PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

Seabirds and North Sea Oil [and Discussion]

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Seabirds and North Sea oil

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The history of large and well-publicized incidents of seabird mortality resulting from oil pollution from tanker accidents (such as the *Torrey Canyon* in 1967) and from unattributed oil slicks at sea, gave rise to real fears that the development of North Sea oilfields would result in serious mortality and declines in the large populations of seabirds breeding and wintering in and around the North Sea. The oil industry recognized the problem and attempted to minimize pollution risks in all exploration, production and transport operations.

Preliminary maps were prepared showing the distribution of vulnerable concentrations of breeding and wintering birds to facilitate contingency planning, and, particularly in Shetland, Orkney and the Moray Firth, extensive and long-term programmes are established to monitor:

(1) the numbers of breeding birds;
(2) wintering concentrations (particularly of sea ducks);
(3) the distribution and abundance of seabirds at sea;
(4) the numbers, and percentage oiled, of birds found dead on beaches.

The feared increase in oil pollution incidents has not materialized. The few accidents associated with offshore production have had little effect on seabirds. Tanker accidents have been few, but have had large, temporary and local effects (e.g. the *Esso Bernicia* at Sullom Voe in 1978–79). Breeding seabird populations in the area have increased, although in recent years, in some places, some species may have declined, but these declines cannot be attributed to oil activities in the North Sea. The Beached Bird Survey suggests that chronic oil-induced mortality is at a relatively low level.

Introduction

Seabirds and oil do not mix. Since the early years of this century oil pollution at sea has continuously caused the contamination and death of seabirds, many of which are washed up on beaches as conspicuous indicators of environmental contamination offshore. Given the widespread public interest in birds, these events receive a great deal of attention, and since the early 1920s the Royal Society for the Protection of Birds (R.S.P.B.) has been actively concerned about the effect of oil pollution on seabirds, and seabird populations (R.S.P.B. 1979). In these early years the source of the oil polluting the sea was largely the discharge of oily wastes from oil burning ships, and from accidents involving ships, especially oil tankers. The dramatic increase in the size of oil tankers in the past thirty years aggravated those concerns, and the grounding of the fully laden *Torrey Canyon* off the Scilly Islands in April 1967, probably killing 30000 seabirds (Bourne *et al.* 1967; Bourne 1970), firmly and clearly focussed attention onto the oil industry.

It is not surprising that when exploration for oil and gas began in the North Sea in the 1960s leading to discoveries of oil in the northern North Sea in the 1970s, ornithologists were very

apprehensive about the consequences of these developments for seabirds. In the North Sea, particularly the northern North Sea, oil exploration and production would occur in very difficult environments: far offshore, in deep water and subject to severe weather conditions, especially in winter. The oil industry had little previous experience of operating in such conditions, and a largely new technology had to be developed (Sanders 1972). The risk of oil pollution at sea resulting from these developments was considered to be large. Although few quantitative data were available it was known that around the northern part of the North Sea large concentrations of breeding seabirds assembled to huge mixed-species colonies, although many species were more widely and more evenly distributed along the coastline. While some of these species stayed throughout the year others left the North Sea for the winter. Ringing recoveries indicated that there was a substantial influx of seabirds into the North Sea in winter from populations breeding further to the north. Several species of sea ducks also gather in various parts of the North Sea in winter. Although most seabirds had been studied to some extent at their breeding colonies, very little was known about the overall distribution of breeding colonies, less about the numbers of breeding seabirds, and almost nothing about their distribution and movements at sea, even in the breeding season.

Perceived threats to seabirds from oil industry operations

Concern about the well-being of seabirds and their populations related to a number of perceived threats from offshore operations. Below I list the major threats and give a brief commentary of the degree to which they have been realized during North Sea operations up to now.

(i) *Tanker accidents*

It was felt that tankers moving to and from the major crude oil terminals at Sullom Voe in Shetland and Flotta in Orkney, especially during bad weather and the short days of winter, would have a high risk of collision, breakdown or running ashore. A major incident such as the grounding of the *Torrey Canyon* or of the *Amoco Cadiz* in Brittany in 1978 (Conan 1982) could cause enormous mortality of seabirds in the northern North Sea at any time of year. No incident of such magnitude has occurred during North Sea operations so far. The largest single tanker incident relates to the *Esso Bernicia* at the Sullom Voe terminal in December 1978. On this occasion over 1100 t of Bunker C fuel oil were spilt into the sea and over 3700 oiled bird corpses were picked up (Heubeck 1979).

The provision of good navigational aids and the maintenance of tight operational procedures are largely responsible for the generally good record of tanker operations. The latest world-wide data on accidental oil spills from tankers show a reduction in the number of spills (to 42%) and in the amount of oil spilled (to 41%) between 1974–79 and 1980–85 (Advisory Committee on Pollution of the Sea 1986). However, the impact of an accident involving a loaded supertanker is still a legitimate fear.

(ii) *Spills at terminals and offshore loading facilities*

At all offshore production installations and loading sites, as well as at oil terminals, elaborate contingency plans have been designed and implemented to cope with spills that may occur during 'normal' operations. These plans include the provision of a wide range of equipment

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

and sometimes major onshore structures (such as the spur booms at Sullom Voe), a body of trained personnel and detailed procedures to be followed in the event of a spillage. In this context particular concern was expressed in relation to the Beatrice oilfield located well inside the Moray Firth and only a few miles offshore from some of the largest seabird colonies in Britain. Records are kept for all spillages and remedial action taken at the time, and so far none of these has caused large mortality of seabirds.

(iii) *Leaks and fractures in pipelines*

New technology was developed to lay and maintain large diameter pipelines in deep water. These now total hundreds of miles of underwater pipes in the North Sea and so far they have been remarkably free from trouble. Although a number of incidents are recorded of pipelines being damaged by external action, they have proved to be safe and efficient. No significant seabird mortality can be attributed to this cause.

(iv) *Blowouts at wells and production installations*

Once again fears relating to this source of oil pollution at sea have been largely unrealized. The only exception was the major blowout on the Ekofisk field in April 1977 when the spilt oil was dispersed rapidly by wind and rough seas but caused little, if any, observed seabird mortality.

(v) *Flares*

The flaring of unwanted gases at production platforms offshore was considered likely to attract birds particularly in misty weather with the obvious probability that the birds would be killed. Sage (1979) considered this to be a major hazard especially for migrating passerine birds in autumn and in spring. However, detailed observations and records from the North Sea Bird Club members have indicated that while some mortality of passerines does occur, this does not reach the large numbers predicted even in poor visibility at the height of the migration season, and the impact on both landbird and seabird populations may be regarded as minimal.

(vi) *Illegal spillages of oil from shipping*

Oil continues to be discharged into the sea illegally from shipping and the first indication of such events is commonly the occurrence of dead or contaminated living seabirds on the beaches. The source of this oil can rarely be attributed to any particular ship or category of ships, although attempts have been made to relate such spillages to oil operations in the North Sea. In particular, between December 1978 and April 1979 there were large numbers of oiled birds on beaches from the Moray Firth to Shetland (Richardson *et al.* 1982). This coincided with the opening of the Sullom Voe terminal before the completion of the ballast water treatment facilities there. It was inferred that tankers approaching the terminal may have discharged dirty ballast water at sea, and it was also inferred that other shipping may have taken the opportunity to discharge oil contaminated water under these circumstances. Since then there has been a great increase in the proportion of tankers using segregated ballast and strict rules for the quantity of ballast on board when ships arrive at terminals. In the beached-bird surveys, which I mention below, dead and dying oiled birds continue to be found on beaches around the North Sea although the numbers of these have shown no detectable trend over the past ten years (Stowe 1982*a*; Heubeck 1987) despite a number of major incidents such as that

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

which occurred in the Skagerrak and the southeastern coastlines of the North Sea in the winter of 1980/81 (Mead & Baillie 1981). The source of this oil was never confirmed.

These risks remain, and I cannot overemphasize the need for the most careful vigilance and tight controls over all aspects of the operations together with highly developed contingency plans, with the full range of equipment and trained personnel necessary to implement them. It cannot be denied that good fortune has played a part in the generally good environmental record of the North Sea operation to date. There is no room for complacency; the highest standards must be maintained.

Studies and actions undertaken by ornithologists

Acutely aware of the general lack of detailed knowledge about seabirds onshore at their breeding colonies, or offshore at sea, ornithologists in Great Britain quickly developed a number of areas of work designed to improve our understanding of the distribution and abundance of breeding seabirds, their distribution and mobility at sea and detailed studies of a variety of parameters relating to population dynamics. It was clearly important to identify species and areas specially vulnerable to spilt oil at sea. Several of the more important of these are listed below.

(i) *Operation Seafarer and subsequent surveys*

The Seabird Group, established in 1965, undertook as one of its first major commitments a survey of the distribution and numbers of seabirds breeding around the coast of Great Britain and Ireland. The main fieldwork was completed in the breeding seasons of 1969 and 1970 and the results were published in book form in 1974 (Cramp *et al.* 1974). Named by the late James Fisher after a poem called 'The Sea Farer', composed probably in the seventh century, this study pioneered methods for locating and counting (or estimating) the numbers of twenty-four species of breeding seabirds with widely differing patterns of breeding biology, breeding habitats and attendance at colonies. Though criticized in detail as better methods were evolved, this still serves as a baseline against which subsequent changes in distribution and abundance can be measured. Arising from the experience gained in Operation Seafarer, methods of counting the numbers of breeding birds of most species have now been standardized and the R.S.P.B. developed a programme of monitoring seabirds by organizing counts at a series of sample colonies around the British coastline (Stowe 1982*b*). Further, intensive sampling of seabird colonies was designed and done in the northern North Sea particularly in relation to the Sullom Voe terminal in Shetland (Richardson *et al.* 1981), the Orkney area in relation to the Flotta terminal and in the Moray Firth area in relation to the Beatrice field (Mudge & Aspinall 1985). The results of these intensive surveys have now been analysed and interpreted and I comment on these below.

In 1979 the Norwegian Seabird Project was established to determine the size of the breeding population of seabirds in Norway, to map the distribution of seabird concentrations along the Norwegian coast, and to perform annual counts on wintering seabirds including sea ducks. Although this programme did not cover the entire Norwegian coastline the results for the period 1979–84 have now been published by Røv *et al.* (1984). Breeding seabirds are rather scarce around the other coastlines of the North Sea but data on their distribution and abundance are available for Heligoland and Denmark.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

(ii) *Preliminary maps of seabird concentrations*

In 1974 the Nature Conservancy Council brought together all the then existing information to produce maps which showed, for the British coastline of the North Sea, breeding concentrations of seabirds and the areas of known concentrations of seabirds, particularly sea ducks in winter. These maps were entirely preliminary in nature and drew arbitrary lines based on presumed foraging distances out to sea from the main breeding concentrations. Areas of known concentrations of sea ducks were also identified. These maps were produced to identify areas of seabird concentrations with special vulnerability in the event of an oil spill. A second edition was produced in 1980.

(iii) *Distribution and abundance of birds at sea*

In the early 1970s the Natural Environment Research Council supported pilot studies of seabirds at sea. This work was carried out by Dr W. R. P. Bourne from the University of Aberdeen and pioneered the development of methods for quantitatively measuring the distribution and abundance of seabirds at sea under the very difficult conditions of observing from a ship. Some early results of this work are presented in Bourne (1976, 1980). These early studies have now been developed in the North Sea by the Nature Conservancy Council in a continuing programme partly funded by the oil industry. Their results from the North Sea have been published in a final report entitled *Seabird distribution in the North Sea* (Blake *et al.* 1984). This report provides a large amount of information on the distribution and indices of abundance of different age-categories of about 30 species of seabird in the North Sea during the period 1979 to 1982. Although these maps provide useful data on seasonal variations in the distribution patterns of different age categories of different species in the North Sea, what they cannot do is provide important information on the mobility of individual birds between the various concentrations of birds and from season to season.

A similar study of the distribution of seabirds offshore in the Moray Firth has been carried out by Mudge *et al.* (1984) for Britoil. This work is on a much smaller scale than the more extensive Nature Conservancy Council programme, and has produced important data showing variations in seasonal patterns of fifteen different species of seabirds. In addition, Barrett (1983) has described the patterns of distribution and mobility of the large flocks of sea ducks occupying this area.

(iv) *Beached-bird surveys*

Records of oiled birds on beaches have been collected for many years, but since 1966 the Royal Society for the Protection of Birds, in conjunction with the Seabird Group, has organized and standardized a national beached-bird survey. From 1969 the February surveys have been incorporated into an international beached-bird survey involving the countries bordering the southern North Sea, and in 1971 the survey was made more systematic by concentrating on five predetermined weekends from September to March (Stowe 1982*a*). Extensive data are now available from these surveys, and more intensive, specialized versions of the survey have been instigated in the northern North Sea, especially in Shetland and Orkney. Recent analyses (Stowe 1982*a*; Heubeck 1987) conclude that in general the data show no statistical trend, but that frequencies of oiled birds are lower than the high levels of 1978–80. However, this level of oiled birds is still a matter for concern in the southern North Sea (Camphuysen 1984; Vauk 1984).

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

(v) *Ringing recoveries*

The ringing of seabirds, mainly at their breeding colonies, has been actively pursued, and sometimes specially encouraged, in the United Kingdom and in other parts of Europe. The recovery of ringed birds during beached-bird surveys have given us a considerable amount of new information on the provenance of birds occurring dead or oiled or both on different North Sea beaches during winter. The British Trust for Ornithology is carrying out an analysis of the pattern of recoveries of ringed birds throughout the North Sea, especially noting the proportion of ringed birds that have been found oiled from various places. An initial analysis of this type is presented by Mead & Bailey (1981) but we look forward to seeing the full analysis in the near future. However, like the mapping projects of birds at sea, these data give us brief information of a one-off nature, and tell us little of the overall mobility of the birds.

The number of seabirds using the North Sea

A number of estimates have been produced over the years of the number of seabirds breeding round the North Sea. Evans (1973) estimated that the number of seabirds (19 species) breeding 'around the North Sea' amounted to 1.28 million pairs. This tally excluded species such as the storm petrels, and had a number of question marks against some of the species which are rather difficult to count. At a seabird conference in Aberdeen in 1977 Bourne (1978) provided 'provisional' numbers of breeding seabirds of the northern Atlantic and northwest Pacific Oceans from which it is possible to extract the numbers associated with the North Sea. He gives as a total for 'North Sea and Baltic' 1.987 million breeding birds, though he makes the point that in some areas counts of individual auks have been equated arbitrarily with pairs. Evans (1984) gave an extensive table of the estimated number of breeding pairs of seabirds in northwest Europe from which with the Norwegian data in Barrett & Vader (1984) it is possible to extract approximate numbers relating to the North Sea. I give this total in table 1, but it

Table 1. Estimates of the number of breeding pairs of seabirds around the North Sea

(Derived from Evans (1984) in Croxall *et al.* (eds) (1984). Note totals for England and Scotland include birds breeding on their west coast and are not associated with the North Sea.)

England	436911
Scotland	2318996 + *ca.* 350000
Belgium	10240
Holland	294786
West Germany	126384
Denmark	308953
Sweden	530674
southwest Norway	*ca.* 150000
totals	4176944 + 350000 = 4526944

is important to note that the totals for England and Scotland will include seabirds nesting on the west coasts of these countries and which therefore are not properly related to the North Sea. In the original table there are large margins of error given for some species (such as the British storm petrel, *Hydrobates pelagious*) and on the orders of magnitude of some populations (for example Leach's storm petrel, *Oceanodroma leucorhoa*) and I have taken where appropriate

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

the minimum rather than the maximum estimate. From this table the total number of breeding pairs is 4.53 million, and is substantially higher than the earlier estimates.

It is obviously difficult to get precise numbers for the breeding populations of seabirds, and we need not ever expect complete accuracy. However, as I have discussed elsewhere (Dunnet 1982*a*), the delayed maturity that is common in seabirds (many species do not breed until they are three to five years old, and some not until they are about ten) indicates substantial numbers of pre-breeding birds related to these breeding populations. Indeed the pre-breeding population may amount to approximately 50 % of the breeding population in terms of numbers (Dunnet 1982*a*, table 2). However, many of these pre-breeding birds will not be in the North Sea. It is well known for kittiwakes, *Rissa tridactyla* (Coulson 1966), and for fulmars, *Fulmarus glacialis* (Dunnet 1982*b*), that young birds may spend the first two or three years of their lives as far from their native colonies as the Grand Banks of Newfoundland and the Barents Sea in the Arctic. Precisely when they all return to 'prospect' for breeding sites is not clear but undoubtedly during the breeding season there will be a number of pre-breeding individuals of most seabird species in attendance at breeding colonies; to estimate this number is at present virtually impossible.

The situation in winter is even more complex. Many of our breeding seabirds are migrants, leaving the breeding area completely for the winter. Others are partial migrants with some components of the population departing while others remain in the vicinity of their colonies. Others may be resident, or undergo only local movements, throughout the year. In addition, large numbers of birds that breed farther north move down into the North Sea for winter. While ringing recoveries and mapping of the distribution of birds at sea tell us something about these winter concentrations and species distributions, these methods are not capable of giving us accurate estimates of the number of birds present at this time.

The results of seabird studies in the North Sea in relation to oil developments

A large amount of data has been accumulated over the past 20 years and subjected to many reviews. Bourne (1968) discussed the general problem of oil pollution and bird populations. At an International Conference of the Sea held in Rome, Tanis & Mörzer-Bruyns (1968) and Clark (1968) reviewed the impact of oil pollution on seabirds in Europe. In 1977 the British Ornithologists' Union organized a conference on 'The changing seabird populations of the North Atlantic' at Aberdeen and several papers were given relating specifically to oil pollution whereas many more were on general population studies of seabirds (Anon 1978). The Royal Society for the Protection of Birds prepared a major review of the topic which it submitted to the Royal Commission on Environmental Pollution in 1979. I prepared reviews of the situation in 1980 (Dunnet 1980) and again at a Royal Society Discussion Meeting (Dunnet 1982*a*). At the annual conference of the Seabird Group in 1982 there was further discussion on the general problem and Clark (1984) provided a further review. In May 1984 the United Kingdom Offshore Operators' Association organized a symposium of this subject at Aberdeen, the results of which are published by Clark *et al.* (1984). Most recently the International Council for Bird Preservation has published its *Status and conservation of the world's seabirds* (Croxall *et al.* (eds) 1984) in which threats to seabirds are discussed generally and in relation to specific areas including northwest Europe.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

With so many recent reviews it may not be surprising that there is not much new left that can be said here today. I will however try to provide a general survey of such conclusions as are possible about the effects of the North Sea oil operations on the seabird populations there.

Monitoring breeding populations

Although extensive data sets exist from programmes of monitoring the numbers of breeding seabirds, few have been formally analysed and published. However, several have been presented at recent conferences, and many exist in the form of annual reports sometimes with analyses of a run of several years.

In general there has been a continuous increase of most species of seabird around the North Sea, but there are signs of patchy declines in some areas of kittiwakes and puffins, *Fratercula arctica* (Stowe 1982*a*). None of these changes can be associated with the activities of the oil industry.

An important problem in interpreting these data is the lack of knowledge of 'natural' variability in the numbers of breeding birds at any colony from year to year. My own data on the total number of fulmars nesting on the Orkney Island of Eynhallow each year from 1958 to 1985 inclusive show large deviations in most years from the overall trend line of population change (Dunnet *et al.* 1979). This study of a breeding population on an uninhabited island, little disturbed by people, may be considered to relate to a 'natural' population not subjected to any abnormal or unusual mortality causes. These data show how difficult it would be to interpret changes in numbers over any small run of years in terms of unusual rates of mortality, or of departures of the population from the long term trend line.

In recent years monitoring at breeding colonies has been extended to include collecting information on reproductive output. Some very interesting results have been obtained. For example at Vedoy, Rost, guillemots, *Uria aalge*, have had only four good breeding years since 1971 and these years have been characterized by a large number of chicks of good mass being produced. In all the other years a few chicks with low masses were produced. However, even in good years the numbers produced were far fewer than in the years from 1958 to 1963 (Røv *et al.* 1984). Similarly for the Arctic tern, *Sterna paradisaea*, in Shetland, there has been very variable reproductive success over the past eight years. Breeding production was very bad in 1984 and 1985, poor in 1978–79 and 1980 and good in only 1982 and 1983 (Heubeck & Ellis 1986). These Shetland results were not due to the weather during the breeding season, because in all years the auks managed to breed reasonably well. In 1985 kittiwakes in Shetland had disastrous breeding success compared with previous years (Heubeck & Ellis 1986). Highly variable breeding success is a feature of many species of marine fish, and has also been demonstrated to occur in the eider, *Somateria mollissima*, breeding on the northeast Scottish coast (Milne 1974). However, in general the many intensive studies of breeding biology of seabirds have shown a tendency for overall breeding success to vary only a little between years. The present situation therefore may indicate some new situation developing, and this is commonly thought to be related to food supply and probably to the increasing industrial fisheries for small fish (Furness 1982). It certainly is not a phenomenon that can be attributed to the activities of the oil industry.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

Birds at sea

The most recent work on the distribution and abundance of birds at sea has been published by Blake *et al.* (1984), Mudge *et al.* (1984) and Barrett (1983). In these studies maps have been produced which show the crude densities of different age categories of the various seabird species in sample areas of the North Sea. Different maps are produced for different seasons and some information is available on the foraging range of different species from their breeding colonies. This is largely new and useful information and is undoubtedly helpful in the context of oil spill contingency planning, although it tells us nothing about the mobility of individual seabirds, also an important feature in relation to possible oil spills.

Barrett (1983) has produced valuable new data about sea ducks in the Moray Firth over two winters. Eight species and a total of over 30000 ducks concentrate there each winter. The seasonal and daily pattern of movements and the locations of feeding and roosting concentrations show considerable stability within and between seasons. Kinnear (1976) and Huebeck (1983) have described the distribution of moulting flocks of eiders in Shetland; at this stage in their annual cycle they are flightless and are especially vulnerable to oil pollution.

Beached bird survey

The Beached Bird Survey continues with monthly counts carried out in each of the winter months. The general pattern of a winter peak in the numbers of dead birds picked up, and in the proportion of these which are oiled, and a summer low is well known. A recent detailed study of the Shetland data (Heubeck 1987) covers the period 1979 to 1985. After the high levels of bird mortality and the high proportions contaminated with crude oil in Shetland and Orkney during 1979 and early 1980 (Richardson *et al.* 1982), the proportion of corpses with oil has never exceeded 26 % since February 1982 which compares favourably with other areas of Great Britain. The proportion of auks found oiled in Shetland in recent years was also low and like that found in similar areas of Britain (Stowe 1982*a*; Underwood & Stowe 1984). Further, the incidence of oiled seabird corpses near the Sullom Voe terminal has been low since the winter of 1979/80, and this is important because a high proportion of the Shetland population of eider and black guillemot, *Cepphus grylle*, form moulting and breeding concentrations within a 20 mile radius of the oil terminal (Ewins & Kirk 1985; Heubeck 1983).

However, the Shetland data show an increase in the numbers of guillemots found dead on beaches. Breeding populations of guillemots have increased in northern Scotland and on the North Sea coast in recent years (Stowe 1982*b*) but the increase in the number of corpses has been too great and too sudden to be accounted for by this. There may be a change in the distribution of guillemots remaining to moult in the Shetland waters after the breeding season (Robertson 1985). An important point is that a few of these guillemots are contaminated by oil, and mortality may possibly be induced by a shortage of food. To conclude, over the six years from March 1979 to February 1985 the incidence of oiled corpses declined from a high in 1979–80, and has remained low ever since.

We await the full analysis of ring recoveries from the beached bird surveys which is currently being undertaken by the British Trust for Ornithology. This information will relate winter mortality in different parts of the North Sea to the colonies of origin of the affected birds, and will enable predictions to be made of the possible changes in breeding numbers which could

result from the presumed lowered recruitment. For example in the winter of 1980–81 approximately 60000 birds may have been killed by oil in the southern North Sea. Rings on some of these birds showed that many were immature and came from breeding colonies in Orkney, Shetland, northeast Scotland and Saltee Island. Given that patterns and processes of recruitment to breeding populations are largely unknown (Ollason & Dunnet 1983; Dunnet 1982*a*), and the lack of precision of monitoring breeding numbers, it is virtually certain that any consequential reductions in the local breeding populations would not be detectable; it is almost certain that present monitoring is insufficiently precise to detect such changes.

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Discussion

Y. Samiullah (*Monitoring and Assessment Research Centre, King's College London, U.K.*). Professor Dunnet's discussions on seabirds and other contributions for fisheries only consider biological effects in terms of overall mortalities. Does he not feel that this could lead to a general complacency within the oil industry, particularly with regard to the possible sublethal and cellular effects of chronic low-level inputs of petroleum hydrocarbons to the marine environment?

G. M. Dunnet. Sublethal effects of pollution are important, especially as early warning of environmental contamination. This approach is used on marine invertebrates in an integrated monitoring programme at Sullom Voe. However, if these effects do not manifest themselves at the population level, they may not be serious in terms of environmental management, nature conservation or the fisheries resource. I think the oil industry is now well informed about the subtleties of biological systems, and certainly there is no room for complacency.

D. P. Stone (*Northern Environmental Branch, Department of Indian and Northern Affairs, Ottawa, Canada*). Is Professor Dunnet aware of any seabird mortality or oiling having occurred which could be attributed to the use of oil-based muds at shallow water drilling sites?

G. M. Dunnet. I am not aware of any oiling or mortality of seabirds that can be attributed to the use of oil-based drilling muds.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

M. L. Tasker (*Nature Conservancy Council, Aberdeen, U.K.*). The oil industry can be congratulated on the fact that there has been no major impact by North Sea oil and gas developments on seabirds so far; however, the potential for damage still exists, and it is hoped that the high standards of safety will be maintained.

Research on seabirds at sea in the North Sea has been conducted by the Nature Conservancy Council with oil industry and Government support since 1979. The mobility of seabirds in the breeding season, and some important features of seabird distribution in the autumn and winter, have been examined in detail during the past two years. In general, areas of the eastern North Sea, particularly off Norway, can now be identified as being in need of survey rather than areas in the southern North Sea.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES