Troup Head	3,094
Total	**66,486**

If Hermaness is excluded (the largest and most distant of this group) the total population of this group is approximately 35,000, which represents about 8% of the total population of Great Britain and Ireland. If the population exposed to the potential additional mortality from the presence of the WTGs is some 32,000, its natural morality rate would be about 2,450 individuals each year. In the context of this wider population, the estimated additional mortality caused by collisions with the WTGs would thus equate to an increase in natural morality of about 0.5%.

10.6 CONCLUSION

The effects of the Demonstrator Project on birds, and in particular bird species which are the qualifying interests of adjacent SPAs in the Moray Firth, are likely to be small. The WTGs will occupy a small area of the Smith Bank in which birds are seen flying, "loafing" and occasionally feeding. The WTGs will not present a major barrier to migrating birds, nor will they exclude or displace individuals from important feeding areas.

The additional mortality that may result from collisions with the WTGs has been estimated using a standard model, conservative assumptions regarding avoidance rates, and average values for bird density. With the exception of great black-backed gulls, the annual mortality from collisions is estimated to equate to less than a 1% increase in the natural mortality of the local population of that species (i.e. the population at sites around the Moray Firth). This conclusion holds for all the species which are qualifying interests in any of the SPAs in the Moray Firth. The gannet is not a qualifying interest nor is it on the UKBAP. Although the estimated mortality rate for gannets is high in relation to the local breeding population at Troup Head, the data from the Demonstrator site indicate that greater numbers of gannet are seen in the area after the end of the breeding season, and there is evidence to suggest that gannets from other colonies in the North of Scotland will be visiting the general area of the Moray Firth, including the Demonstrator site. The total population of the north east of Scotland, excluding Hermaness, is approximately 35,000, and in terms of this wider population the additional mortality from the WTGs would equate to an increase in the natural rate of mortality of about 0.5%.

A review of the potential effects of the Demonstrator Project on SACs, SPAs and other sites is given in Section 13.

10.7 MITIGATION AND MONITORING PROPOSED

The two WTGs will be sited more than 25km from land, and from all SPAs UKBAP sites, Ramsar Sites, IBA sites, and estuaries. They do not appear to be located in a particularly important feeding ground for any species of sea bird, or in an area that is frequented by large numbers of either flying or moulting birds.

No mitigation can be proposed for short-term disturbance effects on birds during construction, except to complete the activities in a timely manner. During their operational life, the WTGs will bear navigation lights, and the lower parts of the towers will be painted to make them more visible to shipping (Section 3.1.11). The rest of the tower, and the blades, will be painted grey so as to reduce their overall visual impact.

Inspection and maintenance will be carried out periodically, using the fast rescue craft deployed from the nearby Beatrice platform. Given the present existence of vessel activity around the Beatrice field, and the fact that few birds have been observed at the Demonstrator site on the water surface or feeding, the localised disturbance caused by maintenance visits is likely to be localised and not significant.

10.8 FURTHER RESEARCH PROPOSED

The University of Aberdeen will conduct field surveys of the feeding and resting behaviour of marine birds in and around the site of the Demonstrator Project. This work will probably use boat transect and may also use radar observations of seabird movements before and after the installation of the WTGs. Work is continuing to optimise the bird data that can be obtained using offshore radar.