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JOINT NATURE CONSERVATION COMMITTEE

MARINE NATURA 2000: UPDATE ON PROGRESS IN MARINE NATURA

Paper by Charlotte Johnston, Caroline Turnbull, Jim Reid, Andy Webb

1. Introduction

1.1 This paper updates the Joint Committee on progress in Marine Natura matters since the March 2003 meeting (JNCC 03 PO1) and responds to discussions held by the Joint Committee at its September 2003 meeting. Since March 2003, Defra and the EU have set up fora for discussion of Marine Natura matters, and several meetings have been held.

1.2 The 'marine subgroup' of the UK Natura 2000 and Ramsar Steering Committee met for the first time in November 2004, prior to the second meeting of the EU Habitats and Ornis Committee's 'marine expert group' on 17/18 November 2004. The UK marine sub group is led by Defra and involves various government departments, JNCC, industry representatives and NGOs. The EU 'marine expert group' is co-chaired by Trevor Salmon (Defra) and Micheal O'Briain (EC), is attended by JNCC and involves all Member States, some accession states, and NGOs. The EU 'marine expert group' is considering Marine Natura matters including developing lists of habitats, species and birds present in the marine areas of Member States, and has held two meetings to date. Three working groups have been set up: 1) Definitions (led by Germany), 2) Locating and assessing sites (led by JNCC on behalf of UK), and 3) Management (led by Netherlands).

1.3 During the work of the working group 1 on definitions, and despite much discussion and correspondence, there has been no agreement to date on a revised definition for the habitat 'sandbanks slightly covered by seawater all of the time', and it remains to be seen if agreement can be reached on this matter. The unresolved issue is over the inclusion or not of a depth limit of 20m below chart datum for this habitat; the principal protagonists being UK (wanting to retain this limit from the original definition) and Germany (wanting to include sandbanks significantly deeper than this within the revised definition). We are also awaiting confirmation as to whether the UK examples of pockmarks with carbonate pavements and structures within them fit the habitat definition for 'submarine structures made by leaking gases'.

1.4 The EU marine expert group will also consider as a medium term issue, proposed changes to the Annexes to the Habitats Directive. The aim is for the Commission to produce an agreed guidance document by the end of 2004 on implementing the Habitats and Birds Directives in marine waters.

1.5 The outcomes of the EU 'marine expert group' and the Commission's guidance on this matter, will determine the final interpretation of Annex I habitats, and of Annex II species and marine birds to be considered for identification of Natura 2000 sites in Member State's marine waters (both inshore and offshore). Therefore the following proposed sites for Annex I habitats recommended to Committee for acceptance are in draft based on existing habitat definitions (EC 1999), and either the boundaries and/or the sites themselves may need to be re-examined once the Commission's guidance (including revised definitions) is complete.

2. SACs for Annex I Habitats

2.1 At its March 2003 meeting Committee approved the methodology for offshore habitat SAC selection (JNCC 03 P01) for the purpose of informal consultation. At its September 2003 meeting, Committee considered how much information should be required to support the selection of a habitat SAC in the offshore marine environment (JNCC 03 D09) and requested that advice should be formulated in the light of the risks and opportunities. Both of these matters are being discussed in the UK and EU level fora described above (UK marine subgroup and EU marine expert group) with input on the two subjects led by JNCC. JNCC's inter-agency Marine Natura Project Group considered the amount of information required to select a habitat site, the associated costs and risks, and likely progress to complete habitat SAC selection taking these matters into account, at its February 2004 meeting.

2.2 In addition to the Darwin Mounds, there are a further 12 areas for which we have sufficient biological and other information, and which can therefore be considered against the selection criteria in Annex III to the Directive to recommend to Defra as SACs. For seven of these areas consideration against the selection criteria has been completed and they are recommended for SAC designation, bearing in mind the proviso at paragraph 1.3 above. For five of these seven areas (listed in Table 1), draft site boundaries have been considered according to the guidelines approved by the Joint Committee in March 2003, and agreed by the Marine Natura 2000 Project Group (shown in the location map). Two of the seven areas require further work to be done on boundary definition (Dogger Bank and North Norfolk sandbanks). The remaining 5 areas need to be considered against the selection criteria and, where there may be comparable inshore habitat, await the completion of work by the agencies (principally English Nature) to identify possible additional areas of habitat to be considered for SAC selection in inshore waters, anticipated to be by December 2004.

Table 1 Draft proposed habitat SACs

Proposed SAC	Location	Qualifying interest feature	Global Assessment grade	Site area (ha)
'Saturn' *Sabellaria spinulosa* reef	Southern North Sea	Reefs	A	1,645
Haig Fras	Celtic Sea	Reefs	A	101,307
Wyville Thomson Ridge	Continental Shelf W. of Scotland	Reefs	A	148,302
Scanner Pockmark	Northern North Sea	Submarine structures made by leaking gases	A	726
Pockmarks near Braemar oil field	Northern North Sea	Submarine structures made by leaking gases	A	713

2.3 Site descriptions for these 5 sites are provided below:

'Saturn' *Sabellaria spinulosa* reef

The area of biogenic reef formed from *Sabellaria spinulosa* discovered as part of the survey for Saturn pipeline undertaken for ConocoPhillips is located in the southern North Sea between Swarte and Broken banks and lies on the edge of a small area of Annex I Shallow sandbank habitat. The density of *S. spinulosa* reef clumps varies across the area from a main central area with 90% coverage, to a peripheral region which varies from 10 – 50% coverage by patches. Images of the reef show the structure to rise well above the seabed (c. 30 cm). Around the outer edge of the area, coverage is sparse (<10%) (ConocoPhillips, pers.comm.). In character, the 'Saturn' reef is most similar to the reef in The Wash and North Norfolk coast cSAC.

Haig Fras

Haig Fras is representative of a bedrock reef in the form of an offshore bank. The faunal communities are zoned and representative of hard marine substrata away from coastal influences and species. In character, Haig Fras is probably most similar to Lundy cSAC as both are granite outcrops with similar species occurring in the circalittoral and also the reefs in the Isles of Scilly complex. However, due to the isolation of Haig Fras from the coast, and consequently lower nutrient and sediment input, the faunal communities are less species diverse compared to those on Lundy and the Isles of Scilly.

Wyville Thomson Ridge

The Wyville Thomson Ridge is representative of a stony reef with iceberg ploughmark topography in this sea area. The faunal communities are composed of species representative of hard marine substrata in deep water. The Ridge is very different in character to any of the current cSACs due to its topographic type, its position on the edge of the continental shelf, its depth, hydrographic influences and, consequently, the fauna it supports.

Scanner Pockmark
Scanner pockmark is representative of a submarine structure in the form of pavement and blocks in the northern North Sea. An epifaunal community composed of urchins, anemones and squat lobster (*Munida* sp.) (Dando *et al* 1991) is dependent on the hard carbonate substratum which lies at the base of a pockmark formed from shallow gas release. The pockmark is actively seeping methane gas.

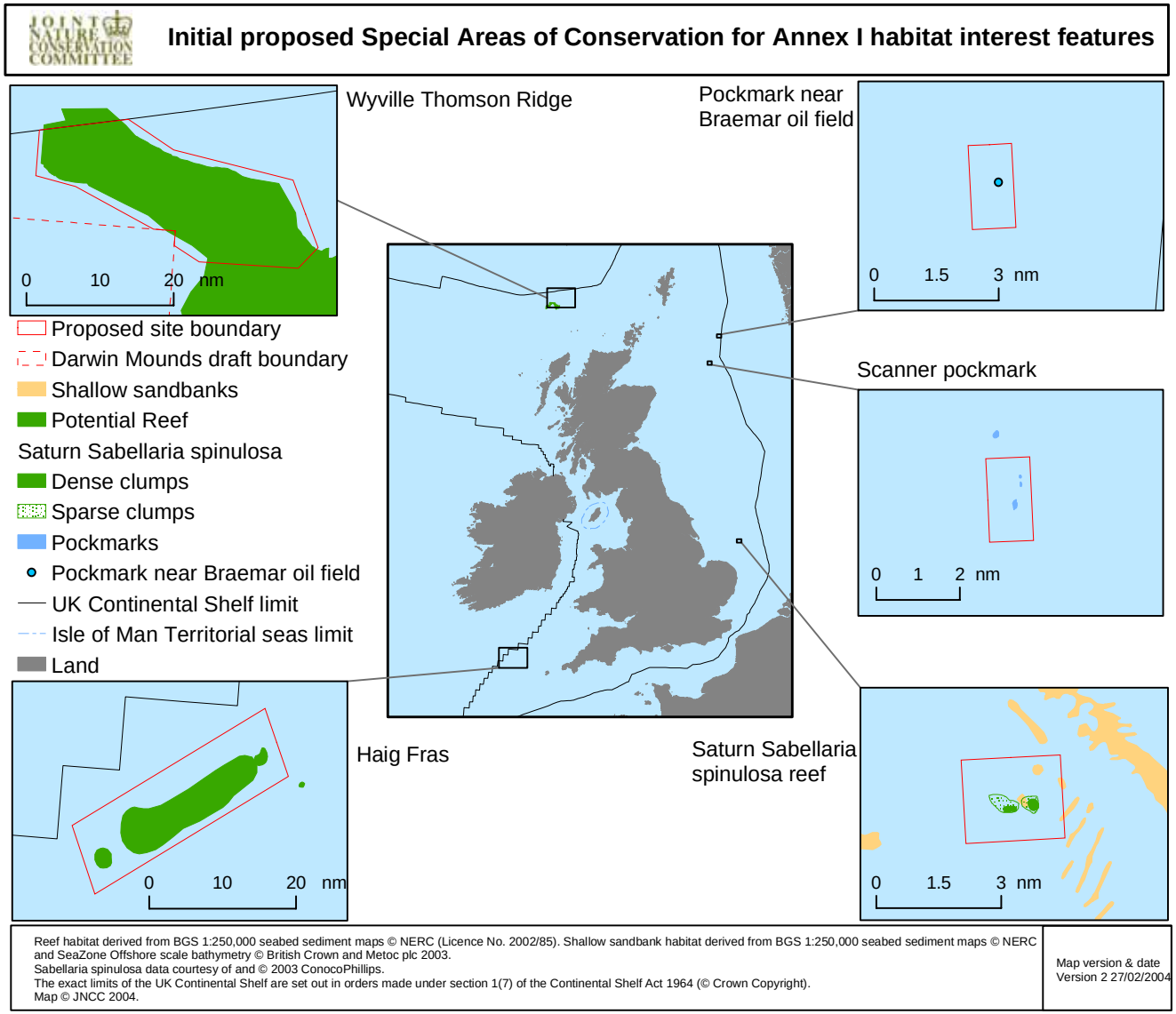
Pockmarks near Braemar oil field
The pockmarks located near the Braemar oil field, close to the UK border with Norway, would be representative of a submarine structure in the form of blocks in the northern North Sea. An epifaunal community composed of hydroids, anemones, *Lithodes* sp. crab is dependent on the hard carbonate substrata (J. Hartley, pers. comm.) which lie at the base of several pockmarks. The pockmarks are actively seeping methane gas.

2.4 Committee is therefore **invited to approve** the selection of these **five** sites as SACs, pending the outcomes of the European Commission's 'marine expert group'.

2.5 The 12 areas of habitat referred to above represent those for which we have sufficient information to consider them for SAC selection. These, combined with the 70 possible and candidate marine SACs already in existence for marine features in UK inshore waters, will not be sufficient to be representative of the range of habitats in UK waters and contribute sufficiently to the completion of a coherent European ecological network of sites.

2.6 Discussions in the UK and at the EU Marine Expert Group have confirmed that modelled geological or physical data alone are not sufficient for the identification of SACs, and that site specific biological data will be necessary to support designation of a habitat SAC. In addition to the 12 areas identified in paragraph 2.2 above, a further thirty areas have been identified from modelled seabed geological data as possible areas of Annex I habitat for consideration in the process for designation as SACs. As discussed in JNCC 03 P01, to recommend sites to Defra for selection as an SAC, JNCC needs to know the extent of the habitat, and that the seabed actually consists of the habitat in question, and have sufficient biological information to justify selection of the site as an SAC. Of the thirty areas of habitat mentioned above, seventeen require survey to obtain both biological and physical data and thirteen require survey to obtain biological data, before they can be considered further for SAC selection.

2.7 JNCC has carried out a cost estimate of the survey requirements implied in paragraph 2.5 above, and these are discussed in Section 5 below.


Initial proposed Special Areas of Conservation for Annex I habitat interest features
Wyville Thomson Ridge
0 10 20 nm
Pockmark near Braemar oil field
0 1.5 3 nm
Scanner pockmark
0 1 2 nm
Proposed site boundary
Darwin Mounds draft boundary
Shallow sandbanks
Potential Reef
Saturn Sabellaria spinulosa
Dense clumps
Sparse clumps
Pockmarks
Pockmark near Braemar oil field
UK Continental Shelf limit
Isle of Man Territorial seas limit
Land
Haig Fras
0 10 20 nm
Saturn Sabellaria spinulosa reef
0 1.5 3 nm
Reef habitat derived from BGS 1:250,000 seabed sediment maps © NERC (Licence No. 2002/85). Shallow sandbank habitat derived from BGS 1:250,000 seabed sediment maps © NERC and SeaZone Offshore scale bathymetry © British Crown and Metoc plc 2003.
Sabellaria spinulosa data courtesy of and © 2003 ConocoPhillips.
The exact limits of the UK Continental Shelf are set out in orders made under section 1(7) of the Continental Shelf Act 1964 (© Crown Copyright).
Map © JNCC 2004.
Map version & date
Version 2 27/02/2004

3. SACs for Annex II species

3.1 Existing data for bottlenose dolphin will be reviewed in 2004-05 to determine if there are 'hotspots' in the distribution of the species in offshore waters and , if there are such hotspots, are there factors which make these areas 'essential to the life and reproduction' of the species and if SACs can be proposed for them in UK offshore waters. Current indications are that no such 'hotspots' exist in UK offshore waters.

3.2 Research work is ongoing on distribution of both common and grey seals whilst at sea, and this data will be reviewed in 2004-05 to determine if any areas can be considered 'essential to the life and reproduction' of the species, and whether SACs can be proposed for them in UK offshore waters.

3.3 During 2001-02 the available data on distribution of harbour porpoise in UK waters (inshore and offshore) were re-analysed to examine if discrete areas could be identified for consideration as SACs using the additional criteria provided by the European Commission. Two contracts were let to perform this work. During 2003, the two reports of this work were independently peer reviewed, and some conclusions drawn. Annex A (CONFIDENTIAL) to this paper proposes a way forward in terms of the identification of SACs for harbour porpoise in UK waters, based on these two reports and the peer reviews.

4. SPAs

4.1 **Seaward extensions to existing seabird coastal breeding colony SPAs**
At its meeting in March 2003, Committee agreed draft guidance on defining the seaward boundaries of extensions to existing seabird coastal breeding colony SPAs for puffins, guillemots, razorbills and gannets. During 2003-04, further work is proceeding on the possibility of defining generic seaward extensions of existing coastal breeding colony SPAs for other species which breed in the UK. A paper will be prepared on this subject for the April 2004 meeting of the SPA and Ramsar Scientific Working Group (formerly the SPA Scientific Working Group).

4.2 **Inshore SPAs for seabirds in the non-breeding season**
Following the analysis carried out on bird distribution data to determine the seaward boundary for the Carmarthen Bay SPA for black (common) scoter, analysis was carried out during 2003-04 on data from two other sites: The Firth of Tay, and Liverpool Bay. These analyses have contributed to the modification of the draft generic guidelines for the seaward boundary identification of SPAs for inshore concentrations of non-breeding seabirds. These analyses have also confirmed that the existing JNCC guidelines on the selection of SPAs (described in Stroud *et al.* 2001), which were developed for terrestrial sites, can be used for the selection of this type of marine SPA, subject to modifications to their application in terms of types of data to be used for site selection. The attached paper (Annex B) presents the guidelines developed and the application of the data standards.

4.3 Committee is requested to **endorse** the approach to selection of inshore SPAs for seabirds in the non-breeding season using the existing SPA selection guidelines and applying the methods set out in Annex B.

4.4 The delegated procedure approved by the Joint Committee at its September 2003 meeting for consideration of marine SPAs will be used in relation to sites assessed through this process.

4.5 **Aggregations of seabirds, probably feeding**
The data analysis method for this aspect of the work on marine SPAs has been tested during 2003-04, and analysis of the European Seabirds at Sea database will proceed during 2004-05, in order to identify this type of possible SPAs.

4.6 If JNCC's work on identification of marine SPAs is to be concluded in timely fashion, considerable resources additional to existing levels will be necessary. Not only will additional resources speed the work, they will allow resumption of our strategic approach, in contrast to some of the reactive work recently and currently underway in response to complaints to the EU by RSPB and others (i.e. Carmarthen Bay and Liverpool Bay). The resource issues are summarised in section 5 below.

5. Resource implications of completing the work

Offshore SACS

5.1 To ensure minimum representation of Annex I marine habitats in SACs in UK waters, fifteen of the areas of habitat mentioned in paragraph 2.5 above need to be considered for SAC selection, and will therefore require survey. A key element of achieving ecological coherence in a network is replication of features within the network. To include replication of habitat sub-types in the different regions of UK seas, additional areas of habitat will need to be considered for SAC selection, which will require additional survey.

5.2 Survey of areas of marine habitat is expensive, particularly where areas of habitat are in deep waters or at considerable distances offshore. Estimates of costs for basic survey of the likely areas required have been made (see Table 2). These estimates are based on separate survey of each area, and costs could be reduced by combining surveys in nearby areas. The estimates do not include for staff time to manage contracts nor to progress sites to designation once surveyed, nor would they include sufficient information for baseline or monitoring surveys should any of the areas be selected as SACs. Another factor to be borne in mind when planning surveys, is the lead-in time required (a minimum of one year, more likely two) for remote areas as there are a limited number of suitable vessels, and ship time gets booked up well in advance. If surveys are carried out in collaboration with other research projects, this will reduce the funds required as vessel costs etc. can be shared, but again, extends the time needed to set up this kind of project.

Table 2 Estimated costs for basic survey of 15 habitat areas to enable consideration for SAC selection

Areas of habitat necessary for full representation of habitat types in UK offshore waters	**Estimated survey costs**
A Bedrock/stony reef in the northern North Sea (East of Shetland reef)	£227,050
A gravelly sand sandbank in the southern North Sea	£141,650
A sand sandbank in the eastern English Channel (Bassurelle)	£141,650
A bedrock/stony reef in the eastern English Channel	£227,050
A biogenic reef in western English Channel or Celtic sea (South West Approaches Shelf break)	£255,800
A muddy sand sandbank in Irish Sea (King William bank)	£141,650
A stony reef in the Irish Sea	£227,050
A biogenic reef in the Irish Sea	£88,425
A stony reef on the Continental Shelf west of Scotland	£227,050
A stony reef in the Faroe-Shetland Channel (Judd Deeps)	£157,200
A stony reef in the Rockall Trough or Bank region	£255,800
A bedrock reef in the Rockall Trough or Bank region	£255,800
A seamount in the Rockall Trough or Bank region	£255,800
A bedrock reef in the Atlantic North West Approaches	£288,000
A biogenic reef in the Atlantic North West Approaches	£185,550
Total	£**3,075,525**

5.3 In order to obtain sufficient physical and biological data necessary to support SAC designation if appropriate, the following types of survey are likely to be required. It is these survey methods upon which the cost estimates have been based. Acoustic techniques with interpolation between sampled areas would be used to characterise the seabed type over large areas, to determine the habitat extent and topography. Sidescan survey would be conducted over smaller areas selected on the basis of the acoustic survey, to provide finer detail. Drop-down video, video tows and/or digital stills photography 'samples' would be used to ground validate the acoustic and sidescan data to confirm habitat type. Such 'samples' will also provide data on biological community type, especially for reef areas. Grab sampling would also be required for sediment areas to provide an infaunal community description. Costs for sample data analysis and contingency for survey down-time due to poor weather have been included. The estimated costs assume a basic level survey to provide sufficient information for site selection, but given that in general, a major part of the cost of survey, particularly for areas further offshore and/or in deep waters, is the cost of the vessel and mobilisation, additional data and samples could be obtained at relatively little extra cost.

5.4 JNCC funding for work on identifying marine SACs for habitats in UK offshore waters is likely to be in the region of £50,000 for 2004-05. As can be seen from the estimates in Table 2, this order of funding will not even be sufficient to survey one potential habitat SAC per year. Combined surveys of

several areas of habitat and collaborative work will reduce survey costs to some extent but, it is clear from the above that current JNCC funding levels are insufficient to deliver even a minimum level of representativity of Annex I habitats in UK offshore waters. At current staffing levels, only a small number (one to three) sites could be surveyed per year even if funding were available, so even given the extra resources required, to complete the required survey work would take a minimum of 5 years. If an ecologically coherent network across Europe is to be achieved, further sites may need to be surveyed in order to designate replicates to provide robustness in the network. Additional resources will also be needed to undertake monitoring of sites once they are formally proposed to Europe.

Marine SPAs

5.5 JNCC has considered the cost of the remaining work to complete the programme of identifying of marine SPAs. The main elements of this work area :

i. completing the work to develop generic guidance to the seaward extensions to existing seabird breeding colony SPAs, by developing guidance for fulmar and gulls;

ii. completing the work on identifying SPAs for inshore aggregations of seabirds in the non-breeding season. An initial trawl through various survey data has resulted in a list of more than 40 inshore sites of seaduck, divers and grebes that might be considered for SPA status. For some, if not most, of these sites the current survey data will be insufficient to apply the SPA guidelines. For all sites, commencing with those for which data is sufficient, analysis in accordance with Annex B will need to be undertaken;

iii. undertaking the work to identify offshore aggregations of seabirds (probably feeding) will require analysis of the European Seabirds at Sea database to identify possible hotspots for seabirds for consideration as SPAs;

iv. some important aggregations of seabirds may not be captured by the above categories and are having to be considered individually , notably possible concentrations of Manx shearwaters, terns and red-throated divers.

5.6 JNCC estimate that the costs of undertaking the work outlined below as £2.3 million spread over a 4-5 year time frame. The breakdown of costs is given in Table 3 below. The maximum that JNCC will be able to allocate to this work in 2004-05 will be in the order of £100,000.

Table 3: Estimated costs for completing work in support of marine SPA identification

Item	**Estimated costs**
inshore aggregations work, including aircraft charter, temporary surveyors per annum	£300,000
aerial survey (terns and shags) per annum	£100,000
equipment (computing radio tags, misc) per annum	£15,000
2 staff (HSO equivalent) per annum	£60,000
T&S per annum	£20,000
Overheads per annum	£75,000
Total per annum	**£570,000**
Additional staff costs for contingency 5th year (including overheads)	£120,000
Total for 4 year programme of work	**£2,280,000**
Total for 5 year programme of work	**£2,400,000**

Consequences of funding shortfalls

5.7 As is clear from the foregoing paragraphs, JNCC's current level of resourcing falls well short of what will be required to complete the Marine Natura 2000 programme over the next few years. JNCC will continue to progress the work on offshore SACs and marine SPAs to the extent that grant-in-aid resources allow, concentrating on the aspects which are most achievable with that level of resourcing.

5.8 However, given the legal implications of this issue for the UK, JNCC will hold urgent discussions with Defra over the degree to which carrying out all the elements of the work summarised above is considered necessary and, in relation to those elements considered imperative, how they are to be resourced, assuming that costs exceed anticipated JNCC grant-in-aid.

References:

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EC (1999) Interpretation manual of European Union habitats. Version EUR 15/2. European Commission (DG Environment), Brussels, 121 pp.

Stroud DA, Chambers D, Cook S, Buxton N, Fraser B, Clement P, Lewis P, McLean I, Baker H and Whitehead S. 2001 The UK SPA Network: its scope and content. Volume I: Rationale for the selection of sites. Joint Nature Conservation Committee, Peterborough.

ANNEX B: GUIDELINES FOR THE SELECTION OF MARINE SPAS FOR AGGREGATIONS OF INSHORE NON-BREEDING WATERBIRDS

March 2004: Andy Webb, Jim Reid

In 1979 the European Community adopted Council Directive 79/409/EC on the conservation of wild birds (EEC 1979) known as the Birds Directive. The Birds Directive provides for protection, management and control of naturally occurring wild birds with the European Union through a range of mechanisms. One of the key provisions is the establishment of an ecologically coherent network of protected areas. Members States are required to identify and classify in particular the most suitable territories in size and number for rare or vulnerable species listed in Annex I to the Directive (Article 4.1) and for regularly occurring migratory species under Article 4.2. These sites are known as special protection areas, referred to as SPAs in the UK.

1.2 Obligations of the Birds Directive were initially transposed into UK law by the Wildlife and Countryside Act 1981 (as amended by the CROW Act 2000) and in Northern Ireland by the Wildlife Order 1985. Certain aspects of the Birds Directive were further transposed into UK law by two Regulations: one for England, Scotland and Wales The Conservation (Natural Habitats, &c.) Regulations 1994 (HMSO 1994), and another for Northern Ireland The Conservation (Natural Habitats, &c.) Regulations (Northern Ireland) 1995 (HMSO 1995). These regulations currently apply only within UK territorial waters, which extend from the baseline out to 12 nautical miles. The baseline consists of the low water mark and various defined lines across bays and inlets and around some of the Scottish Islands.

1.3 Guidelines for selecting SPAs in the UK were derived from knowledge of common international practice and based on scientific criteria (JNCC 1999). These guidelines were applied to available data in two stages:

i. The first stage identified areas likely to qualify for SPA status; and

ii. The second stage considered these areas further using one of more of the judgements in Stage 2 to select the most suitable areas in number and size for SPA classification.

1.4 The task of identifying all of the UK's terrestrial sites is largely complete, and the rationale described by Stroud *et al*. (2001). They describe a network of 243 sites in the UK, some of which include areas used by inshore non-breeding waterbirds, for example in estuaries. However, they do not review the requirements of birds using the wholly offshore environment. Johnston *et al*. (2002) describe a process by which SPAs might be identified for marine birds under the Birds Directive consisting of three strands:

i. seaward extensions of existing seabird breeding colony SPAs beyond the low water mark;

ii. inshore feeding areas used by concentrations of birds (e.g. seaduck, grebes and divers) in the non-breeding season; and

iii. offshore areas used by marine birds, probably for feeding but also for other purposes.

1.5 The process for identifying sites within each of these three strands is driven largely by the types of data available to support relevant SPA identification and classification, but will result in a coherent network of sites for marine birds.

1.6 Work is under way to identify seaward extensions to seabird breeding colony SPAs. This paper describes how sites might be identified under the second of the above strands, i.e. those for inshore concentrations of waterbirds in the non-breeding season. For the purposes of this paper, waterbirds refers to those species listed in section 3.2 (below).

1.7 The principles underlying the guidelines for selecting SPAs in the terrestrial environment (JNCC 1999) are based on widely accepted practice, and these should be applied also to SPA site selection in the marine environment. The main purpose of this paper is to explore if the data to be used for selecting sites for inshore non-breeding birds lend themselves to these principles, and what modification, if any, might be needed to the existing site selection guidelines. This paper also gives guidelines for determining boundaries for sites selected as marine SPAs for inshore concentrations of non-breeding waterbirds.

2 Data sources

2.1 Count data for inshore waterbirds exists in a number of different formats, as described below. In general, the quality of data for these waterbirds is poor compared with data for terrestrial areas, mainly due to the difficulty of obtaining accurate counts. The reasons for this are various and include the difficulty of counting mobile aggregations of birds from distant vantage points and from other mobile platforms, and also the dependence of such counts on favourable environmental conditions such as low sea state. The need for precise counts and spatial information beyond sight of land requires that surveys be conducted from expensive survey platforms such as aircraft or ships, effectively ruling out the use of information from volunteers. Yet land-based count data collected by volunteers provides important contextual information about the history of occupation of important areas and of areas worthy of further survey.

2.2 All bird surveys are vulnerable to census errors (e.g. Bibby *et al*. (2000), and surveys of inshore waterbirds are no exception to this. Surveys targeted at obtaining good information on the numbers and distribution of inshore waterbirds are more likely to have controlled for these errors than results from surveys targeted at collecting data for other species.

2.3 The quantity and quality of data for birds in the marine environment are such that the site selection guidelines previously developed for largely terrestrial use may not be as readily applicable for identifying marine SPAs.

Land-based surveys

2.4 Surveys from land may be carried out systematically, non-systematically or partially systematic.

2.5 A systematic survey will most likely have been commissioned by, for example nature conservation bodies or as part of Environmental Impact Assessments by developers, and the results contained in contract reports. Counts will have been carried out: from fixed locations; generally in good conditions (thereby minimising the effect of weather on count quality); by experienced observers usually with some control for potential over- or under-estimation of flock size; they will cover an entire area (as far as is possible to see from land) and will usually have been repeated at regular intervals within the same season.

2.6 Non-systematic surveys will most likely have been carried out on an opportunistic basis by amateur bird-watchers, the results (usually) disseminated in local bird reports and will be of variable often unknown quality and reliability. However, some will be of high quality and sufficiently robust to provide important contextual information about aggregations in some sites.

2.7 Counts conducted as part of the Wetland Bird Survey (WeBS) are carried out by experienced volunteer ornithologists on fixed dates each month (Musgrove *et al*. 2001; Gilbert *et al.* 1998). However, because of the difficulty of obtaining good counts from land in adverse weather conditions, surveys carried out on fixed dates (instead of under ideal weather conditions) can often be of poorer quality. Similarly, as these surveys rely on volunteers, coverage may not always be complete for a given area. WeBS surveys are usually targeted at collecting data for species other than inshore waterbirds, such as waders feeding in the inter-tidal zone, and observers may therefore be less able to control for census errors involving inshore waterbird species. For these reasons, WeBS data should might not be fully systematic in some or possibly even many cases. On some occasions, counts may produce maximum counts close to the true population of an inshore species at a particular site, but more usually, the maximum count for a season will be considerably lower than the actual numbers using the site.

2.8 All land-based surveys are constrained by the distance it is possible to identify and count birds in inshore flocks. Under good conditions (good visibility, light winds, no sun glare), an experienced observer using a telescope can see and identify birds up to about 2km from land (e.g. Webb *et al*. 1990). Exceptionally this distance may be greater. However, it is always difficult to provide precise information about the location of waterbird flocks and it is impossible to determine if aggregations extend beyond the viewing distance. Therefore, all land-based counts of inshore non-breeding birds should be assumed to be incomplete.

Ship surveys

2.9 Surveys from ships are generally carried out under good survey conditions by professional observers and need to be carried out in a systematic fashion. Usually they are sample surveys, although it is possible under certain circumstances to obtain total counts when the site is small or if the structure of the bird aggregations allow all individuals present to be counted.

2.10 There has been much discussion of the relative merits of ship and aerial counts of waterbirds. These are discussed in greater detail in Dean *et al*. (in press, 2003), Pihl *et al*. (1992) and will be reviewed more fully in a forthcoming COWRIE project. This COWRIE project, established by Crown Estates, aims to review current methods for obtaining bird counts in relatively small areas of sea, using either ships or aircraft as observation platforms and to produce a guidance document or manual.

2.11 Boat-based surveys can be used for determining the limits of waterbird aggregations but are of limited value in areas of extensive shallow water and may result in ship-avoidance behaviour of some waterbird species, such as black scoter and red-throated diver.

Aerial surveys

2.12 Aerial surveys are generally the preferred method for surveying waterbird aggregations because they allow the rapid collection of data about the numbers and location of the bird flocks. They are carried out by professional and trained observers in a systematic fashion usually under very good survey conditions. They can be used for sample surveys or for total counts in large areas. Surveys from boats and from aircraft are considerably more expensive than land-based surveys, limiting opportunities for collecting data and therefore contribute to the paucity of good quality data available for inshore birds.

2.13 In general, aerial surveys cause less disturbance of waterbirds than boat-based surveys, can be undertaken in very shallow waters and can cover large areas in a short space of time. However, because of the speed of the aircraft, some information (such as behaviour) that can be collected from ships or from land cannot be obtained, and there may be reduced accuracy in detecting and identifying species, estimating numbers. Bibby *et al.* (2000) discuss the effects of speed of survey in general terms.

Sample surveys and complete (total) surveys

2.14 Complete surveys result in total counts of birds; that is, observers attempt to count all birds in the study area (the area for which the population estimate is required). Usually, the study area will be divided into smaller units, and birds in each of these units will be counted and treated as one sample.

2.15 Sample surveys obtain data from a representative sub-sample of a larger area and these data are analysed in order to provide an estimated number of birds present in the whole larger area. Buckland *et al.* (2001) and Borchers *et al.* (2002) discuss many aspects of sampling theory.

2.16 Total counts and sample counts are both subject to counting errors. These errors may arise from observers not detecting all bird flocks, or from their systematically under or overestimating flock size, or by not locating flocks in the correct place, thereby counting them twice or missing them altogether. Such errors are usually of unknown magnitude but can be large. Sample surveys minimize counting errors, but add other errors as a consequence of sampling only a portion of the study area, and possibly also by under-sampling within some parts of the study area. However, it is usually possible to estimate the sizes of counting and sampling errors associated with sample survey data. Analysis of sample surveys generates a mean estimate of density (birds per unit area) in the whole study area with 95% confidence limits based on the standard error of the mean. These confidence intervals can be wide. In virtually all cases, it is most appropriate to apply the estimated mean density to the whole study area to arrive at an estimated population size.

2.17 The finest scale at which depiction and analysis of the spatial distribution of birds using complete count data is constrained by the scale at which the data were collected. Clearly, if the bird distribution data are collected at a coarse scale, fine-scale mapping of the distribution patterns is impossible, regardless of how easy it is to understand such information.

2.18 Sample surveys can provide estimates of the total numbers of birds in a given area using a variety of modelling methods. Geostatistical and spatial modelling may be applied to generate detailed predictive thematic maps of bird abundance at scales similar to those at which the data were collected. Such analyses demand that the sampling points, between which bird presence and abundance are predicted, are representative of the whole study area. In cases where waterbird distribution is in some way constrained, by environmental or other factors this requirement may be violated.

2.19 Population estimates obtained from sample surveys can be derived using different analytical methods, such as distance sampling, extrapolation and geostatistical techniques; McSorley *et al.* (in prep.) discuss this fully. McSorley *et al.* (in prep.) note that sample surveys that do not take account of reduced detection of birds at greater distances from survey transect lines result in underestimates of the total population present. Such analytical methods are complex and time intensive.

2.20 In areas that hold very large populations of inshore waterbirds, the total number of birds of a given species counted in a sample survey might exceed the SPA selection threshold for the species, even though only a portion of the total population has been sampled (assuming no double-counting).

2.21 Tables 1 and 2 summarise and evaluate the various methods that may be applied to identify areas that might qualify as SPAs.

Table 1. Evaluation of different types of total counts of inshore waterbirds

Population estimation method	**Quality issues**	**Completeness of population estimates**
Casual counts from land	Usually non systematic; generally of unknown quality.	Incomplete further from shore; boundaries of area counted usually undefined.
WeBS data	Usually systematic; carried out on fixed dates even when weather conditions are unsuitable; some counts are targeted at onshore and not inshore bird species.	Usually incomplete further from shore; occasional coverage problems; count site boundaries not always appropriate for inshore waterbird aggregations.
Systematic counts from land	Best quality of all land-based surveys; generally surveyed when weather conditions good for counting; highest quality of species identification and estimation of numbers; usually targeted at inshore waterbird species.	Usually incomplete further from shore.
Total counts from ships	Usually targeted for inshore waterbird species; ship-avoidance by some species may lead to double-counting or non-detection of some species; carried out in good weather conditions; moderate to high resolution of species identification and estimation of numbers.	No coverage of very shallow waters.
Total counts from aircraft	Usually targeted for inshore waterbird species; counted during good weather conditions; low levels of avoidance by all species; low to moderate resolution of species identification and estimation of numbers.	Generally good, but some data loss close to land.

Table 2. Evaluation of different analytical methods for estimating population size from sample surveys

Analytical method	**Quality issues**	**Confidence intervals for estimated population?**	**Usefulness for boundary determination**
Extrapolation from overall density (total number / total area surveyed x area of site)	Generally a safe, but simplistic method if sampling intensity reflects bird distribution.	No	Not possible
Extrapolation from mean density (mean density x area of site)	Problems when applied to non-normally distributed data and where there is spatial auto-correlation. Population estimates tend to be underestimates because most survey data are non-normal.	Unreliable	Poor without geostatistical or spatial modelling.
Distance estimation	Well-documented, statistically robust method for population estimation. Not applicable to small areas and poor when fewer than 50 flocks encountered.	Yes, but produces very wide confidence intervals for inshore waterbird population estimates	Poor sub-sampling capability.
Geostatistical analysis (kriging)	Good method if procedures carried out correctly. Not used or tested much in animal ecological literature	Possible, but untried	Good
Spatial modelling (general additive models)	Relatively new procedure; statistically robust, though possibly not to problems of spatial autocorrelation.	Yes and generally tighter than for Distance	Good

3 A process for applying site selection guidelines for aggregations of inshore non-breeding waterbirds

3.1 The guidelines for selecting SPAs in the United Kingdom are described in Stroud *et al*. (2001), and are repeated below. These guidelines are adequate and competent for application to site selection in the inshore environment for inshore non-breeding waterbird aggregations. However, the type and quality of count data for waterbirds differ from those used in identifying sites for terrestrial birds. Thus, this paper clarifies the application of the SPA guidelines for site selection of marine SPAs using these types of data.

Bird species to be considered

3.2 These guidelines cover the selection of sites for inshore non-breeding waterbirds. At present, these include the species on the following list, intended to be exemplary rather than exhaustive (for example, further consideration of non-breeding gulls may be necessary):

Red-throated diver	*Gavia stellata*
Black-throated diver	*Gavia arctica*
Great northern diver	*Gavia immer*
Red-necked grebe	*Podiceps grisena*
Great crested grebe	*Podiceps cristatus*
Slavonian grebe	*Podiceps auritus*
Black-necked grebe	*Podiceps nigricollis*
Little grebe	*Tachybaptus ruficollis*
Greater scaup	*Aythia marila*
Common eider	*Somateria mollissima*
Long-tailed duck	*Clangula hyemalis*
Black (common) scoter	*Melanitta nigra*
Velvet scoter	*Melanitta fusca*
Common goldeneye	*Bucephala clangula*
Red-breasted merganser	*Mergus serrator*
Goosander	*Mergus merganser*

Adequacy of count data

3.3 The SPA selection guidelines provide guidance on data adequacy, especially in relation to determining regular occurrence. As previously suggested the application of the guidelines for non-breeding waterbirds in marine waters presents specific problems due to data availability.

3.4 It is recommended herein that in the majority of cases, data collected using non-systematic methods or where there are significant sampling errors should be viewed as inadequate for SPA selection purposes at Stage 1 of the Site Selection Guidelines, but these may be considered for use in some parts of Stage 2 of the selection process.

3.5 Most data available for assessment of inshore SPAs will originate from WeBS counts. Although WeBS is systematic enough in its coverage of the terrestrial environment it is not fully systematic re the counting of birds on the open-

water so may be best described as partially systematic (see above); any count of birds on the water is liable to underestimation (to an unknown extent) of the true population size. However, some maximum counts for a species at some sites will give a reasonable estimate of the true population occurring there. Thus, there may be one or more adequate counts for a species at a site over a number of years. This has implications for applying standard definitions of "regularity" when only WeBS data are available (see 3.4.3 below), and also when making Stage 2 judgements in site selection.

3.6 Seasonal maximum counts carried out from land, even from systematic surveys, will in most cases give a fair representation of the true population. However, for some species and at some sites where divers, grebes or seaduck occur out of sight from land, seasonal maxima will underestimate the true population for the area, perhaps to a significant degree. As with the use of WeBS data, this may have implications for applying standard definitions of regularity when only these data are available, or again when making Stage 2 judgements in site selection..

Selection at Stages 1.1 to 1.3 of SPA guidelines

Selection thresholds

3.7 Stages 1.1, 1.2 and 1.3 of the UK SPA selection guidelines (JNCC 1999) provide a threshold approach to selecting sites that are then considered further under Stage 2:

1.1 An area is used regularly by 1% or more of the Great Britain (or in Northern Ireland, the all-Ireland) population of a species listed in Annex 1 of the Birds Directive (79/409/EEC as amended) in any season;

1.2 An area is used regularly by 1% or more of the biogeographical population of a regularly occurring migratory species (other than those listed in Annex 1) in any season; and

1.3 An area is used regularly by over 20,000 waterfowl (waterfowl as defined by the Ramsar Convention) or 20,000 seabirds in any season.

3.8 At stages 1.1 and 1.2, reference is made to the Great Britain, all-Ireland and biogeographical populations for species. These population sizes should be those adopted by JNCC. GB and all-Ireland population sizes are reviewed and published by the Avian Population Estimates Panel (APEP), most recently in Stone *et al*. (1997), but under review for publication in 2003. Biogeographical population size estimates are published by Wetlands International (2002).

Assembling and assessing adequacy of count data

3.9 The process requires all data that can be used for estimating the total population of divers, grebes and seaduck in a site to be assembled.

3.10 It is necessary to assess the quality of each count of an area on the following criteria:

i. *experience of observers* – a survey conducted by inexperience observers may be susceptible to unacceptable errors in estimating numbers of birds in flocks and species identifications (particularly for divers and grebes);

ii. *systematic* – an assessment of whether counts were part of a systematic survey of a given area or were of a casual nature. A systematic survey should demonstrate that a methodical survey has taken place in the area in question, taking care to avoid over or under-counting because of movement of birds;

iii. *completeness* – an assessment of whether all parts of the given area were covered and a description of those parts omitted from the count. This assessment should include whether the count was made from land, aircraft or ship, and details of parts of the area not counted adequately because of access or other survey difficulties;

iv. *counting method* – an assessment of whether the population estimate is derived from a total count or from a sample survey in which the number is based upon the estimated density of birds multiplied by the total area of the site.

v. *quality of sampling* - if appropriate an assessment is needed of the representativeness of samples. Poor sampling may occur when transect lines are oriented parallel to significant habitat features such as elongated banks or river channels or when significant habitats are omitted from the survey;

vii. *robustness of population estimate* – in some cases, it may be possible to derive more than one population estimate from a single survey. When this is the case, the most robust population estimate should be used (see Table 2); and

vi. *external factors affecting the survey* – it might be important to note that some surveys might have been affected by factors, such as unusual weather conditions or a pollution incident, that might give rise to atypical counts and make inclusion of such data unrepresentative.

3.11 Any data considered inadequate for population estimation should be clearly identified as such. It is difficult to be prescriptive about what renders a count inadequate for population estimation; surveys differ in the approaches used to sample or cover a given area and all are likely to have limitations.

3.12 A well-planned and well-executed aerial sampling survey using experienced observers and distance estimation should yield good population estimates. However, additional information may be needed from land-based or boat-based surveys to supply accurate species identification or to count inconspicuous species or those close to the shore. In some situations (e.g.

small or enclosed sites), boat-based or systematic land-based surveys might provide better population estimates.

3.13 Ideally, sample surveys should be carried out with estimation of the distance of bird flocks from the observer. Transects should be aligned perpendicular to the orientation of any significant habitat features that might concentrate inshore bird species. The population estimate should use a statistically robust method, such as Distance (ideal), spatial or geostatistical modelling and should include confidence intervals for any estimate.

Defining 'regular' for inshore non-breeding waterbirds

3.14 In the UK SPA selection guidelines (JNCC, 1999), the Ramsar site selection criteria are used to define the term regular for SPAs.

3.15 "A wetland regularly supports a population of a given size if:

i. the requisite number of birds is known to have occurred in two thirds of the seasons for which adequate data are available, the total number of seasons being not less than three; or

ii. the mean of the maxima of those seasons in which the site is internationally important, taken over at least five years, amounts to the required level (means based on three or four years may be quoted in provisional assessments only).

3.16 In some instances, however, for example species occurring in very remote areas or which are particularly rare, areas may be considered suitable on the basis of fewer counts."

3.17 There are no inshore sites in the UK where there are five seasons (years) of best quality count data and only a few where there are three years. Most sites will have count data of variable quality, in which qualifying numbers may be proved to occur in some years, but because of the tendency toward significant under-counting in many land-based surveys, it cannot be assumed that qualifying numbers do not occur in other years. In these cases, strict application of the Ramsar criteria would result in under-representation of sites that meet Stages 1.1-1.3 of the SPA guidelines.

3.18 The first definition may be applied more easily to count data for inshore non-breeding waterbirds, because it can still be applied if suitable data are only available for three years, or even if there are two years with good data and one with poor data.

3.19 Although the Ramsar definition of regular allows further compromise for remote areas, such compromise may be inappropriate in the marine environment, where transient aggregations of prey might lead to irregular occurrences of very large numbers of some inshore birds at a site.

3.20 It is likely that greater attention will be needed at Stage 2 of the selection guidelines, given the sparseness of good quality count data in inshore waters

compared with terrestrial site selection. In particular, it might be necessary to give greater consideration to the history of occupancy for inshore sites.

A process for selecting sites that qualify at Stages 1.1 to 1.3 of the UK SPA selection guidelines

3.21 The following is a suggested procedure for selecting a preliminary list of sites that meet Stages 1.1 to 1.3 of the Guidelines and which can then be considered at Stage 2. Several trawls should be made through the available data for any given site addressing 1.1, 1.2 and 1.3 of the SPA selection guidelines. Several trawls allows sites to be selected at these stages without the need for sometimes costly or time intensive analyses to estimate population size. If a site does not qualify at these stages, the poorest quality data should be ignored, and the selection procedure re-iterated. The final iteration might retain only best quality aerial or ship-based survey data and could be selected at Stages 1.1, 1.2 or 1.3 based on only two years of data (with an additional third year, courtesy of poorer data excluded during a prior iteration, to satisfy the first definition of regular used in the Ramsar site selection criteria – see 3.3.3i above).

3.22 It would be prudent to set an age limit to the data used in this process, given that for remote inshore sites, count data may be sparse. Priority should be accorded to data collected within the last 10 years.

The Stage 2 judgements of SPA guidelines

3.23 Seven Stage 2 judgements are listed in the SPA guidelines for use in selecting sites at the second stage of the process. As for the Stage 1 guidelines, there is no fundamental reason for changing the guidelines for the inshore marine environment. The following are observations on the relative value of each of these guidelines:

i. *Population size and density* Population size may be the most useful guideline to apply to selection of inshore sites at Stage 2.

ii. *Species range* Species range should be applied in the same way as for terrestrial sites.

iii. *Breeding success* A judgement of breeding success cannot be applied to non-breeding birds in inshore waters.

iv. *History of occupancy* The sparseness of good quality count data in inshore sites will mean that some sites are selected on very few count data. In such cases, it is essential that all data be used to determine that the site is occupied by the species or species assemblage in other years using poorer quality data. It would be appropriate to use non-systematic count data in determining the history of occupancy.

v. *Multi-species areas* Multi-species areas can be applied in inshore sites in the same way as for terrestrial sites.

vi. *Naturalness* As in terrestrial sites, there are few sites that could be said to be truly natural in the marine environment, although some will be less affected by human activities than others. Useful parameters for use in Stage 2 guidelines might be: presence of aquaculture; presence of sewage outfalls (or other forms of artificial marine enrichment); level of fishing activity; disturbance by humans (e.g. leisure activities); marine dredging; and presence of windfarms. Sites where artificial nutrient enrichment may have elevated counts for some species, such as of greater scaup or common goldeneye, should not be rated more highly than sites where no or less enrichment takes place at Stage 2 of the SPA selection guidelines.

vii. *Severe weather refuges* There is no evidence in the UK that severe weather initiates anything more than very localised movements of divers, grebes and seaduck. However, if it can be established that a site provides refuge for inshore waterbirds during severe weather at other sites, then the refuge site might be considered for selection at Stage 2 of the SPA guidelines.

Sites with especially sparse data

3.24 At some inshore sites, it may prove impossible to determine if qualifying numbers of waterbirds recorded during one survey occur on a regular basis because of an insufficiency of good quality data. There may also be insufficient historical counts to determine the importance of the site. In such a case, it is suggested that a second tranche be used to categorise such sites and that further survey be commissioned at these as a matter of high priority.

Composite sites with disjunct aggregations

3.25 Some discrete diver, grebe and seaduck aggregations will be located near each other. These might be combined into a single composite site, or treated as separate entities. A composite site will encompass a greater population of waterbirds, and therefore be more likely to be selected using population size criteria than if each aggregation were treated separately. The treatment of composite sites with disjunct aggregations is treated more fully in 4.2.5 below.

4. Boundary placement

4.1 The principles for defining boundaries for terrestrial SPAs in the UK are described in Stroud *et al.* (2001) thus:

4.2 “The first stage of boundary determination involves defining the extent of area required by the qualifying species concerned. These scientific judgements are made in the light of the ecological requirements of the relevant species that may be delivered by that particular site, and the extent to which the site can fulfil these requirements. This follows a rigorous assessment of the best-available local information regarding distribution, abundance and movements of the qualifying species. It may also involve the commissioning of special surveys where the information base is weak.

4.3 Following this stage, every attempt is made to define a boundary that is identifiable on the ground and can be recognised by those responsible for the management of the site. This boundary will include the most suitable areas for the qualifying species identified in the first stage, but will relate to landscape features such as changes in habitat, field boundaries, rivers, roads etc., and thus may be marginally more extensive."

4.4 In the inshore marine environment, there is generally little available information about ecological requirements and habitat selection by waterbirds. Inshore concentrations of seaduck, divers and grebes may be associated with waters of particular depth, hydrography, substrate type or benthic fauna. However, the precise relationship between these parameters is unknown. Their distribution of birds may be constrained by land in part of the site, but in the remainder will, in effect, be unbounded. The sea surface is generally featureless, so in a marine site it is usually not possible to define boundaries with respect to natural features except where the site abuts the land.

Landward boundary placement

4.5 Where the distribution of birds at a site is likely to meet land, a boundary should usually be set at the mean high water mark (MHW), or in Scotland at the mean high water mark springs (MHWS), unless there is evidence that the qualifying species make no use of the intertidal region at high water. In the latter case, the mean low water (MLW) mark, or in Scotland the mean low water mark springs (MLWS), should be used. Some small-scale variation from this line might be necessary, for example where a boundary crosses an inlet or estuary.

4.6 In cases where the distribution of birds means that it is unlikely that the site will meet land then the same principles for boundary selection as set out in 2 (Seaward boundary placement) should be followed.

Seaward boundary placement

4.7 Ideally, the seaward boundary of a site (i.e. that part of the site not adjacent to or abutting land) should be placed around the qualifying concentrations themselves using the best available data on their distribution and using the best scientific evaluation of the limits of the species distribution.

4.8 There may be very few cases where habitat characteristics could also be taken into consideration and in such cases, where the relevant habitats occur in association with known bird distribution, it may be possible to define a boundary that takes this into account. However, in such cases there will need to be a clearly demonstrable functional link between the habitats in question and the distribution of the associated birds. The geographical limits of the relevant, associated habitats would guide boundary placement in combination with the distribution of birds.

The nature of waterbird distribution at inshore sites

4.9 Waterbird dispersion at sea can take several forms in a continuous scale from evenly dispersed through randomly dispersed to clumped (aggregated) dispersion. Waterbird dispersion patterns may vary with geographical location or habitat type, or when examined at different spatial or temporal scales.

4.10 Site-based measures under the Birds Directive are not appropriate for the conservation of waterbird populations where species do not occur in significant aggregations (Stroud *et al.* 2001). However, inshore non-breeding waterbirds have mostly aggregated dispersion patterns, driven in the case of most seaduck species by social and habitat interactions. This renders them especially suited to site-based conservation measures.

4.11 Surveys of inshore non-breeding waterbirds in a site usually highlight one or more core areas used by any given species, areas with satellite aggregations around the core and areas where the species is absent (e.g. Webb *et al.* 2003 and McSorley *et al.* in prep.). Determining the boundaries between these zones at the seaward limits of the aggregations is difficult, especially when a species is rare or there is a low encounter rate for the species in question.

Analytical methods for determining seaward boundaries

4.12 The need to distinguish core and satellite aggregations of a species in a site is important when considering the type of analysis most appropriate for determining the most suitable seaward boundary. The issues are discussed in part in Webb *et al.* (2003) and McSorley *et al.* (in prep., 2003) and are summarised in Table 3 below.

4.13 In the majority of cases, it is recommended that the seaward boundary of SPAs for inshore non-breeding waterbirds should be determined by analysing bird data from aerial or boat-based sample surveys using spatial interpolation combined with spatial analysis. If necessary, such surveys must be commissioned to enable these analyses. The main exceptions to this will be when:

i. the bird species in question occurs only in a small number of large, discreet flocks at a site (greater scaup might be one such example);

ii. it is not possible to use sample surveys for the qualifying species (e.g. roosting flocks of species such as gulls);

iii. the bird species only occurs very close to the coast and therefore is difficult to detect from boats or aircraft (e.g. grebes at some sites);

iv. the entire population of birds occurs entirely within a mainly enclosed site where the seaward limits of distribution can be seen clearly from land (e.g. some sealochs or estuaries); and

v. habitat data are also used in combination with bird distribution data to determine boundaries, although this is not exclusive of the above recommended analysis techniques for those bird data.

Table 3. Methods for assessing the distribution of bird species in inshore sites.

Analytical method	Description of / output from method	Advantages	Disadvantages
Raw counts from sample surveys at sea	Display of symbols representing flock size obtained from sample surveys from a boat or aircraft.	Simple, quick; probably most appropriate when few or no satellite aggregations are present.	Cannot be used to distinguish clearly on a small scale between core aggregations, satellite aggregation and areas holding birds under most circumstances.
Total counts at sea	Display of symbols or counts representing total birds counted within survey units from boat or aircraft surveys.	Simple, quick, perhaps acceptable when no satellite aggregations are present.	Resolution too coarse usually for most purposes and provide little detail about locations of satellite aggregations.
Land-based count data	Display of total count data along stretches of coast.	Useful for species known to be restricted to the nearshore (<500m from land) environment also for determining use of intertidal zone and as supportive information for limits of distribution along the coast.	Information usually too coarse resolution and cannot usually be used for determining the seaward limits of distribution.
Spatial interpolation and spatial analysis of sampling surveys at sea	Estimate bird abundance from sample surveys in a fine grid using spatial interpolation methods. Use spatial analysis techniques to define limits of aggregations.	Allows detailed assessment from multiple surveys and species, objective and repeatable, statistically robust, good distinction of core and satellite aggregations from areas with no birds.	Time and data intensive. Poorer information close to the coast.

Spatial interpolation and spatial analysis

4.14 The methods for carrying out spatial interpolation and spatial analysis on aerial or boat-based sample surveys are described in detail in Webb *et al.* (in press 2003), developed and updated in McSorley *et al.* (in prep.). These sources include descriptions of methods for data treatment and should be consulted when carrying out analyses of this type; an outline of the techniques follows.

Spatial interpolation methods

4.15 Spatial interpolation is a suite of modelling techniques in which the probability of bird occurrence or the total number of birds present is estimated at unsampled locations (usually in grid cells) using information on the presence or absence, or the number of birds recorded at sampled locations. There are a number of methods for carrying out such an analysis divided into two types: deterministic methods, such as inverse distance weighted methods, which do not use random errors associated with their predicted abundance estimates; and stochastic methods which use random errors (e.g. Isaaks and Schrivastava, 1989). Stochastic methods allow for an estimation of confidence in the predicted abundance estimates and should be used when attempting to model the distribution of inshore non-breeding birds. There are broadly two approaches to stochastic modelling of distribution patterns: spatial modelling (using generalised linear or ideally general additive models) and geostatistical modelling (using methods known as kriging). Both methods have their advantages and disadvantages, such that either technique, if carried out properly, would be good interpolation methods.

4.16 There are a number of different possible approaches to geostatistical analysis. In most cases, a method which combines indicator kriging with ordinary kriging should be used, or for rare species, only indicator kriging (see McSorley *et al*. in prep.). Kriging should not be used when there is no spatial autocorrelation, in which case spatial analysis or a deterministic method should be used. As these methods are complex and easily misapplied, appropriate care and expertise should be exercised in their application

4.17 If a stochastic method for spatial interpolation is used, then the final step in any analysis should be the removal of any grid cells for which there is low confidence in their values (i.e. excessively high standard errors).

Identifying the most important parts of the site

4.18 The output of spatial interpolation analysis is a grid of cells covering the area surveyed, in which each grid cell contains a geographical locator and a predicted density of birds, total number of birds or the probability of occurrence of the birds. The size of grid cell should be small, typically 100-m squares (e.g. Webb *et al*. 2003 and McSorley *et al*. in prep.) but certainly no greater than 250-m x 250-min. This grid may be imported into a geographical information system (GIS) where it is possible to overlay grids for different species and from different surveys, so requiring that the grid cells are of identical size, have the same geographical locator, projection and reference datum.

4.19 Webb *et al.* 2003 set out a method for classifying grid cells so that the most important ones for a species on any given survey are highlighted. The grid cells were ranked from lowest predicted bird abundance to highest, and the cumulative population calculated from lowest ranked grid cell to highest. The highest ranking grid cells were selected such that they comprised 95% of the total population, this defining the seaward boundary of the site under consideration. Webb *et al.* (2003) set their selection threshold for each survey

at 95% of the total population. McSorley *et al.* (in prep.) applied an improved spatial interpolation method, which revealed that a population threshold of 98% provided the ideal balance between size of area and proportion of the population contained within it (i.e. a small decrease in the population threshold would result in little change to the size of area, whereas the same increase in population size would result in a large increase in the size of area).

4.20 For species that are encountered rarely, which do not occur in large flocks but are generally counted in ones and twos, it would be more appropriate to use the output from an analysis using indicator kriging (see McSorley *et al.* in prep.) where each cell contains an estimate of the probability of occurrence of the qualifying species. There are a number of approaches for describing the most appropriate cut-off value for the predicted probability. One such method uses the same probability of occurrence as the number of sightings as a proportion of all sightings, another chooses a value that maximises the number of grid cells correctly classified by the model using an error matrix.

4.21 The final step in the process requires that selected grid cells (the cells with the highest density holding 98% of the total population in any given survey, or those exceeding the probability threshold for rarer species) are overlaid for all analysed surveys of qualifying species using a GIS.

4.22 A minimum of three separate surveys, covering at least two different years, should be used for such an analysis.

Core aggregations and satellite aggregations

4.23 An analysis of the most important parts of the site for qualifying species, as outlined above, will demonstrate the location of the core aggregations and usually of a number of satellite aggregations around the edge of this core.

4.24 Decisions on which, if any, satellite aggregations should be included within the boundary of the SPA should be made on an individual site basis. A judgement should be made of the regularity with which any given satellite aggregation occurs, if necessary referring to any accessory data not used in the spatial analyses. Regularity is defined in the SPA Selection Guidelines (JNCC 1999).

Disjunct aggregations

4.25 Analysis of the distribution of qualifying species at a site might reveal that core and satellite aggregations might be separated from each other by some distance. In such cases, it will be necessary to make a judgement of whether these should be treated as separate parts of the same site or as different sites.

4.26 Stroud *et al.* (2001) suggest that such aggregations might be combined into a single site where:

i. site elements are ecologically linked in their use by a common bird population (e.g. a group of alternative roost sites or feeding areas used by one population of waterbirds); and/or

ii. habitat was formerly geographically continuous before being separated by human activity.

4.27 Ecological linkage might be established for example when significant movements of birds are found to occur between the core aggregations; if data not used in spatial analyses reveal significant usage of waters between core aggregations; if birds share a common roost; or if their feeding habitat is found to be present between the core aggregations (or would be present, but for degradation by human activity).

4.28 An investigation to establish whether there is ecological linkage between core aggregations within an area might reveal a number of scenarios with potential outcomes described in Table 4 below.

Table 4. Potential scenarios and outcomes resulting from research to determine ecological linkage between core aggregations in an area for inshore non-breeding waterbirds.

Scenario	**Outcome**
There is ecological linkage between core aggregations but that the area as a whole cannot be selected as an SPA according to Stages 1 and 2 of the selection guidelines	No SPA
There is ecological linkage between core aggregations and the area as a whole can be selected as an SPA according to Stages 1 and 2 of the selection guidelines	One big continuous SPA comprising geographically disjunct sites
Ecological linkage between core aggregations cannot be established and no sub-areas can be selected as SPAs according to Stages 1 and 2 of the selection guidelines	No SPA
Ecological linkage between core aggregations cannot be established but one or more sub-areas can be selected as an SPA according to Stages 1 and 2 of the selection guidelines	One or more SPA for each qualifying core aggregation

In some cases, if information on movements between aggregations or habitat information at a site is absent, it might be necessary to make decisions about disjunct aggregations merely based on the distance between them.

Other principles for seaward boundary placement

4.30 The placement of the SPA boundary for inshore concentrations of non-breeding waterbirds will require judgements to be made on a case-by-case basis.

4.31 The seaward boundary should be positioned a minimum of 250m beyond the edge of any included aggregations of qualifying species. This distance is determined by the maximum potential error for assigning the location of any bird sighting during aerial surveys and as such represents a precautionary approach.

4.32 Seaward boundaries can be placed along parallels of latitude or meridians of longitude or as diagonal lines between two points where this provides a more easily identified or more practical boundary.

Using other information

4.33 The position of the final boundary around the site should be tested against data not used in any of the preceding stages (where it exists) to ensure that it delivers the ecological requirements of the qualifying species. A judgement to alter the boundary should be based on good quality data, ideally spanning multiple years and surveys.

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