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Guidance on Survey and Monitoring in Relation to Marine Renewables Deployments in Scotland
Volume 4: Birds

This report was produced by **Natural Research Ltd** and **Royal Haskoning** on behalf of Scottish Natural Heritage (SNH) and Marine Scotland (MS). It provides guidance and protocols for the conduct of site characterisation surveys and impact monitoring programmes for birds for marine (wave and tidal) renewables developments in Scotland. Four accompanying volumes are also available, covering:

- Vol 1. Context and General Principals
- Vol 2. Cetaceans and Basking Sharks
- Vol 3. Seals
- Vol 5. Benthic Habitats

At present, the contents of all five reports should be regarded as recommendations to SNH and MS but not as formal SNH or MS guidance. It is the intention of both organisations to prepare a separate, short overview of the documents offering additional guidance on SNH and Marine Scotland's preferred approach to key issues such as survey effort, site characterisation and links to Scottish Government's Survey, Deploy and Monitor policy.

To assist in the preparation of this guidance note, the views of developers, consultants and others involved in the marine renewables sector are sought on the content of this and the accompanying reports. Specifically we would welcome feedback on:

A. The format and structure of the current reports
B. Changes that should be considered
C. Key issues that you would wish to see incorporated within the guidance note.

Feedback should be provided by e-mail to SNH (marinerenewables@snh.gov.uk) by 31 October 2011, marked 'Marine Renewables Guidance Feedback'.

It is hoped that developers and their advisers will find these documents to be a useful resource for planning and delivery of site characterisation surveys and impact monitoring programmes. They may be cited, but any such reference must refer to the draft status of the report concerned and to its specific authors. For this report (Volume 4), the appropriate citation is: **Jackson, D., and Whitfield, P. (2011). *Guidance on survey and monitoring in relation to marine renewables deployments in Scotland. Volume 4. Birds*. Unpublished draft report to Scottish Natural Heritage and Marine Scotland.**

Queries regarding this guidance should be addressed to:
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Vol 4. Birds.

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Selected Acronyms

AOBs	apparently occupied burrows
AONs	apparently occupied nests
BACI	Before-After-Control-Impact
BAG	Before-After-Gradient
BTO	British Trust for Ornithology
CIA	Cumulative Impact Assessment
COWRIE	Collaborative Offshore Wind Research Into The Environment
EIA	Environmental Impact Assessment
ESAS	European Seabirds at Sea
GPS	Global Positioning System
HRA	Habitats Regulation Appraisal
JNCC	Joint Nature Conservation Committee
LOT	Licensing Operations Team (Marine Scotland)
MS	Marine Scotland
NCI	Nature Conservation Importance
NEWS	Non-Estuarine Wader Survey
OBISSEAMAP	Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations
RSPB	Royal Society for Protection of Birds
SEA	Strategic Environmental Assessment
SNH	Scottish Natural Heritage
SOC	Scottish Ornithologists' Club
SPA	Special Protection Area
SSSI	Sites of Special Scientific Interest
UK BAP	United Kingdom Biodiversity Action Plan
VP	Vantage Point
WCA	Wildlife and Countryside Act
WeBS	Wetland Bird Survey

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1 INTRODUCTION

Scotland's seas and coast supports large populations of marine birds, in particular breeding seabirds, many of which occur in internationally important numbers. Indeed, a substantial part of the global populations of some species breed in Scotland. The term 'marine bird' in this guidance covers all species that use the marine environment that could plausibly be affected by wet renewable developments. This includes true seabirds and other species that use the coast (e.g. waders and wildfowl). For completeness, three land bird species of particular conservation importance that nest on sea-cliffs are also included (white-tailed eagle *Haliaeetus albicilla*, golden eagle *Aquila chrysaetos* and peregrine *Falco peregrinus*) as these could plausibly be adversely affected by disturbance from wet renewable developments. Other land birds are not considered. Of course, the assessment and monitoring of wet renewable developments should also consider the effects of any terrestrial components and activities on land birds. The SNH survey guidance for onshore wind farms (SNH 2005, 2009) provides advice on the survey and monitoring required for land birds.

2 IDENTIFICATION OF KEY SPECIES AND HABITATS

Although at least 50 bird species commonly use the seas and coast of Scotland, only some of these are likely to be key species with respect to wet renewable developments. Key species will be those that either have potential for interaction or are vulnerable to experiencing adverse effects from a development, those that are a qualifying interest at a nationally or internationally designated site, such as Sites of Special Scientific Interest (SSSI) or Special Protection Areas (SPA), and those that are specially protected (species listed on Annex 1 of the Birds Directive (2009/147/EC) (http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:020:0007:0025:EN:PDF), or Schedule 1 of the Wildlife and Countryside Act 1981 (http://www.jncc.gov.uk/PDF/waca1981_schedule1.pdf).

2.1 Seabirds

Scotland has 22 species of regularly breeding colonial seabirds (northern gannet *Morus bassanus*, great cormorant *Phalacrocorax carbo*, European shag *Phalacrocorax aristotelis*, four petrel and shearwater species, four auk species, five tern species, two skua species and four 'sea' gull species). Two other species that are usually classed as seabirds, red-throated *Gavia stellata* and black-throated diver *Gavia arctica*, also breed but these are non-colonial and breed on standing freshwater bodies. Several other seabird species regularly occur in Scottish waters as passage migrants or winter visitors (including two diver species, one auk species, two shearwater species, two skua species and three gull species), and many other species are scarce visitors. Most of these species originate from breeding grounds in the Arctic or South Atlantic.

2.2 Other birds

Scotland also supports nationally important numbers of moulting, wintering and passage sea duck, waders and other water birds. Although these are mostly associated with low-energy localities such as estuaries and firths (habitats outwith the scope of this guidance), there are notable concentrations along some high energy coasts which could be affected by wet renewable developments, for example in part of the Outer Hebrides and Orkney.

2.3 Seasonality and movements

The occurrence of most marine bird species in Scotland shows strong seasonal patterns as most species are migratory to some extent. Typically, most breeding seabirds are present at breeding sites from March or April until their chicks fledge between early July and mid September, depending on the species. Outside the breeding season, most species leave the vicinity of their breeding sites and move to other areas. For some species these may be relatively close to breeding sites, but others move much longer distances, in some case to the tropics or the southern hemisphere. The movement patterns of sea birds are complex and only partially understood (e.g. Wernham *et al.* 2002). For many species, outwith the breeding season, there is wide dispersal of birds from colonies and a degree of merging of populations from different breeding sites. Seabird movements occur in all months but, as for wildfowl and waders, are most marked in March to May and from July to October. Winter visitors are most likely be present any time from October through to April.

Some seabird species range widely and may change locations in response to changing conditions rather than follow a habitual pattern of site use. Furthermore, there may be large spatial and temporal differences in site use between breeding and non-breeding birds (most seabirds do not breed until approximately 3 to 7 years of age (Gaston 2004) so a substantial proportion of any population is likely be young non-breeding individuals.) As a consequence of this complexity it is common for there to be some uncertainty regarding the origins and status of marine birds recorded during survey work.

2.4 Key species

The bird species and families discussed in more detail below are not an exhaustive list of candidates that should be considered in wet renewable assessments, but they include all seabirds that are most likely to be the key species in Scotland and others species that are likely to be encountered and plausibly affected The selection includes all species of seabird that regularly breed around the Scottish coast, coastal cliff nesting raptors that are qualifying features of SPAs and diving waterbird species that use marine areas.

2.4.1 Shearwaters and petrels

Northern fulmar *Fulmarus glacialis*, European storm-petrel *Hydrobates pelagicus*, Leach's storm-petrel *Oceanodroma leucorhoa* and Manx shearwater *Puffinus puffinus* all breed in internationally important numbers in Scotland. Manx shearwaters are of particular importance, with approximately 80% of the global population breeding in the UK, about a third of which nest in Scotland, mainly on Rum in the Inner Hebrides. European storm petrel and Leach's storm petrel are listed on Annex 1 of the Birds Directive. Very high proportions of the breeding sites of these species are contained within SPAs and SSSIs.

With the exception of fulmar these species are nocturnal at breeding colonies. All these species range very large distances from breeding colonies to forage. Migrant sooty shearwater *Puffinus griseus* and great shearwater *Puffinus gravis* also occur in Scottish waters mainly in the summer and autumn months but these are unlikely to be key species to wet renewable developments.

Shearwaters and petrels mostly feed on the wing, picking items off or close to the sea surface and the availability of prey could be affected (positively or negatively) by changes to currents and wave action resulting from wet renewable devices. Shearwater species may also sometimes dive below the surface to catch prey and can reach the depths occupied by marine turbines (Burger 2001). Night time illumination of vessels and infrastructure could potentially affect the nocturnal behaviour of breeding Manx shearwaters and petrels.

2.4.2 Northern gannet

Northern gannets breed in a few, typically very large, colonies around the UK and range widely from their colonies to feed (Hamer *et al* 2007). These colonies hold approximately 200,000 pairs most of which are in Scotland and constitute nearly 60% of the global population. The 13 Scottish gannetries are situated at Bass Rock, Troup Head, Westray (Orkney), Fair Isle, Noss, Hermaness, Foula, Sule Sgeir, Sule Stack, Flannan Islands, Boreray (St Kilda), Ailsa Craig, and Scar Rocks. Over 98% of the UK gannet population breed on SPAs and SSSIs. Gannets from colonies outside Scotland also visit Scottish waters.

Gannets feed by plunge diving for fish, often diving from a considerable height above the surface. Although most dives only take the birds to a few metres depths, dives targeting relatively large fish can be to depths exceeding 10 m below the surface (Brierley and Fernandes 2001) and so could potentially expose the birds to collision risk with marine turbines. There is also a theoretical risk that plunge diving birds could strike submerged wave devices and be injured or killed. Gannets are considered to be relatively tolerant of human activity at sea (Garthe and Hüppop 2004) but may be showing behavioural displacement from offshore wind farms (Krijgsvled *et al*. 2010).

2.4.3 Cormorant and shag

The numbers of European shag breeding in the UK constitute approximately 35% of the global population and the vast majority of these, approximately 21,000 pairs, breed around the coast of Scotland. Shags dive from the surface to moderate depths (typically <30m) to feed mostly on or close to the sea bottom and are therefore at potential risk from collision with marine turbines. They usually forage relatively close to the shore (typically <5km), rarely occurring out of sight of land. Therefore, the potential to be affected by devices is predominantly in near shore environments.

Great cormorants breed in much smaller numbers in the UK and are mainly found in low energy marine habitats and freshwater. Therefore they are relatively unlikely to be affected by wet renewable developments.

Many of the breeding colonies of shag and cormorant are designated as SPAs and SSSIs. Both species are relatively tolerant of human disturbance (Garthe and Hüppop 2004) and commonly use man made structures as perches. Any development superstructure protruding above the sea surface is likely to attract perching birds and possibly encourage them to use a development site.

2.4.4 Skuas and gulls

Scotland supports nearly 10,000 pairs of great skua *Stercorarius skua* (also known as bonxies), approximately 70% of the global population. They breed mainly in Shetland, Orkney and the Outer Hebrides and range widely outside the breeding season. Arctic skua *Stercorarius parasiticus* also breed in moderate numbers in Scotland (2100 pairs in the 2000 census, though numbers have since declined sharply) and these constitute approximately 10% of the NE Atlantic population.

Four species of breeding gull are closely linked to the marine environment in Scotland, namely kittiwake *Rissa tridactyla*, herring gull *Larus argentatus* and great black-backed gull *Larus marinus* and lesser black-backed gull *Larus fuscus*. All breed in large numbers. Two other gull species, black-headed *Larus ridibundus* and common *Larus canus*, also breed in large numbers in Scotland but are much less reliant on marine habitats. Large numbers of little gull sometimes occur off the east coast of Scotland, mainly in summer and autumn. Little gull are listed on Annex 1 of Birds Directive. Many of the breeding colonies of gulls and skuas are designated as SPAs and SSSIs.

Two other skua species and several other species of gull species occur in Scotland in relatively small numbers, on passage, or in winter. None of these species are likely to be key species to wet renewable developments.

Gulls and skua species feed mainly from the sea surface and so are unlikely to be exposed to any collision risk from marine turbines. Gulls and skuas are relatively tolerant of human disturbance, and some individuals are attracted to human activity. Gulls make ready use of man made perches and any wet renewable device superstructure protruding above the surface is likely to be used by perching gulls.

2.4.5 Terns

Of the five species of tern that breed in Scotland, only two, Arctic tern *Sterna paradisaea* and common tern *Sterna hirundo*, are likely to occur commonly at the relatively high energy sites suitable for wet renewable developments. Terns typically forage within a few kilometres of the coast, at least in the breeding season. Although terns typically feed by plunge diving, their dives do not penetrate deeply into the water. Therefore, terns are unlikely to be at collision risk from marine turbines or other underwater devices. It is possible that the availability of prey could be affected (positively or negatively) by changes to currents and wave action resulting from wet renewable devices. Terns readily use man made perches, and devices that have superstructure protruding above the surface are likely to be used by perching terns. All species of breeding terns in Scotland are listed on Annex 1 of the Birds Directive.

2.4.6 Seaduck, divers and grebes

Several species of sea duck, diver and grebe species commonly occur in relatively shallow (approximately <30m) coastal waters around Scotland. These include long-tailed duck *Clangula hyemalis*, common eider *Somateria mollissima*, common scoter *Melanitta nigra*, red-breasted merganser *Mergus serrator*, Slavonian grebe *Podiceps auritus*, and red-throated, black-throated and great northern diver *Gavia immer*. There is increasing evidence of a small but regular wintering population of white-billed divers off the north and west coasts. All these species are migratory to a greater or lesser extent and show seasonal patterns of occurrence. Most are predominantly present in the winter months and at migration times. All diver species and Slavonian grebe are listed on Annex 1 of the Birds Directive.

Sea duck and divers commonly dive to moderate depths (up to ~30m) and so are potentially at risk from collision with marine turbines. Some seaduck and diver species have been assessed as being relatively vulnerable to disturbance (Garthe and Hüppop 2004) and commonly take to flight in response to approaching vessels or aircraft (a factor that surveys need to take into consideration). Sea duck and divers are flightless for a period of several weeks each year, when they undergo wing moult (seaduck in the late summer and divers in winter), and at these times they are especially vulnerable to disturbance due to their reduced mobility and greater potential for stress to their time-energy budgets. There is no experience regarding how any of these species would be affected by the presence of wet renewable devices. However eider and common scoter show strong avoidance of the vicinity of offshore wind farms in Denmark (Petersen et al., 2004), and several sea duck and diver species are known to be particularly sensitive to boat disturbance (Schwemmer et al 2010, Garthe and Hüppop, 2004).

2.4.7 Auks

The four breeding species of auk, namely Atlantic puffin *Fratercula arctica*, common guillemot *Uria aalge*, razorbill *Alca torda* and black guillemot *Cepphus grylle* (also known as tystie), are the most numerous group of seabirds breeding in Scotland. The UK populations of the four breeding species, the vast majority of which are in Scotland, are of global importance representing in each case between approximately 10 - 20% of the global total. Very high proportions of the breeding sites of these species are contained within SPAs and SSSIs. A fifth species, little auk *Alle alle*, occurs in winter mainly well offshore. With the exception of black guillemot all species are migratory and undertake wide ranging and complex patterns of movements with different populations dispersing and mixing widely outwith the breeding season.

Black guillemots rarely occur more than a few kilometres from the coast and breed in small colonies. The other three species typically breed in large colonies and forage both in inshore and offshore waters. Many auk colonies are designated as SPAs and SSSIs.

All the auk species feed by surface diving, swimming down to a wide range of depths to catch small fish, such as sandeels. They are at potential risk of collision from marine turbines. They are also considered to be moderately vulnerable to disturbance from human activity (Garthe and Hüppop 2004). They are particularly vulnerable in the vicinity of breeding colonies (Carney and Sydeman, 1999, Thayer et al., 1999, Rojek et al., 2007), when they have dependent young in attendance (common guillemot and razorbill during July and August) and during wing moult when they are flightless (wing moult occurs mainly late summer).

2.4.8 Coastal waders

Wader species that use exposed coasts could be potentially affected by coastal wave energy developments. The species likely to be affected include sanderling *Calidris alba*, ringed plover *Charadrius hiaticula*, dunlin *Calidris alpina*, purple sandpiper *Calidris maritima*, common redshank *Tringa totanus* and turnstone *Arenaria interpres*. Rotting seaweed cast up on beaches can be an important habitat for these species and wave energy devices might reduce the quantities of seaweed coming ashore. They may also reduce the size and energy of waves breaking on shores which could affect shore habitats and invertebrate prey and, in turn, birds that depend on them. Such effects remain theoretical and would not necessarily be deleterious. Waders and other birds using shores and inter tidal areas are sensitive to human disturbance especially at roost sites.

Numerous stretches of coast and estuaries in Scotland are designated as SPAs or SSSIs for concentrations of wintering and migrant waders and other waterbirds. Dunlin of the '*schinzii*' race (breeds in Scotland and Iceland) are listed on Annex 1 of the Birds Directive.

2.4.9 Cliff-nesting raptors

White-tailed eagle *Haliaeetus albicilla* and peregrine *Falco peregrinus* commonly breed on sea-cliffs and sometimes hunt over the sea. Golden eagle *Aquila chrysaetos* can also nest on sea-cliffs but does not usually hunt over the sea. These species are vulnerable to human disturbance when breeding potentially up to distances of 1 km from the nest site. These species are listed on Annex 1 of Birds Directive and Schedule 1 of WCA and are qualifying species at some coastal SPAs.

2.5 Special Protection Areas (SPA)

A high proportion of Scottish seabird breeding sites are part of the Natura SPA network and the SSSI network. SPAs may be designated for their importance to single species or for their assemblages of mixed species. The latter includes assemblages of >10,000 pairs of breeding seabirds and assemblages of >20,000 waterbirds, generally in the non-breeding season. The boundary of many seabird colony SPAs was extended in 2009 to include adjacent sea areas up to 4 km from the land (http://www.jncc.gov.uk/page-4562).

Birds that are a qualifying interest at a designated site can be considered as higher priority than birds of the same species from non-designated sites. This is especially so for birds from SPA 'populations', where there is a legal requirement for potential impacts to be assessed in relation to regulation 48 of the Conservation (Natural Habitats, &c.) Regulations 1994 as amended – now commonly referred to as Habitats Regulations Appraisal (HRA).

2.6 Requirements

Where a site is designated for its bird interest, either as a SPA or SSSI, the requirement that a wet renewable development proposal should not adversely affect those interests is explicit in both legislation and planning guidance. The protection requirements following from European Directives for Natura sites, require that before a development proposal is approved, it should be ascertained that the proposal will not adversely affect the integrity of a Natura site; exceptions may only be made where there are imperative reasons of overriding public interest.

While neither the legislation or planning guidance preclude marine renewable energy developments in or near an SPA or SSSI designated for bird interests, it follows that a greater study effort will be required to demonstrate if a proposal is acceptable or not. There is also a higher chance that an inappropriate proposal will be refused.

Location is critically important to avoid deleterious effects of wet renewable developments on birds and this may mean a degree of precaution when considering developments in or close to designated sites or other areas with large concentrations of birds. The favourable conservation status of habitats and species populations at these sites is a central tenet of their designation, requiring demonstration of compatibility of this aim by any proposed development. An early identification of whether a proposed development is likely to deleteriously affect bird interests of designated sites will be beneficial to all stakeholders and should be part of the site selection process. At the very earliest stage, an ornithological sensitivity analysis should be undertaken of candidate development sites using existing information.

It is very important to identify in a reasoned way which designated sites are likely to be affected by a proposed development. Given the far ranging behaviour of many seabird species (e.g. foraging ranges >100 km are common in several species) identifying which designated sites are likely to be affected is not always apparent. Therefore, for far ranging species it will be also relevant to show why other sites are not considered likely to be affected and stating where there is uncertainty. When identifying SPAs potentially affected it should be borne in mind that these may lie outwith the national administrative boundary, e.g. some seabird species breeding at SPAs in Ireland and Northern Ireland commonly forage in Scottish waters.

If there is ornithological connectivity by the qualifying species from a designated site and a proposed development site, then even though the development site lies outwith the boundary of the designated site, the bird interests should also be included as explicit targets for analysis of bird impacts. Connectivity means that some or all individuals from a designated site's qualifying population use the proposed site (see Section 8.11). The wide-ranging behaviour of many marine birds means that the effects of a development can potentially affect the viability of a designated site some distance away. Establishing the extent of connectivity between birds using development areas and designated sites is an important element in assessing how designated sites may be affected.

2.7 Overview of marine SPA designations

SPAs may be designated for their importance to single species or for their assemblages of mixed species. The latter includes assemblages of >10,000 pairs of breeding seabirds and assemblages of >20,000 waterbirds, generally in the non-breeding season.

There are too many SPAs to give summary details of individual sites in this guidance. Furthermore, any information provided is likely to soon become out of date as the SPA suite is constantly being added to and evolving. However, it is useful to give some idea of the extent of the SPA suite relevant to marine birds both in Scotland and nationally.

The tendency for many marine bird species to congregate in large numbers at relatively small sites has meant that the SPA designation process has been able to effectively include a large proportion of many populations. This is most marked in species such as gannet and Manx shearwater for which over 90% of the UK breeding populations are contained within SPAs. Most breeding seabirds have over 50% of their national breeding populations contained within SPAs.

All large seabird colonies (>10,000 pairs) are included in the SPA suite; 41 sites were selected under this criteria alone, of which 34 are in Scotland. A further 51 SPAs with less than 10,000 pairs in total are selected for their importance to single species of breeding seabirds. In 2009, the boundaries of many SPAs designated for breeding seabirds was extended outwards by 1, 2 or 4 km (depending on the qualifying species) to include areas of adjacent sea.

There are 57 UK sites designated for their concentrations of wintering and migrant waterbirds (>20 000 birds) including eight in coastal Scotland. All eight are large estuarine sites and all except one (Upper Solway Flats and Marshes) are on the east coast. In addition wintering and passage waders are qualifying interests at coastal sites in the Hebrides and Orkney (South Uist Machair and Lochs, North Uist Machair and Islands, Tiree Wetlands and Coast and East Sanday Coast).

Peregrine is a qualifying species at three coastal SPAs in Scotland (East Caithness Cliffs, North Caithness Cliffs and Hoy).

3 RELEVANT LEGISLATION

The following should be taken into account when deciding what survey work is required:

- The Council Directive on the Conservation of Wild Birds 2009/147/EC (EU Birds Directive);
- The Wildlife and Countryside Act 1981 (as amended) (WCA);
- The Conservation (Natural Habitats &c.) Regulations 1994 (as amended); ('The Habitats Regulations');
- The Nature Conservation (Scotland) Act 2004 (amended);
- Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2000; and
- Wildlife & Natural Environment Act (2011).

Details of legislation relevant to wet renewables development in Scotland, and how this drives the requirements for monitoring is outlined in Volume I, Section 2 of this Guidance. An outline of Environmental Impact Assessment (EIA) and Natura 2000 legislation, including Special Protection Areas (SPAs), Habitats Regulation Appraisals (HRA) and Appropriate Assessment (AA), is provided. Further (bird specific) information on the Wildlife and Countryside Act (1981) is provided below. In addition, up to date information on relevant legislation can be publicly accessed on the SNH website[1]

3.1 Wildlife and Countryside Act 1981

Schedule 1 of the Wildlife and Countryside Act 1981 (as amended) (WCA) and the Nature Conservation (Scotland) Act 2004 lists species that are specially protected and for which it is an offence to disturb at breeding sites. However, few seabird species are listed on Schedule 1 (e.g. roseate tern and little tern) and disturbance of these species is unlikely to be an issue at wet renewable sites. Disturbance of some Schedule 1 raptor species, particularly those that nest on sea cliffs (e.g. peregrine, white-tailed eagle and golden eagle), is a potential issue for projects close to land especially as these species may be susceptible to disturbance at distances of up to 1 km (Whitfield *et al* 2008).

[1] http://www.snh.gov.uk/planning-and-development/environmental-assessment/

SSSIs are designated under the WCA. These include coastal sites (e.g. cliffs and intertidal areas) but do not extend beyond mean low water spring tide level.

3.2 Species Priority: Nature Conservation Importance

For EIA, the priority placed on a species occurring at a development site should be determined by a combination of its nature conservation importance and its sensitivity. All species that require HRA because a proposed development could plausibly affect the qualifying populations from one or more SPA, should be treated as high priority.

Nature Conservation Importance (NCI) is a measure of the value (or potential value) of the birds that may be affected, whereas sensitivity is a measure of how vulnerable they are, both as individuals and the population, to adverse affects. Put simply, all species are not equal, nor are the stages of their life cycle. The highest priority should be given to birds that merit classification as having high NCI and/or high sensitivity.

The nature conservation importance of a species should be determined from a reasoned combination of, legislative protection, inclusion on recognised conservation priority lists and geographical context. Legislative protection may be to the species as a whole or to sub-populations from designated sites (e.g. qualifying species from particular SPAs). Conservation priority lists include: UK Biodiversity Action Plan species (UK BAP - http://www.ukbap.org.uk/), Birds of Conservation Concern red list (BOCC red list - http://www.bto.org/sites/default/files/u12/bocc3.pdf) and IUCN threatened species http://www.iucnredlist.org/. Best practice guidance (IEEM 2010) is to use the following frames of reference for geographical context (IEEM 2010) - http://www.ieem.net/docs/Final%20EcIA%20Marine%2001%20Dec%202010.pdf:

- International;
- UK/national;
- Regional;
- River Basin District;
- Coastal cell;

- County, District or local/parish (where coastal); and
- within zone of influence only (which might be the project site or a larger area).

By convention, international and national importance are defined by the regular presence of >1% of the population under consideration. Judging a site's geographic importance should take into consideration likely turnover rates of individuals as well as the numbers present at any one time.

The Nature Conservation Importance of the species potentially affected by proposed development is determined from combining legislative/conservation status with the appropriate category for the geographic importance of the development site for that species, as defined in Table 3.1.

Table 3.1. Criteria for classifying the Nature Conservation Importance of marine bird species for EIA.

Geographical importance	Species on Annex 1 or Schedule 1	Conservation Priority listed (UKBAP, BOCC Red list, IUCN)	Other species
International (>1% EC population)	High	High	Moderate
National (>1% UK population)	High	High	Moderate - Low
Regional	High-Moderate	Moderate	Low
Local	Moderate - Low	Low	Low

Prioritization should also consider in a reasoned way the importance of life cycle stages to birds' vulnerability to potential effects. For example, actively breeding birds, particularly those provisioning young or temporarily flightless birds undergoing moult, are likely to be more vulnerable due to the constraints on relocating imposed by breeding (large scale relocation is not an option), reduced mobility and greater potential for stress to time-energy budgets . For this reason birds present at times of heightened potential sensitivity should be treated as having higher priority. Similarly, populations that are in an unfavourable conservation status will be more sensitive to potential adverse effects and so may also be reasoned to merit higher priority. Information on conservation status includes the periodically revised Birds of Conservation Concern lists (Eaton et al 2009), RSPB's annual 'State of the UK's Birds' Reports[2], species listed in the UK Biodiversity Action Plan, the Seabird Colony Register (Seabird Monitoring Programme, available from JNCC[3]) and assessments made by SNH/JNCC for individual SPAs (e.g. Seabird Population Trends and Causes of Change: 2010 Report[4]).

Geographic context and legislative protection also come together in the consideration of a site's importance, if any, to sustaining qualifying SPA populations. There is no convention regarding the proportion of an SPA population that needs to be regularly present on a site for it to be regarded as important to sustaining that SPA. Nevertheless it is self evident that the greater the proportion regularly using a site the greater potential there is for a development to impact on an SPA and therefore the greater the importance of the site. In practice information on the magnitude (or likely magnitude) of connectivity for a species between a development site and a SPA (see Section 8.11) is required and needs to be factored into reaching a reasoned judgement on a site's importance.

[2] Available from http://www.rspb.org.uk/ourwork/science/sotukb/index.aspx
[3] http://jncc.defra.gov.uk/page-1550
[4] Available from http://jncc.defra.gov.uk/page-3201

4 POTENTIAL IMPACTS

4.1 Range of impacts

There is a range of wave and tidal energy generation devices in production or in testing and these differ greatly in their design, size and deployment; which in turn changes how they can potentially impact on birds. There is currently very little operational experience or empirical evidence concerning how wave and tide devices may affect birds. To a large extent then, the potential effects of wet renewable technologies on birds are currently hypothetical, unproven and based on a combination of comparison with other marine activities (shipping, oil, wind farms) and perceived risks (Grecian et al. 2010).

The Scottish Marine Renewables SEA 2007 (Faber Maunsel and Metoc 2008). describes how tide and wave devices might impact birds and the topic was reviewed by Grecian et al. (2010). Wilson et al. (2007) review the potential for collision effects with diving birds. Effects may occur during construction, operation & maintenance or decommissioning. In most cases the effects may be adverse but there is also potential for beneficial effects to occur.

The potential effects on birds identified are in the main the same for both tidal and wave energy devices. The potential effects of wet renewable developments are in many cases the same, or closely related to, the effects of other marine developments. With the obvious exception of the higher collision risk to flying birds (wet renewable developments are generally regarded a posing no or only a low collision risk to flying birds), the response of birds to offshore windfarms gives some insight as to how seabirds are likely to respond to wet renewable developments (e.g. Fox *et al* 2006, DECC 2009 Offshore Energy SEA). Despite the lack of experience with tidal and wave devices most of the potential effects on birds are not novel, though the scale of deployment may exceed what birds have previously experienced. The risk of collision for diving birds with marine tidal turbines is unknown, Further work on this issue is required. The main potential effects of these developments on birds are discussed briefly below. The discussion reflects the limited knowledge concerning the effects on birds, a situation which will change as experience of operating wet renewable technologies increases.

4.2 Nature of impacts

An effect may be adverse, neutral or beneficial to a species and can act in a direct or indirect way. In the identification and assessment of potential effects the manner in which they are likely to affect a species should be broadly understood (it is usually obvious). The priority focus for information requirements should be in understanding and quantifying likely adverse affects. However, understanding and quantifying neutral and beneficial effects is also relevant because without this it is not possible to give unbiased predictions concerning the likely overall affects of a development on a species.

4.3 Construction impacts

4.3.1 Increased turbidity

Construction (and decommissioning) is likely to disturb seabed sediments (if they are present) and cause temporary increase in turbidity. In theory this could adversely affect seabirds that rely on eyesight to hunt fish. Even though it is unlikely that this will be a serious issue, as very fine sediments are not usually associated with high energy locations, this impact should be considered.

4.3.2 Noise

Construction (and decommissioning) is likely to create noise, both sub-surface marine noise and air borne noise. There is no evidence that diving seabirds, unlike marine mammals, use auditory signals to navigate underwater or become disorientated by marine noise. . However birds are sensitive to airborne and underwater noise and this could temporally displace birds from the vicinity of construction activities. In most cases, it is unlikely that this will be a serious issue for any species unless the source was close (<1 km) to breeding sites or important feeding areas. Furthermore, indirect effects on birds are possible through impacts on prey populations (especially fish).

4.3.3 Other effects during construction

Other potential impacts during construction include disturbance and displacement, habitat change, night time illumination and contamination. These all potentially occur during operation stages and so are covered in more detail in the next section. The effects of these things are likely to differ between construction and operation stages, reflecting differences in their duration and intensity.

4.4 Operation impacts

4.4.1 Collision risk

It is not currently known whether collision with tidal turbines or wave devices could lead to death or injury of birds. There is an obvious theoretical risk that diving birds could collide with operational tidal turbine blades and be injured or killed. The risks of collision risk from floating type wave generation devices such as the Pelamis design are also unknown but experience suggests that they are likely to be negligible. This is because such devices are similar (from a bird's perspective) to other relatively large man made floating objects that marine birds regularly encounter with no apparent adverse effects (e.g. boats, buoys, floating piers).

There are also theoretical collision risks for flying birds colliding with construction or maintenance vessels and static parts of infrastructure protruding above the water. However, these risks are the same as those posed by marine vessels and modest static structures in general and there is no evidence that these present more than a minor collision risk.

Under water collision risk with tidal turbines can be informed by hypothetical calculations of how much time birds are estimated to occupy the same water space as a turbine rotor and making various assumptions (Wilson et al. 2007). However, such models may not be realistic without taking into account avoidance and evasion behaviour by diving birds. There are currently no measures of these parameters, and there are considerable practical difficulties in obtaining them. Given that underwater visibility and light intensity at the turbine depths are likely to be low, it is possible that diving birds may not normally detect rotors until they are very close, possibly too close to take evasive action. Although some marine mammals use active acoustics to detect underwater obstacles, there is no evidence that diving birds do likewise.

The current uncertainty regarding the effects of marine turbines on diving birds is expected to reduce as the results of research become available. Meanwhile, assessment of the risks posed to diving birds should be precautionary.

4.4.2 Disturbance, displacement and barrier effects

Disturbance may consist of active disturbance caused, for example, by human activity temporarily displacing birds from an area and causing birds to expend additional energy and use time for movement rather than feeding and other activities. It also includes more passive disturbance; for example, birds choosing to avoid the vicinity of a development, which effectively causes displacement from habitat and so is akin to habitat loss.

Large developments can potentially create barrier effects, preventing the free movement of individuals across their normal range and preventing birds from accessing areas of habitat. At present, this is only a hypothetical risk but large arrays of floating wave generation devices could potentially cause a barrier effect to birds that relocate between areas by swimming, for example during flightless moult periods or when attending dependent young. Barrier effects at large offshore wind farms have been demonstrated to affect some flying birds (Christensen et al. 2006). It would appear likely that marine turbines will not form an important barrier effect to any bird species.

With time, some birds, including seabirds, can habituate to regular disturbance. The likelihood that a proposed development will cause important disturbance effects will therefore be partly influenced by the existing background level of disturbing activity e.g. vessel traffic.

4.4.3 Habitat change

Direct habitat loss may occur if the development leads to changes in the local habitats, such as the nature of the sea-bed. Habitat loss implies the destruction of habitats upon which certain wildlife depends. In this case, it is probably more realistic to think in terms of habitat change or enhancement resulting from the introduction of an artificial reef. Such changes have the potential to disadvantage some species and benefit others. In addition, negative habitat losses can occur through scour, scour protection, removal of existing kelp etc.

Developments may cause indirect habitat changes that could affect birds. Changes brought about through the development may attract some seabird species, akin to habitat gain. For example, if the turbine design employed has structural elements above the sea surface then these are likely to attract certain bird species that require perches for resting.

Perhaps the largest habitat change effect on birds is the potential for devices and associated structures (anchors, foundations etc.) to act as an artificial reef environment, providing shelter for fish and other animals and providing new surfaces for epibenthic colonisation. They will also alter the dynamic of current flows and wave action perhaps providing shelter for fish. Although changes that improve conditions for small fish could potentially enhance feeding conditions for some seabird species, there is also a hypothetical risk that they might attract diving species into the vicinity of marine turbines, possibly increasing the potential for collision risk.

4.4.4 Navigation lights

Navigation lights on fixed marine structures or on service vessels have the potential to attract or disorientate flying birds at night and interfere with normal navigation behaviour. Bright lights, especially red lights, can be a serious problem for migrant birds in certain weather conditions, at times leading to disorientation and, occasionally, large mortality events (Percival 2001). Given the scale of wet renewable developments, effects of navigation lights may be small but probably no greater than those for offshore wind farms. Lighting on vessels during any nocturnal construction work is liable to present a more marked concentration of a potential spatial impact, albeit restricted temporally.

4.4.5 Indirect effects

The presence of tidal turbines or wave devices may lead to a number of localised changes in the ecology of the site. The devices will remove a proportion of the tidal or wave energy; and this can potentially lead to large and important changes in the environmental conditions.

Wave devices have the theoretical potential to alter the ecology of exposed wave-washed shores that are important for birds such as waders. The potential magnitude of such effects is unknown but could adversely affect birds if high enough to reduce the amount of seaweed dislodged and washed ashore or interfere with sediment processes. Based on limited existing projects and modelling studies, it is estimated that wave devices could impact on wave energy up to 20 km away (Faber Maunsel and Metoc 2008).

4.4.6 Contamination

Wet renewable developments could lead to contamination of the marine environment by litter, toxins from antifouling paints and oil. All these could have lethal or sub-lethal effects on seabirds. Oil pollution is well known as a serious problem for seabirds and could potentially result from the leakage of gear or hydraulic oils from generation devices, or from ships colliding with devices. The risks from contamination from wet renewables are essentially similar in nature to those from other marine developments and activities. As such, they are relatively well understood and addressed by existing marine legislation and codes of practice. Provided these are adhered to, contamination is unlikely to be a serious issue.

4.5 Decommissioning impacts

The impacts associated with the decommissioning phase will often be similar to those for construction, and will include increased noise and turbidity during the removal of structures, and the risk of accidental spillage of toxic chemicals. Many of the impacts associated with decommissioning are likely to be short term.

5 APPROACH TO INFORMATION GATHERING

The process leading to assessment of likely affects of a proposed development and subsequent monitoring should follow a staged process as outlined below. At all stages it is important to be clear what the objectives are and to ensure that, starting with scoping, the work programme follows a logical and well reasoned progression ending in a comprehensive assessment.

5.1 Scoping

Scoping should outline the type and scale of proposed development and describe where it is proposed to be located and why. Guidance on scoping requirements is given in Marine Scotland EIA guidance[5]. The likely species, habitats and proximity to designated sites that might be affected should also be described taking into account the nature and scale of the development (and consequently risks to marine birds). It is also important to identify all other developments (consented or proposed) that may need to be considered during CIA Scoping, i.e. not just other wet renewable developments. This should identify likely effects, which species are likely to be affected and whether this could plausibly affect the interests of designated sites. Scoping should also clearly set out the information that will be required in order to undertake assessment and state the intended sources. Intended sources are likely to be a combination of existing data and new baseline survey data specifically collected for the project. Similarly, scoping should also set out what information will be required for post-consent monitoring. The methods proposed to gather field surveys data including details of effort and analyses should be explained.

5.2 Reconnaissance visits

It is strongly recommended that at least one reconnaissance visit is undertaken to the site by suitably experienced persons before baseline survey work commences. The purpose of reconnaissance is give an early opportunity to examine the site and to confirm that the proposed scope of survey work and methods is suitable and practical. If proposed methods have elements of novelty, reconnaissance visits provide a chance to undertake survey trials and adapt methods as required. Experience has shown that reconnaissance visits can

[5] http://www.scotland.gov.uk/Publications/2010/09/16112721/4

highlight issues that project designers were not aware of or had not anticipated, and can therefore lead to better project design and method improvements, together with increased confidence that the proposed programme of work is deliverable.

5.3 Field survey work

Field surveys are required to establish base-line conditions and later to monitor changes in conditions should a project be consented/licensed. Developers and consultants should be clear about the dual purpose of establishing baseline conditions and the difference between the needs of these two purposes. The first purpose is to provide information to help make the assessment of the effects on birds of the proposed development that will form part of an Environmental Statement accompanying a planning application. The second purpose of baseline surveys is to provide a bench mark against which post-consent monitoring information can be compared and so establish in a credible way if the development leads to important changes in bird populations. Although the two purposes are distinct there is likely to be considerable overlap in the survey work required for each, hence it is likely that some survey work will simultaneously serve towards both ends, but there are also likely to be differences. For this reason considerable care is required to ensure that both purposes are met. In almost every case, the survey needs will be dictated by the consenting/licensing process, hence baseline survey for post-consent monitoring may also be necessary, but should not drive the methodology at the expense of the consenting/licensing process. Survey work should provide the data required to identify potential impacts on key species and sites, and potential mitigation measures. It may also identify a need for additional survey work.

5.4 Assessment

Assessment follows on from the information gathering stage. It is beyond the scope of this document to go into details. Assessment is first required to predict the effects of a proposed development and this will form part of the ES to support consent applications. Further assessment may also be required post consent, depending on the terms of conditions of consents/licenses.

6 KEY QUESTIONS FOR SURVEY AND MONITORING

6.1 Information needs and scoping

The key questions to be addressed by the pre-consent EIA process are what are the likely impacts of a development and are these acceptable (Tables 6.1 and 6.2). Baseline information from survey work must be adequate to answer these questions. The key questions to be addressed in post-consent monitoring are what are the impacts of a development and are they acceptable (Tables 6.1 and 6.2). The data requirements for post-consent monitoring may be similar to pre-consent data requirements but they are unlikely to be the same. It is essential that developers and their consultants are clear when designing survey programmes what the purpose of survey work is, and what requirements have to be satisfied. The scoping process should distinguish between the two objectives (establishing baseline conditions and monitoring changes) and make clear the specific purpose for which proposed survey work is intended and how methods may need to be adapted as appropriate.

For any EIA or HRA, the aim of survey work is to provide information that will be sufficient to enable an assessment of the various potential effects that arise.

6.1.1 Cumulative impacts

In addition to the effects arising from a development under consideration, scoping, and later assessment and monitoring, must also consider the potential for cumulative impacts with other developments. The other developments considered should not be limited to other renewable energy projects, and must consider both consented and proposed developments. It is recommended that the guidance on assessing cumulative impacts produced by COWRIE is followed (King et al 2009).

Table 6.1. **Questions that should be addressed by surveys to collect information for baseline conditions and post-consent monitoring and likely method differences between them.**

Baseline conditions question	Post-consent monitoring question	Method differences/comments
Which species occur in the survey area (i.e. the site and its vicinity);	Does species composition significantly change following construction /operation	None.
What is the abundance of the species;	Does abundance of species significantly change following construction /operation	None subject to effort considerations required to detect change in key interests.
How does abundance vary spatially across the survey area;	Does spatial distribution of species significantly change following construction /operation	None subject to effort considerations required to detect change in key interests.
How does abundance vary temporally (seasonally especially, time of day and state of tide may also be relevant);	Does temporal patterns of occurrence of species significantly change following construction /operation	None subject to effort considerations required to detect change in key interests.
Which habitats do birds use, (surface, mid-water, seabed, air-space etc);	Does habitat selection at a development site significantly change following construction /operation	None
Why do birds use a survey area and at which life-cycle stages are they present (i.e. what is their behaviour and purpose for being there)	Do species significantly change their behaviour or reasons for using the site following construction /operation	None
What are the origins of birds using the study area (where do they breed, what other areas do they use, i.e. connectivity).	Not relevant as unlikely to change in response to a development	Standard surveys of distribution and abundance are unlikely to provide good information on connectivity to breeding sites. This subject is best addressed by tagging studies.
What human activities occur in the study area and how do birds respond to them (e.g. vessel traffic, fishing);	How do human activities at the site change following construction/operation (be they associated with the development or not), and what behavioural changes occur in response	None subject to effort considerations required to detect change in key interests. It is important to collect data on other human activity so that the effects of changes to this can be factored into monitoring analyses.
Does a study area have any habitat features that appear to be particularly important to birds (e.g. tide races, skerries, sheltered bays, nest sites).	Do features identified in baseline surveys as important continue to be so?	None subject to effort considerations required to detect change in key interests.
Not relevant	Do species initially affected by displacement show habituation to the development with time.	Time series data are required to show habituation. Standard survey methods likely to be suitable.

Baseline conditions question	Post-consent monitoring question	Method differences/comments
Not relevant	For breeding species potentially affected by a development, are there changes in breeding numbers or productivity at corresponding breeding sites (e.g. nearby colonies), and if so is there evidence that these are caused by the development.	Time series data are required of colony sizes and productivity of potentially affected breeding sites and control sites. This is potentially a large and difficult question to address and will require careful study design to give robust conclusions.
Not relevant	If death or injury from collision risk has been identified as a potentially serious issue for a species, what is the magnitude of the actual effect?	Quantification of birds killed or injured.

6.1.2 Pre-construction baseline surveys

The assessment process should consider whether any stage of a development is likely to have an adverse impact on marine bird populations. The process needs to address the following questions:

- Are adverse effects on species of high or medium conservation importance likely to be rated as significant under the EIA regulations;
- Is the site used by birds from SPA populations which will require a Habitat Regulations Appraisal under the Habitats Regulations;
- Are any development activities likely to have an impact which might be illegal under the Wildlife and Countryside Act 1981 (as amended)

Pre-construction baseline surveys should provide sufficient information to ensure that, together with existing information, all these questions can be answered with an appropriate degree of confidence. In particular, pre-construction baseline surveys should provide information to:

- Identify which species of high and medium conservation importance occur on the site, in what numbers, when they are present and for what purpose.
- Identify if the site is used by individuals from SPA populations and if so in what numbers, when they are present and for what purpose.

- Identify if any species listed on Schedule 1 of WCA are likely to be disturbed at their nesting sites by development activities.

Pre-construction surveys should aim to provide baseline information across a proposed development area for all marine bird species. However, existing information examined during scoping may identify species of special concern in which case baseline surveys should pay particular attention to ensuring that the information-needs to assess these species are met.

6.2 Post-consent monitoring

Post-construction monitoring studies will normally be more focused than pre-construction baseline surveys. The focus should be on those species identified through the pre-construction assessment process to be of concern. The minimum post-construction monitoring requirements are likely to be set out as conditions in the consents/licences, including the Marine Licence (post March 2011)

Monitoring should aim to quantify the magnitude of any changes and provide evidence to demonstrate whether changes, should they arise, can be attributed to the development or have occurred for other reasons. This will necessitate careful study design including consideration of the need for some form of control (see Section 8.7). It may also involve predictive modelling.

Specifically post construction monitoring studies should provide information on:

- Changes to the abundance, distribution or behaviour of species considered to be of high or medium conservation importance;

- The extent to which predicted adverse effects such as disturbance and collision mortality are realised; and

- The extent to which, over time, species affected by disturbance and displacement habituate to the presence of a development.

Table 6.2. Key assessment questions to be addressed for marine birds relating to Ecological Impact Assessment (EIA), Wildlife and Countryside Act (WCA), Habitat Regulations Assessment (HRA) and Impact Monitoring (IM).

Task	No	Question
EIA	1	Are any bird species regularly present in the development area and near vicinity (buffer area) that merit classification as species of high or moderate Nature Conservation Importance (see Table 3.1)
EIA	2	What is the spatial distribution of these species in the development area and near vicinity (buffer area)?
EIA	3	What is the abundance of these species in the development area and near vicinity (buffer area)?
EIA	4	What aspects of their biology and life cycle do these species use the development area for?
EIA	5	Where are the nesting sites of individuals of these species that use the development site?
EIA	6	How will the populations (regional or national, depending on areas importance) of these species be affected by the development?
EIA	7	What would be the significance of the impacts on these species' population (regional or national, depending on areas importance)?
EIA	8	What mitigation measures might avoid or offset predicted adverse effects on these species?
EIA	9	Are there likely to be cumulative impacts with other developments on species' populations?
WCA	1	Are there activities associated with a proposed development that may be illegal under the Wildlife and Countryside Act as amended, in particular disturbance of WCA Schedule 1 species?
HRA	1	Do birds from SPA populations regularly use the development area or near vicinity. If so, which SPA(s) and which qualifying features are involved?
HRA	2	What proportion of the SPA population(s) plausibly effected use the development area and near vicinity?
HRA	3	Could the proposed development have an adverse effect on site integrity of any SPAs and if so how?
IM	I	Has there been significant change in the distribution and abundance of high and medium Nature Conservation Importance species in the development area and near vicinity that may be attributed to the development?
IM	2	What is the cause of changes to distribution and abundance of high and medium Nature Conservation Importance species attributed to the development?
IM	3	Do the results of impact monitoring over time show evidence of habituation by birds to potential disturbance from operation of the development?
IM	4	Do the results on impact monitoring point towards mitigation measures that could avoid or reduce adverse effects attributed to the development in question or provide useful lessons for other developments?
IM	5	Are there cumulative impacts with other developments on specie's populations?

7 EXISTING INFORMATION AND DATA SOURCES

7.1 Information required

There are considerable amounts of existing information on the distribution, abundance, status and sensitivity to developments of marine birds and this should be fully used to inform scoping, EIA assessment and post-consent monitoring. Existing information may include the development site itself or a wider area. Wider area information is particularly important as it enables site specific information, including that from baseline surveys, to be put into a wider context. Existing information for development sites is very unlikely to be sufficiently detailed or up to date to negate the need to undertake new baseline survey work. Nevertheless, it may affect the design of baseline surveys, i.e. so that maximum value can be made of existing data.

Considerable survey information exists on marine birds collected by government and non-government bodies. This can provide a good basis for establishing the likely ornithological interests of a site at the scoping stage. Additional contextual information can come from many sources including colony censuses, ringing and electronic tagging studies.

7.2 Databases

Extensive databases on seabirds and the marine environment are managed by various organisations, most of which are accessible online. Those of most relevance to tide and wave renewable projects are listed below:

7.2.1 Government sources

JNCC databases:

- Seabird monitoring online database programme (http://jncc.defra.gov.uk/smp/);
- Seabird and seaduck http://www.jncc.gov.uk/page-1530;
- Seabird colony data http://www.jncc.gov.uk/page-4460;
- Inshore aggregations of non-breeding waterbirds http://www.jncc.gov.uk/page-4563;

- Offshore aggregations of seabirds http://www.jncc.gov.uk/page-4564; and
- Seabird Population Trends and Causes of Change: 2010 Report - latest analysed trends in abundance, productivity, demographic parameters and diet of breeding seabirds, from the *Seabird Monitoring Programme*, along with interpretive text on the likely causes of change based on the most recent research.

SNH databases:

- SNH sitelink website. Information on designated sites, including downloadable GIS files of site boundaries. www.snh.org.uk/snhi/.

Scottish Executive:

Marine Renewables SEA http://www.seaenergyscotland.co.uk/ .

Dept of Energy and Climate Change

- offshore SEAs http://www.offshore-sea.org.uk/site/; and
- Marine Spatial Plans (when available*).*

7.2.2 Non-government sources

Marine Biological Association databases:

- MarLIN - Marine Life Information Network - quality assured information on marine biodiversity ' http://www.marlin.ac.uk/.

European Seabirds at Sea Data Base Co-ordinating Group (ESAS):

- OBISSEAMAP (Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations). This online database includes regional, national and international atlases for seabird and other marine taxa http://seamap.env.duke.edu/.

Bird Life International

- BirdLife Seabird Foraging Range Database - http://seabird.wikispaces.com/ .

British Trust for Ornithology databases:

- WeBS database (Wetland Bird Survey). http://www.bto.org/volunteer-surveys/webs ; and
- NEWS database (Non-Estuarine Coastal Waterbird Survey) http://www.bto.org/survey/complete/news/news2.htm .

- Ringing recoveries database http://www.bto.org/volunteer-surveys/ringing/publications/online-ringing-reports

Scottish Raptor Monitoring Group databases:

- Breeding locations of raptors http://www.scottishraptorgroups.org/raptors/ .

Royal Society for Protection of Birds databases:

- Various datasets on terrestrial and coastal birds; http://www.rspb.org.uk/ and
- Beached Bird Survey, monitoring data on numbers seabirds found dead along the coast. http://www.rspb.org.uk/ourwork/projects/details/203916-national-beached-bird-survey

7.3 Literature

Basic information on status and distribution of marine birds and their biology is summarised in various published in books and reports. Of particular relevance are the following:

- Birds of Scotland (Forrester and Andrews 2007), synthesis of status of all birds recorded in Scotland;
- Birds of the Western Palearctic by Cramp and Simmons (1977 to 1994). Multi-volume work constituting the definitive reference on birds in Britain and Europe;
- Seabird Populations of Britain and Ireland (Mitchell et al. 2004), results of Seabird 2000, the most recent census of seabird breeding colonies in Britain and Ireland;
- Migration Atlas (Wernham et al. 2002). Synthesis of knowledge on bird migration and movements based on analyses on ringing data;
- Atlases of seabird distributions produced by JNCC (e.g. Stone et. al 1995, Skov et al. 1995);
- Annual regional and national bird reports published by regional bird clubs and Scottish Ornithologists Club;
- COWRIE reports. COWRIE is an offshore wind industry group which as produced numerous reports on bird surveys and assessment methods. Whilst these are aimed at offshore wind farm developments many are to a large extent relevant to wet renewable development also - www.offshorewindfarms.co.uk.

7.4 Organisations

Besides the information they manage the following organisations are of particular relevance to wet renewable development projects as they have staff familiar with particular areas, who may be able to help with specific enquires.

- Scottish Natural Heritage (SNH);
- Marine Scotland (MS) Licensing Operations Team (LOT);
- Joint Nature Conservation Committee (JNCC) – Seabirds at Sea Team;
- Royal Society for Protection of Birds (RSPB);
- British Trust for Ornithology (BTO);
- Scottish Ornithologists' Club (SOC).

8 FIELD STUDY DESIGN

8.1 Need for study design

8.1.1 Importance of study design

Study design is an essential early stage in every project and aims to ensure that survey and monitoring programmes are fit for purpose, providing information that is scientifically robust and credible to inform decision making. Study design concerns which methods to use and where and when to deploy them and how much survey effort should be expended. It also concerns the need for information from control or reference areas. Survey design will be determined by a project's information requirements, scientific considerations, and the practical constraints and expected bird life of the area of interest. These will differ for every development and therefore the guidance can not be overly prescriptive regarding the design of survey programmes. However, there are some norms for some elements of study design, for example regarding certain details of boat-based surveys and aerial surveys of birds at sea. Although these norms will provide a good starting point for the study design process they should not be adopted out of hand, rather they should be critically assessed as to whether they are appropriate for a particular project.

8.1.2 Holistic project design

Survey design applies not only to each of the individual types of survey work that may be required for a project but also to the design of the overall survey programme and how the various components relate to each other. Survey design also needs to recognise the need to maintain a degree of flexibility; for example design changes may need to be made in response to new information or changes in circumstances.

8.1.3 Inherent variability

The use of sites by marine birds is often naturally highly variable and this can make it difficult to attribute changes to a particular cause (such as a development). If scientifically valid conclusions are to be drawn from monitoring concerning the effects of development, study design must take into account natural variation and change due to other causes. If this is not done then monitoring results are likely to be of little value as they are likely to lack the power to either detect change or identify the causes.

8.1.4 Overlap in survey aims and coverage

Baseline surveys of distribution and abundance may be required to serve a dual function of providing information for EIA and HRA and to provide data against which to compare future post-consent monitoring data. Although in practice there will be a high degree of overlap between meeting the requirements of both these, the requirements are not necessarily the same. For example, pre-construction data from some form of reference areas may not be required for the pre-consent EIA/HRA process. However, it may later be essential for comparison with post-construction monitoring data. From the start the study design process should take a holistic view of the overall project, assess the data requirements of all stages and ensure that these are appropriately integrated and that opportunities to collect data are not lost. For most projects, there will be many years available to collect post-construction data but the opportunities to collect pre-construction data are likely to be restricted to few years at most.

Post-consent monitoring studies should target the development site and appropriate nearby areas identified in the study design process to provide sufficient scientific context (i.e. buffer zones and control areas if these are being used (see sn 8.7)). Normally these will be the same areas that were covered by baseline pre-construction surveys. Sometimes monitoring will also be appropriate at more distant sites that may be affected by a development, in particular seabird breeding colonies that are likely to be linked to the development area.

The design of monitoring studies should take into account other planned survey work, such as national surveys, and where possible integrate work.

8.1.5 Role of statisticians

It is beyond the scope of this guidance to explore in detail all aspects of study design – this is a large subject and can require the application of relatively complex statistics. For this reason, it is strongly recommended that statisticians are consulted over study design. Nevertheless it is relevant to discuss some of the guiding principles of study design that need to be considered and indicate what is current normal practice, especially for the generic baseline surveys that are likely to form the core of survey work. In mind here are boat-based, shore-based and aerial surveys of birds on the sea, though many of the principles apply equally to other survey types. **The importance of careful study design can not be overstated. The reasoning behind the choices made in study design should be recorded and presented as part of the reports on survey work.**

8.2 Temporal considerations, sampling frequency

Surveys of the distribution and abundance of marine birds on the sea to inform wet renewables projects will normally consist of a series of repeated survey visits extending over two or more years for site characterisation surveys, and over longer for monitoring purposes. The timing of survey visits needs to be carefully planned so that they are as temporally representative as possible. Sampling should be representative of the three main temporal cycles: time of day, time of year and state of the tide.

8.2.1 Time of day considerations

Time of day considerations are not usually specifically considered in generic marine bird surveys, survey work occurring at any time during daylight hours. Nevertheless survey work should as far as possible be evenly distributed through the day.

For some non-generic surveys, for example black guillemot colony counts (undertaken at dawn), time of day is an important consideration. This will also be the case if petrels and shearwaters are breeding in the vicinity of a development as they only visit colonies at night and therefore are likely to be more prevalent on the sea near colonies at certain times of day. For developments close to seabird colonies (within 4 km) it can be best to avoid the very early and very late periods of the day during the breeding season. Since sampling an area must be done progressively over the period of one day it is best to do this during the period of lowest fluctuation in numbers of birds, thus the period immediately following dawn and preceding dusk should not form part of a larger survey within a day.

8.2.2 Seasonal stratification

Generic distribution and abundance surveys of marine birds should cover all seasons of the year. It is common practice to undertake regularly spaced visits, for example boat-based surveys are often undertaken at monthly intervals through the year. This has the advantage of making no assumptions over seasonality but may not be the optimum regime. Although there is variation between species, many marine birds follow a broadly similar annual timetable with regard to breeding, moulting, migration and wintering. Therefore, it can make sense for the survey timetable to reflect this, dividing the year up into periods based around the main annual stages. A suggested division into eight sampling periods is shown in Table 8.1. In some cases it may be possible to reduce the number of survey periods to seven by combining two of the survey periods in the non-breeding season. The dates shown in Table

8.1 are necessarily approximate, the actual dates adopted, particularly for the breeding season stages, should be determined according to the key species of interest, local timing of breeding and latitude.

Table 8.1. **Division of the year into periods for marine bird surveys. Note, the breeding season labels do not accurately describe the phenology of shearwaters, petrels and gannets; these species usually fledge in September.**

Year period	Description	Approximate dates
1	Mid winter	January and February
2	Late winter	February and March
3	Early breeding season	April – mid May
4	Mid breeding season	Mid May – mid June
5	Late breeding season	Mid June – end July
6	Post breeding/moult	August to mid September
7	Autumn	Mid September – October
8	Early winter	November and December

The frequency that each period is sampled should be addressed in survey design. In the case of aerial and boat-based transect surveys, each period should normally be surveyed at least once per year. If a period is sampled more than once in a year then there should be an interval of at least 1 week between visits to allow for redistribution. It may be appropriate to increase sampling frequency at times of year when key species are likely to be present or during periods of particular sensitivity. For example, if breeding seabirds are the key concern then more regular sampling in the breeding season might be appropriate as it will yield higher quality data allowing better assessments and greater sensitivity of detection of effects.

8.2.3 Tidal stratification

The extent to which tidal state (high - low cycle and spring - neap cycle) should be explicitly taken into consideration in the survey design will depend on strength of the tidal influence at the site. Survey work at sites with a strong tidal currents (this is likely to be the case at all tidal energy development sites) should be designed to give equal coverage to all parts of the tidal cycle. The ebb/flow tidal cycle should be stratified into a number of periods for planning survey work, with the aim to undertake equal survey effort in each. A division into six equal periods, each of approximately 2 hours, is recommended as defined in Table 8.2. It is recommended that the sampling regimes for shore based vantage point (VP) surveys should be stratified by year period and tide period.

Table 8.2. **Division of tide cycle into six tidal periods**

Tide period	Description	Notes
1	High, ebb	Starts at high tide
2	Mid, ebb	
3	Low, ebb	Ends at low tide
4	Low, flow	Starts at low tide
5	Mid, flow	
6	High, flow	Ends at high tide

Although achieving even survey coverage with respect to tide cycles is recommended, the practicalities of this for boat-based surveys may have to be tempered by the constraints of operating survey vessels in strong tide currents (these will not affect aerial or VP surveys). In conditions of strong tidal currents (>ca. 8 knots), it is likely that vessels will have difficulty in keeping to survey tracks or maintaining velocity. Although these practical problems can be reduced through avoiding periods when currents are strongest (mid tide during the Spring tide series), this would cause these times to be underrepresented. The problem can also be reduced to some extent by choosing transect line orientation that are at right angles to peak current flow.

8.3 Temporal considerations: survey duration

8.3.1 Baseline surveys

The duration of baseline surveys should be adequate to cover the typical annual variation that occurs at the site. The distribution and abundance of marine birds can be highly variable year to year, particularly in offshore areas. For this reason assessment of baseline conditions should be based on a minimum of two years survey data. Two years baseline has become the norm for offshore wind farm surveys. If results from year 1 and year 2 are very different from each other further survey years may be required so that a more representative averaged description of baseline conditions can be calculated.

Where existing and comparable survey data <5 years old are available these may be used for the assessment of baseline conditions and in which case <2 years new survey data may be sufficient.

8.3.2 Post consent monitoring

To take account of short-term and long-term effects on bird populations, it is recommended that post-consent monitoring for displacement effects should be required in years 1, 2, 3, 5, 10 and 15 of the life of a wet renewable development (this is consistent with the guidance for onshore and offshore wind farms).

8.4 Development site boundary

Surveys to establish baseline conditions should cover the whole of the proposed development area plus any buffer areas or reference sites, if used (see below). A proposed development site will have a lease boundary and this will be the starting point for designing an appropriate survey methodology. The boundary must include the entire area where generation devices could potentially be installed. Consideration must also be given to whether other aspects of the infrastructure effectively extend the boundary, in particular cable routes and shore facilities.

The area that should be covered by post-consent monitoring surveys will depend on the consent conditions and aims of the monitoring. Under most circumstances it is likely that post consent monitoring surveys will cover the same areas as baseline surveys.

8.5 Access routes

The assessment and monitoring of the effects of a development should consider the potential for all impacts on marine birds. In some cases there will be obvious potential for human activities associated with the development but occurring outwith the development area to affect birds and the need for additional surveys in such areas should be addressed at the study design stage. The most obvious example of this is vessels travelling to and from a development site as these could potentially cause disturbance to sensitive aggregations of birds along the route. In many cases, existing information is likely to be adequate to identify sensitive sites at the scoping stage (e.g. SPAs) and if operational protocols can avoid such areas concerns would be allayed. In other cases, scoping and consultation may identify a need for survey information along potential routes, in which case, this will need to be included in the overall study design.

The potential for disturbance by vessels associated with a development to affect bird distribution and abundances should also be factored into the study design considerations of the choice of comparison areas (see Section 8.7).

8.6 Survey buffers and references site

All surveys require the inclusion of an appropriately sized buffer surrounding the development site. In some cases the inclusion of reference site(s) may also be required to comply with monitoring programme included in any consent conditions. It is not possible to give firm guidance on the need for reference sites as this will be determined by the results of EIA and how consenting authorities decide predicted effects should be monitored, if at all. General guidance in the form of the underlying principles of buffers and reference sites in survey design is provided in the BACI and BAG section below.

8.6.1 Buffers size and shape

The inclusion of a buffer in surveys provides information on the birds using the area immediately surrounding a development. Buffers potentially serve multiple purposes and it is through consideration of how these purposes can be met that the most appropriate choice of buffer size and shape can be decided.

The first purpose is to extend the survey to cover areas contiguous with the development area where birds may potentially also be adversely affected. Birds outside a development boundary may be adversely affected because either they respond at some distance from the boundary to infrastructure or the development causes change in the environment beyond the boundary, particularly 'downstream' effects. The second purpose of a buffer is to reduce the importance of uncertainty in determining exactly where birds are; it is not uncommon in survey work to be unable to measure locations of birds at sea to a precision less than a few hundred metres. A third purpose of buffers is in Before-After-Gradient (BAG) study designs, to provide reference data at a series of distances from a development (see BAG versus BACI below). A fourth purpose is to provide information that helps put the survey results for the development site into a wider context. Marine bird surveys typically used wider buffers than equivalent terrestrial surveys reflecting the more mobile nature of marine birds and prey resources they depend on.

The width of buffer area chosen will depend on the scale of the development, the sensitivity of the location and the natural geography of the area. It will also be affected by the approach adopted to reference and control areas as in some cases the buffer may serve a dual role (see BACI/BAG section). There are several reasons in favour of a relatively wide buffer.

Another reason in favour of a relatively wide buffer is that should it prove necessary for whatever reason to change the boundaries of the proposed site then collecting data over a wider area reduces the risk that insufficient data will be available to carry out an assessment for the new site boundary. In particular the need for Distance analysis to have a minimum of 10 - 20 survey transects to produce robust estimates of density. At a site too small to include 10 – 20 transects at an appropriate spacing there may be a need to extend the survey area to cover this minimum requirement.

Buffers around sites should not necessarily be symmetrical. For example at wet renewable energy sites with a strong directionality, there are good arguments for having a larger-sized buffer width ‘downstream’ than either ‘upstream’ or perpendicular to the stream, as some effects are much more likely to extend further in the downstream direction than in other directions. So, for example, a near shore wave device development site might have a 500m wide upstream buffer, but a downstream buffer of 1-2 km extending all the way to the shoreline.

8.6.2 Recommended minimum buffers

In open sea situations, it is recommended that, according to their size, development sites have surrounding buffers of at least the width specified as follows:

- sites <5 km^2, a buffer of at least 1 km
- sites 5 km^2 - 10 km^2, a buffer of at least 2 km
- sites >10 km^2, a buffer of at least 4 km

In enclosed situations such as narrow sea channels (this is most likely to apply to tidal energy developments) the same guidance applies except that marine buffers should not extend into terrestrial areas

For near-shore (<4 km) wave energy developments along open coasts it is recommended that the buffer is asymmetric, having a width of at least 1 km seawards (upstream) and at either end, and extending all the way to the shore landwards (downstream).

8.7 BACI versus BAG monitoring designs

In order to robustly establish and measure the magnitude of any effects of a development on birds some form of comparative data are required for areas away from the development site. The need for comparative information needs to be considered from the earliest stage as it fundamentally affects survey design. In particular careful consideration should be given to whether a Before-After-Control-Impact (BACI) or a Before-After-Gradient (BAG) study design is most appropriate with regards to marine mammal or bird survey and monitoring – in particular, the use of control areas for wide ranging species may be potentially problematic due to the size of potential impact areas which may preclude large areas of resources. Where impact zones overlap between two or more adjacent developments, cooperation between developers will be required to enable successful employment of BAG or BACI designs.

The use of BACI type study design is well established in biological impact assessment studies but has limitations. It is advocated in the COWRIE guidance for offshore wind farm bird surveys (Camphuysen, 2004) but the applicability to situations involving far-ranging seabird species has been questioned (Harding *et al.* 2010). Under the most basic BACI design (Green 1979) a sample is taken *before* and another sample taken *after* a possible impact, in the Impact (i.e. putatively disturbed) and an undisturbed “Control” location. However, the lack of both temporal and spatial replication in this most basic design means that no reliable conclusions can be reached with respect to potential impacts. For such conclusions to be possible, samples must be taken at repeated points in time before and after the development (providing temporal replication, Stewart-Oaten et al. 1986, Underwood 1991) and for multiple controls, randomly chosen from comparable locations (providing spatial replication, Underwood 1991, 1994). Collecting data at multiple points in time before and after installation of turbines is standard practise in the monitoring of wind farm impacts, but many previous studies have only used a single control site, which severely limits their usefulness. To allow the magnitude of an impact to be accurately assessed then multiple control sites must be randomly chosen from within the set of comparable sites. This is difficult to achieve. Control areas should have similar baseline conditions to but be independent from a development site, both in terms of environmental conditions and biology, including the individual birds that use them. However, the wide-ranging behaviour of seabirds, in combination with the fact that birds concentrate into a relatively small number of large breeding colonies means that finding multiple control sites which are both comparable to and independent from the development site is likely to be extremely challenging if not practically impossible. Thus if both the development site and control sites fall within the foraging range of seabirds from a single colony then although they may be comparable to one another they will not be independent because birds feeding on the development site can potentially move to the control site, and vice versa, and also any impact on demographic parameters would potentially affect birds using both control and impact sites. However, if development and control sites are sufficiently distant from one another that the birds using them originate from different colonies then they are unlikely to be comparable. Development and control sites must be comparable for any meaningful conclusions to be reached, and so analyses must be able to take into account that control and impact areas are not independent of one another. This is likely to be difficult to achieve within a BACI framework. There will also be serious constraints on finding suitable relatively distant control sites that are not potentially affected by other renewable energy developments.

Although the exact numbers of control areas required for the BACI design to be potentially effective at detecting impact will depend upon the sensitivity required, the minimum number is likely to be in the order of 5-6. Without a large number of controls, accurately assessing the magnitude and spatial extent of impacts is likely to be problematic. The large number of controls required to obtain meaningful results, in combination with the difficulties outlined above with respect to the lack of independence for comparable control sites suggest that the BACI design may be of limited value for monitoring the impacts of wet renewable developments.

The use of a BACI design for monitoring the effect of wet renewable developments is only recommended provided that, for the key species of interest, it can be shown that the condition for control sites to be comparable and independent are likely to be broadly met.

An alternative to a BACI design is a Before-After-Gradient (BAG) study design (Ellis and Schneider 1997, Morrison *et al.* 2008, Manly 2009, Smith 2002, Harding et al 2010) and in many cases this may be a be a more appropriate approach to monitoring the effects of wet renewable developments for mobile species such as birds and mammals. Under such a design all areas within a given radius of the development (or sample areas radiating from the impact site, for example noise may be best monitored 50+ km from the impact site) are monitored before and after installation. Analyses of such data should be able to evaluate the magnitude and extent of potential impacts under the alternative scenarios that changes in impacted and un-impacted areas are independent of one another (e.g. as a result of the additional mortality of birds using the development area compared to the un-impacted areas, or vice versa) or dependent upon one another (e.g. as a result of birds redistributing from more impacted areas to less impacted areas, or vice versa) A BAG design assumes that impacts decline with increasing distance from the source of the impact (the development), a condition which wet renewable developments are likely to meet. Using appropriate statistical analytical methods a BAG design is a scientifically powerful method for establishing the magnitude and spatial extent of displacement and habitat loss effects along a distance gradient provided data are collected along a long enough gradient. It is recommended that professional statistical advice is sought on the details of a BAG design in particular regarding the length of gradient (distance from development) that should be surveyed in order to attain sufficient power to detect changes. With regards to birds for example, it is likely that the distance will be at least 5 km though there have so far been too few examples to establish a norm. An offshore windfarm site in Scotland that is using a BAG design is sampling out to 8 km in all directions (client in confidence). The COWRIE guidance for offshore wind farm surveys (Camphuysen 2004). states “A high resolution grid should be deployed, covering an area at least 6x the size of the proposed wind farm area, including at least 1-2 similar sized reference areas (same geographical, oceanographical characteristics), and preferably including nearby coastal waters (for near-shore wind farms only).” For wave and tidal energy developments the gradient of potential displacement and habitat change effects are likely to be directional to some extent, i.e. they are likely to be greatest along the direction of the predominant tide current or swell. It may be appropriate to take this into account in the study design, for example collecting survey information suitable for BAG but limiting this to a selection of carefully chosen directions (survey corridors).

The Before-After-Gradient study design and subsequent data analysis provide a formal statistical basis for detecting and characterising the impacts of renewable energy developments through examining the changes in the distribution and abundance of birds with respect to distance from the development. A BAG study design has several advantages over BACI for examining the effects of birds in the marine environment, not the least it overcomes the intractable problems associated with finding suitable independent control sites. In particular, within the study area, both the magnitude and spatial extent of impacts can potentially be assessed. Furthermore, the spatial scale of impacts which can potentially be detected is transparent; if the study area extends 8 km from the development, for example, then this is the spatial scale at which impacts due to habitat loss and displacement can potentially be detected. A statistically significant trend in seabird numbers with distance from the development site appearing after a development is built will provide stronger evidence that the development is responsible than a simple comparison of “impacted” and “non-impacted” areas, thereby reducing the chances of mistaking other effects as an impact of the development (Manly 2009). A further merit of a BAG design is that the results of gradient models are easy to interpret and present to regulatory authorities and other stakeholders (Ellis and Schneider 1997). The BAG approach has been used for offshore windfarm monitoring and is advocated by Fox et al. (2006) and has been used for the Horns Rev, Nysted and Arklow Bank offshore wind farms (Peterssen et al. (2006), Barton, Pollock and Harding (2008).

8.8 Transect line considerations

For surveys based on transect sampling, be it from boats or aeroplanes, survey design needs to consider where transect lines are located in terms of their orientation, distance apart (the transect interval) and start points. The aim is that transects should give spatially representative data. This spatial aspect of transect selection is well covered in the Distance Sampling literature (Thomas et al., 2009) and Distance software includes useful survey design routines that are recommended. The COWRIE guidelines on transect interval for boat-based surveys of seabirds at offshore windfarm developments is also applicable to wet renewable developments and should be normally be followed (Camphuysen et al. 2004). The optimum transect interval depends on detection distances, the average size and spacing of bird aggregations and the need for spatial resolution within the survey area.

Transect interval of boat-based surveys should be between 0.5 and 2 nautical miles (0.93 – 3.7km) (Camphuysen et al. 2004). A distance of 2 km is frequently used for offshore windfarm studies. Narrower intervals may be possible for smaller sites but movements of birds between transects becomes increasingly likely as transect width decreases.

Transects are normally orientated at right angles to the principal environmental axes. For surveys relatively close to the shore, the main environmental gradient is likely to be water depth, so transects should be undertaken perpendicular to the shoreline. Local coastal topography and presence of obstacles such as islands will influence transect locations.

Normally transects would form an array of parallel lines across the survey area but other arrangements such as zig-zag (or saw-tooth) routes may be preferable in some circumstances.

8.9 Vantage point positions

For shore-based vantage point (VP) surveys, survey design needs to consider how many VPs are required, how far apart they are spaced and where they should be located.

VPs should be located at positions that give uninterrupted views of the area of interest. If the area of interest is greater than can be covered by a single VP (which is likely) then additional VPs should be located at a distance apart that optimises coverage without undue overlap. Given that detection using binoculars of marine birds will fall off markedly beyond about 700m it is recommended that adjacent VPs along a coast are located between 1 and 2 km apart. The actual distance will depend on local geography and the ease of detection of the key species.

VP elevation is also important. In general, additional elevation improves detection and the ease of estimating distance to birds, but only to a point. Ideally VPs should be between 10 and 25m above sea level. Lower elevations, particularly less than 5m, are not satisfactory for surveying birds more than approximately 250m away. Higher elevations up to 50m or more above sea level may be satisfactory with regard to bird detection and distance estimation but will present the surveyor with a larger apparent area of sea to search (e.g. up to several times the width of binocular field of view) and so make it more difficult to undertake searches systematically in a short time period. Higher elevations will also increase the distance between the birds and the VP.

8.10 Predictive modelling

There is an increasing trend in EIA and post-consent monitoring work to use predictive modelling to better quantify predicted and realised effects of developments. Spatial modelling software may also be relevant to a project to help visualise bird distribution data.

If it is planned to use modelling techniques in the analysis stage the likely types of data and the format they are required in should be factored into study design.

8.11 Connectivity with designated sites

The subject of connectivity to designated sites is discussed on a generic level in Section 2.6. Further to this, the following information regarding tagging studies is also relevant to birds:

Tagging studies are rapidly improving knowledge on connectivity. For many large seabird colonies relatively large samples (>20) of individuals of the main species been tagged and produced very detailed and unbiased information on their movements, for example where they feed and flight routes. As a result available guidance is likely to change in light of new information as it becomes available.

The following approach should be taken for establishing the importance of connectivity to designated sites:

- For assessment purposes, connectivity to a designated site applies only to the time of year and part of the life-cycle relevant to the designation. For example, connectivity considerations for designated breeding seabird colonies should normally be limited to where breeding individuals go during the breeding season only. Similarly, for birds from sites designated for wintering birds, connectivity considerations should be limited to locations those individuals use in the non-breeding part of the year.
- Where available, tagging and ringing information for individuals from sites of interest should be used to estimate the extent of connectivity. Results from radar studies can also potentially provide information on likely connectivity and flight routes.
- Where inadequate tagging and ringing information exist for the sites of interest, information on foraging ranges and habitat selection from tagging studies elsewhere should be examined as this might be adequate to infer the likely extent of connectivity (e.g. data in BirdLife Seabird Foraging Range Database).

8.11.1 Seabird foraging ranges and connectivity

Some species, notably gannet, fulmar, Manx shearwater, kittiwake, guillemot and puffin have very large potential foraging ranges (foraging distances >100 km are common for all these species and foraging distances >200 km not exceptional for some). As a consequence seabirds using a development site in the breeding season may originate from more than one colony and potentially up to several designated sites. In this situation the relative connectivity to the various candidate colonies should be apportioned in a reasoned way. In the absence of detailed tagging data, this can be achieved by combining species-specific information on distance from colony, colony size and the relationship between distance to foraging site and flight frequency (e.g. using data from the BirdLife Seabird Foraging Range Database http://seabird.wikispaces.com/).

8.12 Data variability

The distribution and abundance of marine birds at sea is typically naturally highly variable, both within and between days, seasons and years and within and between locations. This creates an obvious difficulty for surveys that aim to obtain representative average measures of distribution and abundance. The main way to overcome the problems caused by inherent variability is to undertake multiple survey visits. The problem is especially acute for relatively small-sized sites and in these cases surveying buffer areas also can also help reduce uncertainty caused by variability provided the buffer areas are similar in character. It is also a potential problem when a site has very high importance but for a short period of time only as it possible that surveys visits may completely miss the period of interest, for example migration staging sites used by shorebird species such as sanderling may annually host internationally important numbers of individuals but for a few days only before they move on.

There is no simple answer as to how many survey visits are required to reduced the uncertainty caused by inherent variability to an acceptable level for the purpose the data are required. Indeed this is a large subject that is central to experimental design theory and should therefore have input from statisticians, for example through the use of power analysis. Guidance on the approximate level of survey effort that is likely to be appropriate is given in Section 15 nevertheless this does not negate the need to consider what level of effort is required to answer key questions for particular developments.

Measuring the extent of the variability in distribution and abundance, for example by calculating coefficients of variability of parameters and confidence limits of means, should be a specific aim of surveys. Measures of variability should be reported for all survey results and fully taken into account in drawing conclusions.

9 SURVEY METHODS FOR ESTABLISHEMENT OF PRE-INSTALLATION BASELINE CONDITION OF A WET RENEWABLES SITE FOR BIRDS

A wide range of survey methods are suitable for establishing the baseline ornithological conditions at a site prior to the consent of a development. Some of these are generic methods designed to produce standardised measures of distribution and abundance of all marine bird species. Other methods are more specialised and are designed to address more specific questions. What methods are appropriate to a particular development will depend on the information requirements, the species of primary interest and characteristics of the site.

9.1 Generic methods for birds using the sea

9.1.1 Types of generic method

The generic methods used for baseline surveys of marine birds apply equally to tidal and wave energy developments.

Three distinct generic survey methods are suitable for establishing baseline information on birds using the sea.

- Land-based surveys from fixed vantage points;
- Boat-based transect surveys;
- Aerial transect surveys.

All three methods can give high quality information on the at-sea distribution, abundance and time of occurrence of marine birds when applied appropriately. Other generic survey methods are available to survey breeding and wintering birds using shores, inter-tidal areas and cliffs.

9.1.2 Choice of generic method

For surveys of birds using the sea, the choice between land, boat or aerial survey methods will depend on a site's characteristics, survey objectives and existing information. Typically, developments that are located more than 1.5 km from the shore will use boat based surveys. If the entire development area is <1.5 km from the shore, then shore based VP methods are likely to be most appropriate. In theory static sea platforms could also be used as VP locations for specific survey requirements but in practice suitable platforms are unlikely to be available, at least for pre-construction surveys.

Aerial survey methods, both direct observation and digital imaging based methods, are suitable for all survey sites. They tend not to have been used in the past for frequent (say, monthly) surveys of relatively small sites, presumably due to relatively high costs and constraints on aircraft and surveyor availability, however in principle there is no reason why they are not suitable for such work. Aircraft have some advantages in areas where boats would have to cope with difficult and potentially dangerous conditions such as strong tides and shallows. Aircraft can also complete surveys in a short time span which may be helpful when appropriate weather windows are short (e.g. winter). However, aerial surveys also have disadvantages, in particular with respect to distinguishing similar species, though this problem is currently being studied.

9.1.3 Compatibility of generic methods

Results from the three survey methods are not likely to be strictly comparable or easily combined (Mellor & Maher 2008). Therefore, a particular development would usually choose one method as the primary means of surveying birds using the sea. However, information from other methods may be valuable for providing a wider context. It is important to be confident that the meth (od(s) used for establishing baseline conditions can be applied post-consent.

9.1.4 Checking the suitability of generic methods

All sites are different in character and this may affect the practicalities of deploying generic survey methods at a site. It is recommended that, prior to commencing any programme of survey work, reconnaissance visits are made to survey areas to gain familiarity and check as far as possible that proposed methods are feasible. Where practical difficulties are perceived, then changes may be required to standard methods. It is advised that any significant changes are first discussed with SNH marine ornithologists and approved by Marine Scotland Licensing Operations Team (LOT). This would usually be done through the scoping process.

9.2 Non-generic methods

In some circumstances, more detailed information may be required than that provided by generic surveys of distribution and abundance. The most likely reason for this is the need for information to better understand the behaviour of birds using a site in particular the extent of connectivity with breeding colonies and designated sites. A large number of non-generic methods have been employed to collect information on seabird behaviour. These include relatively simple focal watch observation techniques from the shore or a vessel aimed at recording details of the behaviour of individuals. They also include hi-tech methods such as tracking individuals using telemetry tags attached to birds and radar studies.

Productivity of breeding birds could be affected by wet renewables, for example through reduced feeding rates. Measuring productivity trends is a potentially effective way to monitoring if a development is affecting a bird population. Methods to measure productivity vary between species but usually involve counting the number of large young from a large and representative sample of nest sites, shortly before fledging occurs.

9.3 Information on connectivity

Establishing the extent of connectivity between a development site and other areas of interest, particularly designated sites such as SPA colonies, is likely to be an important aim of baseline survey work. There are several approaches to obtaining such information, for example:

- **Electronic tagging** of individuals can provide very high quality data on their ranging behaviour that can reveal the extent of connectivity. Such methods require the capture (at least once) of individuals and typically are limited to relatively few individuals so can suffer from issues of representativeness.
- **Additional transects**. The extent of connectivity can be inferred approximately by the relative density of a species occurring at different distance form candidate breeding colonies
- **Flight Directions**. Determining the direction of commuting flights of birds using the development area can indicate their likely destination and origins. The flight directions of auks and tern species carrying prey are particularly informative as these birds are likely to be flying to colonies. Observations can be undertaken both at a development area and at breeding colonies, indeed a combination of

both can provide a more complete overall picture of likely connectivity. These data can be collected during baseline surveys, but would need to be carefully analysed using circular statistics, which may require specialist advice.

9.4 Surveys of breeding seabird colonies and raptors

There are well established standardised methods for counting seabirds at breeding colonies and these should be followed (Walsh et al. 1995 http://www.jncc.gov.uk/page-2406). Similarly, there are well established protocols for monitoring cliff-nesting raptors such as eagles and peregrine (Hardy et al. 2009).

There is a large amount of routine monitoring of seabird colonies and cliff-nesting raptors by government agencies (e.g. JNCC), RSPB and raptor study groups (coordinated by Scottish Raptor Study Group). Relevant organisations should be consulted before undertaking surveys of seabird colonies and cliff-nesting raptors to prevent unnecessary duplication of effort and disturbance.

9.5 Response and habituation to human activity

The potentially adverse effects of disturbance to marine birds in response to human activities associated with a development, in particular the disturbance from boat traffic, may be a key interest at sites used by potentially sensitive species (see, Garthe and Hüppop, Maclean 2009, Schwemmer in press). Observations of sensitive species, before consent, to measure behavioural responses could be valuable for assessing this issue and establishing a baseline against which to monitor post-consent. It may be possible to obtain some information on this subject, opportunistically, during boat-based surveys.

9.6 Beached Bird Surveys

Establishing baseline information on the background rate at which dead seabirds are washed ashore on expected depository beaches by the predominant currents in the vicinity of proposed developments may be worthwhile for providing evidence to help establish if devices cause mortality, post-consent. Searches of equivalent reference sites well away from the development (and downstream currents) should also be searched.

The method used in the national Beached Bird Survey coordinated by the RSPB (http://www.rspb.org.uk/ourwork/projects/details/203916-national-beached-bird-survey) provides a basic index of the rate that dead birds are washed ashore. Searches should be undertaken in a systematic way and with due regard to reducing biases that can result from search intensity, double recording and tide conditions. Determining the cause of death of corpses found provides potentially valuable information but, except in obvious causes like entanglement and oiling, is likely to require specialist examination. The cause of death is likely to be indeterminate in corpses that are decayed or damaged by scavengers.

10 MONITORING METHODS TO ESTABLISH IMPACTS OF CONSTRUCTION AND OPERATION OF DEVICES

The developer will usually be responsible for post-consent monitoring of the development site and buffer area. The requirement for monitoring, if any, will be specified as part of development consent conditions. In order to demonstrate if a change to bird numbers or distribution has occurred as a consequence of a development, or not, it might also be necessary to monitor some reference sites (but see discussion on BACI versus BAG survey design in Section 8.7). It is possible that the survey areas of neighbouring developments might overlap, or that more than one development could potentially affect the same breeding colonies. In this case it is recommended that developers collaborate to obtain the required data.

Where assessment has identified possible effects to birds at site(s) away from the development area, post-consent monitoring information may be required from this site(s) also, particularly if it is designated. For example, this situation may be applied to designated breeding seabird colonies that have strong connectivity to the development site. In this case, monitoring should include breeding season counts of seabirds attending the colonies identified. Many seabird colonies are regularly counted anyway and monitoring requirements may be able to take advantage of this.

10.1 Generic methods for birds using the sea

The same range of generic survey methods described for establishing baseline conditions are also appropriate for post-consent monitoring studies. The method used for monitoring of effects must produce data that are directly comparable with those from baseline surveys. Although monitoring aims may be focussed on particular species or issues, this should not affect a generic survey method as this could bias the results, causing either an apparent change or masking a real change. Ideally exactly the same methods should be used as in baseline surveys.

10.2 Non-generic methods

Generic survey methods to measure distribution and abundance will give some information on the effects of displacement and disturbance. However, to comply with the monitoring requirements set out as part of consent conditions additional more specialised studied may also be required that focus on specific questions. For example, this could involve direct observations (focal watches of individuals from the shore or a vessel) or tagging studies to examine how individual birds respond to the presence of infrastructure and maintenance vessels. Radar studies could be used to determine if large areas occupied by above surface wave devices are avoided by some flying birds.

10.2.1 Monitoring collision mortality of marine birds

Remote technologies for the accurate recording of bird collisions with tidal turbines are not currently available. In theory it is possible to monitor mortality rates cause through collision by searches for carcasses, something that is routine at terrestrial windfarms. However, there are serious practical difficulties to undertaking bird carcass searches in the marine environment and drawing robust conclusions from the results. Several potential biases and potentially confounding variables would need to be accounted for when documenting the number of bird deaths which may be attributable to collision with tidal turbines, using carcass searches of shorelines. These factors include:

- Carcass loss (not all carcasses wash up on a shoreline);
- Search area bias (some carcasses wash up outside the search area);
- Crippling bias (birds are fatally injured and die later, well away from the study area);
- Carcass removal (some carcasses are removed by scavengers or sink to the seabed before they can be found);
- Searcher bias (searchers do not find all carcasses that are 'available' to be found);
- Background mortality (not all carcasses result from the development, and although it may be difficult, need to be distinguished).

At present there have been no empirical studies to demonstrate whether there is a serious collision risk posed to diving seabirds by tidal turbines (see Section 4). Furthermore, in light of the difficulties listed above, there is no straightforward protocol to monitor the effect. In light of this it is not currently possible to offer developers or regulators practical advice on how to undertake sub-surface bird collision monitoring, though this viewis likely to be revised as new information on the subject becomes available.

For the reasons listed previously monitoring dead birds washed ashore in the vicinity of developments is very unlikely to give an accurate measure of collision mortality; at best it could provide a crude index. Dead seabirds frequently wash up along beaches and there is a risk that the cause of death of birds found dead in the vicinity of wave and tidal energy developments by members of the public may be attributed, irrespective of any evidence, to the development. Therefore, in some circumstances it may be worthwhile to undertake baseline surveys to establish the background at which dead seabirds are washed ashore, and compare this to equivalent data collected post-consent. The use of data from reference areas would add greatly to the value of such monitoring.

11 SUMMARY OF SURVEY AND MONITORING METHODS

Table 11.1. Summary of methods suitable for baseline surveys of proposed development sites and monitoring development effects on marine birds. The suitability of each would be dependent on the concerns, conditions and constraints of the individual development site.

Method	Metric	Equipment required	Survey design	Suggested monitoring interval	Analyses of change	Comments
ESAS boat-based surveys transect	Distribution, abundance and behaviour of seabirds. Seasonal changes.	Survey vessel with suitable observation deck 5-25 m above sea level, binoculars, GPS unit, compass Note. 1. Binoculars are used to identify birds only and not to detect birds. 2. Vessel speed of 10 knots ideal (range 5-15 knots).	Array of parallel transects, sampled approx. monthly through year, but according to needs.	Variable. Annually at first, every 5 years after 3rd operating year.	Visual and statistical comparisons of distribution and abundance.	Requires a seastate of 4 or less. Require ESAS accredited surveyors Opportunities to collect data on marine mammals simultaneously.
Aerial transect surveys, direct observation method	Distribution and abundance of seabirds. Seasonal changes.	Fixed wing light aircraft, binoculars, GPS unit, compass	Array of parallel transects, sampled approx. monthly through year, but according to needs.	Variable. Annually at first, every 5 years after 3rd operating year.	Visual and statistical comparisons of distribution and abundance.	Requires wind conditions of Force 3 or less. Similar species may not be distinguishable. Opportunities to collect data on marine mammals simultaneously

Method	Metric	Equipment required	Survey design	Suggested monitoring interval	Analyses of change	Comments
Aerial transect surveys, digital imaging method	Distribution and abundance of seabirds. Seasonal changes.	Fixed wing light aircraft, special digital camera equipment, and GPS unit.	Array of parallel transects, sampled approx. monthly through year, but according to needs.	Variable. Annually at first, every 5 years after 3rd operating year.	Visual and statistical comparisons of distribution and abundance.	Similar species may not be distinguishable. Opportunities to collect data on marine mammals simultaneously
Shore-based VP surveys	Distribution, abundance and behaviour of seabirds. Seasonal changes.	Binoculars, spotting scope, compass, and equipment to measure distance/angle of declination.	Various: snapshot scans, flying bird watches, focal bird watches, Sampling approx. monthly through year, but according to needs.	Variable. Annually at first, every 5 years after 3rd operating year.	Visual and statistical comparisons of distribution and abundance.	Only suited to near (<1.5km) shore areas. Requires >5m elevation. Opportunities to collect data on marine mammals simultaneously
Cliff-nesting raptors	Breeding territory occupancy and productivity of eagles and peregrine.	Binoculars & spotting scope	Complete survey of areas of interest. Usually 2-3 visits in breeding season (March-July).	Annually.	Comparison of occupancy and productivity rates.	Disturbance of WCA Schedule 1 species requires a license from SNH. Many sites routinely monitored by SRSG or RSPB.
Seabird colony counts	Number of breeding seabirds. (birds/nests/AOTs)	Binoculars & spotting scope. Digital camera. Reference photos of colony geography	Complete census of areas of interest. Protocol varies with species. Usually based on one carefully timed visit. Additional visit may be needed to measure productivity.	Usually less than annually, depending on needs. 5-year interval likely to be appropriate.	Comparison of numbers and productivity.	Many sites routinely monitored, coordinated by JNCC.

Method	Metric	Equipment required	Survey design	Suggested monitoring interval	Analyses of change	Comments
WeBS and NEWS type surveys	Numbers of waders and waterbirds present along defined stretches of coast and inshore waters.	Binoculars, spotting scope, GPS unit, field maps.	Total counts of pre-defined stretches. Usually monthly.	Variable. Annually at first, every 5 years after 3rd operating year.	Comparisons of distribution and abundance with time and regional/national trends.	Many sites routinely monitored by BTO as part of national WeBS and NEWS surveys.
Telemetry tagging of individual birds	Data on ranging, site connectivity, barrier effects and foraging behaviour.	Telemetry tags (many different designs) and tracking equipment. Equipment to catch and handle birds.	Tailored to project needs.	Usually conducted as one-off study. Repeating after an interval of several years could provide evidence of response to development infrastructure including with time habituation.	Comparison of behaviour through time and in relation to proximity of development.	Provides data on connectivity to designated sites. Catching birds and affixing tags must be undertaken by experienced licensed personnel.
Radar	Activity and travel routes of flying birds	Specialist radar equipment	Tailored to project needs.	Usually conducted as one-off study. Repeating after an interval of several years could provide evidence of habituation to development infrastructure.	Comparison of behaviour pre-construction with post construction through time and in relation to proximity of development.	Can provide data for daytime and night time bird activity, including information on connectivity between sites.
Collision monitoring	Estimates of collision mortality.	Protective gloves for handling dead birds.	Systematic searches of depositional shores for corpses. PM of corpses for evidence of trauma.	Variable. Annually at first, every 5 years after 3rd operating year.	Trends in numbers of dead birds found and attributed cause of death.	Methods under development. Likely to be impractical at some sites due to problems of carcass loss and removal.

12 DATA GAPS AND MITIGATION

12.1 Date gaps

Data gaps should be avoided as far as possible. At best they will add to uncertainty and at worst they may cause delays until the data gap is filled or make it more likely that planning consent will be refused.

If the programme of survey and monitoring work developed through the scoping, study design and annual review are properly followed through then there should be no serious data gaps at least with regard to survey information. If there are serious data gaps then it may not be possible to undertake adequate assessments or comply with reporting requirements for post-consent monitoring. In these cases new survey work may be required to fill the data gaps before assessment or reporting can be completed.

Data gaps may occur for a number of reasons that are outside the control of the developer. In particular, poor weather is likely to restrict the opportunities for boat-based and aerial surveys especially in the winter months and may make it practically impossible to complete planned survey visits on time. It may be possible to make up for missed visits provided not too much time has elapsed. Some small gaps in temporal and spatial coverage may be acceptable. This would need to be judged on a case by case in discussion with SNH marine ornithologists.

Some potential data gaps concern basic aspects of species biology or the interactions between birds and devices that are not addressed by survey and monitoring studies but instead require special research studies. Although such studies may normally be the domain of research institutes and Universities this does not preclude developers undertaking their own studies or contributing to them. This may be cost effective because, where a lack of basic knowledge leads to significant uncertainty, a more precautionary interpretation of available information must be adopted and this could challenge planning consent being awarded.

12.2 Mitigation

The greatest potential for adverse effects comes from inappropriate locating of developments in the first instance. Therefore the single most effective mitigation measure is to avoid locating developments in areas where sensitive species occur, at the site selection stage, in particular in the vicinity of seabird breeding colonies, especially designated colonies, and feeding areas where birds congregate in large numbers. It is expected, though there is some uncertainty, that wet renewable devices themselves will be relatively benign to birds. However, disturbance from boats involved with construction and operational activities could lead to serious disturbance. This disturbance can be substantially mitigated by limiting vessel speed (8 knots maximum is recommended), and choosing routes and times to avoid concentrations of sensitive species. Seabirds have increased sensitivity when they are provisioning chicks (mostly in June and July) and, in the case of auk species, during periods when they are temporarily flightless whilst undergoing wing moult (mostly in August and September).

Monitoring has a crucial role in mitigation. Monitoring data designed to assess impacts will also feed into a mitigation plan and adaptive management.

13 DOWNSTREAM EFFECTS

A potential issue with wet renewable installations is that they alter the movement of water affecting down-stream conditions, changing the distribution and extent or structure, function and supporting processes of habitats that support a species of concern. For marine birds the ultimate impact of such effects may be changes to abundance of key prey, such as small fish, for marine birds. In the case of near-shore wave energy developments these effects may cause changes to littoral habitats such as the wave-washed zone of beaches used by feeding shorebirds. In order to assess potential down stream effects it is essential that, during the EIA process, regular discussions take place between marine bird specialists and ocean modelling, benthic habitat and fish specialists. In this way potential issues can be identified early and baseline survey and monitoring put in place to address any concerns raised.

14 COMBINING MARINE BIRD AND MARINE MAMMAL SURVEYS

The main cost to developers for boat based surveys is the cost of chartering a suitable vessel. Collecting seabird and marine mammal data from a single platform is very cost effective and logistically easier for the developer. Ship-based seabird surveys have been carried out using the European Seabirds At Sea (ESAS) methodology for several decades (e.g. Reid et al., 2003; COWRIE 2004). Marine mammal sightings are also routinely recorded using ESAS methods. However, due to differences in the encounter rate and behaviour of marine mammals it is important that a standard line transect survey method is used for marine mammals rather than ESAS methods. Whilst marine mammal and seabird surveys can be effectively carried out using the same platform, it is important that surveys for birds and marine mammals are conducted by specific staff trained for that purpose and that the two surveys are conducted simultaneously but separately with no interference between them. It is also important that there is a large enough observation platform for the two teams on the survey vessel. If cetacean acoustic data are also of interest then a hydrophone array can be towed from the same vessel; factors affecting "noisiness" of the vessel (such as propeller type) should be checked before charter. Surveys that intend to collect data on both marine mammals and birds must be designed to ensure that survey effort is sufficient to provide adequate information on the species of interest with the lowest (and most variable) expected encounter rate.

Where surveys are unlikely to produce sufficient data for key species it may be necessary to conduct separate species specific surveys (.e.g. tracking studies for some seabirds, the use of PAMs for some cetaceans). The identification of an appropriate survey area must be based upon the species or taxonomic group with the greatest potential impact footprint of the development, and still allow these data to be placed in a local or regional context. Temporal variation may also differ between taxonomic groups therefore survey frequency considered adequate for characterising bird use of an area may not be suitable for marine mammals. Generally speaking, this may result in a marine mammal species of interest (if any are present) being the key determinant of survey effort and survey area. The recommended conditions for ESAS surveys and marine mammal surveys are up to and including Beaufort sea-state 4. Weather windows for survey should be as good as possible, and so whole periods of sea-state 3-4 should be avoided if bird and marine mammal surveys are being combined. A sea-state greater than 2 limits the chances of recording porpoises, and so, although a sea-state 4 is the upper limit, the lower the sea-state the better for cetacean surveys.

There is also good potential for shore-based VP surveys to target birds and marine mammals using the same surveyor as a single field exercise, though surveys of the two taxonomic groups should not be simultaneous. Depending on the requirements of the site this might be done alternating relatively short watch periods (scans) aimed at one group with periods aimed at the other. The amount of time spent surveying and the frequency of survey can be therefore be adjusted in light of the expected encounter rates and variability of each taxa independently.

Digital imaging aerial surveys can survey both birds and marine mammals. As this methodology is relatively new and developing very rapidly as present we recommend that contact is made with the relevant service providers on the ability of this method to survey both taxonomic groups. This should then be discussed with SNH and Marine Scotland prior to surveys commencing.

14.1 Sharing Benthic Data

Data collected during benthic survey work, including bathymetry, depth profiling, acoustic and relevant interpretation data should be made available to the survey and monitoring teams responsible for marine mammal and bird taxa groups. An understanding of the benthic environment is important for identifying areas of rich feeding grounds for the top predators, such as where upwelling causes plankton and nekton to move to the top of the water column.

The creation of a joint database would also be beneficial to allow scientists to access each others data sets easily. There is potential for benthic 'control' sites to be shared between development sites, however close collaboration between developers is essential for this to be successful.

15 BIRD SURVEY AND MONITORING PROTOCOLS

The protocols for survey and monitoring methods described below are only recommendations and variation to methods may be required to accommodate local circumstance and the specific data needs of projects. In several cases the protocols are standard well established methods and full details have been published elsewhere. For this reason, a summary only is provided here and the reader should refer to the publications cited for full details.

15.1 Shore vantage point surveys

15.1.1 Applicability

Surveys from shore vantage points (VPs) can provide distribution, abundance and behaviour information on marine birds relatively close to the shore. Provided there are suitable VPs, shore-based VP surveys are likely to be the method of choice for surveying marine birds at relatively small sites within 1.5 km of the coast. In the right circumstances VP surveys can provide very high quality data without the logistic complications associated with boat-based or aerial surveys.

15.1.2 Basics

The term VP surveys does not describe a single method, rather it encompasses a range of methods that share the same basic approach of recording observational data in the area of interest from a fixed elevated position on the shore. There are no established protocols for VP methods aimed at seabirds and in any case methods should be adapted to suit the needs and circumstances of a particular site. At their simplest, VP methods consist of counts of birds seen in the area of interest from a fixed point. However, VP methods can also be used to collect finely resolved positional data of birds using an area. This involves calculating the position of birds on the sea from a compass bearing and either a distance (measured or estimated) or an angle of declination (angle in the vertical dimension from the observer to the bird). Basic trigonometry is then used to calculate bird positions.

15.1.3 Constraints

VP methods are constrained by the ability to detect birds on the sea at distance and the difficulties in accurate determination of distance or the angle of declination to a bird. In contrast the compass bearing to a bird is relatively easy to measure. The problems of detecting relatively small bird species effectively limits the use of shore-based VP methods to areas within approximately 1.5 km of VPs (detection is discussed in more detail under ‘Equipment and other resources’ below). Beyond a certain distance, bird detection rates will decline with distance, especially in conditions of seastate 4 or greater (i.e. white caps on waves commonly present). Unfortunately, the reduction in detection with distance is not easily corrected for as it can not be assumed that a species’ density is on average constant with increasing distance from a VP. Indeed, for most species it is likely that density will vary with distance from the shore. Thus changes in detection rate and changes in density with distance are likely to be confounding variables. For this reason the approach used in Distance Sampling to correct for detection bias (Thomas et al. 2009) is not valid as the underlying assumptions are violated.

A further constraint is that the method requires suitably elevated VPs close to the sea overlooking the survey area. The minimum permissible VP height will depend on how far out birds are to be surveyed. For surveys aimed at recording birds up to 1 km away VPs need to be at least 5 m above sea level and ideally 10-15m. For surveys aimed at recording birds out to 1.5 km VP heights should be at least 10m and ideally 20-30m a.s.l. Where suitably elevated natural VPs are lacking a raised platform such as a scaffold tower could be used provided it was sufficiently stable.

15.1.4 Types of information

The first part of the VP survey design is to be clear about what is to be measured and this will depend on the data requirements. VP survey data may be either be in the form of an instantaneous assessment of the birds present in the survey area, i.e. a ‘snapshot’ of numbers and distribution, or in the form of a rate of occurrence measure, for example how many birds fly through the area per unit time. Both types of information can be collected in a single VP session but in order to achieve this without compromising data quality different data types should not be collected simultaneously. Instead survey sessions should be divided into sub-periods of different types of survey activity. The practical limits of detecting birds at distance will influence survey design and the quality of information that can be obtained at a particular site.

The types of survey activity that might form part of a VP survey programme include:

- Bird Snapshots Scans (BSS). This survey exercise aims to collect data on the instantaneous distribution and abundance of birds using the survey area. This is likely to be the main aim of VP survey work;
- Flying bird watches (FBW), that quantify the rate that flying birds pass through the survey area in a fixed time;
- Recording human activity that potentially affects birds, e.g. boats and ships, either as a rate or a snapshot.
- Focal watches of individuals of key species aimed at providing data on aspects of their behaviour to address specific assessment questions. For example, the diving behaviour to inform collision risk and breeding season flight headings to infer connectivity to breeding colonies.
- Timed watches for marine mammals and basking sharks (see Volumes II and III for full details on cetaceans and basking sharks, and seals respectively). This is relevant to mention here as the same fieldworker may be used to collect data on marine mammals in which cases the programmes of survey work for birds and marine mammals will need integrated.

15.1.5 Defining survey area

Deciding the limits of the survey area is a fundamental aspect of the VP survey design. The survey area should include all of the proposed development area or search area. In addition the survey area should always include a surrounding buffer of appropriate size and shape (see Section 8) and, perhaps also one or more reference areas depending on information requirements for the intended post-consent monitoring (see Section 8.7 for further details on BACI versus BAG monitoring design).

15.1.6 Determining VP locations

Where multiple VPs are required to give adequate coverage of a survey area, they should be spaced so that coverage is maximised and overlap minimised. The optimal spacing between adjacent VPs is likely to be 2 – 3 km apart, though closer spacing might be appropriate at sites with high bird densities (e.g. close to seabird colonies). The choice of VP locations and spacing will depend on local geography e.g. the availability of suitably elevated positions and the view from them.

15.1.7 Pilot surveys

Given that the VP survey methods will require a degree of fine tuning to meet the needs of a particular site; it is recommended that a pilot exercise is undertaken at the beginning of a project to confirm the suitability of proposed methods.

15.1.8 Survey effort

The amount of VP survey effort in terms of number of replicate samples, length of sessions and frequency of visits will depend on information requirements, inherent variability and species sensitivity. For baseline surveys, a programme of year-round sampling will normally be required and this should be based on stratification with respect to month/season, tide cycle and time of day (Tables 8.1 and 8.2).

Successive snapshot scans (instantaneous counts of the birds present) should not be so close in time as to result in pseudo-replication, i.e. sufficient time should have elapsed to allow birds to redistribute. However in order to make good use of surveyor's time it is likely that up to several snapshot scans might be made from a VP within the same day. In this case, the choice of interval between scans will be determined by local conditions (especially tide state at tidal energy sites), time taken to complete a scan and logistical considerations. At minimum the interval between snapshot scans should normally exceed one hour. Other VP survey activities can be undertaken in the interval between snapshot scans, e.g. timed watches of flying birds or marine mammals.

By way of example, two recent projects using VP methods are based on 12 hours of survey effort per VP per month, spread across 4 three hour sessions. During these sessions about 30% of each hour is spent on bird snapshot scans, 10% on flying bird watches and the remainder on marine mammal watches. One of these projects is a proposed tidal energy site in a narrow sea channel and here bird snapshots are undertaken at approximately 1.5 hours during VP sessions, giving 12 snapshots per month from each VP. The other is a proposed wave energy sited about 1 km off the coast and here bird snapshots are undertaken at approximately 2.5 hour intervals during VP sessions, giving 8 snapshot per month from each VP.

15.1.9 Procedure

There is no set procedure for VP surveys and the procedure that is followed should be designed to meet the data requirements of the project taking into consideration logistical and geographical constraints and the density of birds (of interest) typically present.

- Survey work should be restricted to favourable conditions. It is recommended that surveys are only undertaken when seastate conditions are 4 or less and when visibility is sufficient to give high detection rates at the most distant part of the area being surveyed (this will vary between sites but will mean good visibility to at least 1 km)
- The bird species recorded will depend on information requirements; they are likely to include all seabirds, waders and wildfowl.
- The use of specially designed paper recording forms is recommended.
- Survey data should comprise details of survey effort, environmental conditions and individual species records. Species records should typically include the following: species, number, age, sex, behaviour, bearing and distance, flight direction are the essential variables.

Several recent projects have adopted broadly similar VP survey procedures for the various elements of VP survey programmes. These are outlined below as examples of what has proven to work well at these sites.

15.1.9.1 Bird Snapshot Scans

- Aim. Bird Snapshot Scans aim to obtain an instantaneous assessment of the number and distribution of birds using the survey area watched from a VP.
- Basics. An observer systematically searches the visible arc of sea scanning from one side to the other (e.g. left to right) and records identity, number, behaviour and position of each bird (or flock of birds) using the survey area.
- Flying birds. Birds are defined as ‘using’ the survey area if they are either on the sea or flying around e.g. birds foraging on the wing. Birds that are merely passing through the area with direct flights are considered not be using it and should be ignored during snapshot scans (such flight activity is better measured as a rate, see Flying Bird Watches below). Experience of attempting to record birds flying through the survey area as part of BSS surveys has shown that it leads to two problems. Firstly, these birds are a distraction and can cause a

- Areas of land. The visible area from a VP is likely to include some land, e.g. seashores and small islands and any birds using these may also be recorded if relevant to the information requirements
- Use of optical equipment. Binoculars (x8-x10) should be used to detect and identify birds. For survey areas that extend beyond ~750 m from the VP, a x30 spotting scope should also be used.
- Optimal scan rate. The theoretical ideal of obtaining an instantaneous single snapshot in time is not practically possible because it takes a finite time to complete a scan, however the scan should be undertaken in a manner that makes the data as analogous as possible to this ideal. The rate of scanning across the visible arc should be slow enough so that the chance of overlooking actively diving birds is minimised (typically diving individuals are likely to be underwater for between 30 seconds to 1 minute). However, a scan should also be completed as quickly as is consistent with not overlooking birds. This is important to minimise the problem of birds redistributing during the scan and thus potentially being either missed or double-recorded. Thus the rate of scanning the visible area is inevitably a compromise between going too quickly with the danger of overlooking birds and going too slowly with the danger of double recording birds. In practise surveyors quickly learn and develop a feel for the most appropriate rate of scanning.
- Time taken. The time taken to complete a scan should be recorded. Typically each snapshot will take 10 – 30 minutes to complete, the actual time depending on the size of the visible area, how far out is searched, environmental conditions, the numbers of birds present and the field of view of optical instrument(s) used.
- Double recording. To avoid the danger of double recording, a scan should consist of a single sweep through the visible area so that each part is examined once only.

- Positional data. According to information requirements, bird positional data should be recorded with the aid of compass, declinometer and rangefinder devices as appropriate (see Section 15.1.10).
- Other taxonomic groups and human activity. Depending on the survey aims, surveyors may also record other taxonomic groups (e.g. marine mammals) and human activity (e.g. vessels) seen during bird snapshot scans, as this can provide valuable explanatory information on bird numbers and behaviour. Surveys aimed at recording other taxanomic groups should be undertaken as separate activities. (see Section 14)

15.1.9.2 Flying Bird Watches

- Aim. Flight watches aim to determine the rate that flying birds pass through the survey area watched from a VP.
- Basics. Birds flying past a notional line straight out from the VP are recorded in a fixed time period. Species identity, number, age, direction, distance are recorded together with details of environmental conditions and effort.
- Direction. The approximate direction of travel should be recorded (e.g. N , S, E or W).
- Distance. The estimated distance from the VP should be recorded. It is recommended this is done using a system of pre-defined distance bands, chosen to be appropriate to the survey site.
- Duration. Flight watch sessions should be of a fixed duration of at least five minutes. Although in theory data from sessions of variable length can be combined this may lead to bias if the temporal spread of data are not representative. The amount of effort (duration and frequency) expended on flight watches will depend on the importance of this information to the needs of the project (this is likely to be relatively low for wave and tidal energy developments).
- Flying height. Estimated flying height of birds may be recorded by using height bands. However this information is unlikely to be required for wet renewable developments, unless devices or equipment could pose a sub-aerial collision risk.

15.1.10 Equipment and other resources

15.1.10.1 Bearings and distance

Choice of equipment to measure bearings and angles of declination (to measure distance) will depend on site characteristics and personal preference. Bearings should be measured with a sighting compass or marine binoculars with built in compass, though the latter method is recommended. Use of the compass facility built into handheld GPS units is not recommended if precise readings are required. A clinometer can be used to measure angle of declination though these may need to be adapted for use in conjunction with binoculars and telescopes by fashioning some form of simple attachment bracket. A variant that has been successfully deployed is the use of a digital level (these can give a reading to a precision of 0.05 degrees, e.g. Digi-Pas Pro model) attached to a spotting scope used for surveying. An eyepiece graticule (a vertical measuring scale superimposed on the field of view) can also be used to measure angles of declination relative to reference marks (for example the horizon) after suitable calibration. Some marine binoculars come with a graticule fitted. Another way to measure angle of declination is by the use of a mechanical angulator device, e.g. as described by van der Heide et al. (2011).

New electronic equipment is becoming available that may be suitable for measuring distance and angles of declination. In principle laser rangefinders can be used to measure distance to birds directly, however trials using the small units (predominantly aimed at golf players) that are readily available show that they do not give satisfactory results when used on birds on water that are more than approximately 100m away. Digital clinometers incorporated into binoculars or rangefinders could be a practical solution provided they measure to at least 0.1 degree precision. Ex-military WWII optical rangefinders (e.g. those made by WILD) can also be used to measure distances though these are not well suited for small distant objects that are hard to detect and in any case they are difficult to obtain and expensive.

Distance can also be measured crudely with a graduated measuring stick calibrated as a simple rangefinder (specific for a given VP and surveyor) using the equations given by JNCC web site, Heinemann (1981). This method is not suitable for precise measurement of distance but could be used to allocate sightings into broad distance bands (as routinely done in boat-based surveys).

15.1.10.2 Binoculars and telescopes

The choice of optical equipment used by surveyors will depend on how far away birds need to be detected and identified. Binoculars at minimum, and probably also a tripod mounted spotting scope, are likely to be required. As a rough guide, in optimal survey conditions, observers will experience reduced detection rates of small dark-coloured seabirds (such as puffins) beyond approximately 700m when using good quality binoculars of x7 magnification and beyond approximately 1000m using binoculars of x10 magnification. These distances will decrease markedly with deteriorating conditions. Using binoculars with higher quality optics and larger objectives lenses (more light gathering power), mounting them on a tripod with a fluid head and having a comfortable and optimally elevated VP will all help to improve detection of small distant birds. Survey sites that include areas further than 1 km from the VP will require the use of more powerful optical equipment such as spotting scopes (a 30x magnification wide angle eyepiece is recommended. Zoom eyepieces should NOT be used.) or ‘BigEye’ type binoculars (typically x25 or 40x magnification). These will allow very high detection rates in suitable conditions of small seabirds up to approximately 1.5 km away and exceptionally to 2 km if ideal VPs are available and the site is not too exposed. Although higher magnification optical equipment increases the ability to detect and identify more distant birds it has two disadvantages. First, it is very sensitive to shake and must therefore be mounted on a stable tripod. Second, the reduced field of view compared to handheld lower magnification binoculars makes it more difficult and slower to systematically search the survey area for birds. In theory an engineer’s theodolite could also be used to estimate bird positions (see marine mammal VP protocol). However, in practice the sighting optics fitted to theodolites are unlikely to be powerful or bright enough for bird survey work.

15.1.10.3 Other equipment

The height of the VP above sea level is required to be known precisely (to an accuracy of <1 m), something than can be measured with a suitable altimeter (some GPS units have a built in aneroid altimeter which is suitable provided it is accurately calibrated). At sites with large tidal amplitude (>1 m), the variation in the height of a VP above sea level caused by changing tide state at the time of observations should be recorded, so that this can be incorporated into to data analyses.

The use of marker buoys to delineate survey areas and provide distance reference markers can increase the spatial accuracy of recorded bird locations.

15.1.11 Personnel

Surveyors require specialist training in VP methods and use of equipment. They also need excellent identification skills of all bird species likely to be seen. If bird VP surveys are combined with those for marine mammals, surveyors will also need excellent marine mammal identification skills.

Subject to health and safety considerations (e.g. working in the vicinity of cliffs), a surveyor should be able to undertake VP surveys alone. At sites with high levels of bird activity (e.g. in the vicinity of seabird breeding colonies) it could be advantageous to have a second person to scribe.

15.2 Boat-based surveys

15.2.1 Applicability

Boat-based surveys have been the standard way to survey marine birds at sea for several decades and methods are well developed and highly standardised through the adoption of European Seabirds at Sea (ESAS) protocols to produce consistency of data across Europe. The ESAS protocol is the basis of the survey method recommended by COWRIE for offshore windfarms (Camphuysen 2004, and reviewed in Maclean et al 2009). This method is also suitable for offshore wave and tide development sites and is therefore recommended. The survey method involves recording birds from parallel transect lines and collecting data suitable for Distance Sampling analysis (Thomas et al. 2010). Although in theory, boat-transect surveys can be used for sites extending close to the shore, in practice there are likely to be practical constraints operating survey vessels close inshore such as risks from reefs, islands, tide races etc. Furthermore, for many sites close to the shore (<1.5 km) it is likely that survey data of equal or better quality can be obtained more easily by shore-based VP survey methods. However, the need to provide a buffer may require another survey method (e.g. boat-based or aerial) to survey the outer reaches of the buffer.

15.2.2 Survey design

Survey design should define what area is to be surveyed (including buffers and reference sites (see Field Study Design), the layout and spacing of transects and the sampling intensity. This should be done in light of information requirements, existing information and best practice guidance (see earlier sections, and Camphuysen et al 2004). At large offshore windfarm sites a transect spacing of about 2 km and a buffer width of at least 4 km are commonly used, but this will not necessarily be optimal for wave or tidal energy development sites, particularly small sites. Typically, a programme of monthly surveys over a period of at least two years has been adopted for offshore windfarm developments (i.e. 12 regularly spaced survey visits per annum). This is also likely to be appropriate for wave and tide developments but the particular information needs of the site and local circumstances should be factored into the planning of the survey programme. An annual sampling programme may also be based on dividing the year into a number of periods as described earlier (see Section 8.2.2) and sampling within each, ideally undertaking multiple replicates.

Weather constraints, particularly in the winter months, may prevent a planned survey timetable being adhered to precisely and plans should therefore incorporate flexibility to allow for this. The important point is that there are multiple survey visits, that these are spread through the year and that each of the main periods in the yearly cycle of seabirds is sampled, ideally at least twice (Table 6.1). It may be appropriate to undertake survey visits more frequently at times of the year when there is expected to be a particular sensitivity e.g. at sites close to breeding colonies a greater number of replicates might be undertaken in the breeding season periods than in the winter periods.

15.2.3 Constraints

The biggest practical constraint encountered with boat based surveys is the requirement for favourable survey conditions. During the winter, day length will be a significant limiting factor as well. Heavy seas will prevent surveys going ahead and for large exposed sites this is likely to lead to difficulties adhering to a survey programme, especially in the winter period, when short day length can exacerbate the problem. The availability of suitable survey vessels and accredited surveyors have proven to be recurring problems in the past and these too can lead to logistical difficulties in organising survey work.

15.2.4 Procedure

Full details of the standard ESAS boat-based survey procedure are given in Camphuysen *et al* 2004 and Maclean et al. 2009 and these should be referred to. The main points of the procedure are as follows.

- Minimum conditions. When conditions are sea state 4 or less, the survey vessel motors along pre-defined transect routes at a constant speed;
- Speed. A speed of about 10 knots is recommended (range 5-15 knots);
- GPS track. GPS data are collected that record the exact position of the vessel at regular intervals (e.g. every minute). Operating a second GPS as a backup is recommended;

- Number of surveyors. Two surveyors work together, one undertaking observations and the other recording the data. At sites where divers and/or seaduck are commonly present (species that have a high sensitivity to flushing by boats) it is recommended that a third surveyor is also used who concentrates on scanning well ahead of the boat looking for birds before they flush (Camphuysen *et al* 2004);
- Forms. Data are recorded on pre-defined survey forms. Separate forms are recommended for recording data on conditions and effort, and records of species. All recording forms must be suitably cross-referenced.
- Surveyor ID code. Surveyors should be assigned an ID code that is also recorded on the data forms;
- Recording conditions. The survey conditions prevailing are recorded at regular intervals in terms of sea state, wind force and direction and sun glare;
- Binoculars. Birds are detected with the naked eye. Binoculars (x8 or x10) are used to aid bird identification and should not be used to detect birds.
- Bird records. Surveyors record all birds seen in a 90 degree scan, to one side of the transect line only, noting species, number, age, behaviour, and flight direction and time (by minute intervals). The method can be extended to recording from both sides of a vessel by using additional surveyors;
- Records of other taxonomic groups. An integral part of the ESAS method is the recording of any marine mammals, basking shark and turtles that are seen. This allows associations between birds and other taxa to be examined in analyses and will mean that data are collected consistently with other ESAS data sets. Nevertheless the recording of these taxa during ESAS surveys does not negate the need for separate marine mammal and basking shark surveys to be undertaken by a Marine Mammal Observer (see Volumes II and III for Guidance on cetaceans and basking sharks, and seals respectively., also Section 14 of this Volume);
- Human activity records. Fishing boats or other human activity seen are recorded;
- Associations. Associations between species or with boats including the survey vessel are also noted (e.g. birds attracted to fishing boats);
- Distance bands. Birds on the sea are allocated to one of five distance bands: A, 0-50m; B, 50-100m; C, 100-200m; D, 200-300m and E, >300m. Birds beyond

300m away (Band E) are usually recorded but are not used in later analyses to calculate density estimates;

- Distance Band A. Surveyors pay particular attention to detection of birds in Distance Band A (0-50m) as distance sampling analytical methods assume that all individuals are detected in this band;
- Flying bird density. Flying bird density is measured by taking 'snapshots' at regular intervals and recording if birds in flight are 'in transect' at that moment. Flying birds are assessed as being 'in transect' according to whether or not they are inside a 300m x 300m box extending forwards from the vessel and to either the left or right of the transect line, depending which side is being watched. The interval between snapshots is the time taken to sail 300m, for example at a speed of 10 knots it is one minute.
- Flying height. Estimated flying height of birds may be recorded by using height bands. However this information may not be needed for wet renewable developments.
- Working alongside marine mammal observers. If marine mammal observers are conducting simultaneous surveys on board it is important the two survey teams do not alert one another to their sightings.

15.2.5 Statistical analysis

Distance Sampling (Thomas et al. 2010) and other statistical methods are used to provide estimates of population size and density in study areas.

Developers are encouraged to provide ESAS data from surveys they have commissioned for inclusion into the national data set managed by JNCC.

15.2.6 Equipment and other resources

15.2.6.1 Survey vessel

The choice of survey vessel is very important to the success of a survey. The basic minimum vessel requirements are as follows:

- A forward-looking observation deck that gives surveyors an eye height of between 5 m and 25 m above water level. Five metres is the absolute minimum, viewing heights of >10 metres are preferable as this will facilitate accurate recording of distance and high rates of detection of birds on the sea.

- Secure seating for at least two surveyors. The observation deck must be provided with suitable seating, and preferably be also fitted with some form of consol that affords a degree of shelter and provides a convenient writing surface. If marine mammal observers are also using the vessel (see Section 14) it is likely that the observation deck will need to accommodate at least four surveyors.
- A cruising speed of 5 -15 knots is considered acceptable, and 10 knots as the ideal surveying speed. At some sites, especially tidal energy development sites, vessels are likely to have to contend with strong tidal currents (>5 knots) and this should be factored in when choosing the survey vessel.
- Adequate stability in open-sea conditions of up to sea state 4. Stability is determined by a vessel's overall size, hull shape and whether stabilisers are fitted. Deep hulled vessels of over 20m length are likely to have adequate stability. Vessels with shallow or 'cathedral' hull designs are inherently less stable for a given size and may need to be >25 m to achieve adequate stability. Poor vessel stability can significantly reduce data quality because surveyors will have difficultly using binoculars and recording data and can be more prone to sea sickness. Poor stability is also likely to cause operational constraints in safely mobilising between ports and study areas. Therefore, for areas where the sea conditions are commonly above sea state 3 or that experience strong tidal currents (as will be the case at almost all wave or tidal energy sites in Scotland) it is recommended that vessels with good inherent stability are chosen; all else being equal a larger vessel will be more stable than a smaller one. It is strongly recommended that the suitability of vessels to a particular site is confirmed through pilot work.

A good vessel will greatly facilitate survey work, both in terms of data quality and operational logistics (less downtime due to poor conditions). Comfortable and well rested (and well fed) surveyors will be better motivated and collect better data. For these reasons it is recommended that the choice of survey vessel significantly exceeds the minimum requirements.

15.2.6.2 Other equipment

Other equipment required includes binoculars (x8 or x10), angle board (to assist determining the travel direction of animals), range-finding stick (to assist accurate distance band determination (Heinemann 1981) and backup GPS unit (the vessel's GPS would normally keep a log of the survey route and make this available).

15.2.7 Personnel

Normally there should be three bird surveyors on board the vessel (and four if there is a need to have a surveyor looking for flushed birds) to allow for continuous survey work to take place, thereby maximising vessel use time. For example a team of three surveyors may operate a 2-hour rota system in which at any one time two surveyors are on survey duties and the third is on a break.

All surveyors must be experienced in the use of the ESAS survey method and have excellent marine bird identification skills, including recognition of plumage age classes.

Surveyors should be ESAS accredited and have over 100 hours of survey time experience. In order to maintain high standards yet at the same time allow surveyor capacity to develop, surveyors with less than 100 hours survey experience are permissible however they should at all times be paired with an accredited surveyor with over 100 hours experience.

All surveyors should heed health and safety regulations and advice when working on boats. This is likely to include the compulsory wearing of life jackets or survival suits. Most vessel operators are also likely to insist that all personnel at least have had basic personal sea survival training (e.g. STCW 95 or equivalent) and, for sites well offshore, an up to date Seafarer Medical Certificate (e.g. ENG1).

15.3 Aerial surveys

15.3.1 Applicability

Aerial surveys have commonly been used to survey marine birds. In the past few years there has been a shift away from using traditional direct observation methods to using digital imagery (stills or video) to record information (Mellor *et al* 2007, Mellor and Maher 2008). Recent trials of digital imagery show that this method has significant potential and that with further improvements it is likely to become routinely used in aerial survey work. Indeed, it is likely that digital imagery methods will predominate in future and for this reason the wet renewable survey guidance on the subject of aerial surveys focuses on this approach.

Aerial survey methods are particularly well suited for rapid surveys over large areas. They have some advantages over boat-based and shore-based methods, but they also have some potentially serious disadvantages (see Constraints).

The application of aerial surveys to quantifying the ornithology of offshore windfarm sites has been examined in details in several COWRIE reports (www.offshorewindfarms.co.uk). The information contained in these reports is also relevant to surveys of wave and tidal energy sites and should be consulted for full details of aerial survey methods.

15.3.2 Basics

The generic aerial survey method has many similarities with generic boat-based survey methods in terms of the approach used, study design and applicability. Both are suited to relatively large sites and use a series of transects across the survey area to collect data suited for Distance Sampling analysis (Thomas et al. 2009). Aeroplanes cover the survey area much more quickly than boats (ten times as quickly), and this results in very little time for observers to detect, identify, count and record birds seen. However, this shortcoming is overcome if a digital imaging recording method is employed as then the images can be examined at leisure afterwards.

In trials of digital imagery methods recording was restricted to a relatively narrow band (30-40 m) of sea, but survey band width is expected to increase (to ~ 200m) by mounting an array of several cameras (Mellor *et al* 2007, Mellor and Maher 2008). The recording band width used has implications for transect spacing. In trials a transect spacing of just 300m was used (Mellor and Maher 2008), reflecting the narrow recording band width.

Undertaking aerial surveys is a highly specialised activity and so is likely to be undertaken by a specialist company familiar with the survey theory and practicalities.

15.3.3 Constraints

The biggest constraint of aerial surveys is the problem of reliably distinguishing between similar looking species. For example serious difficulties have been encountered in distinguishing between the following: guillemot and razorbill; tern species; diver species; some seaduck species; and gulls (plus fulmar). This problem is most serious for aerial surveys using direct observations but also affects surveys employing digital image recording. How important this issue is to a particular project will depend on whether these difficult-to-identify species are likely to be key species. Species identification problems encountered with digital imagery methods are being overcome through improvements in image resolution and analysis techniques.

Conventional aerial survey methods are typically conducted from 76 m above sea level and this low flying height can cause serious disturbance to birds, causing them to fly away. This can not only lead, potentially, to recording bias but, if regularly repeated, could affect the use of the area by birds. However, aerial surveys deploying digital cameras are conducted from a much greater height (400 -1000m above sea level) and thereby largely overcome the problem of disturbance.

Direct observation aerial surveys require particularly favourable weather and sea conditions (e.g. light cloud cover, no white caps and winds of Beaufort Force 3 or less), however aerial surveys employing digital imaging can be successfully conducted in a wider range of weather conditions provided there is good visibility and subject to flight safety limitations. Conditions also need to be suitable for aircraft to take off and land at the aerodrome, in particular no fog.

15.3.4 Survey design

The survey design considerations for aerial surveys are essentially the same as for boat-based transect surveys in so much as both concern the design of a Distance Sampling based survey programme. For the sake of brevity this information in not repeated (see Section 8 and Section 15.2).

Survey design will be also be influenced by whether aerial survey data are to provide the primary data on distribution and abundance of marine birds at a site or whether it is being collected to complement data from boat or shore based surveys, for example to provide a wider context. If the area has previously been covered by aerial surveys this should also be factored into survey design to maximise compatibility with historical data.

15.3.5 Field procedure

The recommended procedure for aerial surveys is described in full in Maclean *et al* 2009. Fundamental to the method is a suitable fixed wing aircraft fitted with suitable imaging devices (i.e. cameras or equivalent devices). The aeroplane is piloted along the predefined transect routes, with the aid of GPS navigation, at a fixed height and speed.

Trials of aerial surveys using digital imagery used special cameras attached to aircraft to record a video image of the area surveyed (Mellor *et al* 2007, Mellor and Maher 2008). The method and results of these trials are reviewed in detail in Maclean *et al.* 2009, though it is important to note that methodologies are evolving rapidly. It is recommended that specialist advice is sought on the most up to date information before digital imaging aerial surveys are considered.

The choice of flying height and speed will depend on information needs. The digital camera trials undertaken by Mellor *et al* (2007) and Mellor and Maher (2008) were conducted at altitudes of 400 -1000m above sea level.

15.3.6 Data extraction

Digital images (stills or video) are examined in detail after the survey flight and information of birds extracted. Although bird identification still has to be undertaken by an expert ornithologist, recording birds from digital images has the advantage over conventional aerial surveys in that images can be re-examined multiple times, a second opinion sought if necessary and breaks can taken as often as required to maintain concentration. The task of examining digital images is very time consuming (e.g. for video images it takes several times the real-time, party because they are replayed in 'slow motion') but the process is becoming semi-automated using software to screen out images with no birds.

15.3.7 Statistical analysis

Distance Sampling (Thomas *et al* 2001) and other statistical methods are used to provide estimates of population size and density in study areas.

15.3.8 Equipment and other resources

Twin-engines planes are recommended for offshore areas to increase safety margins.

For direct observation aerial surveys a high-winged light aircraft with excellent all round visibility, with space for the pilot and two surveyors and fitted with GPS navigation is required. Voice-recorders (Dictaphone) and on-board communication system are also required.

For digital imaging-based surveys the main consideration is an aircraft adapted so that suitable cameras can be mounted externally. The trials undertaken by Mellor and Maher (2008) used a 2.1 mega-pixel digital video camera on a gyroscopic mount that countered the effects of aircraft vibration. Current methods have been updated with higher resolution imaging systems.

For direct observation aerial surveys, distance markers need to be set up before survey work commences on the aircraft windows or superstructures to act as distance-band guides for observers. This will entail setting up some form of calibration plot near the airfield, for example using poles set out at appropriate distances apart. Distance markers and calibration plots are not required for digital imaging methods.

15.3.9 Personnel

Conventional direct observation aerial survey methods require rapid counting, and identification of marine birds from the air is a specialised and highly skilled activity, more so than for any other survey method described here. For this reason, aerial surveys based on real time direct observation should be undertaken only by experienced personnel that specialise in this type of survey work.

Aerial surveys that use digital imagery to records birds do not require experienced bird surveyors on board the aircraft. However, depending on the equipment used, there may be a need to for an experienced camera operator on the aircraft, and trained personnel will be required to translate the images in to survey results.

The aircraft pilot must be suitably qualified for low altitude flying over the sea and have good navigation skills to fly transect routes precisely.

There are considerable health and safety procedures and legislation regarding the use of low level aircraft and operators and surveyors must comply with these.

15.4 Surveys of open coasts

15.4.1 Applicability

Bird surveys of open coasts will only be required for proposed developments where birds using nearby coasts could be plausibly affected. The relevance of open coast surveys to a proposed development should be addressed at the scoping stage. Such surveys are likely to be required where downstream effects could plausibly affect birds using coasts within 2 km of a development, e.g. coastal wave arrays. They are also likely to be required wherever there is proposed infrastructure landfall.

Surveys of waders and wildfowl along beaches and hard coasts should be carried out using the ‘look-see’ method developed for the Wetland Bird Survey (WeBS) and Non-estuarine

Wader Survey (NEWS) (Brown et al 1995, Gilbert *et al* 1998, Bibby *et al* 2000, Gilbert *et al* 1998). Many stretches of coastline are routinely counted as part of the national WeBS and NEWS counts co-ordinated by British Trust for Ornithology (BTO) and enquiries should be made as whether the area of interest is already being covered. The aim of such surveys is simple count data on the numbers of birds present, though the basic method can be modified as required to collect additional information on behaviour and habitat use should this be relevant to a particular project.

15.4.2 Survey design

The choice of survey area will depend on the proximity to a proposed development site and information requirements. Generally the survey area should comprise stretches of coast plausibly affected by a development, if any. In the case of near-shore wave energy developments this would include the 'downstream' coast adjacent to the development area.

The length of coast to be surveyed is subdivided into a series of sections, typically between 0.5 and 1 km long. Sections can either be of fixed length or be based on natural geographical and habitat divisions such as headlands and bays.

The survey frequency should be determined by information requirements. For establishing baseline conditions at a proposed tidal or wave energy development site a programme of monthly surveys is likely to be adequate in most circumstances. Additional visits may be required at wader migration time (e.g. May and August/September), when large flocks may be present for short periods only. Consideration should be given at the survey design stage as to what state of the tide is best for detecting and counting birds at the site. The tidal cycle is likely to effect how easily some species can be seen because it can influence their activity and habitat use, e.g. at high tide wader species tend to be inactive at roost sites whereas at low tide periods they are generally feeding over wider areas. Generally, non-estuarine coasts are best counted within 3½ hours either side of low tide (Gilbert et al 1998).

15.4.3 Procedure

A surveyor visits each section in turn and counts the number of birds of each species from suitable vantage points, ideally without causing disturbance. The amount of coastline that a single surveyor can count will depend on ease of access and the numbers of birds present. On most coasts with relatively low bird numbers a surveyor is likely to be able to survey 1-2 km of coastline per hour. Care needs to be taken to prevent double counting of birds potentially visible from more than one vantage point. At some sites it may be necessary to survey inter-tidal rocky habitat more closely to prevent overlooking birds such as turnstone and purple sandpiper which may be hidden from view amongst rocks. Depending on what other bird survey work is being undertaken, birds seen on the sea (sea ducks, grebes, divers and other seabirds) may also be recorded out to distance of approximately 1 km. The broad behaviour (e.g. feeding, roosting) of the birds should be recorded together with their status if this is apparent (e.g. breeding, passage migrants).

Surveys should be undertaken in fair weather conditions at intervals through the year according to the survey design. At sites that support relatively large numbers of waders, gulls or terns, additional visits made at spring high tide periods aimed at finding roost sites are likely to be valuable.

15.4.4 Equipment and other resources

Binoculars, spotting scope, hand-held GPS unit, 1:25000 OS maps and tide tables are required for surveys of open coasts. A tally counter can be useful at sites with large numbers of birds.

15.4.5 Personnel

Surveyors should have excellent bird identification skills, be experienced in counting large flocks and have basic map navigation skills. Surveyors should take heed of the health and safety implications of working in coastal habitats, especially in inter-tidal areas and in the vicinity of cliffs. Lone working procedures should be followed as appropriate.

15.5 Surveys of breeding seabirds

15.5.1 Applicability and constraints

Undertaking surveys of the numbers of seabirds breeding at colonies is unlikely to be a requirement for most offshore wet renewable developments. In these cases the results from the national programme of periodic census (e.g. Walsh et al 1995, web link to JNCC database) are likely to provide adequate estimates of regional and local breeding populations including those at designated sites. Undertaking new surveys of breeding seabirds is only likely to be required when a proposed development is within 3km of a designated breeding colony or when existing survey data are considered inadequate for the purpose required, either because they are too old or too imprecise.

A census of colonial seabirds breeding in the UK is undertaken periodically (approximately every 15 years) as part of the Seabird Colony Register operated by JNCC (Mitchell *et al* 2004). Some colonies are counted more frequently as part of research and monitoring projects. Before embarking on any survey work the existing survey arrangements for a site should be found out.

A constraint of colony countsmethods is that results for some species are sensitive to day-to-day variation in colony attendance and the presence of non-breeding individuals. The standard survey methods for each species are designed to minimise these problems.

15.5.2 Survey Design

For most species the recommended method of survey is a full census of seabirds breeding in the area of interest, however, for burrow nesting species a sampling approach is usually used (Walsh et al. 1995). Survey design also needs to address which breeding colonies are relevant to a particular development, how often surveys are repeated (annually or less frequently) and whether data on productivity are to be collected. These choices will depend on information requirements, likely connectivity and the quality of existing data. New survey work should normally be based on the same coastal divisions and survey protocols previously used at the site.

15.5.3 Procedure

It is beyond the scope of this guidance to go into full details of survey methods; the recommended methods for each species are described in full in Walsh et al. 1995. Most colonial species that nest in the open can be counted by essentially generic methods albeit with small method differences to accommodate the individual species circumstances. A few species (e.g. black guillemot, burrow-nesting species, diver species) are counted using single-species survey methods (Walsh et al. 1995, Gilbert et al. 1998). Cliff nesting species are surveyed by systematically counting sections of cliff from vantage points. Colonies of terns and gulls on flatter ground and which lack suitable vantage points are usually surveyed by temporarily disturbing the colony on foot and counting flying adults. Inaccessible colonies may require counting from a boat or aircraft. The type of count unit used varies according to species; it includes individual birds, pairs, apparently occupied nests (AONs) and apparently occupied burrows (AOBs).

Most species are counted using a single carefully timed visit; the optimum time (peak detectability) varies between species. If the survey aims include measuring productivity then a second visit to count well grown chicks per nest may also required.

15.5.4 Equipment and other resources

Photographs and maps defining survey sections used on previous surveys at the site should be obtained prior to commencing survey work.

Binoculars, and at some sites a spotting scope also, are essential aids to identifying and counting birds. A tally counter is helpful for accurate counts of large numbers of birds. Digital photography is recommended for colonial species nesting in the open. Digital images allow for individual birds and nests to the counted at leisure and provide a simple pictorial record of the extent and density of colonies.

An endoscope is required for surveys of burrow nesting species to establish burrow occupancy.

Surveys that result in disturbance to breeding species listed on Schedule 1 of the Wildlife and Countryside Act 1981 (as amended) require surveyors to have a license from SNH.

15.5.5 Personnel

Seabirds should be counted by surveyors that have been trained in the various methods and are experienced at counting large number of birds.

Surveyors working in the vicinity of sea cliffs should be mindful of the health and safety risks. Lone working procedures should be followed as appropriate.

15.6 Surveys of cliff-nesting raptors

15.6.1 Applicability and constraints

The only three species of land bird that are included in this guidance are white-tailed eagle, golden eagle and peregrine. These species commonly nest on sea cliffs and, with the exception of golden eagle, may hunt over the sea.

Survey information on these species is required if there are suitable nesting cliffs within 2 km of the proposed development site, infrastructure landfall locations or other works associated with the developments. A high proportion of white-tailed eagle, golden eagle and peregrine breeding territories are routinely monitored by the Scottish Raptor Monitoring Group and RSPB. If these groups are monitoring sites of interest already then the results from this are likely to be sufficient to inform wet renewable developments. These organisations should be consulted regarding the likelihood of these species breeding within 2 km of a proposed development sites or related onshore works and what routine monitoring takes place.

15.6.2 Survey design

Survey design should consider the need to undertake such surveys in the first place. All suitable nesting cliffs within 2 km of a proposed development site should be considered for nesting raptor surveys.

The primary aim of such survey is to establish the presence of occupied breeding territories. Secondary aims might include collecting information on productivity, site use and susceptibility to disturbance.

White-tailed sea eagle, golden eagle and peregrine, are listed on Schedule 1 of the WCA (as amended). Surveyors undertaking surveys of Schedule 1 species must first obtain a license from SNH.

15.6.3 Procedure

The survey methods for these species are fully described in Hardy et al. 2009. Briefly a series of visits are made in early spring to establish territory occupancy, typically by watching potential nest cliffs from a distance. Occupied sites should have follow up visits in June or July to determine breeding success if this information is required.

Surveyors working in the vicinity of sea cliffs should be mindful of the health and safety risks. Lone working procedures should be followed as appropriate.

In many cases the potential adverse disturbance effects on breeding raptors can be mitigated against by undertaking potentially disturbing works outwith the breeding season.

15.7 Additional survey methods

The survey methods so far described are all primarily aimed at measuring the distribution and abundance of birds. However, characterisation of some aspects of baseline conditions and fulfilment of some monitoring conditions may also require the use of additional survey methods. For example information may be required on bird connectivity between a proposed development area and designated sites and the behaviour of diving birds to calculate risks of collision with tidal turbines. Such additional survey work is likely to be site specific in terms of methods and aims. The broad aim of additional survey work should be to reduce uncertainty in the decision making process and thus reduce consenting risk for developers. It is beyond this guidance to review all additional survey methods, and therefore consideration is limited to general approaches to collecting additional information of particular relevance, namely tagging methods and behavioural watches. .

15.7.1 Tagging

The question of connectivity is best addressed by tagging studies of individual birds. Full details of tagging methods and technologies are beyond the scope of this document. Walls et al. (2009) provide a summary of tagging methods with respect to offshore wind farm studies which is also applicable to wet renewable developments. Data from tagging provides complimentary information to distribution and abundance surveys, providing an insight into the status and origins of birds seen in an area. The main limitation of tagging is that the data are derived from a relatively small proportion of individuals in the population because of the practical difficulties and costs involved, and the tagged individuals may not necessarily be representative. Indeed, the study design process should address the question of how representative tagging information is likely to be.

Tagging in its widest sense includes all forms of marking birds including traditional ringing and colour-marking and sophisticated electronic tags. Electronic tags of various designs can give very detailed information on the movements of individuals and other aspects of their behaviour. Over the past three decades, electronic tags have been become increasingly sophisticated, miniaturised and more reliable, a trend that is likely to continue. Positional information can be provided by radio-tags, GPS tags, satellite tags and geolocator tags. Tags may also carry miniaturised equipment to record amongst other things, dive depths, swimming speeds, flight altitude and even photographs of prey items. In all cases birds require to be caught (typically birds are caught at the nest site) in order to fit the tag. Various methods have been devised and tested to attach tags safely to birds. Depending on the technology chosen the bird may also need to be caught a second time to retrieve data (e.g. geolocator tags). Tagging must be done by licensed and trained personnel, a further license is needed for Schedule 1 species and an Appropriate Assessment may need to be carried out for tagging work at a SPA.

15.7.2 Collision risk

The difficulties of observing birds underwater present serious practical difficulties to obtaining information on the potential for collisions of diving birds with marine turbines. There is currently no method developed to assess such collision risks, indeed it is completely unknown whether tidal turbines or other submerged devices may pose a risk (Grecian *et al* 2010). Research into sub-surface collision risk is likely to change this situation in the medium term and Supplementary Guidance is likely to be then issued on the subject. In the interim the potential scale of the threat can be partly assessed using surface observations that quantify how many and how often birds of a species dive in the area where devices are proposed or have been constructed. Focal watches of the diving birds can provide data on the proportion of time spent under water and approximate lateral distance of dives, and if prey items can be identified this can indicate whether a bird was feeding mid water or on the sea bed. Information from time-depth loggers fitted to birds can also provide valuable information on a species' diving behaviour.

15.7.3 Radar

Radar is another specialist method that has been used with good effect to collect information on flying birds, including at night. The reviews by Desholm *et al* (2004 and 2006) on the use of radar and other remote recording methods at offshore windfarms summarises the potential for such methods for surveying flying birds. Present designs of wave and tidal energy devices are considered unlikely to have adverse effects on flying birds and so radar studies are unlikely to play an important role in baseline survey and monitoring programmes for wet renewable developments. However, radar is a potentially valuable method for providing information on connectivity between the birds using an area and designated sites.

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