Temperature and the Seasonal and Geographical Occurrence of Oiled Birds on West European Beaches

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Oiled birds appear to be a commoner aspect of oil pollution where it occurs with cold water-temperatures, whereas the formation of tar-balls becomes more prominent with warm ones, possibly because liquid oil becomes reduced to inert solid residues comparatively harmless to birds more rapidly at higher temperatures.

Oil pollution was already listed among potential causes of bird mortality after the occurrence of many dead birds in the Firth of Clyde, south-west Scotland, over a hundred years ago (Roberts, 1859), and that due to natural seeps was attracting attention in California before the end of the century (Anthony, 1894). With the growth of the sea-borne transport of oil and its use as fuel for ships at the time of the first world war this problem began to attract growing attention. In general its character is now well-known, and many individual pollution incidents have now been studied, while ornithologists have played an important pioneer part in agitation for pollution control (Bourne, 1968, 1969, 1970 a, b). However, despite over half a century of intermittent beach surveys in Britain, the Netherlands and subsequently other north-west European countries, there has been comparatively little comparative study of the impact of chronic pollution in different areas and at different seasons. This contribution reports the results of 5 years of investigation of a growing length of north-west European beaches and a reconnaissance in south-west Europe and postulates a reason for the marked seasonal and geographical variations in the amount of bird mortality found.

The Beach Surveys

More systematic beach surveys were started by the Royal Society for the Protection of Birds and Seabird Group in Britain and Ireland in 1966 with the aim of obtaining more information about chronic pollution. At first these were carried out continually on a casual basis (Bourne & Devlin, 1969, 1970, 1971), but it was soon found that the data obtained in this way were unsuited for systematic analysis. Better results were obtained with a survey organized on one week-end at the time of maximum bird mortality in the late winter to coincide with those carried out by Belgian and Netherlands youth organisations (Kuyken, 1967; Zegers, 1970, 1971, 1972; Yeatman, 1973; Bibby & Bourne, 1971, 1972, 1974). This survey has now been extended to cover much of the coast of north-west Europe, and is now being repeated five times during the winter in Britain, while in 1973 trial observations were also made in south-west Europe.

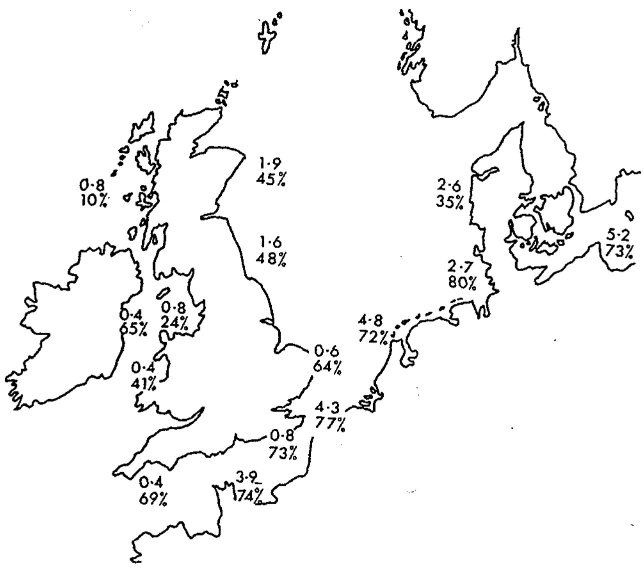

Fig. 1 Bodies per kilometre and proportion oiled found during beached bird surveys in late February 1967–1973.

The results obtained within the British Isles have confirmed the general impression that the mortality rises from a minimum in the summer, when in the absence of a specific pollution incident surveys produce little result, to a maximum in the late winter, when a higher proportion of the bodies also tend to be contaminated with oil (Bibby & Bourne, 1972, 1974; Lloyd & Bourne 1974; Programmes Analysis Unit, 1973; and Table 1). The results for north-west Europe as a whole at the season of maximum mortality (Table 2, Fig. 1) indicate a considerable regional variation in the number of bodies found, the species involved, and the proportion contaminated by oil.

In general, the mortality tends to be greater along the continental coasts than in Britain, and the proportion of the bodies contaminated with oil is greater there and in south-east Britain. This is doubtless explained by a higher incidence of pollution along the busiest shipping-route in the world through the English Channel to North Sea and Baltic ports, and the effect of the westerly prevailing winds in drifting both oil and bodies towards the continent. It is notable that many bodies also come ashore around the north and east shores of the Irish Sea, though fewer are oiled there, and also that more oil and bodies reach the north-east coast of Britain in winters with more east winds, notably early in 1970 (Greenwood *et al.*, 1971). The species concerned vary locally, wildfowl forming a large proportion along the east coast of the North Sea and in the Baltic and its approaches (Lund, 1962; Joensen, 1972, a, b, 1973; Manikowski 1971; Lemmetyinen, 1966), auks in the only feeding-area facing the open Atlantic for which we have much information, south-west Britain, and gulls where other species are scarce in the south.

TABLE 1
Results of beached bird surveys in the three winters 1971–1974.

	Sept.	Nov.	Jan.	Feb.	March	Total
km covered	5049	5078	5583	6253	4713	26676
Bodies found	1490	1730	3441	3735	2164	12560
No. oiled	255	384	1071	1199	651	3560
Bodies/km	0.3	0.3	0.6	0.6	0.5	0.5
%oiled	17	22	31	32	30	28

Taken from annual summaries in Bibby & Bourne (1972, 1974) and Lloyd & Bourne (1975) for the British Isles. Both the number of bodies found and the proportion oiled become very low in summer.

TABLE 2
Results of beached bird surveys in late February 1967–1973.

Area	Ref.	Length of coast (km)	Corpses/km Mean	Corpses/km Range	% oiled	Species (%) Auks	Species (%) Gulls	Species (%) Wildfowl	Species (%) Others	Years covered
E. Scotland	1,2	720	1.88	0.7–4.9	45	36	31	12	21	69–73
N.E. England	1,2	430	1.56	0.2–3.8	48	41	39	3	17	69–73
E. Anglia	1,2	300	0.62	0.3–0.9	64	33	34	9	24	69–73
S.E. England	1,2	360	0.76	0.1–1.2	73	29	52	9	10	69–73
S.W. England	1,2	670	0.43	0–1.2	69	67	22	1	10	69–73
Wales	1,2	670	0.42	0.1–0.8	41	31	34	9	26	69–73
N.W. England	1,2	270	0.81	0.8–6.0	24	18	38	16	28	69–73
W.Scotland	1,2	990	0.77	0.4–2.0	10	27	40	9	24	70–73
E. Ireland	1,2	600	0.37	0.2–0.7	65	44	25	2	29	69–71, 73
E. Germany	3	290	5.20	4.9–5.5	73	?	5	82	<13	70–71
W. Denmark	2	440	2.65	–	35	6	23	61	10	73
W. Germany	4	310	2.67	2.2–3.4	80	5	35	43	17	67–68, 72
Netherlands	5	470	4.78	0.3–19.7	72	14	20	45	21	67–73
Belgium	6	65	4.29	0.9–8.8	77	27	40	19	14	67–73
France	7	960	3.94	0.9–10.4	74	28	43	13	16	67–73

References: [1]Bourne & Devlin (1970, 1971); [2]Bibby & Bourne (1971, 1972, 1974); [3]Manikowski (1971); [4]F. Goethe (in litt.) [5]Zegers (1970, 1971, 1972), R. Wassenaar (in litt.); [6]Kuyken (1967 and in litt.); [7]Yeatman (1973 and in litt.).

In view of these observations it was thought oil pollution in the winter quarters might help explain a recent decline in some British seabirds known to migrate south in the winter, notably the auks and especially the puffin *Fratercula arctica* (Bourne 1972, a, b). A series of trial beach surveys of approximately 10 km each were therefore made between mid-January and mid-March 1973 in Madeira, west, south-west and south Portugal, southern Spain on each side of the Strait of Gibraltar, the west and north coasts of Morocco, eastern Spain and the Balearic Islands (Fig. 2). From other experience while short these should have been sufficient to reveal whether there was much mortality, and its general character, at the time of the maximum mortality of winter visitors in northern Europe, and before the return migration reaches its peak at Gibraltar (Garcia, 1973).

Although twelve out of 241 kittiwakes *Rissa tridactyla* seen at sea between Britain and Madeira were slightly oiled, or 5% compared to the rate of 0.5–1% normal in the southern North Sea (Joiris, 1972) and much less than this off the north of Scotland (personal observation), the limited number of auks seen at sea around Iberia (to be discussed elsewhere) all seemed clean, and only eight bird bodies were found on over 100 km of beach examined, an extraordinarily low number by north European standards. At least three of these birds had been shot, and none was obviously oiled, despite the fact that oil pollution in the form of tar-balls was vastly more prominent on these beaches than in northern Europe. It was worst on those facing the open Atlantic, and reached a climax at Canal in south-west Portugal where the entire beach was covered in old and new tar-balls up to 50 cm in diameter, so that it was impossible to set foot on the beach and avoid them. On analysis they were all composed of crude oil residues, while those from the beach at La Linea north-east of Gibraltar stank of raw sewage as well.

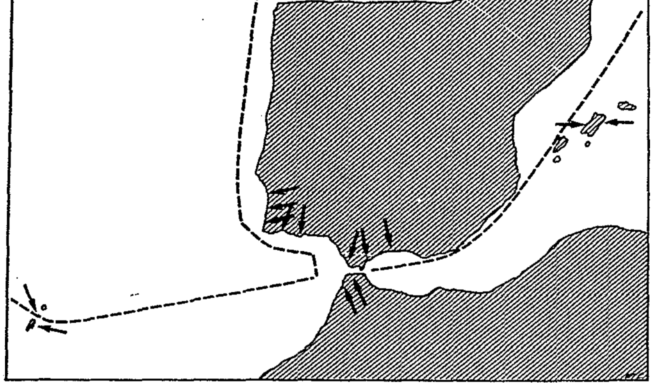

Fig. 2 Routes followed at sea and beaches examined during survey of south-west Europe early in 1973.

Local informants confirmed that while occasional oiled birds are seen around the strait of Gibraltar in particular, they are in fact comparatively scarce there when the vast volume of both shipping and bird-migration known to pass through this bottleneck (Garcia, 1973) is considered. The marked difference in detectable bird mortality associated with oil pollution in the north and south of western Europe at the season of maximum mortality in fact appears to be of at least the same order as the difference found between the winter and summer in the north (Table 1). This could be because a larger population of migrants becomes exposed to oil pollution where they move south into the shipping lanes in the winter in the north, but this seems doubtful because a marked seasonal difference in bird mortality and the amount of oil pollution is also found close to the breeding stations where many birds are present throughout the year. Bodies also last longer during the winter, when there is a good deal of natural mortality in any case, but while this may help explain why the annual peak of observed bird mortality occurs at the end of the winter, it seems doubtful if it will explain not only the increase of mortality but also that of oil pollution over the winter as a whole compared with the summer, because bird mortality remains equally conspicuous with large pollution incidents in summer while scarce at other times then. It seems possible that the incidence of bird mortality may vary not only with the character of the oil encountered, but especially its behaviour at different temperatures.

Variations in the Impact of Different Types of Oil on Birds with Temperature

While there is a vast literature on the physical and chemical properties of petroleum compounds, surprisingly little attention seems to have been given to the behaviour of different types of oil when spilt at sea in relation to the temperature at the time, as opposed to the distribution of the end products, which is attracting growing attention (e.g. Horn *et al.*, 1970; Wong *et al.*, 1974; Blumer *et al.*, 1973). Dean (1968) mentions that both evaporation and bacterial degradation are accelerated by an increase in temperature, and Ludzack & Kinkead (1956) have shown that while there is little detectable oxidation of motor oil incubated at 4°C, the rate of oxidation rises rapidly with moderate increases in temperature until 50–80% of the oil is lost per week at 25°C. While the formation of oil-in-water suspensions may be depressed at higher temperatures (Gordon *et al.*, 1973), the solubility of the more active water-soluble toxic elements in crude oil such as the phenols will doubtless also be increased at higher temperatures as well. It follows that refined oils are likely to disappear entirely, and crude oils will lose their more volatile and soluble toxic components and become reduced to biologically inert solids such as tar-balls much more rapidly at higher temperatures.

There seem to be equally few critical observations on the effects of different types of oil on birds, though they clearly vary greatly. The fact that liquid oil clogs plumage and breaks down its insulating capacity so that birds soon die of exposure attracted attention first (Portier & Raffy, 1934; Hartung 1967), and it has often been stated uncritically that the smallest drop of oil on the plumage is lethal, which may be true in some cases, but not others. Birds which are fed fresh oil may also develop a variety of alimentary, respiratory and stress symptoms (Hartung & Hunt, 1966), which again may explain much of the acute mortality during oil-spills though here also other birds may preen themselves and then pass much oil in the faeces without obvious ill-effects. Clearly the amount of damage birds sustain when they meet oil varies greatly with its consistency and chemical composition, with the worst damage caused by fresh, fluid oils, and progressively less by old, inert, solid residues. These may fail to soak the plumage or poison the birds at all, so that eventually they are able to clean themselves with little permanent damage unless it be to the plumage structure (Birkhead *et al.*, 1973, Bourne, 1974).

The difference in the impact of different types of oil at different temperatures may best be illustrated by considering some recent examples. The damage due to oil-spills appears to be worse with fuel oil, which tends to remain liquid until it is dispersed, than with crude oils, which soon tend to form a semi-solid 'mousse' or tar-balls. Oil spilt at lower temperatures also appears to cause more damage than that spilt at higher temperatures, because in both cases it remains liquid longer. Thus a mere 150 tons of fuel oil are thought to have killed at least 35,000 birds along the coasts of the Netherlands in February 1969 (Swennen & Spaans, 1970), 330 tons at least 7000 birds in the cool-current area off San Francisco in January 1971 (Orr, 1971), 87 tons at least 1300 birds in the Firth of Tay, eastern Scotland, in March 1968 (Greenwood & Keddie, 1968), 700 tons at least 4400 birds in the Irish Sea in May, 1969 (Hope Jones *et al.*, 1970), and some 10,000 tons at least 12,000 birds off Nova Scotia in February 1970 (Brown *et al.*, 1973). Compared with this, that part of her cargo of 112,000 tons of crude oil which escaped from the *Torrey Canyon* off Cornwall in March–April 1967 soon formed a thick 'chocolate mousse' water-in-oil emulsion and is only known to have killed 10,000 birds (Bourne *et al.*, 1967), and the crude oil which leaked from the sea floor off Santa Barbara, California, for many months in 1969 is only known to have killed a few thousand birds (Straughan, 1971), though many more may have been lost at sea.

The pattern is repeated in the colder parts of the southern hemisphere, where Jehl (1974) reports that oil polluted birds are now common off southern South America, 4000 tons of crude oil spilt off Cape Town in April 1968 affected some 2200 birds of which 950 were saved (Westphal & Wowan, 1971), but 50,000 tons which leaked from the *Metula* in the Magellan Strait in August 1974 soon formed a 'mousse' and only 3000 birds are known to have been killed (Baker, in preparation), though here again many more may have been lost at sea. On the other hand, while during a prolonged search of the literature we have come across too many references to the increasing occurrence of tar-balls at sea and on beaches within the tropics to list here, we have failed to trace any reports of important bird mortality due to oil there.

The difference in the impact of different types of oil pollution on birds is best illustrated by two cases from the east coast of Scotland in the breeding season. A small fuel oil slick which drifted up the east coast of Shetland in May 1971 probably killed at least 2000 birds before it dispersed within a day or two (Bourne & Johnstone, 1971). On the other hand, a vast waxy mass of tanker residues which plastered forty miles of shore between Montrose and north of Aberdeen for weeks in the spring of 1974 in amounts ranging up to 74 tons on 4 miles of coast (Tute, 1974), caused little obvious damage to the equally vast bird population. Bourne was so surprised that he went and inspected the breeding colony containing some 30,000 pairs each of kittiwakes and guillemots *Uria aalge* in the middle of the area at Fowlsheugh on 26 May, but while some 3% of the birds (13 out of 501 kittiwakes and 14 out of 380 auks) had managed to get themselves slightly oily, he was unable to locate a single dead bird. On analysis this oil differed conspicuously from the fuel oil that had caused the mortality in Shetland, but resembled that in eleven tar-balls collected around the south-west coast of Europe.

It would appear that once oil has begun to solidify, at first into a 'chocolate mousse' water in oil emulsion, though this can clearly still cause much damage, and certainly into firm tar-balls, it affects birds differently from the liquid oils which first soak their plumage and then poison them when they preen themselves after they meet them on the water, and ceases to cause them much trouble except by sticking to their feathers so that they damage them when they try to preen (Bourne, 1974). The most serious problem may now occur when they seize small tar-balls in mistake for food. This could explain why aerial species taking food from the surface, such as kittiwakes in the eastern Atlantic or the white-tailed tropic-birds *Phaethon lepturus* of Bermuda (Wingate, 1973) further west become the most conspicuous victims in warmer seas. Bridled terns *Sterna anaethetus* have even been seen to offer each other lumps

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of oil in courtship-feeding in the Seychelles (Diamond, 1974), but while this type of mistake may make birds dirty, it does not necessarily kill them.

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W. R. P. BOURNE

The Seabird Group,
Department of Zoology,
University of Aberdeen,
Tillydrone Avenue, Aberdeen AB9 2TN, U.K.

C. J. BIBBY

Royal Society for the Protection of Birds,
The Lodge,
Sandy, Beds., U.K.

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