9 The Environment Impacts of Offshore Wind Turbines on Birds

Abstract

Over the last two years, the Renewable Energy Team has been examining development scenarios involving wind turbines. Primarily, these would investigate the installation of a small array of offshore wind turbines between 3 and 12 miles from the Guernsey coast. Such proposals would likely lead to a range of environmental impacts on birds, especially seabirds and associated bird groups, such as wildfowl. Potential impacts include collisions, noise and visual disturbance and the loss of feeding areas. Although some impacts may be minor or even negligible, available research on such effects is still very limited. The Bailiwick is of international importance for Gannet, Shag and Lesser Black-backed Gull and also supports numerous smaller colonies of various seabird species. In addition, the Channel Islands are situated on a migration flyway across the English Channel, which is used by many thousands of birds during spring and autumn. Due to the difficulties of determining the effects of specific impacts on birds at sea, there would be a requirement to carry out a thorough investigation of existing information and a need to undertake local research where no relevant data currently exists, prior to any project development.

9.1. Introduction

During 2009 and 2010, the States of Guernsey's Commerce & Employment Department's Shadow Guernsey Renewable Energy Commission (GREC), since renamed the Renewable Energy Team (RET), compiled a REA document on the likely impacts of tidal and wave devices on the local environment. The possible effects on the Bailiwick's seabirds were also determined and included in the comprehensive environmental assessment of the concept.

RET is now examining the feasibility of wind energy in a local context. Two broad types of development scenario are to be investigated – a small array of anchored turbines around 3 miles from shore or possibly in the longer term, an array of floating turbines up to 12 miles offshore. Consequently, an examination of possible impacts of wind turbines on local birdlife is necessary.

Much of the information submitted in the 'Birds' chapter of the tidal and wave REA is broadly relevant to wind energy although there is much greater emphasis on bird flyways and migration. Wind turbines may therefore potentially impact a wider range of local bird species, compared to tidal devices, which would generally only affect seabirds.

In this chapter, a brief summary of local birdlife is given, followed by an analysis of possible impact and mitigation. In order to obtain a more accurate assessment, recommendations on future research and monitoring are also provided.

9.2. Overview of the Bailiwick's birdlife

The islands of Guernsey, Sark and Herm and their off-lying islets host a range of seabirds throughout the year and up to thirteen species breed within the study area. Although only a relatively small number of individuals of some species, such as Puffin *Fratercula arctica* breed locally, others such as Shag *Phalacrocorax aristotelis* have a local population of international importance. Similarly, the Bailiwick waters are of unknown importance as a flyway for a number of species of migratory seabirds and wildfowl. Large numbers of birds (particularly seabirds) move through the English Channel during spring and autumn migration and an unknown proportion pass through Bailiwick waters. In addition, a range of wildfowl also overwinters in small numbers.

Similarly, the Channel Islands are used by a considerable number of migrating landbirds, but there is currently insufficient data to determine the magnitude of this importance. However, limited information from local ringing recoveries shows that birds from a large number of European countries move through the islands on passage, especially in spring and autumn.

9.3. Local birds potentially impacted by wind turbines

The Bailiwick of Guernsey hosts a wide variety of birdlife despite the restricted land mass. With its mosaic of habitats, around 60 species breed in a typical year and the total number of recorded breeding birds is c.100 species. Coastline habitats such as cliffs and small islets are well represented and provide widespread opportunities for seabirds to breed and for a range of seabirds and other waterbirds to overwinter.

Recording of local birdlife is generally adequate, with breeding species, and to a lesser extent, migratory species having been surveyed on several occasions in the past. Casual recording has contributed, especially since the establishment of the local 'Guernsey Birds' website (http://www.guernseybirds.org.gg) to provide a more comprehensive database.

9.3.1 Breeding seabirds

Three comprehensive surveys of local breeding populations have been undertaken as part of the UK-wide censuses of seabirds that take place approximately every 10-15 years:

Seafarer (1970)

Seabird Colony Register (1986-1992)

Seabird 2000 (1999-2001)

The fieldwork for the three projects was undertaken by volunteers and each involved numerous visits to survey the widespread colonies. Table 1 provides the population figures for each species.

Photo 1. Fulmars *Fulmarus glacialis* colonised the Bailiwick in the 1980s and there is now a widespread stable population (Photo: Paul Hillion www.islandbirds.co.uk)

Photo 2. Gannets *Morus bassanus*. Internationally important populations breed, feed and migrate through local waters. (Photo: Paul Hillion www.islandbirds.co.uk)

Island Survey	Fulmar	Manx Shearwater	Storm Petrel[1]	Gannet[3]	Cormorant	Shag[2]	Lesser Black-backed Gull[3]	Herring Gull[2]	Great Black-backed Gull	Kittiwake	Common Tern	Guillemot	Razorbill	Puffin[1]
GUERNSEY														
Seafarer 1970	0	0	0	0	0	43	12	500	10	0	7	0	0	0
SCR 1986-92	35	0	0	0	0	130	80	855	60	0	30	0	0	0
Seabird 2000	23	0	0	0	0	120	115	1350	70	0	5	0	0	0
HERM														
Seafarer 1970	0	0	0	0	4	145	40	400	42	0	0	24	2	35
SCR 1986-92	40	15	0	0	30	350	140	290	90	0	80	75	35	95
Seabird 2000	15	0	0	0	13	365	160	375	73	0	23	80	20	45
SARK														
Seafarer 1970	0	0	0	0	0	45	135	1350	40	0	0	110	12	50
SCR 1986-92	60	40	0	0	2	180	685	440	30	0	20	190	30	100
Seabird 2000	45	0	0	0	0	160	855	495	28	0	5	305	28	55
ALDERNEY														
Seafarer 1970	0	0	13	3000	2	75	115	270	45	12	0	40	14	1028
SCR 1986-92	40	0	35	4850	1	180	330	500	45	80	30	170	80	330
Seabird 2000	55	0	130	5920	3	175	345	400	55	3	20	85	50	223
TOTALS														
Seafarer 1970	0	0	13	3000	6	308	302	2520	137	12	7	174	28	1113
SCR 1986-92	175	55	35	4850	33	840	1235	2085	225	80	160	435	145	525
Seabird 2000	138	0	130	5920	16	820	1475	2620	226	3	53	470	98	323

Table 1. Breeding seabird populations of the Bailiwick of Guernsey (Hooper, 2006) [Note - [1] Regional Importance, [2] National Importance, [3] International Importance]

Despite fluctuations in the number of each species recorded between islands and between surveys, the Bailiwick continues to support nationally and internationally important numbers of some species. Of the 13 local species, four (Shag, Gannet *Morus bassanus*, Lesser Black-backed Gull *Larus fuscus graellsii*, Herring Gull *Larus argentatus*) are significant, as shown in the table below:

Species	Bailiwick population (pairs)	British population (pairs)	Percentage in Bailiwick	European population (pairs)	Percentage in Bailiwick
Shag	820	28,580	2.9%	86,630	0.9%
Gannet	5,920	226,500	2.6%	229,660	2.6%
Lesser Black-backed Gull	1,470	142,940	1.3%	219,570	0.7%
Herring Gull	2,670	142,940	1.9%	789,940	0.3%

Table 2. Importance of local seabird populations

Some of Guernsey's seabirds are also important in terms of their location, with Fulmar *Fulmarus glacialis*, Gannet, Razorbill *Alca torda*, and Puffin on or very near to the southern limit of their breeding range. Outlying colonies such as these are often more vulnerable to environmental change.

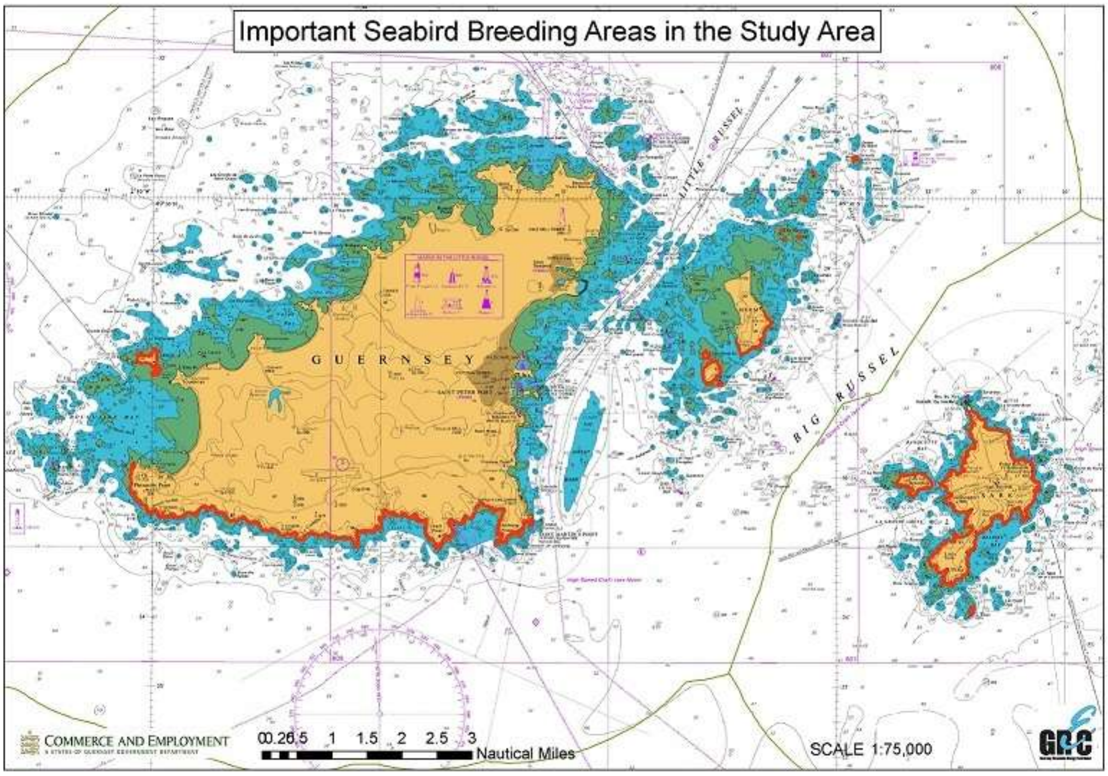

Figure 1. Important seabird breeding areas around Guernsey.

9.3.2 Birds at sea

Data on bird behaviour, specifically seabirds, at sea is extremely sparse. There are three main aspects that need to be assessed (i) foraging areas of locally breeding seabirds, (ii) foraging areas of seabirds and other waterbirds during the winter period and (iii) the use of Bailiwick waters by migrating birds. Although there has been considerable effort in surveying birds at sea in European waters over the last 20 years, it is assumed that in terms of a local context, this database is of limited value as there is little data available for Bailiwick waters. The precise information required to map the use of different areas of Bailiwick waters does not therefore currently exist.

(i) Foraging areas of locally breeding seabirds.

There is little information on where local breeding seabirds feed and forage. The exception is from a recently published study on Northern Gannets breeding in Alderney. Birds visited nine sites earmarked for offshore renewables, suggesting these birds could be affected by development in these areas. Furthermore, these sites fell in three different territorial waters – those of France, the United Kingdom and the Channel Islands – illustrating how the impact of such developments needs to be considered at an international level for highly mobile species.

As recordings were only collected for up to five days per bird, the data is limited and Gannets' movements over the course of the breeding season (and indeed the year) could bring them into contact with an even greater number of offshore developments. Since tracking technology is becoming cheaper, longer lasting, more accurate and easier to use on a wide range of species, such studies should form an integral part of the environmental impact assessment process for marine renewable developments.

(ii) and (iii) foraging areas of birds in the non-breeding and winter seasons.

The majority of data comes from ‘sea-watching’ activity from various headlands by local ornithologists. This shows that the northwest coast of Guernsey produces a corridor effect for many species of seabirds, especially Gannets, and this continues along the length of the west coast. During the breeding season, Gannets often travel parallel with the coast at varying distances, on their way to and from their preferred fishing grounds. Storm Petrels *Hydrobates pelagicus* (presumably from breeding colonies in Burhou and Brittany) also use areas offshore Guernsey for foraging.

Although the extent of this corridor effect, in terms of distance from land, has not been determined, it is certain that a wind farm would interact with resident seabirds. These gaps in our current knowledge can be filled by using GPS-tracking technologies within the study area. Such devices provide accurate location recordings and also log heights above sea level. As a result, collision risk modelling can be used to estimate the likely impact of a development in a particular site.

In addition to collecting detailed data on individual birds of a particular species, boat-based surveys can be used to provide an overview of certain areas of Bailiwick waters. Such research may be useful in determining suitable zones in which specific development sites can be identified.

9.3.3 Migrating seabirds

Local waters are important for some species of migrating seabirds and other waterbirds, especially for populations which use the North Sea/English Channel flyway. Shearwaters (*Procellariidae*), skuas (*Stercorariidae*), terns (*Sternidae*) and non-local Gannets routinely fly parallel to the north and west coasts of Guernsey on migration, in a similar way to locally breeding Gannets. Birds pass Alderney on both north and south coasts and a small proportion of these pelagic species migrates further east, past Herm and Sark. For example, there are regular casual observations of migrating seabirds foraging over fishing banks to the east of the islands.

The wider region of the Gulf of St. Malo has recently been shown to be important for Balearic Shearwater *Puffinus mauretanicus*, a Critically Endangered species which breeds in the western Mediterranean. Significant numbers of shearwaters undertake a northward migration to the gulf to complete an annual post-breeding moult.

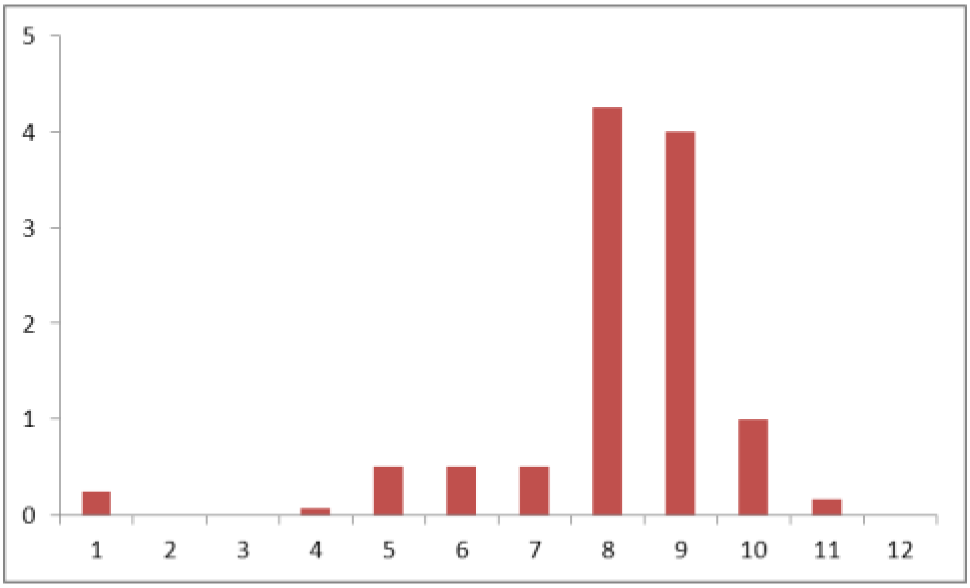

Figure 2. Mean number of local records per month for Balearic Shearwaters from 2000-2012 (1=January, 12=December)

9.3.4 Other waterbirds

In the non-breeding season, variable numbers of divers (*Gaviidae*), grebes (*Podicipedidae*) and wildfowl (*Anatidae*) migrate through local waters and small numbers overwinter. There is some evidence for a slight decrease in some overwintering marine birds in the last 20 years, probably due to milder temperatures meaning they can winter in areas further north and east of Guernsey which formerly were too cold. Some species, such as the over-wintering population of Dark-bellied Brent Geese *Branta bernicla bernicla* are currently increasing.

Observations of overwintering waterbirds are mainly limited to viewable areas such as bays and harbours. Such locations also appear to provide the most suitable feeding habitats, as most species dive to forage on fish or on benthic invertebrates. Deeper water is therefore assumed to be a less productive habitat.

Migrating species are generally more visible from headlands on the north and west coasts. Observations suggest that grebes and divers tend to migrate along a flyway closer to the French coast. There does not appear to be a heavily used migration route close to the Bailiwick islands for many waterbird species. However, observer coverage and the data to support this assumption are currently inadequate. The notable exception is the Common Scoter *Melanitta nigra*, a population of which migrates through Bailiwick waters to undertake a post-breeding moult in the Bay of St Malo.

9.3.5 Land birds

Although the term 'land birds' is not a scientific one, it provides a convenient distinction from those species which live in the local marine environment for all or part of their life cycles.

Any renewable energy proposal would need to address the effects both on migrating species and on birds which live – for all or part of the year - in locations where cables may come ashore.

9.3.5.1 Migrating species

The islands form an important 'stepping stone' to birds en route to or from the British Isles. Migration of species through the Bailiwick can occur at any time during the year although it is concentrated into spring (mainly March – May) and autumn (August – October) periods. Given its mild climate the islands are a haven during extreme cold weather events on the continent. During these times, very large numbers – thousands or even tens of thousands - of birds can move into the islands and an unknown number will pass through to warmer areas further south.

Wildfowl movements are variable and depend on a number of factors. Milder winters generally lead to smaller numbers being recorded although flocks can be rapidly driven to the islands if conditions deteriorate in the UK or continental Europe. For example, some species will respond immediately to snowfall and have been recorded arriving off the sea within a matter of hours. Similarly, if birds encounter poor weather, such as fog, rain or strong wind, their journey can be temporarily stopped until the weather improves. If this happens during the peak migration of certain species and large numbers are involved, it is known as a 'fall'.

Most migratory species occurring in large numbers are small passerines (songbirds) which would not appear to be vulnerable to collision with turbines during the day. However, many such migrants travel at night, possibly using the stars for additional navigational guidance, but also for other reasons such as avoidance of day-flying raptors and to take advantage of cooler temperatures to help with body temperature regulation. In addition, nocturnal migrants can readily feed during the day, whereas diurnal migrants have to feed and migrate during the day.

Nocturnal migrants have been shown to be extremely vulnerable to certain types of obstacle. In the past, lighthouses have caused the deaths of many thousands of nocturnal migrants although much of the problem is associated with the light itself. Generally speaking, migrants flying in the dark will do so at sufficient height to clear most hazards. However, further investigation of this risk is warranted.

Research has shown that birds generally migrate at a height of 500m or less. Occasionally, possibly due to the weather, terrain or species involved, altitudes increase to 1000m or more. Conversely, as birds approach land after a sea crossing, they have a tendency to lose height and will often drop near to sea level. In adverse conditions, loss of height can occur at greater distances from land and if the wind or weather is unusually unfavourable, some individuals may even ditch into the sea, with fatal consequences.

It is assumed that migrating birds leave the French or UK coast in a wide band, with some focusing of numbers from headlands. By the time they reach the Bailiwick after 50 miles or so, they will have dispersed. On reaching land, birds will often veer towards it to make landfall at the earliest opportunity. In this respect, headlands, such as Pleinmont, Jerbourg, Icart and much of the northern coast are important areas for migrants.

On the northward spring migration, birds will generally arrive from the French coast in the south, on a broad front along the cliffs and west coast headlands. Many species will either rest and feed or will slowly move north through the island and become focused on the north coast. Depending on the species involved, they will depart either during the day or overnight, if conditions are favourable. During unsuitable weather, they are forced to wait for the next opportunity to continue their journey.

As birds move south in autumn, they arrive from the English coast and will adjust their course once within sight of the islands. Landfall is mainly made on the north and west coasts, although often considerable numbers of birds also travel along the east coast. Unlike the spring migration which has a more focused departure from Guernsey's north coast, autumn migrants leave the island from various points along the south coast. Passage from Pleinmont, Jerbourg and Icart are especially noticeable.

9.3.6 Birds in cable landing areas

Many coastal areas support various habitats, including beaches, shingle banks and sand dunes and are often in a relatively unspoilt state. The associated wildlife can be rich or locally important. For example, some beaches, such as Belle Greve and Grande Havre, are important feeding areas for overwintering populations of wader species, or may be used as roost sites. A small number of bird species, typically Rock Pipit *Anthus petrosus*, Meadow Pipit *Anthus pratensis*, Stonechat *Saxicola torquata* and Linnet *Carduelis cannabina* breed in coastal locations, some exclusively so.

La Société Guernesiaise has carried out monthly counts of waterbirds around much of Guernsey's coastline as part of the UK's national Wetland Bird Survey (WeBS) for more than 30 years. The results highlight the relative importance of the island's beaches for waders in general and for individual species (Figure 3).

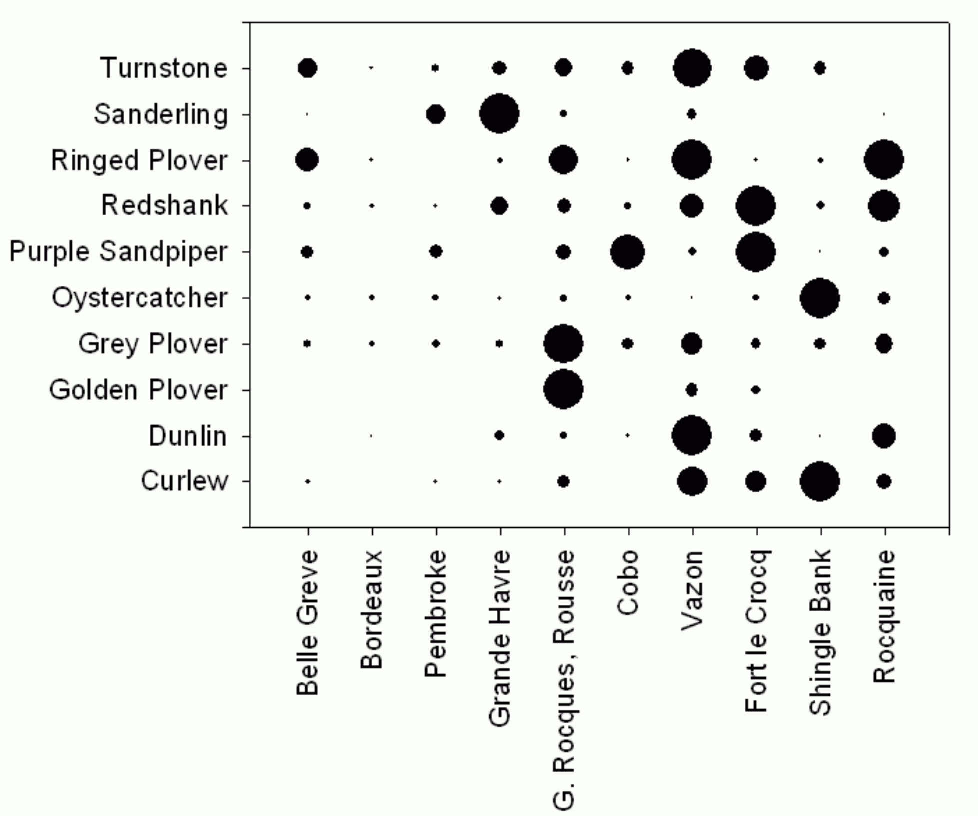

Figure 3. Relative importance of each Wetland Bird Survey count section for different species of waterbirds. (The larger the circle, the more important the area).

Photo 3. Meadow Pipit *Anthus pratensis*. A common migrant and scarce breeding species of coastal grassland.

9.3.7 Protected Sites

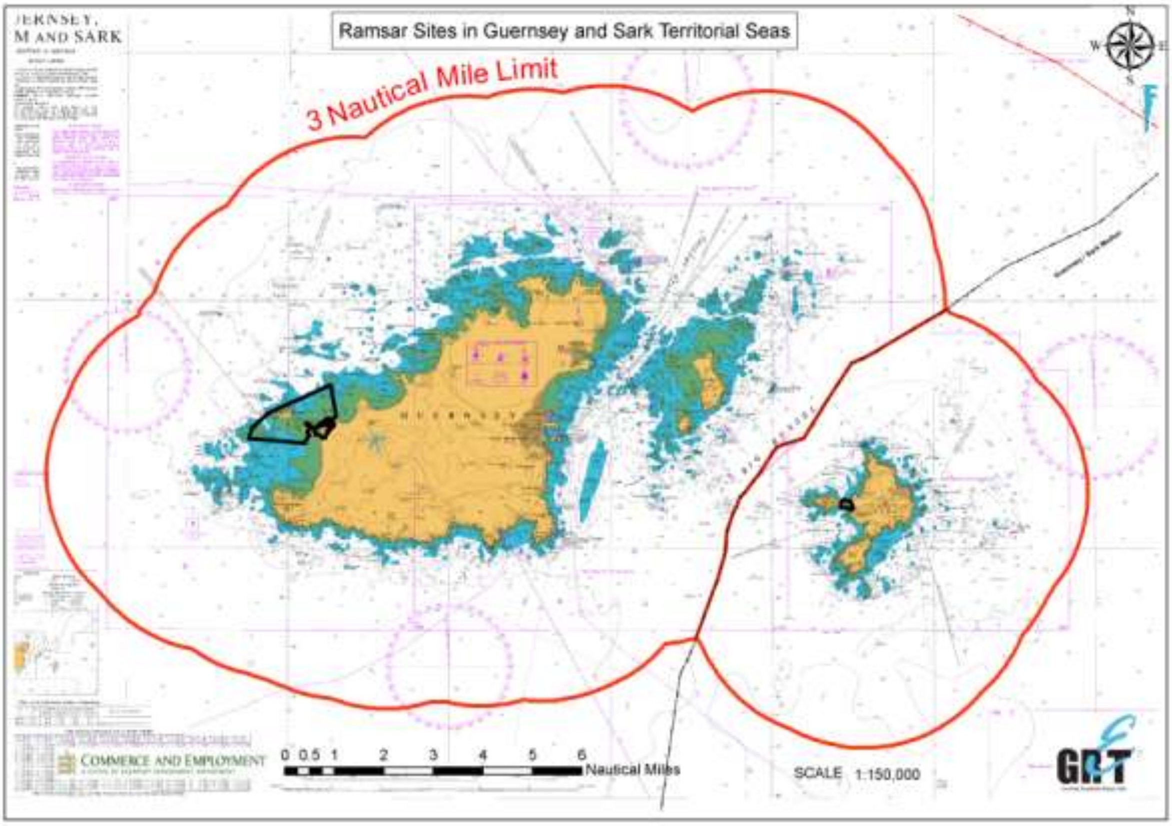

Figure 4. Guernsey's Ramsar site

RAMSAR sites

There are currently three designated sites in the Bailiwick – Burhou and surrounds in Alderney, the Gouliot Caves in Sark, and Lihou Island/L'Eree and surrounds in Guernsey (Figure 1). There are also plans to designate parts of north Herm, including The Humps, as a fourth local site. RAMSAR status recognizes wetland or marine areas which are of international importance.

In terms of birds, the Lihou/L'Eree site is of local importance for breeding gulls (*Laridae*), Shags and Cormorants *Phalacrocorax carbo.* In addition, it hosts a selection of waders and wildfowl and typical wetland breeding species such as Reed Warbler *Acrocephalus scirpaceus*. It is also used as a stop-off for various migrants.

The Alderney site hosts internationally important Gannet colonies and the Bailiwick's largest Puffin and Storm Petrel *Hydrobates pelagicus* colony. The proposed site in Herm would also be of importance in terms of marine birds due to the inclusion of 'The Humps', a group of islets which supports important mixed seabird colonies.

Sites of Nature Conservation Importance (SNCIs)

The network of SNCI sites was introduced by the Board of Administration (now the Environment Department) following recommendations in a report submitted by Land Use Consultants (1989). This local designation mainly applies to terrestrial areas and although some sites include intertidal zones, they do not extend to the marine environment. They include a number of Guernsey's larger beaches and the entire length of the south coast cliffs. There are no designated areas in Herm or Sark although there are potential sites, such as islets of The Humps to the north of Herm, Herm Common and Les Autelets in Sark, which would readily qualify as SNCIs. The designation of some sites such as Belle Greve, Grande Havre or L'Ancresse Common would influnece the site selection process for bringing cables ashore.

Important Bird Areas

There are several sites across the Bailiwick, which meet the criteria for designation as Important Bird Areas (IBAs) as recognized by the RSPB. There is considerable overlap between IBAs and SNCIs although Veron (1997) also lists the islands of Herm and Jethou, and Sark and Brecqhou, together with the numerous associated islets as having 'Channel Island Importance', based almost entirely on their breeding seabird populations.

Photo 4. The Garden Rocks (Les Etacs) near Alderney. One of two local Gannetries (Photo: Paul Hillion www.islandbirds.co.uk)

9.3.8 Foraging and feeding behaviour of seabirds

Some seabirds are migratory and only use local waters during the breeding season. At other times of year, these species either migrate south or resume a pelagic life in the Atlantic Ocean. Some members of the gull family, together with Shag and Cormorant are year-round residents of inshore waters. In most cases, the local numbers of resident birds are bolstered by wintering populations from more northerly latitudes.

In order to find food or catch prey, seabirds may use several sensory capabilities, including vision, sound and chemo-reception. Of these, only the petrels use chemo-reception (smell) to help locate food and for most species, vision is primarily used. Sound is not thought to be used by local species to any degree.

In terms of feeding mechanisms, each species or family feeds in a different manner, as outlined in the table below:

Group	Species	Diet	Feeding method	Diving depth	General range
Petrels	Fulmar, Manx Shearwater, Storm Petrel	Varied	Surface scavenging, shallow dive	Normally <20m Rarely up to 50m	Offshore, mostly beyond study area
Gannets	Northern Gannet	Pelagic fish	Dive from considerable heights	Normally <25m Rarely up to 50m	Widespread, often beyond study area
Cormorants	European Shag, Cormorant	Benthic fish	Dive from surface to seabed	Normally <20m Rarely up to 40m	Normally within 1-2km of coast
Gulls	Herring Gull, Great Black-backed Gull, Lesser Black-backed Gull, Black-headed Gull & other species	Varied	Foraging, scavenging	Surface feeders	Varies considerably depending on species and colony. Some species (Lesser Black-backed Gull) offshore
Terns	Common Tern, Sandwich Tern	Mainly sand-eels	Shallow plunge	Less than 0.5m	Predominantly within 1-2km of shore
Auks	Puffin, Razorbill, Guillemot	Small fish	Deep dive from surface	Normally <60m Rarely 100m+	Up to 50km from breeding colony

Table 3. Feeding mechanisms of local seabirds

9.4. Potential Effects

The possible effects of the installation and operation of marine renewables will vary depending on the location and extent of the project, the type of device involved and the bird species affected. The potential issues involved are outlined below.

9.4.1 Disturbance

There are two main types of disturbance which may affect local birdlife – visual and noise. The main natural threats to birds are primarily recognised in a visual way i.e. a predator will be seen, not heard. Noise is therefore of less importance than visual disturbance although constant noise may eventually have a detrimental impact in some circumstances.

It is possible that wind turbines would be installed on the seabed, which would lead to considerable local disturbance during the installation process, although floating turbines may become a viable alternative in the near future. Some level of noise disturbance would also be generated by operating turbines, both above and below the water surface.

Various studies have examined the impacts of underwater noise on marine mammals, such as whales, dolphins and seals, and also a limited range of fish, especially commercially important stocks of species such as cod and salmon.

Information on the severity of underwater noise on feeding and migrating birds is not currently well understood but the effects would depend on the nature of the noise, in terms of both volume and duration. However, based on observations of seabirds feeding in similar situations, such as busy harbours and ports, it is anticipated that the effects of underwater noise would be minimal, or that resident birds may become accustomed to this type of disturbance.

Residual visual disturbance would be present throughout the life of the devices, with additional disturbance associated with the installation and decommissioning stages. Seabirds are generally unaffected by marine traffic although visual disturbance in close proximity to seabird colonies, where seabirds are most vulnerable, would have a negative impact to at least some degree. Disturbance in the breeding season can lead to egg chilling, chick starvation, increased predation and colony desertion. These effects are also closely linked with the cable installation process.

Visual disturbance is likely to cause two types of problems to migrating birds and also to local seabirds moving through a turbine installation. Most small to medium birds readily recognize obstacles such as turbines and depending on the species, will either continue flying through or close by a wind farm largely unaffected. Passerines (songbirds) will generally adopt this approach.

Some larger birds do not have the agility or manoeuvrability to comfortably fly through a wind farm. Species such as Gannets and larger birds of prey may therefore avoid such areas and opt to fly around the installation. This represents an increase in flight times to and from colonies and feeding areas.

9.4.2 Effect on feeding areas

At present, suitable nesting areas for several species, throughout the Bailiwick, remain unoccupied. For species such as Shag, the main factor limiting population growth is therefore not believed to be the availability of nest sites. Productivity does vary from year-to-year and it is thought that this is related to the availability of food. In some years there has been an almost complete failure to produce any chicks and consequently, any loss of feeding areas for Shags - and probably other seabirds - is likely to have an impact. It is also reasonable to assume that colonies situated closer to an array of wind devices may be impacted to some degree, either through the loss of, or exclusion from nearby foraging areas or by disruption if they have to fly around an array.

There is also a possibility that an array may have a positive effect on some fish species, due to the reduction or cessation of fishing in the area by man. Also, turbine bases may act as underwater reefs, leading to a localized increase in marine biodiversity. This could therefore potentially increase the food supply for some seabird species.

9.4.3 Collision in flight

Collision during flight would be more likely to occur in heavily used flyways such as narrow channels, approaches to major colonies or around important feeding areas and migration points. Local examples include the areas around Alderney's Gannetries, the northern and westerns coasts of Guernsey where a corridor effect can lead to migrating and foraging seabirds passing close to shore, and possibly the approaches to west coast headlands where migratory land birds accumulate. Cliff areas with breeding colonies are also relatively busy.

Larger birds such as some birds of prey, some wildfowl, and seabirds such as Gannets, are adapted to flying in environments where obstacles are not routinely encountered. As a result, once they gain sufficient height above sea level or above the land surface, they are not 'programmed' to overly look straight ahead for obstacles. These species therefore do not pay particular attention to their immediate surroundings once airborne, making them vulnerable to collisions, especially with manmade obstructions such as pylons, tall buildings and wind turbines (Martin 2011).

9.4.4 Collision underwater

Research on the risk of collision underwater is not currently available, although it has been carried out for other animal groups such as marine mammals and fish. Seabirds which feed underwater are fast, agile swimmers and it is reasonable to assume that collision risk is minor. The possible exception is the Gannet which dives, often from considerable height and enters the water at estimated speeds of up to 90mph. A collision with submerged structures may ultimately prove to be fatal and devices would need to be designed accordingly. However, it is assumed that birds which feed in the tidal, rocky environment of the Bailiwick are adapted to avoid collisions with submerged obstacles and would not be greatly impacted.

9.4.5 Pollution and contamination

Although the sources of contamination are numerous and varied, the risks are low and major incidences are very unlikely. Pollution could arise from accidental spillage of oil or similar substances during the installation phase, or from gradual leaching of toxic materials from the devices, such as anti-fouling paints, over time.

9.4.6 Summary of Impacts

The potential impacts on seabirds can be summarized as follows:

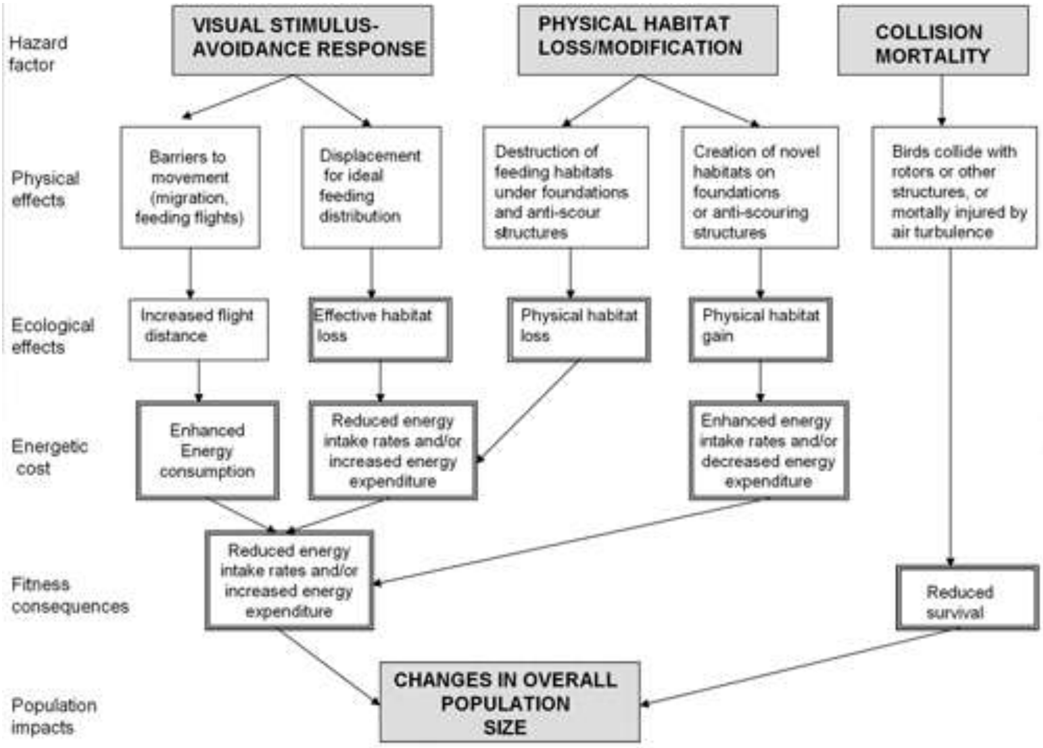

Figure 5. Flow Chart of Hazard Factors to Birds by Offshore Developments

(From - Impacts on Marine Mammals and Seabirds, www.Wind Energy, The Facts.org . Source – Fox et al. (2006), British Ornithologists' Union (BOU))

9.5. Sensitivity of receptors

Marine birds routinely face natural collision hazards and seem able to cope well with localized issues such as these. Also, behaviour patterns will often be modified to a degree, to deal with a changing environment. Seabirds are less able to cope with exclusion from foraging areas. If food is limiting, then reduction in foraging resources will impact at a population level.

A wind farm installation is unlikely to present many hazards or risks which most local seabird species are not able to withstand, at least to some degree. For example, the risk of collision, either above or below the surface may not be much greater than the risk of collision with boats or rocks, although moving rotor blades present a new and unknown level of risk. Possible local exceptions include Gannet and some auks which may not have the ability to safely manoeuvre through rotating turbines. Although such collisions are likely to occur at a low level, for a long-lived species such as Gannets, this may represent a significant population pressure, especially for local breeders which spend much of their lives in local waters. Even a small increase in adult mortality could result in negative impacts at a population level.

Research into the maneuverability of birds in flight using factors such as tail length and wing weighting has provided a scoring of different marine species (Garthe & Huppop, 2004). However, the likelihood of collision is not solely based on maneuverability but is also linked to other aspects of avian perception, in particular, the willingness of a species to fly around an obstacle.

Species	Manoeuvrability Score	Nocturnal Flight Score	Percentage at blade height	Species	Manoeuvrability Score	Nocturnal Flight Score	Percentage at blade height
Common Scoter	3	3	3	Black-throated Diver	5	1	5
Great Northern Diver	5	1	5	Great Crested Grebe	4	2	4
Slavonian Grebe	4	2	4	Fulmar	3	4	5
Sooty Shearwater	3	3	0	Manx Shearwater	3	3	0
Storm Petrel	1	4	2	Gannet	3	2	16
Cormorant	4	1	4	Shag	3	1	5
Arctic Skua	1	1	10	Great Skua	1	1	10
Black-headed Gull	1	2	18	Lesser black-backed Gull	1	3	27
Herring Gull	2	3	31	Great black-backed Gull	2	3	35
Kittiwake	1	3	16	Sandwich Tern	1	3	7
Common Tern	1	1	7	Guillemot	4	2	4
Razorbill	4	1	5	Puffin	3	1	1

Table 4. Flight scores and analysis for selected marine birds (1 = high manoeuvrability/little nocturnal flight, 5 = low manoeuvrability/much nocturnal flight)

Over several years, the Danish Energy Authority has made observations of flocks travelling through the Nysted Wind Farm in Denmark. It was concluded that 71 – 86% of flocks will fly around the array, rather than between the rows of turbines although some species show a variable tendency to reduce height and avoid turbine blades (DEA 2006). This displacement of marine birds means that arrays can be very effective barriers to some species. This may result in secondary environmental pressures such as greater energy expenditure, loss of feeding areas and disrupted migration.

Nocturnal flight scores (Table 4) suggest that few seabird species, apart from Storm Petrel and Fulmar, are particularly active at night. In contrast, many passerine migrants only migrate at night. This is due to a number of factors such as favourable air temperatures, avoidance of predators and the ability to feed and 'refuel' during daylight hours. Consequently, nocturnal migrants can occur in significant numbers in the Channel Islands, especially during spring and autumn. Nocturnal migrants could therefore face a significant risk from turbines. Equally, diurnal migrants, which are unlikely to collide with turbines under most weather conditions, would face a higher risk of collision during periods of poor visibility e.g. periods of fog.

9.6. Potential Significance of Effects

In order to assess the potential significance of the various predicted effects, the magnitude of an impact can be described as 'major', 'moderate', 'minor' or' negligible'. In relation to birds, the definition of these terms is outlined below:

Major - entire local population affected in terms of numbers or distribution, possibly with a residual effect lasting several generations.

Moderate – entire population affected in the short to medium term, or a proportion of the population affected as above.

Minor – proportion of population may be affected in the short term but is able to fully recover.

Negligible or no impact – very minor or no change.

Potential impact	Project phase	Receptor species	Extent of impact	Significance (negative unless stated)
Visual disturbance	All, especially installation	Seabirds, migrants	Installation area	Minor (non-breeding seabirds, migrants), Moderate (breeding birds)[1,2]
Noise disturbance	All, especially installation	Seabirds, migrants	Array area (operation) Installation area (construction)	Minor (non-breeding seabirds, migrants) Moderate (breeding birds)[1,2]
Effect on feeding areas	All	Seabirds	Array area (operation) Installation area (construction)	Minor – may be positive
Collision above surface	All	Seabirds, migrants	Installation area	Moderate (esp. nocturnal migrants and larger birds)[3]
Collision below surface	Mainly operation	Diving seabirds	Array area	Minor
Pollution	All	All	Array area	Minor

Table 5. Analysis of potential impacts on birds.

1. United States Minerals Management Service (Alaska OCS Region), 1990. *OCS mining program, Norton Sound lease sale: second draft environmental impact assessment*.
2. S. M. Percival (Ecology Consulting) 2001, *Assessment of the effects of Offshore Wind Farms on Birds.*
3. Drewitt, A. L. & Langston, R. H. W., 2006. Ibis, 148, (British Ornithologists' Union). *Assessing the impacts of wind farms on birds.*

9.7. Likelihood of Occurrence

The likelihood of birds being affected by the potential impacts is shown in the table below. Although a range of issues has been identified, the likelihood of them occurring and causing changes in the local marine avifauna is generally low - the exception is risk of collision with the turbines.

Studies of bird collision have proved that significant numbers of birds can be killed by wind farms. In the US, wind power is well established as an energy source and as such, wind farms are extensive. Studies at some of the arrays have resulted in the widely accepted figure of 10% of all non-natural bird deaths being attributed to collision with turbines or other associated infrastructure (Source: American Bird Conservancy).

Larger birds tend to be affected by the turbines, whereas passerines are more at risk from other aspects of the installation such as guy wires. For example, a single 60m tower wind turbine in Solano County, California caused seven known fatalities in a five month period and the actual number of deaths, allowing for scavengers and search efficiency was over 50 birds. In most cases, there is a bias towards birds of prey although the biological significance of the level of losses depends on the total number of birds using the flyway (Erikson et. al. 2001).

In considering the difficulties of determining the collision rate of seabirds with wind farms, the US Department of Energy concluded ‘Although one collision of Eiders was witnessed at a Swedish offshore turbine, no other information about mortality from collisions at offshore wind farms is available. As 13 seabird species belonging to different systematic groups were found as casualties at coastal wind farms, seabirds must fundamentally be regarded as vulnerable to collisions. However, collision rates, and hence estimates of additive mortality, remain to be investigated in future.’ (Zucco et. al. 2006).

A large scale offshore wind farm, proposed for the Atlantic Coast of the United States has been predicted to significantly impact a heavily used flyway. Estimates of collisions based on the numbers of birds using the flyway and the scope of the proposal, range from tens of thousands to hundreds of thousands (Watts, 2010).

Based on the scale of measurable bird collision elsewhere ie. land-based installations, a local small-scale turbine installation may not be likely to cause biologically significant levels of mortality in migratory species – although this is not a reason not to undertake all reasonable mitigation measures. However, the level of risk in local seabirds is much higher as local breeding birds would spend a large proportion of their lives in close proximity to the turbines. For example, Gannets breeding in Alderney waters may routinely pass by or through a wind farm off the north coast of Guernsey twice a day. Over an entire breeding season, lasting five months or so, this may represents a considerable risk. Even a low level of fatalities, may cause local population declines in the long term.

Potential impact	Possible effect	Extent	Likelihood
Visual disturbance (construction/decommissioning)	Disruption to feeding Disruption to breeding Disruption to migration	Construction area and surrounds	Possible Possible Unlikely
Visual disturbance (operation)	Disruption to feeding Disruption to breeding Disruption to migration	Array	Probable Possible Possible
Noise disturbance (construction/decommissioning)	Disruption to feeding Disruption to breeding Disruption to migration	Construction area and surrounds	Possible Probable Unlikely
Noise disturbance (operation)	Disruption to feeding Disruption to breeding Disruption to migration	Array and surrounds	Possible Unlikely Unlikely
Loss of feeding areas	Disruption to feeding	Array	Possible
Enhancement of feeding areas	Improved feeding area	Array	Possible
Collision above surface (construction/decommissioning)	Injury or death	Construction area	Possible
Collision above surface (operation)	Injury or death	Array	Probable
Collision below surface (construction/decommissioning)	Injury or death	Construction area	Unlikely
Collision below surface (operation)	Injury or death	Array	Unlikely
Pollution (construction/decommissioning)	Poisoning, oiling, loss of prey	Construction area and surrounds	Possible
Pollution (operation)	Poisoning, loss of prey	Array and surrounds	Unlikely

Table 6. Analysis of potential impacts.

9.8. Mitigation Measures

Of the predicted impacts, most are of minor importance. It is likely that the construction and decommissioning phases would have a moderate impact on breeding birds, mostly seabirds, if the work were to be undertaken close to nesting areas. In all likelihood, an array of 'traditional' wind turbines would be placed at about 3 miles from any shoreline and it is anticipated that newer technologies of floating turbines may extend the scope to at least the 12 mile territorial limit. At these distances, disturbance should not cause significant detriment to seabird colonies, unless turbines are placed in a preferred foraging or feeding area. The site of the cable link onshore may impact areas which support breeding birds but mitigation would be possible by, for example, undertaking works during the non-breeding season.

The four-month period, April – July covers most of the nesting season and all work in close proximity to coasts should be avoided during this time. Ideally, March would also be off limits as most seabirds establish territories and determine nesting sites throughout this month.

Any impacts on breeding birds are particularly important, especially on a local scale, due to the effects on the present and future populations of a species.

Based on the current available information, several impacts are considered to be of a minor or even negligible nature. However, they should still be examined and mitigation measures sought as reductions in the severity of even minor impacts are still possible through appropriate design, and installation and decommissioning methods. Materials used, such as coatings and paints, should also be environmentally benign and of a non-toxic nature.

The risk of birds colliding with the turbines is of major importance. Although many of the larger birds which have been proven to be vulnerable to collision elsewhere, such as swans, geese and large raptors, are generally not common in the Bailiwick, there are several other species which may be affected. In addition, nocturnal migrants of any size may also be impacted by turbines, especially if situated relatively near to a coast. In these areas, migrants which routinely maintain sufficient altitude to avoid obstacles would descend to lower levels as they approach land. Similarly, in poor weather, birds may be forced lower by unfavourable conditions such as headwinds or fog.

If a wind farm project is to be proposed in local waters, it is recommended that a comprehensive EIA be produced. As part of that investigation, it would be essential to obtain sufficient baseline environmental data on the use of possible projects sites, especially by birds. This research would ideally be carried out over a period of at least 2-3 years.

Effect	Phase	Mitigation measures
Visual disturbance	Construction/Decommission	Avoid sensitive seasons (esp. breeding) Avoid locally important feeding areas Use appropriate construction methods
	Operation	Avoid locally important feeding areas Install minimum infrastructure above water
Noise disturbance	Construction/Decommission	Avoid sensitive seasons (esp. breeding) Avoid locally important feeding areas Use appropriate construction methods
	Operation	Install devices with low noise emission
Collision risk	Construction/Decommission	No mitigation necessary
	Operation	Avoid sensitive breeding or feeding sites Locate devices away from known migration flyways Design devices and array alignment to reduce collision risk Minimize lighting of the array Use coatings and colourations which improve device visibility
Accidental contamination	Installation/Decommission	Design techniques to minimize risk Develop contingency plans Use non-toxic alternatives
	Operation	Use non-toxic alternatives

Table 7. Mitigation measures for predicted impacts.

9.9. Confidence and Knowledge Gaps

Through the three comprehensive seabird breeding surveys and an intensive annual programme of monitoring visits (mostly to undertake scientific ringing of seabird chicks), the status of each of the dozen or so breeding Bailiwick seabird species is generally understood. In contrast, seabird activity such as feeding and migration are very poorly known and new research into these areas is required.

Similarly with land birds, the knowledge on local breeding, non-breeding and migratory birds within the islands, is satisfactory. Beyond the terrestrial situation, the behaviour of migrants, both nocturnal and diurnal, is poorly known. The significance of collision risk needs particular attention and comprehensive comparisons with offshore wind farms in other areas would need to be undertaken, especially where issues such as site selection are concerned.

At this investigative stage of local wind energy, there is, understandably, no specific information on potential projects or device design. Predictions on how installations may affect birds have been made by studying the most appropriate comparison, natural or unnatural, and by using pioneering research carried out elsewhere. There are three important points to consider in this respect:

1. Some impacts may be unique to specific turbine installations and at this stage, their local effects can only be estimated, with generally low confidence.

2. The environmental impact will vary between devices and so each design proposal should be analysed in detail.

3. It is likely that new technology will have some impacts which were not foreseen, which highlights the need for ongoing monitoring following installation.

In comparing the two development scenarios, it is possible that floating wind turbines positioned several miles offshore may represent a reduced risk to birds compare to anchored devices closer to land. Birds are probably found in higher numbers closer to land due to the corridor effect caused along the coasts. This will be more pronounced on Guernsey's longest (i.e. west) coast. In addition, migrant land birds are also likely to occur in higher densities closer to shore as they approach or depart coastal headlands. Research to confirm the extent of such theories would need to be given priority ahead of any decision-making on the development scenarios.

Some of the limitations of current data are outlined below in relation to specific impacts:

Data Gap	Relates to	Unknown information	Requirement
Seabird distribution	Site selection	Fine –scale distribution	Field survey or data-logging project of several species
Bird activity in water column	Site selection Device design	Local dive depths	Data logging project Analysis of available research
Flight behaviour and characteristics of migratory species	Site selection Device design	Normal flight heights, preferred approaches to land,	Analysis of available research Data logging projects Field surveys of migratory species Radar studies
Capacity of key senses	Site selection Device design Visual disturbance Noise disturbance	Mainly relating to the avoidance capabilities of seabirds and migrants	Analysis of available research Monitoring of demonstration devices
Ecological changes	Device design Site selection	Level of reliance on certain habitats, relating to sediments	Analysis of available research Monitoring of demonstration devices

Table 8. Requirements to address data deficits

9.10. Residual Significance Effects

All wind devices, irrespective of location, design and mitigation measures, will impact the local environment to some degree and in most cases, these will be of a negative nature. Some of these issues, especially those associated with construction and/or decommissioning work, will be temporary, whereas operational effects will generally be long term.

Effect	Phase	Receptor	Significance (with good practice & mitigation)	Residual effects	Confidence
Visual disturbance	Construction/Decommission	Mainly breeding species	Minor	Negligible	Moderate
	Operation	Mainly breeding species	Negligible	Negligible	Moderate
Noise disturbance	Construction/Decommission	Mainly breeding species	Minor	Negligible	Low
	Operation	Mainly breeding species	Minor	Minor	Moderate
Collision risk	Construction/Decommission	All species	Moderate	Negligible	Low
	Operation	All species	Moderate	Moderate	Low
Accidental contamination	Construction/Decommission	All species	Negligible	Negligible	Moderate
	Operation	All species	Negligible	Negligible	Moderate
Feeding disruption	Construction/Decommission	Seabirds	Minor	Negligible	Moderate
	Operation	Seabirds	Moderate	Moderate	Low
Habitat changes	Operation	Seabirds	Minor	Minor	Low

Table 9. Predicted residual effects on birds.

Although the table indicates that the significance and the residual effect of many impacts are either minor or negligible, these predictions are given with, at best, only moderate confidence. These levels reflect the current level of uncertainty associated with the impacts of offshore wind farms on birds. There is an increasing amount of data now available, with some monitoring programmes, such as those in place at Nysted, Denmark, extending over several years. However, much of the research merely emphasises the considerable degree of variability in terms of impacts from different wind turbine designs and array layouts on site-specific avifauna. Further uncertainties include the effects of different weather conditions and seasonal changes of species composition and bird behaviour.

Collision risk and feeding disruption are the two issues of greatest concern when considering the impacts on birds. This is a reflection on the Bailiwick's unique geographical position, on a migration route, midway between two landmasses, and also the importance of the local marine environment for seabirds.

9.11. Recommendations for Survey and Monitoring

The main gaps in current knowledge are as follows –

1. Specific marine areas used by birds for activities such as feeding or loafing

It is known that certain marine features, such as sand banks and reefs, are attractive to feeding seabirds but on a local scale, there is no available data, apart from sparse anecdotal evidence. Daily, tidal, seasonal or annual variations in feeding activity represent the most significant areas in need of research. This data is required to predict some of the impacts on marine birds with more confidence.

Such data can be obtained by boat-based surveys, use of high definition aerial photography or through the use of GPS tagging of seabirds. Which technique is best will depend on the season and the species involved. The data collected can be used to build up a map of key foraging areas for birds and facilitate the creation of a map of seabird activity in local waters.

It is recommended that before potential locations for marine energy devices are finalised, some pilot work to identify key seabird foraging areas is carried out. The main foraging areas for the most important seabird colonies should be identified. Boat or aircraft hire can be expensive and the most cost effective way to track birds is by using small low-cost GPS tracking devices. These can be attached to birds and the birds' locations recorded every few minutes. By using devices with built-in accelerometers, it is possible to determine whether the bird is actively feeding or is at rest. These devices have been widely used in the UK to inform impact assessment studies of marine energy devices. It is recommended that local ornithologists be consulted in order to develop a programme of field survey work and GPS tracking to identify the main foraging areas of breeding seabirds during both incubation and chick rearing stages. This baseline information will be essential for informing the site selection process, impact assessment and consequent environmental monitoring.

As the development of marine energy progresses, there will be a need to monitor the effects on local seabirds at all stages. Although some monitoring will be possible through continuation of annual visits to seabird colonies, it is possible that additional information, not currently obtained in a scientific or systematic manner, would need to be collected. In addition, project developers should be required to undertake or commission appropriate site-specific surveys and subsequent monitoring in order to assess the associated impacts. These could include boat-based surveys or aerial hi-definition video surveying or additional monitoring of the numbers and breeding success of local breeding seabirds.

2. Various aspects of bird migration in a local context

Although local ornithologists are aware of general bird migration patterns and tendencies, the mechanisms and details are largely unknown. For example, casual observations from headlands during migration periods reveal diurnal migrants arriving or departing the islands at low altitudes. However, there is no local data on the behaviour of nocturnal migrants. It is assumed that nocturnal migrants leave at dusk and simply fly throughout the night until dawn, but there is evidence that artificial lights or poor weather can draw birds down during the night. If this happens on the approach to land, it is possible that an offshore wind farm may represent a significant risk.

Observations of visible migration continue to pose further questions over the mechanisms of migration through the islands. For example, a survey undertaken some years ago showed that autumn migrants used Icart Point, situated along the south coast, more than either the southwest (Pleinmont) or southeast (Jerbourg) corners of the island. It is thought that this may be a result of the topography of the centre of Guernsey, which may have a channelling effect.

Further research into migration is required to provide the data necessary to determine the critical aspects of the phenomenon in relation to wind farm installations, and to mitigate the more important impacts, especially collision risk. As with seabirds, modern technology has led to tracking devices becoming an increasingly viable option for research on smaller bird species. Further data may be obtained through radar studies, which may reveal some aspects of nocturnal (and diurnal) bird behaviour. Such data could be combined with observational studies to help provide some of the required information.

3. Continued monitoring of seabird colonies

Many local seabird colonies are routinely visited either annually or several times during the breeding season to undertake ringing of seabird chicks. This activity is casual but provides limited, and in some areas, the only opportunities for monitoring. It is therefore important that this work continues although with additional resources, the observations could be formalised and improved. The data could then be better used to inform investigations into marine renewables.

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