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Working Group on Seabird Ecology

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1 INTRODUCTION

1.1 Participation

The meeting participants are listed in Annex 1.

1.2 Terms of Reference

The Terms of Reference for the 2003 meeting of the Working Group on Seabird Ecology (WGSE) are given in C.Res.2002/C04. This Resolution is in Annex 2.

1.3 Overview by the Chair

The Working Group met for four days (7–10 March 2003), and was attended by twelve 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 review of the status and population trends of seabirds in the Baltic Sea depended on provision of recent data on seabird counts from coordinators of surveys in the various Baltic countries. We are extremely grateful to all of those who provided these data (listed in the Acknowledgements and in Section 2). Without these inputs this review could not have been completed. The results are quite striking, and slightly unexpected. Numbers of most breeding species of seabirds are declining, whereas the winter surveys indicate that wintering populations are generally increasing. Changes in winter sea ice extent may have influenced the perception of winter population trends, as the distribution of wintering seabirds varies according to the extent of ice (but there are no comparable at-sea survey data across periods of differing sea ice extent). Total numbers of breeding seabirds in the Baltic are only about 20% of the totals breeding in the North Sea (and species composition differs considerably), but winter populations in the Baltic exceed 10 million seabirds.

Work on the comparison of seabird communities and prey consumption between east (ICES areas) and west (NAFO areas) of the North Atlantic continued, with several members concentrating on this topic. Due to the very large amount of data and complexity of the modelling required for this work it proved impossible to complete the analysis for this report; the group has made considerable progress, and a report on numbers of seabirds in the two areas is presented here. However, presentation of the energetics model outputs and their interpretation will be held over until the next report, with the final work on this aspect being completed inter-sessionally.

A review of Protected Areas for seabirds seemed timely given the considerable pressures to develop Special Protection Areas for seabirds in the EEZ of EU member states, and the various developments taking place in coastal waters such as construction of marine wind farms. This review is followed in the report by a second review of the potential impacts of marine wind farms on seabirds, with emphasis on the progress that has been made in determining the risk of bird kills due to collision with turbines, and the issues of alteration to habitat and behaviour of birds. Although there have been advances in understanding of the flight heights of birds at sea in response to different weather conditions, the development of marine wind farms is well in advance of our understanding of their impacts on birds (if any), emphasising the urgent need to develop further research on this topic.

It was felt that it would be useful to identify topics in the areas of particular interest to the ICES community where we perceive major gaps in knowledge. We discussed this several times, and a brief list is included in the report, but this term of reference was given lower priority than, for example, requests from OSPAR. Indeed, much of our time was devoted to requests to continue development of metrics, objectives and reference levels for EcoQOs on rates of oiling of beach-washed common guillemots, mercury in seabird feathers, plastic particles in fulmar stomachs, organochlorines in seabird eggs, seabird population trends as an index of seabird community health, presence of declining species. We felt that the EcoQOs on oiled guillemots, mercury in feathers, plastic in fulmars, and organochlorines in seabird eggs were all suitable for implementation, but that there was a need to carry out a detailed analysis of trends in numbers of seabirds in selected representative colonies as a proxy for North Sea wide trends. EcoQOs may be inappropriate for 'declining and endangered' seabird species; the only one in the North Sea in this category is the roseate tern, and its very small numbers and local 'edge-of-range' distribution make it somewhat inconvenient for this treatment.

In response to a request from WGMSNS we considered whether seabird consumption of prey in the North Sea could be presented for the years 1963 to the present in a form suitable for incorporation into an MSVPA model. Although there would be considerable work required to achieve such an aim, and certain assumptions and simplifications would be necessary, it was felt that such work would be possible providing the form of the data requirement of WGMSNS could be clearly specified.

Our 2003 meeting attracted 12 working group members, with enormous enthusiasm. The work continued from early morning to evening each day. The considerable efforts have been rewarded by a sense of achievement and new understandings from the data brought together, and also of the great benefits and synergies of group working to clear objectives.

1.4 Note on bird names

Throughout the text we provide the common English names of bird species. A full list of species names together with their scientific binomial appears in Annex 3.

1.5 Acknowledgements

The Working Group wishes to thank ICES and their staff for providing rooms for our meeting, and for the excellent computing and photocopying facilities. The following people very kindly provided data on seabird numbers in areas of the Baltic for compilation in Section 2: Måns Marlo (Lilla Karlsö), Åke Andersson (Bullerö), Martti Hario (Finnish archipelago), Gennady V. Grishanov (Kaliningrad region), Alexander Kondratyev (St. Petersburg region), Andres Kuresoo and Leho Luigujõe (Estonia), Antra Stipniece (Latvia), Ramunas Zydelis (Lithuania), Wilfried Knief (Schleswig-Holstein), Ulrich Köppen and H.W. Nehls (Mecklenburg-Vorpommern), Tony Fox (Danish midwinter wetland census), P. Lyngs (Danish razorbills), L. Nielsson (Swedish midwinter wetland census), W. Meissner (Polish midwinter wetland census). We are particularly grateful to Kees Camphuysen, who was unable to attend the Working Group meeting but who nevertheless provided information to the group from his home on several occasions as the meeting progressed.

2 A REVIEW OF THE STATUS AND POPULATION TRENDS OF SEABIRDS IN THE BALTIC SEA

2.1 Status of seabirds in the Baltic Sea

The status of breeding and wintering seabirds in the North Sea has been addressed twice before by the Working Group (ICES 2001, 2002). Seabird numbers in the Baltic Sea were estimated as the basis for estimation of food consumption (ICES 2000), but a detailed assessment of trends was not attempted. This review of the status and trends of seabirds in the Baltic Sea follows the structure of ICES (2002). The management area of the International Baltic Sea Fishery Commission (IBSFC) is adopted to define the geographical area for this review. Since some parts of the Baltic were excluded in the review of 2002, this analysis supersedes ICES (2002) for the IBSFC region (ICES sub-regions III b-d).

In contrast to the North Sea, the Baltic Sea is relatively more important for wintering (c.10 million) rather than breeding (c.0.5 million) seabirds. Seabirds in the Baltic Sea comprise pelagic species like divers, gulls and auks, as well as benthic feeding waterbird species like dabbling ducks, seaducks, mergansers and coots. In contrast to North Sea populations that spend much of their life cycle at sea (e.g., petrels, northern gannet and auks), Baltic seabirds are dominated by seaducks, many of which resort to freshwater habitats outside the nesting period (e.g., scoters, long-tailed ducks). In addition, the common eider exploits marine waters throughout the annual cycle, but ranges from being highly migratory (e.g., in Finland) to being more sedentary (e.g., in Denmark).

Due to incomplete coverage of many areas and the mis-match between regions used during national censuses and ICES sub-regions, estimates and trends are presented at national levels and then combined to construct trends for the major groups of seabirds for the entire Baltic Sea. Most censuses carried out during the breeding and winter seasons have only covered a proportion of the total coastline and, as the offshore areas used by seabirds have not been adequately surveyed recently, total estimates or numbers have not been not provided. Rather, this report attempts to present trends reflected in the time series constructed from 1985 to the present. To set these in context, three species occurring in the Baltic are considered as case studies, following the common treatment of the more abundant species. The time series has been constructed on the basis of mid values for five-year periods. Thus, the calculated trends may therefore be sensitive to abnormal counts, and should be used as preliminary assessments of the development of the seabird populations in question.

2.1.1 Data sources

Data from the breeding and winter seasons have been collated into 5-year periods by the national and regional co-ordinators of seabird monitoring programmes of all countries surrounding the Baltic Sea and supplemented by the literature.

2.1.1.1 Counts of breeding birds

2.1.1.1.1 Sweden

Data from the Swedish part of the Baltic Sea were taken from the Stockholm archipelago monitoring programmes (Skärgårdsstyrelsen 2002, with supplementary information for some species from the Bullerö area, Åke Andersson pers. comm). Additional data on auks were obtained from the seabird colonies of Lilla and Stora Karlsö (Måns Marlo).

2.1.1.1.2 Finland

Data were derived from the Finnish national bird census scheme for the archipelago sea (Martti Hario pers. comm). The census is carried out on 40 islands, which are surveyed at irregular intervals to fit in with specific objectives.

2.1.1.1.3 Russia

The data for Kaliningrad region have been provided by Gennady V. Grishanov, while the data for St. Petersburg have been provided by Alexander Kondratyev, University of St. Petersburg on the basis of Noskov *et al.* (1993), Gaginskaya (1995), Kondratyev (2000) and V.A. Buzun (pers. comm.).

2.1.1.1.4 Estonia

The data have been provided by Andres Kuresoo and Leho Luigujõe, Institute of Zoology and Botany, on the basis of Kuresoo *et al*. (1994), Luigujõe *et al*. (1997), Pehlak *et al*. (2001) and Pehlak (2003).

2.1.1.1.5 Latvia

The breeding bird data have been provided by Antra Stipniece, Institute of Biology, on the basis of Baumanis (1999), Baumanis *et al*. (1997), Celmiņš *et al*. (1998–2002), Priednieks *et al*. (1989), Matrozis (2001), Opermanis *et al*. (1996), Strazds *et al*. (1994), Vīksne and Janaus (1989), Viksne *et al*. (1980), and J. Viksne, M. Janaus, A. Mednis and V. Kerus (pers. comm.).

2.1.1.1.6 Lithuania

The breeding bird data have been provided by Ramunas Zydelis, Institute of Ecology on the basis of Lithuanian literature and G. Vaitkus, L. Raudonikis, M. Dagys, J. Zarankaite and G. Grazulevicius (pers. comm.).

2.1.1.1.7 Poland

Breeding bird data from Poland were not available for this review due to the lack of national/regional co-ordination in Poland.

2.1.1.1.8 Germany

The breeding bird data for Schleswig-Holstein were provided by Wilfried Knief from the Landesamt für Natur und Umwelt Schleswig-Holstein, while the data from Mecklenburg-Vorpommern were provided by Ulrich Köppen, Beringungszentrale Hiddensee am Landesamt für Umwelt, Naturschutz und Geologie Mecklenburg-Vorpommern. Recent accounts of the status of seabirds on the German North Sea coast were given by Berndt *et al*. (2002) and Hälterlein *et al*. (2000). Except for the red-breasted merganser, the numbers in Schleswig-Holstein reflect the breeding population of all coastal breeding areas.

2.1.1.1.9 Denmark

No regular national monitoring of breeding seabird areas is carried out in Denmark. Data from the monitoring programme of Storströms county (Storstrøms Amt 2001) were used to derive trends. Data relating to the breeding population of razorbills on Christiansø were provided by P. Lyngs.

2.1.1.2 Counts of wintering birds

Most recent counts of wintering seabirds in the Baltic Sea have been compiled under the auspices of the midwinter counts organised by Wetlands International. These counts generally cover birds of the coastal zone and lagoons, while offshore areas are surveyed only infrequently. In 1992, the first survey (ship transects) covering all major offshore areas was carried out by Ornis Consult, and this was followed up by international surveys from both aeroplane and ships in 1993 (Durinck *et al*. 1994). Since 1994, line transect counts in offshore areas have not been undertaken as part of an internationally co-ordinated census. The fragmented offshore surveys (using different survey designs and platforms) do not allow comparison of density estimates. As a result, only data from the Wetlands International Midwinter Census have been included in this review, and thus the calculated trends of seabirds reflect only the coastal areas of the Baltic Sea. As a consequence, the calculated trends for divers, grebes, seaducks, gulls and auks should be considered as preliminary and of low reliability.

2.1.1.2.1 Wetlands International Midwinter Census

All participating countries contributing information to the review have collected data using both land-based and aerial surveys. Total aerial surveys were carried out using observers in aircraft in designated sea areas according to the methodology established in Pihl *et al*. (1992), Pihl and Frikke (1992) and Laursen *et al*. (1996). In Sweden, data from the census have been supplied by L. Nielsson, University of Lund. No data have been made available from Finland and the St. Petersburg region of Russia. Data from Estonia have been provided by Andres Kuresoo, Institute of Botany and Zoology. Data from Latvia have been provided by Antra Stipniece, Institute of Biology, while in Lithuania the data were provided by Ramunas Zydelis, Institute of Ecology. In Poland data have been supplied by W. Meissner, University of Gdansk, in Mecklenburg Vorpommern by H.W. Nehls, in Schleswig-Holstein by W. Knief from the Landesamt für Natur und Umwelt Schleswig-Holstein, and in Denmark by A.D. Fox, National Environmental Research Institute.

2.1.2 Methods for estimating population trends

The methods applied for calculating average estimates of population change are in line with the methods used for most of the North Sea (ICES 2002): *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.

2.1.3 Year-to-year variations and ice conditions

In considering the counts and estimates presented here, it is important to judge changes in seabird population distribution and abundance against the background of macro-environmental factors. Dominant amongst these in the Baltic region relates to the position of the 0º C isotherm (and other meteorological parameters) in mid-January, which has considerable consequences for the position and extent of the sea ice. This is the major factor influencing the distribution of all species, but particularly the most abundant seabirds. The patterns of effects differ however, between species. On a macro scale, the numbers of very abundant species such as long-tailed duck, common and velvet scoter may vary in response to the distribution of ice. For example, in the case of ice-cover in the Gulf of Riga hundreds of thousands of seaducks may get displaced westwards to Lithuanian coasts (Vaitkus 1999). Species using freshwater (as well as marine) habitats will be displaced to near shore open marine water areas when inland habitats freeze (e.g., great crested grebes, tufted duck and pochard), but may be forced further offshore when coastal areas also become frozen. Inter-annual effects may also accrue from severe winters. For example, mute swan and coot are generally sedentary in mid-winter, and may suffer heavy mortality in period of prolonged low temperature, depressing numbers in the subsequent season. In this context, it is important to consider that the extent of sea ice in the Baltic has been usually restricted in the years since 1990 (i.e., extremely mild to average, see Figure 2.1 and Table 2.1).

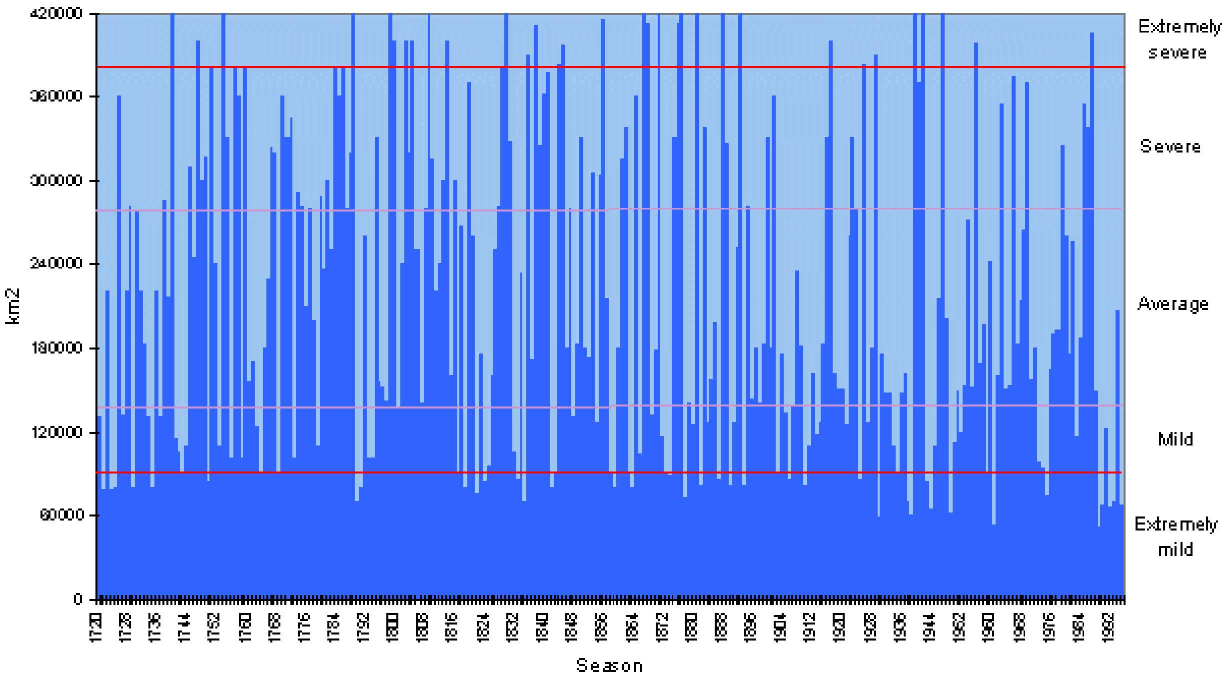

Figure 2.1. Maximum extent of sea ice cover in the Baltic, 1720–1995. (Finnish Ice Service, http//ice.fmi.fi/CLASSIFICATION_1750_1995.html)

Table 2.1. Maximum extent of sea ice cover in the Baltic during the last 6 seasons to compare with long term data above (Finnish Institute of Marine Research).

Winter	Maximum extent of ice cover (km^2)	Condition
1996/1997	128.000	Mild, late spring
1997/1998	129.000	Mild
1998/1999	157.000	Average
1999/2000	95.000	Mild
2000/2001	128.000	Mild, shorter than average
2001/2002	102.000	Mild

For this reason, it is important to bear in mind that in all recent seasons, counts were carried out in comparatively mild winters, with restricted sea ice. Current global climate change models predict a reduction in the extent of maximum ice cover from 38% currently to 10% by 2050, and a reduction to zero by 2100 (Haapala and Leppäranta 1997). Climate change may be reflected in ringing recoveries of seabirds, which indicate that the centre of gravity of winter distributions of several waterbirds have been moving eastwards in the Baltic region (Svazas *et al.* 2001). Hence, this overall trend will contribute to patterns in wintering abundance throughout the area.

2.1.4 Trends in numbers of breeding birds

Population trends for seabirds breeding within the different countries of the Baltic Sea are presented in Tables 2.2 to 2.8. A striking result of the trend analyses is the overall decreasing trends noted for nine of the 19 breeding seabird species. Black-headed gulls are assessed as decreasing throughout the Baltic Sea, whereas velvet scoter, Sandwich tern, common tern, arctic tern, little tern, mew gull, herring gull and lesser black-backed gull are considered decreasing in parts of the Baltic Sea. The most significant decrease in the numbers of breeding terns and gulls has occurred in Germany and Denmark. The population of velvet scoter monitored in Sweden is considered to be decreasing. The status of other species, which predominantly breed in the archipelago areas, like common eider, arctic skua, Caspian tern and black guillemot, is uncertain, and populations of these species may be decreasing in parts of the archipelago areas. More detailed accounts of the development of the seabird communities in the Finnish archipelago are given by Franson *et al.* (2002), Hario (2000), Hario *et al.* (1987), Hario *et al.* (2000), Hario *et al.* (2002), Hario and Rudbäck (1996), Hario and Rudbäck (1999), Hario and Selin (2002), Hario and Rintala (2002), Hario and Öst (2002), Hollmén *et al.* (2002) and Hokkanen (2001). Positive trends are noted for great cormorant and razorbill, of which the former has been expanding throughout the Baltic Sea, recently also into the northern-most parts.

Table 2.2. Population trends for selected seabird species breeding on the Baltic coast of Germany (Schleswig-Holstein and Mecklenburg Vorpommern) between 1985 and 2002. Population estimates are given as mid values (number of breeding pairs) for five-year periods. Population changes have been calculated before rounding the estimates.

	Schleswig-Holstein					**Mecklenburg-Vorpommern**				
Species	**1985–1989**	**1990–1994**	**1995–1999**	**2000–2002**	**Average change**	**1985–1989**	**1990–1994**	**1995–1999**	**2000–2002**	**Average change**
Great cormorant	0	455	1475	1045	5.7					
Common eider	2	5	16	24	11.0	2	8	10	7	
Red-breasted merganser	110	100	100	65	-2.8	250	165	80	80	-7.3
Sandwich tern	55	10	3	0	-17.4	1.200	785	800	700	-3.5
Common tern	80	135	150	140	0.0	1.835	1.235	815	915	-4.5
Arctic tern	295	210	110	65	-7.7	155	100	65	60	-6.0
Little tern	105	125	120	150	1.2	105	75	90	50	-5.0
Black-headed gull	450	350	195	80	-9.4	35000	22060	12400	12500	-6.6
Mew gull	4895	2850	2170	1040	-6.5	5100	3830	4260	3490	-2.5
Herring gull	475	605	645	1100	4.1	495	695	1230	1760	8.8

Table 2.3. Population trends for selected seabird species breeding on the coast of Lithuania and Latvia between 1985 and 2002. Population estimates are given as mid values (number of breeding pairs) for five-year periods. Population changes have been calculated before rounding the estimates.

	Lithuania					**Latvia**				
Species	**1985–1989**	**1990–1994**	**1995–1999**	**2000–2002**	**Average change**	**1985–1989**	**1990–1994**	**1995–1999**	**2000–2002**	**Average change**
Great cormorant	2	135	880	1705	56.8	10	145	450		46.3
Red-breasted merganser						4	15	15		14.1
Goosander						150	125	125		-1.8
Common tern						2.000	1.750	1750		-1.3
Little tern						275	275	275		0.0
Black-headed gull						110000	105000	45000		-8.6
Mew gull						600	550	550		-0.9
Herring gull						600	550	550		-0.9

Table 2.4. Population trends for selected seabird species breeding on the Baltic coast of Russia (Kaliningrad and St. Petersburg Oblasts) between 1985 and 2002. Population estimates are given as mid values (number of breeding pairs) for five-year periods. Population changes have been calculated before rounding the estimates.

	Kaliningrad					**St. Petersburg**				
Species	**1985–1989**	**1990–1994**	**1995–1999**	**2000–2002**	**Average change**	**1985–1989**	**1990–1994**	**1995–1999**	**2000–2002**	**Average change**
Great cormorant	50	340	900	2000	27.9		2600		3000	1.4
Caspian tern							30	60		14.9
Common tern	60	30	50	60	0.0					
Little Tern	50	30	40	10	-10.2					
Black-headed Gull	4000	5000	4000	3500	-0.9					
Black guillemot							60	90		8.4

Table 2.5. Population trends for selected seabird species breeding on the Baltic coast of Finland between 1985 and 2002. Population estimates are given as mid values (number of breeding pairs) for five-year periods. Population changes have been calculated before rounding the estimates.

Species	1985–1989	1990–1994	1995–1999	2000–2002	Average change
Great cormorant			120	700	41.8
Common eider	165000		200000	165000	0.0
Velvet scoter	13000	20000	13000		0.0
Red-breasted merganser	8800	15000	10000		1.3
Goosander	6000	12000	10000		5.2
Caspian tern	700	760	750	800	0.9
Common tern	8000		9000		1.2
Arctic tern	40000		60000		4.1
Little tern	35	40	45		2.0
Mew gull	42000	42000	45000	46000	0.6
Herring gull	28300	20000	25500	24000	-1.1
Lesser black-backed gull	4750	4000	3700	3700	-1.7
Great black-backed gull	2800	3000	3000	2800	0.0
Common guillemot	80	35	30	25	-7.5
Razorbill	6200		8500		3.2
Black guillemot	14000		17500		2.3

Table 2.6. Population trends for selected seabird species breeding on the Baltic coast of Sweden (Stockholm Archipelago, Li. Karlsö and Store Karlsö) between 1985 and 2002. Population estimates are given as mid values (number of breeding pairs) for five-year periods. Population changes have been calculated before rounding the estimates.

	Stockholm Archipelago					Li. Karlsö				
Species	**1985–1989**	**1990–1994**	**1995–1999**	**2000–2002**	**Average change**	**1985–1989**	**1990–1994**	**1995–1999**	**2000–2002**	**Average change**
Common eider	6900	8300	7000	7000	0.1					
Velvet scoter	700	700	330	275	-6.0					
Red-breasted merganser		75	70	80	0.6	20	25	40	97	9.5
Goosander	290	380	330	325	0.8					
Arctic skua*	6	4	4	5	-1.2					
Caspian tern*	6	0	0	1	-11.3					
Little tern						14	3	3	7	-4.5
Black-headed gull						569	818	994	851	2.7
Mew gull						25	21	39	20	-1.5
Herring gull*	325	250	225	180	-4.0					
Lesser black-backed gull*	12	10		10	-1.2					
Great black-backed gull*	65	65	55	45	-2.2	33	35	41	52	3.1
Common guillemot		620	750	850	3.2	885	850	950	810	-0.3
Razorbill	1500	2050	2950	3300	5.4	690	580	1250	1110	3.2
Black guillemot*	25	10	3	2	-15.9	13	15		5	-6.2

* Data only from Bullerö Archipelago (Åka Andersson pers. comm).

Store Karlsö

Species	1990–1994	1995–1999	change
Common eider	1200	1800	8.4
Velvet scoter	200	160	-4.4
Red-breasted merganser	70	39	-11.0
Black guillemot	30	8	-23.2

Table 2.7. Population trends for selected seabird species breeding on the Baltic coast of Denmark (Storstrøms county) between 1985 and 2002. Population estimates are given as mid values (number of breeding pairs) for five-year periods. Population changes have been calculated before rounding the estimates.

		Storstrøms county			
Species	**1985–1989**	**1990–1994**	**1995–1999**	**2000–2002**	**Average change**
Black-headed gull		2325	1300	1700	-3.1
Mew gull		1070	960	1300	2.0
Herring gull		6840	4800	4300	-4.5
Lesser black-backed gull		1	3	7	21.5
Great black-backed gull		85	50	95	1.2
Little tern		50	40	25	-6.3
Common tern		65	40	20	-12.3
Arctic tern		815	410	385	-7.2
Sandwich tern		171	58	55	-10.7

Table 2.8. Simple summary indicating the trends in numbers of breeding seabirds within the IBFSC region of the Baltic Sea between 1985 and 2002, cf Tables 2.2 – 2.7. 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 ± p.a.) are indicated by zeroes. 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. The regions are indicated as follows: GER1: Schleswig-Holstein, GER2: Mecklenburg-Vorpommern, KAL: Kaliningrad, LIT: Lithuania, LAT: Latvia, S PET: St. Petersburg, FIN: Finland, SWE: Sweden and DEN: Denmark.

Species	**GER1**	**GER2**	**KAL**	**LIT**	**LAT**	**S PET**	**FIN**	**SWE**	**DEN**	**Overall Trend**
Great cormorant	++	?	+++	+++	+++	+	+++			++
Common eider	(+++)						0	0		0
Velvet scoter							0	--		-
Red-breasted merganser	-	--			(+++)		+			0
Goosander					-		++	0		0
Arctic skua								(-)		(-)
Caspian tern						+++		(---)		?
Sandwich tern	---	-							---	--
Common tern	0	-	0		-		+		---	-
Arctic tern	--	--					+		--	-
Little tern	+	--	---		0		+		--	-
Black-headed gull	--	--			--				-	--
Mew gull	--	-					0		-	-
Herring gull	+	++					-	-	-	-
Lesser black-backed gull							-	(-)		-
Great Black-backed gull							0	-	+	0
Common guillemot							(--)	+		0
Razorbill							+	++		+
Black guillemot						+	+	(---)		?

2.1.5 Trends in numbers of wintering birds

Population trends for seabirds wintering within the coastal zone of the different countries of the Baltic Sea are presented in Tables 2.9 to 2.17. As stated earlier, trends for the most abundant species of seabirds in the wintering in the marine waters of the Baltic Sea (long-tailed duck, velvet scoter, black scoter) can not be determined due to the absence of international monitoring schemes covering their offshore habitats. Within the coastal zone the principal trends are considered to be positive or stable over the investigated period. This judgement is mainly based upon increasing trends assessed amongst most species in the northern parts of the Baltic Sea. This is most striking for great crested grebe, great cormorant, mute swan, common goldeneye, smew, red-breasted merganser, goosander and Eurasian coot. The populations of greater scaup (based on trends in Poland and Denmark) and common eider (on the basis of the trend in Danish part of the Baltic) show declining trends.

Table 2.9. Population trends for selected seabird species wintering in the Baltic coastal waters of (Schleswig-Holstein and Mecklenburg-Vorpommern) between 1985 and 2002. Population estimates are given as mid values (number of breeding pairs) for five-year periods. Population changes have been calculated before rounding the estimates.

	Schleswig-Holstein				
Species	**1985–1989**	**1990–1994**	**1995–1999**	**2000–2002**	**Average change**
Red-/Black-throated diver	4	6	8	2	-4.5
Great crested grebe	925	1820	4365	4380	10.9
Red-necked grebe	5	30	10	30	12.2
Great cormorant	490	920	1500	1665	8.5
Mute swan	2030	1850	1860	1880	-0.5
Mallard	17600	19400	17000	17500	-0.1
Pochard	3200	3900	3100	2700	-1.2
Tufted duck	61000	25000	24000	22000	-6.6
Greater scaup	13000	18000	13000	18000	2.3
Common eider	46000	105000	110000	90000	4.6
Long-tailed duck	3280	3570	11400	9950	7.7
Black scoter	5200	7100	13100	5900	0.8
Velvet scoter	10	3	6	1	-14.2
Common goldeneye	9000	7900	9400	6500	-2.2
Smew	206	118	187	151	-2.0
Red-breasted merganser	1300	1300	1100	970	-1.9
Goosander	1800	1770	2100	800	-5.3
Eurasian coot	27300	42000	25900	31600	1.0
Black-headed gull	1935	5155	4030	4450	5.7
Mew gull	240	1335	1545	1835	14.5
Herring gull	5170	17600	19500	16000	7.9
Great black-backed gull	165	425	780	930	12.1

Table 2.10. Population trends for selected seabird species wintering in the coastal waters of Poland (Gdansk Bay) between 1985 and 2002. Population estimates are given as mid values (number of breeding pairs) for five-year periods. Population changes have been calculated before rounding the estimates.

Species	**1985–1989**	**1990–1994**	**1995–1999**	**2000–2002**	**Average change**
Great crested grebe	165	475	25	630	9.2
Great cormorant	30	25	135	3075	36.8
Mute swan	2605	1040	1360	2900	0.7
Mallard	1050	5835	2180	2800	6.8
Pochard	745	60	160	20	-21.2
Tufted duck	10000	14750	14590	12100	1.3
Greater scaup	650	5300	475	15	-22.2
Common eider	275	75	15	145	-4.1
Long-tailed duck	3200	9570	1730	3100	-0.2
Black scoter	330	180	220	400	1.2
Velvet scoter	290	500	125	135	-5.0
Common goldeneye	10000	2860	5800	2900	-7.9
Smew	130	20	165	15	-12.9
Red-breasted merganser	1000	60	115	615	-3.2
Goosander	4660	355	6240	480	-14.0
Eurasian coot	195	5620	320	4600	23.5

Table 2.11. Population trends for selected seabird species wintering in the coastal waters of Lithuania between 1985 and 2002. Population estimates are given as mid values (number of breeding pairs) for five-year periods. Population changes have been calculated before rounding the estimates.

Species	1985–1989	1990–1994	1995–1999	2000–2002	Average change
Red-/Black-throated diver	200	310	800	610	7.7
Great crested grebe	450	490	1070	1160	6.5
Mute swan			305	100	-20.1
Mallard			2650	1210	-14.5
Steller's eider	315	800	1690	675	5.2
Long-tailed duck	8300	10300	32300	11900	2.4
Black scoter	580	870	210	139	-9.1
Velvet scoter	12300	19900	45500	22600	4.1
Common goldeneye	930	1020	1480	1400	2.8
Smew	630	590	530	280	-5.3
Red-breasted merganser	115	390	215	70	-3.1
Goosander	3200	14700	12400	7200	5.6

Table 2.12. Population trends for selected seabird species wintering in the coastal waters of Latvia between 1985 and 2002. Population estimates are given as mid values (number of breeding pairs) for five-year periods. Population changes have been calculated before rounding the estimates.

Species	1990–1994	1995–1999	2000–2002	Average change
Red-/Black-throated diver	235	1250	7235	40.8
Great crested grebe	40	35	1135	40.1
Great cormorant	.	7	120	77.1
Mute swan	785	150	565	-3.3
Mallard	1810	1750	440	-13.2
Tufted duck	60	5	20	-11.0
Greater scaup	33		45	3.2
Common eider	12	5	2	-16.4
Long-tailed duck	4340	3160	9670	8.3
Black scoter	160	135	1800	27.2
Velvet scoter	215	55	900	15.5
Common goldeneye	2565	1280	4445	5.7
Smew	4	1	92	36.8
Red-breasted merganser	45	80	435	25.8
Goosander	760	910	1530	7.2
Eurasian coot	65	1	32	-7.0
Black-headed gull	45	535	200	16.5
Common gull	480	1520	8790	33.7
Herring gull	.	14450	8185	-10.7
Great black-backed gull	.	250	490	14.5

Table 2.13. Population trends for selected seabird species wintering in the coastal waters of Estonia between 1985 and 2002. Population estimates are given as mid values (number of breeding pairs) for five-year periods. Population changes have been calculated before rounding the estimates.

Species	1985–1989	1990–1994	1995–1999	2000–2002	Average change
Great crested grebe	3	23	2	48	20.3
Great cormorant	15	45	45	100	13.7
Mute swan	510	4120	4040	6835	18.8
Bewick's swan	3	1	14	11	9.0
Whooper swan	150	385	160	200	2.0
Mallard	1245	6105	2670	3725	7.6
Tufted duck	80	255	75	355	10.5
Greater scaup	115	90	230	100	-0.7
Common eider	8	25	45	70	15.6
Steller's eider	320	3000	2430	1650	11.6
Long-tailed duck	1870	6880	9595	16800	15.8
Black scoter	2	13	20	260	38.3
Velvet scoter	45	295	215	760	20.9
Common goldeneye	1800	4445	9205	12555	13.8
Smew	6	55	150	330	30.7
Red-breasted merganser	73	710	360	920	18.4
Goosander	1000	2120	2885	4700	10.9
Eurasian coot	17	120	16	45	6.7

Table 2.14. Population trends for selected seabird species wintering in the coastal waters of the Kaliningrad Oblasts between 1985 and 2002. Population estimates are given as mid values (number of breeding pairs) for five-year periods. Population changes have been calculated before rounding the estimates.

Species	1985–1989	1990–1994	1995–1999	2000–2002	Average change
Great crested grebe	25	175	90	75	7.3
Great cormorant			4	150	106.4
Mute swan	17	31	32	72	10.1
Mallard	380	650	235	245	-3.0
Tufted duck	245	225	325	9	-19.8
Long-tailed duck	270	3750	1040	2750	16.8
Velvet scoter	95	20	85	440	10.7
Common goldeneye	70	125	215	135	4.4
Goosander	55	160	475	155	7.2
Eurasian coot	55	90	50	0	-1.0
Black-headed gull			250	145	-10.1
Mew gull			300	150	-13.0
Herring gull			30	100	29.8
Great black-backed gull			330	25	-40.2

Table 2.15. Population trends for selected seabird species wintering in the Baltic coastal waters of Sweden between 1985 and 2002. Population estimates are given as mid values for five-year periods. Population changes have been calculated before rounding the estimates.

Species	**1985–1989**	**1990–1994**	**1995–1999**	**2000–2002**	**Average change**
Red-/Black-throated diver	11	40	15	60	12.1
Little grebe	2	13	22	38	21.0
Great crested grebe	46	200	497	887	21.8
Red-necked grebe	3	10	8	7	5.8
Great cormorant	480	2190	2200	2315	11.0
Mute swan	5165	6570	7850	8465	3.4
Whooper swan	550	300	660	690	1.5
Mallard	31300	25600	28900	42000	2.0
Eurasian wigeon	137	1425	2625	5735	28.2
Pintail	3	22	11	91	26.7
Eurasian teal	4	145	115	240	32.3
Common shelduck	19	90	65	120	13.0
Pochard	810	1560	1875	2320	7.3
Tufted duck	50200	61500	72900	88000	3.8
Greater scaup	1275	3105	2705	580	-5.1
Common eider	415	500	635	750	4.1
Steller's eider	10	2	4	2	-11.4
Long-tailed duck	12000	12600	13700	18800	2.9
Black scoter	3	12	11	106	27.4
Velvet scoter	24	60	9	44	4.1
Common goldeneye	11765	8800	16225	18945	3.2
Smew	271	473	1430	1400	11.6
Red-breasted merganser	1255	1140	1545	2500	4.7
Goosander	3985	5600	7200	4800	1.3
Eurasian coot	2185	7545	9800	14000	13.2

Table 2.16. Population trends for selected seabird species wintering in the Baltic coastal waters of Denmark between 1985 and 2002. Population estimates are given as mid values for five-year periods. Population changes have been calculated before rounding the estimates.

Species	**1985–1989**	**1990–1994**	**1995–1999**	**2000–2002**	**Average change**
Great cormorant	5850	13000		14000	6.1
Mute swan	36000	65000		46700	1.7
Mallard	39000	76000		53400	2.1
Pochard	2200	9900		5150	5.8
Tufted duck	85000	129000		84000	-0.1
Greater scaup	19000	15000		6900	-6.6
Common eider	4160	466000		267000	32.0
Long-tailed duck	3245	4060		1865	-3.6
Black scoter	290	27670		14500	29.8
Velvet scoter	6775	3740		970	-12.2
Common goldeneye	32200	38065		45900	2.4
Red-breasted merganser	9280	9470		8030	-1.0
Goosander	8965	8230		4080	-5.1
Eurasian coot	40000	155000		129000	8.1

Table 2.17. Simple summary indicating the trends in numbers of wintering seabirds within the IBFSC region of the Baltic Sea between 1985 and 2002 (see Tables 2.9 – 2.16). 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 ± p.a.) are indicated by zeroes. 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. The regions are indicated as follows: GER1: Schleswig-Holstein, GER2: Mecklenburg-Vorpommern, POL: Poland, KAL: Kaliningrad, LIT: Lithuania, LAT: Latvia, EST Estonia, SWE: Sweden and DEN: Denmark.

Species	**GER1**	**GER2**	**POL**	**KAL**	**LIT**	**LAT**	**EST**	**SWE**	**DEN**	**Overall Trend**
Red-/Black-throated diver					++	+++		(+++)		?
Great crested grebe	+++		++	++	++	+++	+++	+++		++
Red-necked grebe	(+++)							(++)		+
Great cormorant	++		+++	+++		+++	+++	+++	++	++
Mute swan	0		0	(+++)	---	-	+++	+	+	+
Mallard	0		++		---	---	++	+	+	0
Pochard	-		---				++	+	++	0
Tufted duck	--		+	(---)		---	+++	+	0	0
Greater scaup	+		---			+	(0)	(--)	--	-
Common eider	+		(-)			(---)	(+++)	(+)	---	-
Steller’s eider					+		+++	(---)		0
Long-tailed duck	++		0	+++	+	++	+++	+	(-)	?
Black scoter	0		+		(-)	+++	(+++)	(++)	+++	?
Velvet scoter			--	(+++)	+	+++	+++	(+)	(---)	?
Common goldeneye	-		--	(+)	+	++	+++	+	+	+
Smew	-		---		--	(+++)	+++	+++		+
Red-breasted merganser	-		-		-	+++	+++	+	-	0
Goosander	--		---		++	++	+++	+	-	+
Eurasian coot			++		++		++	+++	++	++

2.2 Case study species

In the following the development of the winter population of three duck species, common eider, Steller’s eider and black scoter is dealt with in more detail to illustrate and contrast the factors influencing their abundance in the Baltic Sea. The three species of ducks all pose different problems for their effective conservation and highlight different information needs. The common eider is a widespread and abundant species that is hunted in three Baltic countries, which is showing significant declines in winter numbers in Denmark linked to a number of different factors operating on the wintering and breeding areas. Steller’s eider is a globally vulnerable species and the subject of conservation attention, which shows signs of declines, probably as a result of factors operating outside the Baltic areas. Finally, the black scoter is a very abundant species, about which we know very little, but which is vulnerable because of its highly clumped distribution outside the breeding areas (e.g., at risk from oil pollution and habitat loss). For this species we have very poor monitoring mechanisms with which to follow changes in distribution and abundance, despite considerable and varied threats to its non-breeding habitats (e.g., increases in shipping, shell fisheries, aggregate extraction, windmill and infrastructure construction).

2.2.1 Common eider

The Baltic/Wadden Sea flyway population of the common eider comprises breeding birds from Finland, Estonia, Sweden, Denmark southern Norway, Germany and the Netherlands. Birds nesting in Denmark, Germany, western Sweden and the Netherlands are sedentary or partially migratory whereas those in southern Norway, eastern Sweden, Finland and the Baltic States are completely migratory. Eiders of eastern provenance therefore mix in winter in the western Baltic, Kattegat and inner Danish waters (Swennen 1990, Noer 1991, Fransson and Petterson 2001). The common eider is widespread and common, and numbers increased throughout the late 20th century until the 1990s (Hario and Selin 1988, Camphuysen 1996). At a workshop of the WI Seaduck Specialist Group in Estonia in 2002, a review of available information suggested that there has been at least a 36% decline in wintering numbers in this population between 1991 and 2000 (Desholm *et al.* in press). While similar decreases have been detected at some sites (e.g., Saltholm in Denmark), such a decline is not generally evident amongst breeding colonies monitored throughout the breeding range. This discrepancy between breeding and winter trends could be due to our inability to monitor numbers adequately, but could reflect the buffering effects of the non-breeding element of the population. The latter birds are represented in the winter counts, but do not appear amongst assessments of breeding abundance. Factors known to directly contribute to declines in population size include low duckling survival caused by viral infections (Hóllman, 2002), reduced survival of annual adult breeding females due to avian cholera epidemics (Christiansen *et al*. 1997) and mass starvation events on the wintering grounds (Camphuysen 2001). Eiders are legal quarry in Denmark, Sweden and Norway, and the annual bag is three times larger than the known numbers dying in mass starvation that have occurred in Dutch wintering areas. It is not clear if the current level of hunting is sustainable under present conditions. Other factors may contribute to the declines in numbers, such as the general increase in shipping and increasing shell fishery exploitation. The multifactoral explanation for the declines necessitates an appropriate understanding of the relative importance of the different factors if it is possible to prioritise and target actions and resources to restore this population to favourable conservation status. The current monitoring mechanisms used to track changes in abundance of this population are uneven and partly inadequate. The workshop called for improved international collaboration, to adequately track winter population trajectories and detect significant change in future. Better monitoring of breeding stocks was also flagged as priority. Effective monitoring tools were essential to underpin remedial actions for the species in the Baltic.

2.2.2 Steller's eider

This species of special conservation concern and is listed by IUCN as vulnerable because of declines in number (category A1a IUCN 1996). The world population of Steller's eider has decreased by 50% throughout its range. In North American, declines in breeding numbers continue, trends in East Asia are unknown, but numbers in Europe are considered to be stable or perhaps increasing (Schäffer and Gallo-Ursi 2001). As a result of global concern for the population, a workshop was organised by the Seaduck Specialist Group in Estonia in November 1996. From this meeting, an action plan was developed for the species in Europe (Schäffer and Gallo-Ursi 2001). In the Baltic, regularly wintering concentrations occur in Finland (Åland Archipelago, <200), Estonia (mostly the Vilsandi National Park, maximum 5,800) and Lithuania (coast north of Palanga, maximum 2,000), with less than 50 elsewhere. Although the species has long be known from the Baltic, there was a dramatic increase in wintering numbers during the early 1990s, followed by a recent equally rapid decline (Figure 2.2). Simple modelling shows that the increase and subsequent decrease in the population can be explained by changes in reproductive success over the period, suggesting the major changes in numbers are the results of factors operating at stages of the life cycle other than the winter.

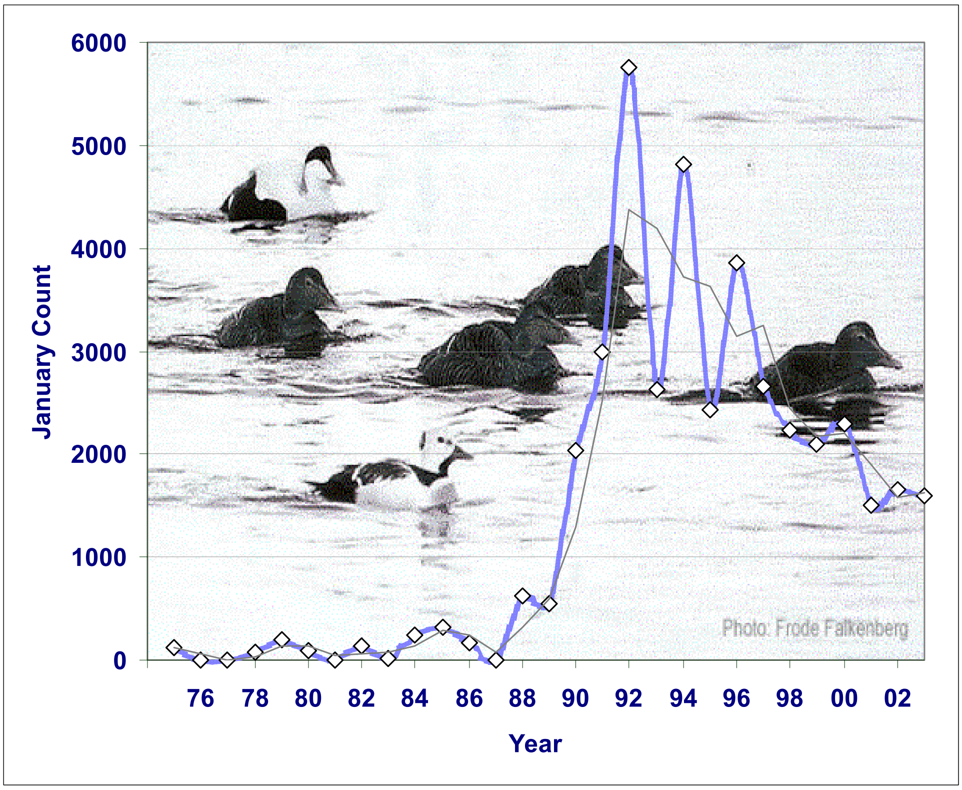

Figure 2.2. January counts of Steller's eider from Estonia 1975–2002. Thick line indicates actual totals, thin line the two year moving average. Data courtesy of A. Kuresoo, Institute of Botany and Zoology.

2.2.3 Black scoter

The Western Palearctic black scoter population is currently estimated to number 1.6 million individuals, and the population in the region is considered stable. However, the current levels of monitoring are not adequate to provide a good indicator of significant changes in distribution and abundance. Many of the large concentrations of this species stay well off shore, out of sight from land, and necessitate expensive aerial or ship based survey to adequately count. In response to the perceived threat from the construction of wind turbines offshore, the WI Seaduck Specialist Group held a workshop in Denmark in 2000, at which a full review of our knowledge of this and the velvet scoter was undertaken. The results of that workshop confirmed that our knowledge of these species was lamentably poor, and that our basic knowledge of distribution and abundance was very poor. It was clear that assessment of numbers from land based observations were totally inadequate for monitoring numbers, and that ship and aerial survey were necessary, especially to locate all the birds present and to describe numbers and distribution with appropriate spatial accuracy.

2.3 References

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3 COMPARISON OF SEABIRD COMMUNITIES AND PREY CONSUMPTION BETWEEN EAST AND WEST NORTH ATLANTIC

3.1 Introduction

This chapter is a continuation of the process initiated in the previous meeting when estimates of seabird population sizes and their consumption were made for the different ICES fishing areas (ICES CM 2002/C:04, sections 2 and 3). The preliminary results showed that the total population of seabirds (adults and immatures) in ICES fishing areas amounted to approximately 92 million individual seabirds, and that their consumption was around five million tonnes per year.

Whereas we can here present a comparison of the seabird communities breeding on both sides of the North Atlantic, it was decided that the discussion concerning prey consumption should be carried over to the next meeting. Considerable progress was made in modelling prey consumption in the NAFO convention area, but the huge numbers of seabirds and seaducks that enter and/or pass through the various subareas at different times of the year complicated the calculations considerably. Neither time nor data were available to be able to finish this modelling by the end of the meeting. A very rough estimate of a total consumption by seabirds and seaducks in the NAFO convention area of 5.5 million tonnes was generated. Although it is emphasised that this figure should be considered as a preliminary estimate only, it is similar to the five million tonnes estimated for the ICES areas. However, during the process of calculating the NAFO total, we became aware of caveats in the calculations that need to be addressed prior to detailed comparisons being made.

3.2 Seabird breeding populations in the NAFO convention area

3.2.1 Methods and data sources

The populations are presented as numbers of breeding pairs and as number of individuals including immature birds. The latter was estimated using a classification of whether the species lay single or multiple-egg clutches, and empirical calculations based on breeding pairs (bp) (single-egg species: no. of immatures = (bp x 0.7) + (bp x 0.7); multi-egg species: number of immatures = (bp x 0.6) + (bp x 1) (see Barrett *et al*. (2002) for methods).

The estimates of numbers presented are primarily of birds breeding on islands and the immediate coast and feeding at sea in the six NAFO subareas (Figure 3.1). Surveys of breeding sites have been carried out at irregular intervals especially at the northern colonies and are not necessarily up to date. There are uncertainties regarding the size of the breeding populations for huge colonies where more detailed censuses would be needed. For NAFO subareas 0, 2, 3, and 4 data were obtained from the Atlantic Canada Seabird Colony Database, maintained by the Canadian Wildlife Service, Atlantic Region, Sackville, New-Brunswick (currently maintained by J. Chardine, pers. comm.) and the Banque Informatisée des Oiseaux Marins du Québec (BIOMQ), held by the Canadian Wildlife Service, Québec Region, Ste-Foy, Québec. Additional references and the original source of many of the older data include Brown *et al*. (1975) and Lock *et al*. (1994).

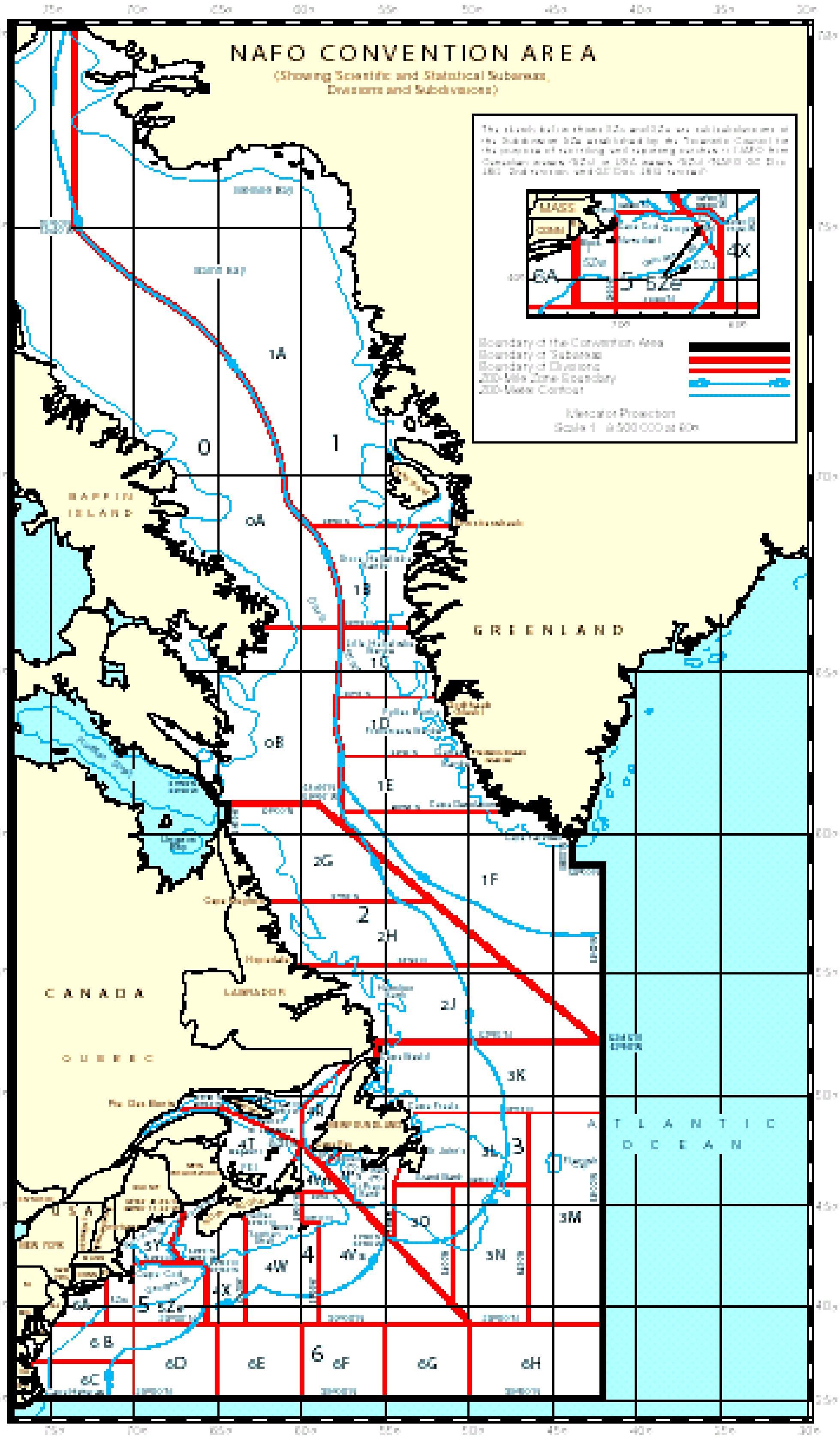

Figure 3.1. Map of NAFO convention subareas.

For western Greenland subarea NAFO 1, most of the data are from Boertmann *et al*. (1996), Boertmann and Mosbech (1998), Falk and Kampp (2001) and the Greenland Seabird Colony database maintained by the Department of Arctic Environment at the National Environmental Research Institute, Roskilde, Denmark (D. Boertmann). For breeding populations in NAFO 5 and 6 most information was found in Andrews (1990), Hoopes *et al*. (1994) and Nisbet (1995).

3.2.2 Results

Approximately 41 million pairs of seabirds (33 species, including the common eider) are estimated to breed within the NAFO subareas (Table 3.1). The total biomass is estimated at 18,000 t (Table 3.2). Including immature birds, the total number is approximately 141 million individuals weighing a total of 30,000 t.

The largest seabird colonies are in northwestern Greenland, eastern Newfoundland and southern Labrador. Approximately 34.8 million pairs (84% of total) of seabirds breed in western Greenland and on eastern Baffin Island (NAFO 0 and 1). Eighty percent of the total NAFO population are little auks (33 million pairs) breeding in northwestern Greenland.

Approximately 5.6 million pairs of seabirds breed in eastern Labrador and Newfoundland (NAFO 2 and 3), about 560,000 pairs breed in the Gulf of St. Lawrence and Scotian Shelf (including Bay of Fundy) (NAFO 4). Finally, ca. 400,000 pairs breed at the southeastern Atlantic cost from Maine to Virginia (NAFO 5 and 6).

The proportion of auks among the breeding seabirds is high in the northernmost subareas (NAFO 0 and 1) (Table 3.3). In numbers the proportions are 80% and 99% respectively for NAFO subarea 0 and 1, and by biomass the proportions are 83% and 97% respectively. In eastern Labrador and Newfoundland (NAFO 2 and 3), the proportion of auks by numbers is only 16%, but by biomass 62%. Both numbers and biomass proportions of auks drop rapidly further south from 17% and 12% respectively in NAFO 4, to 0% by numbers and biomass in NAFO 6.

The proportion of gulls among the breeding seabirds show a reverse trend with 70% by numbers in NAFO 6 to 5% or less in the northernmost subareas NAFO 0, 1 and 2. Terns show the same trend in relative abundance as the gulls, but are less abundant.

Pelecaniformes (cormorants and gannets) tend to be concentrated in the middle part of this north-south gradient where they are most abundant (approx. 20% by number) in NAFO 4 and 5.

Table 3.1 Species composition and numbers of seabirds breeding in the NAFO convention subareas.

	0	1	2 and 3	4	5	6	Total of pairs	Total of individuals including immatures
	E Baffin Island	W. Greenland	NF and Labrador	St. Lawrence and Scotian Shelf	Gulf of Maine and Georges Bank	S. Maine to Virginia		
Northern fulmar	162,000	80,000	60				242,060	871,416
Manx shearwater			100				100	360
Leach's storm-petrel			4,512,000	50,600	19,000		4,581,600	16,493,760
Petrels total	*162,000*	*80,000*	*4,512,160*	*50,600*	*19,000*	*0*	*4,823,760*	*17,365,536*
Northern gannet			24,500	54,000			78,500	282,600
Great cormorant		2,200	200	6,100	50		8,550	30,780
Double-crested cormorant			300	56,600	34,200	2,500	93,600	336,960
Pelicaniformes total	*0*	*2,200*	*25,000*	*116,700*	*34,250*	*2,500*	*180,650*	*650,340*
Common Eider	10,000	13,500	20,000	55,000	26,000	20	124,520	448,272
Seaducks total	*10,000*	*15,700*	*45,300*	*228,300*	*94,450*	*5,020*	*124,520*	*448,272*
Sabine's gull		100					100	360
Black headed-gull		20	10	10	1		41	148
Lesser black-backed gull		10					10	36
Laughing gull					1,570	95,000	96,570	347,652
Ring-billed gull			6,500	33,400			39,900	143,640
Herring gull		10	42,200	67,900	55,000	51,000	216,110	777,996
Iceland gull		32,000					32,000	115,200
Glaucous gull	1,000	13,000					14,000	50,400
Great black-backed gull		4,200	3,500	19,800	20,000	11,000	58,500	210,600
Black-legged kittiwake	56,700	105,000	81,600	86,200			329,500	1,186,200
Gulls total	*57,700*	*122,200*	*85,100*	*106,000*	*20,000*	*11,000*	*786731*	*2,832,232*

Table 3.1 continued.

Gull-billed tern						500	500	1,800
Caspian tern			30	10		10	50	180
Royal tern						5,800	5,800	20,880
Sandwich tern						25	25	90
Common tern			3,100	34,500	8,500	39,000	85,100	306,360
Forster's tern						5,000	5,000	18,000
Least tern					1,500	7,900	9,400	33,840
Roseate tern				100	180	2,800	3,080	11,088
Arctic tern		51,500	4,600	1,000	1,700		58,800	211,680
Black skimmer					10	4,200	4,210	15,156
Terns total	*0*	*51,500*	*4,600*	*1,100*	*1,890*	*7,000*	*171,965*	*619,074*
Common guillemot		500	563,000	55,200			618,700	2,103,580
Brünnich's guillemot	870,000	347,500	12,000	500			1,230,000	4,182,000
Razorbill	50	4,000	15,000	16,400	50		35,500	120,700
Black guillemot	10,000	40,000	15,000	4,900	2,800		72,700	247,180
Little auk	500	33,000,000					33,000,500	112,201,700
Atlantic puffin		1,500	303,700	21,300	150		326,650	1,110,610
Auks total	*10,500*	*33,041,500*	*318,700*	*26,200*	*2,950*	*0*	*35,284,050*	*119,965,770*
Grand total	1,110,250	33,695,040	5,607,400	563,520	170,711	224,755	**41,371,676**	**141,881,224**

Table 3.2. Numbers and biomass of seabirds breeding in NAFO subareas.

	0	1	2, 3	4	5	6	Total
No. of breeding pairs (10^6)	1.1	33.7	5.6	0.6	0.2	0.2	41.4
Number of indiv.* (10^6)	3.8	114.6	19.1	1.8	0.6	0.7	140.6
% by number	3	81	14	1	<1	<1	100%
Biomass of breeders (10^3 t)	2.1	11.7	2.3	1.3	0.4	0.2	18.0
Biomass of indiv.* (103 t)	3.5	19.0	3.9	2.4	0.8	0.4	30.0
% biomass	12	64	13	7	2	1	100%

*Including immature birds

Table 3.3. Relative species composition of seabirds breeding in the NAFO subareas as % of total number and total biomass of breeding pairs for each subarea.

Species composition % by number	0	1	2 and 3	4	5	6
Petrels	14.6	0.2	80.5	9.0	11.1	0.0
Eiders	0.9	0.0	0.4	9.8	15.2	0.0
Pelicaniformes	0.0	0.0	0.4	20.7	20.1	1.1
Gulls	5.2	0.5	2.4	36.8	44.9	69.9
Terns	0.0	0.2	0.1	6.3	7.0	29.0
Auks	79.3	99.1	16.2	17.4	1.8	0.0
% by biomass						
Petrels	12.6	1.1	19.3	0.4	0.4	0.0
Eiders	2.1	0.5	3.8	18.6	27.0	0.0
Pelicaniformes	0.0	0.1	6.8	43.5	26.7	3.5
Gulls	2.5	1.7	7.9	24.9	44.6	88.1
Terns	0.0	0.1	0.1	0.6	0.6	8.4
Auks	82.7	96.5	62.1	11.9	0.6	0.0

3.3 Populations of non-breeding migrants to the NAFO convention area

3.3.1 Methods and data sources

Large numbers of migrants or visitors visit NAFO 1, 2 and 3, 5 and 6 and numbers vary considerably throughout the year. Censuring such migrants is difficult because they are very mobile and disperse over vast and remote stretches of ocean. As a result, existing estimates of the numbers of seabirds visiting these areas are imprecise.

Most of the information about their numbers is derived from Brown (1986), Diamond *et al*. (1986, 1993) Rowlett (1980), Powers (1983), Buckley and Buckley (1984), Clapp and Buckley (1984), Merkel *et al*. (2002), Mosbech and Boertmann (1999), Boertmann and Mosbech (2002), Nisbet (1995) and Montevecchi (unpubl.).

3.3.2 Numbers entering NAFO 5 and 6

In the southern part of the NAFO convention area, the avian community is overwhelmingly dominated by non-breeding migrants. In the northeastern United States (NAFO 5 and 6), the number of non-breeding migrants entering the waters from outside NAFO is estimated to be around 5.7 million individuals (Table 3.4), a little more than four times the total breeding population (1.3 million individuals, Table 3.2). The non-breeders are even more dominant in terms of biomass (4,000 tonnes of visitors compared to 1,200 tonnes of breeders). The bulk of these migrants consist of two shearwater species and a species of storm-petrel from the Southern Oceans which enter northern waters after their breeding season in the southern hemisphere. In addition, the inland-breeding ring-billed gull, and five species of seaducks that breed in inland portions of Canada during the boreal summer come down to the sea outside the breeding season.

Table 3.4 Estimates of numbers of migrant seabirds (when >1000 indiv.) that breed outside NAFO subareas but enter NAFO 5 and 6 (Maine to Cape Hatteras). Source Nisbet (1995).

	Population (individuals)	Biomass (t)
Red-throated diver	29,700	53
Great northern diver	58,300	175
Slavonian grebe	50,000	20
Red-necked grebe	20,850	10
Divers and grebes total	*158,850*	*258*
Black-capped petrel	1,500	<1
Cory's shearwater	22,935	34
Great shearwater	1,902,500	2100
Sooty shearwater	412,500	322
Audubon's shearwater	6,660	2
Wilson's storm-petrel	597,144	24
Petrels total	*2,943,239*	*2483*
Long-tailed duck	233,200	186
Black scoter	58,300	64
Surf scoter	116,600	152
Velvet scoter	102,025	132
Red-breasted merganser	58,300	41
Seaducks total	*510,125*	*575*
Red-necked phalarope	252,500	8
Grey phalarope	240,000	10
Phalaropes total	*492,500*	*18*
Pomarine skua	11,660	10
Arctic skua	1,668	1
Skua total	*13,328*	*11*
Bonaparte's gull	58,300	9
Ring-billed gull	1,500,000	600
Other gulls	1000	5
Gulls total	*1,559,300*	*614*
Terns total	*1266*	*4*
Grand total	5,678,608	3,963

Petrels

Great shearwaters breed on Tristan da Cunha and Gough Islands in the South Atlantic Ocean and spend their winter in the North Atlantic. Population estimates are on the order of 5–10 million breeding pairs (Williams 1984), and the majority of these probably visit the NAFO subareas for at least part of the season. By far the largest concentrations occur on Georges and Grand Banks, although smaller numbers appear east to Western Europe and north to Iceland. This is the most numerous seabird in the United States Atlantic EEZ waters. Diet of great shearwaters consists of schooling fishes such as sand launce, herring and menhaden, euphausiids and squids. Sooty shearwaters breed mainly in the southeast Pacific, but there are relatively small and inadequately censured colonies in the Falklands and on islands off the southern end of South America. Like great shearwaters, sooty shearwaters concentrate on Georges and Grand Banks, where they feed on fishes, squids and euphausiids.

Seaducks

The numerically dominant seaduck off the eastern United States is the long-tailed duck, with a population of some 300,000 birds wintering on the Nantucket Shoals, where they feed on pelagic amphipods. Almost as numerous, but spread over a much larger area are the shellfish-eating species of scoters. Red-breasted mergansers feed on schooling fishes, especially sand launce, and are most numerous over the shoal waters between Cape Cod and Cape Hatteras.

Gulls

Ring-billed gulls breed at inland locations, and the largest colonies are on islands in the Great Lakes and have dramatically expanded their numbers and breeding range during the 20th century. Whereas they are undeniably one of the most abundant seabirds in eastern North America, much of their food is obtained on land. In winter, however, their population is aggregated at the coast and over inshore waters; they are rarely encountered more than about 10 km offshore. The largest concentrations of ring-billed gulls are found from Long Island south to Cape Hatteras.

Estimates of abundance for these non-breeding species is complicated by their mobility. For example, individual great shearwaters probably forage over the entire continental shelf from Cape Hatteras to Newfoundland on their northward migration, so might be counted several times by the separate surveys conducted off Chesapeake Bight (Rowlett 1980), New England (Powers 1983) and Atlantic Canada (Brown *et al*. 1975). Nevertheless, we made estimates of numbers by summing estimates of abundance across regions. The result for great shearwaters, nearly two million birds across these areas in June-August, seems unlikely to be an overestimate, given the estimated breeding population of approx. 10 million birds in the South Atlantic colonies.

3.3.3 Numbers entering NAFO 0, 1, 2 and 3

Huge numbers of seaducks and Brünnich's guillemots spend a large part of the year in the northern NAFO 0, 1, 2 and 3 subareas but do not breed there.

Southwestern Greenland (NAFO 1) is an important wintering area for common eider, king eider and harlequin ducks that breed in the eastern Canadian Arctic and also for long-tailed ducks and other ducks that breed inland. An estimated 825,000 ducks that breed outside NAFO spend an estimated seven months of the year in NAFO 1 (Table 3.5).

Table 3.5. Estimates of numbers of migrant seabirds that breed outside NAFO subareas but enter NAFO 0, 1, 2 and 3.

Species in Southwest Greenland (NAFO 1)	Individuals	Biomass (tonnes)
Mallard	10,000	11
Common eider	400,000	652
King eider	300,000	480
Harlequin duck	10,000	7
Long-tailed duck	100,000	70
Red-breasted merganser	5,000	5
Total	825,000	1,225
Brünnich's guillemot (in NAFO 0, 1, 2 and 3)	4,000,000	3,992
Grand total	4,825,000	5,217

There are large Brünnich's guillemot colonies with about 575,000 pairs west of the NAFO subareas in the eastern Canadian Arctic. The approximately two million individuals related to these colonies spend most of the year within the NAFO convention area especially in the wintering subareas off Southwest Greenland (NAFO 1) and Newfoundland (NAFO 3) as determined by ringing recoveries. SW Greenland and Newfoundland are also important wintering grounds for the approximately one million pairs of Brünnich's guillemot breeding in Svalbard and northern Norway, and probably also for the 579,000 pairs that breed in Iceland. These 1.58 million pairs that breed in ICES waters correspond to approximately 5.4 million individuals and it is estimated that of these Brünnich's guillemots breeding in the ICES subareas, two million spend the winter in the northern NAFO subareas. So in total about four million Brünnich's guillemot visit the NAFO subareas during winter.

Missing from this analysis are ducks that breed in Canada outside the Arctic and which come down to the sea to winter, and arctic-breeding seaducks which enter the Gulf of St. Lawrence (NAFO 4) for the winter. These will be addressed later.

3.4 Population estimates of seabirds breeding in the ICES subareas

3.4.1 Introduction

This section follows from the review made in the last report (ICES CM 2002/C:04). It presents a further breakdown of the population estimates in a format that facilitates a direct comparison to be made between the data for ICES and NAFO subareas.

Table 3.6. Species composition of seabirds breeding in the ICES subareas as % of total number and biomass in each subarea (extracted from ICES CM 2002/C:04)

Species composition	I,IIa,IIb	Va,XIVa,b	IVa-c,VIId,e	IIIa-d	Vb,VIa,b,f,g,j	VIIIa-c, IXa,X
% by number	Barents and Norwegian Seas	East Greenland and Iceland	N. Sea and English Channel	Baltic Sea and approaches	Faeroes and western UK	France, Iberia and Azores
Petrels	9	15	12	0	41	64
Pelecaniformes	<1	<1	4	7	5	1
Eiders	2	3	2	40	<1	0
Gulls	16	6	40	41	14	30
Terns	1	2	4	8	<1	4
Auks	70	73	38	4	39	<1
% by biomass						
Petrels	12	21	12	0	30	61
Pelecaniformes	2	2	16	16	22	3
Eiders	6	8	3	60	<1	0
Gulls	14	6	30	21	11	36
Terns	<1	<1	1	1	<1	1
Auks	65	62	38	2	37	<1

3.5 Comparison of seabird communities in ICES and NAFO subareas

3.5.1 Breeding populations

Approximately 40 million pairs of seabirds breed in the NAFO subareas compared to ca. 27 million pairs in the ICES subareas. However, the total biomass of seabirds that breed in the western North Atlantic (ca. 30,000 t) is only about half that in the northeast North Atlantic (ca.60,000 t (ICES 2002)). This is due to the huge numbers of the small-sized little auks and Leach's storm-petrels which dominate NAFO 1 and NAFO 2 and 3 respectively (Table 3.1).

Auks dominate the seabird community breeding on both sides of the Atlantic. In Western Greenland (NAFO 1), 33 million pairs of little auks comprise ca. 80% of total breeding population and ca. 65% of total biomass of all seabirds in the NAFO subareas. In the ICES subareas, Atlantic puffins, little auks, common and Brünnich's guillemots make up 22%, 18%, 9% and 9% (by number) of the total populations. In biomass, the contribution by little auks falls to 5% while that of the larger species is between 13–16%. As in the western Atlantic, the majority (>70%) of the ICES auks breed in the northernmost subareas, north of the 5° C July isotherm.

The procellariiforms are also very unevenly distributed, with a dominance (60–65% by numbers and biomass) in the southern part of the ICES subareas (VIIIa-c, IXa and X – mostly Cory's shearwaters) and 80% by number but only 20% by biomass in Newfoundland and Labrador (NAFO 2 and 3). The reduction in difference between regions by biomass is due to the small size of the Leach's storm-petrel (it weighs ca. 50 g) that dominates the NAFO population by numbers. Northern fulmars and Manx shearwaters also made up large proportions of numbers (41%) and biomass (30%) of the seabirds breeding in the Faeroes and the western borders of the UK and Ireland. Fulmars are also very numerous on Iceland (ICES Va, estimated to be 1.5 million pairs).

The pelecaniforms (cormorants, shags and gannets) seem to be more important in certain NAFO subareas (NAFO 4 and 5 where they make up 20% by number and 30–45% by biomass respectively) than in any ICES subarea. In the eastern North Atlantic they constitute only 5–7% by number and 16–22% by biomass in the areas encompassing the North Sea and Channel (IVa-c, VIId,e) and the Faeroes and western UK (Vb, VIa,b,f,g,j) (Table 3.6).

Constituting 40% and 41% by number and 60% and 21% by biomass of the population, eiders and gulls respectively dominate the seabirds breeding in the shallow, inland Baltic Sea and its approaches (ICES III). Approximately 45% of all the ICES eiders (ca. 1 million pairs) breed in subarea III. Eiders also reach their largest proportions (10% and 15% by number and 19% and 27% by biomass in the inshore NAFO subareas 4 (St. Lawrence and Nova Scotia) and 5 (Gulf of Maine and Georges Bank) respectively. In these same subareas gulls constitute ca. 40% by number and 25–45% by biomass.

The only subarea in the NAFO and ICES areas where gulls dominate the seabird community is NAFO 6 (south Maine to Virginia). Of nearly 250 000 pairs of seabirds in this subarea, 70% are gulls (mainly laughing gulls and herring gulls). They and terns make up nearly the entire community (88% and 8% of the total biomass). In the groupings of ICES subareas used in this report, gulls make up 6–40% of the numbers and 6–36% of the biomass. Nowhere do terns constitute >10% of the numbers or 1% of the biomass.

3.5.2 Overall populations

The major difference between the seabird communities in the NAFO and ICES areas is the huge influx of auks, petrels and shearwaters into the NAFO areas from populations that breed outside the Convention area. Preliminary estimates show that this influx involves more than seven million individuals. There is no movement of auks, petrels and shearwaters into ICES on this scale of numbers, and indeed there is some movement out of the ICES areas by birds that breed there.

Conversely, whereas at least an additional 1.3 million seaducks enter NAFO waters from outside (and this figure is likely to rise significantly when seaducks breeding in eastern Canada are considered), there are probably much larger numbers of seaducks entering ICES areas. For example, numbers of seaducks wintering in the Baltic Sea alone (ICES III) are estimated to be in the order of 10 million individuals. In addition, there are movements of large numbers of seaducks into ICES waters from both within and outside ICES areas (e.g., eastern Barents Sea and Pechora Sea).

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4 MARINE PROTECTED AREAS FOR SEABIRDS IN THE ICES AREA

4.1 Introduction

Marine protected areas (MPAs) for seabirds in European waters are currently being established under various international instruments. The functions of such areas are diverse but broadly, they aim to protect and conserve seabird diversity within them. If MPAs are an appropriate mechanism to achieve this then at the very least they should:

a) afford protection to seabird populations from damaging human activities. Depending on the nature and use of the site by seabirds, protection here might address all, but more likely some, biological requirements of the birds; and
b) ensure the effective conservation of habitats and associated biological processes that are important to seabird populations.

The extent to which MPAs are an appropriate mechanism to achieve these aims is debatable. Certainly in the marine environment, seabirds, almost by definition, are widely dispersed organisms that often exploit highly mobile prey. They frequently cross territorial boundaries and EEZs, and in many cases wander over vast areas of the high seas. The degree of clustering is not correlated to the range of distribution, however. From the knowledge available to date, seabirds exhibit scale dependencies mainly below 50 km (Hunt and Schneider 1987, Skov *et al.* in prep.) If the scale at which oceanographic or other processes govern seabird distribution patterns is large, then the conservation of these patterns and processes may be addressed still through the MPA mechanism via the establishment of a network of protected sites. However, there might well be scales of seabird occurrence that can only be addressed via wider conservation measures. Such might be the case when the scale of threat or perceived threat to seabird populations is very large in relation to the scale at which seabirds are distributed. For example, certain effects of fisheries on seabirds may occur at a scale spanning major ocean systems, a scale at which MPA establishment within territorial waters or even an EEZ would be wholly inappropriate. The corollary of course is that very localised threats to localised concentrations of seabirds might best be addressed via an MPA.

Clearly, the interaction between the scale of threat to seabird populations (whether they be local, biogeographic or greater – another question of scale), and the scale at which they might be compromised by damaging activities must be considered carefully when deciding on the most appropriate practical conservation measures. This applies as much to temporal variation in scale as it does to spatial variation. Rarely will a generic solution be applicable. A related consideration is that the size of the MPA should be appropriately determined with regard to the reasons for designating it, and also to ensure its future integrity and effective management. In addition, a further practical consideration is that an MPA should be designated only if it has acquired a degree of social and political acceptability; unless such a sense of ownership prevails then management of the MPA becomes ineffective.

Various legal mechanisms provide for the designation of MPAs for seabirds. Both "hard" legislation, which is legally binding upon states and enforceable through courts of law, and "soft" legislation, usually multilateral treaties and agreements which carry less legal threat, exist. In the ICES area, OSPAR and HELCOM fall into the latter category, while the EC Birds Directive falls into the former.

4.1.1 OSPAR

OSPAR is the international Convention for the protection of the marine environment of the north-east Atlantic. *Inter alia*, OSPAR seeks to establish MPAs in this region. These aim to:

- protect, conserve and restore species, habitats and ecological processes that are adversely affected as a result of human activities;
- prevent degradation of and damage to species, habitats and ecological processes, following the precautionary approach; and
- protect and conserve areas that best represent the range of species, habitats and ecological processes in the OSPAR area.

The criteria for selection as an OSPAR MPA include consideration (based on the best available scientific knowledge) of whether the area:

- is important for species, habitats/biotopes and ecological processes that appear to be under immediate threat or subject to rapid decline;
- is important for other species and habitats/biotopes;

- has a high proportion of a habitat/biotope type or a biogeographic population of a species at any stage in its life cycle;
- has important feeding, breeding, moulting, wintering or resting areas;
- has important nursery, juvenile or spawning areas;
- has high natural biological productivity of the species or features being represented;

- has a naturally high variety of species or includes a wide variety of habitats/biotopes;
- contains a number of habitat/biotope types, habitat/biotope complexes, species, ecological processes or other natural characteristics that are representative for the OSPAR Area as a whole or for its different biogeographic regions;
- contains a high proportion of very sensitive or sensitive habitats/biotopes or species;
- has a high degree of naturalness, with species and habitats/biotope types still in a very natural state as a result of the lack of human-induced disturbance or degradation.

4.1.2 HELCOM

The 1992 Convention of the Helsinki Commission (HELCOM) aims to protect the marine environment of the Baltic Sea from all sources of pollution, and to restore and safeguard its ecological balance. In 1995, 62 Baltic Sea Protected Areas (BSPAs) were classified. Millions of seabirds use these areas during migration and more than 30 species breed in them. Many of them are already accorded some degree of protected status and, in the relevant countries, have been nominated for inclusion in the EU NATURA 2000 network (as SPAs).

Protection in BSPAs aims particularly at species and natural habitats with a view to the conservation of biological and genetic diversity, and ecological processes. The objects of protection in BSPAs are *inter alia*:

- areas of high biodiversity,
- habitats of endemic, rare or threatened species and communities of fauna and flora, and
- habitats of migratory species,

with additional guidelines for BSPAs for their size, their naturalness, the extent to which they remain pollution-free and whether they are a representative ecological functional entities for a Baltic Sea area or State.

4.2 EC Birds Directive

The principal international legal instrument that provides for the establishment of protected areas for birds in Europe is the European Community Council Directive on the Conservation of Wild Birds (79/409/EEC), the ‘Birds Directive’. Article 4 of the Birds Directive requires Member States to classify the most suitable territories (in number and size) for the protection and conservation of species of wild birds that are listed on Annex 1 of the Directive, and of regularly occurring migratory species not listed on Annex 1 – so called Special Protection Areas (SPAs). The selection of SPAs should take into account the protection requirements of these birds in the geographical sea and land area of the European territory of the Member States.

When considering measures for the protection and conservation of species, including the establishment of SPAs, Member States should take account of:

- species in danger of extinction;
- species vulnerable to specific changes in their habitat;
- species considered rare because of small populations or restricted local distribution; and
- other species requiring particular attention for reasons for the specific nature of their habitat.

Seabird species (i.e., species which at least partly live at or from the sea) currently listed on Annex 1 of the Birds Directive are: Red-throated diver, black-throated diver, great northern diver, Slovenian grebe, Zino's petrel, Fea’s petrel, Bulwer’s petrel, Cory’s shearwater, Balearic shearwater, little shearwater, white-faced storm-petrel, European storm-petrel, Leach’s storm-petrel, Madeiran storm-petrel, the Mediterranean subspecies of the European shag, Mediterranean, Slender-billed and Audouin’s gulls, Caspian, sandwich, roseate, common, Arctic and black terns and the Iberian subspecies of the common guillemot. The Directive does not define “migratory species”, and the definition used in practice is that provided by the Bonn Convention, which defines migratory species as being species where a significant proportion of the population cyclically and predictably crosses one or more national jurisdictional boundaries. The "European Territory of the Member States" is not defined in any EC Directive, but we assume here that the provisions of the Birds Directive will pertain in the marine environment out to 200 nautical miles from a baseline, usually mean low water mark, and will include the water column. While many SPAs have been classified in the terrestrial environment none, to date, has been classified as marine SPAs for the specific protection and conservation of seabirds outside territorial waters.

Although Member States have a certain margin of discretion in the choice of SPAs, their classification is nevertheless subject to rather general ornithological criteria determined by the Directive. These are:

- that they comprise the most suitable territories in number and size taking into account protection requirements of the species;
- for Annex 1 species that account be taken of such species as listed above;
- for migratory species, that account be taken of their breeding, moulting and wintering areas and staging-posts; and
- for migratory species, that particular attention be paid to wetlands, particularly those of international importance.

An additional EC mechanism that has recently accorded protection to seabird feeding areas (and so presumably to seabirds themselves) is the EC Fisheries Regulations. Breeding success of black-legged kittiwakes is sensitive to changes in their food supply within their feeding area. In some areas this is almost exclusively sandeels, the target of an industrial fishery off the east coast of Scotland. In order to safeguard populations of predators of sandeels, the fishery has been closed in that area while kittiwake breeding success remains low. The understanding was that kittiwake productivity represents an index of the well-being of sandeel-dependent predators and that areas where kittiwake productivity is low may be closed to sandeel fishing to safeguard sandeel stocks required by top predators.

4.3 Application of the Birds Directive in Member States of the EU

4.3.1 UK

The above criteria are rather general, allowing Member States to produce their own, more specific guidance for SPA selection. The guidelines for selection of a site as SPA under the Birds Directive here identify a series of selection stages in the UK:

- Stage 1.1: an area qualifies if it is used regularly by 1% or more of the Great Britain (or, in Northern Ireland, the all-Ireland) population of a species listed in Annex I of the Birds Directive in any season;
- Stage 1.2: an area qualifies if it is used regularly by 1% or more of the biogeographical population of a regularly occurring migratory species (other than those listed in Annex I) in any season;
- Stage 1.3: an area qualifies if it is used regularly by over 20,000 waterfowl or 20,000 seabirds in any season;
- Stage 1.4: an area qualifies if it meets the requirements of one or more of the Stage 2 guidelines in any season, where the application of Stage 1 guidelines for a species does not identify an adequate suite of most suitable sites for the conservation of that species;
- Stage 2: if a species' population status, ecology or movement patterns mean that an adequate number of areas cannot be identified from Stage 1 guidelines then further judgements based on the species' population size and density, range, breeding success, history of occupancy, multi-species areas, naturalness, and requirement for severe weather refuges apply (JNCC 1999, Stroud *et al.* 2001).

Although this protocol was devised for the terrestrial and coastal environments, it is also being applied as far as possible to the marine environment. The process of identifying marine SPAs may demand some modification of this, however. In the UK, three broad types of possible marine SPA have been identified, each aimed at 'capturing' different species or suites of species that require conservation measures under the Birds Directive:

- seaward extensions of existing breeding colony SPAs beyond low water mark;
- inshore areas used by birds such as seaducks, divers and grebes in the non-breeding seasons; and
- offshore marine areas, possibly used by seabirds for feeding.

In addition, a further process may be required aimed at site selection for species not captured by these three strands of marine SPA identification.

4.3.1.1 Seaward extensions to existing SPAs

To date, 87 coastal or island SPAs have been identified for breeding seabirds in the UK. As these sites are already SPAs the criteria for which they qualify as such (see above) have already been identified.

Both breeding and non-breeding seabirds use the waters immediately adjacent to their colonies for a number of activities such as displaying, washing, preening, and other maintenance behaviours, and in some cases for feeding (Tasker and Leaper 1993, Harding and Riley 2000a). Such aggregations, notably of auks, kittiwakes and gulls, have generally been found to occur within 1–2 km from the colony shore. Two studies using very spatially limited, but quite high-resolution transect surveys also indicate that auks form aggregations within 2 km from the colony shore (Furness 1983, Birkhead 1976). Wanless *et al.* (1985) used radio-tracking studies of three adult common guillemots at the Isle of May and found that these birds spent between 1–9% of their day in sea areas within 1.5 km of their nest site.

In order to identify more robustly the use made of waters around seabird colonies, fine scale surveys were conducted around six seabird SPAs in the breeding season of 2001 (McSorley *et al*. 2003). Use of waters around these colonies by seabirds was categorised into use that is independent of the habitat or other physical attributes of the site (non site-specific use) and use that is probably highly dependent on the habitat characteristics of the site (site-specific use). In the latter category lies foraging behaviour; there is some evidence to suggest that concentrations of feeding birds are associated with environmental factors such as bathymetry, substrate type and tidal and other fronts (Wanless *et al.* 1997, Begg and Reid 1997). The locations of food sources of seabirds are likely to be dependent on such habitat features, so the pattern of occurrence of feeding aggregations of seabirds, whether around or away from the colony, can therefore be site-specific.

By contrast, concentrations of seabirds on the sea around colonies engaged in behaviours such as display, preening, bathing and other body maintenance activities, may be said to be distributed in a non site-specific way. Given that the locations of such concentrations do not depend on the physical or biological characteristics of the site, the general pattern of occurrence may be generalised to other sites. That is to say the distances from the colony at which non site-specific behaviours occur (perhaps the nearest point of access to the sea from the breeding site) are probably the same or similar for all colonies. Spatial interpolation of the distribution data for four seabird species (those for which sufficient data were collected during the surveys) indicated that existing SPAs classified for Atlantic puffin, common guillemot and razorbill should be extended by 1 km from the colony into the sea. Such extensions 'capture' the great majority of birds engaged in non site-specific behaviours; Figure 4.1 depicts a typical distribution for common guillemot.

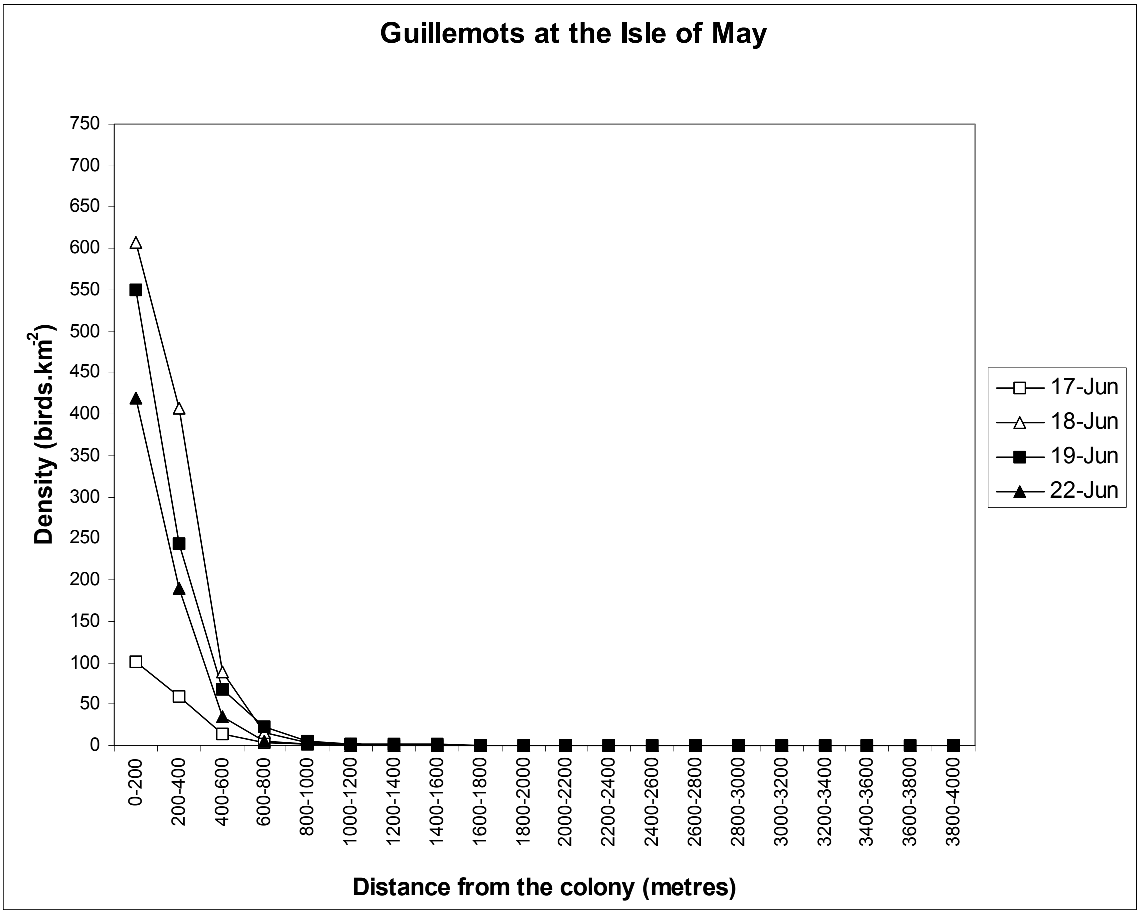

Figure 4.1. Mean modelled density of non-foraging common guillemots (birds.km^{-2}) in 200 m distance bands, at the Isle of May on 17, 18, 19 and 22 June 2001.

Similarly, these analyses indicate that extensions of 2 km into the sea at each of the existing SPAs for northern gannet would result in inclusion of the great majority of individuals of this species into these SPAs (Figure 4.2).

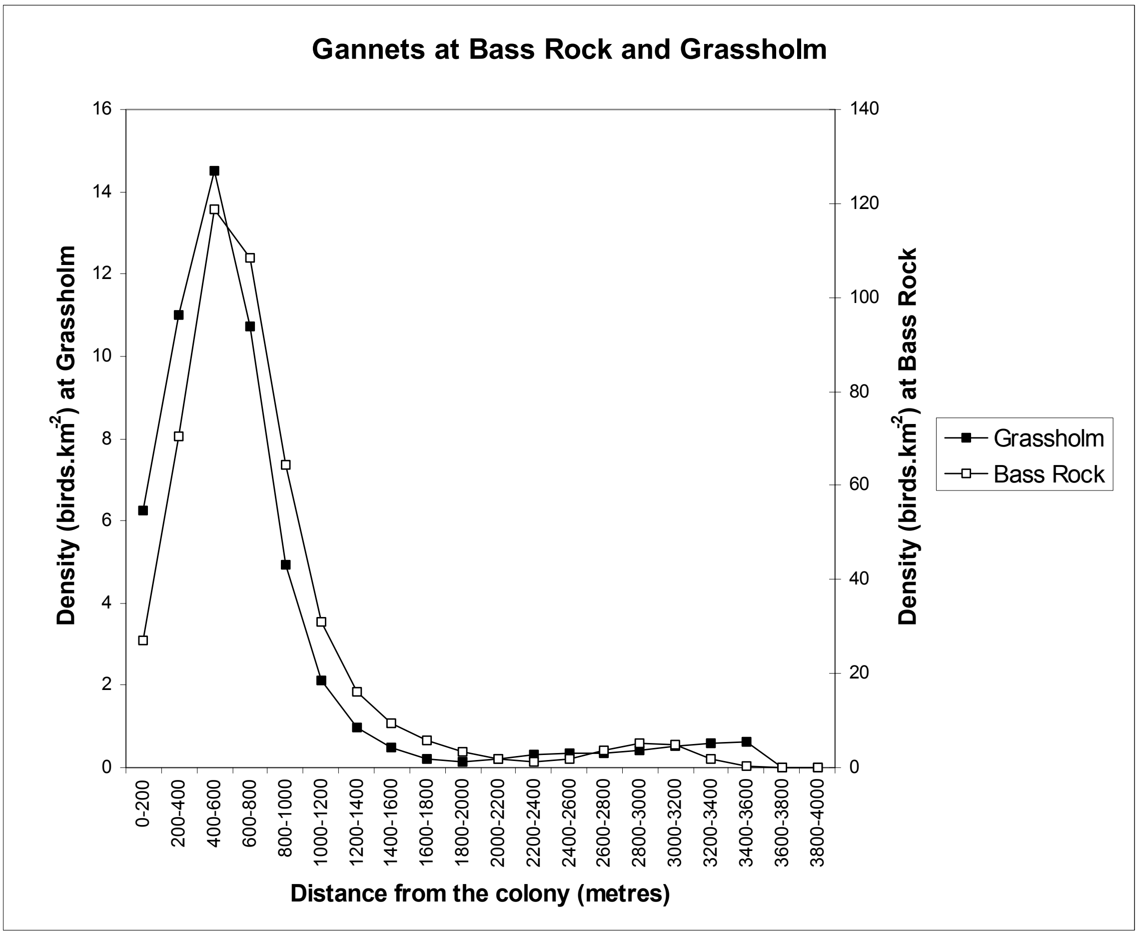

Figure 4.2. Mean modelled density of non-foraging northern gannets (birds.km^{-2}) in 200 m distance bands, at Bass Rock (21 June) and Grassholm (23 June).

Recommendations for extensions into the sea of existing (terrestrial) SPAs for these four species will soon be made to the UK government. The data for another three species from these surveys, while not sufficient to allow robust spatial interpretation, strongly indicate that extensions of 1 km into the sea would be sufficient to capture the majority of individuals engaged in non site-specific use of the waters adjacent to colonies by the following species: European shag, northern fulmar and black-legged kittiwake. Extensions of SPAs for these species and other large gull species is the subject of ongoing work.

4.3.1.2 Inshore areas used by birds such as seaducks, divers and grebes in the non-breeding seasons

In contrast to seaward extensions of existing SPAs, where the SPA guidelines have already been applied to site identification, identification of inshore areas for non-breeding season concentrations of birds in the marine environment requires new application of the guidelines. To this end, the presumption prevails that the best available data should be used.

Several dozen possible inshore SPAs have been identified and for the most part these await consideration with respect to the SPA guidelines. While a strategic approach is being adopted to identify a suite of inshore SPAs and to recommend generic criteria for site identification and boundary definition, work on this issue has begun with one particular site that demanded urgent classification. The black scoter is a migratory species of seaduck, so sites selected for this species qualify as SPAs at Stage 1.2 of the guidelines where they hold 1% of the biogeographical population as defined in Rose and Scott (1997). Stroud *et al.* (2001) indicated that any site in the UK that regularly hosts more than 16,000 individual black scoters qualifies as a SPA. Numbers of black scoter in Carmarthen Bay, Wales (Figure 4.3), were found to exceed 16,000 during land-based counts during December 1994 and January 1995, three separate counts in January 1999, one count in October 1999 and again in November 1999, one in January 2000, two in January 2001 and in one count in February 2002. The mean peak count in the five winters between 1997 and 2002 exceeded 16,000 birds. Based on this evidence, Carmarthen Bay clearly qualifies as a SPA using the established guidelines (Stroud *et al.* 2001).

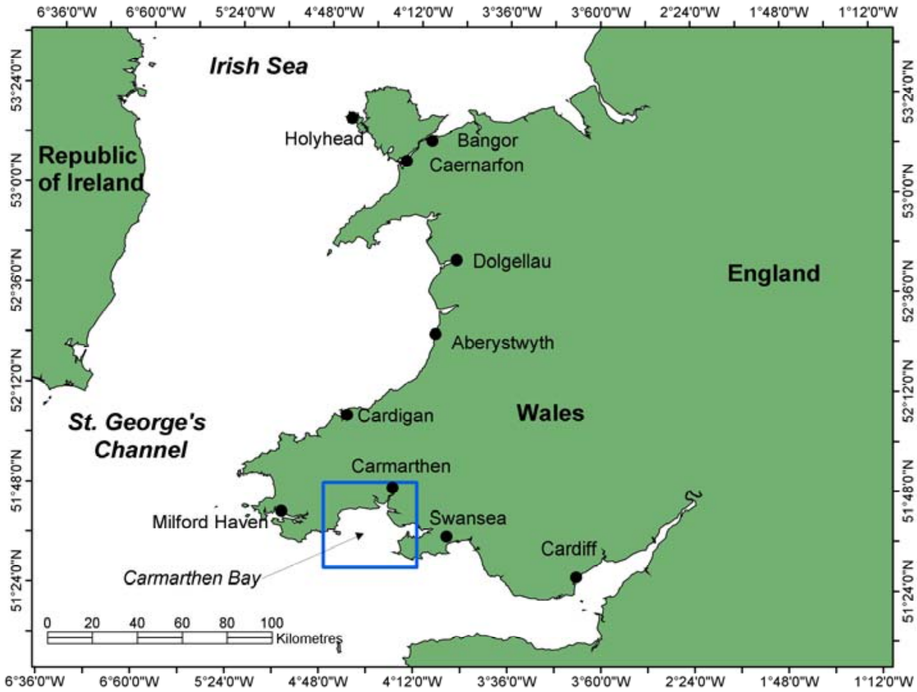

Figure 4.3. The location of Carmarthen Bay, Wales.

While Carmarthen Bay qualifies as an SPA, the definition of the seaward boundary of the site required to be made. The issue here demanded a solution that did not compromise the formulation or future application of generic guidelines for boundary identification of inshore SPAs. The best available survey data of the site comes from three aerial surveys of seaduck, divers, grebes and other seabirds conducted from October to February during the 2001/02 winter. Surveys were conducted using a line transect sampling method that takes account of detection probabilities of bird species and allows estimation of their abundances using Distance software (Buckland *et al.* 2001, Borchers *et al.* 2002).

Again, scoter density across the site was modelled by applying spatial interpolation tools to the aerial survey data. Various options for boundary determination were presented that ensured qualifying levels of black scoter were included (Webb *et al*. 2003; Figure 4.4). The boundary ultimately accepted was one defined by parallels and meridians that included those interpolation points that represented the highest 95% of modelled density values. This might function as a criterion for boundary selection at other inshore sites but requires further consideration in the light of analyses to be conducted at those sites.

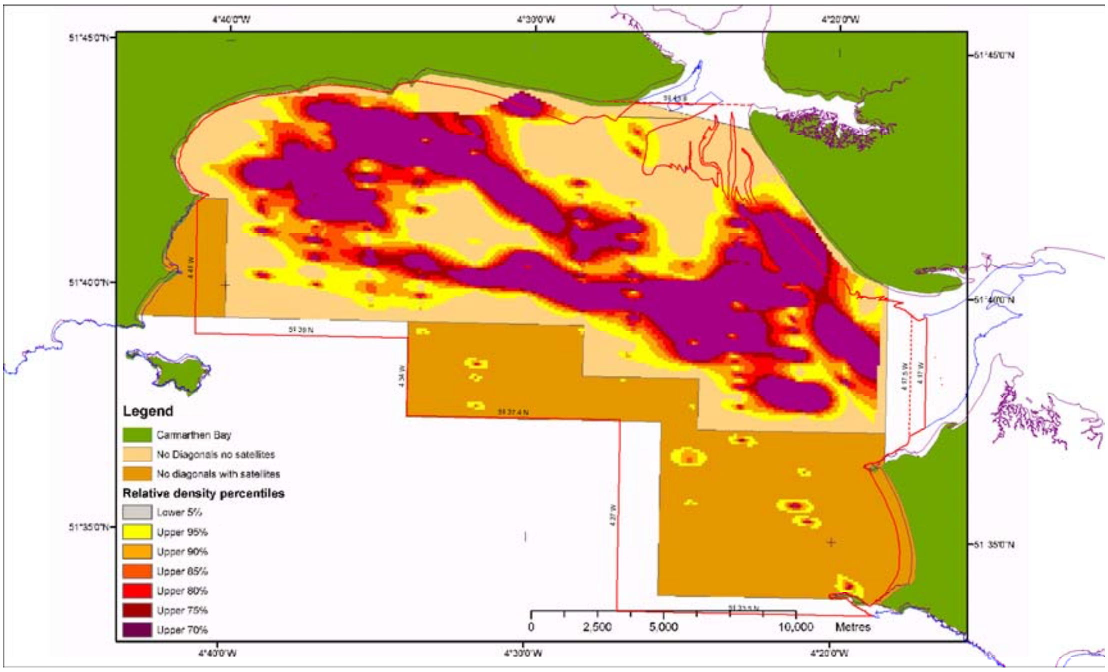

Figure 4.4. Modelled densities of Black Scoter in Carmarthen Bay.

4.3.1.3 Offshore marine areas, possibly used for feeding

SPAs in inshore areas and seaward extensions of existing seabird colony SPAs fall within territorial waters of the UK (i.e., within 12 nm of the coast). To date, no member state of the EU has designated SPAs outside territorial waters. Data on the distribution of seabirds at sea in all north-west European waters (contained in the European Seabirds at Sea database) will be analysed with a view to possibly identifying SPAs in the offshore environment. This approach, however, begs questions of scale that will require careful consideration; the application of the Marine Classification Criterion (MCC; Skov *et al.* in prep.) will inform the procedure (see Section 4.4). Identification of possible offshore SPAs holds the potential for a major collaboration between different Member States of the EU.

4.3.1.4 Consideration of other areas for species not 'captured' by other categories of marine SPA

Clearly, several important populations of seabird will not be captured by the above approach. For example, inshore feeding concentrations of terns, nearshore 'rafts' of Manx shearwaters and possible colony extensions for gulls require further consideration. Such issues are the subject of special surveys or research under way or planned such as aerial and onshore surveys of the dispersion of terns in selected areas, further breeding season surveys at-sea off gull colonies, and radio-tracking of Manx shearwaters off Skomer.

4.3.2 Germany

Germany declared its EEZ in November 1994. Since this area does not belong to the German territory, designations depended for a long time on the interpretations of international rules/laws/conventions as it was unclear whether SPAs can be designated outside the territory. Furthermore, it was not until April 2002 that it was possible to designate SPAs in the EEZ also because of national legislation. At that time, the national law for Nature Conservation was changed in which the responsibilities for the designation of marine protected areas was clarified. The Federal Agency for Nature Conservation is responsible for the rules of selecting potential protected areas whereas the Federal Environmental Ministry is responsible for the designation/submission to the European Commission.

The situation for marine protected area designation is complicated in Germany. In general, nature conservation is under the responsibility of the Federal States. Since the national territory stops at the 12-nautical-mile-zone, the German part of the North Sea is now divided into responsibility of the Federal State of Lower Saxony (within the 12-mile-zone, southern part), the Federal State of Schleswig-Holstein (within the 12-mile-zone, northern part) and the Central

Government (for the EEZ). In the German Baltic, there are responsibilities allocated to the Federal State of Schleswig-Holstein (within the 12-mile-zone, western part), to the Federal State of Mecklenburg-Vorpommern (within the 12-mile-zone, eastern part) and the Central Government (for the EEZ). This complicates the procedure of selecting suitable areas as the process is not well coordinated between the different governmental units and also because these regions are not easily manageable regions (e.g., the EEZ in the Baltic is more or less a small strip in some German areas). Furthermore, due to legislation, the Federal States have started designating SPAs according to the Birds Directive already a few years ago, the first area being announced in October 1997. Under strong time pressure set by the Central Government, two projects dealt with marine protected areas for seabirds in Germany last year. Schreiber (2003) developed criteria for applying the EU Birds Directive to seabirds and coastal birds in German North and Baltic Sea waters. Garthe (2003) applied these criteria to the data available on seabird distribution and developed suggestions for marine SPAs. These suggestions are currently (March 2003) under consideration at the Federal Environmental Ministry (T. Merck pers. comm.).

Schreiber (2003) presented a catalogue of species whose occurrence in German waters has to be considered for the selection of SPAs. First, species of Annex I of the Birds Directive have to be taken into account, second, migratory species occurring regularly. From this list, it was derived which species occur regularly in German “offshore” waters. That way, 19 species for the North Sea and 33 species for the Baltic Sea were considered for the selection of SPAs according to the Birds Directive in the EEZ. Furthermore, these species were weighed by several factors such as threat, population size, type of aggregation etc. (Schreiber 2003). Then, for these species, especially those exhibiting major concentrations, it was recommended to select the most important area or a few of the most important areas to be selected as SPA proposals. The 1 % criterion did not play a major role. Garthe (2003) used the work by Schreiber (2003) as a baseline to figure out the most important areas for the species listed for both the North and the Baltic Sea. Different approaches were used for the two seas. In the Baltic, almost all species ranked high by Schreiber (2003) exhibit (dense) concentrations in restricted areas. The occurrence of these species was modelled by geostatistical methods. The data were analysed spatially by the ordinary kriging procedure based on semi-variograms (e.g., Cressie 1991, Skov *et al.* 2000). The distribution models were then analysed species by species to define a minimum density describing best a concentration. From these minimum densities, the locations of valuable concentrations were defined for all species. These concentrations were then overlaid by GIS to derive areas to be possibly protected (very similar to the selection of Important Bird Areas, see Skov *et al*. 2000). Only one area located to a major extent in the EEZ of the German Baltic Sea was then further taken into account (Garthe 2003). In the North Sea, the most relevant species do not show such dense concentrations as the most relevant species in the Baltic so that analysis of area suitability has been done to a major extent based on classic grid maps (e.g., Stone *et al.* 1995). Furthermore, recent data from aerial surveys were not available in the short time frame in a common data format so they had to be worked with as literature data. The list of species’ priority was worked down and from that a relatively large area in the eastern German EEZ was found to best fulfil the requirements of a SPA. This area satisfied the requirements for most species according to the list by Schreiber (2003). No further area was found to hold concentrations/populations of birds in sufficient quantify to support a further SPA proposal in the German North Sea EEZ. There are, however, additional needs according to the procedure described above to designate further SPAs in the three coastal Federal States of Germany (Garthe 2003).

4.3.3 Denmark

A total of 540,000 ha (55% of the total SPA area) of marine (below mlw) waters has been designated as SPAs (*c*. 30 sites) in Denmark. The selection of SPA sites in general was based on one or both of the following criteria:

a) breeding sites of at least one Annex 1 Birds Directive species;
b) sites that are staging or wintering areas for at least 1% of the flyway population of one or more migratory species.

Sites are protected primarily through a 1994 Executive Order that sets up rules for the administration of the Danish SPAs. SPAs (below mlw) have been selected primarily for seaducks and terns.

4.4 Application of marine protected areas for seabirds in countries outside the EU: Norway

A protection plan for marine areas in Norway is currently being prepared but has not yet been implemented. An advisory committee appointed by the Ministry of Environment reported their preliminary recommendations in February 2003. The report is currently out for review, and protection of the areas on the final list will be established in 2004 at the earliest. The criteria used to identify such areas include assessments of their representiveness, distinctive characteristics, vulnerability, level of threats, and their value as reference areas, with special emphasis on the first two. Seabird data have not been considered in any detail for this work, which has mainly been based on measurements of the species diversity of benthic invertebrates. It is, however, pointed out that a number of the largest areas of shallow waters along the coast are included on the list, that these are the most productive in terms of algae and benthic organisms and, therefore, important foraging areas for coastal fish and seabirds. However, to what degree this judgement is correct has not been assessed by seabird expertise.

Over the past three decades, most of the largest seabird colonies in Norway have been legally protected through the implementation of regional (county by county) protection plans for coastal areas or by specific protection plans for seabird cliffs. However, the adjacent sea areas are not always included in the protected areas, and in most cases only include a very narrow sea zone (probably more because they were found to be most easily defined on the map by drawing a polygon delimited by nearby islets and rocks than on the basis of the seabird communities' actual protection needs). Also, several types of protection levels have been used, and even within such groups the regulation of human activities differs between areas. The criteria used to identify the areas now protected have also varied between different regions, and no assessments have been made to ensure that protection of these areas is sufficient to comply with the SPA and MPA standards.

4.5 Scientific consideration of selecting marine protected areas

There are many political issues that affect the process of selecting and designating marine protected areas involving seabirds. This stands in some way in contrast to the outline given by OSPAR (see chapter 4.1). Currently, the EU legislation is setting the background from which each country seems to work independent of each other. Sudden political changes create time pressures that can preclude international collaboration. Such trans-national collaboration would be needed from an scientific point of view to account for the marine environment being the underlying system to which seabirds respond (this stands in contrast to migratory landbirds which just cross the sea and do not respond specifically to hydrographic or bathymetric features). A recent example is the process of selecting SPAs in German North Sea waters. The SPA proposal is part of a bigger area which can considered one hydrographic system to which birds respond. This is also evident from the fact that this area was selected as an Important Bird Area years ago (Skov *et al.* 1995). Thus, the border between Denmark and Germany is not a natural break in the distribution pattern of seabirds, and thus does not allow for a thorough consideration of the whole area. There are many more examples from other areas where political boundaries run through concentrations of seabirds.

An important criterion to designate SPAs for waterbirds on land is the 1 % level of the respective biogeographic population of a species as given by the Ramsar Convention. Whereas this is rather straightforward for terrestrial and coastal sites having obvious hydrological and/or physical boundaries, such boundaries are less obvious at sea. One major aspect is the rather unlimited size of some habitats at sea. In order to compensate for area size, Skov *et al.* (in prep.) developed the Marine Classification Criterion (MCC). The MCC combines (a) the size of the area, (b) the proportion of the total population and (c) the degree of concentration. It is defined as the estimated number of birds within an aggregation, divided by the total population, and then multiplied by 100, divided again by a quotient of the area of the aggregation and the maximum size of an important area (supporting 1 % of a population). Since there is hardly any information on the home range or spatial extent of activity of single individuals or local concentrations, it is not straightforward to derive the maximum size of an important area. Modelling results within a range of 1000–3000 km^2 for that maximum size indicated however that the selection of the globally important areas for seabirds with clustered distributions is robust (Skov *et al.* in prep.). In combination with the MCC it might thus be possible to apply the 1 % criterion for the identification of concentrations of seabirds of international importance.

Although the EU provides an important legislative background by the Bird Directive as well as the Habitats Directive, it has to be critically evaluated whether these Directives fulfil their objectives to protect seabirds. Of course, not all countries in the ICES area are members of the EU so that the Directives do not apply for large areas, especially in the North and West of the ICES area. From a species point of view, there are no gaps as all seabirds can be considered migratory species so that this part of the Birds Directive applies. The protection of the different functions of seabird aggregations / distributions at sea is hardly dealt with as can be seen from the national examples given above. Most areas tend to be just lines around areas with high densities of the respective species. However, when for example picking just three out of the best five areas per country, it might happen that some areas with certain functional importance (e.g., moulting, roosting, resting, feeding) are not covered. Also, seasonal aspects have to kept in mind; the area in the eastern EEZ of the German North Sea is of major importance for red-throated divers in its northernmost part only in spring but in its southern part also in winter (Garthe 2003). The extension of SPAs around colonies in Britain does not take into account any foraging activities and areas required by seabirds for this, though this issue will be addressed in the future (see above). Such foraging activities may reach as far as several hundred km from the colonies in species such as the northern gannet (Hamer *et al.* 2000). It would be difficult to include such extensive foraging areas into a SPA perspective, and the benefits to seabirds would be debateable. However, most species have much shorter foraging ranges, especially terns and auks (e.g., Pearson 1968, Garthe 1997; see Section 4.1 for consideration of scale).

Another major issue which needs further consideration is the spatial variability of seabird distributions. Especially this is an issue for birds targeting mobile prey (mostly pelagic prey), but also to some extent birds feeding on benthic prey show high variability in distribution. In other words, due to the mobile prey usually being associated with hydrographic features that can be quite variable in nature, some species have strongly varying concentrations, with key aggregation in certain areas. Thus, in order to design fixed boundaries, it is necessary to analyse the variability and predictability of hydrographic features and other mechanisms controlling distributions of seabirds.

If protected areas, whatever type they belong to, should act as a useful tool, then they have to protect all species to a certain degree. Currently, the SPA designations do not involve any automatic restrictions on the use of the marine environment. Restrictions of anthropogenic exploitations (e.g., fisheries, gravel extraction) have to be installed step-by-step. New plans for exploitation of the sea, such as the establishment of marine wind-farms, can be allowed if an EIA does not find any significant adverse effects. Realizing all these shortcomings in the SPA concept, it is worth considering whether different protective measures might protect seabirds to a greater extent. For example, fisheries have to be managed at a larger scale and in a way that minimizes harm to top predators such as seabirds through processes such as localized depletion of prey resources (Furness 1999, 2002, Rindorf *et al.* 2000) or from by-catch (e.g., Kirchhoff 1982, Stempniewicz 1994).

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5 AN ASSESSMENT OF PROGRESS IN MEASURING IMPACTS OF MARINE WIND FARMS (MWFS) ON SEABIRDS

Synopsis: At least 13,000 turbines are currently planned in North East Atlantic marine waters, although only ten marine wind farms with in total 163 turbines are operating worldwide (3 in Sweden, 4 in Denmark, 2 in the Dutch Ijsselmeer and 1 only 1 km off the Northumberland coast, UK; http://www.offshorewindfarms.co.uk/else.html).

The critical impact on seabirds likely to exist from MWFs results from risks of deaths by collision with turbines, but other effects resulting from flight avoidance, habitat modification, feeding displacement and disturbance are also key issues of concern. However, to date the existing projects have provided very little or no information on actual collision mortality and limited information on displacement/avoidance effects. This section reviews the number and extent of currently planned developments. In order to assess collision risk, it is essential to determine bird flight patterns at different spatial and temporal scales. First, the patterns of migration need to be described on a large scale, to identify particularly important areas and corridors used by flying birds to assess the potential numbers at risk. Next, there is a requirement to understand the factors affecting the height trajectories taken by flying birds, that may put particular species at risk of collision with turbines. Finally we need to integrate weather, visibility, diurnal and seasonal patterns into these assessments, since bird flight behaviour is determined by these factors. The study of bird flight patterns has achieved major advances in the last year, so detailed results of recent investigations are presented here. In contrast, little progress has been made with measuring real collision rates, although there has been progress in developing techniques to achieve this, particularly developing remote sensing infrared video monitoring mechanisms and the use of vibration detectors. Although the construction of the large MWF at Horns Rev in western Denmark was completed in the past year, the extremely low densities of seabirds in this area have meant no information relating to bird displacement has been forthcoming from the project. However, its operation has provided data on the levels of maintenance activity associated with each turbine, which helps predict the general levels of disturbance likely to be associated with routine operational maintenance at such facilities. Mitigation mechanisms are offered as a means of reducing collision risks and disturbance effects. However, generally their effectiveness in reducing conflicts remains untested. The energetic consequences of MWF creating a barrier effect or causing disorientation to flying birds are briefly considered. More effort needs to be directed towards developing methodologies to assess the cumulative impacts and effects of all MWFs on bird populations, against a background of increasing development pressure on coastal and marine areas.

Since bats cross the North and Baltic Seas in considerable numbers and since they are known to collide with wind turbines, too, the considerations made here are generally valid for them as well.

5.1 General introduction

Leading on from the review undertaken in the last report of WGSE (ICES CM 2002/C:04), our starting point is that the erection of wind farms in marine waters can affect birds in many ways and at different spatial scales. Generally, however, the predicted effects fall into the following four main categories:

1) Mortality through collisions with wind turbines (which have planned heights up to 180 m above the water)
2) Energetic costs incurred by flight avoidance and barrier effects caused by construction (since some marine wind farms will comprise as many as 3000 turbines)
3) Effective habitat loss through displacement effects (i.e., effective net habitat loss, e.g., caused by avoidance of man-made objects, or the result of increased ship and helicopter traffic during the construction and maintenance of the farm)
4) Hydrographic and physical habitat modification, which includes habitat loss as well as habitat alterations in the course of wind farm construction and maintenance (generally of minimal importance given the restricted areas affected)

In addition, with so many MWFs planned in European waters, it is becoming increasingly important to consider the cumulative effects of multiple developments on birds. Rather than just consider the local effects of individual wind farm construction, it is essential when considering long distance migratory organisms that we ask what are the impacts, at the population level, of construction activities at many sites along the flyway of a bird population?

Throughout the discussion, it is important to differentiate between “effects” of MWFs (generally spatial avoidance, disturbance, etc.) and their “impacts” at the populations level (i.e., that cause changes in reproductive success or survival rate to regulate or limit population number). In considering these impacts, it is also important to understand the population dynamics of a given population in order to assess the consequences of impacts on the population level. In this general context, displacement effects will be expected to be less serious for a population than direct mortality (e.g., through collisions). However, even in this context, it is important to consider additional mortality in the context of the demographics of the seabird population concerned. For instance, additive mortality in a long-lived organism with low reproductive rate may have immediate consequences for population size, yet the same level of mortality will potentially have little effect on short lived birds as their population may be able to compensate by increased reproductive output.

These categories listed above offer the basis for assessment of the risks involved, which in turn shape the environmental impact assessments and the monitoring activities that naturally follow. The study of these effects can be effectively aggregated under common headings (e.g., guidelines for German MWFs: Hüppop *et al*. 2002):

1 and 2. Collision risk/flight avoidance

(a) base-line

- radar investigations to study flight paths (altitude, speed, direction, intensity, local concentrations) of all flying birds and predict collision risk
- visual and infrared observations / flight call recordings to study the number and species of all flying birds

(b) post-construction

- radar investigations to study migration volume, avoidance behaviour and trajectories post-construction

- visual observations / flight call recordings to study flight behaviour post-construction
- on-site monitoring to quantify collision rates

3. and 4. Habitat modification/displacement effects

(a) base-line

- transect studies/spatial modelling to describe the distribution of seabirds at sea prior to construction
- experimental studies of the effects of ship and/or helicopter traffic

(b) post-construction

- transect studies to describe the distribution of seabirds at sea during and post-construction

Cumulative impacts

A Wind Farm Sensitivity Index (WSI) has been developed for a range of seabird species potentially affected by offshore wind farm development in the southern North Sea that can also be used to assess site sensitivity (Garthe and Hüppop in prep.). This approach scores nine parameters relating to species vulnerability: flight manoeuvrability, flight altitude, percentage of time flying, nocturnal flight activity, disturbance by ship traffic, flexibility in habitat use, bio-geographic population size, adult survival rate and European threat and conservation status. Species showed strongly differing sensitivity index values: black-throated and red-throated diver ranked most sensitive, followed by velvet scoter, eider and red-necked grebe; lowest sensitivity values were calculated for black-legged kittiwake, black-headed gull and northern fulmar. In all seasons, coastal waters in the south-eastern North Sea scored higher vulnerability than waters further offshore. On the basis of the derived frequency distribution of WSI scores, the authors suggest using WSI to group proposed MWF sites with regard to birds into three categories: sites of low concern, sites of some concern and a sites of major concern.

However, the estimation of cumulative effects for species is still being tackled at present, and requires further development. As a minimum, the total number of birds killed must be determined (i.e., at all sites) and related to total population size. The habitat loss issue requires some assessment in a top-down approach that assesses the number of wind farm developments, their geographical distribution and overlap with seabird distributions to assess the degree of conflict in time and space through the annual cycle of any one species. Viewed bottom-up, there is a need to quantify the impacts of wind farm construction (i.e., through displacement from favoured feeding area) on the fitness of an individual (perhaps using body mass as a proxy measure) to understand how multiple effects potentially impact at population level. In the case of collision, the measurement of actual mortality rates, in the context of the known demographic parameters for a population, will enable an assessment of the impacts at population level. However, displacement and disturbance will pose more challenges and may require more indirect approaches, such as modelling, using body condition as currency to measure costs of lost foraging opportunities, and ultimately effects on fitness.

5.2 Present status of planned or erected at-sea farms in Europe and North America

OSPAR recently compiled a database of MWFs situated within the North East Atlantic area covered by OSPAR, which includes information such as location, name, operator, size, distance from coast and current status. In total, there are plans for developing 61 different sites, amounting to almost 13,000 turbines in Belgium, Denmark, Germany, The Netherlands, Sweden, Spain, and UK, with the bulk in German waters (Figure 5.1). There are further wind farms planned for those parts of the Baltic Sea not covered by OSPAR. As of January 2003, based on information held on the database, 3 offshore windparks were operative in Denmark and one in Sweden, a further 5 had been authorised in Danish waters, 3 in British, 2 in German and 1 each in Belgium and Dutch waters, respectively.

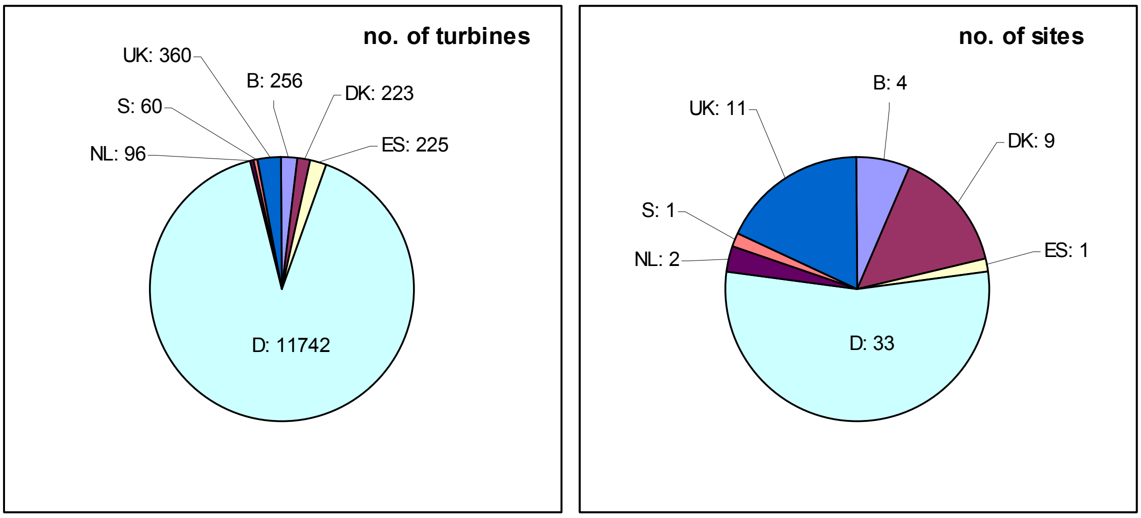

Figure 5.1. Number of sites and turbines planned or erected in the different countries within the North East Atlantic area covered by OSPAR (status January 2003). Source: OSPAR (2003). D=Germany, NL=Netherlands, S=Sweden, UK=United Kingdom, B=Belgium, DK=Denmark, ES=Spain.

Off the United States, at least three marine wind farms have been proposed. The first, consisting of 200 turbines, is planned for Nantucket Sound, about 100 km south of Boston. A second has been proposed for the Nantucket Shoals, and a third for the Atlantic Ocean south of Long Island, New York. No construction has yet begun, due mainly to objections, and threats of litigation, based on the impact of these developments on real estate prices.

5.3 Advances in knowledge of flight altitudes, trajectories, and migration intensities of the main bird species / groups in the North Sea and the Baltic Sea

Recent investigations using visual and radar observations of bird migration in the North Sea and in the Baltic Sea have increased considerably our knowledge of the flight altitudes of birds crossing the sea on migration or on foraging trips. Accurate predictions of the bird collision risk presented by MWF and ultimately the impact at the population level require such detailed information.

According to Bruderer (1971), migration altitude is influenced (within the limits set by the aerodynamic and physiological characteristics of each bird species) by secondary (external) factors, principally meteorological factors such as wind, fog, cloud conditions and precipitation, and changes in overall weather conditions. Among these, wind is of greatest importance (Alerstam 1979a). The horizontal speed of wind over the sea increases with height; directly above the water surface there is a zone of lower wind speed caused by the surface interactions with the water. Wind reaches its full force only above 500 m (Alerstam 1979b, Krüger and Garthe 2001).

Visual observations

Although visual observations are restricted to a height of 200–300 m above the water, they offer valuable information on species, (relative) numbers, group size, and flight altitude, for example in relation to wind speed. During systematic sea-watches carried out from September to November 1999 on the East Friesian island of Wangerooge, observations of the flight altitude of coastal birds were recorded in relation to wind direction and speed (Krüger and Garthe 2001). Amongst red-throated diver, common eider and black scoter, the proportion of birds flying into the wind low over the water (0–1.5 m) increased with wind speed. However, the number of low-flying birds amongst these species decreased in inverse proportion to the speed of a tail wind, flying up to 25 m above the water under certain circumstances.

The proportion of individual birds flying low into the wind was highest in red-throated diver, common shelduck, common eider and black scoter, irrespective of wind speed. This pattern is repeated at higher level in sandwich tern and common/Arctic terns. In contrast, in tail winds, the greatest proportion of birds of these species flew at the highest altitudes. Comparisons of flight altitudes reveal that the species fly noticeably higher in tail winds. This behaviour can be explained in terms of economy of effort on migration. Diurnal movement of the observed species takes place mainly at a low flight altitude (up to 25 m, occasionally up to 50 m, rarely higher) above the sea. This strongly suggests that the construction of the planned MWF will have potentially adverse effects on birds. The data indicate that, to be of any value in the assessment of the potential disturbance of the wind farms to North Sea migrants, the flight altitude records must be seen against the background of the prevailing meteorological conditions (Krüger and Garthe 2001).

Dierschke and Daniels (2003) compiled data on observations of visual migration over sea from the island of Helgoland (54° 11' N, 07° 55' E) from the years 1990 to 2001, covering 3082 hours of observation (including 1347 hours with crude estimations of flight altitudes). Divers, grebes, shearwaters, fulmars, ducks, skuas, gulls, terns and auks particularly fly close to the water surface whereas comparatively high proportions of cormorants, herons, swans, geese and waders were recorded at altitudes above 50 m (Table 5.1).

Table 5.1. Estimated flight altitudes of the major taxonomic groups based on observations of the visual migration at the island of Helgoland (southeastern North Sea) covering the lowest 200–300 m above the sea (after Dierschke and Daniels 2003)

group	n	Flight altitude <50 m	Flight altitude >50 m	Proportion (%) >50 m
divers (3 species)	3275	2995	280	8.5
grebes (3 species)	62	62	0	0.0
Procellariiformes (3 species)	31	31	0	0.0
gannets (1 species)	347	305	42	12.1
cormorants (1 species)	3383	2530	853	25.2
herons (1 species)	176	132	44	25.0
swans (3 species)	301	231	70	23.3
geese (7 species)	30089	22039	8050	26.8
ducks (6 species)	5888	4872	1016	17.3
diving ducks (3 species)	127	125	2	1.6
seaducks (5 species)	37958	37039	919	2.4
mergansers (2 species)	454	419	35	7.7
raptors (10 species)	386	320	66	17.1
waders (28 species)	8476	5347	3129	36.9
skuas (3 species)	150	144	6	4.0
Gulls (6 species)	35585	32814	2771	7.8
terns (5 species)	18464	18223	241	1.3
auks (2 species)	24	24	0	0.0

Within the altitude range from the surface up to 200–300 m covered by the visual observations, the wind direction had a considerable influence on flight altitudes. Strong headwinds led to a higher proportion of birds flying at altitudes below 50 m whereas tailwinds increased flight altitude (Figure 5.2), especially in cormorants, geese and waders.

In North America, one of the largest wind farms currently proposed is one of 200 turbines to be potentially situated over Horseshoe Shoal in Nantucket Sound, about 100 km south of Boston and 350 km northeast of New York. Approximately 300,000 long-tailed ducks have wintered in this area since about 1975 (Veit and Petersen 1993). The long-tailed ducks spend the night sitting on the water in Nantucket Sound, within 10 km of the proposed wind farm site, and commute offshore to the Nantucket Shoals, up to 60 km offshore, during the day to feed. Thus, over the course of the winter, a commuting flight of ¼ million long-tailed ducks potentially pass close to the proposed site. The altitude at which the ducks perform this commuting flight varies according to weather conditions. In calm weather, the ducks fly at about 250 m above sea level (ascertained from aircraft as well as from the ground on numerous occasions between 1979-present, R. Veit, pers. obs., Davis 1997). During strong headwinds, however, the ducks fly just above the sea surface. On any one day, provided the wind is not too strong, some birds can be seen flying at all altitudes between these two extremes. Recent aircraft surveys of Nantucket Sound (2002–2003) indicate that the long-tailed ducks do not approach closer than 5–10 km to the proposed wind farm site at Horseshoe Shoal, so despite their proclivity to fly at altitudes that could put them within the range of the spinning turbine blades, it seems unlikely that the wind farm poses a threat to the ducks.

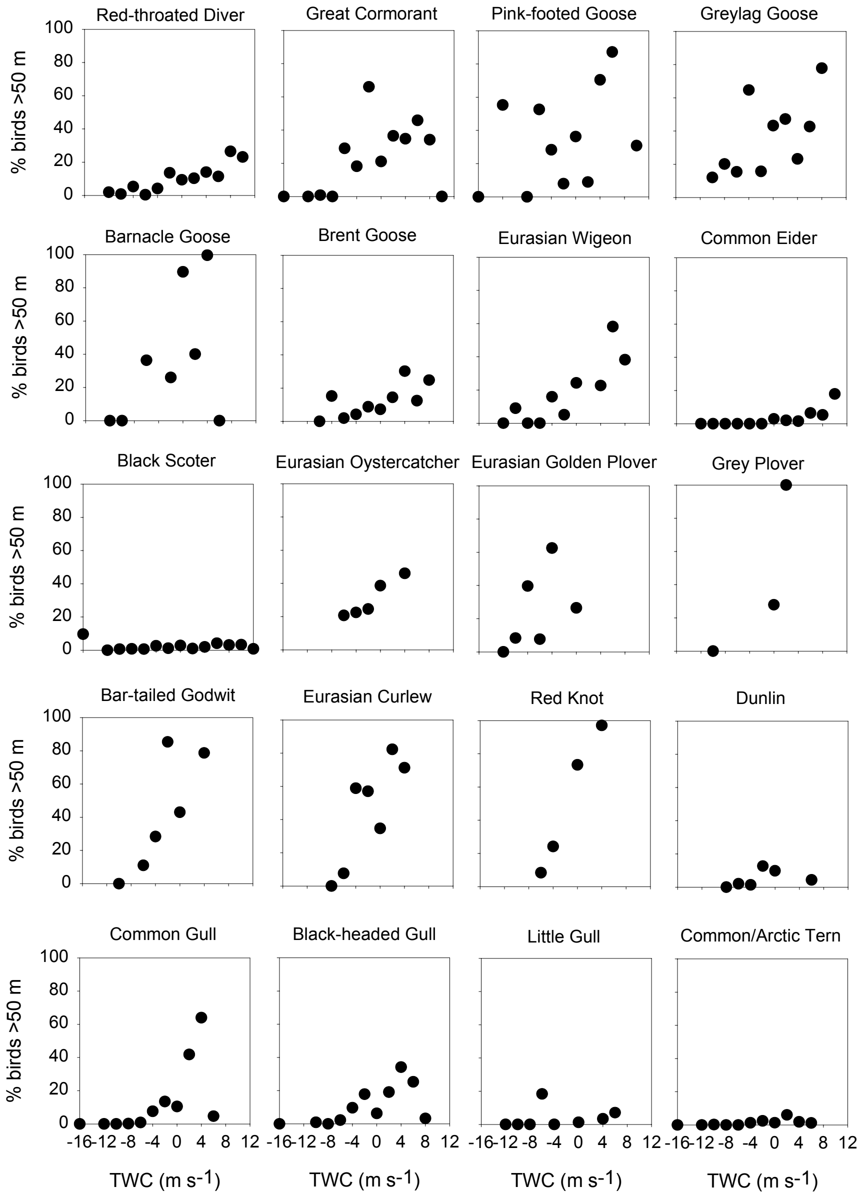

Figure 5.2. Percentages of birds flying above 50 m in relation to the tailwind (TWC) component (after Dierschke and Daniels 2003) TWC = cos (φ) · v (Fransson 1998) with φ being the angle between the flight direction of the bird and the tailwind for the respective flying bird and v being the windspeed in m s^{-1}. A high positive TWC thus means strong tailwinds, a high negative TWC strong headwinds.

In general, strong winds force birds to fly at lower altitudes (Figure 5.3).

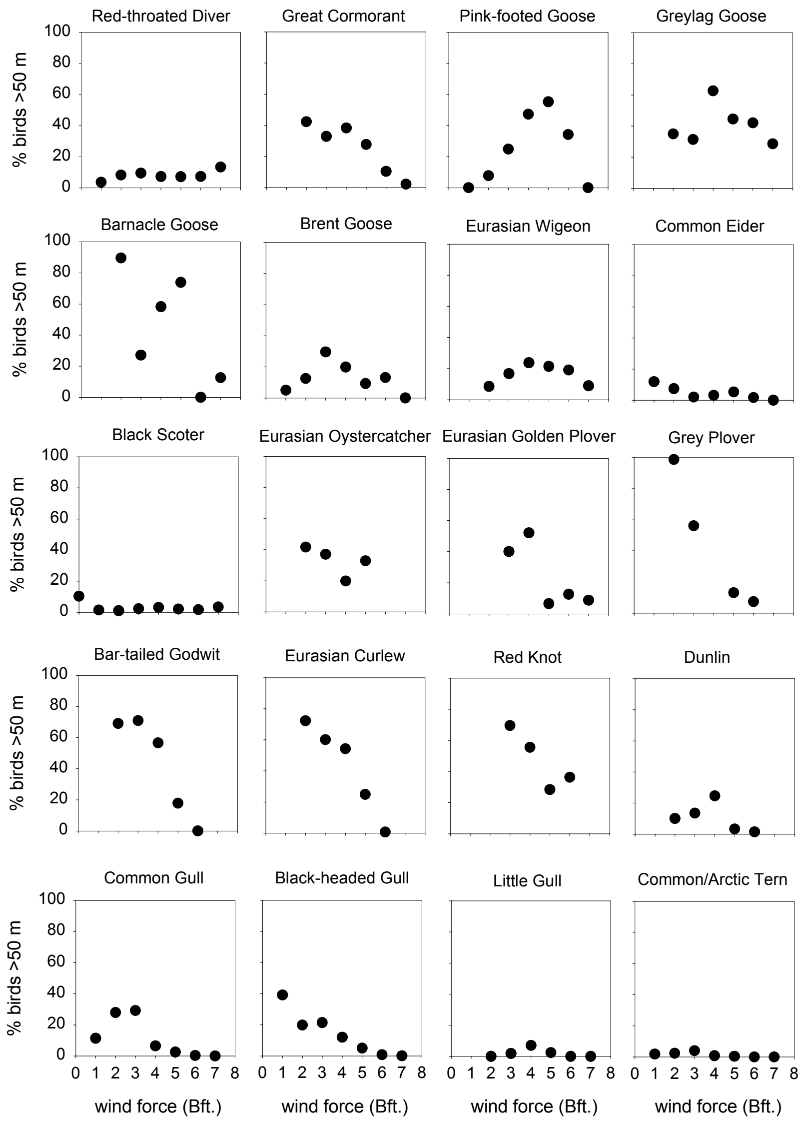

Figure 5.3. Influence of wind speed on flight altitudes in major taxonomic groups (after Dierschke and Daniels 2003).

Additional observations with special emphasis on MWFs aspects were carried out from the islands of Fehmarn and Rügen (Baltic Sea) and Helgoland in 2001 (Hüppop *et al.* 2003). Flight altitudes were estimated in finer scores. Generally five groups regarding flight behaviour could be categorised (see Table 5.2 for details):

1) Species preferably flying higher than 50 m: raptors, cranes, doves / pigeons, swifts, hedge accentor
2) Species flying mainly at moderate height (10 to 50 m): herons, larks, pipits, wagtails, thrushes, finches, corvids, starlings and buntings
3) Species flying mainly at low to moderate height (5 to 50 m): divers, northern gannet, cormorants, swans, geese, swimming ducks, diving ducks, waders, gulls, terns, swallows
4) Species flying mainly below 10 m: grebes, tubenoses, seaducks, mergansers, skuas and auks.

Again there were also significant influences of relative wind direction on flight altitudes.

Table 5.2. Altitudinal distribution of the main groups during spring and autumn migration. Bold values indicate the main category during either period. Differences between flight altitudes in spring and autumn were tested with a G-Test after Bonferroni correction (df = 3) (after Hüppop *et al*. 2003).

	spring					autumn					G-Test)	
group	n	0–5 m	5–10 m	10–50m	>50 m	n	0–5 m	5–10 m	10–50m	>50 m	G	p
divers	724	13.5	34.5	**47.2**	4.7	107	**38.3**	22.4	27.1	12.2	45.1	0.001
grebes	111	**88.3**	9.0	2.7	0.0	36	**100.0**	0.0	0.0	0.0	3.5	n.s.
Procellariiformes	0					9	**100.0**	0.0	0.0	0.0		
Northern gannet	0					149	**32.2**	31.5	32.2	4.0		
cormorants	535	20.6	23.0	20.0	**36.5**	1.005	33.1	10.2	19.7	**37.0**	56.2	0.001
herons	20	30.0	10.0	25.0	**35.0**	49	28.6	4.1	16.3	**51.0**	0.8	n.s.
swans	175	**48.0**	4.5	22.3	25.1	115	**56.5**	6.1	16.5	20.9	2.2	n.s.
geese	1.262	**34.0**	11.4	23.9	30.6	2.449	21.4	9.8	21.4	**47.4**	111.7	0.001
Swimming ducks	77	24.7	**36.3**	5.2	33.8	9.954	**34.0**	15.0	21.0	30.1	29.6	0.001
diving ducks	81	34.6	19.8	**35.8**	9.9	305	24.3	7.9	**41.6**	26.2	17.1	0.001
seaducks	19.324	36.0	**40.6**	20.5	3.0	21.633	**69.9**	21.2	7.1	1.9	4.959.3	0.001
mergansers	272	39.0	**42.7**	16.5	1.8	416	**43.3**	28.6	15.6	12.5	35.4	0.001
raptors	746	0.0	1.5	4.2	**94.4**	621	1.3	2.4	3.5	**92.8**	10.1	0.05
falcons	76	11.8	7.9	14.5	**65.8**	317	16.4	10.1	18.0	**55.5**	1.9	n.s.
crane	36	0.0	**58.3**	0.0	41.7	1.833	0.0	0.0	0.0	**100.0**	177.0	0.001
waders	825	13.5	17.6	25.3	**43.6**	25.609	3.4	0.4	1.2	**95.0**	1.863.5	0.001
skuas	0					12	**83.3**	16.7	0.0	0.0		
gulls	14.482	29.3	**51.2**	14.5	5.0	1.159	35.9	19.6	**37.9**	6.6	568.7	0.001
terns	517	15.5	**59.6**	24.6	0.4	3.123	33.4	**55.6**	9.1	2.0	135.6	0.001
auks	14	**50.0**	28.6	21.4	0.0	30	**56.7**	43.3	0.0	0.0	3.7	n.s.
doves /pigeons	1.428	0.0	0.0	16.6	**83.4**	47	0.0	0.0	40.4	**59.6**	17.3	0.001
swifts	55	0.0	10.9	**81.8**	7.3	50	0.0	10.0	**64.0**	26.0	5.6	n.s.
larks	228	3.5	9.2	21.1	**66.2**	144	0.0	16.0	22.9	**61.1**	7.7	n.s.
swallows	76	**54.0**	26.3	13.2	6.6	5.250	26.4	24.1	**32.6**	16.9	31.4	0.001
pipits and wagtails	655	3.8	17.3	**65.3**	13.6	5.891	6.4	**42.0**	25.2	26.5	412.0	0.001
hedge accentor	7	0.0	28.6	14.3	**57.1**	6	0.0	0.0	0.0	**100.0**	0.6	n.s.
thrushes	106	0.9	9.4	33.0	**56.6**	1.210	0.0	1.1	6.0	**93.0**	87.4	0.001
Corvids	58	12.0	20.7	**48.3**	19.0	265	21.9	9.4	11.7	**57.0**	47.2	0.001
Common starling	767	5.2	12.9	**52.7**	29.2	185	0.0	0.0	37.3	**62.7**	98.2	0.001
buntings	57	0.0	26.3	**68.4**	5.3	110	0.0	3.6	22.7	**73.6**	77.9	0.001
finches	423	0.0	**60.8**	38.3	1.0	4.220	0.4	14.8	34.7	**50.1**	647.8	0.001

Radar observations

In Denmark, much effort has been invested at the Rødsand site in determining migration trajectories across the planned MWF site (Desholm *et al*. 2001, Kahlert *et al*. 2002). These are predominantly in a N-S axis (terrestrial migrants) and a broadly E-W orientation (mainly eiders and geese passing in and out of the Baltic along this coastline). These studies are primarily aimed at defining predictive collision risk probabilities (in combination with flight altitudes and trajectories), but particular emphasis has been placed upon establishing baseline descriptions of the nature and volume of the migration to compare with post-construction scenarios.

In Germany, measurements have been made with vertically operating ship radars at the islands of Helgoland (North Sea), Fehmarn and Rügen (both Baltic Sea) during the main migration seasons in 2001. These revealed migrational activities from sea level up to 3800 m, which was the limit of the radar used. After correcting for the distance dependent sensitivity of the radar, a quantification of the number of echoes up to 1800 m was possible. At Helgoland more than 20 % of all birds migrate at „dangerous altitudes“ below 200 m (Figure 5.4), but this proportion exceeds 30% at Fehmarn and Rügen. In general, birds migrate in spring at lower altitudes than in autumn (Hüppop *et al*. 2003).

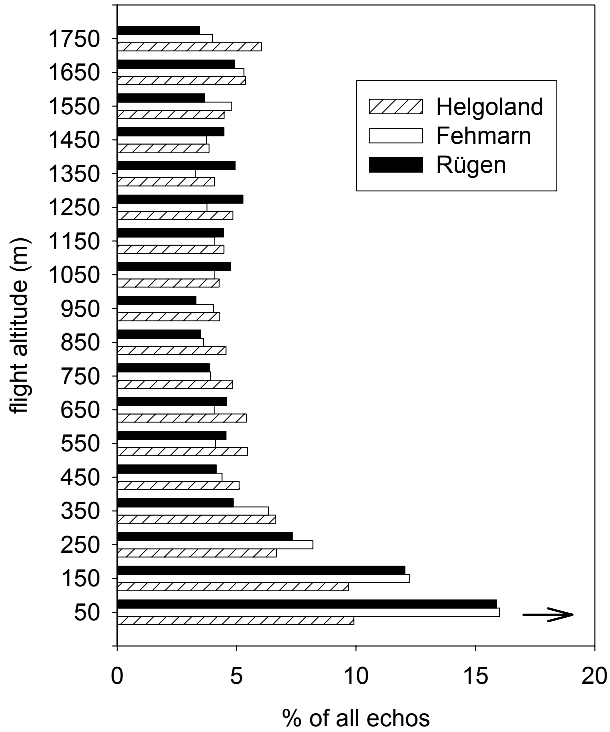

Figure 5.4. Flight altitudes (% of all echoes) in 100m-intervals based on vertically rotating shipradar measurements in the North Sea (Helgoland) and in the Baltic Sea (Rügen and Fehmarn). N = 45.857 echoes. The arrow indicates an underestimation of the lowest height class due to birds that fly close to the water surface and that are hence "invisible" to the radar (after Hüppop *et al*. 2003).

Flight altitudes were lowest during the afternoon, they increased immediately after sunset and reached highest values two hours after sunset. Afterwards they decreased again and stayed at lower values throughout the second half of the night (Figure 5.4). Although the birds tend to fly higher during the night (when the bulk of the migration took place), 16 to 25% of all echoes were detected at altitudes below 200 m.

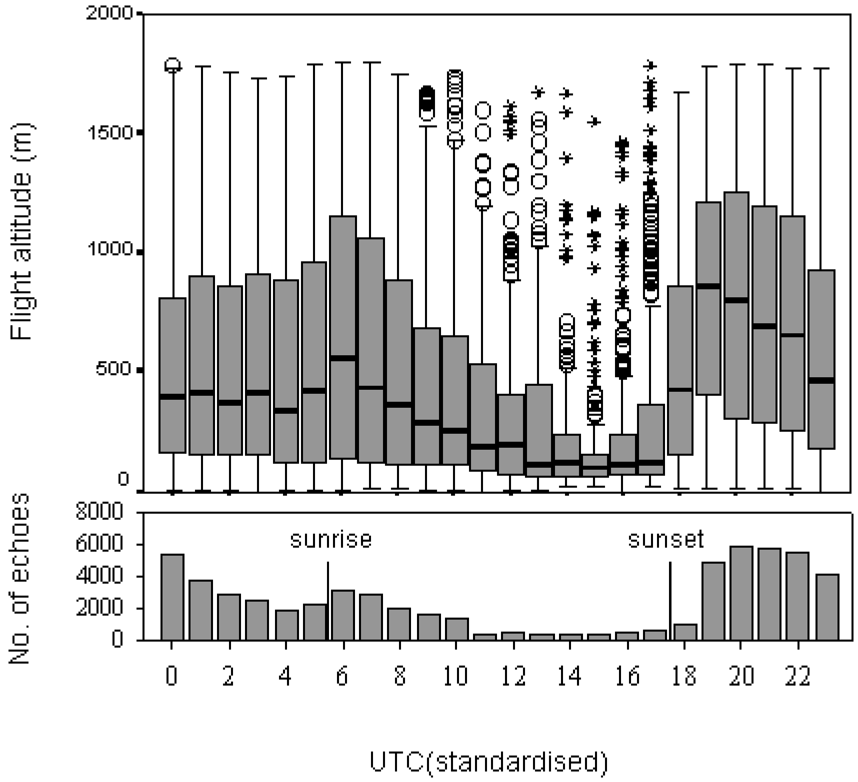

Figure 5.5. Flight altitude in relation to (standardized) time of day. Upper graph: median, 25%- and 75% percentiles (horizontal bars and boxes, respectively), whiskers = range without outliers (circles) and extreme values (asterisks). Lower graph: total echoes per hour. Data from Helgoland, Fehmarn and Rügen combined.

There is clear tendency towards lower altitudes after (and presumably during) rain (Figure 5.5). Furthermore, as with the visual observations, head winds decrease flight altitudes, too.

Based upon data from the German military large scale surveillance radars which are currently being analysed by the Institute for Avian Research "Vogelwarte Helgoland", there is considerable migrational activity throughout the year over both North and Baltic Seas. However, there are large seasonal and regional differences. Since MWFs are operative throughout the whole year, only the latter will briefly be considered here. Over the North Sea a decrease in flight activities towards the open sea is apparent. However, there is a broad 80 to 100 km wide band with high flight intensities along the coasts from the Netherlands up to Denmark. Over the Baltic Sea, the densities of flying birds are more or less uniform from Schleswig-Holstein and Mecklenburg-Vorpommern to Denmark and southern Sweden. Local concentrations are apparent north of the island of Rügen and in the Pommerean Bay (presumably ducks and gulls). Migration between southern Scandinavia and central Europe is somewhat channelled by the islands of Fehmarn and Rügen as is the migration by waterbirds in east-west direction between south Sweden and Rügen.

It can be concluded from both visual observations and radar registrations that considerable migration over the sea takes place at altitudes that bring birds into risk of collision with wind-turbines erected at sea. This risk is especially high at times of low visibility (darkness, fog, rain) or during conditions when birds fail to hear the noise of turbines. The risk is further enhanced by the fact that birds tend to reduce their flight altitudes in such situations.

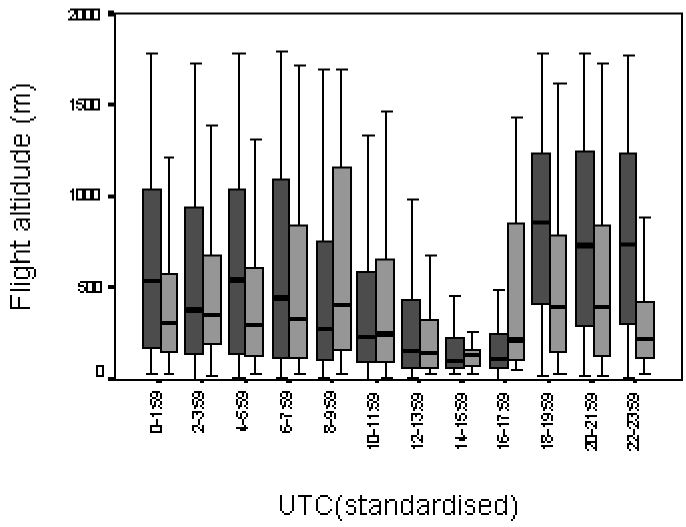

Figure 5.6. Flight altitudes during dry weather (dark boxes, n = 34266 echoes) and after rain (grey boxes, n = 7464) in relation to standardized time of day (sunrise = 06:00, sunset = 18:00). Median, 25%- and 75% percentiles (horizontal bars and boxes, respectively), whiskers = range without outliers and extreme values., data from Helgoland, Fehmarn and Rügen combined (Hüppop *et al*. 2003).

5.4 Advances in the knowledge on disturbance effects

In Denmark, the construction of the first major MWF at Horns Rev has not been useful in defining the effects of disturbance on bird distribution patterns. The MWF was constructed in an area with very low bird densities, due to the prevailing currents and associated unstable sediments of the area. Hence, the project has contributed very little to our understanding of how birds feeding in the general area respond to the construction and operation of an MWF. Such case studies are vital dealing with a range of species, if we are to be in a position to offer scientifically based advice relating to the effects of future MWF developments and if we are to be able to predict cumulative impacts of multiple developments. However, the Horns Rev project has been helpful in establishing that the estimates generated for the frequency of maintenance visits to the individual turbines under operational conditions have been realistic. This has proved that crews need to undertake two regular routine visits per annum plus an additional 1–3 emergency visits per year per turbine to deal with breakdowns. Potentially, MWF comprising 70–120 turbines will therefore necessitate daily visits by maintenance craft and hence daily disturbance to birds feeding in the MWF area. In practice, maintenance crews cannot operate in conditions with waves or swell above 1.5 m, which may reduce the number of operational days when crews can access turbines by 30%. Nevertheless, it is clear that normal maintenance activities will attract levels of boat disturbance to the area of an MWF likely to create a significant source of disturbance compared to pre-construction levels.

5.5 Methods for assessing the impact of at-sea wind farms on birds

Whilst considerable effort has gone into generating realistic predictions of the collision risk presented to birds by MWF, there exists virtually no data on actual measured rates of collision. Visual observations are impractical, and unlike land-based wind farms, it is not possible to collect corpses at sites in the water. Radar observations are not appropriate unsupported by other methods, since a radar track of a flock of, for instance, eiders, may enter and leave the MWF, but individual members of the flock may have impacted turbines *en route*. In order to be able to determine the absolute number of collisions, several systems are in development at the present time. Foremost amongst these are (i) the use of infrared video surveillance equipment and (ii) the use of vibration monitoring systems.

The use of infrared detection equipment enables the generation of imagery by which an observer can track a warm object (i.e., individual birds) against a cold background as they fly though the rotating turbines. Technical developments can already mask warm areas, and exploit movement sensors to trigger recordings of imagery only when moving objects of sufficient temperature threshold enter a specific field of view, and reduce the need to search prolonged archives of imagery containing no information. The technique has the advantage that it can also enable an assessment of injury incurred by those birds that pass between the turbine blades but which become caught in the in the tail vortices behind the turbines.

The infra-red approach is expensive, requiring sophisticated equipment, as well as requiring extended human investment of time in monitoring of imagery that is generated. Hence, other cheaper alternatives have been investigated, and at the moment, research and development effort is being invested in vibration sensors that will simply (and cheaply) record impacts of objects hitting turbines. These rigs require small vibration sensors to be mounted in the turbines linked to modest computer systems and are therefore cheap to purchase and mount for operational use. Preliminary investigations suggest that these devices can be used to estimate body mass of birds colliding with turbines on the basis of the nature of the vibrations created by such impacts (Westra 2001). Mounted in conjunction with infrared video surveillance monitoring equipment, this offers the opportunity to calibrate the two methods. This has the advantage of enabling an assessment of the species involved in collision (identified on infrared imagery) to be compared to signals appearing in the vibration signatures. This could enable the establishment of the relationship between the numbers killed or injured by direct impacts with the super structure and those killed or injured by airflow effects. Used in concert, the two methods offer a very attractive method of supplementing in each other, offering an intensive, detailed monitoring of a few turbines in concert with more extensive monitoring of a larger sample within one MWF to test other hypotheses.

5.6 Means for mitigating collision risks and disturbance effects

Due to the lack of direct experience of wind farms at sea, methods for mitigating collision risk are generally not possible. For terrestrial wind farms Isselbächer and Isselbächer (2001) propose:

- erecting windmills in rows parallel to the main migration direction
- corridors of several kilometres width between individual wind parks kept free of disturbance
- banning of wind parks situated between e.g., resting and foraging sites
- banning of windparks in areas that act as bottlenecks during migration
- no extensive floodlight illumination
- use of reflectors and distinctive colours

These suggestions can equally be applied to offshore wind parks. The most significant means to avoid collisions is to avoid the construction of wind parks in areas which regularly experience high flight intensities of birds. The precise nature of the lighting mounted upon MWFs must comply with the rules for ship- and air traffic, so the possibilities to alter these to mitigate collisions are limited. Obviously all kinds of light, including red lights for air traffic, attract migrating birds under certain conditions (Kingsley and Whittam 2001, Schmiedl 2001), especially in moonless nights (Verheijen 1980). The U.S. Fish and Wildlife Service prefer white navigation lights for communication towers, or red flashing lights as an alternative. These should be installed in minimum number and intensities, the flashes should be as short, the intervals between them as long as possible (Kingsley and Whittam 2001). Until there are experiences with MWFs, these rules should be applied to them as well. Probably adapting the lighting of the MWFs to the instantaneous weather conditions will be necessary.

The majority of birds migrate on relatively few nights/days (Dierschke 1989, Hüppop *et al*. 2003). Further studies of migration patterns will further refine our knowledge about the relationships between the weather and bird migration (Erni *et al*. 2002). Hence, in the near future, a combination of known weather conditions supported by a radar-net, may enable the forecast of bird migration at low altitudes. On nights of especially heavy flight activity in low altitudes the turbines may be stopped to avoid or reduce the collision risk.

5.7 Energetic consequences of barrier effects or disorientation

If flying birds do not head directly through windparks but rather make avoidance manoeuvres, this necessarily increases their energy consumption. Also birds may get disorientated during bad visibility, because the illumination of a wind farm can attract them. Disoriented birds may circulate around illuminated structures for a long time (Schmiedl 2001). Energetic flight costs increases with body size, both in absolute terms and per unit body mass. This means that larger species with flapping flight such as cormorants, cranes, geese, swans, and large ducks will be affected most. Flight alterations in altitude are especially costly. Estimating the costs is very difficult and remains hypothetical since real data on avoidance behaviour are hardly available.

However, time-energy-budgets are an adequate method to estimate flight costs, as this approach was successfully applied in studies on disturbance effects on wildlife (see review by Hüppop 1995). To be able to do this, the following parameters are needed:

a) Body mass of the respective species (available from literature).
b) Flight cost for level flight and for flight including changes in altitude (available from literature).
c) Changes in flight length / altitude during avoidance manoeuvres (to be measured).
d) Changes in flight length / altitude when birds fly around illuminated wind farms due to disorientation in bad visibility (to be measured).
e) The additional flight costs should be set in relation to the daily energy expenditure of a migrating bird. Hence daily flight distances have to be known, too (available e.g., from satellite telemetry).
f) Estimates of the level at which the additional costs will be detrimental to the birds. As a rule of thumb, increasing the energy expenditure over longer periods by a mere 5 to 10 % can be disadvantageous as shown in several species of wildlife (Hüppop 1995)

5.8 Concluding remarks

A year on from the last appraisal, their have still been few marine wind farms built, and those that have (e.g., Horns Rev) provide little or no information on either actual collision kill nor displacement avoidance effects. Most progress has been made in the accumulation of data relating to the nature of bird migration through sea areas where wind farms are planned, and this provides an important baseline upon which to base predictions relating to collision risks and avoidance. The data gathered in northern Germany relating to the volume and routes taken by migrating birds of all species has proved invaluable in defining key areas and corridors of especial importance.

Our goals remain as before to collect as much data as possible on behavioural and spatial responses of seabirds to windmills in the vicinity of offshore farms and to collect collision data throughout all possible weather conditions. The spatial analysis will be achieved by BACI (before/after control/impact area) type mapping of bird distributions, using spatial modelling or other techniques already developed and currently in place. Much progress has been made in developing remote sensing infra-red video monitoring mechanisms and vibration detectors to measure actual collision rates, although these techniques have yet to be deployed and therefore require an inevitable research and development run in time, even when deployed.

Despite the fact that at least 13,000 offshore turbines are currently planned in North East Atlantic marine waters, it remains too early to estimate how many birds will collide each year with these structures. However, given that most seabirds are generally long-lived and are thus susceptible to small increases in annual mortality, it becomes ever more important to obtain accurate data on kill rate from as many sites as possible. The 12,000 turbines planned for German waters will cover an area of 13,000 km^2 (Hüppop *et al.* 2002), hence the effects of habitat loss and the ability for birds to compensate for such a potential major loss of habitat also need to be addressed. The Strategic Environmental Assessment Directive of the European Union will oblige Member and Accession States to undertake strategic appraisal of the environmental impacts of such large scale developments. It therefore becomes increasingly important that the cumulative effects of habitat loss and the cumulative impacts of additional mortality through collisions are assessed in conjunction with the other factors affecting population status amongst birds.

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6 IDENTIFIED MAJOR GAPS IN KNOWLEDGE OF MARINE BIRDS IN THE ICES AREA

Seabirds have been studied in considerable detail within most of the ICES areas. Population sizes, seasonal movements, breeding ecology, feeding ecology and diet have all received much attention, and are documented in much more detail than is the case for other marine animal groups. Nevertheless, there are certain aspects of seabird biology that remain poorly known, either because they are technically difficult to study, or because they have not been a high priority in past research. The Working Group felt that it would be useful to highlight those aspects of seabird biology where a lack of data may impair the ability to provide suitable inputs to the ICES community. Due to the large number of terms of reference for this meeting, we were unable to devote much time to this topic, but the following list of major gaps in knowledge was compiled. These topics are not intended to be ranked in order of importance:

- **Breeding numbers of seabirds, especially auks and northern fulmars, in Iceland, northern Russia and Greenland.** Populations of seabirds in these areas are known to be very large, but the coastal colonies are difficult to survey and as a result the information on population size is incomplete and population estimates have very wide confidence intervals.
- **Declines in breeding numbers of ivory gulls in ICES areas I, IIb and XIVa.** There are thought to have been major declines in numbers of this high Arctic breeding seabird, but data are lacking on detail and on cause.
- **Trends in breeding numbers of seabirds in countries where few species have been counted more than once in the past 50 years.** The ideal is to have total breeding population counts every 15 years or so, but this is available only for a very few countries so far. Any EcoQO based on population trends of seabirds requires regular total population counts, as monitoring of a few colonies or specified plots within colonies can give misleading trends.
- **Winter diet of seabirds, especially abundant species such as northern fulmar.** This is technically difficult, and most sampling of seabird diet has been based on work during the breeding season at colonies. Studies of diet of birds shot at sea have been carried out in several parts of the world, but very little within ICES areas. Use of

molecular biomarkers (e.g., fatty acids, stable isotopes) and specialist application of techniques of ultrasound scanning are at relatively early stages of development.

- **Seabird by-catch.** FAO requires assessment of by-catch impact, but this is little investigated in most ICES areas. Long-line by-catch of northern fulmars may be a significant influence on demography of that species. By-catch in set-net fisheries in the Baltic Sea is a major problem for nearly all diving species of seabirds. It seems possible that the current intensity of set-netting is affecting many of the species at the population level. However, there are only very few local estimates of mortality rates/numbers available.
- **Key sites required by seaduck populations during passage as well as in winter.** Patterns of seasonal movements by seaducks and the factors affecting these from year to year require study given the conservation issues and international importance of seaduck populations in several ICES areas.
- **Seabird distributions at sea.** Although there are large data bases on seabird distributions at sea in several ICES areas, few data have been added to these within the last 15 years. In many areas there are no data available despite there probably being major aggregations of seabirds present (for example possible major wintering areas for guillemots north of Iceland). Although the western Atlantic is very important for nonbreeding seabirds, at sea distribution patterns in this area are little known. In most cases, causes (e.g., oceanographic factors or food distribution/availability) of seabird distributions at sea are not known. There are certainly important populations of seabirds in the Bay of Biscay (ICES VIIIa-d) but no data on the at-sea distributions and densities of these populations.
- **Red-throated diver and black-throated diver population sizes.** These are poorly known. These species are of conservation concern, and are particularly frequent in shallow sea coastal areas of high priority for development of marine wind farms.
- **Cumulative impact on bird populations of a series of individually minor impacts of disturbance and local food depletion.** While single developments may have only slight impacts on seabirds, the process for assessing the cumulative effect of many such impacts along the flyway of migrant seabirds has not been developed. There is a need for development of models that can integrate a range of impacts in terms of an appropriate currency such as energy balance/body condition.
- **Home ranges of individual birds outside the breeding season and migration paths of individual birds are not generally known.** Although the broad geographical distributions of seabird populations have been mapped for the various seasons of the year, the geographical range occupied by the population does not indicate distributions of individual birds. These may influence the exposure of birds to hazards. One particular aspect of this is weather-dependent movement patterns, as shown by birds moving out of the Baltic region during cold weather periods in winter.
- **Long-term data sets on the demographic parameters of seabirds.** These are often needed to allow a reasonably accurate estimation of how factors such as fisheries affect numbers. One needs to distinguish between human-induced and natural factors in the modelling of population trends. However, full demographic data are available for very few species populations. While data on breeding success are available for many species and areas, few data sets exist for adult survival rates, and very few for recruitment and immature survival rates.

7 FURTHER DEVELOPMENT OF THE ECOQO ON PROPORTION OF OILED COMMON GUILLEMOTS AMONG THOSE FOUND DEAD OR DYING ON BEACHES

7.1 Introduction

One of the EcoQOs adopted in the Bergen Declaration related to oiled birds on beaches. The proportion of oiled common guillemots among those found dead or dying on beaches should be 10 % or less of the total found dead or dying, in all areas of the North Sea. OSPAR has requested further advice in order to ensure a scientifically sound implementation of this EcoQO. The request covers four areas:

1) develop draft guidelines, including monitoring protocols and assessment methods, for evaluating the status of, and compliance with, those EcoQOs;
2) provide current levels, on an appropriate geographical basis, to be used as baselines against which progress can be measured;
3) reconstruct the historic trajectory of these metrics and determine their historic performance (hit, miss or false alarm) relative to the objective being measured, as a basis for deciding their relationship to management;
4) provide the basis for advice on what management measures could be taken to help meet the EcoQOs.

These are very large tasks to complete, and perhaps might be more properly contracted out for drafting, but a start on the work has been carried out below. Fortunately there has been considerable previous consideration of some of the technical issues and we have drawn extensively on this body of work.

7.2 Draft guidelines

The process of evaluating the proportion of oiled guillemots on beaches might be split conveniently into three related phases

1) Sampling of North Sea and international coordination;
2) On-beach evaluation and recording;
3) Analysis and reporting.

OSPAR developed guidelines for beached bird surveys within the Joint Assessment and Monitoring Programme (JAMP), led by The Netherlands and Germany in November 1995. These guidelines were endorsed by the OSPAR working groups SIME and ASMO in 1996 (OSPAR 1996). We used relevant parts of these guidelines in developing the following sections. In addition, we have drawn heavily on a report to review this topic commissioned from the European expert on beached bird surveys by The Netherlands (Camphuysen 2002).

7.2.1 Sampling of North Sea and international coordination

Beached bird surveys are presently organized nationally or regionally on North Sea coasts. There is some international coordination, but this amounts to agreeing a common weekend for a single February survey of as many beaches as possible, and to compiling data for this weekend. There is considerable variation in the number of surveys per year, or in proportion of coastline covered by the surveys between areas of the North Sea. All surveys rely on volunteers walking beaches to count and record beached birds, so inevitably some bias will creep in due to variations in availability of volunteers.

The underlying reason to establish and use EcoQOs is to aid in management decision –making. The oiled guillemot EcoQO would indicate the effectiveness of policies to reduce oil pollution in the North Sea (and Channel). It would presumably be useful for managers to know where (at a relatively fine geographic scale) oil is being discharged and approximately from what type of source. The former requires a fairly detailed geographic sampling scheme, while the latter requires a scheme that will examine oil type on birds also. Only one of these is explicit in the EcoQO – the requirement for the EcoQO to be met in “all areas” of the North Sea.

Presently, most results of beached bird monitoring are presented on a national basis (Figure 7.1) in the eastern North Sea. Orkney and Shetland are separated due to different funding arrangements on the two islands. We suggest that the following regionalisation scheme, adapted from Camphuysen and van Franeker (1992) and in conformity with the JAMP monitoring guidelines (OSPAR 1996), might aid managers in identifying the source areas of oil pollution (single spills can potentially be observed directly or back-tracked using oil drift models).

1) Shetland
2) Orkney and north coast of Scotland
3) Moray Firth (Duncansby Head to Rattray Head)
4) Eastern Scotland (Rattray Head to Berwick on Tweed)
5) Northeast England (Berwick on Tweed to Spurn Head)
6) Eastern England (Spurn Head to North Foreland
7) Eastern Channel (line between North Foreland and Belgian-French border to line between Cherbourg and Portland Bill)
8) Western Channel (west of line between Cherbourg and Portland Bill to Land’s End to Ouessant)
9) Eastern Southern Bight (Belgian/French border to Texel)
10) Southern German Bight (Texel to Elbe)
11) Eastern German Bight (Elbe to Hanstholm)
12) Skagerrak (east of line between Hanstholm to Kristiansund, north of a line from Skagen to Gothenburg)
13) SW Norway (Kristiansund to Stadt)

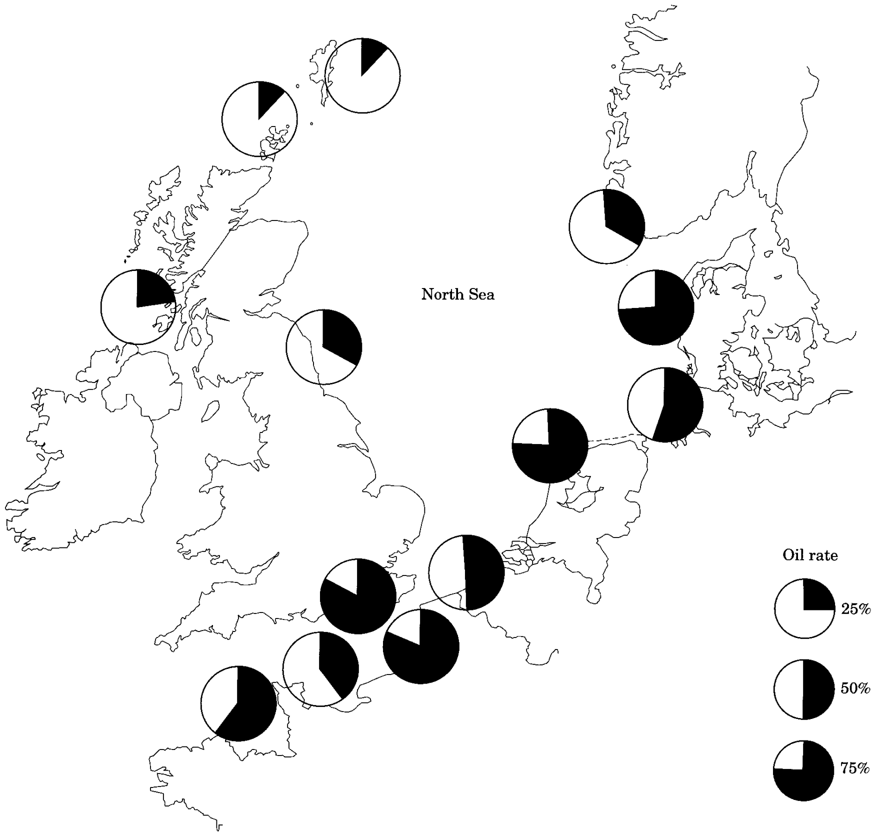


Figure 7.1 Differences in the oiling rates of common guillemots in the North Sea (Furness and Camphuysen 1997).

Analysis of existing information to determine homogeneity in results between sub-divisions of these suggested areas may suggest some changes in this regionalisation, but it is probable that data is too patchy for this to be successful in all parts of the North Sea. We suggest that a co-ordinator would be required for each country around the North Sea, who would aim to ensure that sufficient sampling was carried out within the national sections of each of the above areas. An international analyst/coordinator could gather together relevant results and produce an index for each of the above areas (or others if deemed appropriate).

Sampling within the regions outlined above should be on a representative fraction of the coast directly bordering the North Sea and these fractions should be standardised over the years. Coasts bordering the open sea are of prime importance, sheltered bays and deep fjords are of secondary importance and should be treated separately (OSPAR 1996). As a rule of thumb, at least 10% of the open sea coast length of each region should be covered.

The frequency of beached bird surveys through the year needs consideration. The higher the sampling, the more precise can be the estimate of proportion of oiled beached common guillemots and the less the ratio might be affected by a short-term variation in the amount of oiling. However, much beached bird survey relies on volunteers, who are limited in the amount of sampling that they can do. Additionally, many of the sandy beaches that are suitable for the recording of oiled birds are 'cleaned' in the summer by local authorities to improve them for tourists. At present, the only constant is the international beached bird count in late February. We recommend that beached bird surveys should provide monthly samples for at least the winter period (*i.e.,* October-April). Where possible, year-round counts could be carried out in order to check seasonal trends.

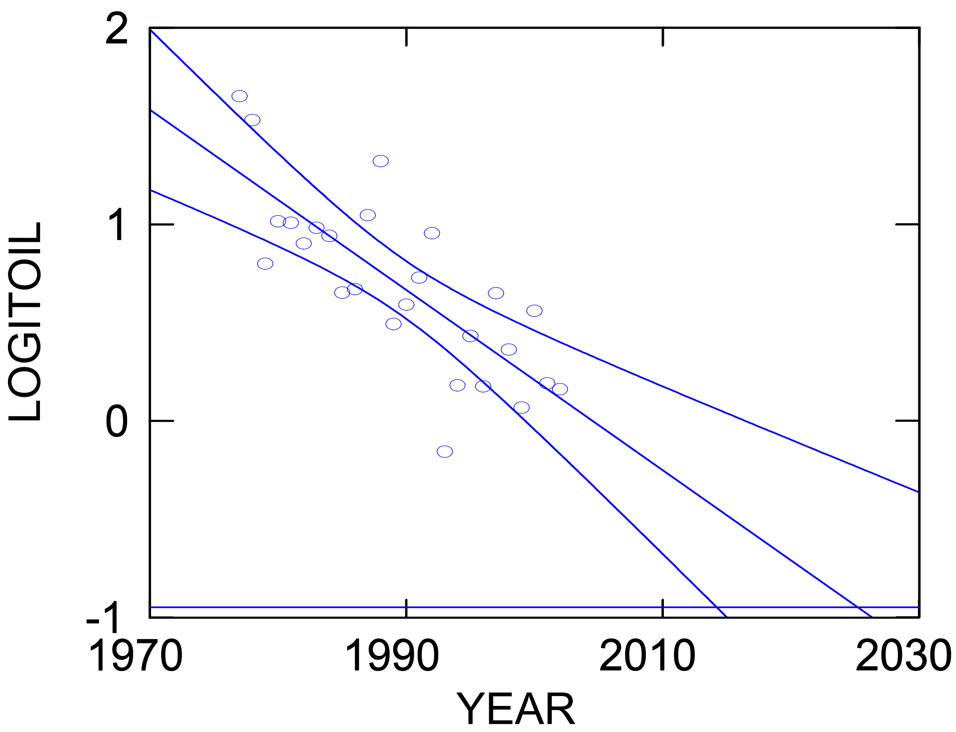


Figure 7.2 Significant decline in (logit-transformed) oil rates of common guillemots found dead along the North Sea coast of The Netherlands in winter 1976/77 (1976) to 2001/02 (2002), showing annual rates, the observed and predicted trend if this is continued at the same rate, and 95% confidence intervals [n = 26, multiple R = 0.781, multiple R^2 = 0.610, adjusted multiple R^2 = 0.593, Standard error of estimate = 0.286, residual mean square = 0.082] (NZG/NSO unpublished data, Camphuysen 2002).

Camphuysen (1995) examined trends in oil rates and the statistical power of appropriate trend tests and Camphuysen (2002) examined the variability of proportion of oiled beached birds from surveys in The Netherlands (*i.e.,* the standard deviation of the (yearly) logit-transformed oil rate indices around the observed linear trend) (Figure 7.2). The results indicate that it would require 6 years of observation to reject the null-hypothesis with 80% chance that the objective of an oil rate of 10% has been reached when in fact 20% is still contaminated with oil. At lower levels of oil pollution the time required would increase substantially (Camphuysen 2002).

We recommend that a period of at least 5 years in which an average of 10% oiled common guillemots has been recorded should occur before the conclusion that the objective has been reached could be justified statistically. Even beyond this time period it would be worth continuing surveys to ensure that there has not been a subsequent deterioration in performance.

7.2.2 On-beach evaluation and recording

Beached bird surveys should preferably be done on foot and not vehicles (e.g., cars) (OSPAR 1996). During each survey, the strandlines on the beach all need to be checked. In some cases the highest and lowest strandlines may be some distance apart on the beach. Only complete corpses should be examined for the presence of oil. Beached common guillemots should be marked (*e.g.,* clipping the primaries) or removed to avoid double counting. Marking should be permanent and easy to identify. Table 7.2.1 lists the information required from each common guillemot corpse (or live oiled bird).

Table 7.2.1. Information recorded for each complete beached common guillemot.

Age	based on plumage characteristics (Kuschert *et al*. 1981, Camphuysen 1995a)
Oiling percentage	100%: fully covered in oil or chemical substance
	30%: upper or underside of rump (both = 60%) fully covered with oil
	10%: upper or underside of wing (both wings, under and upper side = 40%) covered with oil
	1%: single minor speck of oil
	other %: precise estimate of oil cover
	- ?: no oil seen, but corpse incomplete
	+ ?: oil on remains, but corpse incomplete
Recovery	presence of mark from previous count
Rings, notes	careful inspection of the presence of rings and or other obvious causes of death (in the 'notes' section of a record form).

For each count, the following information should be recorded (see also Table 7.2.2): date, place, km surveyed, km of coast with visible oil, characteristics of any oil noted on the beach, name(s) of observers, mark used to avoid double counts, completeness of survey and problems encountered, other significant pollution of the beach, list of beached birds.

Table 7.2.2. Information recorded for each count of beached birds.

Date	day, month, year
Place	place names visited
Stretch coding	unique code for stretch surveyed
Km surveyed	distance surveyed (nearest 100 m)
Presence of oil	yes/no (visibility)
Km of beach contaminated	length of beach with visible oil
Method of survey (vehicle)	on foot (preferred), bicycle, car, otherwise
Method of marking	clipped wings, corpses removed, other marks
Completeness of count	indication of reliability of count (problems with wind and sand, corpses may have been removed by sanitary department of local community)

7.2.3 Analysis and reporting

An overall analysis and compilation from national data would be needed to calculate oil rates for each area (as suggested above or otherwise) of the North Sea. Trends in the overall numbers of beached birds per winter and in the overall proportion of oiled birds (oil rate, % of oiled corpses of all complete corpses found) should be described. We suggest that these trends might be most easily reported as a five-year running mean percentage oiled. Linear or other regression suggests that there is a model underlying any trends, while plain plotting of the percentage recorded each year would be relatively noisy due to short-term fluctuations. Figure 7.3 is an example of running mean for the Dutch North Sea coast (calculated from data in Camphuysen (2002)).

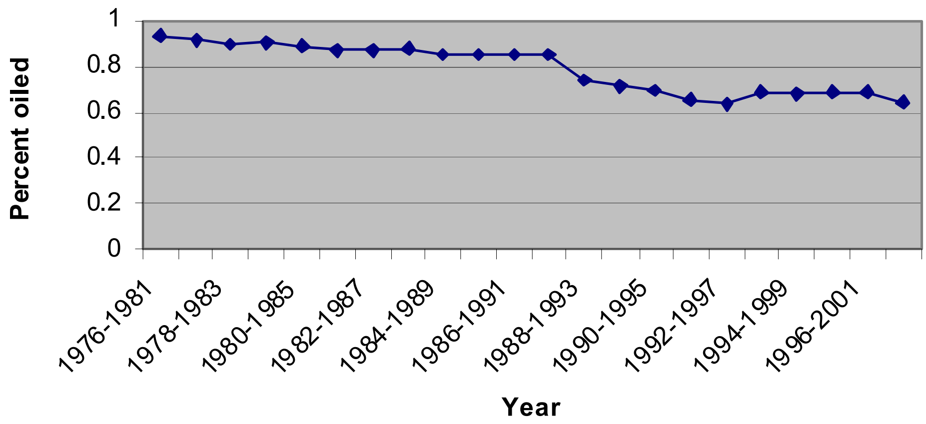


Figure 7.3 Five-year running mean of percentage of oiled common guillemots found as complete corpses on Dutch North Sea coasts, 1976/77 – 2001/02 (from Camphuysen 2002).

One difficulty that needs to be addressed is that of the intermittent large-scale oiling incident, often due to a known shipping casualty. These cause intermittent peaks in proportions of birds oiled and add considerably to the variance of oiling rates. In almost all large incidents, 'emergency' beached bird surveys are undertaken to assess the scale of the impact of the incident, and in some cases the 'humanitarian' response to collect live oiled birds for cleaning. If the percentage oiling of live oiled birds removed from the beach is different from those (oiled or live) left on the beach there would be bias introduced into the results of the regular (monthly) beached bird surveys. Conversely, guillemots in some areas are affected by intermittent large-scale mortality probably caused by starvation. Under these circumstances, large numbers of unoiled birds wash ashore, thus depressing proportions oiled. This underlines the important of note taking at the time of the beached bird in order to aid in interpretation of outliers within the data.

7.2.4 Further development of programme to evaluate oiled bird EcoQO

It is likely that beached bird counters taking part in recording rates of oiled guillemots for this EcoQO will also be undertaking a general survey of beached birds. Feedback on the results of these wider surveys at the same time as reporting on the EcoQO will probably be necessary in order to maintain the interest of the volunteer counters. We note also that if the proposed EcoQO on plastic particles in the stomachs of northern fulmars is adopted (see Section 9), the monitoring protocols for this EcoQO would need to be integrated into beached bird surveys also.

If the results of the monitoring are to be used in decision-making in relation to management (see Section 7.5) then the oils contaminating beached birds need to be characterised. Substances encountered in recent years during beach bird surveys, as dumped in bulk into the sea, or as additives to for example lubricating oils used on vessels, include palm oil and other vegetable oils, paraffin, dodecylphenol, nonylphenol, polyisobutylene, olefines (i.e., Octadecene, Nonadecene, Docosene), and dioctyldiphenylamine ((McKelvey *et al.* 1980, Engelen 1987, Averbeck 1990, Bommelé 1991,. Timm and Dahlmann 1991, Zoun 1991, Zoun *et al.* 1991, Zoun and Boshuizen 1992, Camphuysen *et al.* 1999, Camphuysen 2002). Seabird mortality incidents have been induced by apparently 'harmless' substances such as fish oil (Newman and Pollock 1973; Anon. 1975). The molecular features of contaminants causing disruption of the plumage of seabirds are well known and need not be repeated here (Rozemeijer *et al.* 1992). Camphuysen (2002) proposes a sampling protocol to identify different types of oil and other substances in order to help identify sources of pollution. Since it is not possible to classify contaminants fully by eye in the field, specialised laboratory studies would be required to undertake analysis of the samples.

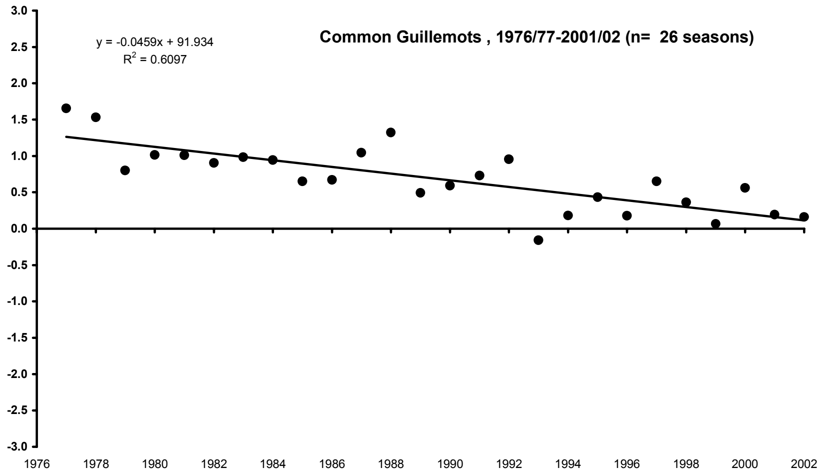
A further study that would support the use of this Eco QO is the improvement in understanding of drift patterns of corpses in the North Sea. Knowledge of type of oil and likely origin of the oil would provide a powerful indicator of where further management measures might be applied.

7.3 Current baseline levels

Figure 7.1 illustrates the most recent (1995) analysis of current baseline levels. These baselines are based on national or local schemes and do not correspond the regions suggested in Section 7.2.1. WGSE does not have access to the data on oiled bird rates, so recommends that an analysis based on the regions suggested in Section 7.2.1 and more recent data be undertaken.

7.4 Historical trajectory of metric

Camphuysen (2002) demonstrated a significant decline in oiling rate of common guillemots on the North Sea coast of



The Netherlands from 1976/77 to 2001/2 (Figure 7.4) and the German Bight (Figure 7.5).

Figure 7.4. The decline in (logit-transformed) oil rates of common guillemots found dead along the North Sea coast in The Netherlands in winter 1976/77 (1976) to 2001/02 (2002) (Camphuysen 2002).

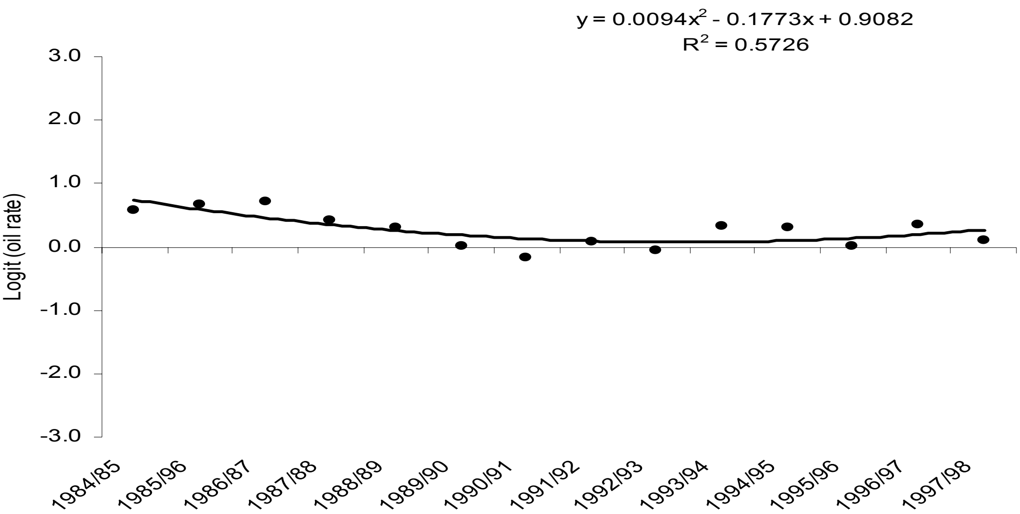


Figure 7.5. Change of proportion of oiled common guillemots (logit-transformed oil rates) in the German Bight, winter 1984/85–1997/98 (modified data from Fleet *et al.*, 1999).

These are the most recent analysis of historic trends, and as WGSE does not have access to the relevant data, it was impossible to analyse other regions. Camphuysen (1995b) showed time series of the observed index x for common guillemots with fitted linear trends (by least squares estimation) for The Netherlands, Denmark, Germany, Norway, and Shetland Islands. The declines found in Shetland, Germany and The Netherlands were significant, whereas the shorter time series for Norway and Denmark did not reveal significant trends (Camphuysen 1995b, Skov *et al.* 1996).

We recommend that the study suggested in 7.3 to determine regional baselines be extended to cover historical trends. Camphuysen's (2002) study described in Section 7.2.1 indicates the likelihood of poor performance of the metric as oiling rates approach the 10% EcoQO. Only two areas of the North Sea appear to have oiling levels at or below the EcoQO – the seas around Orkney and Shetland. It would be helpful to conduct a further analysis on the data from those areas to check the risk of error in this evaluation. All other areas of the North Sea appear to have oiling rates well above the 10% level (30% or more), so it is unlikely that we are unaware that the EcoQO is being met in other regions. Exceptions might be revealed once further regional analysis is undertaken as suggested in 7.2.1.

7.5 Possible management measures

The majority of oil that contaminates common guillemots is believed to come from illegal discharges from shipping or from wrecked ships. Some contamination may derive also from the oil extraction industry or from riverine discharge. There are many well known measures to reduce these causes of oil that are being applied at present. All management measures are related to the need to influence human behaviour.

On the positive side, the provision of free port waste reception facilities has proved very effective in German ports (Averbeck, 1991) and elsewhere. Free oil reception facilities were provided in Hamburg from June 1988 to the early 1990s. Oil rates of birds found dead on German North Sea coasts have generally decreased in the period 1984 to 2001; the oil rate of common guillemots fell from 80% to 40% over this period. These trends in the oil rates reflect the general decline in level of oil pollution in the southern North Sea. The decreases in the German North Sea oil rates were greater at the end of the 1980s and beginning of the 1990s than they were in later years, and in contrast to rates on adjacent sections of German, Danish and Dutch coasts (Camphuysen and van Franeker, 1992). Fleet and Reineking (2001) show this high-low-high-low pattern superimposed on the general decrease in Schleswig-Holstein (Figure 7.6).

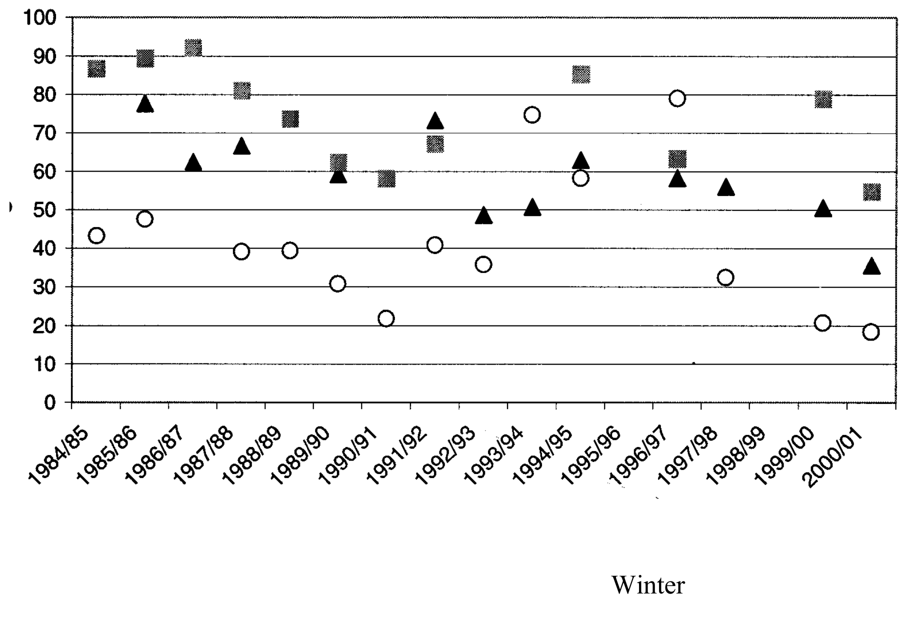


Figure 7.6. Oiling rate (percentage) of common guillemot corpses found on beaches in winter for three parts of the German North Sea coast (triangles: Niedersachsen; circles: Schleswig-Holstein; squares: Helgoland) in winters between 1984/85 and 2000/01.

On the negative side, probably the most critical is the need to improve detection, prosecution and conviction rates among those discharging oil illegally. If polluters were more afraid of the consequences of their actions, it seems likely that their behaviour would change. It would be useful to compare the rates of oiling recorded on common guillemots and density of offshore shipping to see if there are any particular "hot spots" where oiling rates per unit of shipping were higher than elsewhere. This might enable enforcement measures to be better targeted. However, the risk of displacing illegal discharges to other places seems high.

If managers are concerned about reducing the absolute numbers of birds killed by oil, then targeting enforcement and other measures at areas/times of year when most common guillemots are present would be wise. Several oil vulnerability atlases (e.g., Carter *et al*. 1993, Webb *et al*. 1995) are available to provide easy sources of information on this topic. Managers could gain even more precise information on numbers affected by coupling the digital data available in vulnerability atlases to oil drift models.

7.5.1 Kees study: oil pollution around the Shetland Islands: effective measures to stop vessels from discharging oil (from Camphuysen and Heubeck 2001)

Beached bird surveys began in Orkney and Shetland prior to the opening of oil terminals in these islands in 1977 and 1978. Before the first tankers exported oil from these terminals the incidence of oiled birds on beaches was relatively low. Both terminals experienced significant oil spills within months of opening, in March 1977 at Flotta (crude, 110 oiled birds found) and December 1978 at Sullom Voe (bunker fuel, 3,700 found), but the impacts of both these incidents were relatively localised. A relatively high incidence of oiled birds was recorded in Orkney throughout 1978, with analyses indicating that crude oil and its residues comprising 32 % of 43 samples taken.

In early December 1978, ten days after the first shipment of oil left the Sullom Voe Terminal in Shetland, hundreds of oiled birds began to wash ashore in Orkney and along the coasts of north-east Scotland. During the next four months over 4,000 oiled birds were found on the coasts of Caithness, Orkney and Shetland in a series of unattributable spills (i.e., excluding the fuel oil spill at Sullom Voe). Sampling during this period in Orkney showed an increased incidence of crude oils (65 %, n=26) compared to 1978, with a similar pattern in Shetland (57 % crude oils, n=42). Tankers passing the area could not be ruled out as being responsible, but the coincidental timing with the opening of the Sullom Voe terminal led to suspicions that tankers bound there were the main culprits, particularly since the terminal had opened before de-ballasting and oil reception facilities were completed (these only became operational in November 1979).

In the face of a public outcry and calls for the closure of the Sullom Voe terminal until the deballasting plant was completed, measures were introduced in March 1979 to further discourage de-ballasting at sea by tankers bound for Sullom Voe, and to improve navigational safety. These included:

1) dedicated aerial surveillance of tankers and the seas around Shetland;
2) reporting requirements, routing, and areas of avoidance for tankers trading with Sullom Voe;
3) tankers entering Sullom Voe must carry at least 35 % ballast, which was sampled to compare with beached oil;
4) preferential chartering of tankers with segregated ballast and
5) tankers failing to comply with these rules would jeopardise their charter contract and may be refused loading facilities at the terminal.

Tankers were observed breaking these rules on a number of occasions in 1979 and 1980 and legal action was taken. However, the percentage of birds found oiled on beached bird surveys decreased in both Orkney and Shetland during 1980 and 1981. By 1982, crude oil sludges were reduced to 7 % and 4 % of samples taken in Orkney and Shetland, respectively.

In summary, beached bird surveys helped demonstrate (1) low levels of oil pollution before the opening of these oil terminals, (2) the consequence of failing to provide deballasting facilities and to ensure serious enough penalties for illegal discharges at sea, and (3) the effectiveness of the measures taken to combat oil pollution.

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8 DEVELOPMENT OF METRICS, OBJECTIVES AND REFERENCE LEVELS FOR ECOQOS RELATING TO MERCURY CONCENTRATIONS IN EGGS AND FEATHERS OF NORTH SEA SEABIRDS

8.1 Introduction

We were asked to respond to an OSPAR request to commence development, on the basis of the criteria for sound EcoQOs established by ICES in 2001, of related metrics, objectives and reference levels for the EcoQOs relating to mercury concentrations in eggs and feathers of North Sea seabirds. Such an EcoQO is appropriate given that certain fish stocks have mercury levels above WHO guidelines, and human health hazards from consumption of food high in mercury are a matter of concern. Given that mercury input to ecosystems tends to be predominantly anthropogenic and that analysis of feathers from seabird study skins shows approximately a 4-fold increase in mercury levels over the last 150 years in many North Sea seabirds, EcoQO to reduce mercury contamination should be a high priority, and the analysis of seabird eggs and body feathers provides a robust way to measure trends in mercury contamination.

Mercury concentrations tend to increase up food chains, and are much higher in most marine food chains than in most terrestrial or freshwater ones. Mercury concentrations are high in seabird eggs and in seabird feathers (Lewis *et al*. 1993, Monteiro and Furness 1995, Becker *et al*. 1998). Many studies demonstrate that mercury concentrations in seabird eggs and feathers reflect dietary intake (Lewis and Furness 1991, 1993, Burger 1993, Becker *et al*. 1993a,b, Stewart *et al*. 1997, Monteiro *et al*. 1998, Bearhop *et al*. 2000a,b,c, Monteiro and Furness 2001, Becker *et al*. 2002, Burger 2002, Champoux *et al*. 2002, Fournier *et al*. 2002, Nisbet *et al*. 2002), though this is complicated by a pattern of storage of mercury in soft tissues between moults and excretion of most of the body burden of mercury into growing feathers during the moult (Furness *et al*. 1986, Braune and Gaskin 1987a,b, Hario and Uuksulainen 1993, Monteiro and Furness 2001a,b). Moult in most seabirds occurs primarily after the breeding season, but patterns and seasonal timing vary between species and between age classes. Mercury levels in seabird eggs provide a very reliable measure of trends over years in local contamination (Fig 8.1), since seabirds feed close to their breeding colony during the period of egg formation. This also makes eggs very suitable for comparisons between localities (Fig 8.2) as well as over periods of years (Thyen and Becker 2000, Sanpera *et al*. 2000, Scheuhammer *et al*. 2001, Braune *et al*. 2002a,b, Guitart *et al*. 2003, Heinz and Hoffman 2003). Mercury levels in body feathers reflect mercury in the seabird diet over the summer period prior to moult (Thompson and Furness 1989, Furness *et al*. 1986, Bearhop *et al*. 2000c). By selecting particular seabird species with clearly defined diets, it is possible to monitor mercury contamination in a range of food chains. For example, some seabirds feed predominantly on epipelagic fish, other species feed on mesopelagic fish, others on intertidal molluscs, and so on (Monteiro *et al*. 1995, Thompson *et al*. 1998a,b). Changes in diet composition can alter exposure to mercury and hence alter mercury concentrations in seabirds. Examples of significant changes in diet over time affecting mercury levels in seabirds are rather few. One example is the change in trophic level of the northern fulmar between 1900 and 2000 (Thompson *et al*. 1995). Another is the increase in mercury levels in scavenging seabirds resulting from the provision of demersal discards that have higher levels of mercury than the pelagic fish on which these seabirds primarily feed in the absence of discarding by the trawl fishery (Arcos *et al*. 2002). Where such changes are not evident (and this can be investigated by stable isotope analysis of the same feather samples using nitrogen isotope ratio to indicate trophic status and carbon isotope ratio to indicate feeding in pelagic or coastal food webs (Thompson et al. 1995, 1998b)), analysis of body feathers of seabird study skins in museum collections has demonstrated changes in mercury contamination over the last 150 years in a number of food chains and geographical regions (Figure 8.3) (Thompson *et al*. 1992a,b, 1993a,b, 1998a, Furness *et al*. 1995, Monteiro and Furness 1997, Monteiro *et al*. 1999, Scharenberg and Struwe-Juhl 2000).

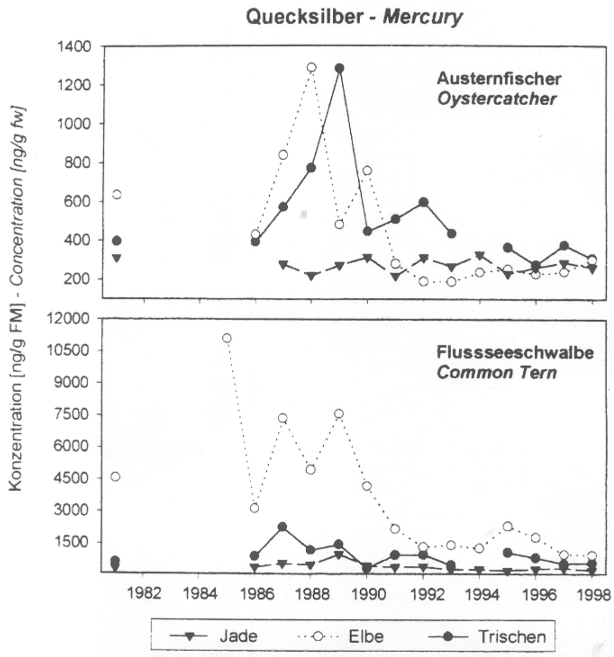

Figure 8.1. Temporal trends in mercury contamination of Eurasian oystercatcher and common tern eggs from selected breeding sites of the Wadden Sea (TMAP). FW=fresh weight of egg content. From Thyen and Becker (2000).

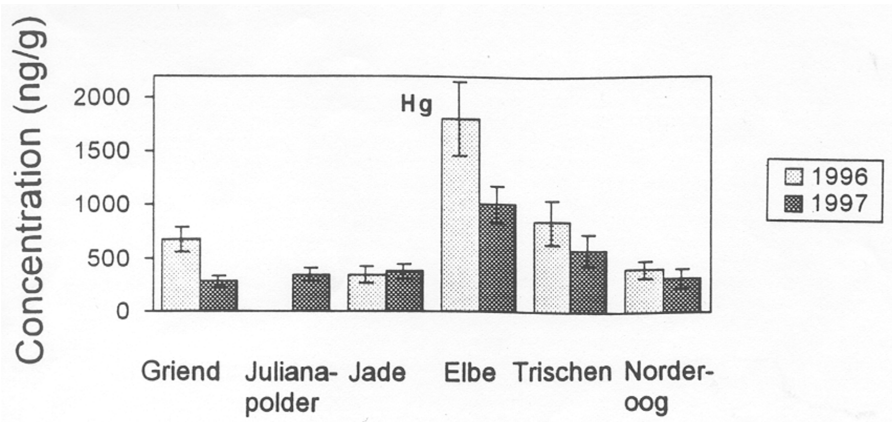

Figure 8.2. Spatial variation in mercury contamination of common tern eggs in 1996 and 1997 from breeding sites of the Wadden Sea (TMAP). Mean concentrations and (ng/g fresh weight of egg content) and 95% confidence intervals are presented. N= 10 eggs each. From Becker *et al.* 1998.

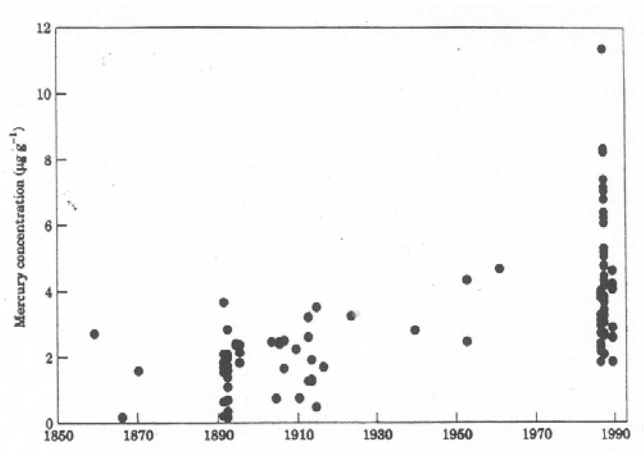

Figure 8.3. Mercury concentrations in body feathers of Atlantic puffin from south-west Britain and Ireland from 1850 to 1990. From Thompson *et al*. (1992a).

8.2 Robustness of proposed EcoQO

Mercury levels in birds are measured using well-established analytical methodologies that can be performed with high accuracy and reproducibility (Appelquist *et al*. 1984, Thompson and Furness 1989, Burger 1993, Becker *et al*. 1994, Bearhop *et al*. 2000a, Christopher *et al*. 2002). The close relationship between levels in birds and in their food is widely documented (Monteiro *et al*. 1998, Monteiro and Furness 2001). The literature on mercury in seabirds is very extensive and detailed. Unlike fish and marine mammals, seabirds do not show accumulation of mercury with age once fully grown. Levels in chicks are usually lower than in adults though in a few species levels are higher in chicks, so sampling does not need to take account of bird age except to separate chicks and older birds (Furness *et al*. 1990, Thompson *et al*. 1991). The use of seabird eggs to monitor mercury is already implemented in the current TMAP monitoring project in the Wadden Sea. Some relevant JAMP guidelines exist (OSPAR 1997). However, reference levels from eggs are unknown and difficult to estimate from existing data. In the case of feathers, large numbers of seabirds collected from North Sea colonies during the 19th century are available in museum collections, and can provide reference levels for a period when mercury contamination from human activities was relatively small. However, previous studies of historical trends have mainly looked at Atlantic populations of seabirds and relatively few North Sea seabird populations have yet been investigated.

8.3 EcoQOs in the North Sea: Mercury concentrations in eggs or in body feathers of selected seabird species

EcoQmetric	Current level	Reference level	Suggested EcoQO target level
Mercury concentration in body feathers of breeding adult common tern, black-legged kittiwake, common guillemot, and northern gannet, from colonies in the southern and in the northern North Sea	Northern North Sea: Common tern 1.5 mg/kg; Black-legged kittiwake 3 mg/kg; Common guillemot 1.5 mg/kg; Northern Gannet 8 mg/kg. Southern North Sea: Common tern 1.8 mg/kg; Black-legged kittiwake 3.5 mg/kg; Common guillemot 2 mg/kg; Northern Gannet 12 mg/kg.	Common tern 1 mg/kg; Black-legged kittiwake 1.4 mg/kg; Common guillemot 1 mg/kg; Northern Gannet 4.4 mg/kg	Mercury levels in all four focal seabird species that average no more than 50% above reference (pre-1900) levels; i.e., targets of: Common tern 1.5 mg/kg; Black-legged kittiwake 2.1 mg/kg; Common guillemot 1.5 mg/kg; Northern gannet 6.6 mg/kg

8.3.1 Reference level

Reference levels for mercury in eggs of seabirds cannot be established because the levels in eggs have been elevated above background for at least the last 100 years. No samples of uncontaminated eggs exist to provide control levels. For this reason, we suggest the use of mercury concentration in body feathers as the metric for this EcoQO, rather than the use of eggs. Reference levels can be obtained from body feathers of seabirds collected before 1900. These reference levels vary considerably between seabird species, depending on diet and trophic status, and to a small extent between regions according to local natural sources of mercury. For many North Sea seabirds reference levels (defined as levels in birds collected before 1900) are about one quarter of the current levels in each species. Examples for breeding adult seabirds collected before 1900 from North Sea colonies are: 2.4 mg/kg fresh mass feather in herring gulls, 4.5 mg/kg fresh mass feather in northern gannets, 1.8 mg/kg fresh mass feather in Atlantic puffin, 3.7 mg/kg fresh mass feather in great skuas, 0.98 mg/kg fresh mass feather in common terns.

8.3.2 Current level

Current levels of mercury vary between seabird species and between regions. Levels tend to be higher in the southern North Sea than in the northern North Sea. For seabird body feathers current levels are reported in a large number of recent publications. Examples for body feathers of adult seabirds include great skua mean 7 mg/kg fresh mass feather (over 100 sampled 1995–2000), increasing by 0.4% p.a. 1900–2000; northern gannet 8 mg/kg fresh mass feather (over 100 sampled 1995–2000), increasing by 0.3% p.a. 1900–2000, black-legged kittiwake 3.3 mg/kg, common guillemot 1 mg/kg. More pelagic species (e.g., Atlantic puffin) show higher rates of increase, around 1–1.5% p.a. In the southern North Sea, herring gulls showed high rates of increase of mercury contamination up to the 1960s, but showed subsequent reductions to 2000.

8.3.3 Target level and objective

The target level should be similar to the reference level for mercury in seabird feathers. The objective should be to reduce mercury contamination so that levels in feathers of the seabird species in the North Sea fall, eventually to reach an average that is no higher than the reference level for feathers of that species sampled before 1900. Reducing human inputs of mercury to the marine environment requires reduction in mercury inputs to the atmosphere resulting from burning fossil fuels (including improved recovery of mercury), and reduction in discharges of mercury by industry. However, given the high levels of mercury entering the environment as a result of human activities at present, reduction to 1.5 times the reference level may be a more realistic objective and target.

8.3.4 Sampling requirements

In order to provide a database of reference values it will be necessary to carry out analysis of mercury levels in body feather samples from seabirds collected before 1900 from defined areas of the North Sea and now held in museum collections. Existing data sets could contribute to this, but would not be as complete or as large as desirable to establish an accurate reference baseline. This baseline needs to be established as a priority before initiating regular sampling from contemporary populations. Because there is high individual variation in mercury concentrations within populations (this is true of animals in general but also of seabirds – see for example Figure 8.3) it is necessary to calculate median or mean levels from a large number of sampled individuals. Power analysis indicates that samples of at least 50 birds per area per species would be needed to detect a 20% difference in median or mean mercury concentration between two samples using conventional statistical tests. Although the distributions of mercury concentrations in samples sometimes deviate from Normal distribution (showing a negative skew), the distribution is often considered to be close enough to Normal to permit the use of parametric statistics on untransformed data. In some cases it is more appropriate to use nonparametric tests (e.g., Monteiro and Furness 1997) and this also reduces statistical power. However, catching large numbers of breeding adult seabirds at colonies to sample body feathers is generally rather easy, and so does not constrain sample size as the main cost of fieldwork is getting to the colonies rather than the time required for catching birds once there. Analytical costs in the laboratory may constrain sample size. If constrained by a small budget then it would make sense to select a small number of seabird species to sample but to take adequate sample sizes from each of these selected species to detect change in mercury concentrations. Sampling should be from both the southern North Sea and from the northern North Sea for those species that breed in both areas. Probably the most suitable species to sample would be common tern, black-legged kittiwake, common guillemot and northern gannet. These species cover a range of prey types and sizes. However, to some extent the selection of species should be informed by the availability of data on 19th century levels of mercury in North Sea seabirds from different species and areas.

8.3.5 Historic trajectory and its historic performance

For the species and areas where historical trajectories of this metric are available, the variance in individual levels of mercury within samples is very high, but the long-term trend is clearly evident. Figure 8.3 is typical in this regard. The variation in mercury levels in seabird body feathers tends to be low from year to year (see also Bearhop *et al*. 2000a,b). In the case of herring gulls in the southern North Sea, there is rather stronger variation in mercury levels on a decadal scale (Thompson *et al*. 1993a). Even in this case, evidence of strong changes in mercury levels in body feathers from year to year is missing; the variation between consecutive years appears to be small, and trends are well indicated by change over a period of one to several decades. This makes the median or mean mercury concentration in a large sample of birds a robust measure that is unlikely to generate false alarms. The risk of false alarms would be highest if the metric was obtained from only one or two seabird species and locations. Local contamination resulting from river discharges can affect levels measured in feathers of seabirds that breed locally and have a short foraging range from the breeding area; this applies, for example, to common terns on the German North Sea coast (Becker *et al*. 1993a,b). If the metric is obtained from a variety of seabird species with different foraging ranges and diets, and from several different localities, any such local 'hot spot' influences will be less influential. As a broad generalisation, the bulk of mercury inputs into marine food webs arises from diffuse atmospheric inputs (Fitzgerald 1995, 1998, Lamborg *et al*. 2002), and these will tend to generate broad and coherent patterns rather than local or short-term pulses of mercury in birds.

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9 DEVELOPMENT OF METRICS, OBJECTIVES AND REFERENCE LEVELS FOR ECOQOS RELATING TO PLASTIC POLLUTION

9.1 Introduction

We were asked to respond to an OSPAR request to commence development, on the basis of the criteria for sound EcoQOs established by ICES in 2001, of related metrics, objectives and reference levels for the EcoQO relating to 'Plastic particles in the stomachs of North Sea seabirds'. We reviewed this topic in 2002 (Section 9 in Report of the Working Group on Seabird Ecology ICES CM 2002/C:04). In that report we endorsed the conclusions made by Van Franeker and Meijboom (2002) that stomach contents analysis of beach washed northern fulmars offers a reliable monitoring tool for changes in the abundance of small fragments of plastic litter at sea. Since then, there have been a few more publications on the abundance of plastic litter at sea based on direct sampling by nets (Moore *et al*. 2001, 2002) and based on sampling stomachs of seabirds (Vlietstra and Parga 2002). All these studies relate to areas of the North Pacific Ocean rather than to the North Sea, but illustrate further the widespread nature of this plastic litter problem. In addition to the literature cited by Van Franeker and Meijboom (2002), papers by Robards *et al*. (1995) and by Blight and Burger (1997) report on the high, and increasing, levels of plastic particles in the stomachs of pelagic seabirds in the North Pacific, while Ryan (1988) gave a detailed account of the kinds of plastic particles found in seabird stomachs off South Africa, and considered the extent of selective ingestion by seabirds based on particle size, shape and colour.

Van Franeker and Meijboom (2002) conclude that stomach contents analysis of beach washed 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, and possibly even years. 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 suggestion for this EcoQO (ICES 2001) 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.

9.2 Metrics, objectives and reference levels

EcoQmetric	Current level	Reference level	Suggested EcoQO target level
Number and mass of plastic particles (industrial and user plastic) in the stomachs of beach-washed northern fulmars collected during winter beached-bird surveys on North Sea coasts	60% of northern fulmars beach-washed on Netherlands coast contain 10 or more plastic particles	zero	Less than 2% of northern fulmars having 10 or more plastic particles in the stomach

We support the suggestions on these points made by Van Franeker and Meijboom (2002). The metrics should be the number and mass of plastic particles of each defined type ('industrial plastic particles', 'user-plastic particles' and mass of 'inert chemical material') in the stomachs of samples of 40 to 100 beach washed northern fulmars collected during winter from areas of the North Sea where such sampling can be achieved as part of beached-bird surveys (e.g., Netherlands, Shetland, mainland U.K.).

Clearly, since plastic is a relatively recent human invention, the natural level of this metric would be that there would be no plastic in any stomachs. The objective should be to achieve a target of as little plastic in fulmar stomachs as possible. A value of less than 2% of northern fulmars having 10 or more plastic particles in the stomach, as proposed by Van Franeker and Meijboom (2002) seems a reasonable and pragmatic choice of target. The present level is that around 60% of northern fulmars in the southern North Sea samples have more than 10 plastic particles in the stomach. Therefore, considerable effort will be required to reduce marine plastic pollution to a level that achieves this target.

9.3 Historic trajectory and its historic performance

The published accounts of changes in amounts of plastic particles in seabirds show evidence of increases up until the present time, with just a few examples suggesting that in the last few years the amounts of industrial plastic particles have decreased in some areas but that user plastic particles have continued to increase in frequency (Van Franeker and Meijboom 2002, Vlietstra and Parga 2002). The period of time that plastic remains in seabird stomachs is not well known, but certainly can be for many months. Therefore, the level of contamination is unlikely to fluctuate widely over short periods. Furthermore, northern fulmars range widely over large areas (thousands of square kilometres) and are believed to ingest plastic in error for food particles. This will inevitably result in the loads carried by fulmars representing an average contamination over long periods of time and over large areas. As a result, we can expect the levels of contamination to be robustly measured, without misleading spatial or temporal variation. The performance of this EcoQO should not result in false alarms, but should indicate long-term trends over periods of several years to several decades. At present an EC funded project (EU Interreg IIIB J-No 1–16–31–7-502–02 'Save the North Sea') is investigating plastic particles in northern fulmars in seven European countries (see http://marine-litter.gpa.unep.org/regional/Nederland/nl_results.htm). This should provide further data to confirm the suitability of this EcoQO.

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10 DEVELOPMENT OF METRICS, OBJECTIVES AND REFERENCE LEVELS FOR ECOQOS RELATING TO SEABIRD POPULATION TRENDS IN THE NORTH SEA AS AN INDEX OF SEABIRD COMMUNITY HEALTH

10.1 Introduction

We were asked to respond to an OSPAR request to commence development, on the basis of the criteria for sound EcoQOs established by ICES in 2001, of related metrics, objectives and reference levels for the EcoQO relating to 'seabird population trends in the North Sea as an index of seabird community health'.

At North Sea latitudes environmental variability is expected to be relatively large and, hence, at any one time most seabird populations will be either increasing or decreasing in numbers. Consequently, healthy seabird communities in the North Sea are also characterised by significant population changes within limits set by natural factors. Documented changes in seabird populations cannot usually be explained in full due to a lack of information on how various natural and human induced environmental factors affect their main population parameters such as reproduction, recruitment and survival rates. Obviously, there is no need to initiate intensive research aimed at explaining all changes in seabird numbers. The magnitude of such changes may, nevertheless, serve as an adequate EcoQO for the intrinsic health of seabird communities. This is based on the simple assumption that a pronounced negative trend in the population of any seabird species could indicate that there is an undesirable effect of human activities. In other words, when a certain level of population change is reached, the public concern is regarded to be so great it represents a provisional reduction of ecological quality. Ideally, and as a precautionary measure, reaching such a threshold should then trigger adequate studies targeted at revealing its underlying causes. If the change proves to be an undesired consequence of human activities, any useful mitigating measures should be identified and implemented. In some cases, monitoring the effect of these measures may benefit from defining additional and more specific EcoQOs for the seabird populations and/or environmental factors involved.

10.2 Robustness of proposed EcoQO

On a short-term scale, seabird breeding population size is not the parameter most sensitive to environmental change. Due to the longevity and delayed maturity of most seabirds, several years are usually needed before changes in their reproduction or immature survival rates affect their breeding numbers. Nevertheless, changes in breeding population sizes are reasonably good indicators of important changes in seabird community structure, where density dependent effects may easily reduce the usability of other population parameters. Furthermore, population size of breeding birds and birds wintering in coastal areas is far easier to count extensively throughout the geographic range of the target populations.

10.3 EcoQO: Population trends of seabirds in the North Sea

EcoQmetric	Current level	Reference level	Suggested EcoQO target level
Change in breeding numbers of seabirds of selected species at selected key colonies	variable	variable	Seabird breeding numbers should not decline by more than 20% over a 20-year period

10.3.1 Reference levels

Variable, and largely of unknown magnitude, but the expectation is that as many species would be increasing in number as decreasing, and that the population trend would not continue for many decades.

10.3.2 Current levels

Variable.

10.3.3 Target level

≤ 20 % decline over ≥ 20 years (more details below)

Setting a target level for a population change that deserves extra attention in this context is no straightforward task. However, we believe the criteria used to identify bird species of European conservation concern based on the definition of a moderate decline (Tucker and Heath 1994) is useful for this EcoQO. This would mean that a reduction in the population of a seabird species deserves special attention if it has, over a period of less than 20 years, declined in size or range by at least 20% in 33–65% of the population or by at least 50% in at least 25% of the population. This criterion has been proposed to the OSPAR Biodiversity Committee for use in other parts of the NE Atlantic. Assessed on the background of the known trends for seabird populations in the North Sea (ICES 2002), WGSE finds that this suggestion sets a reasonable target level for the proposed EcoQO. It is not very different from the target level suggested by Anker-Nilssen *et al.* (1996) to identify the need for more detailed studies or management actions, although they argued that also positive trends of similar magnitude deserve attention. In such cases, we recommend that the attention is primarily addressed to explain increases in species that could conflict with other seabird populations that are falling under the target level.

10.4 Metric and sampling

The data sampling procedures for monitoring breeding populations of different seabird species are standardised (Walsh *et al.* 1995) and applied in much the same way across most North Sea countries. The sampling unit varies between different groups of species, but always either the number of birds present at the breeding site, or the number of occupied (or apparently occupied) nests are counted. Wintering seabirds are counted by land-based total counts of birds within selected coastal areas or from transect surveys at sea using standardised methods to measure the spatial distribution of bird densities.

To examine whether or not the EcoQO is met for any one species, an overall trend for the whole North Sea area should be estimated by simple regression on *ln*-transformed data. When doing this, regional data sets should be weighed according to the proportion of the North Sea population estimated to be breeding or wintering in that area. For some species (e.g., the European shag), large variations in breeding numbers between consecutive years often reflect changes in the proportion of birds breeding rather than real population changes. For statistical reasons, data for at least four (preferably consecutive) years are needed in order to document trends that are significant at the 5% (or 10%) level. Consequently, a drop in breeding numbers by more than 20% in less than four years would only deserve special attention if the historical record for the species in question indicates that such a phenomenon is very rare or has never previously been recorded.

Naturally, the number of sites and species monitored varies from area to area due to geographical differences in population numbers and the diversity of seabird communities. However, the levels of monitoring also vary according to logistic constraints and national differences in the funding situation for the work. Moreover, for each species the intra- and inter-annual frequency of counts and the proportions of the populations occurring within the monitoring plots/areas often differ between areas. Although we believe that most of the current monitoring is of reasonable quality, WGSE realises there is a need to assess in more detail to what extent the present level of monitoring in the North Sea countries is adequate to fulfil the proposed EcoQO. The assessment should take into account the representativeness of the sample populations in relation to the overall seabird community, considering in particular if the selection of species reflects the main ecological groups of seabirds in terms of their range of diets, habitat use and life-history strategies (e.g., Anker-Nilssen *et al.* 1996), and to see if the national programmes need to be adjusted in order to ensure that a sufficient part of the North Sea population of the selected target species is being monitored. Such a task would be relatively time-consuming, and WGSE was not able to take it on within the time frame of its 2003 meeting. Nevertheless, we do suggest it should be done as soon as possible. We do expect, however, that abundant and relatively wide-spread species such as the black-legged kittiwake and gannet (pelagic surface-feeding), common guillemot (pelagic pursuit-diving), common tern (coastal surface-feeding) and common eider (near-shore benthos-feeding) might be particularly useful as primary targets for assessing this EcoQO, as they are all relatively specialised in their food choice and considered to reflect closely important changes in their very different foraging habitats (e.g., Lloyd *et al.* 1991)

Fortunately, the information on seabird population sizes breeding and wintering within the North Sea is fairly good and reasonably up-to-date for most (but certainly not all) areas (ICES 2002 and this report). This makes it relatively easy to derive reasonably accurately how the North Sea population of any given species is distributed in terms of the proportions of the population monitored by each of the national schemes. For the proposed EcoQO, the national level is expected to be an adequate level of resolution when estimating the overall change of the North Sea population, unless there are very significant regional differences in trends within a country housing a large part of the population. However, as total counts are only made on a very irregular basis (e.g., every 15 years for breeding birds in the UK) a regular assessment of this EcoQO is forced to be limited to a selection of reference areas/colonies ('key sites') that, based on historical records, are considered to reflect the overall variation in population numbers for the North Sea population of the species. The identification of the most suitable areas/colonies in this context is also a time-consuming issue that needs to be addressed carefully in the assessment suggested above.

Following similar principals for selecting target species and key areas, we consider it adequate to use this EcoQO for wintering populations of coastal seabirds, whereas it is more unclear how it can be applied for at-sea populations of pelagic species, which would also deserve a more detailed assessment.

10.5 Historic trajectory and its historic performance

To date no-one has tried quantifying the overall change in numbers within the entire North Sea area for any seabird species. The qualitative review of the status of North Sea seabirds made by WGSE last year (ICES 2002) concluded that among the 23 breeding species examined, eight were assessed as increasing (northern gannet, great cormorant, common eider, Arctic skua, great skua, Mediterranean gull, common guillemot and Atlantic puffin) 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). The remainder nine species (northern fulmar, European shag, black-headed gull, mew gull, black-legged kittiwake, sandwich tern, common tern, Arctic tern and razorbill), all were judged to be decreasing by between 1–5% p.a. Being one of the candidates for the selection of target species, the black-legged kittiwake may here serve the purpose of illustrating how the historical records of their population trends would perform in relation to the objective for this EcoQO (hit, miss or false alarm).

Based on the population numbers and trends summarised for black-legged kittiwakes by ICES (2002), the North Sea population of this species, estimated at about 302,000 pairs in 2000, dropped by 41.5% (from an estimated 517,000 pairs) during the 15-year period 1985–2000, a decrease well beyond the EcoQO target level (≤20% in ≥ 20 years). This rather dramatic change was, however, not reflected by the population trends for all colonies. Almost 90% of the North Sea kittiwakes breed in the UK, where their numbers have been monitored in many colonies. Most colonies decreased by more than 20% over this period, but a few decreased by less than 20% during 1985–2000. These few colonies thus missed the EcoQO alarm level despite the overall population declining by more than twice this level. This illustrates the need to have a representative sample of monitoring sites/areas distributed across the main breeding areas in order to avoid misses or false alarms. However, the few colonies that did not show a decline by as much as 20% were mainly small ones.

We recommend that a detailed analysis of trends in individual colonies should be carried out on the existing data (predominantly from UK seabird surveys and monitoring) in order to provide a better understanding of how colony selection may be made to provide an EcoQO metric that is representative of the North Sea as a whole.

10.6 References

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11 DEVELOPMENT OF METRICS, OBJECTIVES AND REFERENCE LEVELS FOR ECOQOS RELATING TO ORGANOCHLORINE CONCENTRATIONS

11.1 Introduction

Marine pollution with environmental chemicals is a worldwide problem, endangering marine organisms and ecosystem health. Persistent toxic substances such as organochlorines, which decompose only slowly, are of special concern. These substances may affect all ecosystem levels and are addressed by this EcoQO. Aspects of seabird biology may be harmed, for instance reproduction may be impaired through eggshell thinning, impact on immune function, and through embryonic mortality (Becker *et al.* 1993, Grasman and Fox 2001, Bosveld and Van den Berg 2002, Champoux *et al*. 2002, Helander *et al*. 2002).

The use of seabirds as monitors of marine contamination with organochlorines such as PCBs, DDT and metabolites, HCB, HCH and others has been advocated many times (Gilbertson *et al.* 1987, Becker 1989, 1991, Furness 1993, Barrett *et al.* 1996, Elliott *et al.* 1996, Becker *et al.* 1998, ICES 1999, Munoz and Becker 1999, Mattig *et al.* 2000, Braune *et al*. 2002a,b, Norstrom *et al*. 2002, Weseloh *et al*. 2002) and is implemented already in some current monitoring programmes in the North Sea. Monitoring of pollutants in seabirds is highly desirable as a cost-effective and informative procedure indicating change in marine contamination. Advantages in the use of seabirds as indicators of organochlorine pollution have recently been reviewed (ICES 1999) and include the following features of seabirds: well known taxonomy and biology, tendency to accumulate high concentrations, ease of sampling (eggs), known foraging range and diets, resistance to toxic effects, low variance of pollutant levels within the population. Consequently, seabirds offer some advantages compared to physical or other marine biotic samples when organochlorine monitoring is needed.

11.2 Robustness of proposed EcoQO

Levels of organochlorines in seabirds show an immediate response to changes in contaminant loads in the marine environment; consequently they clearly indicate changing levels (Thyen *et al*. 2000, Thyen and Becker 2000, Custer *et al*. 2001) and reflect changes in anthropogenic discharge and emissions of organochlorines. In this way effectiveness of measures of reduction of contamination can be demonstrated. Trend data are available for various parts of the North Sea for nearly 40 years. OSPAR (1997) has published guidelines for sampling and analysing (using gas chromatography) seabird eggs. The key compounds are PCBs, DDT and metabolites, HCB and HCH isomers, which can be analysed synchronously using the same analytical procedure. There is a clear parameter signal, as eggs can only be taken in the breeding season, thus reducing the effects of seasonal variation. The objective is relevant to the North Sea, where organochlorine inputs remain high (De Jong *et al.* 1999). Monitoring can investigate temporal and spatial variation as well as local contaminant input, as seabirds forage in restricted distances from colonies during the period of egg formation. Foraging ranges vary between species, but are generally well known. Studies in the southern North Sea show clear local differences in contamination between colonies. In the Wadden Sea, the common tern and the Eurasian oystercatcher were chosen in 1996 as monitor species of organochlorines in the international Trilateral Monitoring and Assessment Programme.

11.3 Discussion

Current programmes demonstrate clearly the value of seabird eggs to indicate spatial and temporal trends in marine pollution with organochlorines (Becker *et al.*1998, Thyen and Becker 2000). In the southern North Sea there has been a decreasing trend in organochlorine levels in seabird eggs since the early 1990s (Figure 11.1), but locally there are high levels (Figure 11.2) which, however, seem not to be harmful to the birds during reproduction (Exo *et al*. 1998).

Sampling of seabird eggs as a means of monitoring seabird contamination with organochlorines should be developed into integrated marine pollution monitoring programmes, with the selection of appropriate locally common and internationally widespread monitoring species. A proposed list of species to be used for monitoring in the North Sea is given (Table 11.1). In addition to the organochlorines, some other relevant contaminants such as mercury can be analysed using the same samples.

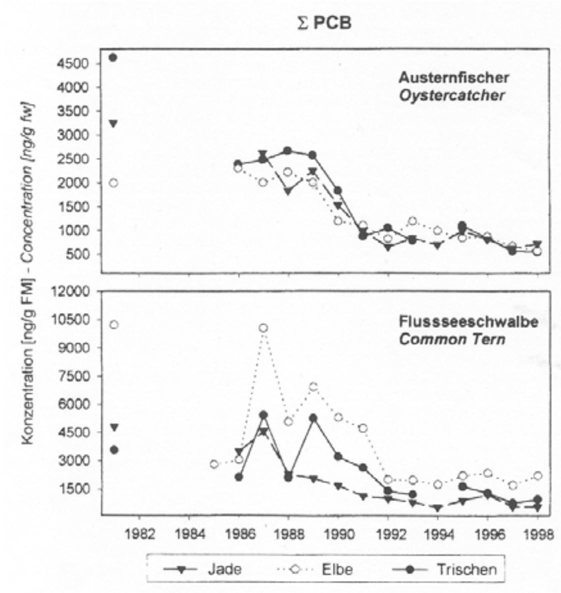

Figure 11.1. Temporal trends in PCB contamination of Eurasian oystercatcher and common tern eggs from selected breeding sites of the Wadden Sea (TMAP). FW=fresh weight of egg content (Thyen and Becker (2000)).

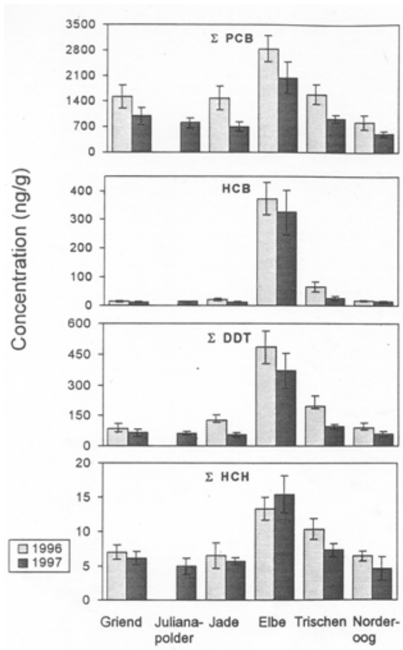

Figure 11.2. Spatial variation in organochlorine contamination of common tern eggs in 1996 and 1997 from breeding sites of the Wadden Sea (TMAP). Mean concentrations and (ng/g fresh weight of egg content) and 95% confidence intervals are presented. N= 10 eggs each. From Becker *et al*. (1998).

11.4 EcoQO for the North Sea

EcoQmetric	Current level	Reference level	Suggested EcoQO target level
Mean concentrations of organochlorine compounds in eggs of common eider, northern gannet, common tern, common guillemot and Eurasian oystercatcher from areas in the southern and in the northern North Sea	Varies according to species and location. See 11.4.3.	zero	See 11.4.4.

11.4.1 Metric

The proposed metric is the mean concentration of each of the various organochlorine compounds in eggs of selected species of seabirds (we propose the use of common eider, northern gannet, common tern, common guillemot, Eurasian oystercatcher) from colonies in the northern and in the southern North Sea.

11.4.2 Reference level

0 ng g^{-1} egg fresh mass. The reference level for this metric is zero as these are man-made chemicals only produced in recent decades.

11.4.3 Current levels and sampling

(ng g^{-1} egg fresh mass, Southern North Sea, range of 6–7 sampling sites, data from 1997, Becker *et al*. 1998):

PCBs: common tern 702 – 2042 ng g^{-1}; Eurasian oystercatcher 492 – 1055 ng g^{-1}

DDT and metabolites: common tern 56 – 371 ng g^{-1}; Eurasian oystercatcher 22 – 103 ng g^{-1}

HCB: common tern 11 – 325 ng g^{-1}; Eurasian oystercatcher 4 – 60 ng g^{-1}

HCH: common tern 5–15 ng g^{-1}; Eurasian oystercatcher 3 – 10 ng g^{-1}

There are few, if any, data for levels of organochlorines in eggs of these species from the northern North Sea, but sampling has been carried out with common guillemots and northern gannets from UK North Sea colonies in the northern North Sea. Data from these are not currently available to WGSE, but are held by CEH Monks Wood (Alcock *et al*. 2002). Those data may be used to set current and target levels for samples of common guillemot and northern gannet eggs as additions to common terns and oystercatchers. This increase to four seabird species as monitors would broaden the coverage of food chains to include offshore as well as coastal, and a range of larger pelagic fish prey (northern gannet). Common guillemots feed predominantly on small pelagic fish, while common terns feed on small coastal fish and crustacea, and oystercatchers feed on intertidal and saltmarsh molluscs and annelids (see Table 11.1). Another suitable sentinel species would be the common eider, which feeds mainly on the blue mussel, but also on a variety of other molluscs and crustacea. Eider eggs have been used to study levels of organochlorines in the coastal ecosystem of Finland (Franson *et al*. 2000), but as far as we are aware, current levels in eggs of North Sea eiders are not documented.

Sampling eggs is normally by taking a single freshly-laid egg from each clutch, preferably consistently the first-laid egg. There tends to be structure within seabird colonies, with higher quality and often older birds nesting in the centre of the colony and poor quality, often first time breeders, nesting on the edge. This structure also tends to result in differences in laying date with higher quality and older birds laying earlier in the season. Organochlorine levels may vary between these categories, so that sampling should attempt to take a random sample of eggs, or at least a consistent sample from year to year.

11.4.4 Target levels

Setting target levels as concentrations is difficult, and rather arbitrary, since the reference levels for organochlorines are zero, and this would also be a desirable target. However, even in the absence of any inputs, due to the very long half-times of these chemicals, the levels in the food web would remain high for many years. Perhaps practical targets could be <20 ng total PCBs g^{-1} egg fresh mass, <10 ng DDT and metabolites g^{-1} egg fresh mass, <2 ng HCB g^{-1} egg fresh mass, <2 ng HCH g^{-1} egg fresh mass for eggs of common tern and Eurasian oystercatcher from both the southern and the northern North Sea. Given that these are persistent chemicals, with long half-times, these targets could not be achieved until some decades from now. Probably the prospects of meeting these targets would be higher in the northern North Sea than in the southern North Sea.

Table 11.1. Seabird species suggested as monitors of marine pollution by organochlorines in the North Sea. Information on population size and trend, clutch size, diets and feeding range is presented mostly from ICES 1999 and ICES 2002). Common tern and Eurasian oystercatcher are already in use for monitoring in the Wadden Sea TMAP.

Species	Population size	Trend	Clutch size	Feeding range	Diet
Common eider	40,000 pairs	-	3–6	coastal	blue mussel, other molluscs and crustacea
Northern gannet	45,000 pairs	++	1	wide-ranging	sandeel, sprat, herring, mackerel, discards
Common tern	62,000 pairs	+/=	2–3	coastal	small fish
Common guillemot	350,000 pairs	+	1	inshore/offshore	small pelagic fish, especially sandeel, sprat
Eurasian oystercatcher	50,000 pairs	+	3–4	coastal, intertidal areas	shellfish, intertidal and terrestrial invertebrates

11.5 Historic trajectory and its historic performance

Eggs provide a measure of organochlorines in seabird diet in the few days before egg laying. At this time, birds are constrained to feed relatively close to the breeding site. This increases the risk of false alarms since high concentrations can arise at one site in one year as a consequence of local contamination. Figure 11.1 gives an indication of this. There were large differences in levels of organochlorines in eggs of common terns from German North Sea colonies each year from 1986 to 1990. These probably reflected short term relatively local fluctuations in amounts of organochlorines being discharged into the North Sea (in this case especially from the River Elbe). Calculating a running mean over 3 or 4 years and sampling from several species and from different colonies would minimize this risk of false alarms.

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12 FURTHER CONSIDERATION OF THE ECOQO FOR THREATENED AND DECLINING SEABIRD SPECIES IN THE NORTH SEA

12.1 Introduction

Five species of seabird were proposed by the 2003 meeting of OSPARs Biodiversity Committee for adoption onto OSPARs list of threatened and declining species at the summer 2003 OSPAR Ministerial meeting. These were lesser black-backed gull (*fuscus* subspecies), Steller's eider, little shearwater, roseate tern and common guillemot (Iberian population). In 2002, ICES recommended a series of steps to be followed to determine which species on the proposed OSPAR list would be suitable for robust and effective EcoQOs (ICES 2002). Of the species on the proposed OSPAR list, only the roseate tern breeds in the North Sea, with the remainder occurring as vagrant non-breeders. We tested this species using the ICES steps.

Step 1 – Establish whether the species occurs in the Greater North Sea (OSPAR Region II).

Step 2 – Establish whether the status of the species can be quantified accurately.

Step 3 – Establish why the species is threatened or declining.

Step 4 – Establish whether trends in population status can be detected reliably on time frames relevant to management (perhaps over five years).

The status of roseate terns is well known in the OSPAR area and is quantified on an annual basis so trends can be comparatively easily detected within suitable time frames.. In terms of accuracy, this species is more difficult than some terns due to its habit if nesting in less open areas (commonly under boulders or long vegetation), but accuracy is reasonable. The roseate tern has a patchy distribution in the north-east Atlantic, with the majority (presently over 1000 pairs) nesting on the Azores. Elsewhere the species breeds only very locally in Britain, Ireland and France. Two main sites in Ireland have held around 600 pairs in recent years. The majority of the UK's population nests in north-west Wales. In years since 1990 in OSPAR Region II, 66–111 pairs have nested in northern Brittany, and 38–50 pairs in south-east Scotland/north-east England (Table 12.1). The North Sea is at the northern end of its range in the north-east Atlantic and globally.

Table 12.1. Numbers of roseate terns nesting in North Sea colonies from 1990 – 2001 (from Cadiou *et al*. 2002, Mavor *et al*. 2002).

UK	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Pairs	42	46	50	50	49	52	47	38	43	47	47	45
Colonies	3	3	3	3	4	4	5	4	4	3	5	4
France												
Pairs	97	92	86	83	81	92	109	109	68	87	80	-
Colonies	4	3	2	2	3	3	4	3	2	2	2	-

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, Mavor *et al*. 2002). 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. This has helped the north-west European population as a whole to increase in recent years.

It is unclear why the species has undergone a long-term decline. All roseate tern colonies in UK, Ireland and France are within nature reserves that control or prohibit any direct human disturbance or other threats to nesting pairs. Productivity at colonies has been good over recent years. However, the roseate terns in the north–east Atlantic are thought to be one metapopulation (Ratcliffe 1997), so lack of protection elsewhere may affect the terns nesting in OSPAR Region II. The key wintering area for birds breeding in the UK is west Africa, particularly Ghana where it is believed that most adult mortality occurs – perhaps as a result of trapping by humans.

In the UK, a Biodiversity Action Plan has been drawn up for the roseate tern. This plan has two targets: a) Increase the UK roseate tern population to 200 pairs by 2008 and b) Maintain favourable conditions at current and historical breeding sites in the UK to ensure there are a minimum of five colonies with at least ten pairs in each by 2008 (UK Biodiversity Steering Group 1995).

12.2 Relevance and usefulness of roseate terns as an EcoQO in the North Sea

The roseate tern passes all of the steps suggested by ICES (2002) with the exception of good knowledge on why the species is threatened or declining. If despite this, managers wish to establish an EcoQO, then this might be couched in similar style to that set for seal populations in the North Sea[1].

An alternative objective might be similar to that used for the UK Biodiversity Action Plan; in other words a target in terms of numbers of sites and population size to be achieved by a certain date; however we can find no scientific foundation for such a target, so the numbers chosen would be a political decision. A suggestion might be to maintain numbers of nesting roseate terns above 160 in more than 7 colonies within OSPAR Area II. These figures are the sum of the peak numbers in France and in UK over the past 11 years, with the modal number of colonies.

We can examine this possible EcoQO against the criteria suggested by ICES (2001) for a good EcoQO:

- relatively easy to understand by non-scientists and those who will decide on their use;
- sensitive to a manageable human activity;
- relatively tightly linked in time to that activity;
- easily and accurately measured, with a low error rate;
- responsive primarily to a human activity, with low responsiveness to other causes of change;
- measurable over a large proportion of the area to which the EcoQ element is to apply;
- based on an existing body or time series of data to allow a realistic setting of objectives.

Numbers in the North Sea are consistently low, but variable – features common in edge of range populations. Examining the criteria for a good EcoQO against a possible EcoQO for population change indicates that setting a level (or objective in a similar style to that for seals) would be difficult. However, such targets would be relatively easy to understand, and to monitor over the relevant parts (Brittany and north-east England/south-east Scotland) of the North Sea with a low error rate. This EcoQO would be relatively meaningless elsewhere in the North Sea.

An EcoQO for roseate tern numbers would though not necessarily be sensitive to a manageable human activity. Plainly, maintenance of current management at colonies is a prerequisite, but is no guarantee that the target will be met as at present there is no certainty in which factors are the most important in controlling population level. It may also be that the causes of change are outside the North Sea and outside manager’s ability to affect them. In addition, edge of range effects on the variance (and possibly trends) in breeding numbers might also confound manager’s abilities to affect the EcoQO.

12.3 Recommendation

We would concur with previous advice from ICES that objectives for threatened and declining species are not very appropriate as EcoQOs (ICES 2002), primarily in the case of roseate tern due to the lack of knowledge on linkage between population levels and manageable human activities. This does not mean that roseate terns do not need programmes of conservation and recovery. We support strongly the need to fully implement existing recovery plans.

Should a decision nevertheless be made to set an EcoQO for this species, then we would suggest that a target population in the order of 160 at seven colonies might be suitable, but we would have no confidence that any existing possible management measures could be sure of meeting this.

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13 A PROCESS TO CONSTRUCT A TIME SERIES OF SEABIRD ABUNDANCE, DIET AND CONSUMPTION RATES FOR THE NORTH SEA SINCE 1963

13.1 Introduction

The Study Group on Multispecies Assessments in the North Sea (SGMSNS) intends to carry out a run of the multispecies model in 2004. The model requires a time series of seabird abundance by quarter and year from 1963 to 2003. There is no subdivision of the North Sea within the model. The model also requires seabird consumption rates and dietary composition by species and size class by quarter and year. Plainly we do not have information on these features, collected by quarter and year, so the process we propose below should provide the best possible information for these parameters, using extrapolation from existing data.

13.2 Seabird abundance: background

In an ideal world, the abundance of seabirds would be calculated from densities observed at sea throughout the year. This procedure was used for WGSE's exploration of North Sea seabird food consumption in the mid 1990s (Tasker and Furness 1996). The data used in that exploration were collected between 1980 and 1995, with particular emphasis on the early 1980s. Any subdivision of the data to years would leave too many gaps and there are no at-sea data for the period 1963 to 1980, and they are very sparse after 1995. Tasker and Furness's (1996) analysis does provide information on the relative abundance of seabirds in the North Sea between quarters of the year, and also indicated that eight species (Table 13.1) consume 94% of the energy usage by seabirds in the North Sea (and no other species takes more than 2% of the consumption). Tasker and Furness (1996) based their food consumption estimates on these top eight species scaled up to allow for those species consuming less than 2% of the total.

Table 13.1 Annual energy requirements of seabirds in the North Sea, ordered by percentage consumption (Tasker and Furness 1996).

Species	Percentage consumption
Northern fulmar	28.1
Common guillemot	26.3
Herring gull	11.6
Black-legged kittiwake	7.9
Great black-backed gull	7.7
Northern gannet	7.0
Atlantic puffin	2.8
Razorbill	2.6
Lesser black-backed gull	1.8
European shag	1.2
Mew gull	1.1
Black-headed gull	1.0
Great skua	0.5
Black guillemot	0.2
Great cormorant	0.2
Arctic tern	0.1
Common tern	0.1
Sandwich tern	0.1

Time series of data do exist for seabird breeding populations. The largest populations of seabirds using the North Sea during the summer breeding season nest on UK and Wadden Sea coasts. The entire UK breeding population of seabirds has been censussed three times: 1969–71, 1985–87 and 1999–2002. Numbers of northern fulmars and black-legged kittiwakes were also counted or assessed prior to 1969–71 on a UK-wide scale, and there are some one-off counts of other species at individual colonies in these earlier times (Cramp *et al*. 1974; Lloyd *et al*. 1991; Seabird 2000 counts, unpublished).

Counts of breeding birds on Wadden Sea coasts are available from 1963 onwards (Garthe *et al*. 2000, Rasmussen, 1996, Spaans 1998). Current populations and trends in the North Sea were summarised by ICES (2002).

Outside the breeding season, seabirds that breed elsewhere migrate to use the North Sea, while some breeding within the North Sea migrate to other regions. The majority of the seabirds coming into the North Sea are from colonies to the north and north-west (the benthic feeding ducks from further east are not included in this analysis) (e.g., Wernham *et al*. 2002). Trends in numbers at selected Norwegian colonies (or for dispersed species, regions) have been monitored annually since 1988, but data from earlier years are available for some species (Lorentsen 2002). Little is known of trends in numbers of species wintering in the North Sea from Iceland or the Faroe Islands.

13.3 Seabird abundance, proposed time series process

Trends in breeding season abundance of the eight seabird species consuming 94% of the seabird community energy requirement in the North Sea will be assessed using standard references and extrapolating between the census periods. Some extrapolation backwards to 1963 will need to be based on changes recorded at individual colonies and making the assumption that these are representative of the whole area.

Trends in abundance in the three non-breeding seasons will be estimated using a key derived from the ratio of numbers present in the breeding season to the numbers present in the relevant non-breeding season in the Tasker and Furness (1996) analysis. An estimation derived by this method alone would rely on the assumption that changes in the breeding populations arriving into the North Sea are the same as those breeding within the North Sea. The literature will be explored to check the veracity of this assumption, and any necessary model-tuning would be made.

13.4 Seabird dietary composition and food consumption rates: background

Tasker and Furness (1996) summarised dietary information for the North Sea from literature published up until 1993. Based on this summary, they presented, for each major energy-consuming seabird species, the best estimate of the fish species and sizes eaten. Wright and Tasker (1996) extended this analysis to look at age classes of fish eaten. Both analyses differentiated some parts of the North Sea for some species as diets were clearly different between areas. A North Sea wide estimate, as requested by the current term of reference, will require some biasing of the dietary information by size of the population using the relevant part of the North Sea.

The quality of the dietary information is highly variable. Of the two largest consumers, dietary information of common guillemot was good, whereas that for the northern fulmar was poor (Tasker and Furness 1996). Diets are very poorly known outside the breeding season as is the degree of variation from year to year, especially in relation to changes in fish stocks. Diet is known to change as a consequence of fish stock (or food availability) changes.

Seabird consumption rates depend on the energy needed by the seabird to live, the energy content of the food consumed and the food utilisation efficiency. Tasker and Furness (1996) listed metabolic rates for seabirds described from field studies made prior to 1995, and measurements of basal metabolic rates from laboratory studies (or modelling based on mean body masses) prior to 1995. The energy content of foods was assessed based on literature studies, and food utilisation efficiency for seabirds was assumed to be 75% for all foods.

13.5 Seabird dietary composition and food consumption rates: proposed time series process

A review of dietary information derived from studies after 1993 will be made. This will be based on the dietary database maintained by WGSE (see ICES 2001). This review will in particular examine whether changes in diets can be detected through time in the North Sea. There is very little information on this aspect for northern fulmars, but some assumptions may be made on the basis of reduction in availability of offal (one of the foods of this species) due to the decline in whitefish offal discharge since 1963. Some information may exist for common guillemots at a few colonies. A table of dietary assumptions will be presented, including size classes of fish taken. These assumptions will take account of the spatial distribution of the species concerned within the North Sea.

A literature review will also be undertaken to check and where necessary update the seabird species consumption rates and the food utilisation efficiencies used by Tasker and Furness (1996). It is unclear if the energy content of foods will be needed as input to the North Sea multispecies model or whether this also should be reviewed by WGSE. Advice on the overall format of information requested from WGSE will be sought prior to the 2004 meeting of the group.

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14 FURTHER DEVELOPMENT OF THE ECOQO RELATING TO THE BREEDING PRODUCTIVITY OF BLACK-LEGGED KITTIWAKES AS AN INDEX FOR THE LOCAL AVAILABILITY IN THE NORTH SEA OF SANDEELS

14.1 Introduction

The Bergen Declaration by North Sea Ministers agreed that an ecological quality element relating to local sandeel availability to black-legged kittiwakes should continue to be developed. OSPAR requested that ICES should continue to develop this metric for possible inclusion as an EcoQO in the future. Due to an oversight, WGSE was not given this as a term of reference in 2003, but the working group on ecosystem effects of fishing activities (WGECO) was given a term of reference on this topic that was "*based on the output of WGSE*". WGSE therefore decided to add this work to its terms of reference.

Sandeels are among the most abundant fish in the North Sea and dominate the summer diets of many marine vertebrates (Furness and Tasker 1997), especially in the north-west of the region where there are few sprat or juvenile herring to provide alternative prey. Sandeel therefore represent an important component of ecological quality in the North Sea. A large industrial fishery also harvests sandeels and there is potential for this to reduce ecological quality through localised over-exploitation, although current evidence suggests that North Sea sandeel stocks are at an all-time high (Furness 1999, 2002). Stocks of sandeel are extremely difficult to assess owing to fluctuations in recruitment, their high, variable natural mortality rate and their burrowing behaviour (Gislason and Kirkegaard 1996). At present sandeel stocks are estimated at a broad spatial scale (Gislason and Kirkegaard 1996) despite evidence for finer-scale population structure (Pedersen *et al*. 1999). Regional stock assessments are therefore desirable, particularly in environmentally sensitive areas that occur at smaller spatial scales (Furness and Tasker 2000). An EcoQO that provides both a recognition of biological impact and a surrogate measure of local declines in sandeel stocks has clear value for ecologically sensitive fisheries management.

The concern over this potential localised biological impact has been partly acknowledged in a closure of the sandeel fishery in a part of the northwest North Sea on grounds of evidence of impact on predators dependant on sandeels (i.e., including fish, marine mammals and seabirds). This closure was introduced for three years (2000 – 2002 inclusive) and has been extended to 2003.

ICES suggested an EcoQO for black-legged kittiwake productivity in its advice to the North Sea conference, and has provided advice in relation to the fishery closure noted above. Based on UK monitoring of black-legged kittiwake breeding performance, we suggest that the EcoQO might be for a mean chick productivity of at least 0.5 chicks per nest in all relevant areas of the North Sea. Monitoring is undertaken currently at between 15 and 20 colonies in the western North Sea each year. Results from these are presented annually, divided between four western North Sea coastal regions (e.g., Upton *et al*. 2000). These, with the addition of Helgoland as another site, might comprise "relevant areas" of the North Sea.

EcoQ metric	Current level	Reference level	Suggested EcoQO target level
Index of local sandeel availability to black legged kittiwakes	0.97±0.28 chicks per pair	Not known	0.5 chicks per pair in all relevant regions of the North Sea

If this EcoQO is assessed against the ICES criteria for good Eco QO:

a) Relatively easy to understand by non-scientists and those who will decide on their use
b) Sensitive to a manageable human activity
c) Relatively tightly linked in time to that activity
d) Easily and accurately measured, with a low error rate
e) Responsive primarily to a human activity, with low responsiveness to other causes of change
f) Measurable over a large proportion of the area to which the EcoQ metric is to apply
g) Based on an existing body or time-series of data to allow a realistic setting of objectives

Monitoring of black-legged kittiwake breeding performance is already undertaken at a good sample of UK colonies in the North Sea using standardised methods (Walsh *et al.* 1995). The species nests also at Helgoland, on a Dutch gas platform, and at sites in southern Norway. It would be very easy to add these localities to the existing scheme and report data in the current annual UK/Ireland seabird monitoring report (e.g., Upton *et al*. 2000).

This EcoQO would therefore pass when assessed against criteria a), d), f) and g). Black-legged kittiwake breeding success is sensitive to changes in food supply within their feeding area, but the food supply (sandeel almost exclusively in some areas) is only partially responsive to fishing by humans. It is thus not tightly linked to a human activity or necessarily particularly responsive to fisheries management. These weaknesses in the EcoQO are unlikely to be improved much by further research. Advice has already provided by ICES on appropriate levels of black-legged kittiwake breeding performance (ICES 1999). Future advice on black-legged kittiwake breeding success might be included within advice on sandeel stocks supplied to fisheries managers.

If appropriate, it would be easy to reconstruct the historic trajectory of this suggested metric and determine its historic performance (hit, miss and false alarm) at the 0.5 chicks per pair level or any other level chosen. This would further enable evaluation as to whether it would be helpful to include a measure of the number of years over which the objective would need to be met (or not) before change in management was triggered.

14.2 References

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15 RECOMMENDATIONS

15.1 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 in Aberdeen, U.K. from Monday 29 March 2004 to Friday 2 April 2004 to:

a) review the factors influencing trends in abundance of seabirds in the Baltic Sea;
b) review progress in studies of seabirds in relation to marine wind farms;
c) review relationships between seabirds and oceanographic features, with particular reference to effects of climate change;

d) consider the selection of seabird species and populations that would be appropriate to use in an EcoQO relating to seabird population trends in the North Sea as indices of seabird community health;

e) complete the work carried out in 2003 to compare seabird communities and prey consumption between the east and west North Atlantic;

f) provide WGMSNS with data on the consumption of different prey by seabirds in the North Sea, in a format specified by WGMSNS.

15.2 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) WGSE reviewed data on population trends of seabirds in the Baltic Sea in the 2003 meeting. Given that there have been major declines in numbers of certain populations and species, it would be useful to review likely causes of these declines, and factors that may have contributed to the increase in numbers in a few species; b) With a rapid development of marine wind farms in many European countries, we wish to review progress in the areas that have been identified as major gaps in knowledge; two of the most important of these are the development of methods to measure bird collision risk, and the behavioural responses of birds to marine wind farms (such as avoidance causing possible loss of foraging habitat, barriers to movement, and use of marine wind farms as new habitat for resting or feeding); c) There has been a large increase in work on the extent to which at sea distributions of seabirds are determined by oceanographic factors. This has been partly by at sea survey work, and partly by the application of data loggers on foraging seabirds. Recent research also indicates effects of climate change on seabird distribution, demography and ecology. It would be useful to review this progress. d) The proposed EcoQO 'Seabird population trends in the North Sea as an index of seabird community health' requires further work with empirical data on seabird population trends and individual colony trends in order that the historical trajectories and performance of the various possible metrics can be evaluated, especially in relation to the use of particular focal species and selected key sites as a proxy for the whole North Sea species' populations (since obtaining accurate and frequent whole-North Sea counts of seabird breeding populations is not a practical proposition). During the 2003 WGSE meeting we had neither the necessary data, nor the time to perform these analyses. e) 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, WGSE03 confirmed that it is 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. f) WGMSNS require a compilation of data on quantities of foods consumed by seabirds in the North Sea for input to an MSVPA model. These data will be compiled in the format required by WGMSNS.
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:	There will be a major conference on Seabirds in Aberdeen starting on Friday 2 April 2004. Since all active members of the group are at present funded outside core funding within the Member Countries (many are privately funded), meeting in Aberdeen immediately before this conference will minimise travel costs of members, as most are likely to be attending the conference.
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.
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 the forthcoming multispecies modelling of the North Sea, and to assessing environmental needs of seabirds and effects of seabirds on fish stocks.]
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 – TERMS OF REFERENCE

At the 89th Statutory Meeting, it was agreed that the Working Group on Seabird Ecology [WGSE] should meet in ICES Headquarters from 7–10 March 2003 (4 days). The terms of reference were 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.

f) respond to an OSPAR request in connection with the EcoQO relating to the proportion of oiled common guillemots among those found dead or dying on beaches [OSPAR 2003/3.1], in particular:

   i) develop draft guidelines (taking into account MON 01/9/1, Annex 6), including monitoring protocols and assessment methods, for evaluating the status of, and compliance with, those EcoQOs

   ii) provide current levels, on an appropriate geographical basis, to be used as baselines against which progress can be measured;

   iii) reconstruct the historic trajectory of these metrics and determine their historic performance (hit, miss or false alarm) relative to the objective being measured, as a basis for deciding their relationship to management;

   iv) provide the basis for advice on what management measures could be taken to help meet the EcoQOs

g) respond to an OSPAR request to commence development, on the basis of the criteria for sound EcoQOs established by ICES in 2001, of related metrics, objectives and reference levels for the EcoQOs relating to [OSPAR 2003/3.2]

   i) Mercury concentrations in eggs and feathers of North Sea seabirds

   ii) Plastic particles in the stomachs of North Sea seabirds

   iii) Seabird population trends in the North Sea as an index of seabird community health

   iv) Organochlorine concentrations in the eggs of North Sea seabirds.

h) commence development, on the basis of the criteria for sound EcoQOs established by ICES in 2001, of related metrics, objectives and reference levels for the EcoQOs relating to (b) presence and extent of threatened and declining species in the North Sea [OSPAR 2003/3.3]. In this respect,

   i) for EcoQ element (b), consider the seabird species and the habitats on the Draft OSPAR list of threatened and declining species for their relevance and usefulness as a basis for EcoQOs for the North Sea;

   ii) where possible and appropriate, reconstruct the historic trajectory of the metrics and determine their historic performance (hit, miss or false alarm) relative to the objective being measured, as a basis for deciding their relationship to management;

i) devise a process to construct in 2004 a time series of:

   i) seabird abundance in the North Sea by quarter and year since 1963

   ii) seabird consumption rates and dietary composition by species and size class for selected periods by quarter and year.

WGSE will report by 24 March 2003 for the attention of the Oceanography, Marine Habitat, Living Resources and Resources Management Committees, and ACE.

ANNEX 3 – 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*
Little grebe	*Tachybaptus ruficollis*
Northern fulmar	*Fulmarus glacialis*
Cory's shearwater	*Calonectris diomedea*
Great shearwater	*Puffinus gravis*
Little shearwater	*Puffinus assimilis*
Audubon's shearwater	*Puffinus lherminieri*
Balearic shearwater	*Puffinus mauretanicus*
Manx shearwater	*Puffinus puffinus*
Sooty shearwater	*Puffinus griseus*
Bulwer's petrel	*Bulweria bulwerii*
European storm-petrel	*Hydrobates pelagicus*
White-faced storm-petrel	*Pelagodroma marina*
Leach's storm-petrel	*Oceanodroma leucorhoa*
Madeiran storm-petrel	*Oceanodroma castro*
Wilson's storm-petrel	*Oceanites oceanicus*
Black-capped petrel	*Pterodroma hasitata*
Zino's petrel	*Pterodroma madeira*
Fea's petrel	*Pterodroma feae*
Northern gannet	*Morus bassanus*
Great cormorant	*Phalacrocorax carbo*
Double-crested cormorant	*Phalacrocorax auritus*
European shag	*Phalacrocorax aristotelis*
Mute swan	*Cygnus olor*
Whooper swan	*Cygnus cygnus*
Common shelduck	*Tadorna tadorna*
Pintail	*Anas acuta*
Eurasian teal	*Anas crecca*
Eurasian wigeon	*Anas penelope*
Mallard	*Anas platyrhynchos*
Greater scaup	*Aythya marila*
Pochard	*Aythya ferina*
Tufted duck	*Aythya fuligula*
Common eider	*Somateria mollissima*
King eider	*Somateria spectabilis*
Steller's eider	*Polysticta stelleri*
Harlequin duck	*Histrionicus histrionicus*
Long-tailed duck	*Clangula hyenalis*
Black scoter	*Melanitta nigra*
Velvet scoter	*Melanitta fusca*
Surf scoter	*Melanitta perspicillata*
Common goldeneye	*Bucephala clangula*
Red-breasted merganser	*Mergus serrator*
Goosander	*Mergus merganser*
Smew	*Mergellus albellus*
Eurasian coot	*Fulica atra*
Eurasian oystercatcher	*Haematopus ostralegus*
Red-necked phalarope	*Phalaropus lobatus*
Grey phalarope	*Phalaropus fulicarius*
Arctic skua	*Stercorarius parasiticus*
Pomarine skua	*Stercorarius pomarinus*
Great skua	*Catharacta skua*

English name	**Scientific name**
Mediterranean gull	*Larus melanocephalus*
Little gull	*Larus minutus*
Black-headed gull	*Larus ridibundus*
Sabine's gull	*Larus sabini*
Mew gull	*Larus canus*
Bonaparte's gull	*Larus philadelphia*
Laughing gull	*Larus atricilla*
Ring-billed gull	*Larus delawarensis*
Audouin's gull	*Larus audouinii*
Slender-billed gull	*Larus genei*
Lesser black-backed gull	*Larus fuscus*
Glaucous gull	*Larus hyperboreus*
Iceland gull	*Larus glaucoides*
Herring gull	*Larus argentatus*
Yellow-legged gull	*Larus cachinnans*
Great black-backed gull	*Larus marinus*
Ivory gull	*Pagophila eburnean*
Black-legged kittiwake	*Rissa tridactyla*
Gull-billed tern	*Gelochelidon nilotica*
Roseate tern	*Sterna dougallii*
Forster's tern	*Sterna forsteri*
Common tern	*Sterna hirundo*
Arctic tern	*Sterna paradisaea*
Little tern	*Sterna albifrons*
Least tern	*Sterna antillarum*
Sandwich tern	*Sterna sandvicensis*
Royal tern	*Sterna maxima*
Caspian tern	*Sterna caspia*
Black tern	*Chlidonias niger*
Black skimmer	*Rynchops niger*
Common guillemot	*Uria aalge*
Brunnich's guillemot	*Uria lomvia*
Razorbill	*Alca torda*
Black guillemot	*Cepphus grylle*
Little auk	*Alle alle*
Atlantic puffin	*Fratercula arctica*
Common starling	*Sturnus vulgaris*
Hedge accentor	*Prunella modularis*