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EXPERIMENTS TO DETERMINE THE FATE OF DEAD BIRDS AT SEA

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ABSTRACT

*This paper describes three experiments aimed at determining the proportion of dead birds at sea which come ashore and are found by members of the public, and discusses the results in relation to wind velocities. From 11% to 58% of the ringed (*Larus spp.*) corpses thrown into the Irish Sea between Liverpool and the Isle of Man on three occasions in 1973 and early 1974 were recovered. There were large differences between experiments in the timing of the recoveries, although half usually occurred within 11–14 days of dropping. The resultant wind velocities during the time the first bodies recovered from each experiment were at sea were calculated. Comparison of the observed and expected tracks of these bodies confirmed that the wind was the main factor influencing the direction of drift. Gull corpses drifted at a minimum of $2.55 \pm 0.93\%$ of the windspeed, although there was much variation and some travelled at over 4% windspeed. With a few exceptions, the observed distribution of recoveries could be broadly predicted by wind vector analysis. The amount of onshore wind when the bodies had reached coastal waters was not related to the subsequent recovery rates. Further experiments are necessary if some of our findings are to be explained and examination of the effect of tidal cycles on the beaching of corpses would also be of value.*

INTRODUCTION

The effects of marine pollution on birds can be assessed by counting corpses, or sometimes dying birds appearing on shore. Beached bird surveys were initiated in Britain by the Seabird Group (Bourne & Devlin, 1969, 1970, 1971) and subsequently developed more systematically by the Royal Society for the Protection of Birds (Bourne & Bibby, 1975 and references therein). Approximately 2000 km of beaches

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are now inspected on five occasions each winter when mortality and the incidence of oil pollution is especially heavy (Bourne & Bibby, 1975). Single winter surveys (International Beached Bird Surveys), usually in February, have simultaneously been carried out elsewhere in north-west Europe, mainly in Eire, Denmark, East and West Germany, The Netherlands, Belgium and France. In addition to these surveys, which monitor natural mortality and the effects of chronic pollution, individual incidents of exceptional mortality have also been assessed by beached bird counts (e.g. Greenwood *et al.*, 1971; Holdgate, 1971; Lloyd *et al.*, 1974).

Allowances made for birds dying at sea but not coming ashore have normally involved multiplying finds by factors of unknown origin (e.g. Holdgate, 1971). Coulson *et al.* (1968) estimated that 25% of shags (*Phalacrocorax aristotelis*) known to have died from a dinoflagellate toxin actually came ashore in north-east England. Hope Jones *et al.* (1970) dropped ringed auk bodies into the sea following a pollution incident and were able to estimate the speed of their drift and subsequent rate of recovery (c 20%). The present experiments aimed to provide further information on the fate of corpses at sea with a view to assisting the interpretation of beached bird counts.

METHODS

Dead gulls, mainly *Larus argentatus* and some *L. fuscus*, were dropped into the Irish Sea in batches at seven uniformly spaced points between Liverpool and Douglas, Isle of Man (Fig. 1). Bodies were marked with uniquely numbered addressed rings provided by the British Trust for Ornithology's ringing scheme. Three experiments were conducted, on 1 February 1973, 29 January 1974 and 25 May 1974 respectively. The freshly dead birds were stored in a deep freeze prior to the experiments, except on the third occasion, when both fresh and frozen bodies were used. Small numbers of birds of other species were also included but not in sufficient quantity to produce any reliable results. Drifters in the form of sealed glass bottles with messages were tested as a more readily available substitute for bird bodies. These were not found to produce comparable results to birds and are not discussed here.

Bodies found by the general public and in a few cases by the RSPB's beached bird survey teams were reported through the normal channels for ringed birds. Reports usually included the date and place of finding and some gave further details about the state of the body. Inadequate reports were followed up by correspondence with the finder where possible.

Anemometrical data in the form of hourly strengths and directions of wind were obtained from the Meteorological Office Weather Station at the Point of Ayre, Isle of Man. These were added over appropriate time periods to calculate the influence of wind on the behaviour of the bird corpses.

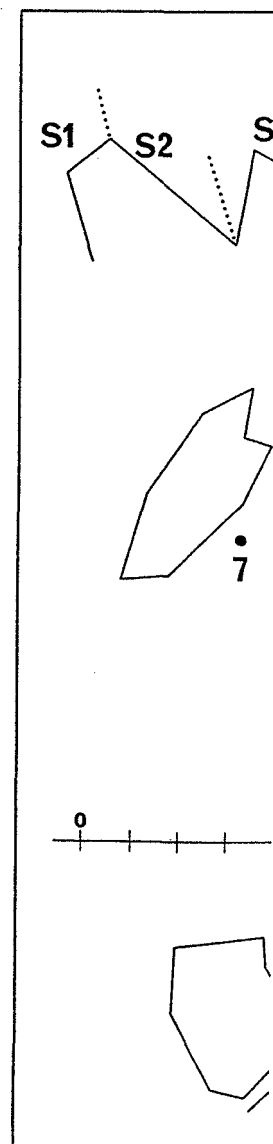


Fig. 1. Map of the north Irish (1-7), and the areas into which

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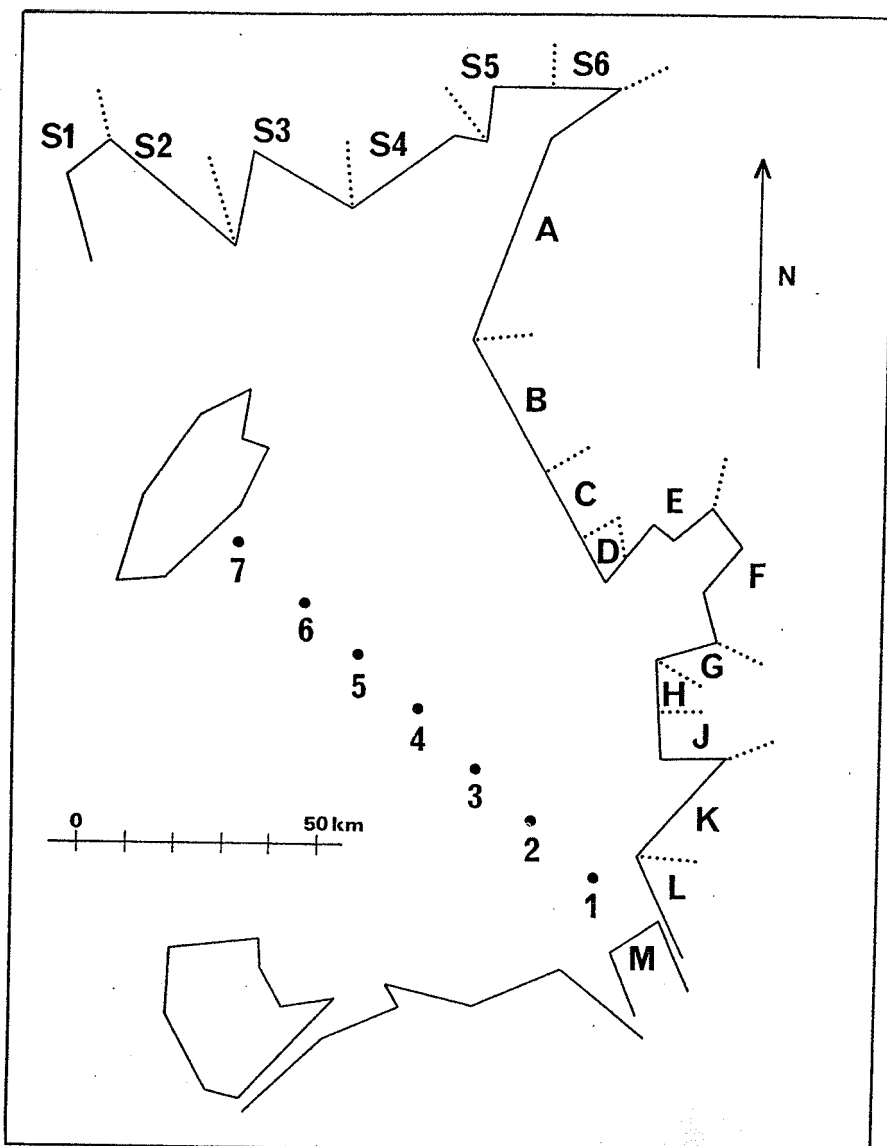


Fig. 1. Map of the north Irish Sea to show the locations of points at which dead gulls were dropped (1-7), and the areas into which the recoveries onshore were divided for presentation in Table 1.

RESULTS

Recoveries of ringed birds

Table 1 shows the distribution of recoveries of corpses. No recoveries were reported from the Manx coast in spite of the fact that the last batch in each experiment was dropped within sight of Douglas Harbour. In Experiments 1 and 3, bodies moved north and east to the English coast, though the pattern differed significantly with recoveries from Experiment 1, being more northerly than those from Experiment 3. In Experiment 2, however, only 24% of the recoveries were in England and the remainder in southern Scotland.

TABLE 1
DISTRIBUTION OF RECOVERIES OF GULL CORPSES IN THE IRISH SEA. SEE
FIGURE 1 FOR THE LOCATION OF AREAS

Recovery area	Experiment 1	Experiment 2	Experiment 3
S1	—	15	—
S2	—	3	—
S3	—	—	—
S4	—	3	—
S5	—	3	—
S6	—	2	—
A	23	6	5
B	61	2	1
C	26	—	10
D	8	—	27
E	—	—	3
F	19	—	1
G	22	—	1
H	43	—	27
J	1	—	5
K	—	—	50
M	—	—	3
TOTALS	203	34	133

All distributions differ significantly from one another $p < 0.001$, Kolmogorov-Smirnov two-sample tests.

The overall rates of recovery were 59%, 11% and 44% respectively in the three experiments (Table 2). In addition, there were substantial variations of recovery rate between batches within separate experiments (see below). The recovery rates of fresh (52%) and frozen corpses (45%) in the even numbered drops of the third experiment did not differ significantly ($\chi^2 = 0.56$, $p > 0.05$).

Although the majority of recoveries occurred within a month, there was a considerable spread of reporting time with the latest recoveries being nearly two years after one experiment (the second). The timing of the recoveries was exponential (Fig. 2). Experiments 1 and 3 produced broadly similar results with half the recoveries after 14 and 11 days and 90% within 35 and 39 days respectively. Experiment 2 produced a very different result with 90% of the recoveries not found

NUMBER OF GULL BODIES DR

Drop point	Experin Dropped Re
1	50
2	50
3	50
4	50
5	50
6	50
7	47
TOTALS	347

NOTE The overall recovery r rates from different drops in ea $p < 0.05$ respectively) and diff

until 335 days. There we obvious in Experiment 1 found at weekends (Tal beaches. In addition, an after the first experimen week.

NUMBER OF CORPSES FOUND ON TIME

Dates	Exper 1-26 Feb Corpses found
Weekdays (W)	56
Holidays (H)	120
No. of corpses found per day	W H

NOTE Relatively large num experiments, significantly fewer

Drifting velocity

The minimum speed a distance and elapsed tir reported from each drc produced no recoveries velocity from the time o interval in each experim

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TABLE 2
NUMBER OF GULL BODIES DROPPED AND RECOVERED AND PERCENTAGE RECOVERY RATE FROM THREE EXPERIMENTS

Drop point	Experiment 1			Experiment 2			Experiment 3		
	Dropped	Recovered	%	Dropped	Recovered	%	Dropped	Recovered	%
1	50	24	48	30	6	20	35	10	29
2	50	25	50	60	7	12	55	32	58
3	50	35	70	30	2	7	35	17	49
4	50	28	56	60	3	5	55	25	45
5	50	30	60	30	1	3	35	19	54
6	50	35	70	60	2	3	55	25	45
7	47	26	55	30	13	43	35	5	14
TOTALS	347	203	59	300	34	11	305	133	44

NOTE The overall recovery rates differed significantly from one another ($p < 0.001$, χ^2), but recovery rates from different drops in each experiment were similar for 1 + 3 ($\chi^2 = 4.26$, $p < 0.05$ and $\chi^2 = 12.49$, $p < 0.05$ respectively) and differed significantly in experiment 2 ($\chi^2 = 38.02$, $p < 0.001$).

pses. No recoveries were at the last batch in each r. In Experiments 1 and 3, ough the pattern differed more northerly than those / of the recoveries were in

IRISH SEA. SEE

Experiment 3

-
-
-
-
-
- 5
- 1
- 10
- 27
- 3
- 1
- 1
- 27
- 5
- 50
- 3
- 133

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, respectively in the three variations of recovery rate he recovery rates of fresh os of the third experiment

a month, there was a overies being nearly two coveries was exponential ar results with half the id 39 days respectively. the recoveries not found

until 335 days. There were short-term irregularities in the recovery rates, especially obvious in Experiment 1. These were caused by a strong tendency for birds to be found at weekends (Table 3), presumably when there were more people on the beaches. In addition, an International Beached Bird Survey took place three weeks after the first experiment and more corpses were found then than in the previous week.

TABLE 3
NUMBER OF CORPSES FOUND ON WEEKDAYS COMPARED WITH WEEKENDS AND BANK HOLIDAYS, DURING THE TIME THAT THE MAJORITY OF RECOVERIES WERE MADE

Dates	Experiment 1		Experiment 2		Experiment 3	
	1-26 February 1973	29 January-28 February 1974	25 May-14 July 1974	Corpses found	No. of days	Corpses found
Weekdays (W)	56	18	3	23	84	34
Holidays (H)	120	8	18	8	50	16
No. of corpses found per day	W	3.1	0.1	2.5	H	3.1
	H	15.0	2.3			

NOTE Relatively large number of corpses found during weekdays in summer (Exp. 3). For all experiments, significantly fewer corpses were found on weekdays ($\chi^2 = 46.0$, $p < 0.001$) than on holidays.

Drifting velocity

The minimum speed at which bodies had drifted was calculated by measuring the distance and elapsed time from dropping to recovery for the first beached bird reported from each drop (Table 4). Four drop points in Experiment 2 which produced no recoveries in the first fortnight were excluded. The resultant wind velocity from the time of dropping to recovery was also calculated for each time interval in each experiment by summing the hourly vectors.

In two of the experiments (1 & 3), there was close agreement between the observed

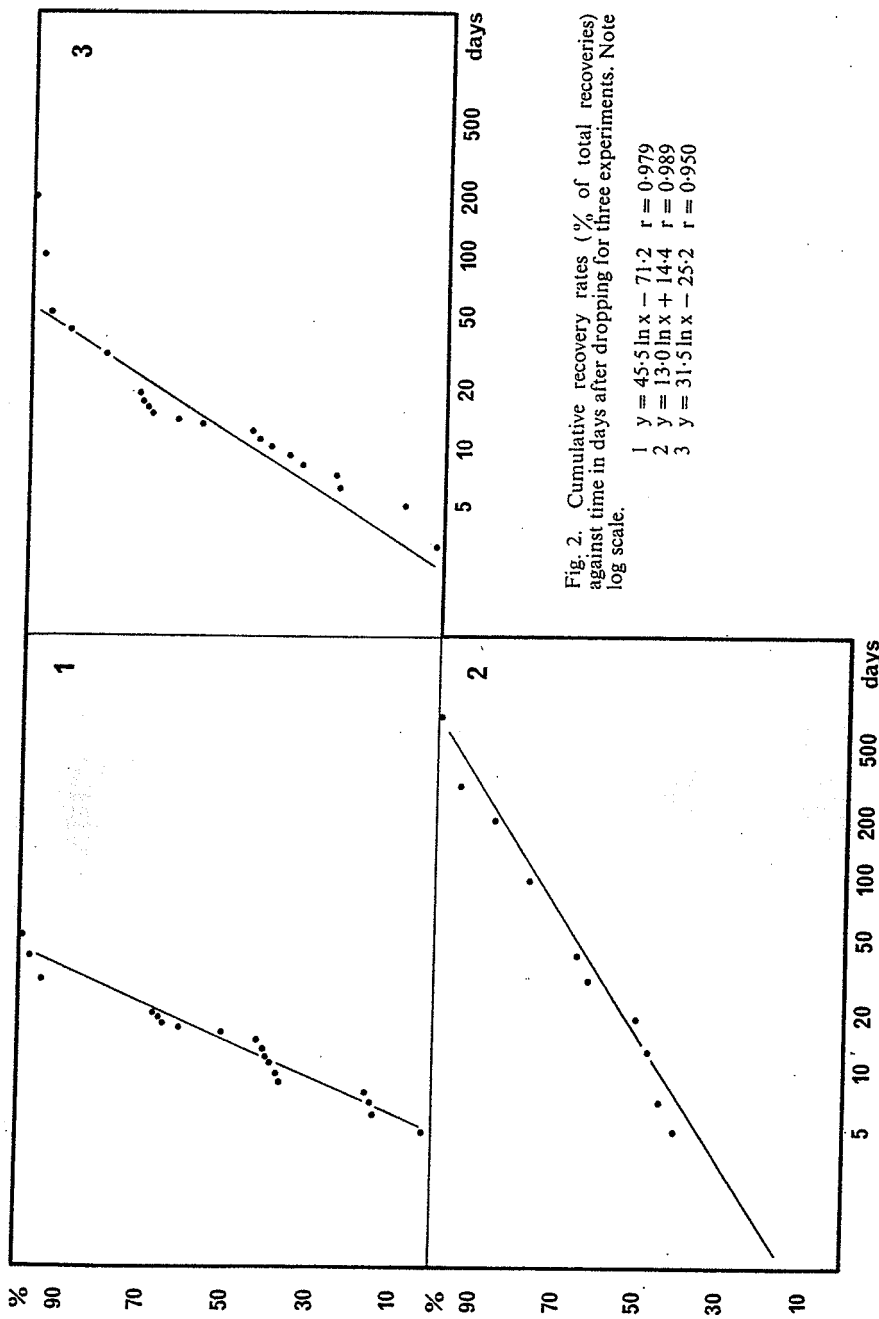


Fig. 2. Cumulative recovery rates (% of total recoveries) against time in days after dropping for three experiments. Note log scale.

1 $y = 45.5 \ln x - 71.2$ $r = 0.979$
 2 $y = 13.0 \ln x + 14.4$ $r = 0.989$
 3 $y = 31.5 \ln x - 25.2$ $r = 0.950$

MOVEMENT OF FIRST BODIES RECOVERED

Exp. no.	Movement of recovery	
	Distance km	Days elapsed
1.1	41.8	5
1.2	41.8	5
1.3	53.1	9
1.4	49.9	5
1.5	62.8	6
1.6	61.2	6
1.7	88.5	9
2.1	128.7	5
2.2	103.0	7
2.7	86.9	5
3.1	20.9	5
3.2	29.0	3
3.3	40.2	6
3.4	54.7	8
3.5	57.9	12
3.6	57.9	11
3.7	66.0	14

and expected tracks of 1 influencing the direction difference ($p < 0.001$) be

The calculated speed considerably (Table 4) b in calculation might ha would have been a syst beached and reported. T drifted at a rate nearer recorded.

Distribution of recoverie

To interpret the diffe summed on a daily basis scaled down to 2.55% to location of bodies from the vector reached land, moved along the coast b other component of the

TABLE 4
MOVEMENT OF FIRST BODIES RECOVERED FROM EACH DROP POINT IN RELATION TO WIND STRENGTH AND DIRECTION. MEANS ARE GIVEN ± 1 STANDARD ERROR

Exp. no. drop point	Movement of first body recovered			Resultant wind in same period		Body speed as % wind speed	$x-y^\circ$		
	Distance km	Days elapsed	Speed km/h	Path ^o (x)	Speed Bearing ^o (y)				
1-1	41.8	5	0.348	206	17.66	224	1.97	-18	
1-2	41.8	5	0.348	229	17.66	224	1.97	+5	
1-3	53.1	9	0.246	246	19.03	240	1.29	+6	
1-4	49.9	5	0.416	243	17.66	224	2.35	+19	
1-5	62.8	6	0.436	220	18.87	227	2.31	-7	
1-6	61.2	6	0.425	232	18.87	227	2.25	+5	
1-7	88.5	9	0.410	223	19.03	240	2.15	-17	
							Mean	2.04 ± 0.37	-1.0 ± 13.6
2-1	128.7	5	1.073	173	27.53	187	3.89	-14	
2-2	103.0	7	0.613	175	23.18	194	2.64	-19	
2-7	86.9	5	0.724	154	27.54	187	2.63	-33	
							Mean	3.05 ± 0.73	-22.0 ± 9.9
3-1	20.9	5	0.174	307	9.99	305	1.74	+2	
3-2	29.0	3	0.403	282	12.99	297	3.09	-15	
3-3	40.2	6	0.279	286	6.39	300	4.36	-14	
3-4	54.7	8	0.283	264	6.17	252	4.59	+12	
3-5	57.9	12	0.201	245	10.14	233	1.97	+12	
3-6	57.9	11	0.219	240	8.82	250	2.48	-10	
3-7	66.0	14	0.196	234	11.03	239	1.76	-5	
							Mean	2.60 ± 1.10	-2.60 ± 11.5

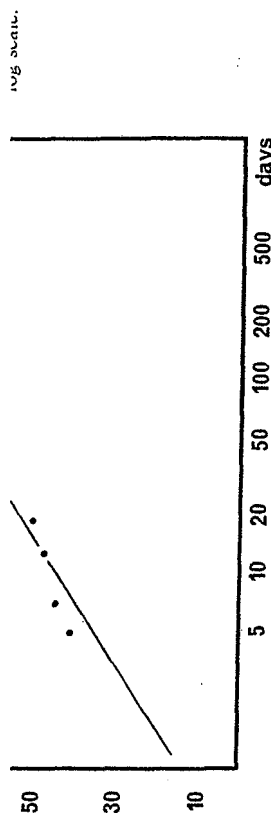
and expected tracks of the bodies, confirming that the wind was the main factor influencing the direction of drift. In Experiment 2, however, there was a significant difference ($p < 0.001$) between the observed and predicted tracks of bodies.

The calculated speed of drift of bodies as a percentage of wind speed varied considerably (Table 4) but averaged 2.55% (± 0.93 standard error $n = 17$). Errors in calculation might have arisen from ignoring tidal effects. Furthermore there would have been a systematic bias resulting from delay between a body being beached and reported. Thus, this figure must be a minimum and bodies may have drifted at a rate nearer 4% of the wind speed as suggested by the higher values recorded.

Distribution of recoveries

To interpret the differences of recovery patterns, hourly wind vectors were summed on a daily basis for the twelve days following each drop. They were then scaled down to 2.55% to estimate the tracks of the bodies (Fig. 3). The geographical location of bodies from each drop after each day was estimated graphically. Once the vector reached land, it was assumed that the bodies which did not come ashore moved along the coast by the length of the vector resolved in that direction. The other component of the vector, blowing onshore, was calculated each day. As a

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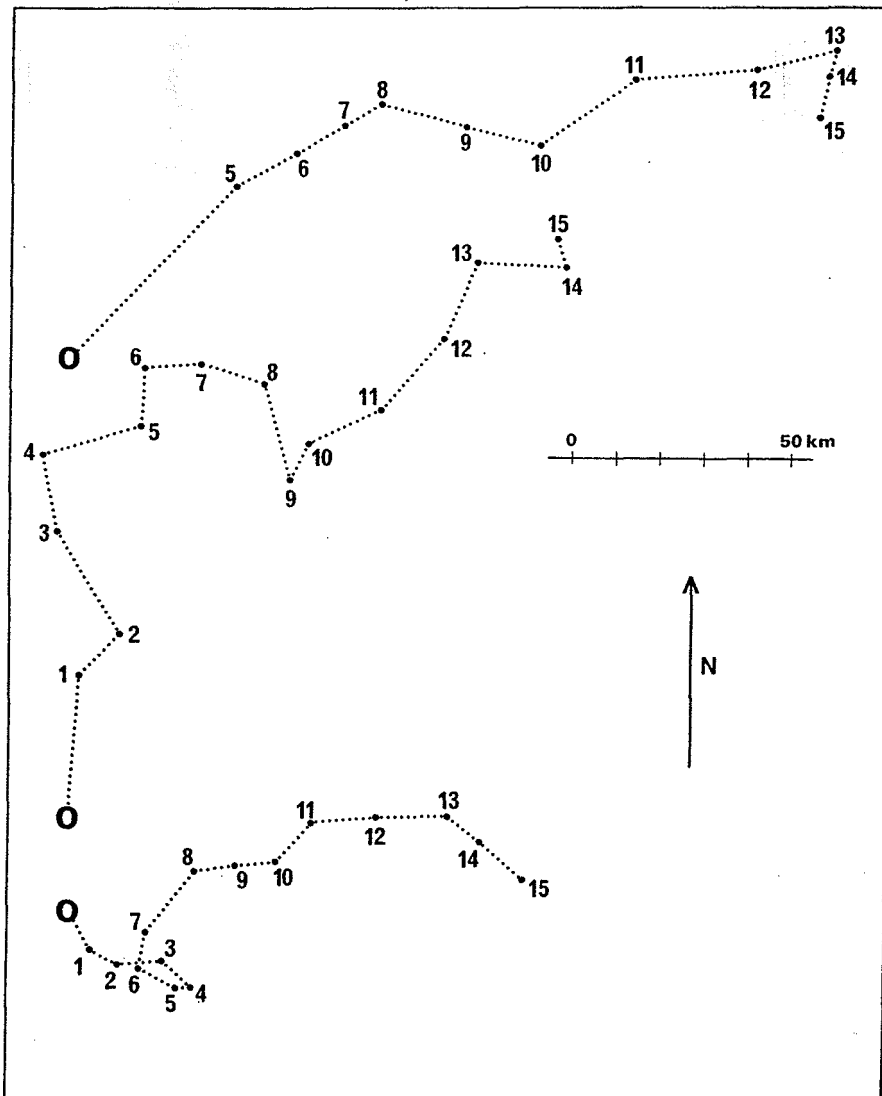


Fig. 3. Vector diagrams showing estimated positions of bodies at daily intervals for the first fifteen days after dropping. Calculations based on summation of hourly vectors reduced to 2.55% as the estimated rate of drift of bodies. From top to bottom, Experiments 1, 2 and 3.

result, it was possible to predict the stretch of coastline along which bodies should have come ashore. These results were then compared with the actual distribution of recoveries (Fig. 4).

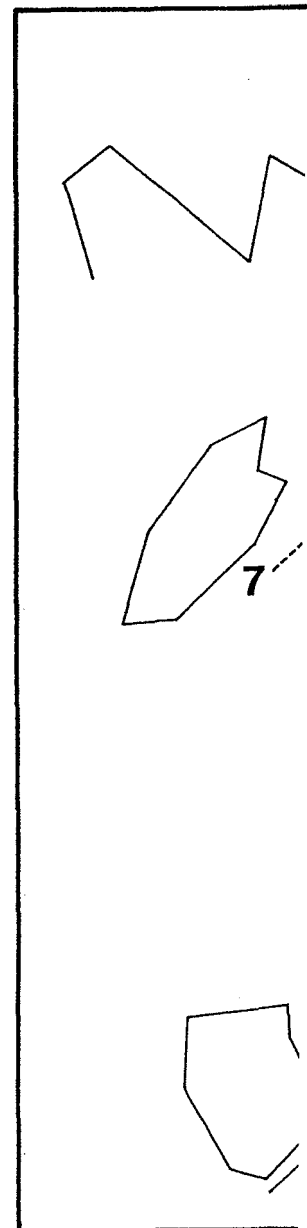
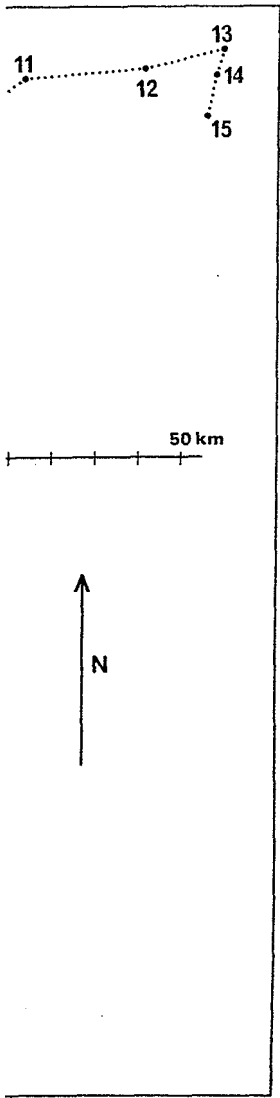


Fig. 4. Distribution of observations inland by wind vector analysis.



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 reduced to 2.55% as the estimated
 tents 1, 2 and 3.

along which bodies should
 the actual distribution of

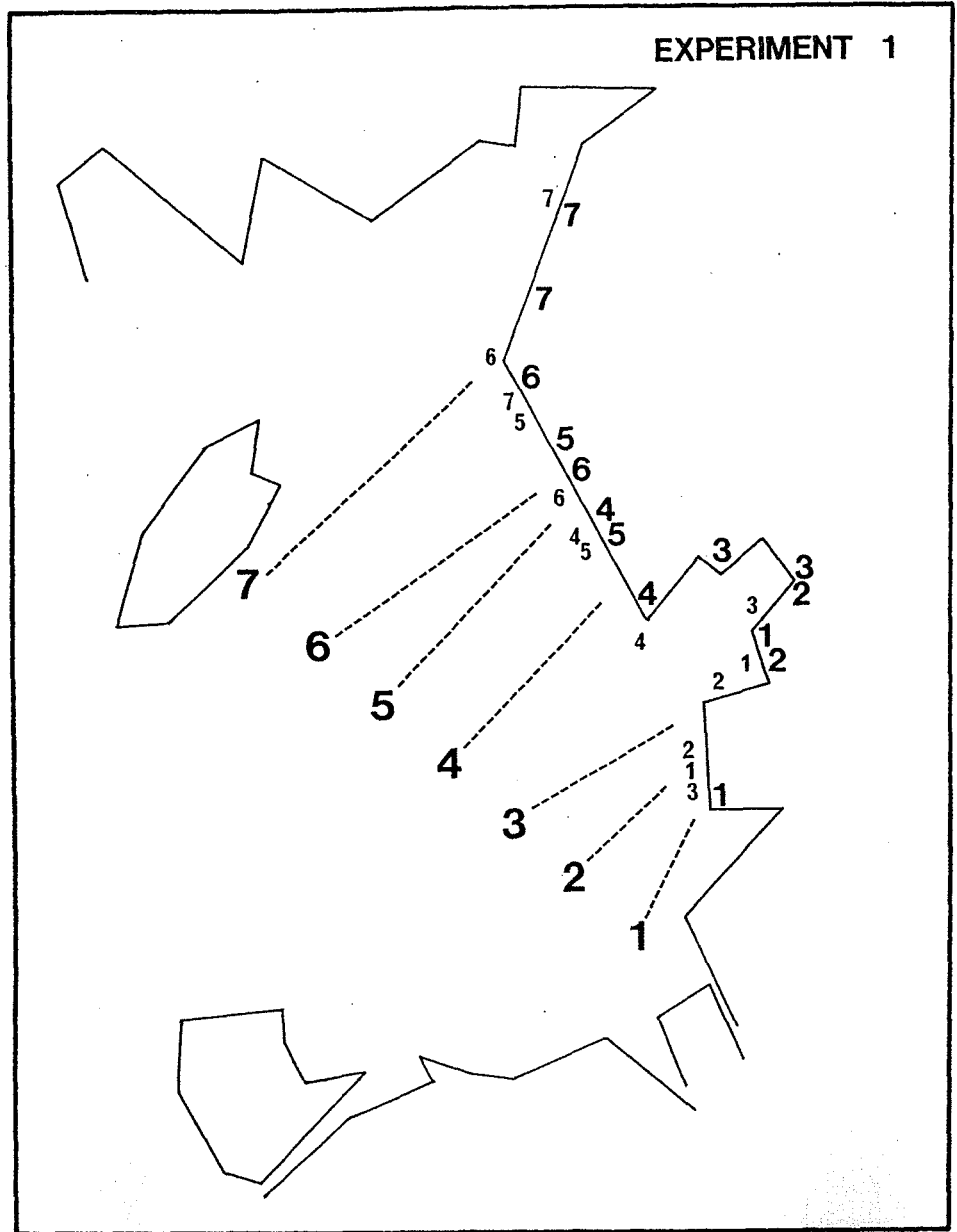


Fig. 4. Distribution of observed recoveries (small figures off shore) and those predicted (heavy figures inland) by wind vector analysis—see text. Dotted lines show the medium tracks of recoveries from each drop.

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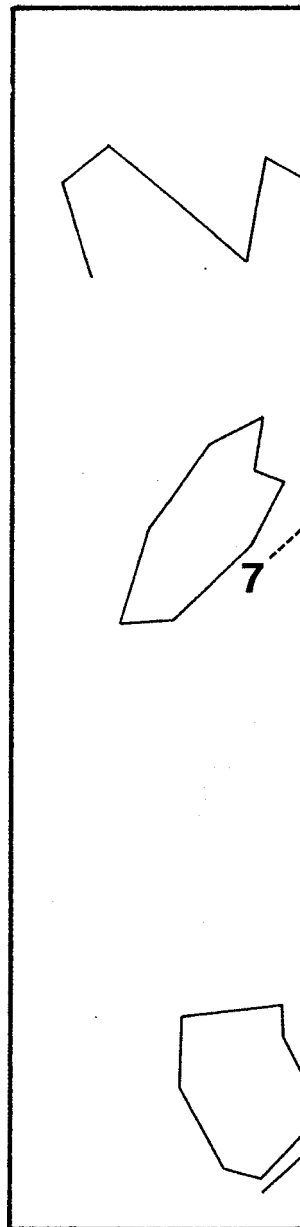
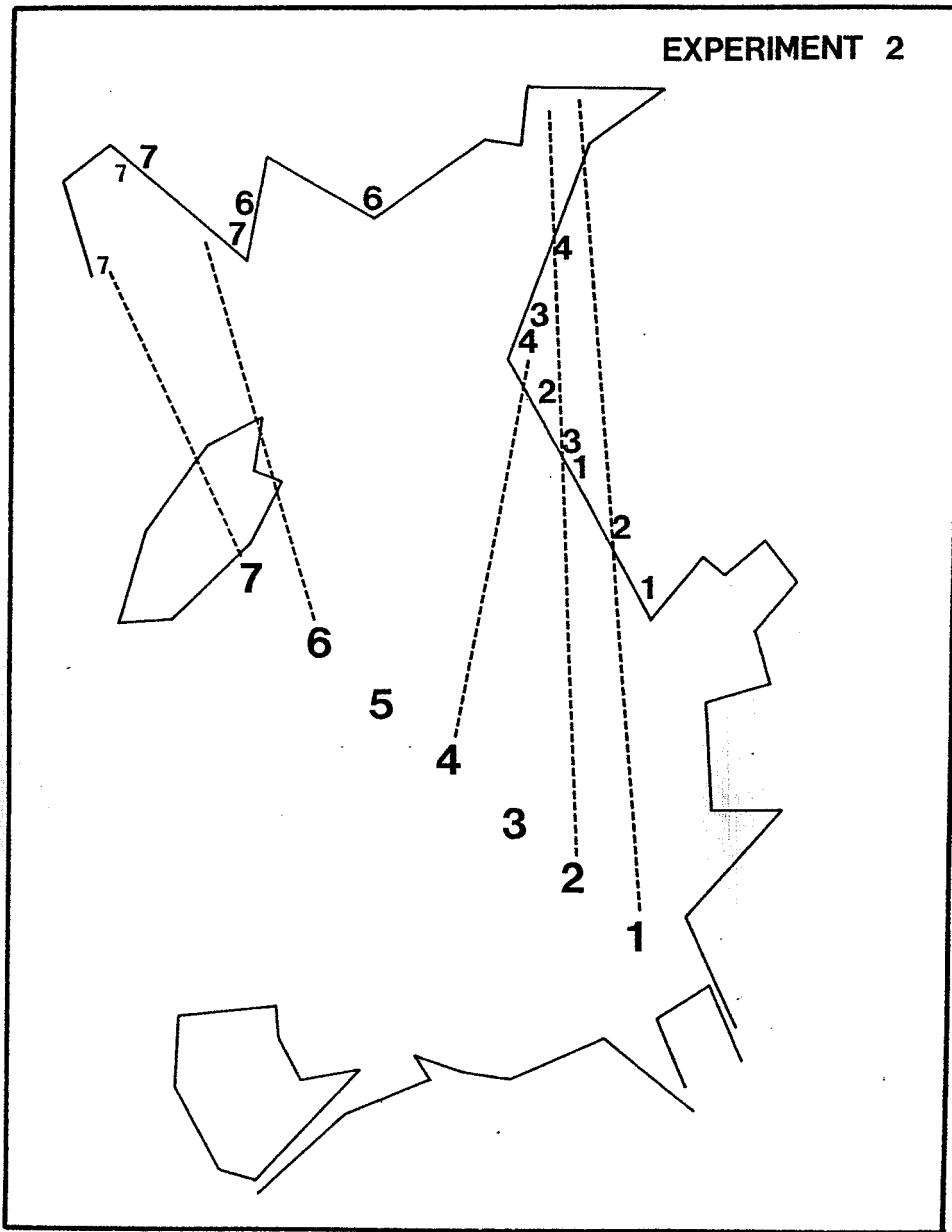
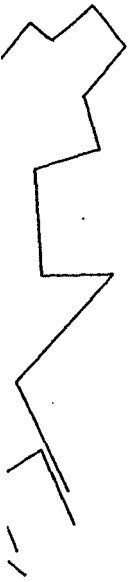


Fig. 4—contd.

EXPERIMENT 2



EXPERIMENT 3

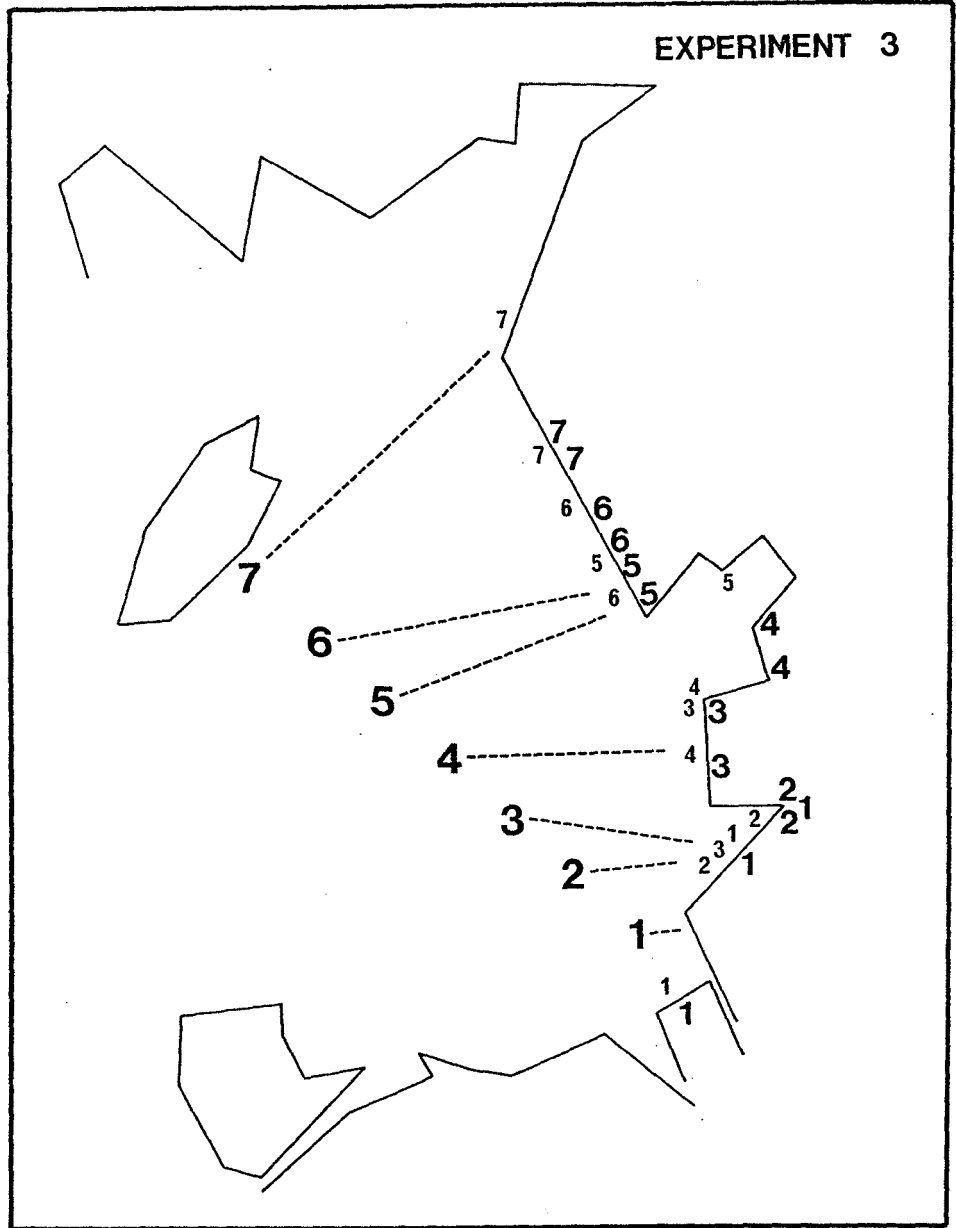


Fig. 4—contd.

The wind vector analysis broadly predicted the recovery patterns of corpses observed. It also accounted for the main difference between Experiment 2 and the others. In Experiment 1, the observed median tracks of bodies fell within the predicted recovery areas for all drops except one (drop 3). In this case, recoveries were predicted in the northeast of Morecambe Bay but in fact occurred along the southern shores, perhaps owing to tidal effects in the bay (Phillips, 1969). Experiment 3 showed a similar agreement between observations and predictions, with drop 7 producing the only serious discrepancy. In this case, the recoveries were rather further north than expected, but four out of the five were also later than 12 days after dropping and must have drifted along shore instead of being beached at first landfall.

Experiment 2 produced the least predictable results in this respect, as well as others already described (overall recovery rates, timing of recoveries and speed of drift relative to wind speed). Four of the seven drops produced too few recoveries for analysis (Table 2) and the birds from drops 2, 3 and 4 in fact moved faster than 2.55% of the windspeed (Table 4). A higher speed of drift could largely account for the discrepancies shown in Fig. 2 by carrying the bodies further north in the first three or four days of southerly gales before the wind veered to the west to produce recoveries on both coasts of the Solway.

Overall recovery rate

An attempt was made to predict the recovery rate for each drop from the calculated component of onshore wind experienced once the bodies had reached a coast and up to 12 days after each experiment (Table 5). However, this analysis failed to account either for the overall differences between experiments or for differences between drops within experiments. Most notably, it failed to account for the very low rate of recoveries in Experiment 2. Hence onshore wind is not solely responsible for high recovery rates of corpses drifting at sea.

There were no apparent correlations between the final recovery rates from different experiments and the time or distance that birds had travelled before being beached. Although the distances travelled were substantially higher in Experiment 2, the times taken by the fastest recoveries were no longer than in the other experiments (Table 4), so the low recovery rate cannot be explained in terms of greater losses at sea. Furthermore, there were no such correlations between drops within Experiments 1 and 3.

DISCUSSION

During these experiments, between 11% and 59% of the dead gulls dropped at sea were subsequently found ashore. Coulson *et al.* (1968), investigating an exceptional mortality of shags, discovered that only 25% of the birds known to have died were

EXPERIMENT

SUMMED COMPONENT
CORPSES (%) IN THE 1
km AS 2.55% OF ONSH

Drop point	Exp Onshore wind km
1	107
2	96
3	84
4	73
5	95
6	95
7	56

NOTE Correlations onshore wind are no Values of coefficient:

found on nearby beaches dropped ringed auk corpses following a much relatively well searched. I of Steephholm in the Bristol Somerset coast. Compar two of the three present landlocked character of Survey. Much lower recovery Sea (unpublished data). I might enable gulls to float once ashore in comparison Britain. Some of our 1 enhanced if corpses are

In recent years, the Irish mortality. In the autumn (*Uria aalge*), were found (Holdgate, 1971). The birds September. The present recoveries have been recorded, though birds. In early 1974, 1322 northern Irish Sea and Scottish coast (Lloyd *et al.*, 1974)

covery patterns of corpses
ween Experiment 2 and the
s of bodies fell within the
p 3). In this case, recoveries
t in fact occurred along the
the bay (Phillips, 1969).
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five were also later than 12
instead of being beached at

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4 in fact moved faster than
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However, this analysis failed
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ms of greater losses at sea.
drops within Experiments 1

ie dead gulls dropped at sea
nvestigating an exceptional
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TABLE 5
SUMMED COMPONENTS OF ONSHORE WIND IN THE FIRST 12 DAYS AND RECOVERY RATES OF
CORPSES (%) IN THE FIRST 15 DAYS AFTER DROPPING AND IN TOTAL. WIND MEASURED IN
km AS 2.55% OF ONSHORE COMPONENT FOR THE DAYS WHEN CORPSES WERE EXPECTED TO
BE AT THE COAST

Drop point	Experiment 1			Experiment 2			Experiment 3		
	Onshore wind km	Recovered 0-15d	Total	Onshore wind km	Recovered 0-15d	Total	Onshore wind km	Recovered 0-15d	Total
1	107	20	48	63	7	20	68	14	29
2	96	24	50	84	2	12	46	56	58
3	84	24	70	85	0	7	44	43	49
4	73	8	56	46	0	5	20	40	45
5	95	44	60	31	0	3	22	23	54
6	95	36	70	36	0	3	25	27	45
7	56	6	55	84	43	43	20	3	14

NOTE Correlations between recovery rates (a) in days 0-15 and (b) overall with
onshore wind are not significant ($p > 0.05$).

Values of coefficients (r) as follows:

Exp.	0-15d	Total
1	0.67	-0.08
2	0.45	0.59
3	0.13	-0.01

found on nearby beaches, although winds were onshore. Hope Jones *et al.* (1970) dropped ringed auk corpses into the sea off north Wales and recovered 20% of the bodies following a much publicised oil spill at a time when beaches would have been relatively well searched. Beer (1968) threw dead ringed gulls into the sea off the island of Steephholm in the Bristol Channel which resulted in a 10% recovery rate along the Somerset coast. Compared with the results of these investigations, recovery rates in two of the three present experiments were unexpectedly high, possibly due to the landlocked character of the Irish Sea and deliberate searches by the Beached Bird Survey. Much lower recovery rates have been found from similar trials in the North Sea (unpublished data). Recovery rates probably differ between species; long wings might enable gulls to float better and conspicuous appearance aid their discovery once ashore in comparison with auks, the most frequent victims of oil pollution in Britain. Some of our findings (unpublished) indicate that recovery rates are enhanced if corpses are conspicuously marked with large yellow tags.

In recent years, the Irish Sea has been the site of two major incidents of seabird mortality. In the autumn of 1969, an estimated 17,347 birds, mostly guillemots (*Uria aalge*), were found on the shores of the Irish Sea and the mouth of the Clyde (Holdgate, 1971). The birds came ashore in a period of stormy weather at the end of September. The present results suggest that up to 60% of the total mortality might have been recorded, though at the time the postulated toll was 50,000 to 100,000 birds. In early 1974, 1322 dead birds were found in beached bird surveys around the northern Irish Sea and soon after a further 800 came ashore oiled on the Ayrshire coast (Lloyd *et al.*, 1974). The timing of this incident coincided with Experiment 2

11%. This suggests that the

bodies that were not found on or a substantial time, though birds at sea, the rings would have been reported more than a few days later. Several such reports could be half buried. Bodies are often covered with copious debris especially during a period of gales which may be in addition, turbulent conditions around the corpses, though this

prolonged recovery period (Fig. 2) for birds buried in rubbish and been reported in some cases years). Another problem is that birds stranded in estuarine areas with few seabird corpses in sheltered creeks and on the shorelines, there is often a large number that have vanished thus in Solway during the present

period of the observed dispersal of birds probably minimal, may have been blown to the north in the north of the Isle of Man. It is noted that birds sank and were recovered by Hope Jones *et al.*

was slightly higher than the Gulls were observed to float. Impact on auks probably offered might have been faster, perhaps delayed, because of delay between

It is noted that not all come ashore at the time stipulated that some remained offshore and washed away. It is reported that a line of flotsam was observed on the Lough Linnhe coast. Apparently it was noted at each tide.

It is probable that the state of the tidal cycle influences the proportion of birds coming ashore in the same way as it is seen to influence the landing of flotsam. Some beached bodies were actually taken back to sea as was observed twice in the present experiments when reports of the same bird came from two different places, separated by 11 and 66 km respectively. The tides in the present experiments were spring tides. Further experiments to investigate these effects could be conducted by simply throwing marked corpses into the sea from a beach at different stages of the daily and monthly cycles of the tide. Such experiments might help to account for the huge variations of recovery rates reported here.

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