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Executive summary

The Working Group on Seabird Ecology (WGSE) met for four days (29 March to 1 April 2005), and was attended by twelve persons from seven countries (Annex 1). Ten persons were nominated members to the group, and two persons were invited by the Working Group Chair to attend this year's meeting. The possibility to invite persons not yet nominated by national delegates was considered by the group to be a very useful tool. During the meeting WGSE was able to address all terms of reference, though in varying detail and the results are reported here.

Term of Reference a) had already been tackled intensively by WGSE at the meeting in March/April 2004. After feedback from Andrew Kenny from CEFAS, UK, it was clear that the work by WGSE has fully developed all available data sets to be used for the REGNS project. It was therefore decided to not consider this ToR for the 2005 meeting.

The Ecological Quality Objective (EcoQO) for seabird populations was further developed. While population trends may be used as an indication of changes in the marine environment there are many problems related to plainly applying such an EcoQO. These problems are addressed in Section 2. Further recommendations are given from which a term of reference for the meeting in 2006 was derived.

Recently, major oil spills have occurred. The impacts of these oil spills are reviewed in Section 3. Effects of these oil spills were rather difficult to demonstrate in most cases although some obvious mass mortalities took place. Sea areas as well as season are two major factors affecting the impacts of oil spills on seabirds. In addition to the original suggestion by WGSE, assessments as related to a recent OSPAR document were part of the ToR for 2005. Those parts of the requests that were considered to be applicable for WGSE have been included into the chapter.

There is substantial evidence that *Spisula* stocks have declined in the southern North Sea recently. As these bivalves are main prey items of common scoters there have been new concerns about present and future threats. From the current information on distribution, numbers and diet it seems that common scoters have partly left the area but also apparently switched to other bivalve species such as *Ensis*.

WGSE has developed a food consumption model for the whole North Atlantic at the meetings over the last years. Remarkable differences between regions in the Northwest and Northeast Atlantic in terms of seabird numbers and consumption rates and aspects of the underlying food web structures in the study area are discussed in Section 5.

In addition to the five Terms of Reference given for the WGSE 2005 meeting, WGSE was discussing some important items related to a ToR from 2004, when the group was asked to provide the Study Group on Multispecies Assessments in the North Sea (SGMSNS) with data on the consumption of different prey by seabirds in the North Sea. This request could not be dealt with last year and is, meanwhile, a part of the EU-funded project 'Critical Interactions between Species and their Implications for a Precautionary Fisheries Management in a variable environment - a Modelling Approach (BECAUSE)'. As these issues are strongly related to the standard WGSE work, these discussions were considered useful for current and future work.

1 Introduction

1.1 Participation

The following members of the Working Group on Seabird Ecology (WGSE) participated in the meeting (see Annex 1 for addresses).

Tycho Anker-Nilssen	Norway
Rob Barrett	Norway
Kees Camphuysen	The Netherlands
John Chardine	Canada
Morten Frederiksen	UK
Stefan Garthe (Chair)	Germany
Ulrike Kubetzki	Germany
Mardik Leopold	The Netherlands
Bill Montevecchi	Canada
Manuela Nunes	Portugal
Mark Tasker	UK
Richard Veit	USA

1.2 Terms of Reference

The 2004 Statutory meeting of ICES gave the Working Group on Seabird Ecology the following terms of reference:

- a) for each seabird species that occurs regularly in the North Sea, compile data (in Excel spreadsheet format) which quantifies the seasonal distribution and abundance at spatial scales, where possible, that correspond to ICES rectangles in the North Sea. The data should be submitted to the REGNS secure website in preparation for the REGNS Integrated Assessment Workshop, 9–13 May 2005. These data should, where possible, cover the period 1984 – 2004 on an annual basis in order to assess trends. In addition, where possible, provide information on diet and variation/change of this for all species;
- b) develop EcoQOs for seabird populations;
- c) review the impacts of recent major oil spills on seabirds (“Erika”, “Prestige”, “Tricolor”) and contribute to the assessment of the long-term impact of oil spills on marine and coastal life for OSPAR [OSPAR 2005/7];
- d) review the consequences for foraging conditions of sea ducks of the *Spisula* decline in the southern North Sea;
- e) examine the food web relationships of seabirds indicated by food consumption estimates in the Northeast and Northwest Atlantic Regions.

1.3 Note on bird names

Throughout the text we provide common English names for bird species. In Annex 2 a full list of both English and scientific names is given.

1.4 Acknowledgements

The Working Group wishes to thank the Royal Netherlands Institute for Sea Research for providing us with a meeting room, copying and computer facilities and for other valuable logistic support. We also thank the ICES headquarter for information.

Dr Roberto Bao (A Coruña University), Martin Heubeck (SOTEAG, Shetland, and Aberdeen University) and Anders Mosbech (NERI, Roskilde) provided valuable information.

2 Development of an Ecological Quality Objective (EcoQO) for seabird populations

2.1 Introduction

WGSE has played an active role in the development of Ecological Quality Objectives (EcoQOs) for the North Sea throughout the involvement of ICES in this issue (ICES 2001, 2002, 2003, 2004). The early stages of development (and piloting of some of the EcoQOs) are now at an end with a decision expected by OSPAR (Convention for the Protection of the Marine Environment of the North-East-Atlantic) and others in summer 2005 as to the future of the EcoQO programme. Several of the seabird-related EcoQOs have been recommended for implementation within the OSPAR system (OSPAR 2005a, b), but the EcoQO relating to seabird population trends as an index of seabird community health (Ecological Quality Objective k) has not been fully developed. ICES (2004b) suggested a precautionary EcoQO of a population decline of $\leq 20\%$ over ≥ 20 years. Thus a precautionary limit of $> 20\%$ over < 20 years could be used to trigger further investigation of the factors behind a decline, but such an EcoQO would need to fit into a more advanced framework for all EcoQOs before becoming operational. In section 2.2 this EcoQO is developed further to make it more specific. This though is not the only possible way of representing population change; the discussion below covers several possible metrics and objectives for seabird populations: rates of change in breeding population size, rates of survival and reproductive rates, diets, community composition, biomass and diversity measures.

2.2 Seabird population trends as an index of seabird community health

As pointed out by WGSE (ICES 2003, 2004), the wellbeing of seabird communities may be best described by monitoring population trends for the full suite of seabird species occurring in “significant” numbers in an area. In most cases, however, a number of practical, logistic and economic reasons make it necessary to restrict this effort to a smaller selection of species. Moreover, numbers of sites that can be effectively monitored are also limited. WGSE has therefore discussed how to make this EcoQO more specific by identifying the most suitable target species and key sites that could be used as a proxy for the whole North Sea seabird community, since obtaining sufficiently frequent and accurate counts of the whole North Sea population of breeding seabirds is not a practical proposition. The set of principles for such a selection of appropriate species and populations should take into account the distribution of seabirds within different parts of the North Sea and include the most representative in terms of their ecology, numbers, distribution and feasibility for monitoring (accessibility and counting accuracy). Inter-specific differences in feasibility for monitoring of various North Sea seabirds are indicated in Table 2–1.

Table 2–1: A coarse assessment of the feasibility for monitoring breeding populations of various North Sea seabirds.

SPECIES	ADVANTAGES/DISADVANTAGES OF MONITORING OF BREEDING NUMBERS IN NORTH SEA
Northern fulmar	Easy to count, but are widely dispersed
Manx shearwater	Rare and difficult to count in burrows
European storm-petrel	Rare and difficult to count in burrows
Leach's storm-petrel	Very rare and difficult to count in burrows
Northern gannet	Easy to count
Great cormorant	Partly fresh-water species, but easy to count
European shag	Moderately easy to count in most colonies
Common eider	Difficult to census accurately, but aerial surveys of males prior to breeding useful
Arctic skua	Easy to count, but are widely dispersed
Great skua	Easy to count
Mediterranean gull	Partly terrestrial species, easy to count when grouped in colonies
Black-headed gull	Partly terrestrial species, easy to count when grouped in colonies
Mew gull	Partly terrestrial species, easy to count when grouped in colonies
Lesser black-backed gull	Partly terrestrial species, easy to count when grouped in colonies
Herring gull	Partly terrestrial species, easy to count when grouped in colonies
Great black-backed gull	Easy to count
Black-legged kittiwake	Easy to count accurately
Sandwich tern	Easy to count
Roseate tern	Rare, but easy to count
Common tern	Partly freshwater species, easy to count
Arctic tern	Easy to count, but are widely dispersed
Little tern	Easy to count
Common guillemot	Easy to count individuals, but many counts needed each year
Razorbill	Difficult to count accurately due to hidden nest sites
Black guillemot	Difficult to count accurately due to hidden nest sites
Atlantic puffin	Moderately easy to count apparently occupied nest burrows

Changes in populations within different ecological groups of species might indicate changes in the health of different components of the ecosystem. As one important aid for the selection of species to monitor we therefore find it convenient to sort the species into six different groups according to their main feeding areas (pelagic or near-shore) and feeding behaviour (diving, plunge-diving or surface-feeding) in the breeding season (Table 2–2). Within each of these groups the most numerous, colonial and widely distributed species were considered more suitable targets than those that are scarce, dispersed breeders and/or very limited in their distribution, although we kept an open eye for cases where pairs of species with very different distribution within the North Sea area could be considered complementary to fulfil the need for geographical coverage. Based on these qualitative criteria, we consider the following eleven species (indicated in brackets in Table 2–2) to be the least useful targets for the seabird community health EcoQO: European storm-petrel, Leach's storm-petrel, Arctic skua, Mediterranean gull, black-headed gull, sandwich tern, roseate tern, Arctic tern, little tern, razorbill and black guillemot.

Table 2–2: Seabird species breeding in the North Sea grouped according to their main feeding areas (pelagic or near-shore) and feeding behaviour (diving, plunge-diving or surface-feeding) in the breeding season. Those that are considered less suitable target species for the proposed EcoQO are indicated in brackets (see text for specific arguments).

	PELAGIC (P)	NEAR-SHORE (NS)
Diving (D)	Common guillemot, (Razorbill), Atlantic puffin	Great cormorant, European shag, Common eider, (Black guillemot)
Plunge-diving (Pd)	Northern gannet	(Sandwich tern), (Roseate tern), Common tern, (Arctic tern), (Little tern)
Surface-feeding (Sf)	Northern fulmar, (European storm-petrel), (Leach's storm-petrel), Black-legged kittiwake	(Arctic skua), Great skua, (Mediterranean gull), (Black-headed gull), Mew gull, Lesser black-backed gull, Herring gull, Great black-backed gull

As changes in seabird population trends often are caused by parallel changes in their food supply, the selection of species to monitor should also take into account some important inter-specific differences with respect to main types of food items. This is indicated for a selection of the North Sea species in Table 2–3. Note that the assignment of species to the different groups in Tables 2–1, 2–2 and 2–3 was made specifically for the North Sea area and should be revised before applying the same principles to other regions.

Table 2–3: Types of main food items during the breeding season for the seabird species considered the most suitable targets for the proposed EcoQO in the North Sea (cf. Table 2–1).

SPECIES	LARGE FISH > ~15 CM	SMALL FISH < ~15 CM	FISH DISCARDS	PLANKTONIC INVERTEBRATES	BENTHIC INVERTEBRATES	INTER-TIDAL INVERTEBRATES	TERRESTRIAL FOOD ITEMS
Northern fulmar			X	X			
Northern gannet	X	X					
Great cormorant	X						
European shag		X					
Common eider					X	X	
Great skua		X	X				
Mew gull						X	X
Lesser black-backed gull		X		X			
Herring gull			X			X	
Great black-backed gull			X			X	
Black-legged kittiwake		X		X			
Common tern		X					
Common guillemot		X					
Atlantic puffin		X					

Preferably, a more detailed analysis of the empirical data on seabird population trends and individual colony trends should be made to evaluate fully the expected performance of the proposed EcoQ on seabird population trends in the North Sea as an index of seabird community health (ICES 2003). However, the main rationale for this EcoQ is the general public concern for declining seabird populations. This makes it practical to define a certain level of population decrease that, when exceeded, should trigger investigations to explore the most likely causes for the decline and considerations of possible countermeasures.

Long-term rates of change

Given the environmental variability at these latitudes many seabird populations are expected not to maintain stable numbers over a period of years, but our ability to detect changes over

the short term depends both on the magnitude and variability of changes in time and space as well as the method(s) used. However, monitoring of breeding seabirds aims to cover at least 10% of the total population of the targeted species and methods are considered highly standardised and reasonably robust. At its 2005 meeting, WGSE decided to refine this EcoQO by recommending a long-term target level to be set at $\leq 20\%$ decrease or $\geq 30\%$ increase over ≥ 20 years for seabird species with a low fecundity potential (Table 2–4). This is justified by the fact that these species are generally long-lived and reproduce slowly. Consequently, more rapid or more severe changes in their numbers are not expected and might indicate that some human-induced factor(s) is affecting the population to an extent that is not associated with a healthy seabird community and require(s) immediate management actions. Correspondingly, we recommend a less conservative long-term target level, provisionally set at $\leq 30\%$ decrease or $\geq 50\%$ increase over ≥ 20 years, for the species with the highest fecundity potential. In the North Sea area this would apply for cormorants, the common eider, gulls, the common tern and the black-legged kittiwake.

The reference level for seabird population trends would typically be less than half the maximum long-term target rate (i.e., in the order of $\leq 10\text{--}15\%$ decrease or $\leq 15\text{--}25\%$ increase over ≥ 20 years, cf. Table 2–4).

Table 2–4: Simple summary of the typical reference levels and recommended target levels for seabird population trends as an EcoQO for seabird community health in the North Sea. Note that the shorter term levels should only trigger more detailed research if the trends are statistically significant and applies to at least 50% of the population breeding on the monitoring sites.

	REFERENCE LEVEL OVER ≥ 20 YEARS	LONG-TERM TARGET LEVEL OVER ≥ 20 YEARS	SHORTER TERM LEVEL FOR TRIGGERING SPECIAL STUD- IES
Low fecundity species	Within -10% to +15%	Within -20% to +30%	Beyond -20% or +30%
High fecundity species	Within -15% to +25%	Within -30% to +50%	Beyond -30% or +50%

Shorter-term rates of change

In the shorter term it is important to bear in mind that the proportion of the adult population that actually breeds often varies greatly from year to year. Consequently, seabird breeding numbers do not always reflect the true population size of adult birds. Nevertheless, when there are clear indications that a target level has been surpassed in a shorter time than 20 years, this warrants more detailed studies to explore the underlying reasons for the change. For low fecundity species we therefore recommend such studies to be triggered only when there is a statistically significant drop by $>20\%$ or increase by $>30\%$ in breeding numbers (requiring at least 4–5 years of data) in $>50\%$ of the population breeding on the monitoring sites (Table 2–4). Consequently, the corresponding levels for high fecundity species would be a significant drop of $>30\%$ or increase of $>50\%$ in $>50\%$ of their population on the monitoring sites (Table 2–4).

Note that setting levels for increasing populations is necessary because it is practically impossible to monitor all populations of the seabird community, and that (e.g., due to inter-specific interactions) an increase in one species could well indicate problems for species that are not being monitored. Also note that these levels are primarily aimed as alarm signals to trigger more specialised studies when the absolute rate of population change crosses the threshold set. (Thus, it is not supposed to be used as the basis for concluding the seabird community is undergoing unacceptable changes).

2.3 Other parameters of seabird community health

The huge variety of possible mechanisms underlying changes in seabird breeding numbers makes it necessary to also monitor different parameters of population dynamics for (at least some of) the key species, although these parameters are usually more labour intensive to

monitor adequately. The great advantage of this approach is that it enables an immediate exploration of possible reasons for any population trends of special concern, without having to spend additional years to collect less adequate *a posteriori* information on the same parameters. As most seabirds are migratory outside the breeding season, trends in population numbers are also affected by environmental conditions far away from the breeding areas, in many cases outside the ICES areas in question. These factors are probably best reflected by changes in adult survival rates, whereas reproductive rates and chick diets (as well as other aspects of adults' feeding ecology or their physical condition) are likely to be better indicators of local conditions within the breeding seasons.

Based on this and on previous assessments, WGSE recommends a review of the variety of methods applied across the North Atlantic region to monitor the performance of seabirds. This review should assemble a set of standardised and cost-efficient guidelines that could make monitoring more, amenable to broad-scale analysis across regions and national borders. Developing recommendations for a comprehensive monitoring programme for seabirds is therefore recommended as a term of reference for the next meeting of WGSE (see Chapter 6.1).

Seabird biomass, community composition and diversity indices

These indices might be used at large scales within a sea area, based on information on the distribution of seabirds at sea. Such indices would potentially provide good indicators of the use being made of a sea area by seabirds, both breeding and non-breeding. The major disadvantage with these indices is the need for sufficient data on seabirds at sea, which are relatively costly to collect and which require dedicated surveys. At present, the majority of (but not all) seabirds at sea information in the OSPAR area is held on the European Seabirds at Sea database. This provides easy access for researchers to the whole dataset. However, most of the data has been collected opportunistically over wide areas, or during intensive studies of smaller areas and there is consequently much spatial and temporal heterogeneity. This makes analysis of the data to derive any of these indices difficult, and in some cases impossible. WGSE does not recommend developing these indices further at this time.

2.4 References

- ICES 2001. Report of the working group on seabird ecology. ICES CM 2001/C:05. 72 pp.
- ICES 2002. Report of the working group on seabird ecology. ICES CM 2002/C:04. 69 pp.
- ICES 2003. Report of the working group on seabird ecology. ICES CM 2003/C:03. 92 pp.
- ICES 2004a. Report of the working group on seabird ecology. ICES CM 2004/C:05. 53 pp.
- ICES 2004b. Report of the ICES Advisory Committee on Ecosystems, 2004. ICES Advice Report, No 1 Book 2 Part 2.
- OSPAR 2005a. Draft report on the North Sea pilot project on Ecological Quality Objectives. BDC 05/3/1. 58 pp.
- OSPAR 2005b Summary record of the meeting of the Biodiversity Committee, Bonn 21–25 February 2005. 32 pp + annexes.

3 Review of the impacts of recent major oil spills on seabirds

3.1 Introduction

The effects of major oil spills and chronic oil pollution on marine wildlife, notably seabirds, are seemingly all too well known. Seabirds are highly vulnerable to oil pollution and hundreds of thousands of seabirds die annually as a result of oil pollution in the North Atlantic alone (Camphuysen 1989; Wiese 2002; Wiese and Ryan 2003). However, oil-induced mortality is surprisingly difficult to assess and few studies have succeeded in identifying changes in population parameters such as trends in population size, caused either by the effect of a given spill or by persistently high levels of chronic oil pollution. One may wonder why it is so difficult to identify the effect of a large spill, killing many tens of thousands of seabirds, on a population numbering a few hundreds of thousands of seabirds, but there are several reasons why the effects may be masked. Seabirds are long-lived, and if a spill kills mostly juvenile or immature birds, any population effect noticeable in the colonies would be delayed at least a few years and spread over several years. Most oil-related mortality occurs in the non-breeding season. Affected seabirds may originate from a large number of different, possibly distant colonies, so that the loss within individual colonies may be modest. Many North Atlantic seabird populations have been growing for several decades as a result of a combination of factors including the relaxation of persecution, reduced human consumption and increases in the availability of food (Camphuysen and Garthe, 2000), so that the spectacular growth of most these populations may have masked any adverse effects of oil pollution.

In this chapter, we will evaluate the damage from a number of recent spills based upon investigations done during and following the spill. Next we will see if any population effects have been found, or indeed if any effects have been searched for in a systematic manner. From these case studies, we will evaluate the methods of oil spill impact assessments and if these are adequate to provide the data needed for an effect evaluation. We will discuss expected population level effects following a number of scenarios and evaluate each of the spills according to these scenarios to see why some effect studies were successful and others may have failed.

When we set out to work on the TOR on oil spill effects, six further requests by HOD(1) May 2004 for inclusion in the draft 2005 ICES Work Programme were to be considered. These six items included specific tasks, some of which fitted nicely in the initial TOR, others were different approaches to the oil problem, or were considered beyond the expertise of the WGSE. HOD(1) suggested that an assessment of the long-term effects of oil spills should consider:

- a) the distinction between the effects of the oil and what is caused by natural changes;
- b) the impacts of oil on different types of habitats (i.e., the nature of the coastline) and ecosystems (variability in rates of recovery);
- c) the impacts of oil in different marine regions subject to different climatic influences;
- d) the impacts of different types of oil, both toxic impacts (toxic effects and accumulation) and non-toxic impacts (physical properties creating nuisance and hazardous conditions – physical contamination and smothering);
- e) the impacts of remedial activities such as the use of heavy equipment and high pressure hosing to clean up oil spills;
- f) whether the current framework of environmental risk assessment and toxicology is sufficient to take account of the long term effects of oil pollution.

We will address these issues in the second part of this chapter.

3.2 Oil spills

Accidental oil spills caused by maritime transport are still an important source of pollution of the world's oceans, especially along some of the major shipping lanes (Couper 1983; Clark 2001; Vieites *et al.*, 2004). The number of oil spills from tanker accidents has declined from 24.2 year⁻¹ during the 1970s to 7.3 year⁻¹ in the 1990s (ITOPF 2003), and the amount of oil spilled has varied in each accident. The biggest tanker-related oil spills in recent history were the *Atlantic Empress* off Tobago (West Indies, 1979), the *ABT Summer* off Angola (1991), the *Castillo de Bellver* off Saldanha Bay (South Africa, 1983) and the *Amoco Cadiz* in Brittany (France, 1978), each with >200,000 tonnes spilled (Table 3–1).

Volume of oil lost, however, is not the most important factor in determining the effects on marine wildlife (notably seabirds), as we will see below. Small amounts of oil in areas with high concentrations of sensitive birds lead to very high numbers of casualties, whereas large amounts of oil in areas with few birds will have only a small effect (Goethe 1968; Camphuysen 1989; Burger 1993; Camphuysen 1998). For the purpose of this evaluation, seven oil spills in Western Europe were analysed, some of which caused substantial wildlife casualties, others of which did little (recorded) damage to seabirds (Table 3–2, 3–3). Among these were tanker incidents (*Amoco Cadiz*, *Braer*, *Sea Empress*, *Prestige*, *Erika*), an incident with a car carrier (*Tricolor*), and a deliberate discharge (*Stylis*). We will evaluate the spills in terms of amount of oil spilled, distance to the coast, seabirds present during the event, timing in the annual cycle of the (main) victims, number of casualties counted and number of casualties estimated to have died. Note that this is not an exhaustive review of all the smaller and larger spills that took place in western Europe over the past 30 odd years, but rather case studies that may be considered representative in various respects.

Table 3–1: The World's largest tanker spills (>100,000 tonnes), 1960–2004 (White and Baker 1999, ITOPF)

DATE	NAME	TONNES	OIL TYPE	LOCATION
19 July 1997	<i>Atlantic Empress</i>	287,000	crude	10nm E of Tobago
28 May 1991	<i>ABT Summer</i>	260,000	crude	700nm W of Angola
06 August 1983	<i>Castillo de Bellver</i>	252,000	crude	70nm NW of Cape Town, South Africa
16 March 1978	<i>Amoco Cadiz</i>	223,000	crude	Brittany, France
11 April 1991	<i>Haven</i>	144,000	crude	off Genoa, Italy
10 November 1988	<i>Odyssey</i>	132,000	crude	700nm off Nova Scotia, Canada
18 March 1967	<i>Torrey Canyon</i>	119,000	crude	Scilly Isles, UK
19 December 1972	<i>Sea Star</i>	115,000	crude	Gulf of Oman
12 May 1976	<i>Urquiola</i>	100,000	crude	La Coruña, Spain



Figure 3–1: Approximate locations of oil spills discussed in this chapter.

3.3 Seven recent oil spills evaluated

The main tanker incidents since the *Torrey Canyon* spill in the late 1960s were the *Amoco Cadiz* in France in 1978, the incident with the *Braer* in Shetland in 1993, the *Sea Empress* in the Irish Sea/Celtic Sea in 1996, the *Erika* in 1999, and the *Prestige* in 2002 (Figure 3–1). In these accidents, vast amounts of oil were released at once (whether or not with subsequent leakages), and the spills took place in winter and early spring, between November and March. The amount of oil spilled varied from 15,000 tonnes with the *Erika* to as much as 223,000 tons with the *Amoco Cadiz*. The *Tricolor*, a car carrier, leaked approximately 170 tonnes of oil during salvage operations on the wreck of the ship that had sunk a month earlier following a collision. The *Styliis* deliberately discharged some 600 tons of carbon black feedstock oil to clean tanks on its crossing from Rotterdam to southern Norway (Anker-Nilssen and Røstad 1982).

The *Styliis* incident ranked highest in terms of casualties recovered, but is otherwise mostly forgotten in recent reviews. A similar number of casualties were recovered following the *Erika* and it is of interest to remember that in both events, the slicks travelled considerable distances to reach the shore. The *Tricolor* spill in 2003, an event with relatively little oil spilled, had substantial consequences in terms of affected wildlife and this spill took place in an area of known sensitivity to oil pollution in winter (Carter *et al.*, 1993).

Four incidents (*Amoco Cadiz*, *Sea Empress*, *Braer*, and *Tricolor*) were nearshore incidents (groundings or collisions within 10km from land), but both the *Erika* and the *Prestige* were towed into the open sea in an attempt to “minimise” the ecological damage (with quite the opposite effect; Camphuysen *et al.*, 2002), and therefore contaminated substantially larger portions of the coastline than most nearshore spills. The *Styliis* discharged oil shortly before entering the Skagerrak and strong southwesterly winds swiftly pushed the oil deeper into the Skagerrak area and towards the Swedish west coast (Anker-Nilssen and Røstad 1981).

The types of oil spilled in each of the selected incidents varied. The *Amoco Cadiz* spilled her entire cargo of 223,000 tonnes of light Arabian and Iranian crude (White and Baker 1999). Much of the oil quickly formed a viscous water-in-oil emulsion (“chocolate mousse”), increasing the volume of pollutant by up to four times. Seabirds were simply smothered in the “mousse”, suffocated and died. The *Braer* ran aground and lost its entire cargo of 84,700 ton-

nes of Norwegian Gulfaks crude oil plus a small amount of heavy bunker oil (Heubeck *et al.*, 1995; White and Baker 1999). The spill was unusual in that a surface slick was not produced. A combination of the light nature of the oil and the exceptionally strong wind and wave energy naturally dispersed the oil through the water column. The oil droplets were adsorbed onto sediment particles which eventually sank onto the seabed. The *Sea Empress* ran aground and over a week released 72,000 tonnes of Forties Blend crude and 480 tonnes of fuel oil into the sea (Anon. 1998). Oil came ashore along 200 km of coastline, but the portion of oil which evaporated (24,000–32,000 tonnes) was higher than at many other incidents due to the large proportion of volatile components in this type of oil. The tankers *Erika* and *Prestige*, as well as the car carrier *Tricolor*, spilled heavy fuel oil into the sea. Heavy fuel oils consist largely of residues from crude oils refining. These residues are blended with suitable gas oil fractions in order to achieve the viscosity required for convenient handling. Residual fuels are the highest viscosity and thus the cheapest and most common fuel available for use in large diesel engines. Suppliers of residual fuels or HFO use various names, including the terms bunker C fuel, heavy fuel oil, bunker fuel oil and marine fuel oil. The oil discharged by the *Stylis* in 1980, carbon black feedstock, is a raw material used in the production of rubber giving it the desired physical properties (primarily in car tires). Carbon black feedstock is an amorphous form of carbon produced by incomplete burning of hydrocarbon materials.

Table 3–2: Major oil spills in Western Europe selected for this review: name, location, season and amount spilled (tonnes).

NAME	LOCATION AND YEAR	SEASON		TONNES	OIL TYPE
<i>Amoco Cadiz</i>	Brittany (F), 1978	Mar	pre-breeding	223,000	Arabian & Iranian crude
<i>Stylis</i>	Skagerrak (S/N), 1980	Dec	winter	600	carbon black feed-stock ²
<i>Braer</i>	Shetland (UK), 1993	Jan	winter	85,000	Norwegian gulfaks crude
<i>Sea Empress</i>	Irish Sea (UK), 1996	Feb	winter	72,000	Forties blend crude
<i>Erika</i>	Brittany (F), 1999	Dec	winter	15,000	heavy fuel
<i>Prestige</i>	Galicia (Esp), 2002	Nov	winter	77,000	heavy fuel
<i>Tricolor</i>	Channel (F), 2003	Jan ¹	winter	170	heavy fuel (IFO 380)

¹Ship sank in December 2002, but leaked oil not before January 2003.

²Carbon Black Oil (CBO) is a co-product by steam cracking of hydrocarbons (naphtha, gas oil, gas condensate) under high temperature in the presence of steam to produce the olefins ethylene and propylene. CBO consists mainly of unsaturated hydrocarbons, predominantly higher than C₁₄ and is used as feedstock for the production of (special) Carbon Black (CB).

Table 3–3: Major oil spills in Western Europe selected for this review: name, most numerous casualties (in declining order), numbers recorded and numbers estimated to have died.

NAME	MOST NUMEROUS CASUALTIES	NUMBER OF BIRDS FOUND	ESTIMATED TOTAL MORTALITY
<i>Amoco Cadiz</i>	Puffin, Razorbill, Guillemot	5,000	22,000
<i>Stylis</i>	Guillemot, Little Auk, Eider	45,000	200,000–300,000
<i>Braer</i>	Black Guillemot, Shag	1,800	5,000
<i>Sea Empress</i>	Common Scoter, Guillemot	6,900	10,000–15,000
<i>Erika</i>	Guillemot	44,000	120,000–300,000
<i>Prestige</i>	Guillemot, Puffin, Razorbill	22,000	100,000–200,000
<i>Tricolor</i>	Guillemot, Razorbill	20,000	40,000–100,000

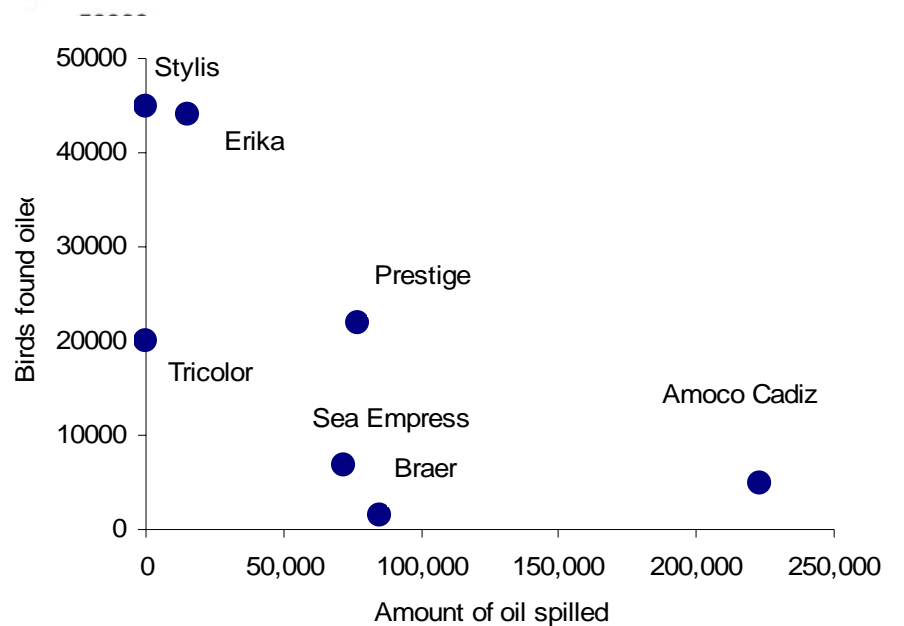


Figure 3–2: The amount of oil spilled versus numbers of seabirds found dead in recent oil spills in Western Europe.

There was no positive correlation between the number of casualties counted and the amount of oil spilled (Figure 3–2). Some spills occurred in areas that were known to be very vulnerable to oil pollution from seabird at sea censuses in the area (e.g., *Tricolor* spill; Carter *et al.*, 1993), others took place in areas of unknown sensitivity (no recent at-sea surveys available), but numerous casualties were recovered, possibly partly because the oil travelled a long way before it reached the coast, sweeping vast sea areas clear of birds (e.g., *Erika* and *Prestige* spills).

The spills were different in their impact on resident seabirds (local breeding populations) and wintering birds (breeding elsewhere). The *Amoco Cadiz* spill, for example, affected wintering seabirds such as common guillemots, razorbills and divers Gaviidae, but also substantial numbers of European shags that were locally breeding. Atlantic puffins, the main casualties, originated from breeding colonies in the UK as well as from the local population (Jones *et al.*, 1978; Monnat 1978). The *Braer* incident on the south tip of Shetland in 1993 mainly affected resident birds, notably black guillemots and European shags (Heubeck *et al.*, 1995). The *Erika* off Brittany killed a very large number of guillemots, and while there is a local breeding population, at least according to numerous ringing recoveries a large proportion (if not the majority) of these birds were wintering visitors nesting further to the north, such as within the UK and on Helgoland (Germany). Common scoters killed in the *Sea Empress* incident probably mainly originated from the distant Scandinavian breeding population. The *Tricolor* spill killed virtually exclusively wintering birds, notably common guillemots and razorbills (Stienen *et al.*, 2004; Grantham 2005; Camphuysen and Leopold 2005), whereas the *Prestige* kill involved a mixture of local residents and wintering individuals (García *et al.*, 2003).

Apart from the numbers found dead or “rescued” (picked up oiled but still alive and where a rehabilitation attempt has been taken place), most spills are reported with a number of casualties *estimated* to have died. These estimates usually have a very slender factual basis. Drift experiments should take place during each and every incident to be able to assess the fraction lost at sea, and few spills have been monitored such that the time and resources were available to conduct such experiments (e.g., Jones *et al.*, 1978). There is little doubt that in most cases, certainly in the offshore spills, a rather substantial fraction may have gone lost at sea, whereas

in some nearshore spills, certainly those with very strong and persistent onshore winds, virtually all the casualties will at least wash ashore and can be counted. We have not evaluated the accuracy of the estimates of total mortality (Table 3–3), but simply observe that there are no firm data presented in any of the papers consulted showing that the upper end of the estimates published for the *Erika*, *Prestige* and *Tricolor* spill are anything more than guesses.

3.4 What population level effects of oil spills should we expect?

Clearly, the effects of an oil spill on the size of breeding seabird populations will depend on several factors in addition to the numbers of birds killed. It is obvious that effects will be more pronounced the smaller the affected population is in relation to the number of birds killed, but determining the size of the affected population is by no means simple. The likelihood of detecting impacts on stable, increasing or decreasing populations is different and the frequency of population monitoring in the years before the oil spill will influence the quality of necessary base-line data. Information on (offshore) wintering populations, pre- and post-spill, is equally important as are data on trends in breeding populations, particularly so for species that breed widely dispersed in very low densities such as divers and seaducks. Among other factors, the most important are the age distribution of birds killed, whether oil mortality is additive or compensatory, and the type of regulation operating in the population. Below, we examine the expected effects under various scenarios and discuss reasons why realized effects may sometimes be difficult to detect with existing monitoring methods.

Adult or immature mortality. It is well known that the population growth rate of long-lived organisms, such as seabirds, is much more sensitive to variations in adult survival than in fecundity or immature survival (Croxall and Rothery 1991). In simple terms, this means that the life of an adult is “worth” more to the population than the life of an immature, simply because it is more likely to survive to the next year and reproduce. Furthermore, in most seabirds recruitment to the breeding population occurs when the birds are 3–7 (up to 12 in northern fulmar) years old, and if mainly first-winter immatures are killed any effect on breeding populations will not be detectable for several years, if at all. On the other hand, large mortality of adults will cause an immediate reduction in the adult population; although this will not necessarily result in a similar reduction in the breeding population (see below). In general, effects on breeding populations should be larger and easier to detect when mainly adults are killed than when immatures are the main victims.

Additive or compensatory mortality. Anthropogenic mortality in general may act in either a compensatory or an additive manner (Burnham and Anderson 1984). Fully compensatory mortality implies that the number of birds alive at the start of the next breeding season is unaffected by the extra mortality, whereas fully additive mortality implies that next year’s population is reduced by exactly the number of birds killed (relative to what it would have been without the extra mortality). Both extreme scenarios are unlikely, and most real situations will fall somewhere in between. When natural mortality is density-dependent, extra anthropogenic mortality will tend to be more or less compensatory. Few if any studies have been able to establish whether extra mortality in seabirds (oiling, hunting or fishery-related) is compensatory or additive. If oil spill mortality is partially compensatory, effects on breeding populations will obviously be smaller than if it is additive.

Population regulation: are breeding populations buffered? There is evidence that many seabird populations are characterised by the presence of substantial numbers of “floaters”, i.e., individuals which, though physiologically capable of breeding, don’t do so in a given year (e.g., Kokko *et al.*, 2004). Some of this evidence comes from experiments, where breeders removed early in the breeding season are immediately replaced, presumably by floaters. If large numbers of floaters are available, even substantial adult mortality may not result in an immediate reduction in the size of the breeding population, simply because their places are immediately filled, and this could be one of the main reasons why population effects of oil

spills have been difficult to demonstrate. Although the breeding population is not reduced immediately, the extra mortality of adults may have long-term effects. First, a reduction in the number of floaters will reduce the population's buffering capacity for future mortality events. Second, floaters are likely to be on average younger and/or of lower quality than established breeders, and the replacement of older high-quality birds by floaters will lead to a decline in the mean quality of the breeding population, which again could have implications for future population growth (Kokko *et al.*, 2004).

A further consideration is that monitoring activity is often not randomly distributed within colonies, but biased towards older, central and by implication more high-quality areas. Even if a mortality event is large enough to cause a reduction in the total breeding population, within-colony redistribution of breeders from peripheral sites to more central ones left empty may lead to effects not being detected.

Monitoring of survival or return rates. Even in cases when breeding populations (total or on monitoring plots) are buffered against substantial mortality events by floaters, turnover among breeders will be increased and this will be detectable through monitoring of individually marked birds. If unusually few marked birds turn up the next year (low return rate), or if survival is subsequently found to be low through capture-recapture analysis, an effect of e.g., an oil spill event is indicated even in the absence of an observed population decline. This provides yet another example of how monitoring demographic parameters rather than just population size improves the ability to detect environmental changes and attribute them to natural or anthropogenic drivers. Because proper capture-recapture analysis allows compensation for e.g., variation in monitoring effort or in the proportion of birds breeding in a given year, it provides the most robust method for detecting change. However, return rates are simple and quick to calculate and thus useful as "early warning" signals of potentially high mortality.

Table 3–4: Expected, detectable effects on seabird populations according to different scenarios.

MAIN AGE CLASS KILLED	NON-BUFFERED POPULATION	BUFFERED POPULATION
Immatures	Small delayed effect	No effect?
Adults	Large immediate effect	No effect on breeding population size, reduced buffering capacity

3.5 Impact assessments during oil spills

It is clear that in the light of *expected* population effects, apart from the total number of casualties affected and the species involved, two variables are important: the age structure of the casualties and their (breeding) origin. We observed that most of the more serious spills in Europe affected wintering seabirds rather than local birds (with some exceptions).

To be able to measure population effects, high quality data should be obtained from the corpses collected during an oil spill, including accurate information on species composition, sex ratio, age structure, and their geographic breeding origin (Heubeck *et al.*, 2003). Estimates of the total number of birds affected has to be based on a combination of dedicated beached bird surveys (effort-corrected data; Camphuysen 1989, Stephen and Burger 1994, Camphuysen and Heubeck 2001) and drift-experiments *during* the incident (Stowe 1982a; Hlady and Burger 1993; Wiese 2003). Only with these two tools can an estimate be made of the number of corpses that may have gone lost at sea, which should be added to the numbers found stranded. An assessment should also be made of numbers of corpses missed during beached bird surveys, for example as a result of oil clean-up operations or removals by scavengers (Page *et al.*, 1983; Camphuysen 1989; van Pelt and Piatt 1995; Camphuysen 2004).

We observed, that estimates of total mortality from an oil spill have often been based on a general rule-of-thumb (e.g., that the body count represents about 5% or 10% of the overall mortality), and that these estimates should therefore be treated with caution. Burger (1993)

analysed total mortality estimates from about 45 oil spills, and identified a conservative figure averaging 4–5 times higher than the body counts. From drift experiments around the globe, we know that the outcomes are highly site- and situation-specific (Bibby and Lloyd 1977; Jones *et al.*, 1978; Bibby 1981; Stowe 1982b; Threlfall and Piatt 1983; Keijl and Camphuysen 1992; Camphuysen and Heubeck 2001; Wiese and Jones 2001). In some nearshore spills with on-shore winds, nearly all the casualties can be found ashore. Some offshore spills may have caused seabird mortality, but drift experiments showed that only a minute fraction was likely to be found on the beach.

Factors such as density of birds in the affected area, wind velocity and direction, current direction, wave action, distance to the shore and temperature all affect the resultant recorded mortality and so an immediate investigation of these parameters at the time of the spill is needed (Burger 1993; ICES 2003). Characterisation of the pre-spill situation contributes to define terms of reference for a certain region and helps to determine the actual effect of the oil spill.

An adequate search for corpses and live oiled birds all over the affected area is important to improve the estimate of total mortality. Such searches should be set-up as the standard beached bird surveys, so that observer effort is known (Camphuysen and Heubeck 2001). Coupled with drift experiments, beached bird surveys are a useful instrument to determine total mortality. A model to estimate actual mortality based on number of corpses found was developed by Ford *et al.* (1991). This model integrates several oceanographic and meteorological parameters. A corpse drift of 2–4% of the wind speed is generally accepted (Bibby and Lloyd 1977; Burger 1993). Drift experiments conducted during oil spills are important, but the permission for a large-scale release of tagged corpses at sea may be difficult to obtain (in time). Wooden drift blocks, as developed and recently improved by Wiese and Jones (2001), are easy to produce devices, relatively easy to release from boat/aeroplane, and may be acceptable substitutes for the ideal experiment. It should be realised, however, that drift experiments are at best approximations of the real trajectories and recovery rates of oiled corpses. When unoiled corpses are used for these experiments, it should be realised that these are less likely to sink than oiled corpses. Wooden blocks do not sink at all, and the movements and drift of casualties that are oiled but still alive is impossible to mimic.

Important baseline data have to be obtained from the corpses *during* the spill and require specialist's assistance. Determining the geographic origin of the oiled birds is of major importance if one wants to assess the ecological impact of the spill in seabird populations. Standardised techniques are required and should be implemented to collect useful data (e.g., Asbirk 1980, Kuschert *et al.*, 1981, Jones *et al.*, 1982, Camphuysen 1995). The information on possible "colonies of origin" is essential to plan post-spill monitoring. Information gathered should include the population structure of the impacted species (sex ratio, age ratio and sexual maturity) as most seabird species are long lived birds that exhibit deferred maturity. The ageing and sexing of seabirds is not straightforward and again requires specialist's assistance (Anker-Nilssen *et al.*, 1981; Van Franeker 1983; Van Franeker 2004). Ringed birds can give information about the origin of the affected seabirds, but relatively few individuals are ringed and the results are biased towards areas where ringing effort is high.

The type of information to be collected from seabirds during oil spills is listed in Table 3–5, including the rationale.

Table 3–5: Base-line data collected during recent oil spills in Europe.

PARAMETERS	RATIONALE
Species composition	to identify impacted species
Biometrics	to assess geographic origin
Age	to predict potential impact on population (delayed versus immediate effects)
Sex	to predict potential impact on population (biased, or non-biased to part of the population); contributes to understanding of distribution at sea of sexes of the affected population (sex segregation) 5
Ringling recoveries	to identify geographic origin (dependent on ringing effort at breeding colonies)
Moult and plumage analysis	to predict potential impact on population (delayed versus immediate effects) geographic origin (colour of plumage of some alcids); winter vs breeding populations affected; immature vs adult birds (e.g., gulls)
Muscle, growing feathers or blood	genetic studies, to identify geographic origin (dependent on seabird population genetic structure)
Body condition at the time of the death	contributes to identify impact of oil spill

Most of these parameters were collected during the *Erika*, *Tricolor*, *Stylis*, *Braer* and *Prestige* oil spills. To support an analysis of these parameters, such as the identification of the geographic origin from biometrics or DNA, baseline information on morphometrics and the genetic structure of breeding populations is needed, as well as population trends and distribution at sea of wintering and breeding populations. Information obtained during the above mentioned oil spills enabled identification of the breeding area / colony of the dead birds, so that post-spill monitoring should have become easier. Information from ringing recoveries gave direct information on the “origin colony” of the corpses and frequently on the age of the bird (e.g., Grantham 2005), but was particularly valuable in combination with simultaneously collected data on age structure and biometrics (e.g., Camphuysen and Leopold 2005).

Age composition is of major importance in determining population effects and is essential to predict immediate versus medium term effects on the breeding populations. In the case of the *Tricolor* oil spill, age composition analysis indicated that mature birds in excellent pre-breeding condition of the wintering common guillemot and razorbill populations were affected (Camphuysen and Leopold 2005). Biometrics suggested that Scottish colonies in the NW North Sea were the most likely breeding areas of the affected guillemots. These results were corroborated by the ringing recoveries (Grantham 2005). The sheer number of casualties, as well the high proportion of mature birds, suggested an immediate effect on the breeding population (Camphuysen and Leopold 2005). Biometrics of razorbills obtained during *Stylis* oil spill indicated that both subspecies, *A. t. islandica* (Iceland, Ireland, UK) and *A. t. torda* (Norway, Sweden), were affected (Anker-Nilssen *et al.*, 1988).

Sex identification might be considered as supplementary data, but should help determining effects of oil spill on population dynamics (Cadiou *et al.*, 2004). Information on body condition of (heavily oiled) corpses found dead will provide information on the condition of the birds at sea and if other factors, such as wrecks, may have played a role during the event (Camphuysen and Leopold 2005).

3.6 Summary of studies of seabirds oiled during selected oil spills

Amoco Cadiz

- Parameters collected: species affected, biometrics, sex, presence of rings. Corpse drift experiments executed, beached bird surveys implemented. Ageing inadequate in guillemots, but appropriate in razorbills and puffins.
- Results: Species composition: auks (69%), cormorants (12%), divers (4%), gannets (3%) (n=4907; Monnat 1978). Age composition: unknown in guillemots (probably mainly immature), 35% first winter and 66% immature and adult razorbills (n=225), 53% adult puffins (n=213). Sex ratio: guillemots 1:1, Plumage characteristics guillemots 13% *U.a. aalge*, 59% *U.a. albionis*. Atlantic puffin biometrics point at France and SW Britain as main areas of breeding origin; ringing recoveries from the Irish Sea (SW Britain), Outer Hebrides, Shiant Isles, Shetland and SE Scotland. Razorbill ringing recoveries from Irish Sea, Outer Hebrides and Fair Isle. No French ringing recoveries in auks (Jones *et al.*, 1978).

Stylis

- Parameters collected: proportion of plumage covered by oil, plumage and rank in shade of colour of the wing, biometrics, sex, age, body condition.
- Results: Species composition: common guillemot (60%), little auk (12%), common eider (11%), razorbill (9%) (Anker-Nilssen and Røstad 1982). Age composition: razorbills 66% adults, 34% immatures (n= 298). Common guillemots 18% adults, 82% immatures (n= 802 birds; Anker-Nilssen *et al.*, 1988); Sex ratio: no significant differences found in razorbills (Anker-Nilssen *et al.*, 1988); Plumage: all birds in winter plumage (Anker-Nilssen *et al.*, 1988); Biometrics: razorbill biometrics enabled to attribute dead birds to subspecies *A. t. islandica* (Iceland, Ireland, UK) and *A. t. torda* (Norway, Sweden) based on the wing length and gonys depth; Little auk: origin could not be established. Common guillemots: a wide range of possible colonies of origin (Anker-Nilssen *et al.*, 1988), which was seemingly confirmed by ringing recoveries: Faroes (1 adult), Helgoland (1 adult), northern Scotland (1 adult and 18 immature) (Anker-Nilssen *et al.*, 1988).

Braer

- Parameters collected: number of casualties, species composition, ringing recoveries. Systematic beached bird surveys were implemented. Post-mortems included age, sex, biometrics and stomach contents.
- Results: Species composition: European shag (55%), black guillemot (12%), black-legged kittiwake (8%), long-tailed duck (7%) and great northern divers (7%) (n=1768 corpses; SOTEAG 1995, Heubeck 1997). Ringing recoveries of shags suggested that the local population should be affected mostly: most of 34 birds found ringed originated from the spill site (15 x Sumburgh Head, 11 x Fair Isle, 6 x Foula, 1 x Hermaness).
- Post-spill monitoring suggested that European shag breeding numbers were significantly reduced in 1993 season and black guillemots on the SW mainland coast were reduced by 20–40% (Heubeck 1994; Ewins and Heubeck 1995). Some 3–4% of the local common eider population had been killed by the *Braer* spill (Heubeck 1997).

Sea Empress

- Parameters collected: birds collected for detailed examination (body condition, cause of death, age, sex and diet, wing and bill measurements), corpse drift experiment executed.
- Results: Species composition: common scoter (66%), common guillemot (23%), razorbill (5%), red-throated diver (1%) (n=6935; Anon. 1998). Sex ratio: common scoter 70% male, 30% female, red-throated diver 75% male. Common guillemot, 53% summer plumage males (possibly Welsh breeding birds), razorbills 30% adult males. Age composition: common scoter 88% adult, 12% first winter, red-throated diver 75% adults. Ringed birds: Common guillemots were local adult birds (3) and 1 adult bird from the Irish Sea; ringed razorbills originated from SE Ireland. Biometrics: razorbills from one morphological population.

Erika

- Parameters collected: ringing recoveries; biometrics; blood, growing feathers or muscle tissue for population genetic studies (micro-satellite markers; Cadiou *et al.*, 2003, 2004). Total numbers: 32,000 birds alive and 42,000 birds dead were recorded along the coast of Bay of Biscay (Cadiou *et al.*, 2003). Many birds were removed prior to inspection in beach clean-up operations.
- Results: Species composition: common guillemot (83%, n= 74,000; Cadiou *et al.*, 2003a, 2004). Age composition / ringing recoveries: common guillemots ranged from 1 to 18 years old but 34% (n=184) and 39% were juvenile and 1 year old birds (Cadiou *et al.*, 2003b). Biometrics: majority of individuals originated from colonies located between western Scotland and the Celtic Sea (3.3% North Sea, 3.8% north Scotland, 49% western Scotland and 44% Celtic Sea; Cadiou *et al.*, 2003a, 2004). Ringing recoveries: 90 birds originated from colonies in west Scotland, 64 from south-eastern Irish colonies, 177 from Welsh colonies, 7 from North Scotland colonies, 4 from Britain and 2 from Germany (Cadiou *et al.*, 2003b). In 89% of the cases, birds were ringed as chicks in the colonies. Biometrics, plumage, age and sex data analysis gave general information: common guillemots - female had longer wings than males, older birds had longer wings than young birds (Cadiou *et al.*, 2003c, 2004). Population genetic approach: the low level of population genetic structured prevented to determine reliably the origin of the oiled birds, based on the fact that less than 6% of the individuals were assigned to the population in which they have been sampled). From the genetic view point, results suggest that a management unit could in fact be the whole North Atlantic population (Cadiou *et al.*, 2004).
- Results obtained underline that for a full assessment of the ecological impact of an oil spill on seabirds populations, it is necessary to combine information on the dynamics of the distribution of seabirds at sea with knowledge of the different processes involved in the dynamics of the breeding populations. The results also indicate the large spatial scale of the oil's spill impact and underline the usefulness of combining multiple approaches to access the local and regional effects of such accidents (Cadiou *et al.*, 2004).

Prestige

- Parameters collected: number of casualties, species, biometrics, sex, age, condition at the time of death, moult and ringing recoveries (external inspection and autopsies). Systematic beach searches implemented.
- Results: Species composition: mainly common guillemot (51%), razorbill (17%), and Atlantic puffin (17%; García *et al.*, 2003). Age composition: common guillemots

84.8% juveniles (n=895, García and Fernández-Boán, in prep.). Razorbills 87.8% first winter (n=924; Dopico and Ramos, in prep.). Atlantic puffins 52.9% adults, 16.5% first winter (n=1597; Bao *et al.*, in prep.). Sex ratio: in common guillemots, razorbills and puffins, females were significantly more numerous than males (guillemots 1 male: 1.6 females, n=922; García and Fernández-Boán in prep.; razorbills, 1 male: 1.58 females; n=186; Dopico and Ramos, in prep.; Puffin 1 male: 2.3 females; n=1579; Bao *et al.*, in prep.). Ring recoveries: Most of the common guillemots affected during the *Prestige* oil spill originated in the Irish Sea and western Scotland areas (about 95% of the rings). Razorbills mostly originated from the Irish Sea and western Scotland (88% of the rings). Atlantic puffins mostly originated from the Orkney Islands (77% of the rings; García *et al.*, 2003).

Tricolor

- Parameters collected: number of casualties, species composition, biometrics, sex ratio, age composition, and body condition at the time of death, moult, ringing recoveries (a combination of external inspection and autopsies; Camphuysen and Leopold 2005). Systematic beach searches implemented.
- Results: Species composition: common guillemot (63.0%), razorbill (24.8%), black-legged kittiwake (3.1%) (n=3302). Age composition: mature birds in excellent pre-breeding condition in both common guillemots and razorbills. Guillemots 76% adult, 6% immature, 18% first year; razorbills 77% adult, 16% immature, 8% first year. Sex ratio: Common guillemots 65% male (n=246), razorbills 62% male (n= 158; both significantly different from equal; Camphuysen and Leopold 2005). Biometrics: analysis would point at the *U. a. aalge* subspecies consistent with Scottish breeding birds at approximately 57°N latitude (Camphuysen and Leopold 2005). This suggestion was confirmed by the ringing recovery data (Grantham 2005). Biometrics analysis of immature and adults razorbills are consistent with measurements of the *A. t. islandica* anywhere in Britain Ireland and Iceland (Camphuysen and Leopold 2005). Ringing recovery analysis suggested that the east coast of Scotland is again a likely breeding area from where many casualties may have originated (Grantham 2005).
- From the information collected from the corpses it is possible to suggest that NW North Sea are probable breeding areas of both common guillemot and razorbills affected by the *Tricolor* spill, which together with the sheer number of casualties, as well the high proportion of mature birds, might suggests an immediate effect on the breeding population. Isle of May being one of the best studied auk colonies is situated in that area and future data might give some insight into impact of oil spill at population level (Camphuysen and Leopold 2005).

3.7 Methods for determining the origin of oiled seabirds

A critical step in evaluating the potential or realised effects of major oil spills is establishing which breeding population(s) the affected birds belong to. The same number of birds killed could have very different implications, depending on whether they originate from a small or a large population. Unfortunately, unambiguous assignment of dead birds to populations or individual colonies is quite difficult. A number of different approaches have been used or suggested, and these differ in utility depending on the species and situation.

Morphology. In some species, birds originating from different parts of the breeding range differ substantially in plumage or biometrical measurements. For instance, common guillemots are larger and darker in the northern part of the range than further south, and a higher proportion of northern fulmars from arctic populations belong to the dark phase. However, in both cases this variation is clinal and thus more useful e.g., for testing statistically differences between samples (Cadiou *et al.*, 2004) than for unambiguously assigning individuals to areas of

origin. Many other species, such as razorbills or northern gannets, show limited morphological variation over large parts of their range, making assignment of origin by this method impossible (e.g., Camphuysen and Leopold 2005). Nevertheless, morphological analysis of a sample of oiled birds is also useful for determination of e.g., sex, age and condition and should thus always be part of any oil spill impact assessment.

Ringling. The recovery of ringed oiled birds offers a cheap and unambiguous way of determining the origin of a sample of birds, and this has e.g., been used to show differences between the origin of common guillemots affected by recent major oils spills in Europe (Grantham 2005). Because most seabirds are ringed as chicks, recoveries also provide information on the age composition of the affected birds. The major weakness of this approach is that ringing effort varies enormously over space and time. In particular, some large breeding populations have received no or little attention from ringers (e.g., the Faroes), potentially leading to biases in geographical assignment of effects. Likewise, some species have been ringed much less than others and are less likely to provide sufficient sample sizes for analysis. Nevertheless, ring numbers should be recorded from all ringed birds found dead or alive after an oil spill, and maximum use should be made of this information, taking these limitations into account.

Population genetics. Seabirds are generally considered to be very philopatric and should therefore exhibit strong genetic population structure. By analyzing sufficiently variable regions of the genome, this could in principle be exploited to determine the breeding origin of oiled birds, if reference samples from a range of colonies/areas are available. To date, this approach has not seen much use. In a study of common guillemots from the *Erika* spill, Riffaut *et al.* (in press) found that this species did not exhibit sufficient population structure within the North Atlantic to allow individuals to be assigned to colonies of origin. Indeed, only 6% of reference samples were correctly assigned to colony in this study. However, other species are known to have a stronger population structure and thus might be more appropriate for assignment using population genetic methods. Costs of collecting and analyzing genetic samples from a large number of oiled birds, as well as from birds from reference colonies, will inevitably be high, and this will limit the general utility of this approach.

Biomarkers. Biochemical methods originally developed for studying trophic relationships, such as stable isotope analysis and fatty acid analysis, can also be adapted to indicate geographical origin. In particular, because of variation in the underlying geology, various regions have different stable isotope signatures, and feathers and hard parts grown at a particular location will preserve this signature. This approach can e.g., be used to infer breeding or wintering areas of birds sampled at different times of the year (Hobson *et al.*, 2001, Lott *et al.*, 2003). To our knowledge, nobody has yet attempted to use this technique to establish the origin of oiled seabirds, but it should be possible for first-winter birds as well as adults of species that grow feathers during the breeding season, such as gulls (BWPI 2004). As for genetic methods, there is a need for a reference collection of feathers from birds of known origin, but in some cases museum specimens may be sufficient. Fatty acid analysis is less likely to be useful, as it would require differences in diet between birds of different origin, as well as fat deposits laid down during the breeding season – both conditions that are unlikely to be met in the majority of cases. Stable isotope analysis seems a promising method for assigning oiled birds to specific geographical origin, and we recommend that this method is tried out on a sample of birds of known origin, e.g., ringed birds.

Table 3–6: The pros and cons of different approaches to determining the geographical origin of seabirds affected by oil spills.

METHOD	PROS	CONS
Morphology	Cheap, simple, can be applied to large samples of birds, data also useful for sex and age determination	Limited resolution, some species show no relevant geographical variation
Ringing	Cheap, simple to check, unambiguous assignment of origin	Requires large ringed sample from all potential areas of origin
Population genetics	Can potentially establish origin of birds where no morphological variation or ringing data exist	Expensive, some species show no relevant genetic variation, requires reference collection of genetic material
Biomarkers (stable isotopes)	Can potentially establish origin of birds where no morphological variation or ringing data exist	Only works if species has feathers (claws, bill) grown during breeding season, requires reference collection of e.g., feathers

3.8 Observed impacts on seabird populations

Detection of the effects of large oil spills on seabird populations is difficult for a variety of reasons (see above). Large oil spills can cause direct seabird casualties, and sub-lethal effects on timing of breeding, breeding success, future survival, or reduced food supply through fish kills (Eppley and Rubega 1996; Velando *et al.*, unpubl.).

Direct population-level effects such as on survival rates and age-structure are rarely detected because specific long-term studies involving individually marked birds need to be in place in the area affected by the spill, before its occurrence. These types of studies, although becoming more common are still relatively few in number. More commonly, numbers of birds breeding in affected colonies are compared before and immediately after the spill, and sometimes this comparison is made within and outside affected areas, the latter considered the control against which the effect of the spill can be compared. Typically, major spills have occurred in the winter months when marine birds are dispersed from their breeding colonies. Thus it is sometimes difficult to determine which colonies are affected (but see above), and affected birds may breed over a wide area such that impacts are geographically diluted and difficult to detect.

Heubeck (in press) provides an excellent review of the impacts of oil pollution from tanker accidents on seabird populations in the UK over the past 25 years. Early spills described by Heubeck such as the *Amoco Cadiz* occurred at a time when seabird monitoring in the UK was not widespread, and population-level impacts could not be detected for this spill. By 1993 when the *Braer* ran aground off the Shetland Islands, seabird monitoring in the UK was well underway (see Lloyd *et al.*, 1991) and so detection of changes in seabird populations was more likely.

In the *Braer* incident, locally resident species and winter visitors were the most commonly found oiled (European shag, black guillemot, black-legged kittiwake, long-tailed duck and common eider). Pelagic species such as northern fulmars and the larger alcids were much less affected because of the time of year, and the fact that the prevailing storms drove them well offshore. Impacts on colony size were detected for shags breeding in the vicinity of the site of the spill. The number of shag nests counted at Sumburgh Head in 1993 (151) was half that counted the year before (Heubeck 1994, 1997), and numbers are still below pre-spill levels. Black guillemots nesting around southern Shetland were reduced by 31% immediately after the spill, and again have not recovered to pre-spill numbers (Heubeck in press).

In the *Sea Empress* oil spill (Baines and Earl 1996), species oiled were predominantly common scoters, common guillemots and razorbills. The latter two species breed around the Welsh coast in the vicinity of the spill. Local common guillemot colonies had been increasing before the spill, however, despite this, the 1996 breeding census indicated colony declines of

up to 50%. One colony (Skomer) remained stable from 1995 to 1996 however, this was the first time since 1990 that it had not increased. This underlines another problem in detecting population-level impacts of oil spills- the spill may cause a decline in the rate of increase in a particular population that is not sufficient to place the population itself in decline. Negative impacts on guillemot breeding success in 1996 were not detected. By 1997, numbers of common guillemots at affected colonies had recovered. Common scoters overwinter in large numbers in the vicinity of the incident and were the most commonly found species oiled in this incident. Peak counts after the spill and in the following winter were about 3–4 times lower than before the spill but returned to “normal” by the winter of 1998–1999.

A very large number of marine birds were recovered in the *Erika* spill. The majority were common guillemots, whose origin was likely the Irish/Celtic Seas and western Scotland (based on ringing returns). Many of the oiled guillemots were immature (first year), of which a large proportion would have died naturally rather than have recruited into the breeding population in the years following the spill. It is therefore rather *unlikely* that impacts at the colony level would have been detected, even after several years.

The *Prestige* and *Tricolor* oil spills occurred away from major concentrations of breeding marine birds. Both resulted in large numbers of birds recovered and data were collected immediately after the spills that will be useful in identifying candidate colonies that may have been affected. Similar to the *Erika* spill, the *Prestige* spill involved a large number of immature common guillemots, some of which were ringed in the Irish/Celtic Seas. Therefore, delayed colony impacts may be expected. Interestingly, there is evidence that this spill may have had an impact on European shags breeding in the vicinity of the spill (Velando *et al.*, unpubl.). The European shag was not one of the species heavily impacted by the spill, but the effect appears to have been via negative effects of the oil on the benthic feeding habitat of the shag. In the case of the *Tricolor* spill, a large proportion of the ringing returns of common guillemots recovered oiled were from adult birds ringed on the Isle of May. Despite this, Isle of May common guillemot numbers increased in the breeding season after the spill (2003), although return rates of ringed birds was “below average”, “although not markedly so” (Mavor *et al.*, 2004).

3.9 Further requests

Further requests considered by HOD(1) May 2004 for inclusion in the draft 2005 ICES Work Programme included six specific tasks, some of which fitted nicely in the initial TOR, others were different approaches to the oil problem. HOD(1) suggested that an assessment of the long-term effects of oil spills should consider:

Distinction between effects of oil spills and natural changes

It is important to be able to distinguish between population effects of oil spills and those caused by other anthropogenic drivers as well as natural environmental variation. There is no failsafe way of making this distinction, and indeed in some cases we will never know if observed effects were due to an oil spill, or if real effects were masked by other counteracting effects. The best way to improve the chances of successful attribution of observed changes to the underlying drivers is to have a baseline monitoring programme allowing replicated before/after and affected/unaffected comparisons, and to employ proper statistical analysis methods that can identify several simultaneous effects.

Impacts of oil on different types of habitats (i.e., the nature of the coastline) and ecosystems

An evaluation of impacts of oil on different types of habitats (i.e., the nature of the coastline) and ecosystems would be beyond the expertise of the WGSE and we suggest that the question is forwarded to an appropriate group of experts.

The impact of oil in different marine regions, subject to different climatic influences

Generally, sea-surface temperatures and air temperatures are important factors, because oil weathers faster in warmer water and the external effects of oil on birds are less severe in warmer water because the chances of hypothermia are reduced. It is important to be able to distinguish between population effects of oil spills and those caused by other anthropogenic drivers as well as natural environmental variation. There is no failsafe way of discriminating between all these influences on seabird populations, in the absence of the appropriate base-line data. In a correlative approach, one might find positive or negative trends according to expectation, but in the absence of a mechanistic understanding, these correlations may not be very meaningful. With oil spill impact assessments, it is very important to be able to compare patterns seemingly caused by the spill with long-term trends in the population studied. This TOR is a very complicated one, and if understanding is to be gained from published accounts, it is recommended to reformulate the request more precisely.

The impact of different types of oil

The spills discussed were different in the types of oil spilled and although from these few case studies the TOR on differential impacts of different types of oil cannot fully be addressed, we can make at least some remarks. Different crude oils and oil products vary widely in physical and chemical properties, and in toxicity. Polyaromatic hydrocarbons (PAHs) are the most toxic component of oils. Experiments on plants and animals have shown that severe toxic effects are associated with hydrocarbons with low boiling points (particularly aromatics) because these hydrocarbons are most likely to penetrate and disrupt cell membranes (White and Baker 1999). The greatest toxic damage has been caused by spills of lighter oils, particularly when confined to a small area.

High temperatures and wind speeds increase evaporation and lighter oils evaporate easier and faster than the heavy oils. The *Amoco Cadiz* spilled light crude, and much of this formed a “chocolate mousse” simply smothering the seabirds affected. The *Braer* lost 84,700 tonnes of a rather fine crude oil plus a small amount of heavy bunker oil. A combination of the light nature of the oil and the exceptionally strong wind and wave energy naturally dispersed the oil through the water column. *Erika*, *Prestige* and *Tricolor* spilled (very) heavy fuel oil that was difficult to combat in offshore clean-up operations, and that affected seabirds in the most dramatic way: immediately immobilising them and smothering them to death. Affected birds were often so heavily oiled, that each corpse, untreated, weighed 2–3 x normal body mass. External examinations, including the basic identification, were seriously hindered.

The *Braer* spill, as a result of a combination of violent storms and rather light oil, was different from most other incidents in that most oil was naturally dispersed before (more) harm to seabirds could be done. The effects of the spill would have been more devastating, had it been calmer weather and had the spill occurred during the breeding season. Yet, despite being a spill where relatively few birds were affected, the localised nature of the event, coupled with a pre-spill monitoring programme, meant that population effects were relatively easy to determine: negative trends, without doubt related to the spill, were found in locally nesting shags and black-guillemots, as well as in resident common eiders (Heubeck 1997).

The impacts of remedial activities such as the use of heavy equipment and high pressure hosing to clean up oil spills

An evaluation of impacts of remedial activities such as the use of heavy equipment and high pressure hosing [on habitats i.e., the nature of the coastline and] ecosystems would be beyond the expertise of the WGSE and we suggest that the question is forwarded to an appropriate group of experts.

Whether the current framework of environmental risk assessment and toxicology is sufficient to take account of the long term effects of oil pollution

At present, to the best of our knowledge, there is no international framework of either oil spill impact assessment, or the environmental risk assessment and what is available is at best incomplete and perhaps outdated (Carter *et al.*, 1993; IPIECA 1994; Williams *et al.*, 1995; Begg *et al.*, 1997). There are no standardised protocols to guarantee a balanced post-spill evaluation of oil spill effects. There seems to have been no formally established communication between oil spill response teams and governmental bodies or scientific groups that should be involved in the post-spill evaluation in most spills. There are a number of initiatives in this direction, such as manuals for and evaluations of oiled wildlife response (often with emphasis on the treatment of live casualties rather than oil spill impact assessments) (Corbett 1977; Oiled Wildlife Care Network 2000; Heubeck *et al.*, 2003; IPIECA 2004; Nijkamp *et al.*, 2004), but usually it is left to the good intentions of those involved at the time.

3.10 Discussion

Our evaluation of recent oil spills resulted in some rather important conclusions. Of seven oil spills examined, the amount of oil spilled ranged from 170 tonnes (*Stylis*) to 223,000 tonnes (*Amoco Cadiz*). The number of casualties recorded, varied from 1800 (*Braer*) to 45,000 (*Stylis*). Most spills took place in winter or in the pre-breeding season, and most events affected winter visitors breeding elsewhere.

There was no positive correlation between the amount of oil spilled and the number of casualties recorded. Some of the smaller spills caused major mortality. There is a large difference in the sensitivity of different sea areas with regard to surface pollutants, and these differences were in part responsible for the observed variability in the impact on seabirds. Seasonal and spatial patterns in sensitivity are rather well known for the North Sea (albeit slightly outdated) and for the west of Britain. For major parts of Europe, however, notably for the Bay of Biscay and for Spanish and Portuguese coastal waters, a lot of additional information is needed.

Even in the absence of a protocol, scientists involved in most of the spills examined, apparently intuitively performed an impact assessment in which most of the required data were indeed collected (Table 3–7). Although the accuracy varied between spills, an attempt to collect and count the casualties was always included. Often, it was the private achievement of some individuals that the data were collected in a systematic manner. Only the *Sea Empress* spill, the *Braer* spill and the Belgian part of the *Tricolor* spill were dealt with almost entirely by dedicated teams, fully supported by or established by national authorities. The ageing and sexing of birds was not always conducted in a standardised manner, as a result of which, spills are not always easy to compare. It is recommended to produce an oiled wildlife impact assessment protocol for future events, building on experiences from these and other major oil spills, in an attempt to standardise the field observations, the dissections and the manner in which the results are published, to facilitate future evaluations.

Table 3–7: Baseline data collected during evaluated oil spills in W Europe.

SPILL	SPECIES COMPOSITION	NUMBERS FOUND	DRIFT EXPERIMENT	BIOMETRICS	AGE	SEX	RINGS	PLUMAGE	GENETIC STUDIES	BODY CONDITION
<i>Amoco Cadiz</i>	x	x	x	x	x		x			
<i>Stylis</i>	x	x		x	x	x	x	x		x
<i>Braer</i>	x	x		x	x	x	x			x
<i>Sea Empress</i>	x	x	x	x	x	x	x	x		x
<i>Erika</i>	x	x		x	x	x	x	x	x	
<i>Prestige</i>	x	x	?	x	x	x	x	x		x
<i>Tricolor</i>	x	x		x	x	x	x	x		x

In order to establish where seabird victims of oil spills come from, it is necessary to employ multiple methods. Morphological data and ring recoveries should always be collected and will often provide useful pointers, but may not be sufficient to unambiguously assign birds to colonies or areas of origin. Genetic methods have not yet proved very useful, and considering the high cost may not be a fruitful way forwards. Stable isotope analysis may be the most promising method, and as suggested by Cadiou *et al.* (2004) should be tried out on a sample of birds of known origin.

As stressed above, the effects of most oil spills on seabird populations were difficult to demonstrate. Both the *Braer* and the *Prestige* spills have affected local breeding populations of shags. The *Braer* also caused a decline in local breeding numbers of black guillemots. Declines in (adult) survival rates and changes in age-structures of breeding populations are rarely detected, mainly in the absence of sufficient and specific long-term studies involving individually marked birds in areas affected by oil spills (*i.e.*, the breeding sites from where oiled birds found originated), before and after its occurrence. Usually, numbers of birds breeding in affected colonies are compared before and immediately after the spill (population trends). Sometimes this comparison is made within and outside affected areas, the latter considered the control against which the effect of the spill can be compared. Typically, major spills have occurred in the winter months, affecting seabird wintering areas. It is usually difficult to accurately determine which colonies are affected (but see above; general areas could often be pinpointed), and affected birds may breed over a wide area such that impacts are geographically diluted and were difficult to detect.

3.11 References

- Anker-Nilssen, T. and Røstad, O.W. 1981. Undersøkelser av oljeskadede sjøfugler i forbindelse med oljekatastrofen i Skagerrak december 1980/januar 1981. Viltrapport, 16: 1–41.
- Anker-Nilssen, T., and Røstad, O.W. 1982. Oljekatastrofen I Skagerrak ved årsskiftet 80/81 – omfang og undersøkelser. Var Fuglefauna, 5(2): 82–90.
- Anker-Nilssen, T., Jones, P., and Røstad, O. W. 1988. Age, sex and origins of auks (Alcidae) killed in the Skagerrak oiling incident of January 1981. Seabird, 11: 28–46.
- Anonymous, 1998. Effaith amgylcheddol arllwysiad olew y Sea Empress. Sea Empress Environmental evaluation Committee, The Stationary Office, London, 135pp.

- Asbirk, S. 1980. Field identification, ageing, moult and subspecies of Black Guillemot (*Cephus grylle*). Dutch Birding, 2: 65–67.
- Baines, M.E., and S.J. Earl. 1996. Breeding seabird survey of south-west Wales, 1996. CCW Sea Empress contract report no 173. Dyfed Wildlife Trust, 118 pp.
- Begg, G.S., Reid, J.B., Tasker, M.L., and Webb A. 1997. Assessing the vulnerability of seabirds to oil pollution: sensitivity to spatial scale. Colonial Waterbirds, 20: 339–352.
- Bibby, C.J. 1981. An experiment on the recovery of dead birds from the North Sea. Ornis Scandinavica, 12: 261–265.
- Bibby, C.J. and Lloyd C. S. 1977. Experiments to determine the fate of dead birds at sea. Biological Conservation, 12: 295–309.
- Burger, A.E. 1993. Estimating the mortality of seabirds following oil spills: effects of spill volume. Marine Pollution Bulletin, 26: 140–143.
- Burnham, K.P., and Anderson, D.R. 1984. Tests of compensatory vs. additive hypotheses of mortality in mallards. Ecology, 65: 105–112.
- BWPI, 2004. Bird of the Western Palearctic interactive. DVD Birdguides, Shrewsbury.
- Cadiou, B., Cam, E., Fortin, M., Monnat, J-Y, Gelinaud, G., Cabelguen, J., and Le Roch, A. 2003c. Impact de la maree noire de l' *Erika* sur les oiseaux marins migrateurs: determination de l'origine et de la structure des populations par la biometrie. Rapport Bretagne Vivante –SEPNB, CRBPO, DIREN Bretagne, 56pp.
- Cadiou, B., Chenesseau, D., and Joslain, H. 2003a. Maree noire de l' *Erika*- contribution a l'etude de l'impact des echouages et de la mortalite des oiseaux (BNEMO). Rapport Bretagne Vivante –SEPNB, LPO Loire Atlantique, Observatoire des Marees Noires, DIREN Bretagne, 96pp.
- Cadiou, B., and Dehorter, O. 2003b. Maree noire de l' *Erika*- contribution a l'etude de l'impact sur l' avifaune. Analyse des reprises / controles de bagues. Rapport Bretagne Vivante –SEPNB, CRBPO, DIREN Bretagne, 24pp.
- Cadiou, B., Riffaut, L., McCoy, K.D., Cabelguen, J., Fortin, M., Gélinaud, G., Le Roch, A., Tirard, C., and Boulinier, T. 2004. Ecological impacts of the “*Erika*” oil spill: determination of the geographic origin of the affected common guillemots. Aquatic Living Resources, 17: 369–377.
- Camphuysen, C.J. 1989. Beached Bird Surveys in the Netherlands 1915–1988; Seabird Mortality in the southern North Sea since the early days of Oil Pollution. Techn. Rapport Vogelbescherming 1, Werkgroep Noordzee, Amsterdam 322pp.
- Camphuysen, C.J. 1995. Leeftijdsbepaling van Zeekoet *Uria aalge* en Alk *Alca torda* in de hand. Sula, 9: 1–22.
- Camphuysen, C.J. 1998. Beached bird surveys indicate decline in chronic oil pollution in the North Sea. Marine Pollution Bulletin, 36: 519–526.
- Camphuysen, C.J. 2004. Notes on seabirds 78. Deposition rates of carcasses on the beach in The Netherlands. Atlantic Seabirds, 6: 79–80.
- Camphuysen, C.J., and Garthe, S. 2000. Seabirds and commercial fisheries: population trends of piscivorous seabirds explained? Chapter 11 In: Kaiser, M.J. and Groot, S.J. de (eds). Effects of fishing on non-target species and habitats: Biological, Conservation and Socio-Economic Issues: 163–184. Blackwell Science, Oxford.
- Camphuysen, C.J. and Heubeck, M. 2001. Marine oil pollution and beached bird surveys: the development of a sensitive monitoring instrument. Environmental Pollution, 112: 443–461.
- Camphuysen, C.J., Heubeck, M., Cox, S., Bao, R., Humple, D., Abraham, C., and Sandoval, A. 2002. The *Prestige* oil spill in Spain. Atlantic Seabirds, 4: 131–140.

- Camphuysen, C.J., and Leopold, M.F. 2005. The *Tricolor* oil spill: characteristics of seabirds found oiled in The Netherlands. *Atlantic Seabirds*, 6: 109–128.
- Carter, I.C., Williams, J.M., Webb, A., and Tasker, M.L. 1993. Seabird concentrations in the North Sea: an atlas of vulnerability to surface pollutants. Joint Nature Conservation Committee, Aberdeen, 39pp.
- Clark, R.B. 2001. *Marine Pollution*. Fifth Edition, Oxford Univ. Press, Oxford.
- Corbett, C.R. 1977. Needs of the federal on-scene coordinator and regional response team for wildlife expertise. *In*: Fore, P.L. (ed) 1977. *Proceedings of the 1977 Oil Spill Response Workshop*. US Fish & Wildl.Serv., Biol.Serv.Progr. FWS/OBS/77–24, National Space and Technology Laboratories, Mississippi pp29–31.
- Couper, A. (ed.) 1983. *The Times Atlas of the Oceans*. Times Books, London.
- Croxall, J.P., and Rothery, P. 1991. Population regulation of seabirds: implications of their demography for conservation. *In*: Perrins, C.M., Lebreton, J.-D., and Hiron, G.J.M. (eds) *Bird population studies: relevance to conservation and management*: 272–296. Oxford University Press, Oxford.
- Eppley, Z. A., and Rubega, M. A. 1996. Indirect Effects of an Oil Spill: Reproductive Failure in a Population of South Polar Skuas Following the Bahia Pariaso, Oil Spill in Antarctica. *Marine Ecology Progress Series*, 67: 1–6.
- Ewins, P.J., and Heubeck, M. 1995. Monitoring the effects of a major oil spill on an inshore seabird: Black Guillemots (*Cepphus grylle*) in Shetland. Abstracts of the Joint Conference of the Colonial Waterbird Society and the Pacific Seabird Group, 8–12 November 1995: 47–48. Victoria, B.C.
- Ford, R. G, Varoujean, D. H., Warrick, D. H., Williams, W. A, Lewis, D. B., Hewitt, C. L., and Casey, J. L. 1991. Seabird mortality resulting from the Nestucca oil spill incident winter 1988–1989, Portland, Oregon. Unpublished report. Ecological Consulting, Inc.
- Franeker, J.A. van 1983. Inwendig onderzoek aan zeevogels. *Nieuwsbr. NSO* 4(4/5): 144–167.
- Franeker, J.A. van 2004. *Save the North Sea Fulmar-Litter-EcoQO Manual Part 1: Collection and dissection procedures*. Alterra-rapport 672, Alterra Groen Ruimte, Texel.
- García, L., Viada, C., Moreno-Opo, R., Carboneras, C., Alcalde, A., and González, F. 2003. Impacto de la marea negra del “Prestige” - sobre las aves marinas. SEO/BirdLife, Madrid, 126 pp.
- Goethe, F. 1968. The effects of oil pollution on populations of marine and coastal birds. *Helgoländer Meeresuntersuchungen*, 17: 370–374.
- Grantham, M. 2005. Age structure and origins of British and Irish guillemots *Uria aalge* recovered in recent European oil spills. *Atlantic Seabirds*, 6: 95–108.
- Heubeck, M. 1994. The impact of the *Braer* oil spill on Shetland’s breeding seabirds. *Seabird Group Newsletter*, 67: 3–5.
- Heubeck, M. 1997. The direct effect of the Braer Oil Spill on seabird populations, and an assessment of the role of the Wildlife Response Centre. *In*: Davies J.M. and Topping G. (eds) *The Impact of an Oil Spill in Turbulent Waters: The Braer*: 73–90. The Stationary Office Ltd, Edinburgh.
- Heubeck, M., Camphuysen, C.J., Bao, R., Humple, D., Sandoval, A., Cadiou, B., Bräger, S., and Thomas, T. 2003. Assessing the impact of major oil spills on seabird populations. *Marine Pollution Bulletin*, 46: 900–902.
- Heubeck, M., Harvey, P., and Uttley, J. 1995. Dealing with the wildlife casualties of the *Braer* Oil spill, Shetland, January, 1993. Shetland Oil Terminal Envir. Adv. Group & Aberdeen University Research and Industrial Services Ltd, Aberdeen, 83pp.

- Heubeck, M. *in press*. The impact of oil pollution on seabird populations of the United Kingdom during the past 25 years. Proceedings of Sardinia oil meeting, 2003.
- Hlady, D.A., and Burger, A.E. 1993. Drift-block experiments to analyse the mortality of oiled seabirds off Vancouver Island, British Columbia. *Marine Pollution Bulletin*, 26: 495–501.
- Hobson, K.A., McFarland, K.P., Wassenaar, L.I., Rimmer, C.C., and Goetz, J.E. 2001. Linking breeding and wintering grounds of Bicknell's thrushes using stable isotope analyses of feathers. *Auk*, 118: 16–23.
- ICES. 2003. Report of the Working Group on Biological Effects of Contaminants. ICES CM/2003/E:06.
- IPIECA, 1994. Sensitivity mapping for oil spill response. IPIECA Report series, Vol 1., International Petroleum Industry Environmental Conservation Association, London.
- IPIECA, 2004. A guide to oiled wildlife response planning. IPIECA Report series, Vol 13, International Petroleum Industry Environmental Conservation Association, London.
- ITOPF, 2003. Oil tanker spill statistics. International Tanker Owners Pollution Federation, London.
- Jones, P.H., Blake, B.F., Anker-Nilssen, T., and Røstad, O.W. 1982. The examination of birds killed in oil spills and other incidents - a manual of suggested procedure. Unpublished Report, Aberdeen, May 1982.
- Jones, P.H., Monnat, J.-Y., Cadbury, C.J., and Stowe, T.J.S. 1978. Birds oiled during the *Amoco Cadiz* incident: An interim report. *Marine Pollution Bulletin*, 9: 307–310.
- Keijl, G.O., and Camphuysen, C.J. 1992. Resultaten van een verdriftingsexperiment voor de Nederlandse kust, februari 1991. *Sula*, 6: 41–49.
- Kokko, H., Harris, M.P., and Wanless, S. 2004. Competition for breeding sites and site-dependent population regulation in a highly colonial seabird, the common guillemot *Uria aalge*. *Journal of Animal Ecology*, 73: 367–376.
- Kuschert, H., Ekelöf, H.O. von and Fleet, D.M. 1981. Neue Kriterien zur Altersbestimmung der Trottellumme (*Uria aalge*) und des Tordalken (*Alca torda*). *Seevögel*, 2: 58–61.
- Lloyd, C., Tasker, M.L., and Partridge, K. 1991. The Status of Seabirds in Britain and Ireland. T. & AD Poyser, London, UK.
- Lott, C.A., Meehan, T.D., and Heath, J.A. 2003. Estimating the latitudinal origins of migratory birds using hydrogen and sulphur stable isotopes in feathers: influence of marine prey base. *Oecologia*, 134: 505–510.
- Mavor, R.A., Parsons, M., Heubeck, M., and Schmitt, S. 2004. Seabird numbers and breeding success in Britain and Ireland, 2003. UK Nature Conservation No. 28, Joint Nature Conservation Committee, Peterborough, 100 pp.
- Monnat, J.-Y. 1978. Mortalités d'oiseaux a la suite du naufrage du pétrolier *Amoco Cadiz*. *Penn. Ar. Bed.*, 11: 339–360.
- Nijkamp, H., Conroy, J., Clumpner, C., and Thomas, T. 2004. Guidelines for Oiled Wildlife Response Planning - Results Athens Workshop. Sea Alarm Foundation, Brussels.
- Oiled Wildlife Care Network, 2000. Protocols for the care of oil-affected birds. Wildlife Health Center, School of Veterinary Medicine, University of California, Davis.
- Page, G.W., Stenzel, L.E., and Ainley, D.G. 1983. Beached bird carcasses as a means of evaluating natural and human-caused seabird mortality. Final report. Point Reyes Bird Observatory, 150 pp.
- Pelt, T.I. van and Piatt, J.F. 1995. Deposition and persistence of beachcast seabird carcasses. *Marine Pollution Bulletin*, 30: 794–802.

- Riffaut, L., McCoy, K.D., Tirard, C., Friesen, V.L., and Boulinier, T. *in press*. Population genetics of the common guillemot *Uria aalge* in the North Atlantic: assessing the geographic impact of oil spills. Marine Ecology Progress Series.
- SOTEAG, 1995. Dealing with the wildlife casualties of *Braer* Oil Spill Shetland, January 1993. Heubeck, M. (ed). Aberdeen.
- Stephen, C., and Burger, A.E. 1994. A comparison of two methods for surveying mortality of beached birds in British Columbia. The Canadian Veterinary Journal, 35: 631–635.
- Stienen, E.W.M., Van de Walle, M., Courtens, W., and Kuijken, E. 2004. Strandingen van vogels langs de Belgische kust in de winter 2003–2004. *In*: Stienen, E.W.M., Courtens, W. and Van de Walle, M. (eds) Interacties tussen antropogene activiteiten en de avifauna in de Belgische zeegebieden: 6–19. Rapport IN A.2004.136, Instituut voor Natuurbehoud, Brussel.
- Stowe, T.J. 1982a. Experiments on the beaching and removal of bird corpses. *In*: Stowe T.J. 1982. Beached Bird Surveys and Surveillance of Cliff-breeding Seabirds. RSPB, Sandy pp127–134.
- Stowe, T.J. 1982b. Experiment to determine the fate of bird corpses in the Southern North Sea. *In*: Stowe T.J. 1982. Beached Bird Surveys and Surveillance of Cliff-breeding Seabirds. RSPB, Sandy pp135–138.
- Threlfall, W., and Piatt, J.F. 1983. Assessment of offshore oil mortality and corpse drift experiments. Unpubl. report for Mobil Oil Canada Ltd., Memorial Univ. Newfoundland, St. John's, Newfoundland, 31pp.
- White, I.C., and Baker, J.M. 1999. The Sea Empress oil spill in context. Paper presented at the International Conference on the Sea Empress oil spill, 11–13th February 1998, Cardiff, Wales, The International Tanker Owners Pollution Federation, <http://www.itopf.com/seeec.pdf>, accessed 25/4/2005.
- Vieites, D.R., Nieto-Román, S., Palanca, A., Ferrer, X., and Vences, M. 2004. European Atlantic: the hottest oil spill hotspot worldwide. Naturwissenschaften, 91: 535–538.
- Wiese, F. 2002. Seabirds and Atlantic Canada's Ship-Source Oil Pollution. World Wildlife Fund Canada, Toronto, Canada.
- Wiese, F.K., and Jones, I.L. 2001. Experimental support for a new drift-block design to assess seabird mortality from oil pollution. Auk, 118: 1062–1068.
- Wiese, F.K. 2003. Sinking rates of dead birds: improving estimates of seabird mortality due to oiling. Marine Ornithology, 31: 65–70.
- Wiese, F.K., and Ryan, P.C. 2003. The extent of chronic marine oil pollution in southeastern Newfoundland waters assessed through beached bird surveys 1984–1999. Marine Pollution Bulletin, 46: 1090–1101.
- Williams, J.M., Tasker, M.L., Carter, I.C., and Webb, A. 1995. A method of assessing seabird vulnerability to surface pollutants. Ibis, 137: S147–S152.

4 Review of the consequences for foraging conditions of sea ducks of the *Spisula* decline in the southern North Sea

Sea ducks, particularly common scoters winter in large numbers in the southeastern North Sea. The total biogeographic population size of the species amounts to some 1,600,000 individuals (Wetlands International 2002) of which some 200,000–400,000 winter in the SE North Sea. Common scoters have their core wintering area in the Baltic, Belt Seas, Kattegat and Skagerrak, with several hundreds of thousands of birds ‘overflowing’ into the North Sea and onward into the waters off France and Iberia and around the British Isles. Some common scoters may winter as far south as NW Africa (Laursen 1989; Keijl 1993). In the southeastern North Sea, common scoters prefer the comparatively exposed North Sea coastal waters over the more sheltered waters of the inner Wadden Sea. The Wadden Sea itself is an important wintering area of common eiders that seem more reluctant to venture out into exposed North Sea waters. However, in the 1990’s large flocks have been noted to join the scoters in the North Sea off the Netherlands, when they were driven out of the Wadden Sea by food shortage (severely depleted stocks of their principal foods, blue mussels *Mytilus edulis* and edible cockles *Cerastoderma edule*; Swennen *et al.* 1989; Leopold 1993; Berrevoets *et al.*, 2001, 2003; Leopold *et al.*, 2001; Camphuysen *et al.*, 2002). It is not known whether this has led to significant competition between the species for the North Sea food stocks. A third species of seaduck, the velvet scoter is usually found in relatively small numbers among the much more numerous common scoters in the North Sea, sharing the same wintering locations and food stocks (Durinck *et al.*, 1990; Leopold 1993). Velvet scoters rarely reach numbers of > 10,000 in the SE North Sea; they are much more abundant both to the northeast (Baltic) and southwest (France) of this area.

Common scoters are almost exclusively benthivorous, preying mainly on bivalve molluscs, with occasional additions of gastropods, annelids, crustaceans, echinoderms and fish (Madsen 1954; Cramp and Simmons 1977; Stempniewicz 1986; Schricke 1993; Leopold 1996; Aulert and Sylvand 1997; Leopold *et al.*, 2001; Frengen and Thingstad 2002; Žydelis 2002; Fox 2003). An extreme example of the ducks’ feeding versatility is given in Bauer and Glutz von Blotzheim (1969), of a group of some 1000 common scoters feeding for a month on a shipload of beans, spilled out of a ship stranded on Helgoland, Germany in the late 1800s. Prey are caught by diving to the bottom of shallow nearshore marine waters. Mussels are torn off from their holdfast; burying clams are dug out from the sediment. Mussel clumps and other large or awkwardly shaped prey (crabs, starfish) may be taken to the surface for additional handling, before they can be swallowed. Smaller clams are swallowed under water, either one by one or they may be siphoned up if they are very small (Guillemette *et al.*, 1992). Most prey are hard-shelled, swallowed whole and crushed in the muscular stomach. The soft parts are then digested while the remaining shell fragments leave the body in the faeces. This way of feeding is energetically costly (Nehls 1995; de Leeuw *et al.* 1999), and only rich stands of shellfish can be exploited successfully. Rich shellfish banks may attract huge flocks of seaduck (of up to > 100,000) that may remain there during the whole winter or even successive winters (Leopold *et al.*, 1995, I.K. Petersen *pers. comm.*). Scoters are versatile foragers in that they may feed on any bivalve species locally available, provided that local densities are sufficiently high and that prey size is right (roughly 5–50 mm in length; see Fox 2003 for a review).

Diets of common scoters wintering off the east Atlantic seaboard have been found to differ between locations, with often one or a few prey species dominating local diets. In the Baltic, the clams *Cerastoderma edule*, *C. lamarcki*, *Mya arenaria*, *M. truncata*, *Cyprina islandica*, *Mytilus edulis* and *Macoma balthica* were all found to be important prey in different studies (Kirchhoff 1979, 1981; Stempniewicz 1986; Meissner and Bräger 1990; Meissner 1992; Rumohr 2001; Žydelis 2002; Rumohr and Evert unpublished data), while fish (sandeels and discards) were on occasion found to contribute to the diet (Stempniewicz and Meissner 1999). In

Danish and Dutch North Sea waters *Spisula subtruncata* has dominated the diet of wintering scoters in the 1990s (Durinck *et al.*, 1990; Offringa 1991; Leopold *et al.*, 1995; 1996; 1998); there is no dietary information on the German North Sea waters situated in between (Rumohr 2001). Further south, in Belgium and French waters the diet was found to be more diverse again. Van Steen (1978) and Degraer *et al.* (1999) have considered that 13 species of bivalves are likely to be eaten by scoters in Belgium (*Donax vittatus*, *Abra alba*, *Tellina fibula*, *T. tenuis*, *Macoma balthica*, *Spisula subtruncata* and *Barnea candida*), with *A. alba*, *T. fibula* and *S. subtruncata* probably being the most important. Off NW France, a similar wide variety of bivalve prey species has been found in common scoter stomachs, although only one species, *Donax vittatus*, dominated the diet at the time when the ducks were sampled for diet analysis (Aulert and Sylvand 1997). Diets further south, from Spain and Portugal to NW Africa, are presently unknown.

The overall situation thus appears to be that common scoters can feed on a wide variety of shellfish, providing that densities are high and sizes are manageable (Fox 2003). Comparatively wide prey spectra are found in areas that are biologically diverse, such as the Baltic or French/Belgium waters, where mosaics of benthic species occur over a relatively small area. In the SE North Sea, with its rather monotonous sandy foreshores from the Netherlands up to Denmark, species richness seems to be lower and the ducks have a smaller variety to take from. However, studies following mass-strandings of live shellfish on Dutch beaches have shown that over decades, different bivalve species have replaced each other as the dominant one (Oosterbaan 1991) and so probably has the diet of scoters varied over time at any one place (Madsen 1954; Leopold *et al.*, 1995; Rumohr 2001). The dominance of *Spisula subtruncata* in Dutch waters in the 1990s was thus probably preceded by a dominance of other species in earlier decades (such as cockles, Leopold *et al.*, 2005), and likewise, other prey species may feature as the staple diet in the future.

In the mid- or late 1990s, *Spisula* stocks started to decline in the SE North Sea. This decline was witnessed in Belgium (van Waeyenberge *et al.*, 2001), the Netherlands (Craeymeersch and Perdon 2003, 2004), Germany (Rumohr 2001) and Denmark (Jensen *et al.* 2003). Several factors may have contributed to this decline. Massive die-offs were noted in the severe winter of 1995/96. Recruitment of shellfish, including *Spisula subtruncata* (Hagmeier 1930; Degraer 1999) is notoriously variable. From that time onward, recruitment of *Spisula subtruncata* also seems to have fallen. Stocks of *S. subtruncata* did not recover, while remaining banks that were situated just south of the ice cover, remained to be fished until very little was left. *S. solida* did also fail to recover in shallow (<10m) Danish waters where they were fished until 1995, but fishable densities may have survived in deeper waters, where a fishery was resumed in 2000 after a gear change (longer suction pipes) made this possible (Jensen *et al.*, 2003). These three factors in concert (winter die-off, recruitment failure and on-going fisheries on the remaining stock) made that *Spisula subtruncata* was hardly harvestable by either fishermen or seaduck by 2005. In the Netherlands, where both *Spisula* and seaduck numbers have been monitored over a number of years, *Spisula* stocks in 2003 were by far the lowest since the yearly stock assessments commenced in 1995 (Craeymeersch and Perdon 2004), and have continued to decline since (J. Craeymeersch *pers. comm.*). Wintering numbers of scoters in The Netherlands decreased from 135,000 in 1993 to 32,500 in 2005 (de Jong *et al.*, 2005). It should be added however, that numbers were also lower in earlier years (no data on *Spisula* available), with the exception of winter 1986/87 when some 80,000 were found wintering in Dutch waters (no good data before that year; Leopold *et al.* 1995; Figure 4–1A). Similar population trajectories were noted in Belgian, French and Portuguese waters with increases in the early 1990s to reach a peak in 1993 or 1994, followed by decreases in later years (Figures 4–1B,C,D). Note that the *Spisula* stocks in these countries have not been subject to the same severe winter conditions as were the stocks further north and that also the fishery was probably less intensive. In the western parts of German North Sea waters (Niedersachsen) waters scoter numbers also seem to have gone down recently, but data are more fragmentary here (S.

Garthe *pers. comm.*). Data from Danish North Sea waters are not yet available for a similar reconstruction (Henning 2001; H. Skov and I.K. Petersen, *pers. comm.*).

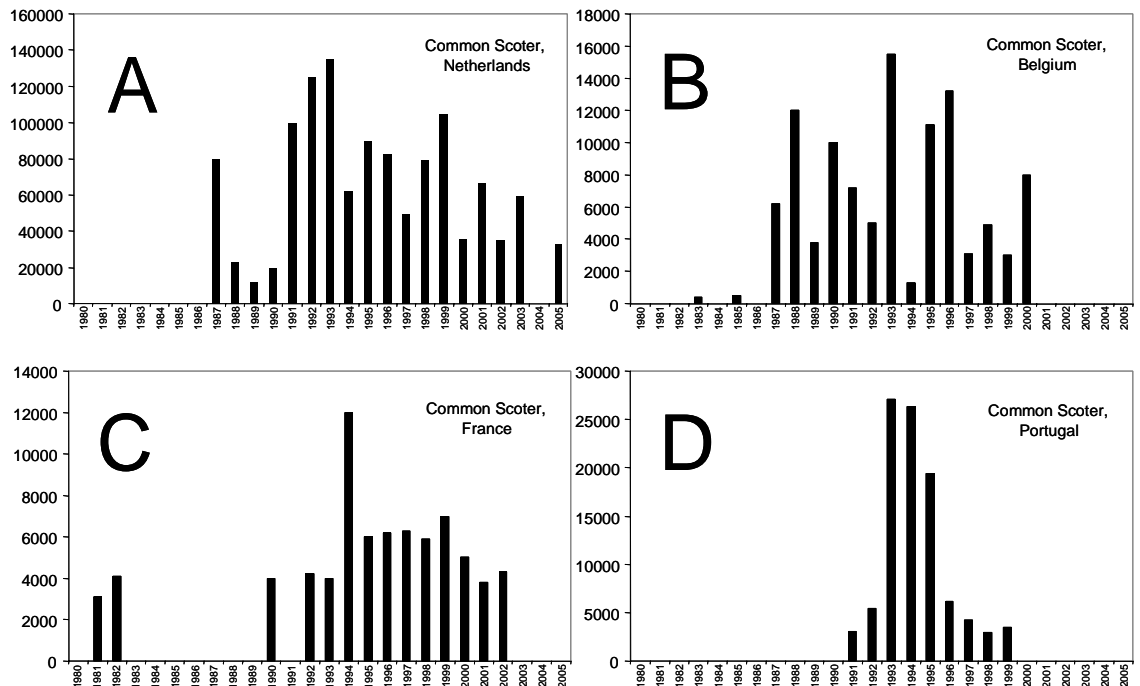


Figure 4–1. Numbers of common scoters wintering in The Netherlands (A), Belgium (B), France (C and NW Portugal (D), as taken from de Jong *et al.* (2005), van Waeyenberge *et al.* (2001), Le Dréan-Quéneec’hdu *et al.* (2003) and R. Rufino (*in litt.*), respectively. Note differences in scale on Y-axes. Years without bars had no surveys, rather than no ducks.

There may thus have been a general increase of numbers wintering along the east Atlantic seaboard in the early 1990s, followed by a decline. This decline was marked in the Netherlands and Belgium where the diet was mainly *Spisula subtruncata*, which also declined in abundance. Numbers of common scoters did not decline in France, where *Spisula* probably was far less important, but numbers did decline sharply in Portugal, where their diet is presently unknown. One can therefore conclude that recent declines in numbers of wintering common scoters coincided with declines in *Spisula* stocks, but that other factors than the availability of this prey species may also have played a role. Whatever the factor(s) governing scoter numbers might be, common scoters wintering from Denmark to Belgium have been facing a marked decrease of their principal prey species recently, *Spisula solida* in the north and *S. subtruncata* in the south. The ducks had three options: leave (to winter somewhere else), starve or change their diet. Mass-mortality of scoters (other than through oiling incidents) has not been recorded in the region at the time of the decrease in wintering numbers, unlike in common eiders that did go through mass die-offs in the Netherlands (Camphuysen *et al.* 2002). Unfortunately, scoter surveys have not been conducted with sufficient intensity throughout the species’ wintering range to pick up a shift in wintering locality of some 100,000 common scoters now ‘missing’ from the Netherlands and Belgium. However, as they apparently did not die in the ‘*Spisula* crisis area’ where they did decline in numbers, they must have moved. There is also mounting evidence that ducks that kept wintering in the Netherlands, changed their diet and switched to taking *Ensis americanus*. Common Scoters were seen taking this razor clam as their main prey in the southwest of the country (Leopold and Wolf 2003; Wolf and Meininger 2004), and shell fragments of *Ensis americanus* were found in the stomachs and guts of oiled scoters in the north of the country. Similarly, *Ensis* was

found as the main prey species in faeces of common eiders wintering in the North Sea off the Dutch Wadden island of Texel in 2001–2003 (Leopold *et al.* in prep). Recent evidence from common scoters collected at Horns Rev, Denmark, also show that these ducks now feed on *Ensis* (I.K. Petersen *pers. comm.*). Although razor clams seem an awkwardly shaped prey for scoters to ingest and crush in their gizzard, they have been found as prey of seaduck in an increasing number of studies (Swennen and Duiven 1989; Hughes *et al.*, 1996; Aulert and Sylvand 1997; Thingstad *et al.*, 2000; Ens *et al.*, 2002; Leopold 2002; Fox 2003; K. Laursen *in litt.*). The American razor clam was introduced in the eastern North Sea in the late 1970s and has spread and increased in numbers dramatically since (Swennen *et al.*, 1985), to become the dominant bivalve in Dutch nearshore waters today (Bult *et al.*, 2004; Craeymeersch and Perdon 2004; Leopold *et al.*, in prep.). Evidence from mass-strandings from Belgium to Germany suggest the same for a much larger area (E. Stienen and S. Garthe *pers. comm.*) and there must to be sufficient biomass of *Ensis* available to sustain large numbers of scoters. However, this prey species is probably far less easy to catch, handle and digest than *Spisula*, so it seems a less suitable prey and this could explain the dwindling numbers of wintering seaduck in the region. Seaduck will probably keep on eating mainly *Ensis* for some time, until a more suitable prey species becomes available in large quantities. Until there is evidence of a general decrease of the total wintering population of common scoters, there may not be a reason for great concern about the impact of declining *Spisula* stocks on seaduck. Some seaduck will probably keep on wintering in the region where *Spisula* formally was important for them, using *Ensis* as an alternative prey species. Common scoters are versatile foragers that cannot afford to rely on a single prey species, as bivalve communities are known to vary greatly in species composition and abundance. Instead, common scoters seem to be able to switch quickly from one prey species to the next and from one wintering site to another along their vast wintering range. The birds that used to winter from Belgium to Denmark, taking *Spisula*, probably moved to other sites, and/or switched to other prey.

The only reason for concern might be that *Spisula* stocks were fished until very few remained in both Dutch waters and in (shallow) Danish waters. Such fisheries probably are not sustainable over longer time periods, given the intrinsic variability in recruitment and susceptibility to severe winter conditions of *Spisula* (Craeymeersch *et al.*, 2001). *Spisula* fisheries also exist off Portugal (where numbers of Scoters have also declined) and fisheries for *Ensis americanus* are currently being developed in the Netherlands, while the Dutch may also export their offshore shellfishery techniques and hardware to NW Africa. This implies that all shellfish stocks that might in future be exploited by scoters and other seaduck, are within reach of shellfishermen and the implications of this are yet far from clear.

4.1 References

- Aulert, C., and Sylvand, B. 1997. Les Macreuses noires (*Melanitta nigra*) et brunes (*Melanitta fusca*) hivernant au large de Côtes du Calvados: relation entre le régime alimentaire et les peuplements macrozoobenthiques marins littoraux. *Ecologie*, 28: 107–117.
- Bauer, K.M., and Glutz von Blotzheim, U.N. 1969. *Handbuch der Vögel Mitteleuropas*, Vol. 3. Akademischer Verlag, Frankfurt am Main.
- Berrevoets, C.M., Witte, R.H., and Arts, F.A. 2001. Midwintertelling van zee-eenden in de Waddenzee en Nederlandse kustwateren, januari 2001. Werkdocument RIKZ/IT/2001.814, Rijksinstituut voor Kust en Zee, Middelburg.
- Berrevoets, C.M., and Arts, F.A. 2003. Midwintertelling van zee-eenden in de Waddenzee en de Nederlandse kustwateren, januari 2003. Rapport RIKZ/2003.008. Rijksinstituut voor Kust en Zee, Middelburg.
- Bult, T.P., Ens, B.J., Baars, D., Kats, R., and Leopold, M. 2004. Evaluatie van de meting van het beschikbare voedselaanbod voor vogels die grote schelpdieren eten. Eindverslag EVA

- II (Evaluatie Schelpdiervisserij tweede fase), Deelproject B3. RIVO-rapport C018/04, 108p. (www.eva2.nl).
- Camphuysen, C.J., Berrevoets, C.M., Cremers, H.J.W.M., Dekinga, A., Dekker, R., Ens, B.J., van der Have, T.M., Kats, R.K.H., Kuiken, T., and Leopold, M.F. 2002. Mass mortality of common eiders (*Somateria mollissima*) in the Dutch Wadden Sea, winter 1999/2000: starvation in a commercially exploited wetland of international importance. *Biological Conservation*, 106: 303–317.
- Craeymeersch, J.A., and Perdon, J. 2004. De halfgeknotte strandschelp *Spisula subtruncata*, in de Nederlandse kustwateren in 2003. RIVO rapport C040/04.
- Craeymeersch, J.A., Leopold, M.F., and van Wijk, M.O. 2001. Halfgeknotte strandschelp en Amerikaanse zwaardschede: een overzicht van bestaande kennis over visserij, economische betekenis, regelgeving, ecologie van de beviste soorten en effecten op het ecosysteem. RIVO rapport C033/01, 34 p.
- Cramp, S., and Simmons, K.E.L. 1977. *The Birds of the Western Palearctic*, Vol 1. Oxford Univ. Press, Oxford 722 p.
- Degraer, S. 1999. Macrozoobenthos of shallow marine habitats (Belgian coast) and its use in coastal zone management. PhD thesis, University of Gent.
- Degraer, S., Vincx, M., Meire, P., and Offringa, H. 1999. The macrozoobenthos of an important wintering area of the Common Scoter *Melanitta nigra*. *Journal of the Marine Biological Association of the UK*, 79: 243–251.
- Durinck, J., Christensen, K.D., Skov, H., and Danielsen, F. 1990. Diet of Common Scoter *Melanitta nigra* and Velvet Scoter *M. fusca* wintering in the North Sea. *Ornis Fennica*, 70: 215–218.
- Ens, B.J., and Kats, R.K.H. Evaluatie van voedselreservering Eidereenden in de Waddenzee - rapportage in het kader van EVA II deelproject B2. Alterra rapport 931, 155 p. 2004. Wageningen, Alterra. (www.eva2.nl).
- Fox, A.D. 2003. Diet and habitat use of scoters *Melanitta* in the Western Palearctic - a brief overview. *Wildfowl*, 54: 163–182.
- Frengen, O. and Thingstad, P.G. 2002. Mass occurrence of sandeels (*Ammodytes* spp.) causing aggregations of diving ducks. *Fauna Norvegica*, 22: 32–36.
- Guillemette, M., Ydenberg, Y.C., and Himmelman, J.H. 1992. The role of energy intake rate in prey and habitat selection of Common Eiders in winter: a risk-sensitive interpretation. *Journal of Animal Ecology*, 61: 599–610.
- Hagmeier, A. 1930. Eine Fluktuation von *Mactra (Spisula) subtruncata* da Costa an der ostfriesischen Küste. *Berichte der Deutschen wissenschaftlichen Kommission für Meeresforschung*, 5: 126–155.
- Hennig, V. 2001. An evaluation of available knowledge on the necessity of undisturbed moulting sites for seaducks in the offshore area, in order to investigate the possibilities for creating such undisturbed moulting sites. Report – Wadden Sea Plan Project 35, to the Nationalparkamt Schleswig-Holsteinisches Wattenmeer, Germany.
- Hughes, B., Underhill, M., Stewart, B. and Woodrow, W. 1996. Conservation and research on Common Scoter in the United Kingdom. *Wetlands International Seaduck Specialist Group Bulletin*, 6: 9–12.
- Jensen H., Kristensen P.S., and Hoffmann E. 2003. Sandeels and clams (*Spisula* sp.) in the wind turbine park at Horns Reef. Report Danish Institute for Fisheries Research, Department of Marine Fisheries, Charlottenlund to TechWise.
- de Jong, M.L., Ens, B.J., and Leopold, M.F. 2005. Het voorkomen van Zee- en Eidereenden in de winter van 2004–2005 in de Waddenzee en Noordzee-kustzone. Alterra Rapport: in press.

- Keijl, G.O. 1993. Enkele waarnemingen aan zeevogels aan de Atlantische kust van Marokko, oktober-december 1991. *Sula*, 7: 20–24.
- Kirchhoff, K. 1979. Nahrungsökologische Untersuchungen an benthosfressenden Enten in der Hohwachter Bucht. Diplomarbeit, Universität Kiel.
- Kirchhoff, K. 1981. Zur Verbreitung der überwinternden Meeresenten auf der offenen Kieler und Lübecker Bucht (westliche Ostsee). *Corax*, 8: 197–207.
- Laursen, K. 1989. Estimates of sea duck winter populations of the Western Palaearctic. *Danish Review of Game Biology*, 13 (6): 1–22.
- de Leeuw, J.J., van Eerden, M.R., and Visser, G.H. 1999. Wintering Tufted Ducks *Aythya fuligula* diving for Zebra Mussels *Dreissena polymorpha* balance feeding costs within narrow margins of their energy budget. *Journal of Avian Biology*, 30: 182–192.
- Le Dréan-Quénez'hdu, S., Le Mao, P., and Mahéo, R. 2003. Pression de prédation sur les mollusques bivalves par les limicoles malcophages et la Macreuse noire de la Baie du Mont-Saint-Michel. *Le Cormoran*, 13: 31–36.
- Leopold, M.F. 1993. *Spisula*'s, zeeëenden en kokkelvisser: een nieuw milieuprobleem op de Noordzee. *Sula*, 7: 24–28.
- Leopold, M.F. 1996. *Spisula subtruncata* als voedselbron voor zee-eenden in Nederland. BEON rapport 96–2.
- Leopold, M.F. 2002. Eiders *Somateria mollissima* scavenging behind a lugworm boat. *Journal of Sea Research*, 47: 75–82.
- Leopold, M.F., Baptist, H.J.M., Wolf, P.A., and Offringa, H. 1995. De Zwarte Zeeëend *Melanitta nigra* in Nederland. *Limosa*, 68: 49–64.
- Leopold, M.F., van der Land, M.A., and Welleman, H.C. 1998. *Spisula* en zee-eenden in de strenge winter van 1995/96 in Nederland. Beon-rapport 98–6.
- Leopold, M.F., Kats, R.K.H., and Ens, B.J. 2001. Diet (preferences) of Common Eiders *Somateria mollissima*. *Wadden Sea Newsletter* 2000–1: 25–31.
- Leopold, M.F., and Wolf, P. 2003. Zee-eenden eten ook *Ensis*. *Nieuwsbrief Nederlandse Zeevogelgroep* 4(3): 5.
- Leopold, M.F., Verdaat, H.J.P., Spannenburg, P.C., and Kats, R.K.H. in prep. Identification of *Spisula subtruncata* and *Ensis americanus* remains in stomachs and faeces of Common Eiders *Somateria mollissima* and Common Scoters *Melanitta nigra*. ms for Atlantic Seabirds.
- Madsen, F.J. 1954. On the food habits of the diving ducks in Denmark. *Danish Review of Game Biology*, 2: 157–266.
- Meissner, W., 1992. Untersuchungen zum Vorkommen überwinterten Meeresenten in Abhängigkeit vom Nahrungsangebot in der Kieler Bucht. Thesis, Univ. Kiel.
- Meissner, J., and Bräger, S. 1990. The feeding ecology of wintering Eiders *Somateria mollissima* and Common Scoters *Melanitta nigra* on the Baltic Sea coast of Schleswig-Holstein, FRG. *Wader Study Group Bulletin*, 58: 10–12.
- Nehls, G. 1995. Strategien der Ernährung und ihre Bedeutung für Energiehaushalt und Ökologie der Eiderente (*Somateria mollissima* (L., 1758)). PhD thesis, Christian-Albrechts Universität, Kiel, 173 p.
- Offringa, H. 1991. Verspreiding en Voedseloecologie van de Zwarte Zeeëend (*Melanitta nigra*) in Nederland. NIOZ rept. 1991–13, Nederlands Instituut voor Onderzoek der Zee, Texel, 39 p.
- Oliver, P.J. 1999. The decline of Common and Velvet Scoters as autumn migrants in the English Channel. *Wetlands International Seaduck Specialist Group Bulletin*, 8: 12–16.

- Oosterbaan, A. 1991. De grote vijf van de Hollandse kust. *Natura*, 88: 86–87.
- Reis, A.M.M. (unpubl. Ms). Seabirds mortality on the continental portuguese coast, 1985–1990.
- Rufino, R., Neves, R., Pina, J., and Reis, S. in prep. Seaduck monitoring in Portugal.
- Rumohr, H., 2001. Untersuchungen zur Nachhaltigkeit der Schwertmuschel- (*Ensis directus/americanus*) und Dickschaligen Trogmuschel (*Spisula solida*)- Fischerei in Schleswig-Holsteinischen Küstengewässern. Schlußbericht zum Forschungsvorhaben im Rahmen des Gemeinschaftsvorhabens PESCA. Unpublished report to the Amt für Ländliche Räume.
- Schricke, V. 1993. La baie du Mont-Saint-Michel, premiere zone de mue en France pour la macreuse noire (*Melanitta nigra*) *Alauda*, 61: 35–38.
- van Steen, E. 1978. Het macrobenthos van een overwinteringsgebied van *Melanitta nigra* (Linnaeus, 1758) voor de Belgische kust. Unpublished Report, Rijksuniversiteit van Gent, 1977/78.
- Stempniewicz, L. 1986. The food intake of two scoters *Melanitta fusca* and *M. nigra* wintering in the Gulf of Gdansk, Polish Baltic coast. *Vår Fågelvärld*, Suppl. 11: 211–214.
- Stempniewicz, L., and Meissner, W. 1999. Assessment of the zoobenthos biomass consumed yearly by diving ducks in the Gulf of Gdansk (southern Baltic Sea). *Ornis Svecica*, 9: 143–154.
- Swennen, C., and Duiven, P. 1989. Eidereend *Somateria mollissima* gestikt in Amerikaanse Zwaardscheden. *Limosa*, 62: 153–154.
- Swennen, C., Nehls, G., and Laursen, K. 1989. Numbers and distribution of Eiders *Somateria mollissima* in the Wadden Sea. *Netherlands Journal Sea Research*, 24: 83–92.
- Swennen, C., Leopold, M.F., and Stock, M. 1985. Notes on growth and behaviour of the American razor clam *Ensis directus* in the Wadden Sea and the predation on it by birds. *Helgoländer Meeresuntersuchungen*, 39: 255–261.
- Thingstad, P.G., Hokstad, S., and Frengen, O. 2000. Nye opplysninger om aerfuglens *Somateria mollissima* naeringsbiologi [Some new notes considering the Common Eider's *Somateria mollissima* foraging biology]. *Fauna-Oslo* 53: 66–71.
- van Waeyenberge, J., Stienen, E.W.M. and Offringa, H. 2001. Overwinterende zee-eenden voor de Belgische kust. *Vogelnieuws* 2: 20–23.
- Wolf, P., and Meininger, P.L. 2004. Zeeën van zee-eenden bij de Brouwersdam. *Nieuwsbrief Nederlandse Zeevogelgroep* 5(2): 1–2.
- Žydelis, R. 2002. Habitat selection of waterbirds wintering in Lithuanian coastal zone of the Baltic Sea. PhD Thesis, Biomedical Sciences, Ecology & Environmental Sciences, University of Vilnius.

5 Further examination of the foodweb relationships of seabirds indicated by food consumption estimates in the Northeast and Northwest Atlantic regions

In many areas, a single species provides the dominant prey for a wide diversity of predators, including seabirds, seals, whales and fishes (Springer and Speckman 1997). For example, in the North Sea, the lesser sandeel *Ammodytes marinus* is the primary prey item of many seabird species including common guillemots, black-legged kittiwakes, Atlantic puffins as well as a number of non-avian predators. Capelin *Mallotus villosus* fills a similarly dominant trophic position in the northwest Atlantic (Montevecchi 2002) and, at times, in the Barents Sea.

Most seabirds are opportunistic to some degree and able to exploit alternative prey if or when they become available, or when previously preferred species disappear. Thus northern fulmars and shearwaters, for example, appear to equally adaptable eating large zooplankton (e.g., euphausiids) or fish (sandeels, capelin). Individual seabird species may thus simultaneously sample from more than one trophic level. For example several seabirds species can feed on both schooling fishes and the prey upon which those schooling fishes feed. Furthermore, different species of seabirds may differ in diet and trophic level by exploiting different age classes of the same prey species. For these reasons, it can at times be difficult to categorize seabirds as belonging to any one foraging guild.

As with other pelagic communities, species within the North Atlantic avian communities at times depend upon one another for the location of prey (Camphuysen and Webb 1999). For example, in Europe, common guillemots, razorbills and/or Atlantic puffins are often the first piscivores to locate schools of fish, because they can dive deeply and thus exploit a broad range of depths in the water column and drive some fish to the surface in the process of trying to capture them. Surface-feeding black-legged kittiwakes and larger gulls searching for fish converge on groups of auks that have located schools of fish. The surface feeders thus benefit from access to these fish that would otherwise be too deep to reach. These mixed feeding flocks of auks and black-legged kittiwakes are then often joined by northern gannets, which use the former species as cues to the presence of prey. When the much larger gannets join the flock, they often aggressively chase away both auks and black-legged kittiwakes (Camphuysen 2005). This basic sequence of events may be initiated by other diving birds, by seals, cetaceans or predatory fish such as saithe (*Pollachius virens*) or tuna (*Thunnus thynnus*) (Hoffman *et al.*, 1981; Evans 1982; Pierotti 1988; Harrison *et al.*, 1991; Pitman and Balance 1992). This behaviour has important consequences for population dynamics as it implies mutualism as well as competition. The food web consequence of these mutualistic interactions is that concurrent declines could occur due to the dependence of one species upon others to efficiently locate food.

5.1 East-west comparison of consumption rates in the North Atlantic

5.1.1 Numbers

In consideration of the above points and the striking oceanographic differences between the cold low arctic waters of the northwest Atlantic and the warmer boreal waters of the northeast Atlantic, there are significant avian community and food web differences across the North Atlantic (ICES 2002; 2003; 2004).

For example, planktivores dominate the breeding community in the northwest Atlantic, especially in NAFO 1, 2 and 3, whereas piscivores play dominant trophic roles in the northeast Atlantic. The dominance by planktivorous species in the Northwest Atlantic is almost entirely a consequence of the vast number (30+ million pairs) of little auks nesting in northwestern

Greenland. In Newfoundland, the community of breeding seabirds is dominated numerically, but not in terms of biomass, by Leach's storm-petrels. In the Northeast Atlantic, the avian communities are dominated by large alcids (mainly common guillemots and Atlantic puffins) that feed primarily on small schooling fish (sandeels, capelin, herring, young gadoids). The northwest Atlantic community is further supplemented by high numbers and a large biomass of trans-equatorial migrant shearwaters that are predominantly planktivorous and breed in the south Atlantic Ocean (Brown *et al.*, 1981, Cairns *et al.*, 1991).

The oceanographic rationales for these differences should be explored. For example, what are the oceanographic conditions off western Greenland that support a vast abundance of plankton-eating (plus historically large numbers of fish-eating guillemots)? For seabirds, presence of suitable nesting sites may limit population size (Ashmole 1963, Olsthoorn and Nelson 1990), so this limitation must also be considered. It is possible that western Greenland provides especially large number of little auk nest sites, or that islands off Newfoundland provide especially abundant burrow sites for Leach's storm-petrels (compared to similar latitudes in the northeast Atlantic).

More likely, differences in bird species composition between regions reflect differences in prey base. The little auk situation in northwest Greenland deserves special consideration. This is an arctic community, located near a marginal ice zone and, like other polar ecosystems, with especially high secondary productivity and zooplankton abundance (e.g., Zelickman and Golovkin 1972; Pederson and Schmidt 2000; Munk *et al.*, 2003). Little auks in northwest Greenland eat small polar cod (*Boreagadus saida*) but also amphipods and copepods (Gaston and Jones 1998, Nettleship and Birkhead 1985).

The superabundance of Leach's storm-petrels in Newfoundland may be explained by a combination of nest-site and foraging opportunities. This species requires remote and mammal-free islands, suitable soil in which to dig nest burrows, and sufficient nighttime in which to access burrows without being eaten by avian diurnal predators. Sufficient soil for burrowing disappears a short distance to the north of Newfoundland, and the summer day length increases. Secondary productivity furthermore is considerably higher around Newfoundland and on the Grand Banks than it is a short distance to the south (Backus and Bourne 1987). Paradoxically, the species' largest colony is on Baccalieu Island, which is inhabited by a small population of red foxes (*Vulpes vulpes*). The foxes prey and cache storm-petrels but owing to food shortages in winter, the fox population has remained small. In turn, the fox population prevents larid gulls that are major predators of Leach's storm-petrels (Stenhouse and Montevecchi 1999; Stenhouse *et al.*, 2000) from nesting on the island and hence provide a "net benefit" for the storm-petrels (Sklepkevich and Montevecchi 1989).

The piscivorous birds that dominate the bird communities of the northeast Atlantic are primarily guillemots and Atlantic puffins, which feed almost exclusively on schooling forage fish such as sandeels, herring, pilchards and sprat (Mitchell *et al.*, 2004). These fishes are found in shallow shelf waters (defined here as depth < 200m; Daan *et al.*, 1990). The North Sea is 89% shelf waters (cf. average proportion of shelf waters overall in the North Atlantic is 20–25%, Table 5–1). Thus, part of the dominance by piscivores in the northeast (ICES I–VII) could be due to the high proportion of shelf waters there. However, a similar extent of the shelf waters of NAFO 2 and 3 not only support large numbers of piscivorous auks which breed in the area, but also greater numbers of planktivorous petrels and shearwaters consuming an almost equal biomass of food.

Table 5–1: Surface areas of ICES and NAFO regions based on GEBCO 1-minute global bathymetric grid and approximate total annual seabird harvest and harvest rate km⁻².

REGIONS	TOTAL AREA IN MILL. KM ²	AREA OF WATERS <200 M DEEP	% <200 M DEEP	TOTAL CONSUMPTION IN MILL. T	CONSUMPTION RATE IN T KM ⁻²	CONSUMPTION RATE OF T*KM ⁻² OF WATERS <200 M DEEP
ICES I,II	3.8	1.0	25.7	1.55	0.4	1.6
ICES Va,XIV	1.6	0.3	16.5	2.00	1.3	7.5
ICES IV,VIIId,e	0.7	0.6	89.0	0.74	1.1	1.2
ICES III	0.4	0.4	96.4	0.63	1.4	1.5
ICES Vb,VI,VII ¹	1.3	0.4	31.4	0.93	0.7	2.4
ICES VIII,IX,X	3.9	0.1	3.5	0.11	<0.1	0.8
ICES XII	2.1	0.0	0.0	-	-	-
ICES Total	13.9	2.8	20.0	5.93	0.4	2.1
ICES excl. VIII- XII	7.8	2.4	30.9	5.82	0.7	2.4
NAFO 0	0.6	0.1	16.4	0.27	0.5	2.9
NAFO 1	1.0	0.1	14.5	1.97	2.0	13.7
NAFO 2 and 3	2.1	0.4	20.2	2.00	1.1	5.4
NAFO 4	1.0	0.3	32.9	0.23	0.2	0.7
NAFO 5–6	1.6	0.2	14.8	0.27	0.2	1.2
NAFO Total	6.2	1.6	26.3	4.99	0.8	4.1

¹except VIIId,e

5.1.2 Consumption

As for the numbers of seabirds, there is also considerable spatial variation in consumption rates across the ICES and NAFO areas but overall the consumption per unit area is similar between the eastern and western regions (0.5–0.8 t km⁻², Table 5–1).

An effect of shelf area is most apparent in the Baltic Sea of which > 95% of its extent is < 200 m in depth and 84% is < 100m. Here the annual harvest rate per unit area is the highest in the whole northeast Atlantic (1.4 t km⁻², Table 5–1) and is taken by a community dominated by piscivorous and benthic-feeding seaducks, including nearly half a million breeding pairs of common eiders. These are supplemented by up to nearly 7 million individuals of other species including long-tailed duck, common scoter, velvet scoter, common goldeneye and greater scaup that visit during the late winter and early spring.

A slightly higher harvest rate (2.0 t km⁻²) was calculated for the area off western Greenland where the planktivorous little auks dominate the community, and rates above 1.0 t km⁻² are also apparent in the North Sea and around Iceland where guillemots, Atlantic puffins and northern fulmars are the main consumers. The lowest rates (0.02 t km⁻²) were found in the deep seas off France, Iberia and around the Azores.

An exploratory analysis that assumed that most birds forage in shelf waters (here defined as those shallower than 200 m) corroborated these general conclusions, again showing that feeding is most intense per unit area off western Greenland and around Iceland and eastern Greenland, and lowest in the deepwater south eastern sectors of ICES (VIII, IX and X), but also in NAFO 4. Such analyses taking into account physical parameters (sea temperature, extent of frontal systems, length of coastline/continental shelf, etc.), biological production, etc. should be addressed.

5.1.3 References

- Ashmole, N.P. 1963. The regulation of numbers of tropical oceanic birds. *Ibis*, 103b: 458–473.
- Backus, R.H., and Bourne, D.W. (eds.). 1987. Georges Bank. MIT Press, Cambridge, MA.
- Brown, R.G.B., Barker, S.P., Gaskin, D.E., and Sandeman, M.R. 1981. The foods of great and sooty shearwaters *Puffinus gravis* and *P. griseus* in eastern Canadian waters. *Ibis*, 123: 19–30.
- Cairns, D.K., Chapdelaine, G., and Montevecchi, W.A. 1991. Prey harvest by seabirds in the Gulf of St. Lawrence. In *The Gulf of St. Lawrence: Small Ocean or Big Estuary?* Ed. by Theriault, J.C. Canadian Special Publication of Fisheries and Aquatic Science, 113: 277–291.
- Camphuysen, C.J. 2005. Seabirds at sea in summer in the NW North Sea. *British Birds*, 98: 2–19.
- Camphuysen, C.J., and Webb, A. 1999. Multi-species feeding associations in North Sea seabirds: jointly exploiting a patchy environment. *Ardea*, 87: 177–198.
- Daan, N., P.J. Bromley, Hislop, J.R.G., and Nielsen, N.A. 1990. Ecology of North Sea fish. *Netherlands Journal of Sea Research*, 26: 343–386.
- Evans, P.G.H. 1982. Associations between seabirds and cetaceans: a review. *Mammal Review*, 12: 187–206.
- Gaston, A.J., and Jones, I.L. 1998. *The Auks*. Oxford University Press, Oxford.
- Greenstreet, S.P.R., and Tasker, M.L. (eds.). 1996. *Aquatic predators and their prey*. Fishing News Books. University Press, Cambridge.
- Harrison, N.M., Whitehouse, M.J., Heinemann, D., Prince, P.A., Hunt, G.L., Jr., and Veit, R.R. 1991. Observations of multispecies seabird flocks around South Georgia. *Auk*, 108: 801–810.
- Hoffman, W., Heinemann, D., and Wiens, J.A. 1981. The ecology of seabird feeding flocks in Alaska. *Auk*, 98: 437–456.
- ICES. 2002. Report of the Working Group on Seabird Ecology. ICES CM 2002/C:04.
- ICES. 2003. Report of the Working Group on Seabird Ecology. ICES CM 2003/C:03.
- ICES. 2004. Report of the Working Group on Seabird Ecology. ICES CM 2004/C:05.
- Mitchell, P.I., Newton, S.F., Ratcliffe, N., and Dunn, T.E. 2004. *Seabird Populations of Britain and Ireland*. T. and A.D. Poyser, London. 511 pp.
- Montevecchi, W.A. 2002. Interactions between fisheries and seabirds. In *Biology of Marine Birds*. Ed. by Schreiber, E.A. and Burger, J. CRC Press, Boca Raton, FL: 527–557.
- Munk, P., Hansen, B.W., Nielsen, T.G., and Thomsen H.A. 2003. Changes in plankton and fish larvae communities across hydrographic fronts off West Greenland. *Journal of Plankton Research*, 25: 815–830.
- Nettleship, D.N., and Birkhead T.R. (eds.) 1985. *The Atlantic Alcidae. The Evolution, Distribution and Biology of the Auks Inhabiting the Atlantic Ocean and Adjacent Water Areas*. Academic Press, London.
- Olsthoorn, J.C.M., and Nelson, J.B. 1990. The availability of nesting sites for some British birds. *Bird Study*, 37: 145–164.
- Pedersen, S.A., and Schmidt, E.L.B. 2000. Zooplankton distribution and abundance in West Greenland waters, 1950–1984. *Journal of Northwest Atlantic Fisheries Science*, 26: 45–102.

- Pierce, G.J., Boyle, P.R., and Thompson, P.M. 1989. Diet selection by seals. *In* Trophic Relationships in the Marine Environment. Ed. by Barnes, M., and Gibson, R.N. Proceedings 24th European Marine Biological Symposium, Oban, Scotland.
- Pierotti, R. 1988. Associations between marine birds and mammals in the northwest Atlantic Ocean. *In* Seabirds and Other Marine Vertebrates. Ed. by Burger, J. Columbia University Press, New York: 31–58.
- Pitman, R.L., and Balance, L.T. 1992. Parkinson's Petrel distribution and foraging ecology in the eastern Pacific: aspects of an exclusive feeding relationship with dolphins. *Condor*, 94: 825–835.
- Sklepkevych, B.O., and Montevecchi, W.A. 1989. The world's largest colony of Leach's storm-petrels on Baccalieu Island, Newfoundland. *American Birds*, 43: 36–42.
- Springer A.M., and Speckman, S.G. 1997. A forage fish is what? Summary of the symposium. Forage fishes in marine ecosystems. Proceedings International Symposium, Role of Forage Fishes in Marine Ecosystems. Alaska Sea Grant College Program No. 97-01: 773–805.
- Stenhouse, I. J., Robertson, G. J., and Montevecchi, W. A. 2000. Herring Gull predation on Leach's Storm-Petrels breeding on Great Island, Newfoundland. *Atlantic Seabirds*, 2: 35–44.
- Stenhouse, I.J., and Montevecchi, W.A. 1999. Indirect effects of the availability of forage fish and fisheries discards: Gull predation on breeding storm-petrels. *Marine Ecology Progress Series*, 184: 303–307.
- Zelickman, E.A., and Golovkin, A.N. 1972. Composition, structure and productivity of neritic plankton communities near the bird colonies on the northern shore of Novaya Zemlya. *Marine Biology*, 17: 93–108.

6 Recommendations

6.1 Proposal for next meeting

The Working Group on Seabird Ecology [WGSE] (Chair: Stefan Garthe, Germany) will meet in Texel, The Netherlands, from 3–7 April 2006 to:

- a) review the current approaches for identifying offshore seabird aggregations and delineating Important Bird Areas (IBAs) and Special Protection Areas (SPAs);
- b) develop recommendations for a comprehensive monitoring programme for seabirds;
- c) develop recommendations on how to sample diet and how to report results of dietary studies in seabirds.

WGSE will report by 15 May 2006 for the attention of the Living Resources Committee, ACE and ACME.

Supporting Information:

Priority:	This is the only 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:	<p>a) Marine SPAs are currently designated by several EU Member States. Other descriptions of offshore seabird aggregations are conducted e.g., by BirdLife International and non-EU states. While there are certain guidelines as related to the different Directives, rules, conventions etc., WGSE may review the current approaches from a scientific point of view. This builds on the work done by WGSE at the meeting in 2003.</p> <p>b) Although WGSE has recommended an EcoQO for changes in seabird population size, further monitoring is desirable for detecting and interpreting changes in seabird demography and the implications for marine ecosystems. By focussing on target values and on monitoring that can be implemented throughout the OSPAR area, EcoQOs cannot accommodate the full suite of appropriate monitoring tools. We consider it useful to have a discussion of how an “ideal” seabird monitoring programme should be designed.</p> <p>c) WGSE has calculated and reviewed data on food choice and food consumption in seabirds many times. Although some species have been studied frequently, the use of these data may still be enhanced when standard protocols on how data may be presented.</p>
Relation to Strategic Plan:	Action Plan Nos. 1.2, 1.8, 2.2, 4.15
Resource Requirements:	Facilities for WGSE to work in Texel are anticipated to be excellent.
Participants:	The Working Group should be able to achieve most of the above objectives. However, some members may not be able to attend through lack of funding. Funding of these members from Member Countries would be very welcome.
Secretariat Facilities:	None.
Financial:	No financial implications for ICES.
Linkages to Advisory Committees:	ACE, ACME
Linkages to other Committees or	WGSE is keen to continue the process of integration of seabird ecology into ICES work.

Groups:	
Linkages to other Organisations:	EU, OSPAR, HELCOM

6.2 Other recommendations

It has become very obvious throughout most terms of reference at this year's meeting as well as at previous meetings that comprehensive information on the distribution and numbers of seabirds at sea in the North Sea are an essential basis for a further understanding of relationships between seabirds and the marine environment. Such data are partly available from existing data sets but are too sparsely distributed in time and space to allow for detailed time trends and some indications of changes in the North Sea. WGSE strongly recommends exploring the possibilities of including seabird at sea studies as a standard parameter in regular and large-scale marine surveys. Herring acoustic surveys and the International Bottom Trawl Survey (ICES) are very useful programmes and seabirds have already been studied at some occasions from these platforms.

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Annex 2: English and scientific names of birds mentioned in this report

ENGLISH NAME	SCIENTIFIC NAME
Red-throated diver	<i>Gavia stellata</i>
Great northern diver	<i>Gavia immer</i>
Northern fulmar	<i>Fulmarus glacialis</i>
Manx shearwater	<i>Puffinus puffinus</i>
European storm-petrel	<i>Hydrobates pelagicus</i>
Leach's storm-petrel	<i>Oceanodroma leucorhoa</i>
Northern gannet	<i>Morus bassanus</i>
Great cormorant	<i>Phalacrocorax carbo</i>
European shag	<i>Phalacrocorax aristotelis</i>
Greater scaup	<i>Aythya marila</i>
Common eider	<i>Somateria mollissima</i>
Long-tailed duck	<i>Clangula hyenalis</i>
Common scoter	<i>Melanitta nigra</i>
Velvet scoter	<i>Melanitta fusca</i>
Common goldeneye	<i>Bucephala clangula</i>
Arctic skua	<i>Stercorarius parasiticus</i>
Great skua	<i>Stercorarius skua</i>
Mediterranean gull	<i>Larus melanocephalus</i>
Black-headed gull	<i>Larus ridibundus</i>
Mew (= Common) gull	<i>Larus canus</i>
Lesser black-backed gull	<i>Larus fuscus</i>
Herring gull	<i>Larus argentatus</i>
Great black-backed gull	<i>Larus marinus</i>
Black-legged kittiwake	<i>Rissa tridactyla</i>
Roseate tern	<i>Sterna dougallii</i>
Common tern	<i>Sterna hirundo</i>
Arctic tern	<i>Sterna paradisaea</i>
Little tern	<i>Sterna albifrons</i>
Sandwich tern	<i>Sterna sandvicensis</i>
Common guillemot	<i>Uria aalge</i>
Razorbill	<i>Alca torda</i>
Black guillemot	<i>Cepphus grylle</i>
Little auk	<i>Alle alle</i>
Atlantic puffin	<i>Fratercula arctica</i>