Oceanography Committee

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Report of the

Working Group on Seabird Ecology

ICES Headquarters
8–11 March 2002

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

Palægade 2–4 DK–1261 Copenhagen K Denmark

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1 INTRODUCTION

1.1 Participation

The following nominated members of the Working Group participated in the meeting:

T. Anker-Nilssen	Norway
R.T. Barrett	Norway
E. Bell	United Kingdom
R.W. Furness	United Kingdom (Chair)
S. Garthe	Germany
D. Oro	Spain
J. B. Reid	United Kingdom
H. Skov	Denmark
M.L. Tasker	United Kingdom
R. Veit	United States of America

Their contact details are listed in Annex 1.

1.2 Terms of Reference

At the 88th Statutory Meeting, it was agreed that the Working Group on Seabird Ecology [WGSE] should meet in ICES Headquarters from 8–11 March 2002 (4 days). The terms of reference were to:

a) continue to compile a first model of food consumption by seabirds for the entire ICES area

b) compile population estimates for breeding seabirds in the ICES area, preferably divided by ICES fishing areas

c) provide further information to the review of status and threats to seabirds in the North Sea

d) review methods for assessing seabird vulnerability to oil pollution

e) review the effects of wind farms on seabirds

f) work with ICES Secretariat to provide summaries of seabird information via the ICES website

g) prepare a summary report listing relevant bio-ecological variables and indicators suitable for operational use

The Working Group on Seabird Ecology will report by 16 April 2002 for the attention of Oceanography, Marine Habitat Committees and ACME and ACE.

1.3 Justification of Terms of Reference

a) The Working Group has been modelling consumption for a number of years, with a view to developing a model of the whole ICES area in due course. The information should be of interest to other ICES Working Groups, as well as to OSPAR and HELCOM. The Group did not address this same term of reference at its 2001 Meeting. This was partly due to pressure of time generated by the OSPAR requests, and partly due to the absence of key members of the group who had been working on this area over a number of years. However, intersessional work by group members has led to the preparation of a manuscript published in ICES Journal Marine Science (Feb. 2002) on food consumption by seabirds in Norwegian waters.

b) The most recent agreed and published figures for breeding numbers in the ICES area derive from the mid-1980s. A compilation in 2002 will allow the results of major recent censuses to be incorporated.

c) The review conducted in 2001 had to use some information on status that is more than ten years old. The Group is aware of further surveys and analysis that will be carried out in 2001. This new information should be incorporated in any status statement. A review of threats to seabirds in the North Sea was started at the 2001 meeting, but it was not completed. It is proposed to work inter-sessionally to complete this review in time for agreement at its meeting.

d) A number of methods exist to assess the sensitivity of birds to marine oil pollution; WGSE proposes to review these methods in order to help attempts to agree international standards.

e) Proposals to develop marine sites for wind farms have grown very rapidly in recent years. Several studies of their effects on marine birds are under way, and now would be a very opportune moment to review these studies to see if any wider conclusions can be drawn.

f) The group wishes its work to be better known within ICES and in the wider world.

g) Recent developments in the field of sensor instrumentation offers new chances for improvements and cost-efficient monitoring strategies which could be adopted in new monitoring programmes or replace current methodologies or offer possibilities not available until now. A series of new developments have been listed in the EuroGOOS Publication No. 15. Apart from compiling these new developments the WGs should evaluate their potential use for operational oceanography. This should strengthen the incorporation of ICES activities in future GOOS relevant studies. The working Group should compile a list of relevant marine bio-ecological variables and indicators suggested for operational use.

Two additional items were inserted shortly before the Working Group met:

a) review the report on 'Marine litter monitoring by northern fulmars – a pilot study' tabled by Dr J.A. van Franeker via Lisette Enserink. This builds on the EcoQO proposed by WGSE last year 'An index of plastic particle pollution of the North Sea'.

b) respond to the request from ACE to assess the data upon which an initial list of seabird species has been derived by OSPAR as requiring action in accordance with the OSPAR strategy on the Protection and Conservation of the Ecosystems and Biological Diversity of the Maritime Area.

1.4 Overview by the Chair

The Working Group met for four days (8–11 March 2002), and was attended by ten nominated representatives from six countries (Annex 1). It was able to address all terms of reference, though in varying detail, and the results are reported here.

The first term of reference, estimating the energy requirements of seabirds in each ICES area, could only be achieved after compiling data on breeding numbers of seabirds in each region, which was term of reference (b). For sake of logical presentation, we put the population section before the energetics section despite the terms of reference listing these in the opposite sequence. The population compilation required considerable effort and coordination to obtain the most up to date national data on seabird breeding populations from all countries bordering, or within, ICES regions. This work was coordinated by R. T. Barrett. Thanks to the help of many WGSE members and others who made data available (gratefully acknowledged in Section 1.6) he was able to bring to the WGSE meeting a tabulation of the data that was virtually complete for all ICES regions. The figures for the UK, which has large populations of seabirds, and coasts within several ICES regions, were provided by J.B. Reid as preliminary tabulations, since the Seabird 2000 survey data have not yet been fully checked and defined as definitive data sets. Nevertheless, these data have almost all been checked and any discrepancies from the figures that will eventually be published for Seabird 2000 are likely to be small. For some regions, especially at high latitudes and remote locations, population estimates are of relatively low accuracy, but the figures give interesting comparisons between areas in terms of total numbers and proportions of particular seabird groups (auks versus gulls and terns, for example). The total of around 100 million seabirds estimated to inhabit the ICES area is an impressive figure.

Estimating energy requirements based on the population figures gives a fairly simple tabulation by ICES regions, showing that these large breeding populations of seabirds require in the order of 5 million tonnes of food per year for the entire ICES area. For many regions, the diet data are too few to permit this consumption to be disaggregated by species and size classes of fish, but that can be done for some regions.

Our review of status and threats to seabirds in the North Sea identified that there are now more species of seabirds showing declines in breeding population size than there have been in any previous decades of the last 50–100 years. Whereas most populations were increasing during the 1970s and 1980s, in the 1990s slightly more were declining than increasing, while those still increasing show slowing in rates of increase in most cases. The fact that northern fulmars are now declining in the North Sea comes as a surprise after 120 years of sustained increase. The cause of this reversal is not yet known, but considerable decreases in amounts of offal discharged by North Sea fisheries, and high rates of long-line by-catch of fulmars might lead to speculation that either of these may contribute.

The review of methods for assessing seabird vulnerability to oil pollution provides a comparison of the many indices developed to score oil vulnerability, and may help to focus attention on the merits of developing a uniform approach. While oil impacts on seabirds have been subject to study for many decades, the effects of wind farms on seabirds are largely a matter of speculation at this early stage of development of the industry. We reviewed this subject, and the large, but predominantly 'grey' literature, and highlight a need for further effort to be put into assessment of the technologies and scientific approaches to quantification of these impacts, especially the difficult problem of counting numbers of seabirds colliding with blades.

In response to request from the Oceanography Committee we prepared a brief introduction on the integration of seabird research with physical and low trophic level oceanographic studies; one important technological development is the increasing use of data loggers attached to seabirds to permit the integrated study of seabird foraging ecology with the biological and physical parameters of their immediate marine environment.

We briefly returned to the question of an EcoQO assessing plastic contamination of the seas indicated by northern fulmar stomach contents. A recent report on this topic indicates that trends in plastic contamination at sea can be measured over periods of a few years with relatively small annual samples of beach-washed birds (about 40 per year), and that estimates of plastic levels are robust to variations in fulmar body condition, sex, date of sampling.

We responded to the OSPAR list passed to us by ACE by reviewing the data on which the OSPAR draft list of priority declining and threatened taxa of seabirds had been drawn up. We had some difficulty in this process due to the lack of explicit criteria on which the OSPAR selections have been made, but we were fortunate in having highly appropriate experts at the meeting who could provide authoritative inputs for all of the listed seabird taxa.

1.5 Note on bird names

Keen-eyed readers of the past reports of this Working Group will note a change in English names of many of the birds mentioned. Most of these changes have come through the addition of an adjective to an already existing name (e.g., lapwing to northern lapwing). These changes are in line with those agreed a few years ago by the British Ornithologists' Union and are now in line with the nomenclature used by most European English-language ornithological journals. A full list of species names with their scientific binomial appears in Annex 2.

1.6 Acknowledgements

The Working Group wishes to thank ICES and their staff for providing rooms for our meeting, computing and photocopying facilities. We thank Tycho Anker-Nilssen, Redik Eschbaum, Henrik Skov, Stefan Garthe, Marcin Weslawski, Jim Reid, Ian Mitchell, Tim Dunn, Roddy Mavor, Claude Joiris, Mardik Leopold, Kees Camphuysen, Henrik Skov, Kristjan Lilliendal, Bergur Olsen, Bernard Cadiou, Daniel Oro, Jose Pedro Granadeiro, Bob Furness, Jorge Mourino, Antonio Sandoval and David Boertmann for their help in supplying the most up to date information on seabird breeding numbers used in Section 2 to compile population estimates for ICES areas. We thank Norman Ratcliffe for making available a report by Rowena Langston (RSPB) on seabirds and offshore wind farms, and Ommo Hüppop for considerable help on wind farm issues.

2 POPULATION ESTIMATES FOR BREEDING SEABIRDS IN ICES AREAS

2.1 Introduction

Many seabird species (e.g., petrels, gannets, auks) spend nearly their entire life cycle at sea feeding exclusively on marine resources whereas others (e.g., gulls) spend much less time at sea and find much of their food on land or in brackish or fresh water. Common for most of them is that they breed along the coast, often in dense single-species or mixed colonies, but some species (black guillemot) may be widely dispersed along the coast or others (cormorants and gulls) may also breed inland.

The estimates of numbers presented here are primarily of birds nesting on the coast and feeding wholly or partially at sea, but the numbers of gulls breeding in e.g., Britain and around the North and Baltic seas may also include non-marine, inland-breeding segments of the populations.

Surveys of seabirds are carried out at a large variety of intervals and spatial scales varying from annual counts of one or two species at very local scales to national censuses at, say, 10–20 year intervals. Available data reflect these strategies and range from well-documented detailed counts of single species at local or even national scales to large-scale national databases (Norway, UK) into which data from a variety of sources (ranging from organized surveys to *ad hoc* counts) are entered at regular or irregular intervals.

The estimates presented here are based on the input by members of the ICES-WGSE who were asked to provide the best estimates of the numbers of seabirds currently breeding in their respective countries. These have largely been taken at face value despite the fact that some results are several years old and those of current surveys have still to be finally analysed. This applies especially to the huge British and Irish 'Seabird 2000' project that aims to present the numbers of seabirds breeding in the UK and Ireland at the turn of the millennium. Results from this project are included here. Although a number of known caveats have been considered, and the final analysis of the database will undoubtedly end up with figures slightly different to those used here, any discrepancies should be small.

There are also other data from the huge colonies of e.g., northern fulmars, guillemots, little auks and Atlantic puffins in Greenland, Iceland, Svalbard and the Barents Sea, which should not be considered as definitive. Some are quoted as "guesstimates" and await more detailed censuses. Furthermore, while data for many species were presented to the nearest hundred, ten or even individual pairs, others were presented as ranges, some as large as 100 000–1 000 000 pairs. For the sake of simplicity, all such ranges were tabulated as mid-points between the two extremes.

Of the many species of divers, ducks and geese, some of which may be equally defined as seabirds as some of the gulls, only the eider duck is included in this exercise due to their total dependence on the sea for food and to their very large numbers in some areas. At the other end of the scale, some rare species whose total numbers do not total more than a few hundred (e.g., gull-billed tern, Sabine's gull) are not included in the tables.

It should also be noted that the numbers presented in the tables are of pairs of breeding birds and do not include the large numbers of immature birds which may occupy the colonies or their immediate surroundings for much of the breeding season.

In addition to birds breeding in the ICES areas, there are also, at times, large numbers either visiting from breeding sites outside the ICES areas or moving through one area while on migration into or from another area. As a result, the numbers of seabirds within a given area vary considerably throughout the year and may be, at least during parts of the breeding season, much larger than the numbers actually breeding within that area. This is exemplified in Table 2.1 of the ICES-WGSE 2001 report that presents large differences between wintering and breeding populations of all species seen in the North Sea.

This report considers only birds breeding in the ICES areas. Those who sent data were: Tycho Anker-Nilssen, Redik Eschbaum, Henrik Skov, Stefan Garthe, Marcin Weslawski, Jim Reid, Claude Joiris, Mardik Leopold, Kees Camphuysen, Henrik Skov, Kristjan Lilliendal, Bergur Olsen, Bernard Cadiou, Daniel Oro, Jose Pedro Granadeiro, Bob Furness, Jorge Mourino, Antonio Sandoval and David Boertmann.

2.2 Results

Notwithstanding the potential errors and that the result should be regarded as being preliminary, the numbers of breeding seabirds in the ICES areas presented here are considered to be comparable and reveal a number of interesting points.

Approximately 30 million pairs of seabirds are estimated to breed within the ICES fishing areas. When the immature part of the population is also considered, this gives a grand total of between 90–100 million individuals weighing over 50 000 tonnes (see Section 3).

Of these, ca. 19 million pairs or more than 60% of the overall total breed in areas I, II, Va and XIV. More than 25–30% (in number and biomass respectively) apparently breed on Iceland alone (area Va), with a further 20% on Svalbard (IIb) and the Norwegian coast of IIa (Table 2.1). In accordance with the importance of the northernmost areas for seabirds, an apparent 12% of the numbers breed in eastern Greenland. However, when considered as biomass, the proportion in Greenland drops to 3% due to the large numbers of the (literally) little auks. The breeding distribution of these small plankton-feeding auks is restricted to the high Arctic.

Approximately 2.5 million pairs (8%) of seabirds breed within the boundaries of the North Sea and the English Channel (Table 2.2), 1 million pairs in the Skagerrak and Baltic (Table 2.3), about 3 million in the Faroes and western Scotland, ca. 500 000 pairs in the Irish Sea (Table 2.4) and approximately 300 000 pairs in western France, the western Iberian Peninsula and the Azores (Table 2.5).

There is also a clear differentiation in the distribution of the different families of seabirds. While auks comprise more than 60% of all seabirds breeding in the northernmost areas (Table 2.1), the proportion drops to 40–50% in areas IVa, IVb, Vb and VIa (W. Scotland, Faroes, Shetland and the North Sea), fewer in southern Britain to near zero in France, Iberia and the Azores. Numbers of petrels also vary greatly being nearly absent in some areas to a total dominance on the Azores. While northern fulmars are common (>20%) on Svalbard, Iceland, the Faroes, Shetland and NE Scotland, the smaller petrels and shearwaters are common in the more southern areas (SW Britain and Ireland) and totally dominant on the Azores (>95%). The proportions of gulls and terns also vary greatly between areas, much of the variation of the former due to the distribution of kittiwakes being limited mainly to areas I, II, IV and V. A further discussion about numbers and distribution of gulls should be deferred until more detailed data, which distinguishes coastal and inland breeding populations, are available.

Whereas no petrels and very few auks breed in the Baltic, Skagerrak and Kattegat, nearly 40% of the seabird population is comprised of common eiders, the highest proportion anywhere within the ICES areas (Table 2.5).

Table 2.1 Approximate numbers (in pairs) of seabirds breeding in the northern and western ICES areas

	ICES area					
	I	IIa	IIb	Va	XIVa	XIVb
Northern fulmar	5,000	106,000	600,000	1,500,000	2,700	0
Manx shearwater	0	0	0	8,500	0	0
Leach's storm-petrel	0	550	0	115,000	0	0
European storm-petrel	0	5,500	0	75,000	0	0
Northern gannet	500	2,500	0	25,000	0	0
Great cormorant	4,000	21,000	0	3,150	0	0
European shag	750	10,600	0	6,600	0	0
Common eider	50,000	110,000	17,000	300,000	1,700	0
Great skua	10	80	280	5,400	0	0
Arctic skua	25,000	6,000	1,000	7,500	3,000	0
Black-headed gull	120	10	0	27,500	0	0
Mew gull	9,000	78,000	5	550	0	0
Lesser black-backed gull	2,000	2,000	0	30,000	0	0
Herring gull	85,000	75,000	0	7,500	0	0
Glaucous gull	3,000	200	7,000	12,500	730	190
Great black-backed gull	13,000	25,000	100	17,500	0	0
Black-legged kittiwake	465,000	235,000	270,000	631,000	2,300	5
Ivory gull	2,000	750	0	0	0	116
Common tern	0	3,000	0	0	0	0
Arctic tern	22,500	28,000	10,000	250,000	0	0
Common guillemot	30,000	10,000	100,000	990,000	0	0
Brünnich's guillemot	875,000	50,500	850,000	580,000	10,000	0
Razorbill	3,500	37,500	100	380,000	0	0
Black guillemot	19,000	24,000	20,000	15,000	300	210
Little auk	300,000	100,000	1,000,000	0	3,500,000	0
Atlantic puffin	10,000	2,060,000	10,000	2,760,000	0	0
Total no.	1,924,000	2,990,000	2,885,000	7,748,000	3,521,000	520
% of grand total	6.6	10.2	9.9	26.5	12.1	0.0
Total biomass (t)	2,680	3,260	3,400	10,500	1,200	980
% of grand total	8.0	9.7	10.2	31.3	3.4	0.0
% petrels by no.	0.3	3.7	20.8	21.9	0.1	0.0
% petrels by biomass	0.3	5.3	28.3	23.4	0.4	0.0
% gulls by no.	30.1	13.9	9.6	9.4	0.1	59.5
% gulls by biomass	22.7	14.8	7.0	6.5	0.4	82.7
% terns by no.	1.2	1.0	0.3	3.2	0.0	0.0
% terns by biomass	0.2	0.2	0.1	0.5	0.0	0.0
% auks by no.	64.3	76.3	68.6	61.0	99.7	40.5
% auks by biomass	69.1	63.6	62.9	58.2	98.5	17.3

Table 2.2 Approximate numbers (in pairs) of seabirds breeding around the North Sea and in the English Channel

	ICES area				
	IVa	IVb	IVc	VIId	VIIe
Northern fulmar	286,700	9,300	200	1,100	1,400
Manx shearwater	0	0	0	0	190
Leach's storm-petrel	20	0	0	0	0
European storm-petrel	9,200	0	0	0	750
Northern gannet	22,000	41,500	0	0	15,000
Great cormorant	6,900	5,000	740	1,400	1,300
European shag	1,100	3,100	0	170	7,900
Common eider	30,000	1,200	8,600	0	0
Great skua	11,000	0	0	0	0
Arctic skua	1,300	0	0	0	0
Mediterranean gull	0	10	840	80	0
Black-headed gull	3,750	82,400	122,100	12,000	1,500
Mew gull	62,500	10,200	6,200	10	0
Lesser black-backed gull	8,800	35,500	59,800	500	17,000
Herring gull	73,500	62,400	68,200	24,700	36,500
Great black-backed gull	13,800	100	10	340	4,200
Black-legged kittiwake	147,100	133,600	370	6,600	2,200
Sandwich tern	170	14, 600	17,400	720	690
Roseate tern	0	40	0	0	71
Common tern	5,000	9,300	17,800	480	770
Arctic tern	22,300	11,000	2,000	0	0
Little tern	1,110	1,100	2,200	550	130
Common guillemot	400,200	175,000	0	750	650
Razorbill	29,400	12,000	0	20	350
Black guillemot	12,960	10	0	0	0
Atlantic puffin	154,000	60,360	0	0	500
Total no.	1,302,000	668,000	306,000	49,000	91,000
% of grand total	4.5	2.6	1.0	0.2	0.3
Total biomass (t)	2,100	1,000	340	70	250
% of grand total	6.4	3.5	1.0	0.2	0.2
% petrels by no.	22.7	1.2	0.1	2.2	2.5
% petrels by biomass	21.6	1.3	0.1	2.4	0.9
% gulls by no.	23.8	42.2	84.0	89.5	67.4
% gulls by biomass	17.5	28.6	86.8	84.5	46.1
% terns by no.	2.2	4.7	12.9	3.6	1.8
% terns by biomass	0.2	1.0	3.9	0.7	0.2
% auks by no.	45.8	45.3	0.0	1.6	1.6
% auks by biomass	46.3	43.3	0.0	2.1	0.9

Table 2.3 Approximate numbers (in pairs) of seabirds breeding in Skagerrak, Kattegat and the Baltic Sea

	ICES area			
	IIIa	IIIb	IIIc	IIId
Great cormorant	2,500	0	36,000	35,500
European shag	0	0	1,000	0
Common eider	32,000	8,000	0	390,000
Great skua	0	0	0	0
Arctic skua	150	0	0	825
Black-headed gull	35,000	4,000	17,000	120,000
Mew gull	41,500	4,300	6,600	57,000
Lesser black-backed gull	29,000	80	400	250
Herring gull	34,500	9,000	2,000	65,000
Great black-backed gull	9200	1,400	500	7,000
Black-legged kittiwake	640	0	0	0
Sandwich tern	0	65	740	1,000
Common tern	10,500	110	1,200	39,000
Arctic tern	1,450	500	2,100	34,000
Little tern	120	140	260	600
Common guillemot	10	0	0	12,000
Razorbill	0	10	0	12,000
Black guillemot	0	5	0	16,000
Total no.	197,100	27,600	67,700	790,200
% of grand total	0.7	0.1	0.2	2.7
Total biomass (t)	320	55	200	1,800
% of grand total	0.9	0.2	0.6	5.3
% eiders by no.	16.2	29.0	0.0	49.4
% eiders by biomass	33.0	48.2	0.0	71.5
% gulls by no.	76.3	68.0	39.0	31.5
% gulls by biomass	62.1	51.4	9.6	14.4
% terns by no.	6.2	3.0	6.4	9.4
% terns by biomass	0.9	0.3	0.6	1.0

Table 2.4 Approximate numbers (in pairs) of seabirds breeding in the Faroes and the western borders of the UK and Ireland.

	ICES area						
	Vb	VIa	VIIa	VIIb	VIIf	VIIg	VIIj
Northern fulmar	600,000	164,300	16,100	14,700	2,300	3,100	5,700
Manx shearwater	25,000	124,600	15,700	3,500	200	151,000	60,000
Leach's storm-petrel	1,000	49,000	0	310	0	0	0
European storm-petrel	250,000	13,200	0	15,000	0	3,000	77,000
Northern gannet	2,300	109,600	3,200	5	0	30,700	28,300
Great cormorant	0	2,100	4,500	210	520	400	110
European shag	1,500	10,800	3,000	580	860	290	350
Common eider	3,500	0	0	0	0	0	0
Great skua	450	460	0	0	0	0	0
Arctic skua	900	70	0	0	0	0	0
Black-headed gull	250	2,200	25,500	470	0	0	40
Mew gull	1,000	5,500	110	480	0	0	50
Lesser black-backed gull	9,000	0	34,600	580	6,500	25,700	800
Herring gull	1,500	24,000	37,300	530	11,700	3,800	420
Great black-backed gull	1,200	5,500	1,200	930	360	490	350
Black-legged kittiwake	230,000	71,800	16,000	10,000	2,300	6,600	2,200
Sandwich tern	0	1	2,300	0	0	0	0
Roseate tern	0	0	620	0	0	0	0
Common tern	0	660	2,500	20	0	0	0
Arctic tern	2,000	2,200	160	620	0	0	0
Little tern	0	120	50	30	0	0	0
Common guillemot	175,000	305,000	74,000	13,600	5,600	31,000	4,200
Razorbill	4,500	68,000	8,000	5,000	1,500	7,000	750
Black guillemot	3,500	10,000	1,700	600	0	20	600
Atlantic puffin	550,000	230,000	300	3,000	9	0	0
Total no.	1,863,000	1,199,000	247,000	70,000	32,000	263,000	181,000
% of grand total	6.4	4.1	0.8	0.2	0.1	0.9	0.6
Total biomass (t)	2,100	2,200	420	80	60	470	260
% of grand total	6.3	6.5	1.2	0.2	0.2	1.4	0.8
% petrels by no.	47.0	29.3	12.9	47.9	7.7	59.6	78.9
% petrels by biomass	47.9	17.6	9.6	33.9	6.5	30.1	25.3
% gulls by no.	13.0	9.1	46.5	18.3	65.6	13.9	2.1
% gulls by biomass	9.8	5.9	38.3	16.5	61.8	11.9	1.9
% terns by no.	0.1	0.2	2.3	0.9	0.0	0.0	0.0
% terns by biomass	9.8	5.9	0.5	16.5	0.0	0.0	0.0
% auks by no.	39.4	51.1	34.1	31.7	22.3	14.5	3.1
% auks by biomass	40.6	42.1	38.6	45.6	22.3	15.3	3.8

Table 2.5 Approximate numbers (in pairs) of seabirds breeding in western France, the Iberian Peninsula and the Azores.

	ICES Area				
	VIIIa	VIIIb	VIIIc	IXa	X
Northern fulmar	5	0	0		
Cory's shearwater	0	0	0	250	189,000
Manx shearwater	5	0	0	0	180
Little shearwater	0	0	0	0	1,200
Madeiran storm-petrel	0	0	0	200	1,000
European storm-petrel	10	15	1,360	0	0
European shag	1,010	2	800	2,000	0
Mediterranean gull	25	0	0	0	0
Lesser black-backed gull	10,500	5	360	70	0
Herring gull	30,000	40	0	0	0
Great black-backed gull	920	5	0	0	0
Yellow-legged gull	85	110	3,000	43,500	3,000
Black-legged kittiwake	250	0	5	25	0
Sandwich tern	370	4,200	0	0	0
Roseate tern	0	0	0	0	700
Common tern	900	0	0	100	4,000
Little tern	0	0	0	2700	0
Common guillemot	0	0	10	13	0
Total no.	44,100	4,400	5,500	49,000	199,000
% of grand total	0.6	0.2	0.0	0.2	0.7
Total biomass (t)	85	2	10	100	330
% of grand total	0.3	0.0	0.0	0.3	1.0
% petrels by no.	0.0	0.0	24.6	0.9	96.1
% petrels by biomass	0.0	0.0	0.7	0.4	97.6
% gulls by no.	94.8	3.6	60.9	89.2	1.5
% gulls by biomass	95.2	14.4	70.8	92.3	2.0
% terns by no.	2.9	96.3	0.0	5.7	2.4
% terns by biomass	0.5	85.3	0.0	0.3	0.4
% auks by no.	0.0	0.0	0.0	0.0	0.0
% auks by biomass	0.0	0.0	0.2	0.0	0.0

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3 FOOD CONSUMPTION BY SEABIRDS IN ICES AREAS

3.1 Introduction

The estimates given here are built on the preliminary model presented in the 1999 ICES-WGSE report (ICES CM 1999/C:5) using the same equations to calculate numbers of birds and their energy requirements in each ICES area. Approximate occupation dates for the breeding populations in each area were estimated for each species.

Although the estimates are based on breeding population data (as estimated in Section 2 of this report), the model does calculate numbers of birds in the immature, non-breeding part of the populations. Note that the consumption by non-breeding migrant populations of birds from other regions of the world that may enter the ICES areas for a shorter or longer period of time is not included in the results, but this quantity is likely to be small by comparison with consumption of local birds, and to an extent will be offset by the small proportions of non-breeding populations of local birds that may disperse beyond the ICES area.

At this stage, it was not possible to enter the diet composition of each species (fatty fish, lean fish, invertebrates) into the model (as used in the 2000 ICES-WGSE report (ICES CM 2000/C:04) and Barrett *et al*. (2002)) as this was generally unknown. Instead a mean energy density of 6 kJ/g (wet mass) of food items and an overall digestion efficiency of 75% was used (see ICES-WGSE 1999 report). Although less accurate, the results are considered sufficient to allow an estimate of overall consumption and comparison between ICES areas.

3.2 Results and discussion

This preliminary study estimates that the breeding population of seabirds in the ICES areas plus the associated component of immature birds comprises nearly 100 million individuals, and has a total energy requirement of 22.4 million kJ, equivalent to about five million tonnes of food per year (Table 3.1).

This is similar to Furness' (1994) estimate of a total consumption of 4.5 million tonnes by seabirds (excluding common guillemots, black-legged kittiwakes and herring gulls) in the NE Atlantic. Similarly, the present model and that of Furness and Tasker (1997) both result in an annual harvest by seabirds from the North Sea of approximately 600 000 tonnes.

It should be noted, however, that the present consumption estimates will improve when diet composition (and hence energy content of the diet) of the various species are entered into the model. For example, when comparing results in three areas (I, IIa, IIb) obtained using this preliminary model with those from the model in which the diet composition is considered, it seems that the present model underestimates the overall consumption by 10–36% (Table 3.2). In this model, an overall energy density of food is set at 6 kJ/g (wet mass). This may be a little high in areas where birds eat mainly lean fish or plankton whose energy densities are in the region of 4–5 kJ/g (wet mass). Using a density of e.g., 5 kJ/g increases the consumption values by 20%.

As with the population numbers, estimates for the different ICES areas vary greatly primarily due to the numbers of birds breeding in each area, but also their energy requirements, which vary between species and according to the stage of breeding season. There is, for example, a strikingly high consumption by seabirds in Icelandic waters (Va) amounting to ca. 30% of the total harvest in the ICES areas. This is mainly due to the huge numbers of seabirds breeding in that region. The value presented here of 1.5 million tonnes is 50% higher than the figure first estimated by the WGSE in 1999.

At the other end of the scale, the apparent low levels of seabird consumption in the Bay of Biscay, off western Iberia and the Azores (VIII, IX and X) may be misleading as these waters are often frequented by large numbers of immigrants and immature birds from other ICES areas and from further afield (e.g., Mediterranean seabird populations). However, until the numbers of these non-breeding visitors are known, it is impossible to estimate the seabird harvest in this region more accurately.

Furthermore, until the diet composition of seabirds in each ICES area is known and entered in the model, a discussion of the levels and possible effects of seabird predation on e.g., specific fish stocks should be deferred. At this stage we simply present consumption levels by seabirds in the different ICES areas.

Table 3.1. Numbers, biomass, approximate annual energy requirements (kJ x 10^{12}) and food consumption of breeding seabirds in ICES areas.

ICES area	Description	Total population. (millions of birds)	Total biomass (x 1000 t)	Annual energy requirements (kJ x 10^{12})	Approx. food consumption (x 1000 t)	%
I	E. Barents Sea	6.7	4.8	1.75	390	7.8
IIa	Norwegian Sea	10.3	5.8	2.21	490	9.9
IIb	Svalbard	9.9	6.0	2.27	500	10.1
IIIa-d	Baltic Sea & Skagerrak	3.9	4.3	1.69	370	7.5
IVa-c	North Sea	8.3	6.3	2.65	590	11.8
Va	Iceland	26.6	18.0	6.76	1500	30.1
Vb	Faroes	6.4	3.6	1.38	310	6.2
VIa,VIIa,b,f,g,j	W. UK & Ireland	6.8	5.9	2.22	490	9.9
VIIe,d	English Channel	0.5	0.6	0.22	49	1.0
VIIIa-c	Bay of Biscay	0.2	0.2	0.07	16	0.3
IXa	W. Iberia	0.2	0.2	0.07	17	0.3
X	Azores	0.7	0.6	0.17	38	0.8
XIVa,b	E. Greenland	12.0	2.0	0.97	220	4.3
Total		92.5	58.3	22.43	5000	

Table 3.2. Estimates of annual food consumption (x1000 t) by seabirds in areas I, IIa and IIb using the present, preliminary model (A) and that, which takes diet composition into account (B).

Area	A	B	% difference
I	388.4	425.5	10
IIa	492.0	668.5	36
IIb	505.1	563.6	12

3.3 References

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4 STATUS OF SEABIRDS IN THE NORTH SEA AND THREATS TO THEIR POPULATIONS

4.1 Status of seabirds in the North Sea

The status of marine birds in the North Sea region was addressed by ICES WGSE in March 2001 (ICES 2001). It was clear then that few data were available to allow accurate and comprehensive assessment at the relevant geographical scale of the status and trends of most wildfowl and shorebird populations. Nevertheless an attempt was made at highlighting general trends in these groups of birds. However, consideration of more data and the recent availability of the results of recent surveys now allow the status and trends of marine birds (*sensu strictu*) to be more accurately assessed. Seabirds are among the more conspicuous elements of the biodiversity of the marine environment. As top predators in this ecosystem they are important not only in their own right at a north-west European scale and also at the present geographical focus of the North Sea (ICES areas IVa,b,c and IIIa,b,c, see Chapter 2), but also more widely as potential indicators of the health of the marine environment. For this review we define the North Sea to exclude the Channel, but include the Skagerrak/Kattegat, so we include ICES areas IIIa-d and IVa,b,c.

4.1.1 Data Sources

4.1.1.1 United Kingdom (UK)

Data from the UK sector of Areas IVa, IVb and IVc come from two complete censuses of all seabird colonies in Britain and Ireland conducted in 1985–1987 (Seabird Colony Register (SCR), Lloyd *et al.,* 1991) and 1999–2001 (Seabird 2000, unpubl. data). The count unit in these surveys for each species of seabird varies; for example, apparently occupied nest sites for northern fulmar, but number of individuals on breeding cliffs for common guillemots and razorbills. In addition, the count unit differs within some species. In Table 4.1 all count units have been converted to numbers of breeding pairs using previously accepted conversion factors (e.g., Lloyd *et al.,* 1991). Counts of individual gulls were divided by 2.0 and added to the number of occupied nests to arrive at breeding numbers. Similarly, breeding numbers of terns were estimated by dividing the number of individuals counted by 1.5, and adding the result to the number of occupied nests counted. Counts of individual common guillemots and razorbills were converted to numbers of breeding pairs by multiplying by 0.67. Counts of individual Atlantic puffins were converted to numbers of breeding pairs by dividing by 2.0 and adding the result to the number of apparently occupied burrows.

No population estimates are presented for European storm-petrel, Leach's storm-petrel or Manx shearwater as the counts for these species have not been processed yet. These species were not censured accurately during the SCR so it would not be possible to draw any conclusions regarding trends. Counts of northern gannets for Seabird 2000 are from surveys conducted in 1994/95, although Troup Head (ICES IVa) was surveyed in 2001. No Seabird 2000 data for skuas in the Shetland Islands (ICES IVa) have been included in the estimates of population sizes and consequently trends for Seabird 2000. The sizes of the 1999–2001 populations were estimated by adding the 1985–87 SCR counts of 5647 apparently occupied territories of great skuas and 1899 apparently occupied territories of Arctic skuas to Seabird 2000 counts in other areas in ICES IVa. An estimate of 10,000 Atlantic puffins on Hoy and 60,000 on Fair Isle (both ICES IVa), to date unsurveyed for Seabird 2000, has been added to the Seabird 2000 total. Seabird 2000 is an ongoing investigation and all population figures presented here should be regarded as preliminary.

4.1.1.2 Norway (NOR)

Most of the available data on the spatial and temporal distribution of Norwegian seabirds after 1970 are stored in the National Seabird Database maintained by the Norwegian Institute for Nature Research (NINA) in Trondheim. For the purpose of this report, the breeding and winter population sizes for each species in the Norwegian parts of the North Sea (Table 4.2) were derived by adjusting the most recently published estimate of the national population size (Nygård *et al.,* 1988, Anker-Nilssen 1994, Gjershaug *et al.,* 1994) by the relative proportion of birds found in the North Sea region as compared to the whole country. The calculations of these proportions were based on the most recent counts entered into the national database. The reason for doing it this way is that the database data for different localities have often been collected in different years and the spatial coverage is not complete. Thus, accurate regional or national population sizes cannot be calculated without some manual evaluation of the data for each species. When the estimate of the national population size was indicated by a range, we used the mean of the maximum and minimum values.

The national monitoring programme for Norwegian seabirds was formally established as late as in 1988 (e.g., Lorentsen 2001). Nevertheless, in some areas the monitoring of several species was initiated earlier with the longest series in the North Sea region dating back to 1972 (cf. Tables 4.3–4.6 and 4.10). The monitoring of colonial species was carried out following internationally standardised procedures (Walsh *et al.,* 1995). Note that the monitoring areas do not cover the entire coastline of the counties where they are situated. Unfortunately, no total censuses have been carried out in the Norwegian part of the North Sea. The trends reported applies for the specific sites or areas that have been selected for monitoring on an annual (or almost annual) basis, an can only be assumed to reflect the overall change in numbers for each species.

The colony at Runde, which is situated 55 km north of ICES IVa, is included because it is the only large bird cliff in southern Norway and because the long-term data on the population development of northern gannet, black-legged kittiwake, common guillemot and Atlantic puffin at this site are the southernmost monitoring results for these species in Norway (Table 4.6). Moreover, the negative population trend for European shags breeding at Runde is strikingly different from the parallel increase in Rogaland (Table 4.5).

Note that for the Norwegian results the significance levels of the trends are indicated as $p<0.01$, $p<0.05$, $p<0.1$ or n.s. ($p\geq0.1$) as recommended for management purposes by Anker-Nilssen *et al.* (1996). Some of the most significant trends also satisfy the $p<0.001$ level.

4.1.1.3 Sweden (SWE)

Data from the Swedish part of the North Sea were taken exclusively from Svensson *et al.* (1999) who give more specific references to some of the population data presented in Table 4.7. Note that for most species they do not report data that allows the calculation of population trends. In these cases the trends indicated in the table applies for the period from the data collection period of the atlas project that ended in the mid 1980s to the present.

4.1.1.4 Denmark (DEN)

Data from the Danish part of the North Sea (including the Skagerrak and the Kattegat) were taken exclusively from Grell (1998) who gives more specific references to some of the population data presented in Table 4.8. Note that it was not possible for us to divide these figures by ICES areas and that the reported trends thus are summaries for Denmark, which is enclosed within five different ICES areas (IIIa-d and IVb).

4.1.1.5 Germany (GER)

The sources of data were Hüppop (1997 and pers. comm.), Dierschke and Dierschke (2000), Garthe *et al.* (2000), Hälterlein *et al.* (2000) and Südbeck and Hälterlein (2001). Note that the significance levels for trends in 1990–2000 given in Table 4.8 were taken from Hälterlein *et al.* (2000) and apply to Spearman rank correlations based on annual counts.

4.1.1.6 Netherlands (HOL) and Belgium (BEL)

When we prepared this status report, we had no data or publications at hand documenting in sufficient detail seabird population trends in the Netherlands and Belgium, but population estimates for these areas are included in Chapter 2.

4.1.2 Methods for estimating population trends

For the UK, Denmark and Germany, the given average estimates of annual population changes were calculated from total counts as $\exp[(\ln(LC)-\ln(FC))/t]$, where LC and FC are the last and first count, respectively, and t the number of years between the two. For Norway, all trends were calculated using Monte Carlo simulations based on the annual monitoring results (see e.g., Anker-Nilssen *et al.,* 1996 and Lorentsen 2001 for further details).

4.1.3 Trends in numbers of breeding birds

Preliminary or documented population trends for seabirds and common eider breeding within different areas in the North Sea (including the Skagerrak but excluding the Channel) are reported in Tables 4.1–4.9, which include references to the sources of information. Note that the southernmost monitoring areas in Norway (in the county of Vest-Agder) are enclosed in two different ICES areas (IIIa and IVa, Table 4.4). A less detailed summary is presented in Table 4.10, which also suggests an overall trend for each species in terms of total numbers breeding within the North Sea. The table includes 23 species, of which eight were assessed as increasing (northern gannet, great cormorant, common eider, Arctic skua, great skua, Mediterranean gull, common guillemot and Atlantic puffin), nine as decreasing (northern fulmar, European shag, black-headed gull, mew gull, black-legged kittiwake, sandwich tern, common tern, Arctic tern and razorbill) and six as being more or less stable (herring gull, lesser black-backed gull, great black-backed gull, roseate tern, little tern and black guillemot).

It is not within the scope of this report to address the multitude of possible reasons for these trends, although some of them were commented on in a preliminary species by species review in our previous report (ICES 2001). However, the even distribution of species between increasing and decreasing populations is not surprising at these latitudes where natural factors likely to affect seabird reproduction and survival are expected to be much less stable over time than in e.g., tropical or sub-tropical waters. However, our assessment does indicate that the general increase in seabird numbers observed within the North Sea region in the 1970s and 1980s (Dunnet *et al.,* 1990) has not continued through the 1990s.

Table 4.1. Preliminary population trends for some seabird species and common eider breeding in the North Sea part of UK estimated by comparing the Seabird Colony Register (SCR) count in 1985–1987 and the Seabirds 2000 (S2000) count in 1999–2001, divided by ICES areas IVa, IVb and IVc. Population estimates (numbers of pairs) are from Lloyd *et al.* (1991) and Seabird 2000 (unpubl.) and presented as rounded figures. Note that trends were calculated before the population estimates were rounded.

Species	IVa			IVb			IVc		
	SCR	S2000	Average annual change (%)	SCR	S2000	Average annual change (%)	SCR	S2000	Average annual change (%)
Northern fulmar	350,000	280,000	– 1.5	15,000	9,200	– 3.5	610	200	– 7.5
Northern gannet	17,000	22,000	+ 1.8	22,000	41,000	+ 4.5	0	0	
Great cormorant	1,500	860	– 3.7	1,200	750	– 3.7	210	470	+ 6.0
European shag	11,000	8,400	– 2.0	5,800	3,100	– 4.4	0	0	
Common eider	Not available		+	Not available		+	Not available		+
Arctic skua	2,500	2,900	+ 1.1	0	0		0	0	
Great skua	6,400	11,000	+ 3.6	0	0		0	0	
Mediterranean gull	0	0		0	0		0	41	
Black-headed gull	6,700	3,800	– 4.0	30,000	8,600	– 8.5	31,000	38,000	+ 1.4
Mew gull [1]	13,000	32,000	+ 7.0	170	340	+ 5.2	23	22	
Lesser black-backed gull	2,400	1,200	– 4.7	4,300	4,000	– 0.6	5,000	11,000	+ 5.9
Herring gull	23,000	15,000	– 3.3	39,000	17,000	– 5.6	4,800	5,700	+ 1.3
Great black-backed gull	10,000	8,200	– 1.8	21	84	+ 10.4	0	4	
Black-legged kittiwake	200,000	140,000	– 2.4	240,000	130,000	– 4.5	3,600	370	– 15.0
Sandwich tern	490	170	– 7.2	6,200	4,200	– 2.7	3,900	4,600	+ 1.1
Roseate tern	0	0		53	46	– 1.0	0	1	
Common tern	1,200	540	– 5.7	2,200	2,600	+ 1.2	1,600	1,300	– 1.9
Arctic tern	27,000	16,000	– 3.6	4,800	4,100	– 1.1	7	11	
Little tern	30	20	– 2.9	460	170	– 6.7	1,700	1,500	– 0.5
Common guillemot	540,000	600,000	+ 0.8	200,000	260,000	+ 1.7	0	0	
Razorbill	43,000	43,000	– 0.1	22,000	17,000	– 1.7	0	0	
Black guillemot	21,000	21,000	0.0	3	10		0	0	
Atlantic puffin [2]	95,000	79,000	– 1.3	36,000	68,000	+ 4.8	0	0	

1) Populations breeding inland have been decreasing severely in the same period (Seabird 2000 unpubl.)

2) The conversion factors used to calculate numbers of pairs were set at 0.5 for individual birds and 1.0 for apparently occupied burrows. Note also that the puffin population on the Farne Islands (IVb) have not yet been counted for S2000 and data **therefore**////////

Table 4.2. Rough population estimates for some seabird species and common eider breeding in Norway within ICES areas IIIa and IVa, derived by using the most recent data contained within the Norwegian Seabird Database (Norwegian Institute for Nature Research unpubl.).

Species	IIIa	IVa
Northern fulmar	0	750
European shag	0	1,700
Common eider	11,000	30,000
Great skua	0	5
Arctic skua	100	300
Mew gull	35,000	31,000
Lesser black-backed gull	21,500	7,500
Herring gull	11,500	13,500
Great black-backed gull	2,200	5,500
Black-legged kittiwake	5	6000
Common tern	7,500	4,500
Arctic tern	0	5,000
Common guillemot	0	150
Razorbill	0	300
Black guillemot	30	350
Atlantic puffin	0	14,000

Table 4.3. Estimated population trends (Monte Carlo simulations) for some seabird species and common eider breeding in Norway within ICES area IIIa (from Lorentsen 2001). AS = aerial surveys covering most of the coastline in the county, AdM = adult male in breeding area early in the breeding season, AON = apparently occupied nest.

Species	County (Municipality)	Time period	No. of years counted	No. of colonies	Counting unit	Average annual change (%)	Significance level
Common eider	Østfold	1988–2001	14	AS	AdM	+ 9.0	$p<0.01$
	Oslo & Akershus	1990–2001	10	AS	AdM	+ 13.8	$p<0.1$
	Buskerud	1990–2001	10	AS	AdM	+ 6.5	$p<0.1$
	Vestfold	1988–1997	10	AS	AdM	+ 6.3	$p<0.05$
	Telemark	1988–2001	14	AS	AdM	+ 4.1	$p<0.05$
	Aust-Agder	1988–1997	10	AS	AdM	+ 2.5	n.s.
Mew gull	Østfold	1989–1996	7	4	AON	– 5.7	n.s.
	Telemark	1974–2001	28	24	AON	– 6.8	$p<0.01$
	Telemark	1989–2001	13	8	AON	– 11.0	$p<0.01$
	Vest-Agder (Mandal)	1989–2001	11	many	AON	– 7.7	$p<0.05$
Lesser black-backed gull	Østfold	1989–1996	7	7	AON	– 9.7	$p<0.01$
	Telemark	1974–2001	28	19	AON	+ 1.9	$p<0.05$
	Telemark	1989–2001	13	7	AON	– 4.4	$p<0.1$
Herring gull	Østfold	1989–1996	7	6	AON	+ 6.1	n.s.
	Telemark	1974–2001	28	24	AON	+ 5.6	$p<0.01$
	Telemark	1989–2001	13	8	AON	+ 0.7	n.s.
Great black-backed gull	Østfold	1989–1996	7	2	AON	+ 0.2	n.s.
	Telemark	1974–2001	28	26	AON	+ 5.9	$p<0.01$
	Telemark	1989–2001	13	7	AON	+ 14.6	$p<0.1$
Common tern	Østfold	1989–1996	7	2	AON	+ 4.3	n.s.
	Telemark	1974–2001	28	24	AON	– 5.4	$p<0.01$
	Telemark	1989–2001	13	15	AON	– 13.2	$p<0.05$

Table 4.4. Estimated population trends (Monte Carlo simulations) for some seabird species and common eider breeding in Vest-Agder county, Norway, which is enclosed within ICES areas IIIa and IVa (from Lorentsen 2001). AS = aerial surveys covering most of the coastline in the county, AON = apparently occupied nest, AdM = adult male in breeding area early in the breeding season.

Species	Time period	No. of years counted	No. of colonies	Counting unit	Average annual change (%)	Signifi-cance level
Northern fulmar	1995–2001	7	1	AON	+ 60.9	p<0.1
Common eider	1988–2001	12	AS	AdM	+ 3.2	p<0.05
Mew gull [1]	1989–2001	13	2	AON	– 11.9	p<0.05
Lesser black-backed gull	1988–2001	14	5	AON	+ 5.4	p<0.01
Herring gull	1989–2001	13	2	AON	+ 6.2	p<0.05
Great black-backed gull	1989–2001	12	2	AON	+ 2.1	n.s.
Common tern	1990–2001	11	many	AON	– 6.3	p<0.1

1) Excluding Mandal municipality in ICES area IIIa (cf. Table 4.3)

Table 4.5. Estimated population trends (Monte Carlo simulations) for some seabird species breeding in Norway within ICES area IVa (from Lorentsen 2001). AON = apparently occupied nest.

Species	County (Munici-pality)	Time period	No. of years counted	No. of colonies	Counting unit	Average annual change (%)	Signifi-cance level
Northern fulmar	Rogaland	1973–1998	23	2	AON	+ 18.0	p<0.01
European shag	Rogaland	1979–2001	18	1	AON	+ 18.4	p<0.01
Lesser black-backed gull	Rogaland	1988–1996	7	1	AON	– 7.0	n.s.

Table 4.6. Estimated population trends (Monte Carlo simulations) for some seabird species breeding at the Norwegian colony Runde (62°25'E) situated 55 km northeast of ICES area IVa (from Lorentsen 2001). TC = total counts, AON = apparently occupied nest, IND = individual, AOB = apparently occupied burrow.

Species	Current population estimate (pairs)	Time period	No. of years counted	No. of study plots	Counting unit	Average annual change (%)	Significance level
Northern gannet	1,664	1946–2001	26	TC	AON	+ 9.8	p<0.01
European shag	1,377	1975–2001	14	TC	AON	– 4.4	p<0.01
Black-legged kittiwake	15–20,000	1980–2001	18	10	AON	– 4.6	p<0.01
Common guillemot	4–6,000	1980–2001	18	22	IND	– 2.5	p<0.01
Atlantic puffin	50–100,000	1980–2001	17	11	AOB	+ 1.2	p<0.05

Table 4.7. Population trends for some seabird species and common eider breeding on the North Sea coast of Sweden, which is enclosed within ICES areas IIIa. The information is taken from Svensson *et al.* (1999) who, for most species, do not give exact data on population sizes within this area. When no time period is indicated, the trend applies for the period from the late 1980s to present. When only range of years or numbers were given, we used the mid point and mean value, respectively. Population changes calculated to be less than ±2% p.a. over a period of less than ten years are denoted as stable. Note that except for black-legged kittiwake and black guillemot, parts of these populations are breeding inland.

Species	Time period	Area	First count	Last count	Average annual change (%)	Indicated trend from late 1980s to present
Great cormorant						++
Common eider						+?
Black-headed gull						+
Mew gull						–
Lesser black-backed gull						0
Herring gull						0?
Great black-backed gull	1968–1994	Bohuslän	2600	6700	+ 3.7	+
Black-legged kittiwake	1990s	Nidingen	25–30		Stable	0
Sandwich tern						–
Common tern		Bohuslän				+
Arctic tern						+
Little tern						0?
Common guillemot	1988	1 colony	10			?
Razorbill	1993/1997	2 colonies	75			?
Black guillemot	1975–1995		650	880	+ 1.5	+

Table 4.8. Estimated population trends for some seabird species and common eider breeding in Denmark, which is enclosed within ICES areas IIIa, IIIb, IIIc, IIId and IVb. Count data (number of pairs) are from Grell (1998). When only range of years or numbers were given, we used the mid point and mean value, respectively. Population changes calculated to be less than ±2% p.a. over a period of less than ten years are denoted as stable. Note that except for black-legged kittiwake and black guillemot, parts of these populations are breeding inland.

Species	Time period	First count	Last count	Average annual change (%)
Great cormorant	1982–1995	3,713	38,500	+ 20
Common eider	1980–1989	19,500	22,000	stable
Black-headed gull	1989–1995	220,000	150,000	– 6
Mew gull	1988–1995	29,000	27,500	stable
Lesser black-backed gull	1980–1995	1,500	4,400	+ 7
Herring gull [1]	1989–1995	54,500	56,500	stable
Great black-backed gull	1980–1995	825	1,550	+ 4
Black-legged kittiwake	1995-1995		625	variable
Sandwich tern	1988–1995	5,700	4,500	– 3
Common tern	1988–1995	1,500	1,000	– 6
Arctic tern	1980–1995	7,000	8,500	+ 2
Little tern	1988–1995	435	500	+ 2
Black guillemot [2]	1988–1996	500	1,119	+ 11

1) The population index for colonies counted annually was increasing in the same period.

2) The vast majority of these birds breed within ICES area IIId, which is not part of the North Sea.

Table 4.9. Population trends for some seabird species and common eider breeding at the North Sea coast of Germany (within ICES area IVb). Trends were estimated using rounded population sizes (numbers of breeding pairs) in the given years reported by Hüppop (1997 and pers. comm.), Dierschke and Dierschke (2000), Garthe *et al.* (2000), Hälterlein *et al.* (2000) and Südbeck and Hälterlein (2001). The significance levels for trends in 1990–1999 are from Hälterlein *et al.* (2000) and applies to Spearman rank correlations based on annual counts.

Species	1970	1990	1999	Average annual change 1970–1990 (%)	Average annual change 1990–1999 (%)	Significance level 1990–99	Average annual change 1970–1999 (%)
Northern fulmar	0	20	102		+ 19.8		
Northern gannet	0	0	69				
Great cormorant		300	1,300		+ 17.7	p=0.004	
Common eider		850	1,300		+ 4.8	n.s.	
Black-headed gull	12,000	58,000	65,000	+ 8.2	+ 1.3	p=0.048	+ 6.0
Mew gull	1,000	4,700	8,600	+ 8.0	+ 6.9	p=0.005	+ 7.7
Lesser black-backed gull	100	3,200	31,000	+ 18.9	+ 28.7	p=0.003	+ 21.9
Herring gull	20,000	44,000	42,000	+ 4.0	– 0.5		+ 2.6
Great black-backed gull	0	3	12		+ 16.7		
Black-legged kittiwake	400	3,700	7,600	+ 11.8	+ 8.3		+ 10.7
Sandwich tern		9,200	8,900		– 0.4	n.s.	
Common tern		9,500	6,400		– 4.3	p=0.017	
Arctic tern		6,500	5,800		– 1.3	n.s.	
Little tern		500	700		+ 3.8	p=0.040	
Common guillemot	600	1,800	2,000	+ 5.6	+ 1.2		+ 4.2
Razorbill	0	6	11		+ 7.0		

Table 4.10. Simple summary indicating the most recent trends in numbers of breeding seabirds and common eider within different ICES areas in the North Sea (including the Skagerrak but excluding the Channel), cf. Tables 4.1 and 4.3–4.9. Increases or decreases are indicated by plusses and minuses, respectively, three signs indicating the change was larger than 10% p.a., two signs that it was within 5-10% p.a. and one sign that it was within 1–5% p.a. Fairly stable populations (within ±1% p.a.) are indicated by zeros or +/– (variable). The overall trends were assessed by taking into account the differences in population sizes between areas, giving highest weight to the trends documented for the largest populations. For very small populations the trends are indicated in brackets.

Species	IVc UK	IVb UK	IVb GER	IVa UK	IVa[1] NOR	IVa/IIIa NOR	IIIa NOR	IIIa SWE	IIIa,b,c +IVb DEN	Overall trend
Northern fulmar	– –	–	(+++)	–	+++	(+++)				–
Northern gannet		+	(+++)	+	++					+
Great cormorant	++	–	+++	–				++	+++	+
European shag		–		–	+++/–[1]					–
Common eider	+	+	+	+		+	++	+?	0	+
Arctic skua				+						+
Great skua				+						+
Mediterranean gull	(+++)									(+++)
Black-headed gull	+	– –	+	–				+	– –	–
Mew gull	(0)	(++)	++	++		– – –	– –	–	0	–
Lesser black-backed gull	++	0	+++		– –	++	–	0	++	0
Herring gull	+	– –	0	–		++	+	0?	0/+	0
Great black-backed gull	(+++)	(+++)	(+++)	–		+	++	+	+	0
Black-legged kittiwake	(– – –)	–	++	–	–			(0)	+/–	–
Sandwich tern	+	–	0	– –				–	–	–
Roseate tern	(+++)	0								0
Common tern	–	+	–	– –		– –	– –	+	– –	–
Arctic tern	(+)	–	–	–				(+)	+	–
Little tern	0	– –	+	(–)				(0)	+	0
Common guillemot		+	+	0	–			(?)		+
Razorbill		–	(++)	0				(?)		–
Black guillemot		(+++)		0				+		0
Atlantic puffin		++		–	+					+

1) Including the colony at Runde, situated only 55 km north of IVa (Table 4.6), where especially the negative population trend for European shag is strikingly different from the parallel increase in Rogaland (Table 4.5).

4.1.4 Trends in numbers of wintering birds

An analysis of the trends in numbers of seabirds and waterfowl wintering in Norway was recently reported by Lorentsen and Nygård (2001). A selection of their results applying to the North Sea are presented in Table 4.11, which also indicates approximate estimates of the winter population sizes for the same species along the Norwegian North Sea coast, divided by ICES areas IIIa and IVa. Note that the southernmost monitoring area (in the county of Vest-Agder) is enclosed in both of these ICES areas.

Table 4.11. Population trends (Monte Carlo simulations) for some seabird and waterfowl species wintering within regular monitoring areas in the Norwegian part of the North Sea, divided by ICES areas (from Lorentsen and Nygård 2001). Note that the monitoring areas do not cover the entire coastline of the counties where they are situated. For most species, rough population estimates for marine areas are given as rounded figures derived from the Norwegian Seabird Database (Norwegian Institute for Nature Research unpubl.).

Species	ICES area	Population estimate (individuals)	Location of monitoring area (county)	Time period	No. of years counted	Average annual change (%)	Significance level
Red-throated diver	IIIa	50					
	IVa	200	Rogaland	1980–2000	21	+ 2.2	n.s.
Black-throated diver	IVa	< 100	Rogaland	1980–2000	21	– 7.6	p<0.1
Great northern diver	IIIa	40					
	IIIa/IVa	–	Vest-Agder	1981–2000	20	+ 7.4	p<0.01
	IVa	200	Rogaland	1980–2000	21	+ 0.3	n.s.
Slavonian grebe	IIIa	few					
	IIIa/IVa	–	Vest-Agder	1973–2000	28	+ 8.7	p<0.01
	IVa	< 1,000	Rogaland	1980–2000	21	– 2.0	n.s.
Red-necked grebe	IIIa	40					
	IIIa/IVa	–	Vest-Agder	1978–2000	23	+ 2.4	p<0.05
	IVa	500	Rogaland	1980–2000	21	– 5.9	p<0.01
Great cormorant	IIIa	5,000	Østfold	1981–2000	20	+ 11.3	p<0.01
	IIIa/IVa	–	Vest-Agder	1972–2000	29	+ 8.6	p<0.01
	IVa	12,000	Rogaland	1980–2000	21	– 2.8	p<0.05
European shag	IVa	5,000	Rogaland	1980–2000	21	+ 7.9	p<0.01
Eurasian wigeon	IVa	1,000	Rogaland	1980–2000	21	+ 13.0	p<0.05
Eurasian teal	IVa	variable	Rogaland	1980–2000	21	+ 2.9	n.s.
Mallard	IIIa	10,000	Østfold	1981–2000	20	– 4.1	p<0.05
	IIIa/IVa	–	Vest-Agder	1972–2000	29	+ 4.6	p<0.1
	IVa	24,000	Rogaland	1980–2000	21	+ 3.3	p<0.01
Tufted duck	IVa	variable	Rogaland	1980–2000	21	– 2.3	n.s.
Greater scaup	IIIa	100					
	IVa	700	Rogaland	1980–2000	21	+ 1.1	n.s.
Common eider	IIIa	13,000	Østfold	1981–2000	20	+ 6.1	n.s.
	IIIa/IVa	–	Vest-Agder	1972–2000	29	+ 4.8	p<0.05
	IVa	23,000	Rogaland	1980–2000	21	+ 1.8	n.s.
Long-tailed duck	IIIa	2,000					
	IIIa/IVa	–	Vest-Agder	1972–2000	29	+ 6.1	p<0.05
	IVa	17,000	Rogaland	1980–2000	21	– 4.3	p<0.01
Black scoter	IIIa	800					
	IIIa/IVa	–	Vest-Agder	1972–2000	29	+ 8.3	p<0.05
	IVa	1,200	Rogaland	1980–2000	21	+ 2.5	n.s.
Velvet scoter	IIIa	700					
	IIIa/IVa	–	Vest-Agder	1972–2000	29	+ 5.6	p<0.05
	IVa	8,000	Rogaland	1980–2000	21	+ 2.6	n.s.
Common goldeneye	IIIa	7,500	Østfold	1981–2000	20	– 0.1	n.s.
	IIIa/IVa	–	Vest-Agder	1972–2000	29	– 1.6	n.s.
	IVa	6,500	Rogaland	1980–2000	21	– 1.7	n.s.
Red-breasted merganser	IIIa	3,000	Østfold	1981–2000	20	– 3.7	p<0.1
	IIIa/IVa	–	Vest-Agder	1972–2000	29	+ 6.4	p<0.1
	IVa	6,000	Rogaland	1980–2000	21	0.0	n.s.
Goosander	IIIa	?	Østfold	1981–2000	20	+ 4.8	n.s.
	IIIa/IVa	–	Vest-Agder	1972–2000	29	+ 0.9	n.s.
	IVa	?	Rogaland	1980–2000	21	– 2.7	n.s.
Mew gull	IIIa/IVa	–	Vest-Agder	1973–2000	28	+ 1.9	n.s.
Herring gull	IIIa/IVa	–	Vest-Agder	1973–2000	28	+ 4.4	p<0.05
Great black-backed gull	IIIa/IVa	–	Vest-Agder	1973–2000	28	+ 6.4	p<0.1
Black guillemot	IVa	?	Rogaland	1980–2000	21	– 0.9	n.s.

4.2 Threats to marine birds in the North Sea region

Factors that can cause local extinctions or severe declines in colonies or larger parts of seabird populations over the medium to longer term are many and varied. Such threats have been reviewed (e.g., Lloyd *et al*. 1991, Furness 1993, Tasker *et al*. 2000, Melvin and Parrish 2001, Furness 2002), and no attempt is made here at providing another comprehensive appraisal. In the light of Working Group on Seabird Ecology's recent work on setting target levels for population changes that would merit further attention we have attempted here to apply as an indication of threat the criterion identified in our proposed EcoQO of using seabird population trends as an index of seabird community health in the North Sea (ICES 2001). Thus we identify an agent of change as a threat if it causes a decline in size or range of at least 20% in 33–65% of the population, or by at least 50% in at least 25% of the population, over a period of less than 20 years. Clearly, applying this was no straightforward task. Nine different potential threats to North Sea marine bird populations are highlighted here. These are competition with fisheries, discarding of fisheries waste, by-catch in fishing gear, mariculture, oil pollution, windfarms, disturbance, conflict with other species and predation by introduced (alien) predators.

Although pollution other than hydrocarbons has affected seabirds in some locations (e.g., terns and gulls in the Wadden Sea, Becker *et al.,* 1998, Thyen and Becker 2000), the extent to which this is a general problem in the North Sea region is probably very small. Similarly, harvesting of some species occurs on a small scale within the region, but this was thought not to present a significant threat to bird populations and is not considered in further detail here. Note also that the effects of climate change are not addressed. The possible effects of changes in, for example, mean wave heights, sea temperatures and rising sea levels, and the temporal scales over which putative changes might occur, are difficult to predict. Such changes may affect the food supply of all species, while those species whose nesting habitat occurs near the sea surface might experience disruption to breeding.

A broad-brush attempt has been made to assess the likely importance of each of the nine threats listed above for each of 39 marine bird species breeding or occurring in the North Sea Region. None of the factors were considered to be a threat (as defined above) for common shelduck, Arctic skua, Mediterranean gull and great black-backed gull. Table 4.12 presents the assessment for the 35 other species. In terms of number of species that could be affected, the most significant threats were oil pollution (18 species), competition with fisheries (13 species) and predation by introduced predators (10 species). The highest threats were associated with the competitive effect of fisheries on common eider, black-legged kittiwake, common tern and Arctic tern, the effect of competition with other naturally occurring species on black-legged kittiwake and the predation by introduced species (particularly the North American mink *Mustela vison*) on black guillemots.

4.2.1 Fishery catches

Some fish prey species are exploited by both marine birds and humans. The competitive effects of fisheries on marine birds have been demonstrated to be quite significant (e.g., Anker-Nilssen *et al.,* 2000). The overfishing of herring *Clupea harengus* in the Norwegian Sea and capelin *Mallotus villosus* in the Barents Seas during unfavourable periods for fish recruitment contributed to the discrete population declines observed in Atlantic puffins and common guillemots, respectively (Vader *et al.,* 1990, Anker-Nilssen 1992, Krasnov and Barrett 1995, Anker-Nilssen *et al.,* 1997). Similarly, sandeel fisheries could harm seabird populations through overfishing; in 1993 over 100,000 tonnes of sandeels were landed (mainly in Denmark) from the Wee Bankie in the North Sea (ICES IVb), an important feeding ground for many seabird species breeding in the North Sea. The black-legged kittiwake, a small cliff-nesting gull that feeds its young on sandeels caught at or near the sea surface, is particularly sensitive to changes in sandeel availability (Furness and Tasker 2000). This species feeds over the Wee Bankie to a considerable degree, so the sandeel fishery might have harmed these birds in some years in the early 1990s (Harris and Wanless 1997). The effects of other fisheries practices such as discarding of waste and by-catch of marine birds are considered separately (see below).

4.2.2 Fishery discarding practices

Populations of some seabird species have increased significantly over the last century, possibly as a consequence of their food supply being augmented by fisheries waste that is discarded from fishing vessels. The growth of the northern fulmar population (Fisher 1952) in the North Sea, however, appears to have ceased and there is evidence of recent decline certainly in the British populations over the last 15 years (see Table 4.1). Although discarding rates (proportions of catches discarded) may have remained fairly stable in this period, the large decline in catches of cod, haddock and whiting translate into large decreases in amounts of offal discharged, and in amounts of these fish that are discarded. These reductions in amounts of offal and discards might be reducing food supply to scavenging seabirds.

4.2.3 By-catch in fishing gear

Gill-nets and longlines are responsible for the drowning of thousands of marine birds annually. Northern fulmars, northern gannets, black-legged kittiwakes, common guillemots and Atlantic puffins have all been recorded as common casualties of the longline fishery (BirdLife International 1999, Dunn and Steel 2001), while nets targeting capelin and salmon for example have resulted in by-catch of guillemots and razorbills (Frantzen and Henriksen 1992, Strann *et al.,* 1991). In addition, pots and creels are responsible for by-catch of great cormorants (Follestad and Runde 1995). Dunn and Steel (2001) estimate (conservatively) that the Norwegian longlining fleet takes about 20,000 northern fulmars annually, but the overall effect of by-catch on marine bird populations remains unclear. A need to estimate the significance of the by-catch problem is required so that remedial measures may be proposed and set into action.

4.2.4 Mariculture

Many species come into conflict with humans at shellfish and salmon farms, for example, common eider and great cormorants. The extent to which bird persecution at these locations affects their populations is probably minimal, except locally in north and west Scotland, where great cormorant breeding numbers appear to have declined as a result of shooting at marine fish farms (Lloyd *et al.,* 1991). However, food pellets available at fish farms can provide a rich source of food for some seabird species, especially large gulls (Furness 1996).

4.2.5 Oil pollution

Oil pollution includes all forms of coastal and offshore oil spills, including chronic spillage from ships, oil platforms and land-based terminals. Due to the intense exploration, production and transportation of oil from the North Sea region, the potential threat from oil pollution events is ever-present. Oil pollution may affect a bird’s thermoregulation and waterproofing capacities, may result in poisoning due to ingestion, and may lead to habitat deterioration. There is no evidence of any long-term effects on seabird populations in the North Sea (defined in this report as ICES IIIa-d, IVa-c) from oil pollution.

4.2.6 Disturbance

This threat includes any form of human-related disturbance, which may affect the behaviour or population parameters of marine birds. Most typical are industrial activities, such as air traffic, shipping and tourism. Disturbance can also arise from area encroachment, and from people visiting seabird areas for various purposes (hunting, harvesting, research or recreation). Another threat is increased traffic connected with the establishment of new human settlements. The threat of human-related disturbance is likely to increase with the expansion of both industry and settlement, along with the ongoing development of tourism and recreation activities. Terns are particularly susceptible to disturbance at their breeding colonies, although the actual threat to their populations from disturbance is deemed to be moderate only here because most colonies of roseate and little terns and many of the other species are on protected sites that are subject to no or minimal disturbance.

4.2.7 Marine wind farms

The potential effects of marine wind farm developments in the North Sea region are largely unknown. Birds may be displaced and their feeding habitats altered or rendered unavailable or inaccessible during the construction phase of developments. The increase in traffic of maintenance vessels at operational wind farms may elevate birds disturbance levels and the possibility of shipping collisions with the wind farms and consequent surface pollution remains. Bird collisions with the turbines and associated constructions have been quantified for some areas. See Chapter 6 for a more comprehensive review of this issue.

4.2.8 Conflict with other species

Predation, competition and parasitism may represent a threat to marine birds and can cause significant harm to marine bird populations, either by killing incubating adults or by the consumption of eggs and chicks (Anker-Nilssen *et al.,* 2000). Competition between two or more species vying for the same resource (food, breeding site) may also pose a possible threat. Infestation by internal (nematodes, cestodes, trematodes) and external parasites (mites, ticks) may also directly or indirectly affect the general health of marine birds.

4.2.9 Predation by introduced predators

An increase in predation pressure on eggs, chicks and adult birds through the introduction of alien predators (for example North American mink, rats *Rattus norvegicus*, and domestic cats and dogs) has reduced some seabird populations at least on a local scale (e.g., Johansen 1978, Craik 1995).

Table 4.12. Indices of perceived threats over the next decade to marine birds of the North Sea. While there may be small, insignificant effects of various threats to many seabird species only those threats deemed to be moderate (●) or high (●●) are indicated. b = breeding season, nb = non-breeding season. No significant threats were identified for common shelduck, Arctic skua, Mediterranean gull and great black-backed gull. See text for further information.

Species	Threat category								
	Fisheries	Fishery waste	By-catch	Mari-culture	Oil	Wind farms	Disturbance	Conflict with other species	Introduced predators
Red-throated diver (b)	●				●	?			
Black-throated diver (nb)					●	?			
Great northern diver (nb)					●				
Great crested grebe (nb)					●	?			
Red-necked grebe (nb)					●	?			
Slavonian grebe (nb)					●	?			
Northern fulmar		●	●						
European storm-petrel								●	●
Leach's storm-petrel								●	●
Northern gannet					●				
Great cormorant	●			●	●	?			
European shag	●			●	●	?			
Common eider	●●				●	?			
Long-tailed duck (nb)					●	?			
Black scoter (nb)	●				●	?			
Velvet scoter (nb)					●	?			
Common goldeneye (nb)						?			
Red-breasted merganser						?			
Goosander (nb)						?			
Great Skua		●							
Black-headed gull						?			●
Mew gull						?	●		●
Lesser black-backed gull		●							
Herring gull		●				?			
Black-legged kittiwake	●●	●						●●	
Sandwich tern (b)	●					?	●		●
Roseate tern (b)	●					?	●		●
Common tern (b)	●●					?	●		●
Arctic tern (b)	●●					?	●		●
Little tern (b)						?	●		●
Common guillemot	●		●		●				
Razorbill	●		●		●				
Black guillemot					●				●●
Little auk					●				
Atlantic puffin	●				●				
High threat (species)	4	0	0	0	0	?	0	1	1
Moderate threat (species)	9	5	3	2	18	?	6	2	9

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5 REVIEW OF METHODS FOR ASSESSING SEABIRD VULNERABILITY TO OIL POLLUTION

5.1 Introduction

Marine oil pollution is one of the most widely known anthropogenic causes of seabird death. One of the ways of reducing this mortality is through spatial and temporal management of human activities causing oil pollution. In order to understand the most appropriate times and places for such management, it is important to know when and where seabirds that are vulnerable to such pollution might be. The scale of this vulnerability will depend not only on numbers present but also on the behavioural and other characteristics of the particular seabird species present. This review does not look at how to assess numbers of birds present in an area as this has been covered well in a number of published reviews (e.g., Tasker *et al.* 1984, Komdeur *et al.* 1992). Instead, it examines ways of assessing the characteristics of species that may make them more sensitive to oil pollution. First, the various studies in this area are described and then themes are bought out from these. Finally, recommendations are given.

5.2 Studies

5.2.1 King and Sanger (1979)

The first publication to address this issue for seabirds in a systematic way was King and Sanger (1979). They graded the 176 species using marine habitats in the northeastern Pacific on the basis of 20 factors (Table 5.1) that affect their survival. Each of these factors was given a score of 0, 1, 3, or 5 representing respectively no, low, medium or high relevance of that factor in increasing sensitivity to oil pollution.

The scores for each of the 20 factors were summed to provide an overall oil vulnerability index for each of the 176 species. Scores ranged from 88 (out of a possible score of 100) for Kittlitz's murrelet and whiskered auklet down to 19 for marsh hawk, not including those rare stragglers or endangered species occurring in the area. The authors suggest that if a species with a high score occurs in an area of a proposed development then research money, project modifications, contingency plans for disasters and other conservation actions would be likely to be required, while much less concern would be expressed in areas holding only low scoring species. On a wider scale, if there is a choice for location of a risky development between areas with differing numbers of highly vulnerable birds, then planning agencies might choose to locate the development in the lower risk area.

King and Sanger (1979) note that if relevant sub-species were used instead of species, then scores for several taxa would alter greatly indicating the importance of choice of taxonomic level. They also suggest that such vulnerability rating could be extended to cover other human activities.

Table 5.1. Factors used by King and Sanger (1979) to assess oil vulnerability of waterbirds in the northeastern Pacific.

a) Range (entire world population)
Breeding range size
Migration length
Winter range size
Marine orientation
b) Population
Population size
Productivity (derived from a combination of clutch size and age at first breeding)
c) Habits
Roosting
Foraging
Escape (reaction to disturbance)
Flocking on water
Nesting density
Specialisation (generalist versus specialist)
d) Mortality
Hunted by man
Animal depredations
Non-oil pollution
History of oiling
e) Annual exposure
Spring
Summer
Autumn
Winter

5.2.2 Ford *et al*. (1982)

The authors explore oil spill sensitivity in the specific context of pelagic bird distributions around the Pribilof Islands in the Bering Sea. A model was constructed that takes account of 16 primary demographic factors (Table 5.2) and 9 secondary factors (derived from the primary factors).

Table 5.2. Primary factors used by Ford *et al*. (1982) in a demographic model of red- and black-legged kittiwakes and Brünnich's and common guillemots near the Pribilof Islands, Bering Sea.

Average adult weight
Timing of colony arrival
Length of time at colonies
Length of breeding period
Maximum proportion of birds breeding
Maximum probability of chick death per day
Fledging period
Proportion of time spent at three stages of chick growth
Probability of death of egg per day
Length of time away from colony
Digestive efficiency and conversion factor for a growing chick
Fledging weight
Hatching weight
Incubation period
Colony population size
Proportion of weight gained at end of three stages of chick growth

A foraging model produces projected distribution of birds around a colony, upon which a perturbation such as an oil spill can be placed. The effects of this "oil spill" can then be assessed against the standard demographic model without the spill. A sensitivity analysis indicated that the model was very sensitive to the rate at which the population adjusts its foraging distribution in the period after an oil spill and to large changes in food availability of areas following perturbation.

The model identified nine critical gaps in field information. These were 1) the number of non-breeding birds within a population; 2) the movement patterns of birds in a foraging area; the spatial and temporal distribution of food about a colony; 4) the relationship between food delivery and chick growth-rate; 5) the degree of density dependence in various population factors; 6) mortality rates caused by oil spills; 7) normal age-specific mortality schedules; 8) the rate at which a population responds to a perturbation and 9) the effect off a spill on short-term food availability.

Wiens *et al*. (1983) paper enlarges on the discussion of needs in Ford *et al*. (1982), and propose rating many colonies on the basis of the parameters used in the model described above. Research and information needs are prioritised.

5.2.3 Tasker and Pienkowski (1987)

Tasker and Pienkowski (1987) allocated 37 species of seabird in the North Sea to three categories (very high, high and moderate) of vulnerability to oil pollution on the basis of three factors (substantial period of life spent on water surface; importance of the North Sea for a large proportion of the world population of the species; species rare on a world basis). This allocation was done on an expert judgement basis. Tasker *et al*. (1990) used the same basis for allocation for waters to the west of Britain. In both cases, the vulnerability rating was combined with information on at-sea distribution of birds to identify areas holding concentrations of birds vulnerable to oil pollution.

5.2.4 Anker-Nilssen (1987)

Anker-Nilssen (1987) assessed 17 factors that make a species vulnerable to oil pollution that can be conveniently divided between individual and population levels (Table 5.3).

Table 5.3. Factors used by Anker-Nilssen (1987) to describe the sensitivity of a seabird to oil pollution.

Individual vulnerability
1. Time in area
2. Time at sea
3. Area utilisation
4. Behaviour at sea
5. Shore affinity
6. Possibility of reaction
7. Flight capability
8. Physical fitness
9. Recovery capability
Population vulnerability
10. Degree of exposure
11. Population size
12. Flocking tendency
13. Frequency of immatures
14. Reproductive potential
15. Population trend
16. Proportion of population at risk
17. Potential immigration

These factors were placed in a chain of consequences: Presence, time at sea when in area, exposure to oil, possibility of injury from oil and effects of oiling. If any one of these links in the chain is zero, then total vulnerability is zero. Thus Anker-Nilssen's vulnerability index was calculated as a product of the vulnerability in these five groups. The 17 factors (Table 5.3) were also weighted for their relative importance. After further calculation, the index was used to categorise each bird in an area to either low, moderate or high vulnerability.

5.2.5 Camphuysen (1989)

Camphuysen (1989) proposed a similar index to King and Sanger (1979) for the North Sea, and suggested scores for all regularly occurring species of waterbirds. This was refined in Camphuysen and Leopold (1998) and Camphuysen *et al*.

(1999) to 14 factors (Table 5.4). These were combined with an oiling rate (based on beached bird surveys) and numbers occurring in an area to evaluate the risk to two areas off the Dutch coast from industrial developments.

Table 5.4. Factors used by Camphuysen (1989) in evaluating an oil vulnerability index in the southern North Sea.

Range
1. Breeding
2. Migration
3. Wintering
4. Marine orientation
Behaviour
5. Roosting
6. Foraging
7. Reaction to disturbance
8. Flocking
9. Nesting density
10. Specialisation
Exposure
11. Spring
12. Summer
13. Autumn
14. Winter

5.2.6 Speich *et al*. (1991)

Speich *et al*. (1991) scored 14 factors (in three groups) on the basis of exert judgement in order to calculate a Bird Oil Index (BOI) for Puget Sound (Table 5.5).

Table 5.5. Components and elements used by Speich *et al*. (1991) to calculate a Bird Oil Score.

Component 1: Vulnerability of species as determined by behaviour of individual birds
Night roosting
Escape behaviour
Flocking on water
Nesting concentration
Feeding specialisation
Component 2: Vulnerability of species as determined by total population characteristics
Population size
Reproductive potential
Breeding distribution
Winter distribution
Seasonal exposure to marine habitats
Component 3: Significance of Puget Sound to North American population
Spring
Summer
Autumn
Winter

These BOI scores represented the importance of the general geographic region to the species, but these were refined by multiplying by the abundance of a species determined by counts from each study site within the region. This could be further tuned if these numbers changed by season. Within Puget Sound, such Species Seasonal Site BOI scores were ranked to indicate which areas were of particular importance.

5.2.7 Carter *et al*. (1993)

Carter *et al*. (1993) and Webb *et al*. (1994) both use the method described in Williams *et al*. (1994) to asses seabird sensitivity to surface pollutants. These authors used data derived from surveys and scientific studies rather than expert judgement in their scoring procedure for four factors (Table 5.6). Each of the four factors received a score between one (low vulnerability) and five (very high vulnerability). These factors were then summed using the formula below to give an Oil Vulnerability Index (OVI) score. Extra weighting was placed on factors a and b as these were considered the most important. The authors recognised that these scores were area specific – in other words the score for each species might change depending on the area under consideration.

$OVI = 2a + 2b + c + d$

Table 5.6. Factors used by Williams *et al*. (1994) to assess seabird sensitivity to surface pollutants

a) Behaviour (scored using proportion of birds oiled found dead or moribund during beached bird surveys and by the ratio of birds flying to birds on the sea during at-sea surveys)
b) Biogeographical population size
c) Reproductive potential (scored on the basis of mean clutch size, maximum clutch size and age at first breeding)
d) Reliance on the marine environment (proportion of a population of birds feeding at sea compared with on land)

Carter *et al*. (1993) and Webb *et al*. (1994) both then used the OVIs in combination with data from at-sea surveys to map (on a ¼ ICES rectangle basis) Area Vulnerability Scores using the following formula for each rectangle.

$\text{Area Vulnerability Score} = \Sigma\ ({}_{\text{species}}\ln(\rho + 1) \times OVI)$

where ρ is the density calculated for a species in the area and OVI is the oil vulnerability index for that species.

5.3 Discussion

It is not surprising that there is a relationship between oil vulnerability indices calculated for the same species but in different parts of the world. Thus, there is a significant correlation (Spearman's rho = 0.572, $p = 0.001$, $n = 32$) between the OVIs scored using the same parameters for species common to both King and Sanger (1979) and Camphuysen (1989) (Table 5.7). There is a similar significant correlation (Spearman's rho = 0.685, $p = 0.001$, $n = 21$) between the proportion of birds found dead or moribund that were oiled on Netherlands beaches and OVI scores of Camphuysen (1989), indicating that scoring reflects the risk of oiling.

The oil vulnerability indices of Camphuysen (1989) and of Williams *et al*. (1994) for the North Sea are also correlated (Spearman's rho = 0.454, $p = 0.004$, $n = 37$). There is a significant correlation (Spearman's rho = 0.446, $p = 0.015$, $n = 29$) between the proportion of birds found dead or moribund that were oiled on Netherlands beaches and OVI scores of Williams *et al*. (1994).

Table 5.7. Oil vulnerability index scores of King and Sanger (1979), Camphuysen (1989) and Williams *et al*. (1994) for species common to the northeast Pacific and the North Sea. The percentage of birds found dead or moribund on that were also oiled on Netherlands beaches is also shown (Camphuysen 1989).

Species	King & Sanger (1979)	Camphuysen (1989)		Williams *et al*. (1994)
	OVI	OVI	Oil %	OVI
Red-throated diver	49	68	92.1	29
Black-throated diver	58	65	93.2	29
Great northern diver	47	67	-	29
Great crested grebe		58	58.2	23
Red-necked grebe	44	54	67.4	26
Slavonian grebe	48	46	71.1	-
Northern fulmar	57	65	68.0	18
Manx shearwater	-	54		23
Sooty shearwater	51	47	-	19
European storm-petrel		54		18
Leach’s storm-petrel	63	49	-	-
Northern gannet	-	65	86.5	22
Great cormorant		59	36.2	20
European shag	-	73	-	24
Brent goose	70	42	21.8	-
Mallard	36	29	31.9	-
Pintail	36	27	25.9	-
Shoveler	34	30	-	-
Greater scaup	52	58	37.7	20
Long-tailed duck	66	55	88.9	17
Common eider	68	75	67.3	16
Common scoter	72	66	95.8	19
Velvet scoter		65	76.5	21
Common goldeneye	48	50	35.3	16
Red-breasted merganser	56	58	43.0	21
Goosander	56	45	42.5	-
Red-necked phalarope	62	37	-	-
Grey phalarope	58	39	-	-
Pomarine skua	41	40	51.4	-
Arctic skua	43	43	70.0	24
Great skua		58	70.6	25
Long-tailed skua	39	36	-	-
Little gull	-	58	56.9	24
Sabine’s gull	44	41	-	-
Black-headed gull		44	44.2	11
Mew gull	36	46	59.6	13
Lesser black-backed gull		50	40.3	19
Herring gull	38	47	32.9	15
Glaucous gull	45	36	-	-
Great black-backed gull		57	46.5	21
Black-legged kittiwake	49	66	84.0	17
Sandwich tern		51	36.4	20
Common tern		46	26.2	20
Arctic tern	32	46	-	16
Little tern		49		19
Common guillemot	70	82	89.0	22
Razorbill	-	86	89.3	24
Black guillemot	70	72	-	29
Little auk		65	84.6	22
Atlantic puffin		80	85.0	21

Oil vulnerability indices are used for a number of purposes, related mostly to management of human activities. Virtually all oil-spills carry a risk of affecting seabirds, but unless all oil exploration and usage ceases, then the likelihood is that accidents and discharges will continue. We cannot realistically expect to manage activities to ensure that no birds will be killed by oil pollution. We can however attempt to manage activities to reduce oil pollution effects on birds. If there are limited resources to undertake this management, then it is best to use these resources in the most effective way possible. Oil vulnerability indices provide a method to grade the effects of oil spills on marine birds, usually by comparing relative impacts between areas. Once this knowledge is available, it may be possible to select the most effective ways to manage human activities to prevent, avoid or mitigate damage to seabirds.

The two main periods when such information might be used are prior to a development or activity (the planning stage) and in the case of an actual oil spill (emergency situation). In the first case, a comparison of possible locations or times for a development or activity (e.g., shipping route) might allow the choice of a less risky place or time to be made. It might also indicate where or when special measures might be taken to reduce risk. In the case of an oil spill, such information would enable mitigation and clean-up resources to be targeted at the places and times when birds are at greatest risk. In practice, in both cases, birds are usually only one of the considerations in decision-making and usually environmental impact assessments or environmental sensitivity atlases (e.g., Mosbech *et al*. 2000) cover many more natural and other features.

All of the above purposes require not only oil vulnerability indices, but also some information on the relative occurrence of the species within the area of interest. This may be both temporal and spatial information. In the earlier OVIs (e.g., King and Sanger, 1979), temporal information is included as a seasonal exposure factor. In more recent atlases (e.g., Carter *et al*. 1993), bird density information is included on a monthly basis. Use of such information obviously makes atlases of vulnerability a much more precise tool for planning and emergency response.

Oil vulnerability indices and their use have progressed since King and Sanger (1979) first proposed them. In essence, all indices score the sensitivity of a species to oil pollution. Some indices divide these factors between those that apply to the population as a whole, and those that apply to an individual's behaviour (though these are of course linked). Early indices used expert judgement to allocate scores for each factor, while in more recent years, scientific data have been applied to the scores. Despite this, a degree of subjectivity is still used in allocating information to a score value in weighting the factors against each other.

The factors relating to population as a whole relate primarily to the ability of a population to recover from additional mortality. Population size has been used in all vulnerability indices, usually this is of the biogeographic population, but sometimes this is not explicit. The usual taxonomic level is species, though perhaps in some cases, sub-species or isolated population size might be more appropriate. The key factor though must be proportion of the population that is at risk; and this must therefore depend on the area that might be covered by an oil spill compared with the overall area inhabited by a population. A species, such as northern gannet or Manx shearwater, that nests at comparatively few sites would be substantially more at risk from an oil spill affecting those breeding sites, than a species that is more dispersed. However, the concentrated species would be less at risk in areas away from the breeding site.

In most OVI scoring systems, areas containing highest numbers of birds towards the centre of ranges tend to be emphasised. This will mean that actions tend to look after the core of the range of species, rather than the peripheries. These peripheries may however be important in representing genetically distinct populations or groups of birds that might be of greater economic (e.g., for tourism) value. This point is perhaps best illustrated by an example. A core of the Atlantic puffin range is in Iceland; southwest England holds populations several orders of magnitude smaller. However, it is likely these puffins are morphologically and genetically distinct from the Icelandic population and are probably of greater tourism value per bird than those in Iceland. Any vulnerability assessment that covers both areas would highlight Icelandic waters for this species, but not southwest English waters. OVIs thus may not fully reflect non-biological properties of populations.

The overall size and geographic location of the area that is being assessed for its sensitivity will affect results if a relative rather than absolute sensitivity scale is used. In most cases described above, a relative scale is used (e.g., the highest third of area sensitivity scores are described as being of high vulnerability) rather than an absolute scale based on an absolute score. The choice of size of area over which relative vulnerability of birds is being mapped is important and will affect the sensitivity of the results. Carter *et al*. (1993) and similar more recent atlases of vulnerability divide the range of vulnerability scores are available into four equal quartiles that were then mapped as being of very high, high, medium and low vulnerability. Using this relative scale, the varying vulnerability of areas of continental shelf around the UK may be distinguished relatively easily. However, if a large area of low density (and therefore vulnerability) is added, through for instance surveying deep waters to the west of UK, the relative vulnerability of all shelf waters increases and sensitivity in these areas decreases. This problem might be best dealt with by careful choice of areas mapped to encompass primarily those at risk from the activity that is being managed.

Assessment of vulnerability is sensitive to the spatial scales of such assessments in several ways. Begg *et al*. (1997) examined the effects of scale-dependence in the maps derived from the methods described by Williams *et al*. (1995) (see above). These maps are based on the scale of ¼ ICES rectangles. Begg *et al*. (1997) found that there was decreasing heterogeneity in Area Vulnerability Scores (see Section 5.2.7) with increasing spatial scale. They also found, as a consequence of patterns in seabird distribution, the presence of some spatial structure at a scale of 20–30 km that could not be detected when estimating Area Vulnerability Scores at larger scales. Begg *et al*. (1997) suggest that the calculation of Area Vulnerability Scores should be done at a fine spatial scale (dimensions less than 20–30 km). However it is unusual for there to be sufficient data to work at a fine scale without combining data over an extended period of time, which might distort spatial patterns. These authors suggest that such effects might be mitigated by stratifying the assessments and calculating Area Vulnerability Scores at a high resolution in areas of high bird density and coverage, and at low resolution in areas of low density and low coverage.

In all studies where 'area vulnerability indices' are the sum of individual species oil vulnerabilities in that area (whether combined with quantitative censuses of numbers or not), it is important that consideration is given to the effects of varying survey effort in determining the presence or density across the area. In all AVI scoring systems proposed so far, areas (of the same overall bird density) with more diverse faunas are rated more highly than areas with less diversity. However, in general there is an asymptotic relationship between survey effort and numbers of species found in an area. White *et al*. (2001), working in an area off the Falkland Islands where a relatively even distribution of species might be expected, found that the number of species seen levelled off after about 20 km^2 of survey effort in a ¼ ICES rectangle (Figure 5.1). This represents about 5% of the ¼ ICES rectangle. Without such consideration, areas of low survey effort will be indistinguishable from areas with low numbers of species. This percentage is likely to vary and be high in areas of high habitat heterogeneity used by different bird communities.

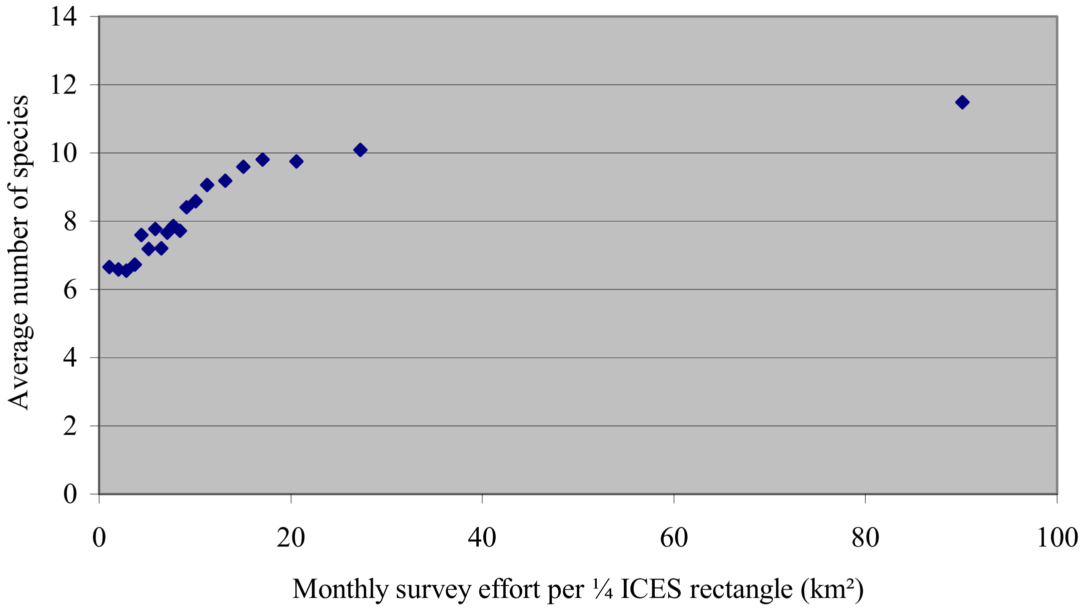

Figure 5.1. Species discovery curve - species richness (number of species per ¼ ICES rectangle per month) with respect to monthly survey effort (km² per ¼ ICES rectangle) (White *et al*. 2001).

5.4 Recommendations

1) Oil vulnerability indices should include empirical scientifically derived information on the characteristics of species relating to their vulnerability to oil pollution.
2) Any necessary subjective scoring or weighting of scores is probably best done through agreement across a range of relevant specialists.
3) Consideration should be given to the taxonomic level chosen for the biogeographic population assessment.
4) Scientifically-derived information on distribution and abundance should be included in assessments of the relative vulnerabilities of areas.
5) The effects of varying survey effort within an area need to be allowed for when comparing the apparent vulnerabilities of bird communities between areas. Preferably, sufficient survey should be undertaken to minimise this effect.
6) Area vulnerability indices should be calculated at a high spatial resolution in areas of high bird density and high coverage, but may be at lower spatial resolution in areas of low bird density or survey coverage.

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6 EFFECTS OF MARINE WIND FARMS ON BIRDS

6.1 Introduction

The production of electrical energy using banks of turbines ("wind farms") has undergone a rapid development in recent decades. Land-based wind farms have been operational in North America and Europe since the mid 1980s, and the first marine wind farms were built in the early 1990s, off Denmark and Sweden (Larsson 1994; Table 6.1). There are now at least nine operational marine wind farms, all in Europe (Table 6.1). As well as proposals to build many wind farms around the UK, and off Germany and Denmark (Anon 2000a,b; Anon 2001, Anon 2002), there are plans for one in Nantucket Sound, Massachusetts, and USA. Plans to construct marine wind farms may consist of up to one thousand turbines each, extending as far offshore as 100 km, and in waters of up to 40 m deep (Anon 2002). Within north-west Europe, there are about 83 turbines in existing marine wind farms, but about 2400 are planned for construction in the next few years (Table 6.1). This enormous development gives rise to concern over effects on seabirds, since the impacts of such a huge development are largely a matter of speculation at present.

The first large (> 15 turbines) marine wind farms are being constructed in Danish waters in spring 2002 at Horns Rev in the North Sea (Christensen *et al*. 2001) and in spring 2003 at Rødsand in the Baltic Sea (Desholm *et al*. 2000). According to the current plan of development for the German parts of the North and Baltic Seas, marine wind farms alone will require an area of 2,000 to 2,500 km^2 between 2002 and 2030 (DEWI 2001, BMU 2001, BSH 2001). The United Kingdom has recently issued licenses for the development of about 40 marine wind farms in its waters (Figure 6.1). Thus, erection of wind facilities offshore may become Europe's most extensive technical intrusion into marine habitats (Merck and von Nordheim 2000). Since substantial numbers of birds have been killed at land-based wind farms (Byrne 1983, CEC 1989, Orloff and Flannery 1996, Johnson *et al*. 2001) it seems prudent to consider potential impacts upon birds within environmental impact assessments (EIAS) of proposed marine wind farms (e.g., Garthe 2000, BMU 2001, Runge 2001, Exo *et al*. 2002). After more than a decade of rapidly increasing development of land-based wind farms, consequences of their impact on birds have not been satisfactorily assessed (e.g., Breuer and Südbeck 1999, Schreiber 1999, BFN 2000) despite documentation of mortality.

6.2 Use of marine areas by birds

Marine environments, especially those located close to land, are frequented by a variety of bird species. These include not only true seabirds or waterbirds which feed, rest or otherwise stay on the water for extended times but also many landbirds which migrate over the sea. Non-marine migrants that traverse marine environments include songbirds, hawks, owls, storks, swifts and cranes. Since landbirds often cross marine areas to reduce flight distances or because there are no land bridges, they might be affected by wind farms at sea in the same or in a similar manner as are seabirds.

Waterbirds are most likely to fly at sea when feeding (e.g., gulls and terns) or when they move from resting to feeding areas (e.g., sea ducks). Migrating birds tend to move rather long distances (100s to 1000s of km) non-stop when crossing the sea. Their altitude of flight is strongly influenced by wind speed and direction (e.g., Alerstam 1990, Krüger and Garthe 2001).

6.3 Importance of the North Sea and the Baltic Sea for birds

6.3.1 Internationally important bird populations in the North Sea and Baltic Sea

Comprehensive data on spatial and temporal distribution of waterbirds in marine areas have been obtained within the scope of the European Seabirds at Sea Co-Ordinating Group (ESAS), as well as by means of aerial counts, particularly in the Wadden Sea and the Baltic (e.g., Durinck *et al*. 1994, Skov *et al*. 1995, 2000, Nehls 1998, Stone *et al*. 1995). They show that the shallow offshore areas are of prime importance for seabirds and other waterbirds. Even within the same sea, different areas support very different species so that most areas have distinctive assemblages of species.

6.3.2 Bird migration over the sea

Every year during spring and autumn migration, several ten millions of birds cross the North Sea and the Baltic on their way between breeding grounds and wintering areas. Both seas are located in the midst of the European migration routes, and also in the global flyway systems that stretch between NE Canada and NE Siberia (breeding grounds) to South Africa (wintering areas). This puts international responsibility on all the countries affected within the scope of numerous agreements and conventions, such as the African-Eurasian Migratory Waterbird Agreement (AEWA).

Migratory birds cross the North and Baltic Seas in broad front (Figure 6.2; e.g., Jellmann 1977, Buurma 1987, Alerstam 1990). Only a few species use real "corridors", e.g., along shores or rivers (Jellmann 1988, Alerstam 1990). Migratory birds cross the North and Baltic Seas area during the day as well as at night (Alerstam 1990). Flight altitudes of migratory birds above the sea are poorly known, yet it is generally believed that waterbirds mainly use low-altitude (500 m or less) migration while passerines mainly pass at somewhat higher altitudes (1000 m or more). All migrating birds tend to fly much lower during fog or rain, or when there is a low cloud ceiling (Alerstam 1990, Able 1999). In addition, many birds such as sea ducks commute on a regular basis between feeding at roosting areas and during such commuting flights they are presumably susceptible to striking wind turbines.

6.4 Effects of wind farms on birds

6.4.1 General overview

Erection of wind farms in offshore zones can affect birds in many ways. These effects strongly depend on the spatial scale at which they are to be considered. For example, influences on a scale of a few kilometres (e.g., disturbance by a medium-sized wind farm) might affect local birds by forming a barrier between resting and feeding sites. However, this hardly seems to be relevant for birds migrating thousands of kilometres between breeding and wintering sites. Birds migrating long distances might rather be affected by a set-up of many wind farms in a certain area, which might act as a barrier. Generally, the foreseeable effects can be grouped into the following four categories:

- Collision with wind turbines
- Habitat modification, which includes habitat loss as well as habitat alterations in the course of wind farm construction and maintenance
- Disturbance and barrier effects
- Secondary effects (e.g., by increased traffic by ships used in the construction of the farm)

Since marine wind farms are so new, there are few data with which to evaluate the above risks to birds. Therefore at this point we need to draw inferences from impacts of land-based wind farms upon birds.

6.4.2 Collision with wind turbines

Winkelman (1985, 1989, 1992a) estimated bird collision rates on two coastal, land-based wind farms in the Netherlands at 0.04 (Urk, autumn) and 0.09 (Oosterbierum, spring) birds per turbine per day. These rates are consistent with other European studies, which cite from 0 to 40 birds killed per turbine per year (Clausager and Nøhr 1995). Substantial mortality of terrestrial birds has been reported at American wind farms, even during the daytime in fair weather, mostly from birds striking the spinning turbine blades, but also from birds striking guy wires or other associated structures (NWCC 2001). An overall average mortality rate of 2.19 birds killed per turbine per year has been calculated. Estimates of mortality range from 0 birds per turbine per year in Vermont and Iowa (Kerlinger 1997, DeMastes and Trainer 2000) to 4.45 birds per turbine per year in Minnesota (Johnson *et al*. 2000). Much of the mortality has been of raptors, owls and nocturnally migrating passerines. The species composition of birds killed has ranged from one dominated by hawks and owls in California to one dominated by passerines in Minnesota. At Altamont Pass, California, 47.6 % of birds killed were diurnal raptors, 18.6 percent were "protected" (i.e., not European starlings or house sparrows) passerines, 17.8% were European starlings and house sparrows and 11.3% were owls. At Buffalo Ridge, Minnesota, 72.7% of birds killed were protected passerines, 9.1% were waterfowl and 5.5% were "fowl-like birds" and "waterbirds". The most damaging mortality has been recorded at the Altamont, California wind farm, where 292 diurnal raptors, including 181 red-tailed hawks, 30 golden eagles and 49 American kestrels were killed in one year (Howell and DiDonato 1991, Howell *et al*. 1991, Orloff and Flannery 1992, Howell 1997).

Other types of lighted towers of approximately 150 m height (communication towers) have killed hundreds of migrating passerines in the USA (Trapp 1998, Shire *et al*. 2000), although daily rates. In both Europe and North America, particularly high collision risks seem to be associated with larger, soaring birds, and when turbines have been placed in areas of elevated bird abundance, such as along ridges used by soaring raptors (CEC 1989, Böttger *et al*. 1990, Winkelman 1990, 1992a-d, Clausager and Nøhr 1995, Colson 1996, Musters *et al*. 1996, Scherner 1999).

Behavioral analyses of flying birds that approached an experimental wind farm at Oosterbierum, The Netherlands, showed that more birds appeared in close proximity to rotor blades at night rather than during the day (Winkelman 1990). More individuals collided at night (14 of 51 birds) than during the day (1 of 14 birds). Birds reacted with dodging movements in headwind more often than in tailwind. The diversity of reactions is likely to have resulted from a different acoustical perceptibility of turbines and varying maneuverability caused by a flight speed difference in head and tail winds. With radar observations under 'quasi offshore conditions' at Lake Ijsselmeer (The Netherlands), Dirksen *et al*. (1998a) showed that the distance of flying ducks to wind turbines was the shortest at times of poor visibility. On Tunø Knob offshore wind farm (Kattegat, Denmark), flight activity of ducks was the lowest during dark nights (Tulp *et al*., 1999). On the other hand, the ducks that were active on dark nights were more likely to approach the wind turbines closely in the dark and so presumably increased their risk of collision.

Diurnal observations show that seabirds, especially during foraging, mostly fly very low above the water surface (<< 150 m, often < 50 m; Krüger and Garthe 2001) although many species fly higher during high wind speeds. This result is supported by radar observations of waterbirds and waders resting at the coast: these regularly moved between roosting and feeding sites at altitudes below 150 m (e.g., Dirksen *et al*. 1996, 1998b). In general, flight activity at lower altitudes seems to be higher when close to the shore (Dierschke 2001).

According to visual observations, diurnal flights of birds in general occur above the sea at much lower altitudes than those above land and are likely to reach the height of wind turbines (Figure 6.3; Berndt and Busche 1993, Bruderer 1997, Koop 1997, 1999). Clemens (1978a, 1978b) showed by means of radar surveys that flight activities of birds in the North Sea area largely took place at altitudes between 200 and 400 m. From all bird echoes registered by radar from the island of Helgoland (North Sea) between 0 and 1800 m, 19 % were from an altitude between 0 and 200 m thus close to the height of the rotors (O. Hüppop pers. comm.). However, birds sometimes fly high enough that they cannot be detected visually (Buurma 1987, Jellmann 1989, Becker *et al*. 1997); this of course impedes quantitative analyses of altitudinal distribution and, thus, identification of potential impacts of wind facilities on flight patterns.

Weather conditions, in particular wind speed and direction, strongly affect flight altitudes of birds. Gätke (1891) described that migratory birds often flew just above the water surface in heavy headwind. This has been supported many times since. Recent sea-watching observations from Wangerooge Island, Germany, showed that many sea and coastal birds (e.g., red-throated diver, common eider, black scoter, common shelduck, Sandwich tern, common tern, and Arctic tern) flew very low, mainly below 10 m, above the water surface in heavy headwind; contrastingly, they preferred higher altitudes (> 25 m) as their speed increased in tailwind (Figure 6.4; Krüger and Garthe 2001 and unpubl. data). Dirksen *et al*. (1998a) came to similar conclusions: ducks flew mainly at altitudes up to 75 m in the coastal zone and up to 50 m above open water; the altitude sank to 30 m in strong headwind. According to Koop (1999), small passerines fly over land at altitudes of 40 to 60 m in strong headwind. In tailwind, birds seem to have a reduced perception of the turbines and to be less manoeuvrable so that they can get into the span of rotor blades. However, it has to be kept in mind that visual detectability by humans of migrating birds decreases with increasing flight altitude.

Wind farms potentially threaten local waterbirds as well as visitors and passage migrants. Although no collisions by common eiders were registered on a single Danish offshore wind farm (Guillemette *et al*. 1999), the collision risk at sea is likely to be higher than on the mainland for several reasons. Offshore wind facilities are likely to be considerably taller; acoustical perception of them by birds will be obviously hampered by louder background noise of the sea; besides, nearly all seabirds fly low above the water surface and many terrestrial species, too, tend to descend above the sea as they leave the mainland. The greatest collision risk occurs at night, especially in moonless nights or under unfavourable weather conditions, such as fog, rain, and strong wind. Tulp *et al*. (1999) have shown that seaducks are more likely to strike wind turbines on dark nights or nights with restricted visibility.

On a larger (global population) scale, the effects might be lower. For long-lived species, even a small reduction in annual survivorship of adults can have a profound effect upon population growth. Hunt *et al*. (1999) showed that mortality of golden eagles at the Altamont Pass, California, wind farm impacted the growth rate of the population. Such an effect has also been shown for albatrosses suffering from mortality at fishing vessels, leading to severe population declines (Brothers 1991).

6.4.3 Habitat modification

In the course of wind farm construction some habitat may be lost. This is probably a lesser risk compared to that posed by collisions and disturbance effects. Changes in seabed structure, for example by deposition of hard substrates or by altering sedimentation, may cause changes in species composition, diversity and density of the fish benthic fauna. Since fish and shellfish are the main prey of most seabirds, this might have an effect on their distribution and abundance near wind farms. This effect is assumed to be much stronger if commercial fishing is not allowed in the wind farms, and will possibly lead to an improved food basis for many birds and wind farms may thus attract more birds than were present in the area before. This in turn may lead to an elevated risk of collision.

6.4.4 Disturbance and barrier effect

Birds, in particular species inhabiting open landscapes, tend to avoid tall vertical structures. The addition of flailing rotor blades on wind turbines may further scare birds. Therefore, even relatively compact wind turbines may indirectly affect a much larger area. This is particularly true for sensitive species with a preferred offshore distribution, such as divers and certain species of seaducks, which typically avoid human constructions and coastal environments. Waders and shorebirds have been shown to be behaviourally affected within a radius of 300 to 800 m around wind turbines, with the amount of disturbance increasing proportional to turbine height (Pedersen and Poulsen 1991, Clausager and Nøhr 1995). Numbers of birds roosting or feeding within 250 m of land-based wind turbines decreased 60–95%, relative to areas > 250 m away, both in local breeders and visitors (Pedersen and Poulsen 1991, Winkelman 1992a-d, 1995, Schreiber 1994, Clemens and Lammen 1995, Brauneis 1999, Kruckenberg and Jaene 1999). On the other hand, Thomas (2000) recorded little or no disturbance to northern lapwings and Eurasian curlews within 100 m of a wind farm in the U.K. It is possible that locally breeding species are more likely to become habituated to wind turbines than are passage migrants. Stübing (2001) showed that several species of songbirds altered their migration in order to perform a wide detour of wind turbines. Species that seem particularly sensitive to disturbance by wind turbines include geese, Eurasian wigeon, and waders, such as Eurasian curlew and European golden plover that sometimes keep more than 500 m away from wind turbines. Kruckenberg and Jaene (1999) studied the behaviour of white-fronted geese near a wind farm in the Rheiderland (Germany). This is one of the few quantitative studies containing pre- and post-construction surveys as well as an investigation of impact and reference area. Up to a distance of 600 m from wind turbines, the density of grazing white-fronted geese was low compared to that in reference areas of the Rheiderland. Even at distances of 400–600 m from the wind farm, a density drop of about 50% was recorded. Distribution of geese became independent of the location of the turbines only at distances of more than 600 m.

Direct reactions of birds, except for common eiders, to offshore wind turbines have been little studied. On Tunø Knob wind farm (Kattegat, Denmark), no impacts on numbers of resting and/or feeding common eiders were recorded. Area utilization by common eiders seemed to be determined by the spatial distribution of food rather than by the location of the wind farm (Guillemette *et al*. 1998, 1999). Tulp *et al*. (1999) reported from the same site that takeoffs and landings of common eiders 100 m distant from turbines occurred significantly less frequent than those at 300–500 m. Nocturnal flight activities were reduced within a radius of 1,500 m from the wind farm, so the facility produced a barrier effect on flight patterns of common eiders. Similarly, Dirksen *et al*. (1998a) concluded from their observations at Lake Ijsselmeer (The Netherlands) that flights of diving ducks to their feeding sites could be impeded due to the barrier effect of wind turbines. Divers and scoters are particularly sensitive to disturbance (Camphuysen *et al*. 1999, Mitschke *et al*. 2001). They sometimes flee from ships as far as several kilometres away. Therefore, they occur mainly in marine areas with little sea traffic (Mitschke *et al*. 2001). These birds, being so sensitive to disturbance, may suffer severe loss of access to feeding habitat as a result of installation and maintenance of wind farms. Since offshore areas are rich in large bird species that are often considered very sensitive to disturbance, and since offshore wind turbines will be substantially taller than inland ones (up to 150 m total height), one might expect a greater potential impact here compared to that on existing land-based wind farms.

The most ambitious recent proposal for a marine wind farm site in North America is in Nantucket Sound. The proposal is to place 170 wind turbines about five miles south of Osterville, Cape Cod. The towers would each be 150 m tall and would have propeller blades 45 m long. Nantucket Sound provides habitat for large numbers of seaducks in winter and also for 90 % of the North American population of the federally endangered roseate tern. Between 250,000 and 500,000 long-tailed ducks winter in Nantucket Sound (Veit and Petersen 1993). Unusual to the Nantucket SoundlLong-tailed duck population is their daily commute from Nantucket Sound to the Nantucket Shoals, 70 km offshore. They feed during daylight hours on pelagic amphipods that are found in dense swarms on the Nantucket Shoals (Veit, unpubl. data). The ducks spend each night in Nantucket Sound, and commute to sea to feed. Thus near or over Nantucket, vast (often 10,000 per flock) flocks of Long-tailed Ducks can be seen flying *en masse* to the Nantucket Shoals at dawn and then returning to the sound at night. Depending on wind conditions, the ducks fly at heights ranging from just above the water surface up to 200 m or so. There are few data on exactly where in Nantucket Sound the ducks spend the night, but recent surveys that most roost near the Tuckernuck Shoal, about 18 km to the southeast of the proposed wind farm site on Horseshoe Shoal.

Ninety percent of the North American roseate tern population breeds in the limited region between the eastern end of Long Island, New York and Nantucket Sound (a span of about 140 km) (Buckley and Buckley 1981). The nesting terns are about evenly divided between two areas with two colonies each. Following the nesting season, most of the terns from both places travel to the Nantucket Sound area to feed on fish prior to migrating south. In recent years, the areas of maximum concentration have been near Monomoy Island at the southeastern corner of Cape Cod, and on the shoals surrounding Nantucket and its offshore islands. Thus it appears that almost the entire Long Island-Massachusetts population of roseate terns flies directly past the proposed windfarm site in Nantucket Sound during late summer. As fog is frequent in Nantucket Sound during summer, there seems to be the potential for terns striking the turbines.

A third area of concern is the susceptibility of nocturnally migrating passerines to striking wind turbines, especially during fog or rain. While most passerines migrate at elevations of a few thousand feet (Alerstam 1993, Able 1999) large numbers of passerine migrants often fly much lower during inclement weather and there is a vast literature on migrants being killed at lighted man-made structures such as television and radio towers, lighthouses and tall buildings (e.g., Banks 1979, Trapp 1998, Shire *et al*. 2000). Banks (1979) estimated that 1.2 million passerines per year were killed in the United States by striking communications towers.

The basic difficulty of assessing the possible risk associated with wind farms is that we have few data on how birds respond behaviourally to turbines. It is likely that during the daytime in fair weather birds will see the turbines and avoid them. However during reduced visibility (fog is frequent in the area) or storms collisions may be more likely to occur. Surveying the vicinity of the turbines for killed birds will be extremely difficult during storms but may be possible in calm, foggy weather. Quantification of bird strikes at turbines may be improved through use of an infra-red sensitive video camera (Desholm 2001).

6.4.5 Secondary effects

The construction of wind farms at sea may cause secondary effects to take place. There can be increased disturbance of birds by increased ship traffic in areas where ship traffic has been low or negligible before. Also, the locations of wind farms are important; many wind farms in the southern North Sea are planned very close to main shipping lanes. Possible collisions between ships and wind turbines can cause huge problems such as oil pollution. It has to make clear that such collision risks are kept low.

6.5 Research Concept and Methods

6.5.1 General aspects

Between the countries that have started environmental investigations into potential impacts of wind farms, research concepts and methods are currently poorly standardized. This is particularly true for cumulative effects on feeding sites and international migration routes. Standard “strategic analyses” are important in order to address seasonal variability of vulnerability of roosting and feeding sites. It is also important to map migratory behaviour (seasonal and daily occurrence, flight altitudes) of land- and seabirds along major flyways. Strategic analyses and standardization of assessment techniques could conveniently be carried out at an international level. Moreover, one should develop a standard program including standardized methodologies for writing EIAs for proposed wind farm sites.

In Germany, detailed methodological recommendations for impact assessment of wind facilities upon the marine environment during construction and maintenance have been prepared (Projektgruppe OffshoreWEA 2001). This region-wide research concept might be appropriate to provide a basis for a general assessment of proposed wind farm sites. However, only studies on pilot facilities can provide data on actual risks and, thus, enable a proper assessment of the potential impact. In Germany, governmental licensing authorities are supposed to identify potential sites for offshore wind farms after consulting research findings (see BFN 2001a, b, BMU 2002). These findings may be based on pre-construction surveys which include analyses of existing databases (e.g., European Seabirds at Sea [ESAS] Database) as well as field studies carried out by independent institutes and/or experts (Kahlert *et al*. 2000, Noer *et al*. 2000, Clausager 2001, Christensen *et al*. 2002).

It will be useful in future EISs for proposed wind farms to compare data collected from the immediate vicinity of the turbines to nearby reference areas. It can happen however that parallel investigations in reference areas alone will not provide enough data on possible construction-induced alterations, and hence additional experiments will be required after installation of the wind farm (e.g., Green 1979, Hulbert 1984, Stewart-Oaten *et al*. 1992, Guillemette *et al*. 1998, SDN 1998). Since bird abundance at sea is highly variable through time, impact and reference areas should normally cover at least 200 km^2 each. In addition, the proposed construction sites should be overlapped by a minimum of 25% from all sides (for proposed sites ≤ 50 km^2: 200 km^2 for construction could include the reference area).

6.5.2 Methods

To be able to assess risks, environmental impact assessments and monitoring activities will have four objectives (see Projektgruppe OffshoreWEA 2001):

1) Transect studies to study the distribution of seabirds at sea;
2) Radar investigations to study the flight paths of all migrating birds;
3) Visual observations / Flight call recordings to study the number and species of all migrating birds
4) Quantification of rates of collisions by birds

Transect studies: Application of the transect method allows one to determine the large-scale distribution and densities of seabirds in the study area (impact and reference areas). Bird counts can be carried out from ships as well as from aircraft. Ship-based censuses shall be performed according to the ESAS standardized technique for Northwest European water bodies (e.g., Tasker *et al*. 1984, Webb and Durinck 1992, Garthe and Hüppop 1996, 2000). From the top deck or the bridge-wing of a seagoing ship, all birds should be counted that appear within a 300-m wide transect to one side of the keel line. Species particularly sensitive to disturbance, such as divers, grebes, and sea ducks that may take off at long range away from the ship (> 1 km), should be spotted by one additional observer with binoculars looking out forward (Webb and Durinck 1992). The resultant transect should cover at least 10% of the study area. The ship-based counts have the advantage that baseline data are available from nearly all areas (ESAS Database), which facilitates analysis, and that samples of explanatory variables like hydrographic data can be made, thereby reducing the residual variation apparent in most models of seabird variability. Moreover, ship-based counts enable one to identify to species level all birds, including such difficult species pairs as black-throated/red-throated diver, common/Arctic tern, common guillemot/razorbill as well as different species of gulls (e.g., Pihl and Frikke 1992, Webb and Durinck 1992). Aerial counts have the advantage that large areas can be covered within a relatively short time. On the other hand, they cannot be as easily paired with hydrographic data as can shipboard counts.

Radar investigations: Movements of migratory birds, as well as commuting flights between feeding and roosting areas can be recorded radar. One should use a marine surveillance radar to detect flight directions and intensity, as well as an 'up-looking' radar to analyse flight altitudes (e.g., a vertically directed antenna, see Harmata *et al*. 1999). Besides detecting bird movements, radar can provide quantitative data on possible manoeuvres in the vicinity of wind farms (e.g., Tulp *et al*. 1999, van der Winden *et al*. 1999). Currently, the use of small, boat-mounted radars seems to be possible only at moderate wind speeds (< 4–5 Bft depending on vessel type), so measurements should be preferably taken from stationary sites. Islands and sometimes lighthouses are available for this purpose in the nearest offshore zone, observation platforms should be used farther from the coast.

Visual observations / Flight call recordings:

Visual observations of birds flying near turbines should be carried out during the day, and flight call recordings made at night, in order to determine the species composition and the total number of birds passing through the study area.

Rates of collisions:

At present, there is no satisfactory technological solution to provide counts of numbers of birds colliding with turbines. It will be essential to develop such technologies and methods very quickly, given the massive rate at which numbers of turbines at sea will increase over the next few years. An infrared video system such as that being developed by Desholm (2001) appears to be a likely solution, but will require development and testing over the next few years. This is particularly important for sites, such as the development at Rødsand, where some of the largest internationally important concentrations of seabirds occur. In parallel with the development of quantification of rates of bird kills, there is an equal need to develop a framework for deciding on what are acceptable levels of bird kill. A preliminary attempt has been made to do this in the context of Danish wind farms (Anon 2000), but given the international nature of seabird populations and their movements across national boundaries (which may expose the same populations to mortality risk in wind farms in several different countries), there is a need for an international approach to such assessments of 'acceptable impacts' and mitigation responses.

6.5.3 Quality Control

Several studies of bird abundance and behaviour at wind farms have lacked standardized techniques (e.g., several reports in BUND 1999, BFN 2000, Handke 2000). Unified census techniques and minimal standards ought to be promptly approved by governmental licensing authorities. In Germany, recommendations were prepared early in the summer 2001 (Projektgruppe OffshoreWEA 2001). Similar recommendations have not yet been made in other countries.

6.6 Conclusions

Few marine farms have yet been built and few data on their impact upon bird populations are therefore available. We can draw, however, upon the few studies that have been carried out and also draw inferences from the larger quantity of data that have been collected at land-based wind farms. The major risk at the moment seems to be that of collisions of birds with the turbines themselves, as substantial numbers of collisions have occurred in North America. Mitigation of the risk of collision seems to be possible through careful positioning of the turbines, i.e., away from areas of heavy use by birds. Other potential impacts include loss of foraging habitat and alteration of migration of commuting routes.

What seems most sensible now is to collect as much behavioural data on birds in the vicinity of wind turbines as possible. Since collisions are most apt to occur episodically, and at night or during bad weather, some method of continuous monitoring, such as infrared video imaging (Desholm 2001), should be employed. Use should be made of available databases such as oceanographic atlases and atlases of seabird distribution in order to help determine potentially risky sites for wind farms. There is a need not only to develop technological solutions to quantifying the numbers of birds killed by collisions with blades and other structures, but also to transfer technologies and best practice between countries and companies involved in this rapidly expanding industry. It is far too early to estimate how many seabirds will be killed by impacts with turbines at sea. However, if there will soon be over 2000 turbines at sea in European waters, an estimate of the numbers and ages of seabirds killed becomes important given that the natural mortality rates of adult seabirds are low.

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Table 6.1 Marine wind farm developments. Adapted from data presented at www.offshorewindfarms.co.uk/else.html and www.crownestates.co.uk/estates/marine/windfarms/wfmap.html
http://www.bmu.de/download/dateien/windenergie_strategie_br_020100.pdf
http://www1.bsh.de/Meeresumweltschutz/Rechtsangelegenheiten/CONTIS/CONTIS_2001.htm

Location	Country	Online	Megawatts	Number of Turbines	Rating
Existing sites:					
Vindeby	Denmark	1991	4.95	11	Bonus 450 kw
Lely (Ijssekmeer)	Holland	1994	2.0	4	Nedwind 500 kw
Tuno Knob	Denmark	1995	5.0	10	Vestas 500 kw
Dronten (Ijsselmeer)	Holland	1996	11.4	19	Nordtank 600 kw
Gotland (Bockstigen)	Sweden	1997	2.75	5	Wind World 550 kw
Blyth Offshore	UK	2000	3.8	2	Vestas 2 mw
Middelgrunden, Copenhagen	Denmark	2001	40	20	Bonus 2 mw
Uttgrunden, Kalmar Sound	Sweden	2001	10.5	7	Enron 1.5 mw
Yttre Stewngrund	Sweden	2001	10	5	NEG Micon NM72
Totals to 2001			90.4	83	
Sites due in next few years:					
Horns Rev	Denmark	2002	160	80	Vestas V80 2 mw
Rodsand	Denmark	2003	158.4	72	2.2 mw
German coasts	Germany	2003+	Perhaps 2000	Perhaps 1000	
UK coasts	UK	2003+	Perhaps 1000–1500	Perhaps 600	
Scheldt Mouth	Netherlands	2003+	100		
Ijmuiden	Netherlands	2003+	100		
Lillgrund Bank	Sweden	2003+	48		
Barsebank	Sweden	2003+	750		
Kish Bank	Ireland	2003+	250		
Arklow	Ireland	2003+	200		
Likely totals 2002 to 2020			4750	2400	

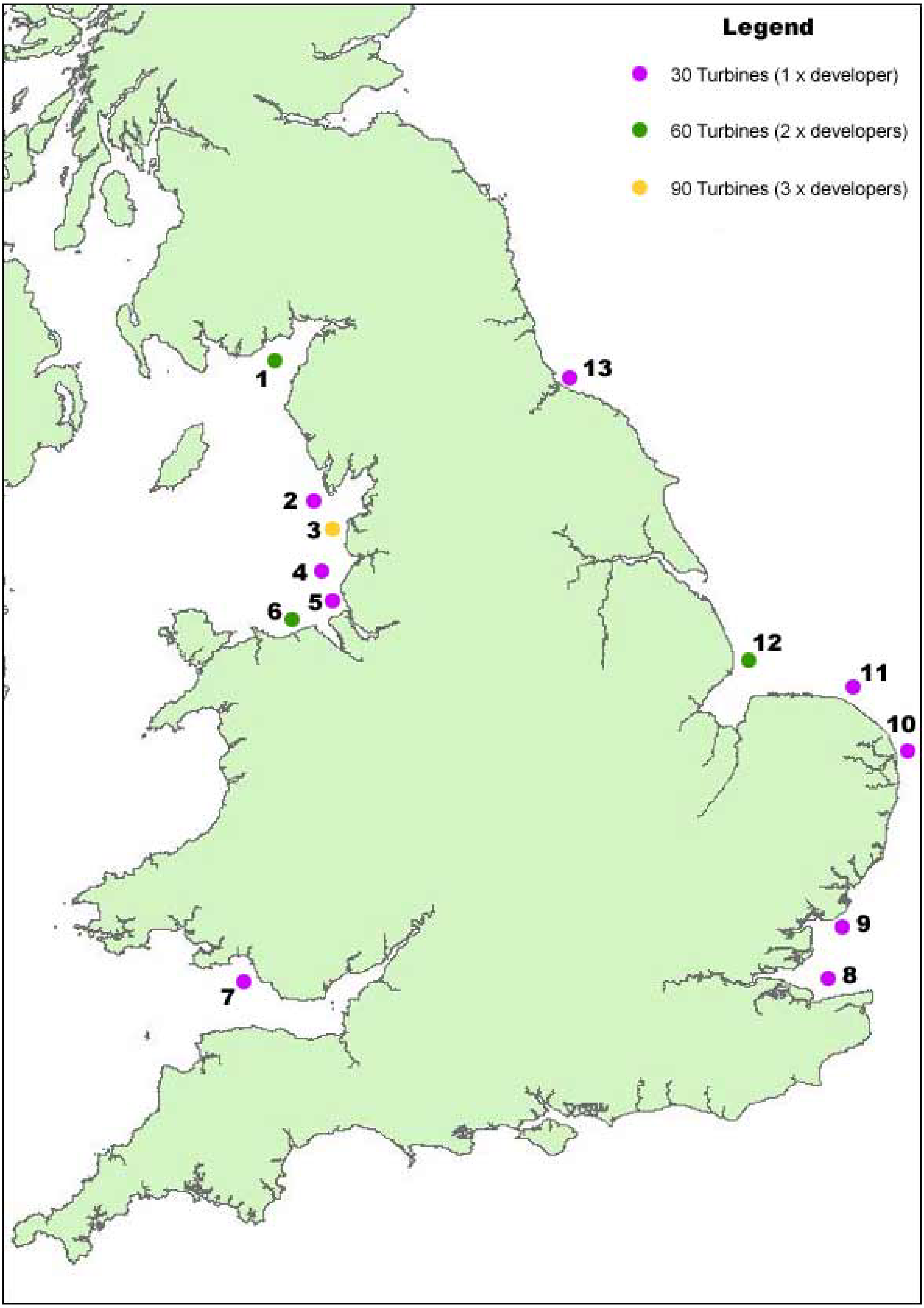

Figure 6.1. Locations of planned wind farms in U.K. waters:
(http://www.crownestate.co.uk/estates/marine/windfarms/wfmap.shtml)

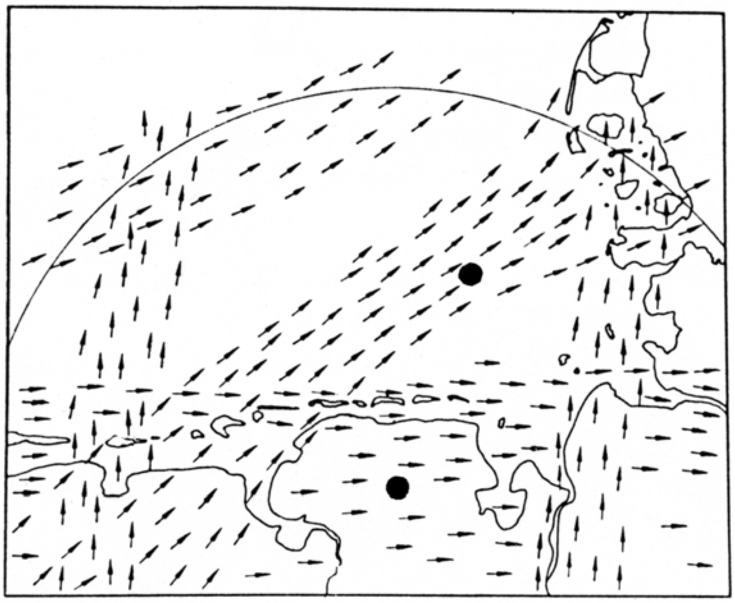

Figure 6.2. Major migration routes in the German Bight according to radar observations in spring 1971 (02 April 1971 – 16 May 1971). Filled dots mark approximate locations of Wittmund (East Friesland) and Helgoland radar stations; the semi-circle circumscribes the radar view (80 km) (from Jellmann and Vauk 1978).

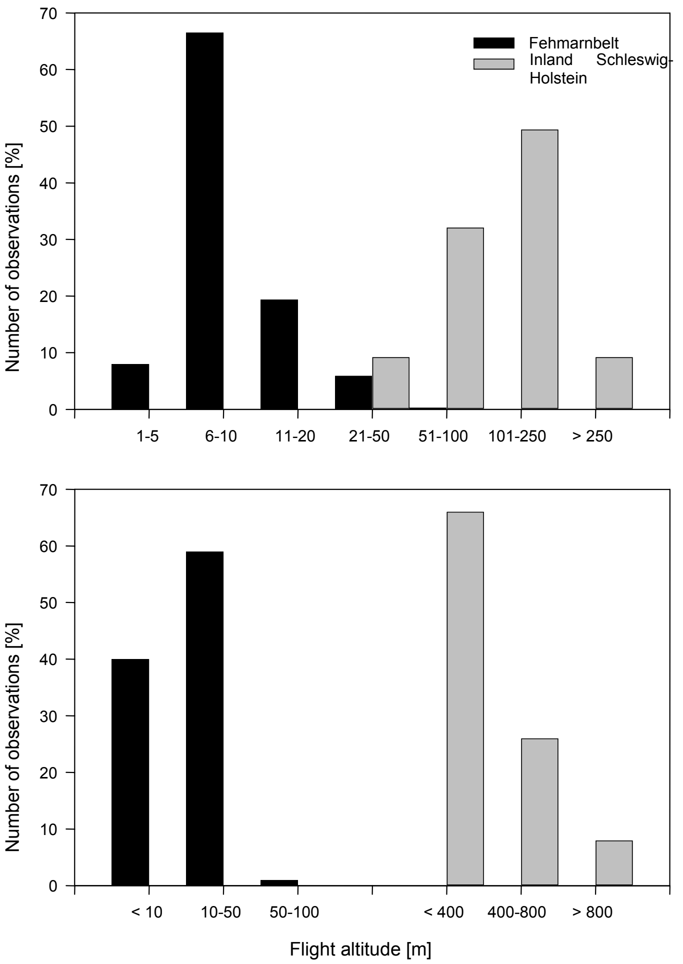

Figure 6.3. Flight altitudes of common eiders (above) and black scoters (below) in Fehmarnbelt compared to those in inland Schleswig-Holstein (from Berndt and Busche 1993).

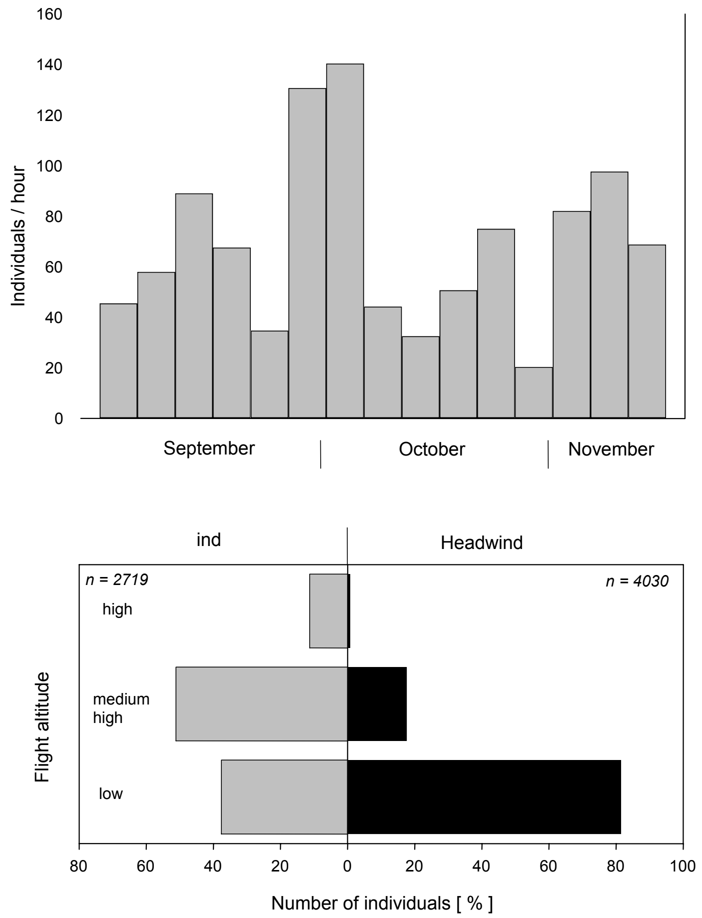

Figure 6.4. Seasonal occurrence (above; mean numbers per hour and five-day periods, n=19,233) and flight altitudes (below) of black scoters seawards off Wangerooge Island during autumn migration 1998–1999 (from Krüger and Garthe 2001 and pers. comm.). Low: < 1.5 m, medium high: 1.5 – 11 m, high > 11 (– 25 m).

7 WORK WITH THE ICES SECRETARIAT TO PROVIDE SUMMARIES OF SEABIRD INFORMATION VIA THE ICES WEBSITE

WGSE held a brief discussion with Neil Fletcher, ICES Secretariat, about the suitability of information on seabirds for uploading onto the ICES web site. Useful types of information include scientific products, such as Seabird Ecology Working Group Reports, which already now go onto the web site. The recent Cooperative Research Report produced by the Working Group (No. 232 on "Diets of Seabirds and Consequences of Changes in Food Supply") is also available for viewing on the website at http://www.ices.dk/pubs/crr/crr.htm. These are of interest to ICES scientists and to the broader scientific community outside ICES, but there is also a need for information of more interest to the general public who may visit the ICES web pages. This latter category of information might include details of seabird numbers, biomass, species composition, food consumption, and population trends in different ICES areas. This could be placed on the 'Status' web pages of ICES. It would also be worthwhile to place information on research findings from current studies, such as satellite tracking of seabird movements, and data from data loggers fitted to diving seabirds showing dive depths and water temperature profiles recorded during dives. It was agreed that we would continue discussions on this by e-mail.

8 MARINE BIO-ECOLOGICAL VARIABLES AND INDICATORS SUITABLE FOR OPERATIONAL USE – A SEABIRD PERSPECTIVE

8.1 Bio-ecological observations in operational oceanography from a general ornithological perspective

The aim of the third workshop related to the Euro-GOOS Plan was to broaden the focus to include biological oceanographic components and advance an ecosystem approach for ocean monitoring and forecasting. However, the results of the workshop as published in the Euro-GOOS Publication No. 15 show that the scientific basis for including higher levels of the food web still needs further work. From a seabird perspective, there is an increasing scope for developing efficient, integrated top predator and marine biological feedback monitoring systems. Essentially, most of the ecological variables and models that are indirectly or directly important in relation to fish distribution are also conceived as being important to pelagic seabirds. In many cases, the knowledge of the association between seabirds at sea distribution and oceanographic structures is at least as good as the knowledge for other marine top predators. In relation to operational forecasting and monitoring, data on seabird breeding numbers and densities at sea can offer data sampled with narrow confidence intervals at unique spatial and temporal scales. In addition to the fact that there is a detailed knowledge of general aspects of seabird biology, a particular advantage of seabirds is the existence of long-term databases on breeding seabird colonies and seabird densities at sea within the ICES area (European Seabirds at Sea database, PIROP).

Generally, offshore monitoring of seabird's use of marine habitats is inexpensive, as it can be conveniently carried out either as part of ongoing ship-based biological monitoring programmes or by means of coupled colony-based data and data collected by external data- loggers. Below, an example of the potential applications of seabird data-loggers within a oceanographic context is given. As an example of a useful platform, ICES International Bottom Trawl Survey can provide sufficient geographical coverage to produce seasonal models of seabird distribution throughout the North Sea (Camphuysen *et al*. 1995).

With zooplankton and fish data, quantitative information on seabirds (breeding numbers/distribution) can help in evaluation of the biological effects of climatic oscillations and changes in the boundaries of water masses and currents. At a finer scale, due to the high spatial resolution, seabird density data may be used to assess changes in specific high-diverse/productive ecosystems with which seabirds are particularly associated such as hydrographic fronts and eddies, offshore banks and shelf breaks regions. Similarly, seabird density data may provide supplementary information on the development of coastal environments attributable to alterations of spawning areas, eutrophication levels etc. With respect to modelling efforts within EuroGOOS, seabird data can be especially useful in the development of new ecosystem models (and nested models) at finer spatial scale.

In order to explore the potential for integrating seabirds into the EuroGOOS scheme, it is recommended to identify key oceanographic variables and models in relation to seabird distribution and abundance. These variables should include sub-surface hydrographic structures and topographic variables.

8.2 Data loggers and telemetry systems

Recent advances in microelectronic technology have made it possible to equip many seabird species as well as marine mammals with devices during their forays at sea so as to determine animal movements and habits (e.g., Bost *et al*. 1997, McCafferty *et al*. 1999, Wilson *et al*. 2002). In further developments of the technology, it is now also possible to measure marine environmental variables with these devices (e.g., Weimerskirch *et al*. 1995). As a result of this, it has been suggested that seabirds, appropriately equipped, could be used to measure and monitor the physical parameters of the oceans in which they forage, with specific localities being ascribed specific measurements (e.g., Wilson, 1992, Wilson *et al*. 1993, Weimerskirch *et al*. 1995, Koudil *et al*. 2000). In contrast to telemetry systems which transfer information constantly or in given intervals after the birds have been equipped, data loggers need to be retrieved and data to be downloaded into a computer. Usually, birds are captured and recaptured in breeding colonies with most equipments taking place just for a few days. However, birds have successfully been equipped for over-winter periods (e.g., Grémillet *et al*. 2000, Weimerskirch and Wilson 2001).

There are two different components that need to be considered. First, there needs to be a more or less accurate determination of the position of the bird at sea. Currently, five systems can potentially be used to determine position; VHF telemetry, PTT telemetry, GLS/geolocation methods, dead reckoning, and GPS, each of which has its own advantages with respect to accuracy, potential number of fixes and size of system (see Wilson *et al*. 2002 for a review). The greatest potential in terms of accuracy is to be expected from GPS loggers (e.g., Weimerskirch *et al*. 2002). Second, the marine environmental variable to be measured has to be selected and appropriate sensors used. Many sensors, even most standard temperature sensors, respond slowly to changes in water temperature so that only measurements of birds staying in a particular area for some time can be used (see Wilson *et al*. 2002 for a review). However, further development of technology enables us now to precisely measure several environmental variables and the technical development as well as the number of applications will no doubt increase. Using loggers on common guillemots it was possible to measure temperature profiles down to nearly 100 m along the Scottish east coast in summer 2001 (S. Wanless *et al*. pers. comm.). Forthcoming sensors which are expected to be available for use on seabirds in just a very few years are salinity and chlorophyll sensors.

An apparent disadvantage of seabirds for monitoring the marine environment is often seen in the fact that they usually select certain ocean areas and avoid others so that the sampling regime might be spatially and temporally biased. However, when commuting between breeding and feeding grounds, areas of less interest for the birds are frequently visited, e.g., for resting and/or searching for food patches. Furthermore, a bias towards certain areas can ideally be interpreted as an indication of hot spots of marine productivity. Even bird-derived figures such as catch per unit effort are possible to achieve now (e.g., Grémillet 1997, Garthe *et al*. 1999) so that food availability assessment might be obtained on a variety of scales and regions in the future.

8.3 References

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Weimerskirch, H., Wilson, R. P., and Koudil, M. 1995. The use of seabirds to monitor sea surface and validate satellite remote-sensing measures in the southern ocean. Marine Ecology Progress Series 126: 299–303.

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9 MARINE LITTER MONITORING USING NORTHERN FULMARS

Last year, WGSE proposed an EcoQO ‘An index of plastic particle pollution of the North Sea’ (see ICES 2001 ‘Report of the Working Group on Seabird Ecology 16–19 March 2001’ Section 3.2.5). We understand that ICES Advisory Committee on Ecosystems intends to revisit this issue under its agenda item ‘Scientific components needed for provision of scientific advice required by an EcoQO framework’. Therefore we felt it would be useful to revisit this proposed EcoQO since a report by J.A. van Franeker and A. Meijboom on ‘‘Marine litter monitoring by northern fulmars – a pilot study’ has become available. It contains much work relevant to the EcoQO proposed by WGSE last year and so seemed to be highly appropriate for discussion as contributing to the scientific assessment of that EcoQO.

In the proposal for an EcoQO, we suggested that current levels of plastic in fulmars should be established as a matter of high priority. The report by van Franeker and Meijboom has done that for the Netherlands coast. The report presents data on stomach contents of 329 fulmars beachwashed in the Netherlands between 1982 and 2000. Potential biases to estimated plastic contamination due to sex, age, origin, condition, cause of death, season of death were found to be unimportant, except in the case of age. Juveniles accumulated more plastic than found in adults. Given that plastic fragments may remain in the stomach of petrels for many weeks or months, this strongly suggests less discriminatory feeding by juveniles, resulting in higher equilibrium numbers of plastic items retained in their gizzards. Significant trends from 1982 to 2000 were detected in plastic incidence. Amounts of industrial plastic particles decreased, whereas numbers of fragments of used plastic and insoluble chemical substances increased. Industrial plastic particles are the raw material produced by the plastic manufacturing industry and can be lost as a result of blocked filters during manufacture or through losses in transit before being used in manufacture of plastic objects. ‘Used-plastic’ in fulmar stomachs is small fragments from larger plastic items being broken down in the environment. The authors report current levels of used-plastic incidence of 97% with mean of 28 items (0.52g) per bird, while industrial plastic pellets were present in 64% with mean of 3.6 granules (0.08g) per bird. Insoluble chemical substances were reported in 28% of birds, with mean of 2.1 items per bird (0.53g).

The authors conclude that stomach contents analysis of beachwashed fulmars offers a reliable monitoring tool for changes in the abundance of plastic litter at sea. Such monitoring would increase public awareness of the fact that environmental problems from marine litter persist even when larger plastic items are broken down to sizes below the range of normal human perception. As a result of power analysis they recommend that annual monitoring of 40+ fulmars from beaches of the Netherlands should be carried out, and that a synoptic study of fulmar stomach contents should be made in countries around the North Sea in order to establish patterns of geographical variation. They also recommend that funds should be made available for analysis of the chemical composition of the inert ‘chemical’ substances found in a proportion of the fulmars.

WGSE supports these recommendations. We agree with van Franeker and Meijboom (2002) that the ‘chemical material’ found in many fulmar stomachs should receive further analysis to determine its nature, likely origins and toxic hazard. We note that the skewed nature of numbers of plastic items per stomach makes the use of geometric means rather than arithmetic means more appropriate for statistical analyses. Since it is unclear whether incidence (frequency of presence), mean number of items, or the total biomass of plastic, provides the most appropriate measure it seems sensible, as in the van Franeker and Meijboom (2002) report to record each of these statistics. We note that residence times of plastic in fulmar stomachs are not known, though likely to be in the order of many weeks or months. These long periods achieve an integration of plastic contamination over extended periods prior to the death of the birds collected on beached bird surveys. This long sampling period is a positive attribute in terms of generating representative samples of plastic pollution over what may be highly patchy spatial and temporal distributions of plastic at sea. However, we note that some aspects of fulmar behaviour that might affect the suitability of these birds as biomonitors of plastic pollution require further attention. For example, if fulmars move into the North Sea from (probably less contaminated) areas of the Atlantic Ocean, then the numbers of plastic items may be less in those birds than in fulmars that have been resident within the North Sea for a longer period. Similarly, if fulmars tend to remain within one area of the North Sea, they may have levels of plastic contamination representative of local pollution. Hence a study of geographical variation in fulmar contamination around the North Sea would be helpful in quantifying spatial pattern. If fulmars show varying amounts of plastic according to their local origin, then the contamination level measured from beachcast birds on the Netherlands coast might be susceptible to variation related to weather (since weather may influence regional movements of fulmars). However, the data presented by van Franeker and Meijboom (2002) show no strong evidence for year-to-year fluctuations in fulmar contamination, so this effect may be negligible in practice.

Although our initial EcoQO did not discriminate between 'industrial plastic pellets' and 'used plastic fragments' van Franeker and Meijboom (2002) clearly show trends in opposite directions for these two types of plastic. Any EcoQO for plastic at sea should take note of the differences between these two categories as done by van Franeker and Meijboom (2002). The data presented in that report show significant trends in plastic contamination of fulmar stomachs over the study period (1982–2000). This demonstrates that sampling fulmar stomachs can provide data on plastic pollution not available from any other current research programme, at least to monitor temporal trends, although not necessarily informing about spatial patterns.

Reference

Van Franeker, J.A., and Meijboom, A. 2002. Marine litter monitoring by northern fulmars – a pilot study. ALTERRA Report No 401. Alterra Green World Research, Wageningen.

10 OSPAR SELECTION OF LIST OF DECLINING AND THREATENED SEABIRDS

10.1 Background

OSPAR has requested ICES to assess the data upon which an initial list of species and habitats in need of protection measures have been based. The purpose of this assessment is 'to ensure that the data used is sufficiently reliable and adequate to serve as a basis for conclusions that the species and habitats can be identified as requiring action in accordance with the OSPAR strategy on the Protection and Conservation of the Ecosystems and Biological Diversity of the Maritime Area'.

MCAP asked the Chair of ACE to contact relevant Working Groups. The Working Group on Seabird Ecology (WGSE) agreed to provide an assessment of the data used to select seabird species for the OSPAR 'Priority list of threatened and endangered species and habitats'.

The species of seabirds in this list are:

Whole OSPAR area:
Steller's eider *Polystica stelleri*
Little shearwater *Puffinus assimilis baroli*
Roseate tern *Sterna dougallii*
Guillemot, *Uria aalge ibericus* Iberian subspecies – exact name to be checked

Certain OSPAR regions:
Lesser black-backed gull *Larus fuscus fuscus* subspecies – Arctic

In addition to the list of bird species/subspecies selected, we were provided with a list of references to literature on each of the selected taxa, and copies of background papers on the OSPAR meetings and reviews that led up to the selection of taxa. These include details of the development of the 'Texel/Faial criteria' used to make the species selections.

WGSE had less time than it would have liked to review these extensive papers. However, the membership of WGSE at this meeting included experts with considerable experience of each of the selected birds on the OSPAR list so we feel that we have been able to provide accurate assessments of the data as requested by OSPAR.

10.2 Comments on the selected seabird taxa

10.2.1 Steller's eider

10.2.1.1 Key references, if any, missing from OSPAR review

Anker-Nilssen, T., Bakken, V., Strøm, H., Golovkin, A.N., Bianki, V.V., and Tatarinkova, I.P. (Eds). 2000. The status of marine birds breeding in the Barents Sea region. Report No. 113. Norsk Polarinstitutt, Tromsø. 213pp.

Nygard, T., Frantzen, B., and Svazas, S. 1995. Steller's eider *Polysticta stelleri* wintering in Europe: number, distribution and origin. Wildfowl 46: 140–155.

10.2.1.2 Status, including concentration within OSPAR area

Nygard *et al*. (1995) estimate the population of Stellers eiders in the Barents Sea to be between 25,000 and 40,000 wintering birds. This represents 15–20% of the world population of this species. The wintering population is predominantly found within the Varanger Fjord, north Norway, and along the Murman coast, so is fairly concentrated.

10.2.1.3 Decline in population

Bustnes, Bianki and Koryakin, in Anker-Nilssen *et al*. (2000) summarise the population trend as 'reasonably stable'. They report that there are some indications of an increase in wintering population off the eastern Murman coast.

10.2.1.4 Threats

Steller's eiders are vulnerable to drowning in fishing gear, especially nets set for lumpsuckers in spring (Frantzen and Henriksen 1992). They are also vulnerable to oil pollution. Increased tanker traffic offshore from the Murman coast represents a hazard to this highly concentrated population.

10.2.1.5 Comments on the OSPAR review text

It is not explicit from the text why this species has been selected for priority list inclusion given that it appears to have a stable, or possibly increasing, population within the OSPAR region. We are unable to comment on the listed reference Nygard *et al*. (in prep) as this manuscript is not available in the public domain, and we have no knowledge of the content. The status of this species elsewhere in the world may be relevant (we could not decide from the rather unclearly expressed criteria for selection how much OSPAR wishes to take that factor into account). The Steller's eider is a red-listed species for the Bering Sea (references to this are not included in the OSPAR reference list for the species). It is not clear to us whether OSPAR wishes to list this species because it has a severely threatened status elsewhere in the world, despite its apparently healthy population status within the OSPAR area.

10.2.2 Little shearwater *Puffinus assimilis baroli* subspecies

10.2.2.1 Key references, if any, missing from OSPAR review

Monteiro, L.R., Ramos, J.A., Pereira, J.R.C., Monteiro, P.R., Feio, R.S., Thompson, D.R., Bearhop, S., Furness, R.W., Laranjo, M., Hilton, G., Neves, V.C., Groz, M.P., and Thompson, K.R. 1999. Status and distribution of Fea's petrel, Bulwer's petrel, Manx shearwater, little shearwater and band-rumped storm-petrel in the Azores archipelago. Waterbirds, 22, 358–366.

Monteiro, L.R., Ramos, J.A., and Furness, R.W. 1996a Past and present status and conservation of the seabirds breeding in the Azores archipelago. Biological Conservation. 78, 319–328.

Monteiro, L.R., Ramos, J.A., Furness, R.W., and del Nevo, A.J. 1996b Movements, morphology, breeding, molt, diet and feeding of seabirds in the Azores. Colonial Waterbirds 19, 82–97.

10.2.2.2 Status, including concentration within OSPAR area

Monteiro *et al*. (1999) located several previously unknown colonies of little shearwater in the Azores during seabird surveys in the late 1990s. They estimated that there were 840–1530 pairs of little shearwaters in Azores. This represents the entire known breeding population within the OSPAR region.

10.2.2.3 Decline in population

Evidence for decline in breeding numbers within the OSPAR region is based on relatively poorly documented population trends in Azores (Monteiro *et al*. 1996a). However, there is very strong circumstantial evidence indicating that most areas of Azores have become unsuitable as breeding habitat due to rats and cats introduced by human colonisation and established settlement on the main islands. Almost all remaining colonies of little shearwaters are on rat and cat-free islets or on relatively inaccessible cliffs.

10.2.2.4 Threats

Little shearwaters are clearly threatened by mammal predators, such as rats and cats. Yellow-legged gulls may also kill some birds, and yellow-legged gull numbers appear to be increasing in Azores.

10.2.2.5 Comments on the OSPAR review text

The Monteiro *et al*. (1999) paper is missing from the OSPAR references listed for this species but provides the most up to date assessment of the population within the OSPAR region. The listed reference Harrison (1983) seems not to be relevant. The little shearwater as a species is widely distributed and not considered to be endangered or threatened. Thus we assume that OSPAR is considering only the subspecies baroli as a taxon for priority listing. Numbers of this subspecies outside the OSPAR area are rather larger than numbers within OSPAR area, but the population in Cape Verde appears to be declining and threatened, while that in Madeira is currently stable but has probably declined in the past. It is not clear how much the status and trends outside the OSPAR area should affect decision to list this subspecies within OSPAR.

10.2.3 Roseate tern (nominate subspecies)

10.2.3.1 Key references, if any, missing from OSPAR review

Lloyd, C., Tasker, M.L., and Partridge, K. 1991. The status of seabirds in Britain and Ireland. T and AD Poyser, London.

Monteiro, L.R., Ramos, J.A., and Furness, R.W. 1996. Past and present status and conservation of the seabirds breeding in the Azores archipelago. Biological Conservation 78, 319–328.

Monteiro, L.R., Ramos, J.A., Sola, E., Furness, R.W., Feio, R., Monteiro, P., Ratcliffe, N.R., Thompson, D.R., Bearhop, S., Pereira, J., Wilson, L., Hewitson, L., Tavares, A., and Laranjo, M. 1997. Exploracao e censos de aves marinhas no arquipelago dos Acores. 1 Congresso da Sociedade Portuguesa para o Estudos das Aves, Vila Nova de Cerveira, 1–3/11/96.

Annual reports on the numbers and breeding success of Roseate terns in Britain and Ireland have been published by the Joint Nature Conservation Committee (JNCC). These also indicate population trends. The most recent of these annual reports are:

Mavor, R.A., Pickerell, G., Heubeck, M., and Thompson, K.R. 2001. Seabird numbers and breeding success in Britain and Ireland, 2000. Joint Nature Conservation Committee, Peterborough. UK Nature Conservation, No. 25.

Upton, A.J., Pickerell, G., and Heubeck, M. 2000. Seabird numbers and breeding success in Britain and Ireland, 1999. Joint Nature Conservation Committee, Peterborough. UK Nature Conservation, No. 24.

10.2.3.2 Status, including concentration within OSPAR area

The nominate subspecies breeds in Europe, in Azores, France, Ireland and United Kingdom. About 379–1051 pairs of Roseate terns have nested in the Azores between 1985 and 2000, and represent the largest part of the population of this subspecies. There are now about 70 pairs in France, 618 pairs in Ireland and 50 pairs in United Kingdom (data for 2000 or 2001). Counts vary considerably from year to year and it is not clear how much of the variation is due to counting difficulties, and how much to birds choosing not to breed in some years, perhaps in response to changes in food availability. Certainly, distribution of pairs around the Azores can change considerably from year to year, suggesting that birds are responding by moving site according to conditions. This may also be influenced by predation impacts at particular colonies. The Azores population has consistently been by far the largest in the OSPAR region in recent years, but may have been overtaken by the colony at Rockabill, Ireland, in the last two or three years.

10.2.3.3 Decline in population

Counts of breeding pairs of Roseate terns in the Azores in the period 1995–2001 have been only about 50% of those in 1985–95. Long term declines have been well documented in Britain, Ireland and France (Lloyd *et al*. 1991, JNCC reports). The numbers in Britain and Ireland fell by 70–75% between 1969 and 1985, for example, although conservation efforts at Rockabill have led to an important increase in numbers there over the last few years.

10.2.3.4 Threats

Killing of terns in West Africa is a major concern. There is strong evidence to implicate trapping as the primary cause of population decline (Lloyd *et al*. 1991). Other threats include predators at colonies, including foxes, rats, gulls, egg collectors and peregrine falcons in Britain, Ireland and France (Lloyd *et al*. 1991). Birds in Azores are killed at colonies by common buzzards and yellow-legged gulls, and eggs taken by European starlings. Human disturbance can be a problem at colonies, although most sites have legal protection. This is not very effective in Azores where fisherman and tourists may visit nesting islets and cause serious disturbance.

10.2.3.5 Comments on the OSPAR review text

Spelling of author's names is inaccurate in OSPAR reference list. In particular, del Nivo should be del Nevo, Perins should be Perrins. Otherwise, the text appears to be accurate and reasonably complete. The recent annual counts of Roseate terns in Azores suggest that numbers have decreased by about 50% over the last 15 years. There is evidence of predation on eggs and chicks by European starlings and common buzzards at some Azores colonies (to add to the list of threats in the OSPAR text), but breeding productivity has not been quantified accurately. Although OSPAR lists cats, dogs, rats, mustelids as threats to colonies, most Roseate tern colonies are located on predator-free islets.

The Roseate tern is a very clear case for listing as a priority species due to well documented and severe population decline within the OSPAR marine area. It has also declined seriously in numbers in several other parts of the world. There is some evidence that birds can move between the OSPAR region and North American colonies, but since both have adverse conservation status, such movements will do little to mitigate population declines.

The listed reference Avery *et al*. (in prep) is unavailable so we cannot comment on content. Del Nevo (1990) reference to a report not generally available appears to be the same work as del Nevo *et al*. (1993) in a journal; if so, only the latter should be listed.

10.2.4 Guillemot, Iberian 'subspecies'

10.2.4.1 Key references, if any, missing from OSPAR review

Barcena, F., Teixeira, A.M., and Bermejo, A. 1984. Breeding populations of seabirds in the Atlantic sector of the Iberian peninsula. In Status and Conservation of the world's seabirds. Croxall, J.P., Evans, P.G.H., and Schreiber, R.W. (Eds.) pp. 335–345. ICBP Technical Publication No. 2. Cambridge.

Gaston, A.J., and Jones, I.J. 1998. The Auks. Oxford University Press, Oxford.

Mourino, J. 1999. Consideraciones taxonomicas acerca de la poblacion iberica de Arao comun (*Uria aalge*). Chioglossa 1: 165–166.

Paterson, A.M. 1997. Las aves marinas de Espana y Portugal. Lynx Edicions, Barcelona.

The OSPAR review provides no evidence that the common guillemot in Iberia can be defined as a distinct subspecies. This taxonomic approach is contrary to the treatment in recent definitive texts on ornithology such as Hoyo *et al*. Birds of the World, or Cramp *et al*. Birds of the western Palearctic, or in a recent major monograph on 'The Auks' (Gaston and Jones 1998), which recognises only three subspecies of the common guillemot, *aalge, albionis* and *hyperborea*. The subspecies 'ibericus' was first proposed by Salomonsen in the 1930s but was retracted by Salomonsen in his later works as not being a sufficiently distinct form to merit subspecific recognition. The subspecies 'ibericus' was supported by Bernis (1949) and by Tuck (1960). However, it has been rejected by more recent experts in guillemot biology and taxonomy (see Gaston and Jones 1998, Mourino 1999).

There is thus a difficulty: the form of the guillemot in Iberia may or may not be taxonomically separable from other forms, and most experts consider that it is not. It nevertheless is an outlier population (the nearest breeding group is 500 km to the north).

The only reference cited by OSPAR for the guillemot (Rufino *et al*. 1989) is a Portuguese bird atlas with which none of the WGSE members are familiar. We note that the list 'Europe's most threatened birds' on the European Commission's web page at http://europa.eu.int/comm/environment/nature/directive/index_en.htm lists (among about 180 bird taxa) *Uria aalge ibericus*, and that this form is listed in the 1979 Annex I of the Council Directive 79/409/EEC of 2 April 1979 on the conservation of wild birds.

Further references to this Iberian population include:

Alcalde, A. 1997. Situación del arao común (*Uria aalge*) en Galicia. Proceedings of I Jornadas Ornitológicas Cantábricas. Aviles, Asturies.

ARCEA. 1994. *Censo de arao común e outras aves mariñas e rupícolas de interese*. Unpublished Report. Dirección Xeral de Montes e M.A.N. Xunta de Galicia.

Bermejo, A., and Rodríguez, J. 1983. Situación actual del Arao Común (*Uria aalge ibericus*) como especie nidificante en Galicia. Alytes 1: 341–346.

Bernis, F. 1949. Las aves de las Islas Sisargas en junio. Bol. Soc. Hist. Nat. 46: 647–648.

Cramp, S. 1985. The birds of the western Palearctic. Vol. IV. Oxford University Press, Oxford.

Sandoval, A.; Torres, A.; Martínez-Lago, M., and Martínez-Lago S. (in press). *Rissa tridactyla* and *Uria aalge*. In R. Salvadores and C. Vidal (coords.): VII Anuario das Aves de Galicia 1999. Sociedade Galega de Ornitoloxía. Santiago de Compostela.

Tuck, L.M. 1960. The murres: their distribution, populations and biology. Canadian Wildlife Service Monograph No. 1. Ottawa.

References to decline in OSPAR region I:

Lorentsen, S.-H. 2001. The national monitoring programme for seabirds. Results including the breeding season 2001. NINA Oppdragsmelding 726: 1–36. Norwegian Institute for Nature Research, Trondheim.

Vader, W., Barrett, R.T., Erikstad, K.E., and Strann, K.B. 1990. Differential responses of common and thick-billed murres to a crash in the capelin stock in the southern Barents Sea. Studies in Avian Biology 14: 175–180.

10.2.4.2 Status, including concentration within OSPAR area

The Common guillemot is an abundant and widespread breeding seabird throughout much of the OSPAR area. The current breeding population is around 3.5 million pairs, with about half of these in OSPAR I, and most of the rest in OSPAR II and III. Numbers breeding in OSPAR IV are extremely small, and none breed in OSPAR V.

10.2.4.3 Decline in population

Common guillemot numbers have declined drastically in parts of OSPAR IV (and may indeed now be extinct in Iberia) and in one part of OSPAR I (Barents Sea and Norwegian Sea). In the remaining OSPAR areas numbers have increased over the past 30 years.

10.2.4.4 Threats

Common guillemots are very sensitive to oil pollution. There have been major problems with drowning in set nets, particularly salmon nets and gillnets for cod. As a specialist piscivore feeding on small shoaling lipid-rich fish in winter as well as in summer, common guillemots can show mass mortality of fully-grown birds, especially during winter, if stocks of these food fish are low. For example, well over half of the common guillemots in the Barents Sea died in winter 1986–87 when the capelin stock collapsed (Vader *et al*. 1990; Lorentsen 2001). Colonies in the extreme south of the species' breeding range (France-Iberia) have declined and may now be extinct, apparently as a result of combined impacts of egg collecting (in the past), capture of unfledged young to keep as pets (Berlengas), taking of adult birds for food, shooting (off the north coast of Spain), by-catch in fishing nets, oil spills and predation at colonies by introduced mammals, large gulls and other birds (Barcena *et al*. 1984).

10.2.4.5 Comments on the OSPAR review text

The OSPAR reference list for common guillemot cites only one reference, to an atlas of breeding birds of Portugal. There is, as far as we are aware, no recent scientific justification for separating guillemots from Iberia as a distinct subspecies. The normal current treatment is to group Iberian guillemots with those from France, Ireland, England and southern Scotland as subspecies Uria aalge albionis (Gaston and Jones 1998).

The text in the OSPAR documents describing status of common guillemot fails to deal with the relevant Iberian population as a unit, but describes numbers in the UK and North Sea, details of little relevance to the question of listing Iberian guillemots for special status. The statement 'there is a low breeding success in the Azores and Madeira and as a consequence the population in these areas has declined severely' is misleading. The common guillemot does not breed in the Azores or Madeira. Possibly the text was intended to read 'in Portugal and Spain'?

There clearly is a case for identifying the common guillemot in Iberia as requiring urgent conservation action to halt the rapid decline in numbers.

The division by OSPAR of the OSPAR marine area into 5 regions has created a huge 'Arctic' region I, compared to the much smaller regions II, III and IV. This creates some difficulty when looking at declines that are of conservation concern but are geographically restricted to an area that does not coincide with OSPAR regional boundaries. In the case of the common guillemot, there are highly divergent population trends for common guillemots in different sections of OSPAR Region I. In the eastern sector (Barents Sea and Norwegian Sea) common guillemot numbers have decreased drastically, whereas in the western part of Region I (e.g., Iceland) numbers appear to be fairly stable. A strong case could be made for identifying the common guillemot in the Barents Sea region (including the Norwegian coast south to the Lofoten Islands) as a priority for listing as a seriously declined population.

10.2.5 Lesser black-backed gull subspecies *Larus fuscus fuscus*

10.2.5.1 Key references, if any, missing from OSPAR review

Strann, K.B., and Vader, W. 1992. The nominate lesser black-backed gull *Larus fuscus fuscus*, a gull with a tern-like feeding biology, and its recent decrease in northern Norway. Ardea 80: 133–142.

10.2.5.2 Status, including concentration within OSPAR area

Five subspecies of the Lesser black-backed gull have been described and the classification is widely accepted. Three subspecies, *L. f. fuscus*, *L. f. intermedius* and *L. f graellsii*, breed entirely or partly within the OSPAR area. The subspecies *Larus fuscus fuscus* breeds in Sweden and northern Norway to the western part of the Kola Peninsula and the western White Sea (Strann, Semashko and Cherenkov, in Anker-Nilssen *et al*. 2000). The total population of this subspecies is under 15,000 pairs, of which about 2,500 pairs breed within the Barents Sea on Norwegian and Russian coasts (Anker-Nilssen *et al*. 2000). In late summer these birds migrate following a southeasterly route to the Black Sea and east Africa.

10.2.5.3 Decline in population

The evidence for a marked decline in breeding numbers of *L. f. fuscus* in northern Norway is very strong. The species has also disappeared from the Murman coast and northwest White Sea (Anker-Nilssen *et al*. 2000).

10.2.5.4 Threats

Causes of the decline of *L. f. fuscus* are not known (Anker-Nilssen *et al*. 2000). Strann and Vader (1992) suggested that a change in food resources in breeding areas (particularly the long-term lack of young herring) was the main reason.

10.2.5.5 Comments on the OSPAR review text

The OSPAR species description text states that *Larus fuscus fuscus* has been nominated for three of the five OSPAR regions. This must be a mistake, since this subspecies only occurs in OSPAR I. The other nominations must presumably be for other subspecies of this gull, or may be a misreading of tables, as there do seem to have been three nominations for the mew gull, which is in an adjacent row in the table.

The references listed in support of the nomination of *Larus fuscus fuscus* include several papers that deal only with other subspecies, so have little or no relevance to *L. f. fuscus*. These include papers by Camphuysen (1995), Reid *et al*. (2001), Stone *et al*. (1992), Verbeek (1977) and Webb *et al*. (1990), which should be removed from the reference list for this subspecies. The key reference by Strann and Vader (1992) should be inserted.

Listed threats seem to refer to other subspecies of this gull, and may not be applicable to *L. f. fuscus*. Threats to *L. f. fuscus* are summarised by (Anker-Nilssen *et al*. 2000). Status reported in the OSPAR text refers predominantly to *L. f. graellsii* or *L. f. intermedius*. This provides a misleading picture as regards the particular subspecies of concern. However, the evidence that numbers of L. f. fuscus have declined is compelling, and this subspecies is a strong candidate for inclusion as a priority taxon of concern for OSPAR.

10.3 General comments on taxa of birds not taken forward to the priority list.

We feel that the scientific case for including the Bulwer's petrel and Madeiran storm-petrel in the priority list of declining and threatened species within the OSPAR area would be strong, and that these cases might merit further evaluation.

We would have found it helpful to see more explicit criteria for taxon selection. It appears that subspecies have been selected as equivalent to selection of species, but we found no explanation in the OSPAR criteria as to how subspecies should be considered. A list of species that are endemic to the OSPAR area, or for which most of the world population occurs within the OSPAR area would also be a useful document, since that would focus some attention on endemic biodiversity, regardless of whether such species (or subspecies) have declining or threatened populations. The only seabird endemic to the OSPAR area is the great skua *Catharacta skua*. We found no mention of this species in any of the papers from OSPAR; although relatively rare and localised (total population only about 13,000 breeding pairs) the species is considered to have secure conservation status. Several other seabirds have very high proportions of their global population within the OSPAR area, including northern gannet and European storm-petrel. Tabulation of these percentages and population trends/threats would be useful, though certainly less urgent than the priority list of declining and threatened taxa currently being prepared.

It was not clear to us from reading the criteria how much the status of a taxon outside the OSPAR area should be considered when deciding to list taxa. It seems that the adverse status of Steller's eider in the Bering Sea might have been the main reason for listing this species within the OSPAR area since it has apparently a healthy population within OSPAR. It seems that there is a need for clearer expression of selection criteria to make such selections transparent rather than apparently arbitrary.

The Working Group for Seabird Ecology would be happy to peer review OSPAR texts on the final selection of bird taxa for the priority list of declining and threatened 'species' if this would be considered useful.

11 RECOMMENDATIONS

11.1 Proposal for next meeting

The Working Group on Seabird Ecology makes the following proposals:

1) The Working Group on Seabird Ecology [WGSE] (Chair: R.W. Furness) will meet at ICES headquarters from 7–10 March 2003 or 14–17 March 2003 to:

a) review the status and population trends of seabirds in the Baltic Sea;
b) compare seabird communities and prey consumption between east and west North Atlantic;
c) review marine protected areas for seabirds in the ICES area;
d) assess progress in measuring impacts of at-sea wind farms on seabirds;
e) identify the major gaps in knowledge of marine birds in the ICES area.

11.2 Supporting information

Priority:	This is the only major forum for work being carried out by ICES in relation to marine birds. If ICES wishes to maintain its profile in this area of work, then the activities of WGSE must be regarded as of high priority.
Scientific justification:	a) Detailed reviews of the status and population trends of seabirds have been published for the North, Barents and Norwegian Seas. These have proved to be extremely useful sources of data to underpin assessments of species that should be listed as priority species for conservation action (such as recent work by and on behalf of OSPAR). No such assessment has been undertaken for Baltic seabirds, although there is evidence of severe declines having occurred in some species and locations. A review of seabird status and trends in the Baltic would therefore provide a strong scientific underpinning for any assessment of seabird conservation needs in that area. b) WGSE 2002 meeting completed a summary of the breeding seabird numbers by species, and total seabird energy requirements, and approximate food consumption equivalents, in all ICES areas (approximately described as the 'east North Atlantic'). Given the pronounced differences in seabird community composition and species abundances, and in fish stocks and fisheries, between the west and east North Atlantic, we feel that it would be instructive to compare and contrast the patterns of seabird community composition and energy requirements between ICES and NAFO areas (approximately 'west' and 'east' North Atlantic), in relation to broad differences in the histories of fish stocks and fisheries in these areas. c) Many countries in the ICES area are establishing marine protected areas, including areas for seabirds. Procedures vary among countries, and there would be merit in examining the practices and achievements, particularly in relation to the extent to which these national programmes provide a coherent conservation approach at the spatial scale relevant to seabird populations. d) The 2002 WGSE meeting reviewed knowledge of the effects of wind farms on seabirds. At this early stage in growth of the marine wind farm industry, impacts must be assessed largely by analogy and extrapolation, so must be somewhat speculative. This led us to identify that the important task of quantifying impacts of wind farms on seabirds is at an early stage, of developing and testing scientific methods and technological approaches. There is a clear and urgent need to review progress in these developing methods. Such a review should help to coordinate approaches being tested in different countries and assist in the transfer of ideas and best practice. e) The focus of WGSE has generally been on gathering existing data sets to respond to specific questions. We feel that there is a need to look at the large volume of research on seabirds to identify significant gaps in knowledge and understanding of ecological processes in order to identify possible priority areas for future research.
Relation to strategic plan:	The above will help achieve the following within the initial ICES strategic plan Goal 1. Develop a challenging core science programme to fulfil the ICES Mission. Goal 2. Provide sound, credible, timely, and understandable advice that is relevant to today's and future societal needs.

	Goal 5. Raise public understanding of marine ecosystems and their relevance to society. Objective 1. Understand the physical, chemical, and biological functioning of marine ecosystems. Objective 2. Understand and quantify human impacts on the marine environment, including living marine resources. Objective 3. Develop the scientific basis for sustainable use and protection of the marine environment, including living marine resources. Objective 4. Provide advice on the sustainable use and protection of the marine environment, including living marine resources. Objective 5. Co-ordinate and support interdisciplinary and international marine science programmes. Objective 6. Broaden the diversity of the scientists that participate in ICES activities. Objective 11. Make the scientific products of ICES more accessible to the public
Resource requirements:	The ICES Headquarters is a good working environment. Since all active members of the group are at present funded outside core funding within the Member Countries (many are privately funded), meeting over a weekend will minimise travel costs of members. If the meeting started on a Friday and finished on a Monday, beneficial interaction with the Secretariat would still be possible. This is a Core Activity. In addition, Copenhagen is easily accessible from Baltic countries (see below).
Participants:	The present members of the group should be able to achieve most of the above objectives. However, some may not be able to attend through lack of funding. Funding of these members from Member Countries would be very welcome. In addition, the focus of topic (a) on Baltic seabirds will require participation of members from Baltic countries, and especially the participation of experts on Baltic seaduck populations. Olof Olsson (Sweden) would add valuable experience from the Baltic. The focus of topic (b) will require participation of relevant experts from Canada, USA, and Europe to make comparisons between these contrasting areas and ecosystems.
Secretariat Facilities:	The usual excellent support from the Secretariat will be appreciated.
Financial:	No financial implications for ICES.
Linkages to advisory committees:	Both ACFM and ACE would find the information on consumption by seabirds of relevance to multispecies modelling, and to assessing environmental needs of seabirds and effects of seabirds on fish stocks. ACE may find the review of marine protected areas of interest.
Linkages to other committees or groups:	WGSE is keen to continue the process of integration of seabird ecology into the workings of ICES.
Linkages to other organisations:	Several national governments have encouraged the development of at-sea wind farms to increase the proportion of electricity generated from renewable resources. Review of the impacts of at-sea wind farms on seabirds will be of interest to several statutory agencies and NGOs. Information on seabird communities, population trends and environmental impacts should also be of interest to OSPAR and HELCOM.

ANNEX 1 – NAMES AND ADDRESSES OF PARTICIPANTS

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ANNEX 2 – ENGLISH AND SCIENTIFIC NAMES OF BIRDS MENTIONED IN THIS REPORT

English name	Scientific name
Red-throated diver	*Gavia stellata*
Black-throated diver	*Gavia arctica*
Great northern diver	*Gavia immer*
Slavonian grebe	*Podiceps auritus*
Great crested grebe	*Podiceps griseigena*
Red-necked grebe	*Podiceps grisegena*
Northern fulmar	*Fulmarus glacialis*
Cory's shearwater	*Calonectris diomedea*
Little shearwater	*Puffinus assimilis*
Manx shearwater	*Puffinus puffinus*
Sooty shearwater	*Puffinus griseus*
Bulwer's petrel	*Bulweria bulwerii*
European storm-petrel	*Hydrobates pelagicus*
Leach's storm-petrel	*Oceanodroma leucorhoa*
Madeiran storm-petrel	*Oceanodroma castro*
Northern gannet	*Morus bassanus*
Great cormorant	*Phalacrocorax carbo*
European shag	*Phalacrocorax aristotelis*
White-fronted goose	*Anser albifrons*
Brent goose	*Branta bernicla*
Common shelduck	*Tadorna tadorna*
Pintail	*Anas acuta*
Shoveler	*Anas clypeata*
Eurasian teal	*Anas crecca*
Eurasian wigeon	*Anas penelope*
Mallard	*Anas platyrhynchos*
Greater scaup	*Aythya marila*
Tufted duck	*Aythya fuligula*
Common eider	*Somateria mollissima*
Steller's eider	*Polysticta stelleri*
Long-tailed duck	*Clangula hyenalis*
Black scoter	*Melanitta nigra*
Velvet scoter	*Mellanitta fusca*
Common goldeneye	*Bucephala clangula*
Red-breasted merganser	*Mergus serrator*
Goosander	*Mergus merganser*
Marsh hawk	*Circus cyaneus*
Common buzzard	*Buteo buteo*
Red-tailed hawk	*Buteo jamaicensis*
Golden eagle	*Aquila chrysaetos*
Peregrine falcon	*Falco peregrinus*
American kestrel	*Falco sparverius*
European golden plover	*Pluvialis apricaria*
Northern lapwing	*Vanellus vanellus*
Eurasian curlew	*Numenius arquata*
Red-necked phalarope	*Phalaropus lobatus*
Grey phalarope	*Phalaropus fulicarius*
Long-tailed skua	*Stercorarius longicaudus*
Arctic skua	*Stercorarius parasiticus*
Pomarine skua	*Stercorarius pomarinus*
Great skua	*Catharacta skua*
Mediterranean gull	*Larus melanocephalus*
Little gull	*Larus minutus*
Black-headed gull	*Larus ridibundus*
Sabine's gull	*Larus sabini*
Mew gull	*Larus canus*
Audouin's gull	*Larus audouinii*
Lesser black-backed gull	*Larus fuscus*
Glaucous gull	*Larus hyperboreus*

English name	Scientific name
Herring gull	*Larus argentatus*
Yellow-legged gull	*Larus cachinnans*
Great black-backed gull	*Larus marinus*
Black-legged kittiwake	*Rissa tridactyla*
Red-legged kittiwake	*Rissa brevirostris*
Gull-billed tern	*Gelochelidon nilotica*
Sandwich tern	*Sterna sandvicensis*
Roseate tern	*Sterna dougallii*
Common tern	*Sterna hirundo*
Arctic tern	*Sterna paradisaea*
Little tern	*Sterna albifrons*
Common guillemot	*Uria aalge*
Brunnich’s guillemot	*Uria lomvia*
Razorbill	*Alca torda*
Black guillemot	*Cepphus grylle*
Little auk	*Alle alle*
Atlantic puffin	*Fratercula arctica*
Kittlitz’s murrelet	*Brachyrampus brevirostris*
Whiskered auklet	*Aethia pygmaea*
Common starling	*Sturnus vulgaris*
House sparrow	*Passer domesticus*