Exceptional mortality of auks, terns and Kittiwakes *Rissa tridactyla* in West Scotland in July 1985

Uitzonderlijke sterfte van alkachtigen, sterns en Drieteenmeeuwen Rissa tridactyla *in West-Schotland in juli 1985*

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Introduction

In July 1985 a substantial wreck of seabirds occurred on the coasts of the Firth of Lorn, western Scotland (*c.* 56-57°N 5°30'W; figure 1), many hundreds of dead and dying birds were washed ashore, most of them within a period of twelve days. The most numerous species affected was Guillemot *Uria aalge*, with Kittiwake *Rissa tridactyla* and Razorbill *Alca torda* dying in smaller numbers. A brief account of the wreck was given by Mudge *et al.* (1985a) and a more detailed analysis of the Guillemot corpses by Mudge *et al.* (1985b).

At the same time and in the same area there was very heavy chick mortality, approaching 100% in most cases, at all colonies of Common Tern *Sterna hirundo* and Arctic Tern *S. paradisaea*. The coincidence in time and place of these two events was striking, as was the fact that immediately north and south of the affected area no abnormal deaths of auks, Kittiwakes or chicks of terns were observed or reported. This paper records the numbers of these bird deaths and shows that they were almost certainly caused by a single factor.

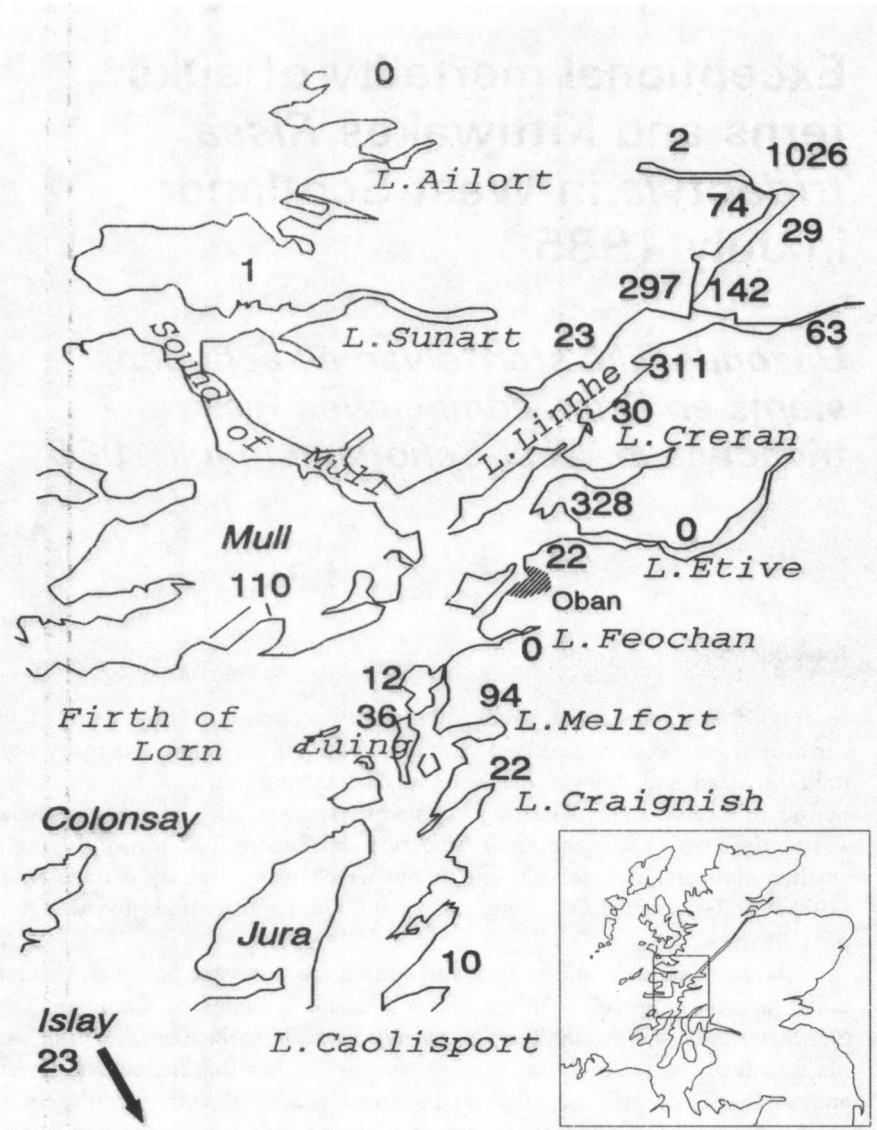

Figure 1. Map of Loch Linnhe area showing distribution of dead Guillemots in auk wreck of July 1985.

Figuur 1. Loch Linnhe gebied en aantallen dood gevonden Zeekoeten, juli 1985.

Methods

In the prevailing southwesterly winds of mid-July 1985, beaches facing south or southwest received most dead birds and the search was organised accordingly. Systematic counts of birds on the high-water marks along 85 km of beaches of sand, shingle or boulders were supplemented by reports from members of the public. To avoid count duplication, dead birds were thrown well above the highest tide line, or removed completely. Samples of dead stranded birds (excluding those with saturated plumage) were weighed to the nearest 10 g with a 1 kg Salter spring balance. Freshly dead specimens of 20 Guillemots, ten Razorbills and four Kittiwakes were collected for examination of stomach contents and fat deposits. Dead auk chicks hatched in 1985 were recognisable by their much smaller body size, and in some cases by the presence of down. Many full grown auks were in winter plumage accompanied by full primary moult: these are here termed 'immature'. Others were in full breeding plumage and are called 'adult'. During June and July 1985, visits were made every five to seven days to 14 colonies of Common and Arctic Terns on small marine islands within 100 km of Oban (figure 1). Biometrics were obtained from adults trapped on the nest in early and mid-June and from chicks in late June and July. Dead chicks were removed and were counted and measured away from the colony. Bill length was measured to the nearest 0.5 mm with Vernier callipers, and body weight to the nearest g with 50 g Pesola or 200 g Salter spring balances. Since, to minimise disturbance, visits were not made daily to tern colonies, it was not possible to ring chicks on the day of hatching and know their precise age at death. Instead, bill length was used as an index of chick age, and state of nutrition of chicks was assessed by the bill length - body weight relation (figures 2-4). Values obtained for dead and live chicks in 1985 were compared with those obtained in the study area from live chicks in 1982 and 1983, years of food sufficiency in which little or no starvation was observed. From the presence or absence of fledged chicks, and numbers of dead or starving chicks, chick mortality at each colony in 1985 was assessed as '*heavy*' (approaching or at 100%: no juveniles seen flying), '*medium*' (abnormal numbers of starving chicks but some juveniles seen flying) or '*light*' (few dead chicks found; large numbers of juveniles flying). In deserted colonies ('*failed*'), no eggs or dead or living chicks were found. Meteorological records were obtained from Dunstaffnage Weather Station (Oban). Sea temperatures over several years were not available in the area concerned, and records from Keppel Pier (100 km to the southeast, in the Firth of Clyde) were used for inter-year comparisons.

Results

GENERAL OBSERVATIONS The episode was preceded and accompanied by several unusual observations of the species affected in the Oban area. In early and mid-July, adult Guillemots and Razorbills, many with small chicks, were observed in the seas near Colonsay, Islay and Mull, seemingly in greater numbers than usual. Small parties of Guillemots were seen far up sea-lochs and generally closer inshore than is usual. They were often seen swimming with head submerged, presumably seeking food. When approached in a small boat, some of these birds were unable to fly or dive, so that some could be caught by hand. A flock of 20-30 Guillemots was seen ashore intertidally near Oban, a unique observation in my six previous and six subsequent years' experience of the area. Others reported Kittiwakes flocking unusually close inshore in Loch Sunart (Campbell 1985). The general impression in early July 1985 was of an abnormal distribution of Guillemots, Razorbills and Kittiwakes.

AUK AND KITTIWAKE DEATHS Most auks and Kittiwakes died between 12 and 24 July. Dead and dying Guillemots and Razorbills were drifted ashore in the Firth of Lorn and Loch Linnhe by the prevailing southwesterly winds, many landing on crowded holiday beaches. Many of the dying auks were accompanied by dying half-grown chicks. The number of dead or dying birds counted is given in table 1. The area of shore along which the Guillemots were found is shown in figure 1. The distribution of dead Razorbills and Kittiwakes was approximately the same as that of the Guillemots. The numbers of deaths of the other species shown in table 1 were probably close to normal values for the time of year. Since it is likely that many corpses escaped detection, the numbers in table 1 represent a lower limit to the number that actually died.

Figure 1 clearly shows the localised nature of the auk mortality. Away from the principal southwest facing beaches around Loch Linnhe and the Firth of Lorn, the corpses were spread much more thinly. On the northwest shore of Loch Linnhe, for example, dead auks were distributed fairly regularly at a density of one bird per 50 - 200 m of shore. Searches of the shores at Loch Ailort and Loch Sunart, and south of Loch Caolisport, revealed few (< 2 per km) or no dead birds.

Table 1. Numbers of dead birds found on beaches in L. Linnhe area, July 1985 (85 km of shore checked).
Tabel 1. Aantal dood gevonden vogels op 85 km strand in het Loch Linnhe gebied.

Guillemot *Uria aalge*	2616	(211 chicks)	Zeekoet
Kittiwake *Rissa tridactyla*	110		Drieteenmeeuw
Razorbill *Alca torda*	97	(49 chicks)	Alk
Common Gull *Larus canus*	16		Stormmeeuw
Manx Shearwater *Puffinus puffinus*	12		Noordse Pijlstormv
Herring Gull *Larus argentatus*	12		Zilvermeeuw
Shag *Phalacrocorax aristotelis*	9		Kuifaalscholver
Puffin *Fratercula arctica*	7		Papegaaiduiker
Gannet *Sula bassana*	6		Jan van Gent
C/A Tern *Sterna hirundo/paradisaea*	6		noordse dief
Total *Totaal*	**2891**		

ORIGINS OF DEAD AUKS Of 2713 dead Guillemots and Razorbills found during or just after the wreck (July-August), only nine (0.3%) were ringed. Eight of these (seven Guillemots, one Razorbill) were one-year old birds ringed as chicks in 1984. Three came from Canna, one from Treshnish, one from Fair Isle, one from the Isle of May and one each from North Sutor and Ceann Ousdale (the last three places are on the east coast of Scotland). The ninth was a Guillemot ringed as a chick in 1985 on Canna. These findings accord with the fact that Guillemots disperse widely from their natal colonies during their first 18 months (Cramp 1985).

The proportion of immatures among the fully grown birds increased from about 4% on 14 July to about 50% on 23 July and, overall, birds in adult plumage outnumbered immatures and chicks by a considerable margin (Mudge *et al.* 1985b). It is therefore remarkable that not one ringed adult bird was found. Since most breeding adults would presumably have been at their colonies at that time of year, this absence of ringed adults suggests strongly that the adult birds in the wreck came from a colony in which few birds are ringed. The three nearest large Guillemot colonies are at Colonsay, Treshnish and Canna, all on the west coast of Scotland. Treshnish and Canna had been regularly ringed by different ringing groups for the previous ten or more years. At Canna (90 km to the northwest), 39% of 1249 fully grown Guillemots and 53% of 89 Razorbills caught in 1985 were already ringed (R.L. Swann & A.D.K. Ramsay, *pers. comm.*) while at Treshnish (60 km to

the west) in 1986 these percentages were somewhat lower (B. Lawson, *pers. comm.*). At Colonsay (80 km to the south west), however, little or no auk ringing was undertaken in the years preceding this incident. The absence of rings among the wrecked adult Guillemots therefore suggests that they came from Colonsay. Strong additional support for this hypothesis is given by the fact that the prevailing southwesterly winds would have swept weakened birds from Colonsay into the Firth of Lorn and Loch Linnhe, just as was observed, and by the fact that so few Puffins were among the wrecked birds. Very few Puffins, if any, breed on Colonsay (Clarke & Clarke 1986), while on Treshnish they are present in large numbers. Large numbers of dead or dying birds were not found on Colonsay despite searches there (M. Hall-Gardiner *pers. comm.*). However, birds originating from the Colonsay auk colonies, which are at the extreme northwest of the island, would generally not have been washed ashore on the island's beaches by the southwesterly winds. The 1985 incident did not produce detectable effects on the Guillemot numbers breeding on Colonsay. A count in May 1985 gave 13,460 Guillemots and 1780 Razorbills (Clarke & Clarke 1986). In 1986, the same counters found 13,617 Guillemots and 1440 Razorbills (J. Clarke *pers. comm.*). Most of the Kittiwakes found dead were in immature plumage (about 12 months old). None of the Kittiwakes was ringed.

CAUSE OF DEATH OF WRECKED AUKS AND KITTIWAKES None of the wrecked birds was oiled, and independent examination of Guillemot and Razorbill carcases by A.R. Jennings and myself revealed no indications of disease or unusual numbers of parasites, confirming the results of examination of larger numbers of Guillemots from this wreck by Mudge *et al.* (1985b). These authors also showed that pesticides and mercury were present at background levels, but concluded that their findings did not fully exclude the possibility of pollutants or disease as the cause of some deaths. The dead Guillemots, Razorbills and Kittiwakes were emaciated. The subcutaneous and pelvic fat deposits, which would be present in well-nourished birds, were completely absent, the fat score being almost invariably zero for both deposits. The stomachs were almost always empty; in a very few Guillemots fragments of fish bones, including a pair of *otic bullae* from a clupeid fish, probably Herring *Clupea harengus*, were found. The body weights of the fully grown birds found freshly dead, when compared with normal summer body weights, suggest that the proximate cause of death was starvation (table 2). The body weights (g) of samples of Guillemot and Razorbill chicks found dead were (mean ± SD, number and range): Guillemot 242 ± 57(14) 168-360; Razor-

bill 186 ± 64(5) 135-270. Most of these weights are not unusually low for recently fledged chicks, since Guillemot chicks leave the ledges at *c.* 210-250 g and Razorbills at 180-220 g body weight (T. Birkhead *pers. comm.*). However, no attempt was made to relate auk chick body weight to an age-related measure such as bill length.

Table 2. Body weights (g) of fully grown birds: mean ± SD (n).
Tabel 2. Gewicht (g) van volgroeide vogels: gemiddelde ± SD (n).

	Birds found dead *Gevonden vogels*	Normal body weights[1] *Normaal gewicht*	
Guillemot	654 ± 103 (24)	860 ± 35 (23)	Zeekoet
Razorbill	459 ± 24 (5)	634 ± 46 (7)	Alk
Common Tern	108 ± 12 (5)	126 ± 10 (30)	Visdief
Kittiwake	241 ± 12 (4)	424 ± 50 (21)	Drieteenm
Gannet	2147 ± 127 (3)	3000 ± 450 (54)	Jan van Gent

[1]Cramp & Simmons 1977, 1983, Cramp 1985

DEATHS OF COMMON AND ARCTIC TERNS During incubation, adult tern weights were constant in the period 2-23 June : Common Tern 125.8 ± 7.5 g (n= 65), Arctic Tern 108.5 ± 6.4 g (n= 62). These values are similar to those reported in the literature: 126 ± 10 (30) and 107 ± 8 (5) respectively (Cramp 1985). Thus, there were no indications at that stage of food shortage or adult starvation. After hatching in mid- and late June, the first indications of chick starvation were obtained on 2 July at the largest colony in the study area, which held *c.* 250-300 pairs of Common Tern. Several of the smaller chicks then appeared to be very weak and emaciated. On 9 July at the same colony, large numbers of chicks were dead or dying. This sequence of events was observed in mid- to late July at all the colonies of Common and Arctic Terns within 75 km of Oban. The numbers of adults present at the colonies declined steadily until few or none remained by late July. In "good" years, adults remain at larger colonies in west Scotland until well into August.

CAUSE OF DEATHS OF TERN CHICKS The bill length/body weight relationship for healthy Common Tern chicks between hatching and fledging was obtained in the study area in 1982 and 1983, years in which food availability appeared adequate, since little or no starvation was observed (figure 2). Lines have been drawn to enclose 95% of the points, and these lines are drawn identically in figures 2, 3 and 4. The same quantities were obtained for live and

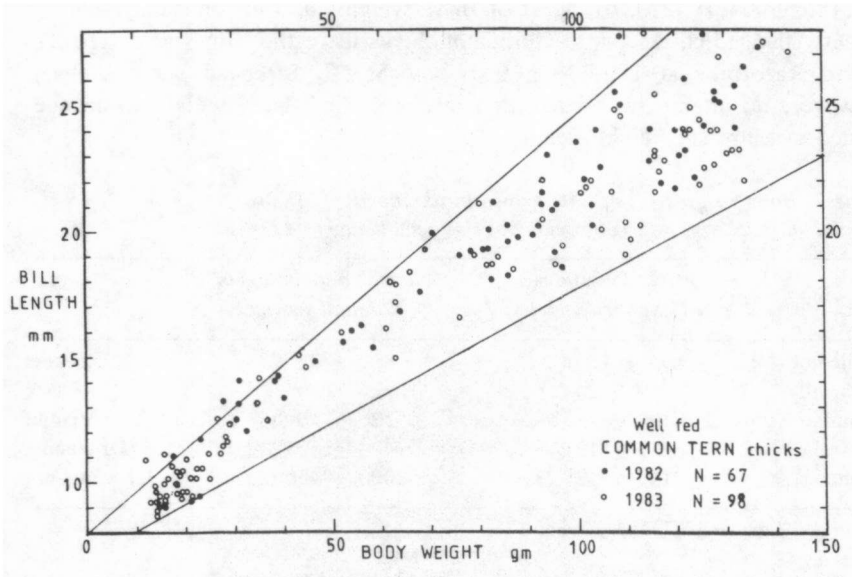

Figure 2. Bill-weight relationship for live and dead chicks in years of food abundance. Each point represents a different chick. Lines have been drawn to enclose 95% of the points. Compare with figures 3 and 4.

Figuur 2. Verband tussen snavellengte en gewicht van sternkuikens in jaren met een groot voedselaanbod.

dead chicks from the largest colony in mid-July 1985 (figure 3). Comparison with figures 2 and 4 shows that these body weights were very low, with many points falling outside the two lines representing well-fed chicks. This suggests that starvation was the cause of the deaths of the tern chicks. A similar pattern of reduced body weights was observed at a further four colonies between Fort William and Lochgilphead (table 3). The same quantities were obtained from one colony near Lochailort and two colonies near Loch Caolisport (figure 4). Comparison with figure 2 shows that these were normal body weights, most of them falling well inside the two lines. Starvation of tern chicks was confined to a zone between approximately 56° and 56°50'N. Immediately to the north and south of this zone, tern chicks did not die from starvation in unusual numbers (table 3). This zone of starvation of tern chicks coincides very closely with the area in which dead auks and Kittiwakes were being washed ashore at the same time. Small numbers of dead

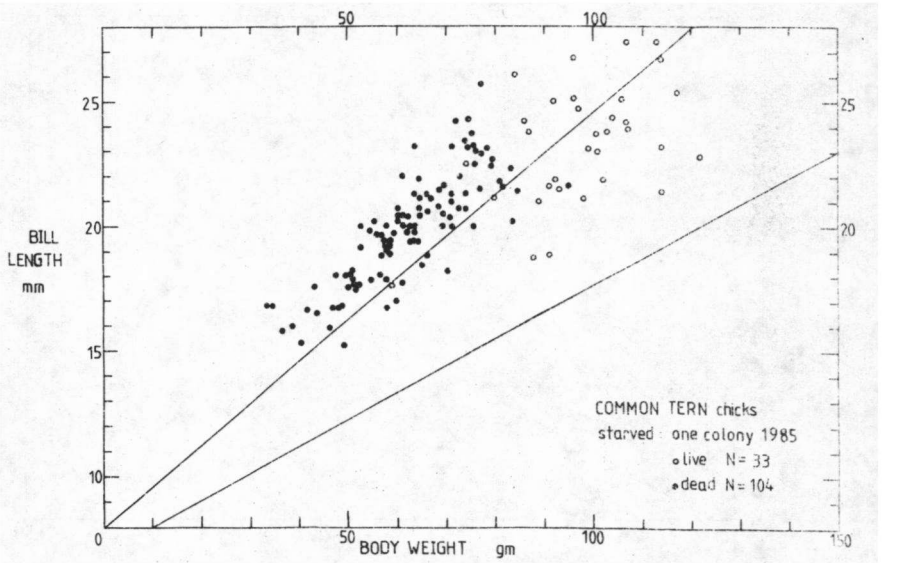

Figure 3. Bill-weight relationship for live and dead chicks from largest tern colony, mid-July 1985. Each point represents a different chick. The lines are those of figure 2 and enclose typical values for well-fed chicks. Similar results were obtained at the L. Linnhe, L. Etive, L. Feochan and L. Melfort colonies in July 1985.

Figuur 3. Verband tussen snavellengte en gewicht van sternkuikens in de grootste kolonie, half juli 1985. De lijnen zijn dezelfde als in figuur 2 en deze omsluiten de waarden voor goed doorvoede kuikens.

adult Common Terns were found at the breeding colonies during mid- to late July (included in table 2). Their weights suggest that adult terns also died of starvation, although the numbers found were small.

CAUSE OF STARVATION OF AUKS AND TERNS One of the few studies of the food of Guillemots in western Scotland (Swann & Ramsay 1986) showed that sandeels formed 33% and clupeids 46% of 89 food samples examined in 1981-1984, the remainder being mainly gadoids. Likewise, food brought by adult terns to colonies in the present study area was composed principally of sandeels, clupeids and gadoids in 1984 and 1986 (J.C.A. Craik). Such results resemble those reported for auks and terns elsewhere in the British Isles

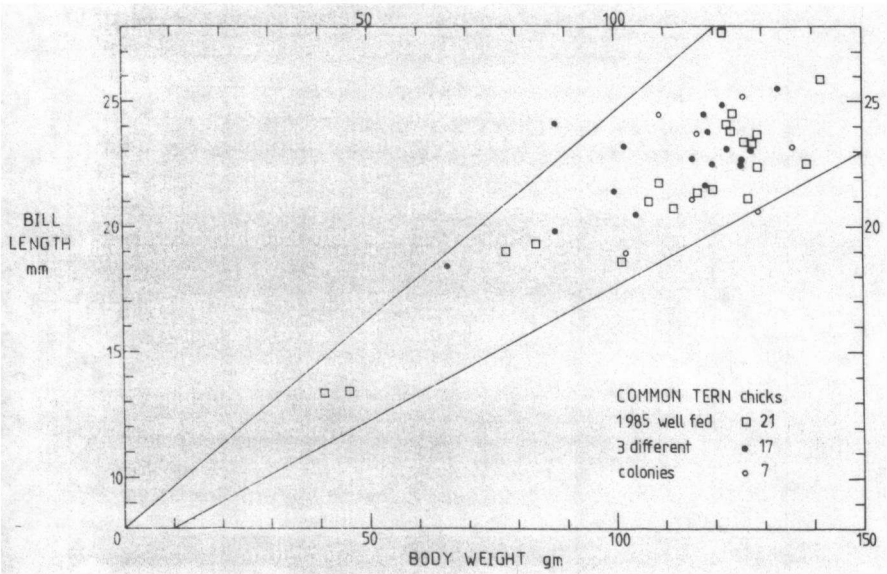

Figure 4. Bill-weight relationship for live chicks from three colonies in July 1985. (□ L. Ailort, ● L. Tarbert, ○ L. Caolisport). Each point represents a different chick. The lines are those of figure 2 and enclose typical values for well-fed chicks. Body weights were thus normal at these colonies which were just N and S of the starvation zone.

Figuur 4. Verband tussen snavellengte en gewicht van levende sternkuikens in juli 1985 (□ L. Ailort, ● L. Tarbert, ○ L. Caolisport). De lijnen zijn dezelfde als in figuur 2 en deze omsluiten de waarden voor goed doorvoede kuikens.

(Cramp 1985). There were reliable indications that in 1985 both sandeels and Herring were less abundant than usual in the Loch Linnhe area. In particular, the records of catches by beach-seine net deployed regularly throughout 1984 and 1985 show that no Herring and only 17 sandeels were caught in 1985, whereas in 1984 "many hundreds" of each were caught (R.N. Gibson *pers. comm.*) These catch data are supported by numerous anecdotal observations which indicated that the shoals of small Herring and sandeels, often numerous in sea lochs in summer, were scarce or absent near Oban in 1985. By contrast, 1984 was a highly successful breeding season in this area, particularly for Common Tern. At the largest tern colony in 1984, eggs were found until mid-August and chick mortality by starvation was very low. It is likely,

Table 3. Summary of tern chick mortality, July 1985, West Scotland. Each line denotes a separate colony. The purpose of this table is to show that chick weights were normal, and mortality light, both north and south of the zone of starvation.
Tabel 3. Overzicht van kuikensterfte in sternkolonies, juli 1985, in West-Schotland. Elke regel is een aparte kolonie. Uit de tabel blijkt dat de gewichten normaal en de sterfte gering is ten noorden en zuiden van het Loch Linnhe gebied.

Area (Lat N)	species[1]	clutches if counted	chicks dead & alive	chicks dead	weight larger chick[2]	starvation mortality[3]
Plaats	*soort*	*legsels*	*aantal kuikens*	*dode kuikens*	*gewicht van grote kuikens*	*sterfte*
Ailort (56°55)	C	-	83	6	normal	light
Linnhe (56°45)	C	-	26	15	reduced	heavy
Sunart (56°40)	C	44	0	-	-	failed
Mull (56°30)	C	250	589	253	reduced	heavy
Mull (56°30)	A	40	0	-	-	failed
Etive (56°28)	C	12	26	3	reduced	heavy
Etive (56°28)	C+A	25	25	-	-	failed
Etive (56°28)	A	15	1	-	-	failed
Feochan (56°20)	C	-	153	60	reduced	heavy
Luing (56°15)	A	50	27	3	-	failed
Melfort (56°15)	C	-	121	55	reduced	medium
Craignish (56°10)	C+A	24	0	-	-	failed[4]
Caolisport (55°55)	C+A	-	146	20	normal[5]	light
Tarbert (55°50)	C	-	86	8	normal	light

[1] C = Common Tern *Sterna hirundo*, A = Arctic Tern *S. paradisaea*

[2] weights of larger live chicks (bill >15mm) / *gewicht van kuikens met snavellengte > 15mm*

[3] 'failed' denotes eggs or small chicks present in June, but in July colony almost wholly deserted and no chicks found / *'failed' betekent mislukt; wel eieren of kuikens in juni, maar kolonie geheel verlaten in juli*

[4] total failure due to predation of incubating adults by North American Mink *Mustela vison* / *broedsels mislukt door predatie van Amerikaanse Nerts* Mustela vison

[5] heavy chick losses due to Otter *Lutra lutra* / *veel kuikens gepredeerd door Otter* Lutra lutra

therefore, that a local shortage of these small fish species was the reason for the bird deaths in 1985. This was undoubtedly exacerbated by the exceptionally high rainfall in July (see below).

METEOROLOGICAL AND HYDROLOGICAL CONDITIONS Rainfall, hours of sunshine, wind strength and sea temperature were not exceptional in spring and early summer. At the time of the incident in July, wind strength and sea temperatures were not unusual, and wind directions did not vary markedly from previous years. However the rainfall in July was the highest on record locally for that month (251 mm compared with 96, 43, 51, 76 mm in July of 1981-1984) and hours of sunshine were correspondingly reduced. The high rainfall and reduced solar radiation would have increased the calorific requirements of the chicks. However, the rainfall in July 1985 was exceptionally high throughout most of Scotland. The seabird deaths were confined to a limited area, implying that rainfall alone cannot have been the principal cause.

Discussion

Auk wrecks are not uncommon on British coasts and have been recorded regularly since the middle of the last century (*e.g.* Gibson 1970, Holdgate 1971, Underwood & Stowe 1984). However most recorded wrecks have taken place in autumn or winter when adverse conditions are perhaps to be expected. Two notable features of the auk wreck in the Firth of Lorn are that it occurred in July and that it took place at the same time and in the same limited area as an episode of near total mortality of tern chicks. Massive mortalities of tern chicks before fledging are likewise regularly recorded. Bent (1921) quotes descriptions from North America published in 1890, 1903 and 1905; for early British examples, see Galloway & Landsborough-Thomson (1914), Baxter & Rintoul (1916) and Marples & Marples (1934). These early records show that such events were normal, if infrequent, before the recent growth of industrial fisheries. Becker & Finck (1985) identified weather and food supply as the two most important factors which, in the absence of predation, determine breeding success in Common Tern.

The proximate cause of death in both groups appears almost certainly to have been starvation, and there was circumstantial quantitative evidence that this was brought about by a severe local shortage of both Herring and sandeels, the usually abundant small fishes on which the chicks of both auks and terns depend for most of their food. This condition must have been exacerbated by the exceptionally high rainfall in July which would have increased the demands for metabolic energy by the chicks (Ricklefs & White 1981). Unlike terns, auks are capable of feeding at considerable depths, and the auk starvation adds weight to the view that the food shortage was a genuine one, not merely a vertical redistribution of fishes in response to lowered salinity.

No reason can be established for the shortage of small fishes. Neither the chicks of auks or terns nor the immature auks, most of them in primary moult, would have been able to fly out of the starvation zone. The adult auks, however, would have had the means to leave the area. That many did not do so presumably reflects the fact that they remained attached to their offspring or colony until too weak to evade the consequences. More adult terns may have died than were found. Terns are more aerial than auks and, unlike auks, rarely swim. They may have responded to food shortage by airborne dispersal over a larger area. Unlike the dying auks, they would then not have been concentrated by wind onto certain beaches. This may explain the absence in this incident of numbers of dead adult terns from beaches and tern colonies.

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Samenvatting

Half juli 1985 trad een massale sterfte op van Zeekoeten, Alken en Drieteenmeeuwen op de kusten van de Firth of Lorn en Loch Linnhe (West-Schotland). Bijna alle jongen van elf kolonies Visdieven en Noordse Sterns in hetzelfde gebied stierven in diezelfde periode. Het leek erop dat al deze vogels door verhongering aan hun eind kwamen. Zowel zandspiering als Haring, die in sommige jaren talrijk in deze estuaria voorkomen, bleken zeldzaam of zelfs afwezig in de zomer van 1985. Zowel ten noorden als ten zuiden van het besproken gebied was nergens sprake van abnormale zeevogelsterfte en de gewichten van sternkuikens bevonden zich op normaal niveau, terwijl ook hun mortaliteit gering was. De conclusie luidt dan ook dat hier sprake was van een zeer lokale sterfte, veroorzaakt door een lokale en incidentele voedselschaarste.

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