

EARLY SPRING WRECK OF BLACK-LEGGED KITTIWAKES *RISSA TRIDACTYLA* IN NORTH NORWAY, APRIL 2003

ROBERT T. BARRETT¹, TERJE D. JOSEFSEN² & ANUSCHKA POLDER³

Barrett, R.T., Josefsen, T.D. & Polder, A. 2004. Early spring wreck of Black-legged Kittiwakes *Rissa tridactyla* in North Norway, April 2003. *Atlantic Seabirds* 6(2): 33-45. *Large numbers of dead Black-legged Kittiwakes Rissa tridactyla were washed ashore in North Norway in late April 2003. Inspection of 51 corpses indicated that they had died of starvation. More than 90% of those collected were males. Coincidental with the wreck were reports of many of the large colonies in the region being temporarily abandoned at a time when birds would normally be starting to breed. It seems that North Norwegian Black-legged Kittiwakes are dependent on the annual spring spawning migration of Capelin Mallotus villosus along the coast of Finnmark. In 2003, however, the stock was low and spawning took place exceptionally far west, forcing the birds to leave their colonies in their search for food. When small amounts of Capelin appeared along the Finnmark coast in mid-May the kittiwakes returned to their colonies and breeding proceeded as normal. This episode was unusual as the victims of starvation wrecks are usually auks, not kittiwakes.*

¹ Department of Zoology, Tromsø University Museum, N-9037 Tromsø, Norway;

² National Veterinary Institute, Stakkevollveien 23b, NO-9292 Tromsø, Norway;

³ Norwegian School of Veterinary Science, PO Box 8146, dep 0033 Oslo, Norway. E-mail: robb@tmu.uit.no

INTRODUCTION

Between 25 and 29 April 2003, reports were received of dead and dying Black-legged Kittiwakes *Rissa tridactyla* on the shore and on the sea at various localities along the coast of Troms, North Norway (Fig. 1). These were accompanied by observations of uncharacteristic behaviour, such as birds with "uncoordinated flight", "tame" birds landing on fishing boats, and of boats steaming through rafts of "sick" kittiwakes. Both the "tame" and "sick" birds were reported as being "easily caught by hand". How many died or were sick is unknown, but one anecdotal report suggested that "thousands" were affected.

The reports of dead and dying birds were soon followed by those of many kittiwake colonies in Finnmark (see Fig. 1), including Eidvågen (3,000 pairs; Strann & Vader 1986), Ranvika (5,000 pairs; Barrett 2003), Sværholt (25-50,000 pairs; Tromsø Museum, unpubl. data) and the largest in the country,

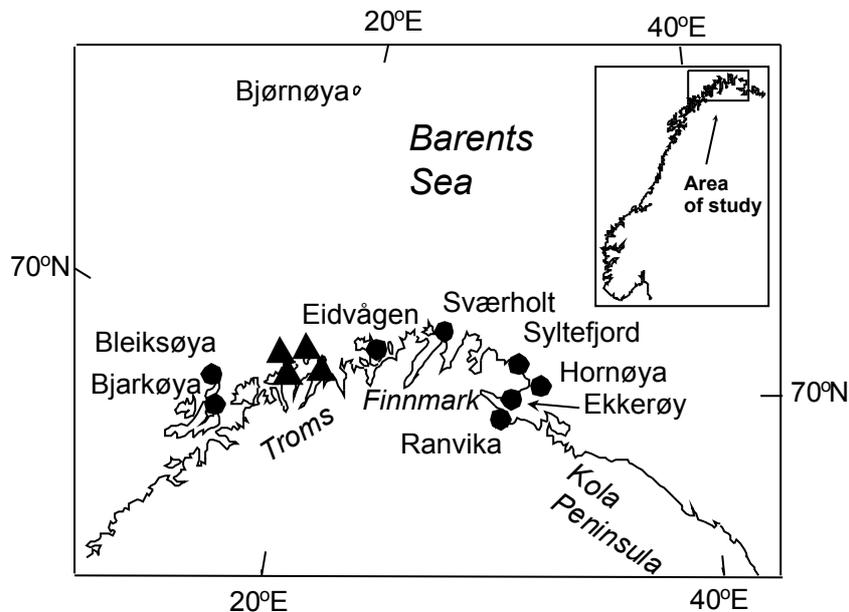


Figure 1. Map of North Norway and the south-west Barents Sea showing seabird colonies mentioned in the text (dots) and sites where dead or sick kittiwakes were seen or collected (triangles, clockwise from top left: Torsvåg, Nord-Fugløy, Badderøya, Dåfjord).

Figuur 1. Kaart van Noord-Noorwegen en de zuidwestelijke Barentssee met de kolonies die in de tekst genoemd worden (stippen) en plaatsen waar dode of zieke Drieteenmeeuwen werden gezien of verzameld (driehoeken, vanaf linksboven met de klok mee: Torsvåg, Nord-Fugløy, Badderøya, Dåfjord).

Syltefjordstauran (140,000 pairs; Stougie *et al.* 1989) being abandoned in late April-early May. The captain of one of the coastal steamers that daily travels the whole coastline reported on 29 April that seabirds had "deserted" the coast of Finnmark and he, and the harbourmaster at Vardø, reported a complete lack of the usual hectic fishing activity among seabirds in the region. In a colony on Hornøya, East Finnmark, where daily observations began on 16 April, numbers of kittiwakes on the cliffs dropped from "normal" (the colony is estimated to number 15-20,000 pairs, *pers. obs.*) on the first day to no birds between 18 and 28 April, none to "few" between 29 April and 15 May, and "normal" again from 16 May (Vincent Staszewski, *pers. comm.*). Common Guillemots *Uria aalge* and Atlantic Puffins *Fraterecula arctica* also abandoned the colony between 19

and 25 April and again on 4-5 May. At Ekkerøy and Eidvågen, kittiwakes were reported as having returned on 2 and 3 May respectively.

This study aims to determine the cause of the mass mortality of kittiwakes, the cause of the temporary abandonment of the colonies, and the provenance of the dead birds (i.e. where they would have bred).

METHODS

Collection and examination of corpses Soon after the first reports of dead kittiwakes were received, a plea was made via the media for birds to be collected and delivered to Tromsø Museum or the National Veterinary Institute, Tromsø. This resulted in a sample of 51 birds, six of which were collected at Torsvåg and five at Dåfjord (including three that were shot) on 28 April; a further three were collected at Badderøen on 30 April. These 14 birds underwent a complete autopsy at the National Veterinary Institute, including external measurements and weighing, macroscopic inspection of internal organs, search for gastrointestinal parasites, histological examination of liver, heart, lungs, brain and skeletal muscle, and cultivation of bacteria from liver, lungs and kidney. Levels of PCB, HCB and pp-DDE residues in the brain of the six Torsvåg individuals were measured at the accredited laboratory (Norwegian Standard NS-EN and ISO/IEC guide 17025, test 051) at the Norwegian School of Veterinary Science, Oslo, using standard methods.

The remaining 37 corpses were collected at Torsvåg on 4 May and brought to Tromsø Museum where external body measurements and weights were taken before they were deep frozen. The birds were later skinned, their sex determined by gonad inspection, and the subcutaneous and body cavity fat deposits scored (on a scale of 0 = no fat to 3 = much fat; Jones *et al.* 1982).

External measurements included wing length (maximum flattened chord \pm 0.5 mm using a stopped ruler), culmen length and gonys depth (\pm 0.1 mm using Vernier callipers), and total head length (head + bill \pm 0.5 mm using callipers described by Coulson *et al.* 1983). Corpses (excluding waterlogged specimens) were weighed to the nearest 1 g using an electronic balance.

Origin of the birds Because Black-legged Kittiwakes vary in size across their breeding range with a general increase in size with increasing latitude (Sluys 1982, Barrett *et al.* 1985, Weir *et al.* 1996), the measurements of birds collected during the incident were compared with those of birds collected at various colonies and sites in North Norway and the Barents Sea. This was supplemented by the data from one ringed bird found among the wrecked specimens.

Table 1. Mean mass and body measurements of adult Black-legged Kittiwakes wrecked in North Norway, April-May 2003.

Tabel 1. Gemiddeld gewicht en lichaamsmaten van adulte Drieteenmeeuwen die april-mei 2003 in Noord-Noorwegen waren gestrand.

		Males	Females	All
Mass (g) ¹	mean	279.1	250.6	275.5
	SD	19.7	23.2	22.0
	N	35	5	40
Wing (mm)	mean	324.1	313.7	322.7
	SD	7.0	5.9	7.6
	N	41	6	48
Culmen (mm)	mean	37.7	35.6	37.3
	SD	1.1	2.1	1.5
	N	41	7	49
Gonys (mm)	mean	11.7	11.3	11.7
	SD	0.6	0.2	0.6
	N	31	5	36
Head + bill (mm)	mean	94.0	89.1	93.2
	SD	2.2	19.7	2.8
	N	41	7	49

¹Excluding juvenile, shot or waterlogged birds.

Table 2. Levels (ppb or µg/kg wet weight) of five PCB congeners, HCB and pp-DDE and % fat in the brains of six Black-legged Kittiwakes found dead in North Norway on 28 April 2003.

Tabel 2. Gehalte (ppb of µg/kg nat gewicht) van vijf PCB-typen, HCB en pp-DDE en vetpercentage in de hersens van zes Drieteenmeeuwen die op 28 april 2003 in Noord-Noorwegen dood waren gevonden.

	Bird no.						Mean	SD
	252	253	254	255	256	257		
PCB-118	134.1	168.2	138.5	294.1	174.4	203.3	185.4	59.0
PCB-153	633.2	734.8	450.0	1428.9	416.9	578.0	707.0	373.0
PCB-138	362.8	443.2	295.4	934.9	293.7	387.7	453.0	242.9
PCB-180	182.5	189.1	116.8	347.6	93.3	135.8	177.5	91.2
PCB-170	59.9	72.4	40.5	145.2	37.2	51.1	67.7	40.1
ΣPCB	1372.6	1607.8	1041.1	3150.7	1015.5	1355.9	1591.0	796
HCB	201.4	157.3	153.4	199.5	187.0	189.1	181.3	20.9
pp-DDE	43.4	120.6	82.7	296.0	235.5	126.2	150.7	95.9
% fat	5.0	7.8	7.7	7.4	7.6	7.1	7.1	1.1

RESULTS

Age and sex All but two of the birds were in adult plumage. The exceptions were immature birds. Of 50 birds whose sex was determined, 43 (86 %) were males and 7 (14 %) were females.

Body condition The mean body mass of 40 individuals was 275.5 ± 22.1 g (range 220-346 g, Table 1).

With the exception of the three shot birds, the 11 that underwent a complete autopsy were extremely emaciated with very little subcutaneous and no body cavity fat. There were no food remains in any of the alimentary canals, and the breast muscles were very atrophied, dark and dry. Gastrointestinal parasites were absent in nine, present in small numbers in four and present in moderate numbers in one of the autopsied birds. Bacterial cultivation from liver, lungs and kidneys was negative. Histological examination of liver, kidney, heart, lungs and brain revealed no abnormalities apart from relatively large amounts of haemosiderin (a pigment composed of colloidal ferric oxide formed by the breakdown of haemoglobin and indicative of muscle atrophy) in the liver. The body masses of the three shot birds were 309 g, 392 g, and 366 g.

The mean subcutaneous and body cavity fat scores of the remaining 37 birds were 1.0 ± 0.2 and 0.1 ± 0.5 respectively.

Organochlorine residues Relatively high levels of residues of five PCB congeners (PCB 118, 138, 153, 170 and 180), HCB and pp-DDE were found in the brains of six birds (means = 1591.0 ± 796.0 , 181.3 ± 20.9 and 150.7 ± 95.9 $\mu\text{g}/\text{kg}$ wet weight respectively, Table 2).

Origin of the birds Only male birds were used in the analyses due to the low numbers of females in the sample of wrecked birds. The mean head lengths of the wrecked birds were similar to those of males measured on Bleiksøya and Hornøya during the breeding season, but shorter than those of birds caught east of Bjørnøya soon after the breeding season (ANOVA, $F_{3,127} = 3.4$, $P = 0.02$, Fisher's pairwise comparison, Fig. 2). There were no differences in their mean wing lengths (ANOVA, $F_{3,132} = 1.5$, $P = 0.21$). The recovery of a bird ringed as a breeding adult on Hornøya in 2002 again suggests strongly that the dead birds were breeding birds from Finnmark.

DISCUSSION

How did the kittiwakes die? It is most likely that the birds died of starvation. The mean body mass of the birds found (275.5 g) was only *ca.* 60% of that of

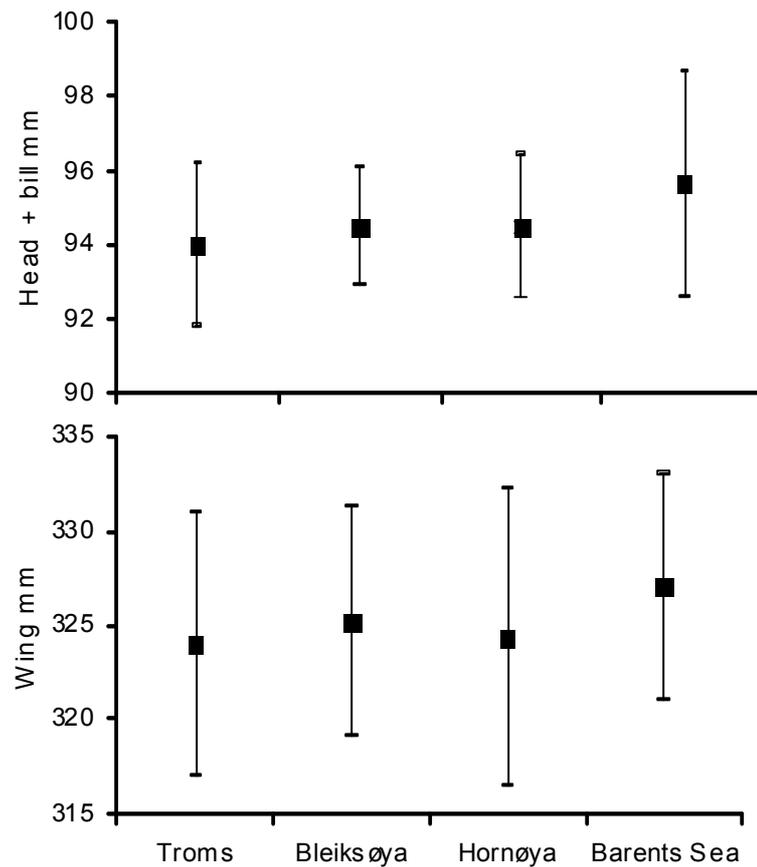


Figure 2. Mean (± 1 SD) body measurements of 41 male Black-legged Kittiwakes found dead in Troms in April-early May 2003 compared with those of male birds measured in colonies in North Norway (Bleiksøya ($n = 20$), Hornøya ($n = 32-35$) or collected in the Barents Sea (east of Bjørnøya between $74-75^{\circ}$ N, $23-29^{\circ}$ E, $n = 40-42$) during or soon after the breeding season (Source: RTB, unpublished data).

Figuur 2. Gemiddelde lichaamsmaten (± 1 SD) van 41 mannelijke Drieteenmeeuwen die april-mei 2003 in Troms dood waren gevonden, vergeleken met maten van mannetjes die tijdens of vlak na het broedseizoen waren gemeten in Noord-Noorwegen (Bleiksøya ($n = 20$), Hornøya ($n = 32-35$) of in de Barentssee ($n = 40-42$) op zee ten oosten van Bjørnøya tussen $74-75^{\circ}$ N, $23-29^{\circ}$ E. (Bron: RTB, ongepubl. data).

Black-legged Kittiwakes weighed in the region at the same time of year (when birds are building up body reserves prior to breeding, e.g. at Bleiksøya 465.0 ± 41.6 g, $n=24$, and at Hornøya 456.2 ± 38.2 g, $n=29$; RTB unpublished data). Furthermore, the almost complete lack of fat deposits was in sharp contrast to the condition of apparently healthy birds shot off Bleiksøya in mid-April 1986. These birds had mean subcutaneous and body cavity fat scores of 2.6 ± 0.6 and 1.8 ± 0.1 respectively (RTB unpublished data). The low parasite burden and the absence of bacterial pathogens exclude parasitic and bacterial diseases as contributing causes of death.

The levels of organochlorine residues in the brains of six birds were 10-20 times higher than those previously found in brains of apparently healthy North Norwegian kittiwakes (*ca.* 50-170 $\mu\text{g}/\text{kg}$ for ΣPCB and *ca.* 8 $\mu\text{g}/\text{kg}$ for HCB; Savinova *et al.* 1995, Henriksen *et al.* 1996). Although the redistribution of organochlorines as a result of the mobilization of fat during the period of starvation might contribute to impaired viability (Ingebrigtsen *et al.* 1984, Henriksen *et al.* 1996), the levels recorded here were much lower than those associated with illness or death found in other studies. For example, Gabrielsen *et al.* (1995) recorded much higher levels of ΣPCB , HCB and pp-DDE (means = $14\,800 \pm 10\,000$, 655 ± 388 and 2798 ± 1633 $\mu\text{g}/\text{kg}$ respectively) in the brains of 12 dead Glaucous Gulls *Larus hyperboreus* on Bjørnøya, but concluded that the PCBs only may have contributed to their death. Similarly, approximately the same levels of PCB and DDE (mean = 2020, maximum 60 000, and mean = 470, maximum 9700 $\mu\text{g}/\text{kg}$, respectively) in the brains of 37 dead Great Northern Divers *Gavia immer* were not associated with their death (Stone & Okoniewski 2001). Furthermore, Dahlgren *et al.* (1972), Sileo *et al.* (1977) and Stickel *et al.* (1984) suggest that lethal brain levels are as high as 300 000 $\mu\text{g}/\text{kg}$ for both ΣPCB and DDE, i.e. at levels several orders of magnitude higher than found here.

Origin of the birds It is unlikely that the desertion of the colonies in Finnmark at the same time as the wreck was coincidental; based on body measurements and the recovery of a Hornøya bird, it seems that most of the wrecked birds originated from colonies in Finnmark. Of the nearly 1,000,000 pairs of Black-legged Kittiwakes that breed in the Barents Sea region, approximately 50% breed in Finnmark (Barrett & Tertitski 2000). Outside the breeding season, they disperse over the whole North Atlantic and some into the Mediterranean Sea (Barrett & Bakken 1997, Nikolaeva *et al.* 1997, Bakken *et al.* 2003) but return and occupy the breeding colonies in late March-early April. An observation on *ca.* 28 April, i.e. at the time of the wreck, of a fully occupied colony (*ca.* 2,000 pairs) on Bjarkøy (Fig. 1), with no dead birds in the neighbourhood, suggests that only the northerly populations were involved.

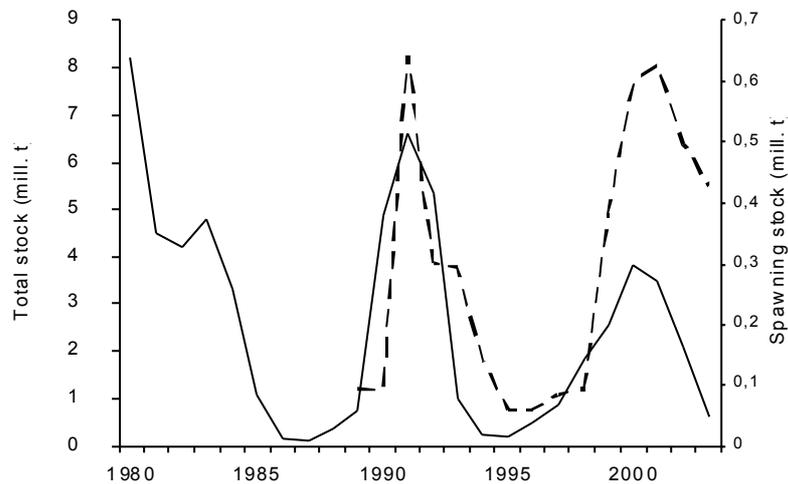


Figure 3. Estimates of total biomass (solid line) and median value of the modelled stochastic spawning stock (broken line) of capelin in the Barents Sea, 1980-2003. (Source: ICES 2003).

Figuur 3. Schatting van de totale biomassa (doorlopende lijn) en mediane waarde van de gemodelleerde stochastische populatie (onderbroken lijn) van Lodde in de Barents Sea, 1980-2003. (Bron: ICES 2003).

Why did the birds starve? There are many reports of seabird wrecks from the North Sea and one recent one (March/April 2002) from central Norway, but in most instances the victims have usually been auks *Alcidae* (Underwood & Stowe 1984, Weir *et al.* 1996, Anker-Nilssen *et al.* 2003). The main cause of death in all cases was starvation, generally as a result of poor weather preventing birds feeding.

As far as we are aware, this episode is only the second known wreck involving kittiwakes alone. The first was on the south-west coast of Britain in January and February 1957, when many birds were found dead or with symptoms very similar to those recorded here ("tame", "tired", "lethargic", etc.; McCartan 1958). *Post-mortem* examinations of the British birds also showed severe starvation as the cause of death but, in contrast to the present episode, this was probably the result of prolonged gales in the North Atlantic carrying the birds away from their regular feeding grounds (McCartan 1958).

Another winter incident in Shetland in 1993 also involved storm-driven birds, but the situation then was exacerbated by oiling from the wreck of the *Braer*, 94% of the recovered birds being reported as oiled (Weir *et al.* 1996).

This is the second seabird wreck due to starvation reported in North Norway. The first was in January 1987 when thousands of dead Common Guillemots, which usually winter in the southern Barents Sea, were reported washed ashore in Finnmark (Vader *et al.* 1990). In common with the present kittiwake wreck, the guillemots were emaciated and their death was attributed to starvation. It was proposed that this was a result of a sudden collapse in 1986/87 in the stock of Barents Sea capelin *Mallotus villosus*, the main food item of the guillemots (Fig. 3).

Of all demographic parameters, adult survival is considered to be the most strongly buffered against effects of food shortage such that significant mortality as reported here and in the Barents Sea in 1987 would occur only when food is extremely scarce or when severe weather prevents the birds from feeding (Hudson 1985, Cairns 1987, Furness & Camphuysen 1997). In both the present case and the guillemot wreck of 1987, weather conditions were not exceptional (*pers. obs.*, <http://weather.cs.uit.no>) and may be ruled out as the proximate cause of death.

Long-term studies in East Finnmark have suggested that Black-legged Kittiwakes are much more dependent than guillemots and other auks on capelin as a food source during the breeding season (Krasnov & Barrett 1995, Barrett 2003). In April 2003, the total stock of the Barents Sea capelin was very low, and the springtime migration of the spawning stock (which was also declining, Fig. 3) was much further westward than normal, with very few appearing on the traditional spawning grounds along the northern Finnmark coast. Instead, it seems that the majority spawned along the southern coast of Troms and as far west as Bleiksøya (Fig. 1; T. Pedersen, H. Gjørseter, *pers. comm.*). The large concentration of seabird colonies in Finnmark is probably dependent on the annual movement of capelin to the coast prior to and during the breeding season as a food source (Krasnov & Barrett 1995, Barrett & Krasnov 1996, Gjørseter 1998). In 2003, the absence of capelin probably caused the birds to temporarily abandon their colonies at the end of April and to forage much further from their breeding sites than usual. This is a time when egg laying has normally started or is about to start, and established sites are rarely left unattended (Barrett 1978, 1989). These birds would probably have remained in the colonies as long as possible but, as their body condition deteriorated, they had to leave in search of food. Observations of the occupied colony with no dead birds at Bjarkøy, which was close to the capelin spawning area, support this possibility. Although the capelin stock was also very low in the mid-1990s (Fig. 3), spawning occurred further north and east in Finnmark and closer to the main breeding colonies, and presumably supported the food demands of the kittiwakes.

The dominance of males among the wrecked birds in this incident is in contrast to the dominance of female (up to 70%) Black-legged Kittiwakes that

died in Shetland in January 1993 (Weir *et al.* 1996), and suggests different behaviour patterns between the sexes early in the breeding season. Gabrielsen (unpublished data, *pers. comm.*) found that male Black-legged Kittiwakes may attend the nest for as long as 5-6 days and twice as long than females just before egg laying. It is possible therefore that the males in Finnmark remained longer than the females in the colonies (to defend their nest sites after the females had left) such that they were in poorer condition when they finally left. It is also possible that females at this time of the season would have built up body reserves prior to egg laying, thereby giving them a better chance of survival.

Unpublished studies suggest that, in the absence of food, adult kittiwakes in normal pre-breeding body condition would exhaust all body reserves within 5-8 days (G.W. Gabrielsen, *pers. comm.*). Those that waited too long in the Finnmark colonies would probably have been too weak to forage efficiently when they finally reached the capelin in Troms, and subsequently succumbed.

At the time of the wreck there were reports of apparently starving kittiwakes ignoring dead capelin that were floating on the sea surface in the area of the wreck. These are fish that die after spawning (Gjøsæter 1998). In subsequent conversations with fishermen, this paradox was corroborated by their reports of gulls *Larus* spp. also avoiding these fish during the capelin spawning season. Why these fish were not eaten is unknown.

Kittiwakes probably survived the capelin shortage in the 1986/87 winter in that the few that were not dispersed outside the Barents Sea were either able to move quickly to richer feeding grounds or survived on, for example, crustaceans that not suitable for auks. The following breeding season, however, was for many species in Finnmark one of complete or very nearly complete breeding failure, again suggesting insufficient movement of capelin into coastal waters in 1987 (Vader *et al.* 1987, Gjøsæter 1998). By 1989, however, when the capelin stock had recovered only slightly and was still very low, breeding success was again normal (Barrett & Furness 1990).

By mid-May 2003, all colonies in Finnmark that had been abandoned were reoccupied, and breeding proceeded, albeit a little late. This coincided with reports of small amounts of capelin spawning in East Finnmark (H. Gjøsæter, *pers. comm.*). On Hornøya, kittiwakes started to lay 2-3 weeks later than usual, around 1 June (RTB, *pers. obs.*), although mean clutch size reached 1.4 eggs/nest (SD = 0.83, $n=845$ nests), which is normal for the colony (mean for 21 years = 1.4 eggs/nest, RTB, unpublished data). As in 1987, however, fledging success was very low as a result of chick starvation (RTB, *pers. obs.*, T. Boulinier, *pers. comm.*). Although not monitored in detail, the 2003 kittiwake breeding season on Bjørnøya was rather poor, with fewer pairs than usual laying eggs, and low breeding success (H. Strøm, *pers. comm.*). Furthermore, there

was a report in June from a whaling vessel operating east of Bjørnøya of kittiwakes in poor condition landing on deck, where some even laid eggs!

Although annual monitoring counts at two colonies in Finnmark, on Bjørnøya and in Svalbard, revealed lower numbers of apparently occupied nests, it is very difficult to attribute this to the wreck as population trends had been declining in all colonies since the mid-1990s (Lorentsen 2003).

This wreck emerges as yet another example of the consequences of the breakdown in the normal trophic interactions between prey fish and seabirds. A strong association between capelin spawning behaviour and seabirds, particularly Black-legged Kittiwakes, has also been reported from Newfoundland, where delays in the capelin spawning movements adversely affected chick production (Massaro *et al.* 2000, Jamieson *et al.* 2000, Carscadden *et al.* 2002, Davoren & Montevecchi 2003).

VOORJAARSSTRANDING VAN DRIETEENMEEUWEN *RISSA TRIDACTYLA* IN NOORD-NOORWEGEN, APRIL 2003

In Noord-Noorwegem spoelden eind april 2003 grote aantallen dode Drieteenmeeuwen *Rissa tridactyla* aan. Onderzoek aan 51 kadavers gaf aan dat deze dieren door voedselgebrek gestorven zijn. Meer dan 90% van de verzamelde kadavers waren mannetjes. Ten tijde van de stranding kwamen ook berichten door dat veel grote kolonies in Noord-Noorwegen tijdelijk verlaten waren en dat in een tijd dat vogels normaaliter met broeden zouden beginnen. Het lijkt erop dat Noord-Noorse Drieteenmeeuwen afhankelijk zijn van de jaarlijkse voorjaarstrek gericht op het kuit schieten van Lodde *Mallotus villosus* langs de kust van Finnmarken. In 2003 was de populatie echter klein en kuit schieten vond uitzonderlijk ver in het westen plaats, waardoor vogels in hun zoektocht naar voedsel gedwongen waren om de kolonies te verlaten. Toen kleine aantallen Lodde half mei langs de kust van Finnmarken opdoken keerden Drieteenmeeuwen terug naar hun kolonies en verliep het broedproces verder normaal. De beschreven stranding was uitzonderlijk, omdat alkachtigen gewoonlijk slachtoffer worden van voedselgebrek, geen Drieteenmeeuwen.

ACKNOWLEDGEMENTS

We thank the many members of the public who sent reports of dead, dying or strangely behaving birds and abandoned colonies, Per Olav Akselsen (County Governor, Troms) for organizing the collection of some of the birds, and Håkon Dahlen and Stefan Hügel (Tromsø Univ. Museum) for their help in the laboratory. Special thanks go to Beate Carolin at the Norwegian School of Veterinary Medicine for the organochlorine analyses, and to ICES for permission to use data from one of their reports. Thanks too to Harald Gjørseter (Institute of Marine Research, Bergen), Torstein Pedersen (Norwegian College of Fishery Science, Tromsø), Hallvard Strøm and Geir W. Gabrielsen (both Norwegian Polar Institute), Vincent Staszewski (University of Paris) and Tycho-Anker-Nilssen (Norwegian Institute for Nature Research), all of whom contributed unpublished data or observations and/or commented on an earlier draft of the manuscript.

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TEMPORAL COMPARISONS IN FEEDING ECOLOGY AND GROWTH OF YOUNG COMMON GUILLEMOTS *URIA AALGE*

SABINA I. WILHELM^{1,3} AND ANNE E. STOREY²

Wilhelm, S.I. & Storey, A.E. 2004. Temporal comparisons in feeding ecology and growth of young Common Guillemots *Uria aalge*. *Atlantic Seabirds* 6(2): 47-64. *Short and long-term changes in feeding ecology of Common Guillemots Uria aalge breeding in Witless Bay, Newfoundland, were investigated across three consecutive breeding seasons (1998-2000) and across decades (late 1970s to mid 1980s versus 1998-2000). The relationship between feeding rates and two chick growth parameters (mass and wing length) was also examined. From 1998-2000, observations were focused on the same subset of colour-ringed guillemots. Chick provisioning rates were highly variable within and across seasons. In all years, young guillemots were fed primarily medium-sized Capelin Mallotus villosus. In 1999 and 2000, their diets were supplemented with sandeel Ammodytes spp. Chick mass did not differ across years, however, a positive relationship existed between feeding rates and chick mass. Although no relationship was found between feeding rates and wing length, chicks reared in 2000 had longer wings than same aged chicks reared in 1998 and 1999. During unfavourable breeding conditions, wing growth may be prioritized to allow earlier departure. Overall, the diet and condition of Common Guillemot chicks reared in Witless Bay are similar to those reported in the 1970s and 1980s, despite important changes in Capelin biology and distribution in the Northwest Atlantic.*

¹Cognitive and Behavioural Ecology Programme, Department of Psychology, Memorial University of Newfoundland, St. John's, NL, A1B 3X9, Canada; e-mail: sabina.wilhelm@ec.gc.ca ²Department of Psychology, Memorial University of Newfoundland, St. John's, NL, A1B 3X9, Canada. ³Current address: 45 Alderney Drive, 16th floor (mailing)/7th floor (office), Dartmouth, NS, B2Y 2N6, Canada.

INTRODUCTION

In the spring, many seabirds return to land to breed, often in large dense colonies. Off the east coast of Newfoundland, this spatial and temporal clustering of birds is generally timed to coincide with the inshore arrival of spawning Capelin *Mallotus villosus*, the main prey fed to many seabird chicks (Massaro *et al.* 2000; Davoren & Montevecchi 2003). Prior to 1990, Capelin was the primary prey item for Common Guillemots *Uria aalge* breeding in Labrador (Birkhead & Nettleship 1987), but following a sharp decline in Capelin abundance, chicks were fed primarily Daubed Shannies *Lumpenus maculatus* (Bryant *et al.* 1999). This diet shift had no apparent effect on chick

feeding rates and growth, although adults were exhibiting high foraging effort as shown by low co-attendance time at the colony (Bryant *et al.* 1999).

The impact of changes in Capelin biology is of growing concern on Common Guillemots and other seabirds breeding off the east coast of Newfoundland. There is evidence that Capelin abundance may have decreased since the 1980s while Capelin size and condition declined throughout the 1990s (reviewed in Carscadden *et al.* 2002). In 1991, inshore migration and spawning of Capelin was delayed due to unusually cold sea temperatures (Carscadden *et al.* 1997). Sea temperatures subsequently returned to normal, but delayed inshore spawning persisted at least to the 2000 season, presumably because of the smaller size of the fish since smaller Capelin spawn later (Carscadden *et al.* 1997; Carscadden *et al.* 2002).

The Witless Bay Ecological Reserve, off the south-east coast of Newfoundland, has approximately 100,000 breeding pairs of Common Guillemots on three islands: Gull, Green and Great Island (Robertson *et al.* 2004; Canadian Wildlife Service, unpubl. data). During the late 1970s, guillemot chicks on Gull Island were fed mostly Capelin (97%) with the remainder of their diet consisting of sandeel *Ammodytes* spp (Mahoney 1980), whereas in 1982-1985, chick diet while still primarily Capelin, included 9% sandeel (Burger & Piatt 1990). In the latter study, hydroacoustic data showed that Capelin abundance varied during the chick-rearing period in two of the four years. Low Capelin abundance resulted in higher foraging effort and, in at least one year, to lower Capelin but higher sandeel proportions in the chicks' diet. Chick feeding rates and breeding success did not vary across years, suggesting that parents were able to compensate for reduced Capelin abundance by increasing their foraging effort and/or bringing in more sandeel to the chicks (Burger & Piatt 1990).

Common Guillemots breeding on Great Island, 7.5 km south of Gull Island, showed variable foraging effort and chick feeding rates within and between the 1998, 1999, and 2000 seasons (Wilhelm 2004). Despite high foraging effort, parents fed the chicks at low rates during early chick rearing in 2000, suggesting that prey availability was low, presumably due to the late arrival of spawning Capelin (Wilhelm 2004). In 1999, however, adults fed chicks at high rates with lower foraging effort compared to the other years, due to chicks hatching after the inshore arrival of spawning Capelin and/or higher sandeel availability around the breeding colonies (Wilhelm 2004).

This study investigated changes in guillemot chick feeding rates, prey type and size across the chick-rearing period in three consecutive years (1998-2000). Our results were compared with those from earlier studies in the area. Chick growth is directly linked to the amount of food parents bring to their young (Harris 1978). The relationship between feeding rates and two chick

growth parameters (mass and wing length) was examined within and across years, and in comparison to other Common Guillemot colonies.

MATERIALS AND METHODS

This study was conducted on a group of Common Guillemots nesting on Great Island (47°11'N, 52°49'W), Newfoundland, Canada, from June to August 1998-2000. Continuous observations from dawn (first light after 04:30 h) to dusk (last light before 21:30 h), were made on 11 days in 1998 (175.8 hr total), 15 days in 1999 (238 hr total) and 12 days in 2000 (190.8 hr total). Guillemots were individually colour-ringed and breeding sites were easily viewed from the blind. Some adults had been previously marked with a Canadian Wildlife Service metal band in the 1980s (D. Cairns, *pers. comm.*) and were observed to be rearing chicks up to 2003. Breeding success (fledged chicks/eggs laid) was monitored in 1999 and 2000 and was generally high (75% and 79% respectively; Wilhelm & Storey 2002).

Chick provisioning rates and diet composition Number of daily chick feeds, type and size of prey were determined by direct observation of fish being carried in the bill by adults and delivered to the chick. In 1998, fish species were identified as "Capelin" or "other". During the second half of the 1998 chick-rearing period, "other" fish were primarily identified as sandeel. In 1999 and 2000, fish species were identified as "Capelin" or "sandeel". Fish sizes were estimated by the length of fish (including tail) protruding from the bird's bill tip upon its arrival at the nest site and designated to one of three size classes: small (< 3 cm of fish length protruding from bird's bill), medium (3-6 cm) and large (> 6 cm). Diet composition was investigated across Julian date and in relation to age of chick.

Chick body mass and wing length Body mass (± 1 g, with a 300 g Pesola spring scale) and wing length (± 1 mm, from the carpal joint to the tip of the longest primary covert, with a ruler) were obtained once from chicks aged 12-20 d in each year (1998: $n = 13$, 1999: $n = 14$, 2000: $n = 18$). The hatching date of a chick was determined by observing the actual hatching ($n = 15$), by seeing a chick at a site where there had not been a chick on the previous observation day ($n = 24$) or by counting forward the mean incubation period (33 days, *pers. obs.*; $n = 7$) from the date the egg was laid.

Data analysis Chick feeding rates were analysed for 23 pairs in 1998, 20 pairs in 1999, and 26 pairs in 2000. However, sample sizes varied across the chick-rearing period as a function of hatch dates, colony departure dates, and the fate

of individual chicks. Daily provisioning rates (mean total number of fish received by both parents per day) were compared across Julian dates (grouped into 7d categories: Julian date 178-184, 185-191, 192-198, 199-205, and 206-212) among years using a mixed within-subjects ANCOVA with nest site as the repeated subject variable and hatch date as the covariate, to control for age, as there is evidence that parents may modify frequency of daily feeds depending on the age of the chick (Harris & Wanless 1985, 1995; Hatchwell 1991). The Tukey-Kramer Method (Sokal & Rohlf 1995) was applied to make pair-wise comparisons for significant ANOVAs. All interactions were examined, however, none were significant.

Chi-squared tests were applied to assess if prey species differed within each year across Julian date. Chi-squared tests were also used to investigate differences in type and size of prey delivered to chicks across years for three age categories separately (1-8d, 9-16d and 17d to departure) and within each year across the three age categories. If a significant difference was found, pairwise comparisons were made using the Yates' correction (Sokal & Rohlf 1995).

To quantify differences in chick growth parameters between years, an ANCOVA with age as a covariate was conducted on each growth parameter separately. Chicks were randomly selected and matched by age across years (mean = 15.2 d and $n = 10$ for each year) to ensure that age of chick was not a confounding factor. Wing lengths were log-transformed to homogenize the variance. Pairwise comparisons were adjusted using the Bonferroni correction.

To assess if provisioning rates were related to chick growth, mean daily chick feeding rates prior to measuring the chick was calculated for all chicks. These means were then grouped into three age categories: 12-14d, 15-17d, and 18-20d, and averaged. A Pearson's correlation was subsequently applied to examine the relationship between chick feeding rates with chick mass and wing length (all years combined). All values are reported as means \pm SE. Statistical significance was set at $\alpha = 0.05$.

RESULTS

Chick provisioning rates Provisioning rates differed across years ($F_{2,35} = 14.18$, $P < 0.0001$) and across Julian date ($F_{4,88} = 11.10$, $P < 0.0001$; Fig. 1). Overall, mean daily chick-feeding rates were significantly lower in 2000 (3.44 ± 0.24 fish d⁻¹, $n = 26$) compared to 1999 (5.30 ± 0.21 fish d⁻¹, $n = 20$; Tukey-Kramer Method, $P < 0.05$), with chicks being fed on average two extra fish per day in 1999. In all years, provisioning rates were lowest during the first week of chick rearing and peaked between Julian dates 192-198 (Fig. 1).

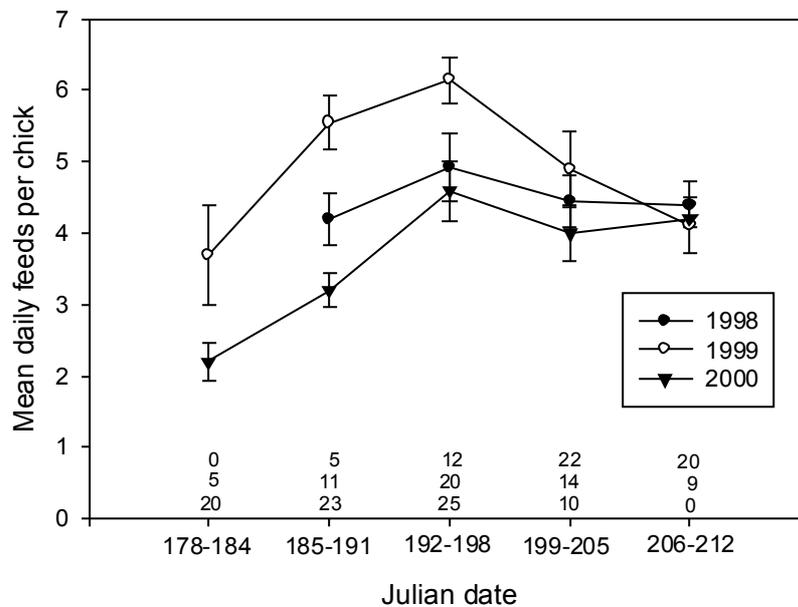


Figure 1. Mean number of daily feeds (\pm SE) received by Common Guillemot chicks across five Julian date categories (178-184, 185-191, 192-198, 199-205, and 206-212) during the 1998-2000 chick rearing periods. Numbers above x-axis represent sample sizes for each year in each age category (top row = 1998; middle row = 1999; bottom row = 2000).

Figuur 1. Gemiddeld aantal dagelijkse voedselafdrachten (\pm SD) aan zeekoetkuikens gedurende vijf Juliaanse datumcategorieën (178-184, 185-191, 192-198, 199-205 en 206-212).

Species and size of fish fed to chicks Capelin dominated the diet in all years (Tables 1 and 2). However, type of prey fed to chicks across Julian date varied differently in each year. In 1998, chicks were fed almost exclusively Capelin throughout chick rearing, with the exception of the first week (Table 1). In 1999, chicks were fed exclusively Capelin during the first week of chick rearing. However, by the end of the season, sandeel made up 29% of the diet (Table 1). In 2000, chick diet did not vary significantly. Chicks were fed mostly Capelin, however, their diets were consistently supplemented with sandeel (Table 1).

Table 1. Fish species fed to Common Guillemot chicks across Julian dates grouped into 7-d categories (178-184, 185-191, 192-198, 199-205, and 206-212) during three chick-rearing periods (1998-2000) on Great Island, Newfoundland. Chi-squared analyses examine diet shifts across Julian dates.

Tabel 2. Vissoorten die gevoerd werden aan zeekoetkuikens per zevendaagse periode (in Juliaanse data) gedurende drie kuikenperiodes (1998-2000) op Great Island, Newfoundland. Chi-kwadraat analyses vergelijken een verschuiving in dieet.

	Capelin		Other ¹		Total	χ^2	P
	No.	%	No.	%			
<i>1998</i>							
185-191	20	80	5	20	25	18.81	<0.001
192-198	145	96	6	4	151		
199-205	153	94	10	6	163		
206-212	135	93	10	7	145		
<i>1999</i>							
178-184	21	100	0	0	21	40.26	<0.001
185-191	167	87	25	13	192		
192-198	205	92	18	8	223		
199-205	201	82	43	18	244		
206-212	61	71	25	29	86		
<i>2000</i>							
178-184	74	86	12	14	86	4.51	> 0.10
185-191	205	85	36	15	241		
192-198	181	92	16	8	197		
199-205	79	82	17	18	96		

¹For 1999 and 2000, fish species were identified as sandeel.

Chick diet composition varied significantly among years in all three age groups (Table 2). Chicks were fed a higher proportion of sandeel in 2000 compared to 1998, regardless of chick age (1- 8 d: $\chi^2_1 = 9.40$, $P < 0.01$; 9-16 d: $\chi^2_1 = 5.80$, $P < 0.05$; 17 d to departure: $\chi^2_1 = 9.26$, $P < 0.01$; Table 2). In 1999, chicks were also fed more sandeel compared to 1998 at ages 9-16 d ($\chi^2_1 = 4.94$, $P < 0.05$) and 17 d to departure ($\chi^2_1 = 13.64$, $P < 0.01$; Table 2). Prey composition did not vary within any given year across age of chick (1998: $\chi^2_2 = 0.8$, $P > 0.10$; 1999: $\chi^2_2 = 2.6$, $P > 0.10$; 17 d to departure: $\chi^2_2 = 1.5$, $P > 0.10$; Table 2). Overall, sandeel or other fish (most likely sandeel) made up 3% of a chick's diet in 1998, 15% in 1999 and 14% in 2000.

Table 2. Fish species fed to Common Guillemot chicks across three age categories (1-8 d, 9-16 d and 17 d to departure) during three chick-rearing periods (1998-2000) on Great Island, Newfoundland. Chi-squared analyses examine diet shifts between years.

Tabel 2. Vissoorten die gevoerd werden aan zeekoetkuikens per leeftijdscategorie (1-8, 9-16 en 17 dagen voor 'uitvliegen') gedurende drie kuikenperiodes (1998-2000) op Great Island, Newfoundland. Chi-kwadraat analyses vergelijken een verschuiving in dieet.

	Capelin		Other ¹		Total	χ^2	P
	No.	%	No	%			
<i>1-8d</i>							
1998	179	97	6	3	185	10.99	<0.01
1999	194	89	24	11	218		
2000	207	83	42	17	249		
<i>9-16d</i>							
1998	223	96	9	4	232	11.17	<0.01
1999	136	86	22	14	158		
2000	248	89	31	11	279		
<i>17d to departure</i>							
1998	120	98	2	2	122	15.06	<0.01
1999	53	81	12	19	65		
2000	168	85	30	15	198		

¹For 1999 and 2000, fish species were identified as sandeel.

Chicks were fed primarily medium-sized Capelin (48%), and there was no significant difference in size between years at any of the age categories (Table 3). Within each year, chicks were also fed primarily medium-sized Capelin across all age groups (1998: $\chi^2_4 = 3.81$, $P > 0.10$; 1999: $\chi^2_4 = 8.31$, $P > 0.05$; 2000: $\chi^2_4 = 4.56$, $P > 0.10$; Table 3). In 1998 and 1999, other researchers collecting chick diet at another guillemot colony on Great Island reported that chicks were mostly fed Capelin measuring 100-150 mm in length, which they classified as medium-sized; no difference in fish sizes were found between years (Davoren & Montevecchi 2003).

Size of sandeel varied across years with chicks aged 1-8 d being fed a higher proportion of large sandeel and lower proportion of medium sandeel in 2000 compared to 1999 (Table 4). Conversely, chicks aged 17 d or older were fed more small sandeel in 2000 compared to 1999 (Table 4), although most sandeel fed to chicks in both years were medium and large. Size of sandeel did

Table 3. Number (%) of small, medium, and large Capelin fed to Common Guillemot chicks across three age categories (1-8 d, 9-16 d and 17 d to departure) during three chick-rearing periods (1998-2000) on Great Island, Newfoundland. Chi-squared analyses examine diet shifts between years.

Tabel 3. Aantal (%) kleine, medium en grote Lodde dat aan zeekoetkuikens gevoerd werd per leeftijdscategorie (1-8, 9-16 en 17 dagen voor 'uitvliegen') gedurende drie kuikenperiodes (1998-2000) op Great Island, Newfoundland. Chi-kwadraat analyses vergelijken een verschuiving in dieet.

	Small	Medium	Large	Total	χ^2	<i>P</i>
<i>1-8d</i>						
1998	38 (18)	114 (54)	59 (28)	211	5.43	>0.10
1999	62 (28)	107 (48)	53 (24)	222		
2000	36 (23)	65 (42)	53 (34)	154		
<i>9-16d</i>						
1998	31 (21)	64 (43)	55 (37)	150	3.00	>0.50
1999	38 (16)	129 (54)	72 (30)	239		
2000	39 (19)	93 (45)	75 (36)	207		
<i>17d to departure</i>						
1998	15 (23)	27 (42)	22 (34)	64	5.49	>0.10
1999	22 (14)	83 (51)	56 (35)	161		
2000	12 (12)	53 (51)	39 (38)	104		

not differ across years in chicks aged 9-16 d (Table 4). Size of sandeel fed to chicks varied across age in 1999 ($\chi^2_4 = 20.43$, $P < 0.001$) but not in 2000 ($\chi^2_4 = 3.91$, $P > 0.01$; Table 4). In 1999, older chicks (17 d to departure) were fed a higher proportion of large sandeel compared to younger chicks (1-8 d; $\chi^2_1 = 6.24$, $P < 0.025$; Table 4).

Chick growth parameters and provisioning rates Chick body mass did not differ across years ($F_{2,26} = 0.92$, $P = 0.41$). However, inter-annual differences were found in wing length ($F_{2,26} = 9.87$, $P = 0.01$), with chicks reared in 2000 having longer wings compared to the other two years (Fig. 2). A significant correlation was found between chick feeding rates and chick mass for chicks aged 12-14 d ($r = 0.49$, $P = 0.05$, $n = 14$). A similar relationship was found in the other two age categories, although correlations were not statistically significant (Fig. 3). No relationship was found between chick feeding rates and wing length in any of the age groups (Fig. 4).

Table 4. Number (%) of small, medium, and large sandeel fed to Common Guillemot chicks across three age categories (1-8 d, 9-16 d and 17 d to departure) during two chick-rearing periods (1999-2000) on Great Island, Newfoundland. Chi-squared analyses examine diet shifts between years.

Tabel 4. Aantal (%) kleine, medium en grote Zandspiering dat aan zeekoetkuikens gevoerd werd per leeftijdscategorie (1-8, 9-16 en 17 dagen voor 'uitvliegen') gedurende twee kuikenperiodes (1998-2000) op Great Island, Newfoundland. Chi-kwadraat analyses vergelijken een verschuiving in dieet.

	Small	Medium	Large	Total	χ^2	P
<i>1-8d</i>						
1999	3 (11)	19 (70)	5 (19)	27	30.42	<0.001
2000	5 (16)	10 (32)	16 (52)	31		
<i>9-16d</i>						
1999	6 (15)	21 (53)	13 (33)	40	3.54	>0.10
2000	4 (16)	10 (40)	11 (44)	25		
<i>17d to departure</i>						
1999	2 (5)	18 (49)	17 (46)	37	7.38	<0.05
2000	3 (17)	8 (44)	7 (39)	18		

DISCUSSION

Inter and intra-annual variation in chick provisioning rates and diet (1998-2000) Provisioning rates were unusually low during early chick rearing in 2000. During this time, chicks were being fed primarily medium-sized Capelin. Adults were presumably foraging at long distances from the breeding colony or allotting longer search times per prey item, reflected in the low chick feeding rates. Common Guillemots presumably feed well away from the breeding area in May and early June, as shown by low colony attendance during this time (Wilhelm & Storey 2002). However, they forage in the vicinity of the breeding colonies (< 5 km; Davoren *et al.* 2003) when spawning Capelin arrive inshore (Cairns *et al.* 1987; Piatt 1990). Hence, low chick feeding rates during first half of chick rearing in 2000 was likely due to a mismatch between Capelin arrival and chick hatching (Wilhelm 2004). During this time, however, chicks were fed higher proportions of large sandeel compared to other years. Although adults appeared to be partially compensating for potentially low Capelin availability by selecting large sandeel, feeding rates were still lower compared to other years and other colonies (see Wilhelm 2004). These results suggest that guillemots breeding in Witless Bay do not have a suitable alternate prey to Capelin, as seen

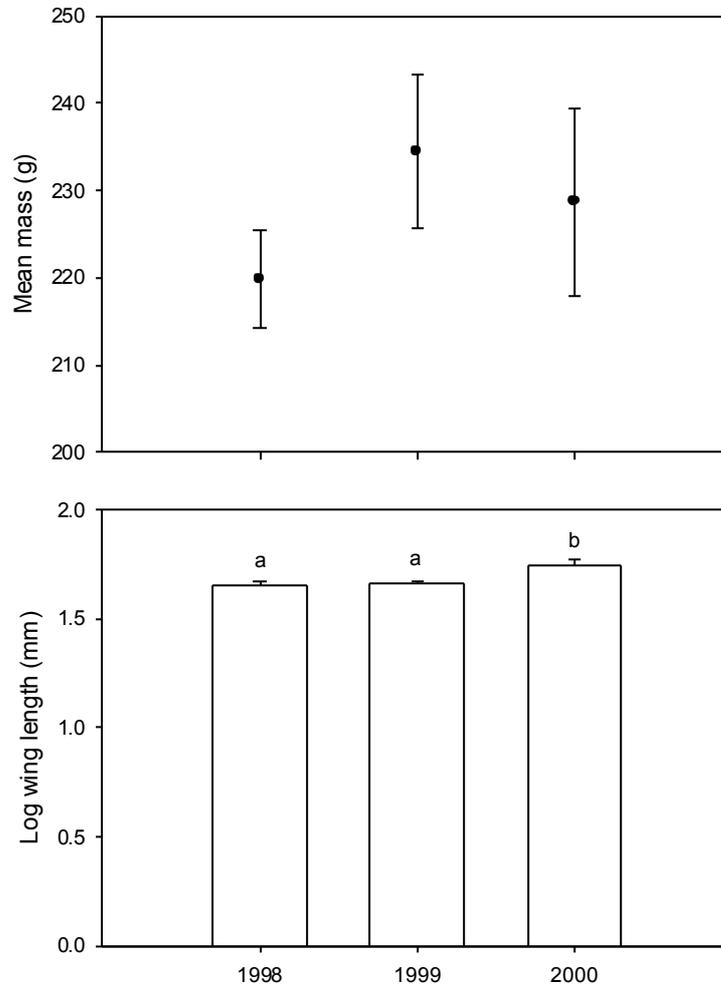


Figure 2. Analysis of covariance on body mass and wing length of Common Guillemot chicks aged 13 to 20 d during three consecutive chick-rearing periods (1998-2000). $n = 10$ for each group. Letters above bars show significant differences among groups.

Figuur 2. Covariantie-analyse van lichaamsgewicht en vleugellengte van zeekoetkuijken in de leeftijd van 13 tot 20 dagen gedurende drie achtereenvolgende kuikenperiodes (1998-2000). $n = 10$ voor iedere groep. Letters boven de staafjes geven significante verschillen tussen groepen aan.

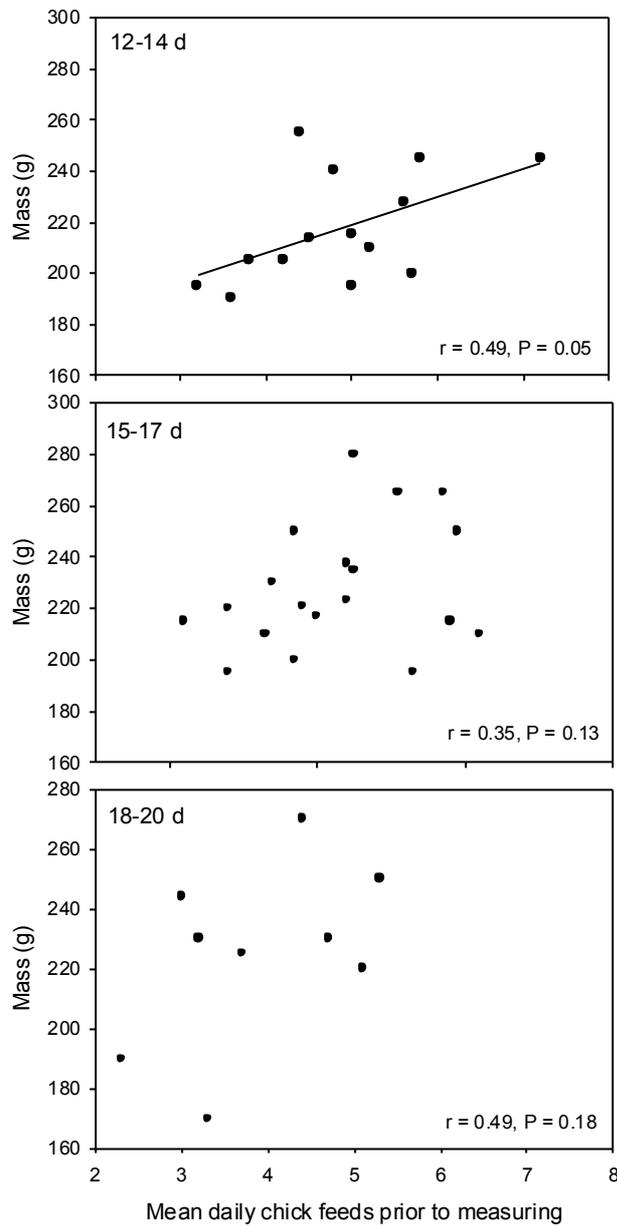


Figure 3. Relationship between chick mass (g) and provisioning rates (mean number of chick feeds per day) across three age categories: 12-14 d (n = 14), 15-17 d (n = 20), and 18-20 d (n = 9).

Figuur 3. Relatie tussen kuikengewicht (g) en voerfrequentie (gem. aantal dagelijkse voerbeurten per kuiken) per leeftijdscategorie: 12-14 d (n = 14), 15-17 d (n = 20), and 18-20 d (n = 9).

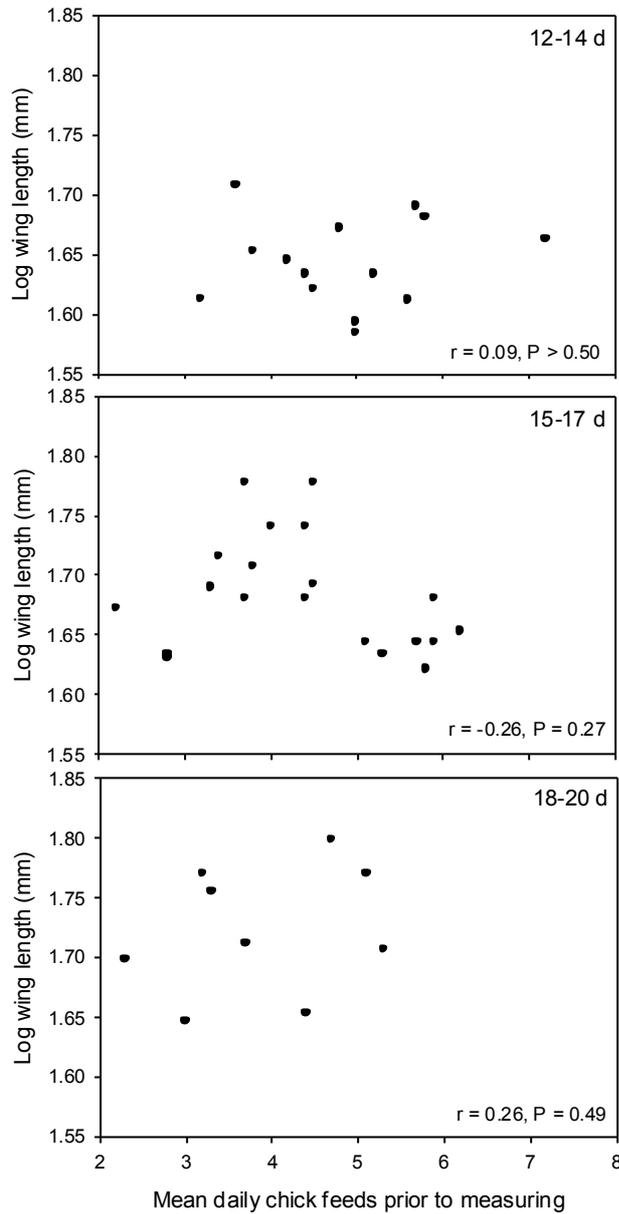


Figure 4. Relationship between wing length (mm; log-transformed) and provisioning rates (mean number of chick feeds per day) across three age categories: 12-14 d (n = 14), 15-17 d (n = 20), and 18-20 d (n = 9).

Figuur 4. Relatie tussen vleugellengte (mm; na log-transformatie) en voerfrequentie (gem. aantal dagelijkse voerbeurten per kuiken) per leeftijds-categorie: 12-14 d (n = 14), 15-17 d (n = 20), and 18-20 d (n = 9).

elsewhere (Harris & Wanless 1985; Hatchwell 1991; Bryant *et al.* 1999; but see Burger & Piatt 1990).

Chicks were fed a higher proportion of sandeel during the entire chick rearing periods of 1999 and 2000 compared to 1998. Large increases of juvenile sandeel abundance were recorded over the Grand Banks in 1998 and 1999 (Anderson 2001), which may have contributed to the increase in adult sandeel fed to guillemot chicks in subsequent years. However, it does not appear that the observed increase in sandeel abundance was related to the high chick feeding rates in 1999. When chick-feeding rates peaked during mid-chick rearing in 1999, chicks were being fed primarily Capelin (92%). Sandeel proportions did, however, increase seasonally as chick feeding rates declined, suggesting that Capelin became less available as the chick-rearing period progressed.

During both instances of apparent low Capelin availability (early chick rearing in 2000 and late chick rearing in 1999), birds were returning to the colony with a higher proportion of large sandeel. Sandeel have a higher energy density (7.3 kJ per g) than ovid female Capelin (4.6 kJ per g) and adult male Capelin (3.8 kJ per g; reviewed in Cairns *et al.* 1990), thereby making sandeel a higher quality prey for growing chicks. When Capelin abundance in surrounding waters is low, guillemots spend more time away from the colony, presumably searching for prey (Burger & Piatt 1990). Therefore, if schools of Capelin were not as predictably found or were located far from the colony, and guillemots were required to increase their foraging time, then a more effective strategy may have been to spend extra time searching for the higher quality large sandeel.

Diet comparison with Gull Island 1977-1978 and 1982-1985 The current diet of Common Guillemot chicks reared in Witless Bay has changed little since the late 1970s. The proportion of Capelin ingested by guillemot chicks from 1977-1985 ranged from 89-97%, with the remainder of the diet consisting primarily of sandeel (Mahoney 1980; Burger & Piatt 1990). In 1998-2000, the proportion of Capelin fed to chicks ranged from 85-97%, with the remainder being sandeel. Fish sizes also appear to have remained similar since the 1980s. From 1982-85, most fish delivered to chicks measured between 106-141 mm in length (estimated from Burger & Piatt 1990). The majority of fish delivered to chicks in this study (1998-2000) and at another guillemot colony on Great Island (1998-99) were medium-sized, and estimated to measure 100-150 mm (Davoren & Montevecchi 2003).

Chick mass, wing length, and provisioning rates Chick mass did not differ across years, although analyses were restricted to a sub-set of chicks sampled to control for age. However, at the individual level, a positive relationship was

Table 5. See opposite page for legend.

Tabel 5. Zie tegenoverliggende pagina voor bijschrift.

chick age (d)	year	mean mass \pm SE (g)	mean wing \pm SE (mm)	<i>n</i>
<i>Great Island, Newfoundland, Canada. Source: this study</i>				
12-14	1998	216.0 \pm 6.5	41.9 \pm 1.3	6
	1999	231.0 \pm 10.9	45.8 \pm 1.2	5
	2000	212.0 \pm 10.2	54.2 \pm 5.6	5
15-17	1998	220.5 \pm 7.7	46.4 \pm 2.5	5
	1999	236.9 \pm 10.5	45.1 \pm 0.8	7
	2000	227.9 \pm 9.1	52.8 \pm 1.8	8
18-20	1998	234.5 \pm 9.5	48.0 \pm 3.6	2
	1999	260.0 \pm 10.0	48.0 \pm 3.0	2
	2000	208.0 \pm 12.0	57.6 \pm 2.1	5
<i>Gull Island, Newfoundland, Canada. Source: Mahoney & Threlfall (1981)</i>				
13	1977-78	193.3	n.d.	?
17		223.0	n.d.	?
19		236.0	n.d.	?
<i>Isle of May, Scotland. Source: Harris & Wanless (1995)</i>				
13	1983-92	236 ¹	n.d.	?
16		248 ¹	n.d.	?
19		250 ¹	n.d.	?
<i>Gannet Islands, Newfoundland, Canada. Source: Hipfner & Bryant (1999)</i>				
13	1997	205 ¹	43 ¹	8
16		215 ¹	50 ¹	8
19		220 ¹	58 ¹	8
<i>Hornøya, Norway. Source: Barrett et al. (1997)</i>				
12-14	1990	240 ¹	46 ¹	15
15-17		250 ¹	56 ¹	15
18-20		250 ¹	66 ¹	12
<i>Skomer Island, Wales. Source: Hatchwell (1991)</i>				
12-13	1985-87	180 ¹	43 ¹	25
16-17		200 ¹	53 ¹	35
18-19		198 ¹	57 ¹	30

¹Values estimated from graphs

Opposite page: table 5. Inter-annual differences in mass and wing length of Common Guillemot chicks of three age groups (12-14 d, 15-17 d, and 18-20 d) reared on Great Island, Newfoundland, and in comparison to Common Guillemot chicks of similar ages reared in other colonies.

Tegenoverliggende pagina: tabel 5. Jaarlijkse verschillen in gewicht en vleugellengte van zeekoetkuikens in drie leeftijdscategorieën (12-14, 15-17 en 18-20 dagen) op Great Island, Newfoundland, vergeleken met zeekoetkuikens van dezelfde leeftijd in andere kolonies.

found between provisioning rates and chick mass: individuals that were fed more frequently also had higher body mass. This linear relationship between amount of food received and chick mass has been observed in other auks, including Atlantic Puffins *Fratercula arctica* (Harris 1978; Barrett *et al.* 1987; Øyan & Anker-Nilssen 1996) and Cassin's Auklets *Ptychoramphus aleuticus* (Hedd *et al.* 2002).

Wing length differed across years, with chicks reared in 2000 having overall longer wings than those reared in 1998 and 1999. Although no relationship was found between provisioning rates and wing length, a trend toward a negative relationship was found at age 15-17 d. The relationship between wing growth and nutrition has been studied in other auk chicks, including Razorbills *Alca torda*, Black Guillemots *Cephus grylle* and Atlantic Puffins (reviewed in Gaston 1985; Øyan & Anker-Nilssen 1996). Most report no relationship between wing length and food supply (but see Øyan & Anker-Nilssen 1996). The results in this study suggest that during unfavourable breeding conditions, such as low Capelin availability, wing growth can perhaps be prioritized in Common Guillemots. Rapid wing growth can benefit chicks as well as parents by allowing earlier departure, thereby bringing the chick to the food source rather than adults depleting their reserves by bringing the food to the chick (Sealy 1973). This strategy is used by intermediate auk species, including the Common Guillemot, where the male parent brings the chick to sea and continues to provide parental care for several weeks (Harris & Birkhead 1985).

Growth parameters of Great Island chicks in comparison to other colonies

Chick mass and wing length from this study and of chicks of similar age from other Common Guillemot colonies are summarized in Table 5. Although growth parameters in this study showed considerable intra-colony variation across years, the weights of chicks reared on Great Island from 1998-2000 fell within the range of chick masses reported at other colonies, and are similar to chicks reared on Gull Island in the late 1970s. Furthermore, relative to other guillemot colonies, the seemingly low mass of chicks reared on Great Island in 2000 (208 g) that were close to fledging (18-20 d) were comparable to chick weights on

Skomer Island in Wales (198 g), and higher than fledging masses of chicks on Funk Island (192 g; Davoren & Montevecchi 2003), 60 km away.

Similarly, the apparent long wings of chicks reared in 2000 on Great Island resembled those reported in Labrador and Wales. However, Great Island chicks reared in 2000 had considerably shorter wings compared to guillemot chicks reared in Norway and to fledging Funk Island chicks (estimated at 66.1 mm; Davoren & Montevecchi 2003). Chick feeding rates on Funk Island are among the lowest of any reported (Davoren & Montevecchi 2003) as a result of parents travelling approximately 45 km each way to find predictable food sources (Davoren *et al.* 2003). The low mass and long wings of these chicks are consistent with the view that wing growth is maintained or may be prioritized when feeding conditions are poor (Harris 1966).

Prey type and size brought back to chicks by breeding Common Guillemots in Witless Bay did not appear to have changed since the late 1970s. Furthermore, there is no indication that fish fed to chicks were of lower quality/condition, as chick growth parameters were similar between the late 1970s and the late 1990s. These results do not corroborate with the view that Capelin abundance and size have decreased since the 1980s (Carscadden *et al.* 1997). However, Common Guillemots do not sample the ocean randomly (Davoren *et al.* 2003), but may instead selectively choose high quality fish for their chicks. Mean daily chick feeding rates prior to measuring appeared to be a good predictor of chick mass, although the relationship with wing length was unclear. Wing growth may be more plastic than previously thought, as wing lengths of chicks were highly variable within and between colonies. Caution is warranted when using wing measurement as a single indicator of chick body size or age.

ACKNOWLEDGEMENTS

We thank the numerous colleagues and assistants who helped with this study, particularly Carolyn Walsh, Joel Heath, Allison Moody, and Maureen Cameron-MacMillan. Appreciation is also extended to the Reddick family for transportation to and from Great Island. John Piatt, Mike Harris and Tycho Anker-Nilssen provided valuable comments on previous drafts of this manuscript and Gregory Robertson was helpful with statistical analyses. Canadian Wildlife Service and Newfoundland Parks and Natural Areas Division provided us with permits to carry out this study. Funding was provided by the Natural Sciences and Engineering Research Council of Canada (individual operating grant AES and postgraduate scholarships to SIW) and Memorial University fellowships to SIW.

TEMPORELE VERANDERINGEN IN DE VOEDSELECOLOGIE EN GROEI VAN KUIKENS BIJ DE ZEEKOET *URIA AALGE*

Veranderingen op korte en lange termijn in de voedseleecologie van Zeekoeten *Uria aalge* broedend in Witless Bay, Newfoundland werden onderzocht in drie opeenvolgende broedseizoenen (1998-

2000) en in twee verschillende decaden (eind jaren zeventig tot halverwege jaren tachtig vergeleken met 1998-2000). Daarnaast werden fluctuaties in voedselafdrachten in verband gebracht met variaties betreffende de groei van kuikens (massa en vleugellengte). In 1998-2000 concentreerden de waarnemingen zich op dezelfde, individueel herkenbare (gekleurringde) Zeekoeten. De frequentie van voedselafdrachten wisselde enorm, zowel binnen elk seizoen als in vergelijking tussen de broedseizoenen onderling. Elk jaar werden de jonge kuikens vooral met Lodde *Mallotus villosus* gevoerd, maar in 1999 en 2000 werd daarnaast ook zandspiering *Ammodytes* spp. aangebracht. De gemiddelde massa van de kuikens met leeftijd verschilde niet van jaar tot jaar, maar er was een positief verband tussen de frequentie van voedselafdrachten en kuikengewicht. Ofschoon er geen verband werd gevonden tussen het aantal voedselafdrachten en de groei van de vleugels, vertoonden de kuikens in 2000 een sneller groei dan in 1998 en 1999. Verondersteld wordt dat de groei van de vleugels prioriteit krijgt over het lichaamsgewicht in jaren met ongunstige omstandigheden rond de kolonie, zodat de jongen eerder de kolonie kunnen verlaten. Over het algemeen waren dieet, groei en conditie van de kuikens in Witless Bay goed vergelijkbaar met de in eerdere jaren vergaarde gegevens, ondanks dat er belangrijke veranderingen zijn geweest in de groei en verspreiding van Lodde in het Noordwest Atlantische gebied in deze periode.

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POST-BREEDING SEASON DIET OF THE
MEDITERRANEAN GULL *LARUS*
MELANOCEPHALUS AT THE BULGARIAN BLACK
SEA COAST

BOYAN MILCHEV¹, NIKOLA Y KODJABASHEV², YANAKI SIVKOV³ &
DRAGAN CHOBANOV¹

Milchev B., Kodjabashev N., Sivkov Y., Chobanov D. 2004. Post-breeding season diet of the Mediterranean Gull *Larus melanocephalus* at the Bulgarian Black Sea coast. *Atlantic Seabirds* 6(2): 65-78. *The seeds of three cultivated plants, Barley Hordeum vulgare, wheat Triticum sp., and Sunflower Helianthus annuus, and of ragwort Senecio sp., constituted the staple diet of Mediterranean Gulls Larus melanocephalus during their post-breeding residence at the Atanasovsko Lake Reserve (in 99% of pellets, n = 2,397 pellets). Pellets with fully digested seeds of Barley, Wheat and Ragwort contained a significantly greater number of gastrolith fragments. The pellets containing only visibly undigested seeds constituted 19% of samples (n = 2,397). Of these, the seeds of seven species germinated, and five of them had germination rates over 50%. Animal remains were found in 27% of the pellets (n = 2,397) with terrestrial animals predominating. Of the invertebrate species, ground beetles in the genus Harpalus (32%, n = 1,226 individuals) and grasshoppers (24%) occurred in greatest numbers. Vertebrates consisted mainly of marine and brackish benthic fishes (76%, n = 238 individuals). The seeds and stones ingested as gastroliths came from stubble in crop fields. Gulls flew to beaches to obtain bivalve seashells as gastroliths and to forage extra food. Gulls feeding mainly in fields after the nesting season probably reflect the seasonal flush of available food in habitats suitable for feeding in the region.*

¹ SU "St. K. Ohridski", Faculty of Biology, Dragan Tzankov 8, 1164 Sofia, Bulgaria e-mail: milchevboyan@biofac.uni-sofia.bg; ² University of Forestry – Sofia, Wildlife Management Department, 10 Kl. Ochriski Blvd., 1756 Sofia, Bulgaria, e-mail: ndkodjak@ltu.bg; ³ Museum of Natural History, P.O.Box 173, 9000 Varna, Bulgaria. E-mail: nhmuseum_varna@yahoo.com

INTRODUCTION

Gulls as adaptive, opportunistic omnivores have developed diverse methods of feeding and have mastered multiple feeding strategies (Burger & Gochfeld 1996, Oro *et al.* 1997). During the nesting period Mediterranean Gull *Larus melanocephalus* feeds mainly on land, chiefly consuming terrestrial and aquatic invertebrates. However, at other seasons, the species frequents shorelines and feeds mainly on marine fish and molluscs, as well as on garbage and on the

refuse from trawlers (Cramp & Simmons 1983, Fasola & Bogliani 1990, Burger & Gochfeld 1996, Snow & Perrins 1998, Meininger & Flamant 1999). Apparently, it adapts more easily than many other species to new habitats for nesting and wintering. Mediterranean gulls over the last century have successfully colonized regions vastly different from their original habitats in the Mediterranean and the Black Sea regions (Bekhuis *et al.* 1997, Pfeifer *et al.* 1997). Variability in their reported diet reflects differing uses in multiple habitats across seasons and years and depends on the available food sources (Glutz von Blotzheim & Bauer 1982, Zubakin 1988, Goutner 1986, 1994, Meininger *et al.* 1991, Meininger *et al.* 1993, Baccetti & Smart 1999).

This study describes the spectrum of feeding by Mediterranean gulls at the beginning of their post-breeding wanderings by analyzing the pellets of a flock residing at Atanasovsko Lake Reserve on the Bulgarian Black Sea coast. The observations were made during the birds' post-breeding moult, one of the most energy-demanding periods in the species' annual cycle. No in-depth study of diet of the species during this period has been available to date.

STUDY AREA AND METHODS

Lake Atanasovsko is situated in close proximity to the Western Black Sea Coast, near the town of Bourgas, Bulgaria. Historically used as salt-pans, the Lake has 12% of the total surface (1690 ha) are coastal and halophytic communities, 80% standing brackish and salt water and 8% fringe water vegetation. The lake is a nature reserve, RAMSAR site and IBA site. The Mediterranean Gull breeds irregularly there. The largest nesting colony to date was 62 pairs in 1994 (Michev *et al.* 1999). The species did not nest at the lake in 2001 (Michev, *pers. comm.*). Historically, in August and September, exclusively juvenile birds used to forage along the Bulgarian Black Sea Coast, while the mature birds appeared early in October (Nankinov *et al.* 1997). Our observations refer to a resting flock of predominantly mature birds in August 2001. The Lake is surrounded by plains and hills, mainly arable stretching to several scores of kilometres to the northeast, northwest and west. Crops from these lands are largely barley, wheat, and sunflower, with vineyards, orchards and other row crops on a smaller area. Barley harvesting starts about 20th June; wheat is harvested about 1st July; and sunflower about 15th August.

Observations on the diet spectrum is based on pellets from Mediterranean gulls resting on a salt pan (65 m x 10 m) and a dike (80 m x 3 m) among the network of evaporation ponds for seawater salt at the southern end of Atanasovsko Lake (42°31'N 27°29'E). The material was collected at noon on 4 August 2001 (a flock around 250 adults), 15 August 2001 (330 adults and 18 juveniles), 24 August 2001 (425 adults, 18 juveniles and 10 subadults) and 4

September 2001 (470 adults, 7 juveniles and 5 subadults). The sample comprised altogether 2397 intact pellets, 1.33 to 3.92cm long, averaging $2.63 \text{ cm} \pm 0.36$, and 1.04 to 2.7 cm wide, averaging $1.64 \text{ cm} \pm 0.15$ ($n = 2,137$ for measured pellets) plus disintegrated pellets. The flock of moulting gulls used the site for diurnal resting and did not spend the night there. Preparations for salt production in close proximity to the pan started in mid-August. Therefore, irrespective of the growing number of birds in the flock, the amount of collected diet refuse decreased, because gulls were increasingly driven away by workers.

Intact pellets remained in storage wrapped in paper until processing. Disintegrated pellets were combined into a sample from the respective collection date. The intact pellets were softened individually in water, rinsed with water through a thick-meshed sieve, and then dried. The combined sample of disintegrated pellets was processed in the same way. The seeds of wild-growing plants were identified by comparison with the Collection of the Faculty of Biology and the University of Forestry in Sofia. Animal remains were determined by comparison with our comparative collections and the Collection of the National Museum of Natural History. Quantification procedures always followed the rule of minimum numbers. We present the numbers of animal groups in the summarised material of intact and disintegrated pellets, as well as the average number of individuals per pellet from the corresponding taxonomic category. Biomass is not reported owing to the very small amounts of animal parts as compared to vegetation in the pellets and inherent inability to determine the amount of seeds ingested.

Stones and single pieces of glass consumed as gastroliths were counted and distributed into different categories: 1-5 pieces per pellet, 6-10 pieces, 11-20 pieces and > 20 pieces. The amount of fragments from bivalve shells is not reported. Pellets with very small fragments are probably the remains after digestion of larger fragments. Their counting out would not have given the actual number of swollen bivalve shells that took part in digestion. Various inorganic products, predominantly man-made, were also noted.

The pellets fall into three groups, according to the degree of seed digestion: type A – completely digested seeds, or with small quantities of undigested fragments; type B – about half of the seeds in the pellet were digested to some extent, while the rest remained unchanged or slightly damaged; type C – most seeds remained visibly unchanged, or slightly damaged.

The seeds visibly unchanged by digestion and having no traces of charring were tested for germination on moist cotton batting in Petri dishes at room temperature.

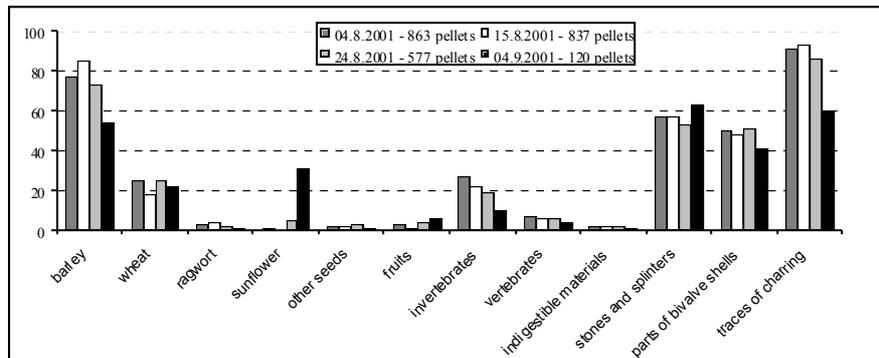


Figure 1. Contents of the pellets (%) of the Mediterranean Gull, Atanasovsko Lake, Bulgarian Black Sea coast.

Figuur 1. De inhoud van braakballen (%) van Zwartkopmeeuwen langs het Bulgaarse meer Atanasovsko, Zwarte Zeekust.

Statistical differences in occurrence of organic remains in the samples and the degree of digestion, depending on the existing gastroliths in the pellets, were calculated by means of a chi-square test, with $P < 0.05$.

RESULTS

Plant matter in the diet Most intact and disintegrated pellets contained remains of seeds and fruit (99.2%, $n = 2,397$ pellets). The seeds of four plant species predominated in intact or in mixed pellets, with Barley *Hordeum vulgare* and wheat *Triticum* sp. seeds being the most numerous (Fig.1, Fig 2). Of these, only ragwort *Senecio* sp. is not a crop plant, but occurs as a weed in crop fields. Six pellets showed prevalence of fruit remains: Cultivated Grapes (3 pellets), Asian bittersweet *Celastrus orbiculata* (1 pellet) and European Plum *Prunus domestica* (2 pellets). Pellets with traces of charring on seeds and ears were common owing to the frequent post-harvest practice of burning the straw and stubble in the fields.

The occurrence of pellets with various vegetation remains was highly significant among the four collections ($\chi^2_{15} = 350.5$, $P < 0.001$). The pellets with Sunflower *Helianthus annuus* remains dominated in the collections after mid-August, when 82% ($n = 79$) of the pellets collected sunflower seeds. In the same period, the occurrence of pellets with fruit remains (mainly of Cultivated Grapes) increased while the frequency pellets with Barley decreased. No significant differences were found in the occurrence of pellets with mixed seeds

Table 1. Pellets with various seeds of the principal plant species in the diet of the Mediterranean Gull, Atanasovsko Lake, Bulgarian Black Sea coast.

Tabel 1. Braakballen met verschillende zaden van de voornaamste plantensoorten bij de Zwartkopmeeuwen langs het Bulgaarse meer Atanasovsko, Zwarte Zeekust.

Number of pellets with assorted seeds	Wheat	Senecio	Sunflower
Barley	92	66	4
Senecio	18	-	0
Sunflower	11	0	-

of the four principal plant species in the different collections ($\chi^2_9 = 8.6$, $P > 0.05$). Barley was found most often in intact pellets, and ragwort seeds occurred predominantly in the mixed samples (Table 1).

Gastroliths and the status of seed digestion Mediterranean Gulls ingest small stones, pieces of glass and fragments of bivalve shells as gastroliths (Table 2). The stones and occasional fragments of glass averaged 6.3 ± 8.0 pieces in the pellets containing them, with a maximum 69 in one pellet. Most had rough edges and therefore were not ingested from seashores. The fragments of bivalve shells belonged to various marine species and did not form whole shells when reconstructed. Most shell pieces had well smoothed edges, even in the pellets with indigestible seeds. This observation supports ingestion at the seashore. Stones and bivalve shells were found in 852 pellets (43.5%, $n = 1,957$ pellets with gastroliths). 341 pellets had charred fragments, mostly seeds of wheat and barley. Some seeds were quite hard and probably also served as gastroliths.

The pellets with better digested Barley and Wheat seeds showed a significantly greater number of stones and pieces of glass ($\chi^2_8 = 534.3$, $\chi^2_8 = 39.5$, $P < 0.001$) and prevalence of bivalve shell fragments ($\chi^2_2 = 177.9$, $\chi^2_2 = 31.7$, $P < 0.001$). Ragwort seeds in the pellets appeared to have undergone better digestion with in the presence of shell fragments ($\chi^2_2 = 6.4$, $P < 0.01$), and their digestion was higher in the pellets with stones and shells ($\chi^2_8 = 20.2$, $P < 0.01$). Sunflower digestion did not depend on the presence and amount of gastroliths in the pellets.

The pellets containing only apparently unchanged seeds constituted 19% ($n = 2,397$) (Table 2). Barley seeds were hardest to digest and were completely digested only in 53% of the pellets containing them. The maximum number of undigested seeds, occasionally in entire ears, was respectively 65 for Barley (21 ± 11.1 seeds, $n = 412$ pellets) and 43 for Wheat (15 ± 12.2 seeds, $n = 45$ pellets). Over 20 stones were in one pellet with Wheat and Barley seeds, but 20 and 16 seeds respectively remained undigested. Eighteen regurgitations with

Table 2. Degree of digestion (%) of seeds and fruits in the pellets of the Mediterranean Gull, Atanasovsko Lake, Bulgarian Black Sea coast.

Tabel 2. Mate van vertering (%) van zaden en vruchten in braakballen van Zwartkopmeeuwen langs het Bulgaarse meer Atanasovsko, Zwarte Zeekust.

Contents	type A	type B	type C
barley	53	25	22
wheat	81	11	8
ragwort	96	2	2
sunflower	93	1	6
other seeds	0	0	100
fruits	100	0	0
with stones and splinters			
barley	69	26	5
wheat	87	10	3
ragwort	100	0	0
sunflower	94	0	6
with parts of bivalve shells			
barley	63	2	10
wheat	89	8	3
ragwort	100	0	0
sunflower	90	0	10

Barley (2%, $n = 985$ type A) and 25 with Wheat (6%, $n = 432$ type A) did not contain gastroliths, while the seeds in them were entirely digested.

The seeds of bedstraw *Galium* sp. predominated among the intact seeds of various weeds: 44 pellets (70.1%, $n = 62$), containing between one and 36 seeds (309 seeds altogether and averaging seven seeds per pellet). Other weeds were present as single seeds in the pellets, except for yellowcress *Rorippa* sp. Yellowcress was likely ingested as whole inflorescences, and between 42 and 66 seeds were present in each of three pellets.

Germination Seeds and fruit stones of seven plant species germinated in flats. Five of species had greater than 50% germination (Table 3). Despite being difficult to digest, the apparently intact Barley seeds had damaged embryos. A great number of the Bedstraw seeds tested probably also had damaged embryos. Individual intact Sunflower and Ragwort seeds had high germination rates.

Table 3. Seeds and fruit stones tested for germination from pellets of the Mediterranean Gulls, Atanasovsko Lake, Bulgarian Black Sea coast.

Tabel 3. Zaden en pitten uit braakballen van Zwartkopmeeuwen die getest werden om het vermogen nog te ontkiemen na te gaan.

Plant species	Seeds Tested Number	Germination Number (%)
Barley <i>Hordeum vulgare</i>	140	0
wheat <i>Triticum</i> sp.	21	2 (9.5)
ragwort <i>Senecio</i> sp.	8	5 (62.5)
Sunflower <i>Helianthus annuus</i>	10	8 (80)
bedstraw <i>Galium</i> sp.	128	0
Wild radish <i>Raphanus raphanistrum</i>	13	7 (53.8)
Asian bittersweet <i>Celastrus orbiculata</i>	13	13 (100)
yellowcrees <i>Rorippa</i> sp.	102	81 (79.4)
sage <i>Salvia</i> sp.	7	0
geranium <i>Geranium</i> sp.	1	0
Cantaloupe <i>Cucumis melo</i>	2	0
Mahaleb cherry <i>Prunus mahaleb</i>	2	1 (50)
Russian olive <i>Elaeagnus angustifolia</i>	4	0

Non- plant materials in the diet Only 18 pellets (0,8%, $n = 2,397$) contained no seeds or fruit. Thirteen of these had mainly animal components: 5 pellets - fish, 4 - bird, 3 pellets - mammals and insects, and 1 pellet - Isopoda. Indigestible sausage packaging formed four pellets. One of the pellets contained the distal part of a corn cob, without seeds. Pieces of plastic, tinfoil, rubber, styrofoam, and textile were found in small quantities in the pellets.

Animal remains occurred in 656 pellets (27%, $n = 2,397$; Table 4). Of the invertebrates, grasshoppers *Calliptamus italicus* predominated - 187 individuals (accounting for 15% of the invertebrates), and ground beetles *Harpalus* sp. of the other insects - 184 individuals (15% of the invertebrates). One single pellet contains 33 *C. italicus* grasshoppers and one Vole *Microtus arvalis/rossiaemeridionalis*. The invertebrate prey species mainly inhabit the surface soil layer and grassy vegetation in both natural and agricultural habitats with xerothermic vegetation and prevalence of grass species.

Fishes constituted the greatest share of vertebrates in the diet of Mediterranean Gulls (76%, $n = 238$ individuals). They chiefly belonged to marine and brackish benthic species (89%, $n = 180$ individuals). All vertebrates occurred in low numbers in the pellets: 1.1 individuals on average. The soft tissues of animals consumed were digested, except in one pellet with undigested barley seeds and a well-preserved part of the distal tail column of a Gread

Table 4. Animals in the diet of the Mediterranean Gull, Atanasovsko Lake, Bulgarian Black Sea coast.

Tabel 4. Dierlijke resten in braakballen van Zwartkopmeeuwen langs het Bulgaarse meer Atanasovsko, Zwarte Zeekust.

Animals	04.08	15.08.	24.08	04.09	Total
Carabidae	122	155	95	24	396
Tenebrionidae	41	23	12	4	80
Curculionidae	40	44	20	1	105
Coleoptera (other)	57	36	24	0	117
Orthoptera	132	105	49	4	290
Other Insecta	72	38	68	1	179
Malacostraca (Isopoda, Decapoda)	14	39	6	0	59
Subtotal Invertebrata	478	440	274	34	1226
(average per pellet)	(1.8)	(2.0)	(2.1)	(1.2)	(1.9)84%
<i>Rutilus rutilus</i>	0	1	0	2	3
<i>Carassius auratus gibelio</i>	3	0	1	0	4
<i>Syngnathus acus</i>	12	30	17	2	61
<i>Syngnathus</i> sp.	3	5	6	0	14
<i>Perca fluviatilis</i>	3	0	1	0	4
<i>Symphodus roissali</i>	2	4	1	0	7
<i>Symphodus ocellatus</i>	1	2	0	0	3
<i>Symphodus</i> sp.	0	2	1	0	3
<i>Ophidion rochei</i>	3	1	0	0	4
<i>Scorpaena porcus</i>	1	0	0	0	1
<i>Neogobius ratan</i>	14	5	2	0	21
<i>Neogobius</i> sp.	6	3	5	2	16
<i>Mesogobius batrachocephalus</i>	14	11	5	0	30
Osteichthyes	5	3	1	0	9
Subtotal Pisces	67	67	40	6	180
(average per pellet)	(1.1)	(1.1)	(1)	(1)	(1.1)12%
<i>Sylvia</i> sp.	1	0	0	0	1
<i>Phylloscopus</i> sp.	0	0	0	1	1
<i>Carduelis</i> sp.	1	0	0	0	1
Passeriformes ordo	1	0	0	0	1
Aves nonid.	1	0	1	0	2
Subtotal Aves	4	0	1	1	6
(average per pellet)	(1)		(1)	(1)	(1) 0.4%

Table 4. Continued. Tabel 4 vervolg.

Animals	04.08	15.08.	24.08	04.09	Total
<i>Neomys anomalus</i>	0	1	0	0	1
<i>Crocidura suaveolens</i>	1	1	0	0	2
<i>C.leucodon</i>	1	0	0	0	1
<i>Mus musculus/spretus</i>	8	4	4	1	17
<i>Rattus</i> sp. juv.	2	0	1	0	3
<i>Microtus arvalis/rossiaemeridionalis</i>	12	11	4	1	28
Subtotal Mammalia	24	17	9	2	52
(average per pellet)	(1.3)	(1.5)	(1.2)	(1)	(1.3) 4%
Subtotal Vertebrata	95	84	50	9	238
(average per pellet)	(1.1)	(1.2)	(1.1)	(1)	(1.1) 16%
Total All Animals	573	524	324	43	1464

Note: The total number of individuals in the intact and disintegrated pellets excludes here one pellet with two tortoise *Testudo* sp. eggs from the first collection and the eggs of Thomas's Rapa Whelk *Rapana thomasiana* in the disintegrated pellets from the second collection.

Pipefish *Syngnathus acus*. No significant differences were found in the pellets containing invertebrates and the three groups of vertebrates, or in their amounts in the diet. Highly significant differences were apparent in the catch of the seven groups of invertebrates ($\chi^2_{18} = 108.1$, $P < 0.001$). Carabid beetles occurred in significantly greater numbers on the last collection date in contrast to the lower numbers in the first collection date. Crustaceans occurred in greater numbers on the second collection date, in contrast to the first date. Among the "other" insects, significantly greater numbers were found in the third collection (47 individuals of ants) and lesser numbers in the second.

DISCUSSION

The seeds of three crop plants, Barley, Wheat and Sunflower, plus Ragwort constituted the main diet of the Mediterranean Gulls during this study. Ragwort was mostly mixed in with pellets containing barley and wheat seeds, as Ragwort grew in the fields under these crops. Seeds of crop plants have been found in gull diets during their breeding period as well, but were not a staple in the diet (Ardamatskaya *et al.* 1988, Goutner 1986, 1994, Meininger *et al.* 1991). Predominance of seeds in the gull diet reported here does not correspond to previous accounts of Mediterranean gull diets after nesting is completed, citing chiefly marine fishes and molluscs (Burger & Gochfeld 1996, Snow & Perrins 1998).

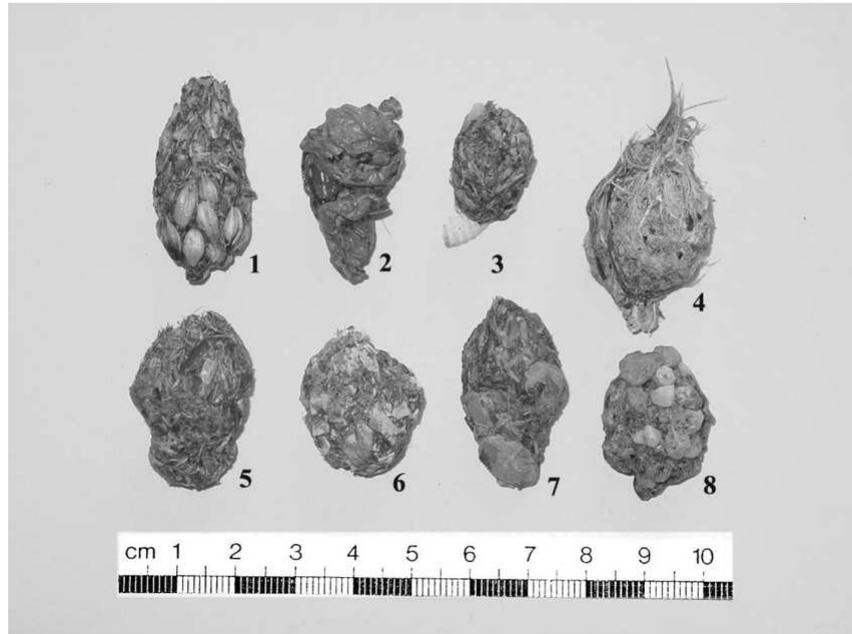


Figure 2. Pellets of the Mediterranean Gull, Atanasovsko Lake, Bulgarian Black Sea coast. 1) Barley *Hordeum vulgare* seeds which were visibly unchanged and with traces of charring. 2) Indigestible sausage package. 3) Completely digested wheat *Triticum sp.* seeds with fragments from bivalve shells and stones as gastroliths. 4) Warbler *Phylloscopus sp.* 5) Good digested Barley and Sunflower *Helianthus annuus* seeds and stones as gastroliths. 6) Two tortoise *Testudo sp.* eggs with a vole *Microtus sp.* and some good digested seeds. 7) Fruit remains of European plump *Prunus domestica*, Cultivated Grapes and Wheat seeds. 8) Completely digested Barley and Wheat seeds with 26 stones as gastroliths.

Figuur 2. Braakballen van Zwartkopmeeuw, Atanasovskomeer, Bulgaarse Zwarte zee kust. 1) Gerstezaden. 2) Omverteerbaar worstenvelletje. 3) Volledig verteerde tarwezaden met stukjes schelpen en steentjes als gastrolieten. 4) Boszanger *sp.* 5) Goed verteerde gerste- en zonnebloemzaden met steentjes als gastrolieten. 6) Twee schildpadeieren, een woelmuis en enkele verteerde zaden. 7) Restanten van pruim, druiven en tarwezaden. 8) Volledig verteerde gerste- en tarwezaden met 26 steentjes als gastrolieten.

Gulls collected seeds from field stubble, and many seeds were charred from field burning. The correlation of Barley and Wheat in the diet probably reflects the acreages under these crops. Mediterranean gulls fly up to 80 km

away off the nesting colonies (Burger & Gochfeld 1996) and flew up to 40 km away from Atanasovsko Lake. Therefore, this study cannot correlate diet with foraging from specific fields under these crops. An opportunistic diet consisting of seeds, seasonally accessible and widely available, is confirmed by the significant increase in the number of pellets with Sunflower seeds after the start of sunflower harvest in mid-August, and with seeds of cultivated grapes in the same period. Pellets with Sunflower seeds were rare before mid-August. According to Hoogendoorn (1995), Sunflower seeds were probably pecked directly from the combs, a much more difficult operation than picking them up among stubble.

Despite the prevalence of seeds in the diet, seeds are not the preferred food component of the gulls (Burger & Gochfeld 1996). Their digestive systems are not well suited for digesting seeds and the predominant Barley seeds were not visibly damaged in 22% of the pellets containing them. Probably the glumes, retained only in the Barley seeds, have higher silica content than glumes of the other three most frequently occurring seeds (Georgiev & Tschakalova 2000). Irrespective of the intake of gastroliths to make seeds more digestible, some pellets with a large number of gastroliths still had intact seeds. At the same time, a small number of pellets without gastroliths had well-digested barley and wheat seeds. Apparently, not only the quantitative proportion of the swallowed seeds and gastroliths, but the length of their processing in the stomach is important for their digestion. Pellets with undigested seeds is not unusual, and this evidence indirectly corroborates the assumption of Goutner (1994) that the death of young gulls is linked to their stomachs being full of Wheat seeds. Regurgitation of intact seeds was confirmed by the germination of seeds of seven plant species, testifying to the role of the Mediterranean Gull in ornithochory.

Animals supplemented the principally plant diet. Terrestrial animals predominated and appeared to be collected at random. No significant preferences appeared among major taxonomic groups. Dominance of grasshoppers and ground beetles among the insects and significant differences in the occurrence of invertebrates corroborate opportunism in food collection already verified by Isenmann (1975), Goutner (1986), Ardamatskaya *et al.* (1988), Zubakin (1988) and Meininger *et al.* (1991). Single pellets with predominantly animal remains reflect use of locally most numerous species. Fishes were mostly benthic species and, considering the ability of Mediterranean Gulls to fish (Cramp & Simmons 1983), they were probably gleaned as refuse from the fishing with dragnets in the Bourgas Bay. Ardamatskaya *et al.* (1988) have also established prevalence of pipefish and gobies in the fish diet of the gulls in the Ukraine, but during their breeding period.

The contents of the pellets point to the preferred feeding places of gulls. The unsmoothed edges of stones and pieces of glass showed that they were picked up in fields together with the seeds. The numerous fragments of bivalve shells had smooth edges and in our opinion were picked up along the seashore as gastroliths, after consuming vegetable food in the fields. The use of bivalve shells as gastroliths is supported by Ardamatskaya *et al.* (1988), but molluscs were the most important animal prey in Greek populations of Mediterranean gulls during the breeding period (Goutner 1994). Van Impe (1978) reported behavior of a Mediterranean gull dropping bivalves in September. Feeding in the fields with subsequent flights along the seashore to collect gastroliths and extra food before rest by day on Aatnasovsko Lake is also corroborated by the fact that 97% of the pellets with fish also contained seeds. The low content of garbage waste in ingested food corresponds to the paucity of gull visits to trash dumps in the Bourgas region. Feeding predominantly in the fields after the breeding season is not typical for Mediterranean Gulls. The diet as discerned from pellets probably reflects the seasonal supply of the most accessible food sources in suitable feeding habitats in the region and demonstrates typical feeding behavior of gull species in general (Burger & Gochfeld 1996).

ACKNOWLEDGEMENTS

We wish to thank Dr. D. Dimitrov, P. Glogov, Dr. Z. Boev and Dr. V. Beshkov for the identification of some of the food remains. Thanks also to V. Georgiev for his assistance in the field and to Dr. J. Weigand for improving the English-language text. Peter Meininger provided additional literature and he and an anonymous referee kindly commented on an earlier version of this paper.

HET VOEDSEL VAN ZWARTKOPMEEUWEN *LARUS MELANOCEPHALUS* NA DE BROEDTIJD AAN DE BULGAARSE KUST VAN DE ZWARTE ZEE

De zaden van drie gecultiveerde planten, Gerst *Hordeum vulgare*, tarwe *Triticum* spp. en Zonnebloem *Helianthus annuus* vormden het hoofdbestanddeel van het voedsel dat Zwartkopmeeuwen *Larus melanocephalus* bij elkaar scharrelen na de broedtijd in het Atanasovsko reservaat (aangetroffen in 99% van de braakballen, $n = 2397$). Braakballen met min of meer verteerde graankorrels en zaden bevatten een significant grotere hoeveelheid resten van gastrolieten (steentjes en harde brokjes die ter bevordering van de vertering in de maag worden opgeslagen). Sommige braakballen bestonden uit zo goed als onverteerd materiaal (19%, $n = 2397$). Zeven verschillende soorten zaden in deze braakballen bleken nog uit te lopen en van vijf soorten liep niet minder dan 50% van de aangetroffen zaden nog uit.

Dierlijke resten werden in 27% van de braakballen aangetroffen en daarbij overheersten dieren van terrestrische oorsprong (landdieren). Bij de ongewervelden ging het vooral om loopkevers *Harpaus* spp. (32%, $n = 1226$ individuen) en sprinkhanen (24%). Onder de gewervelde prooidieren werden hoofdzakelijk zout- en brakwatervissen aangetroffen (76%, $n = 238$

exemplaren). De als gastrolieten ingeslikte zaden en steentjes kwamen van stoppelvelden. Langs de kust werden ook schelpen (*Bivalvia*) als gastrolieten opgezicht en daarnaast werd hier actief gevist.

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DEPOSITION RATES OF CARCASSES ON THE BEACH IN THE NETHERLANDS

Few accurate estimates exist of deposition rates of carcasses on beaches. Scavengers remove corpses and many carcasses become buried in sand or wash back into the sea, as a result of which normal beached bird surveys have a tendency to underestimate the numbers of birds washing ashore. To eliminate such factors as good as possible, a very intense survey programme is required, including daily visits to the shore. In The Netherlands, an 8 km stretch of coastline (six km of dike and two km of sandy beach) has been visited nearly daily since March 1988 by a dedicated team of observers. In contrast to most other beached bird surveys, corpses found here are typically recorded as 'fresh' and most washed ashore the night before the survey. We may assume that very few corpses have been missed, certainly so on the dike, where persistence rates are extremely high (Camphuysen 1989), and where diurnal scavengers (mainly crows and gulls, increasing numbers of Red Foxes *Vulpes vulpes* in recent years) often arrived only after the observers.

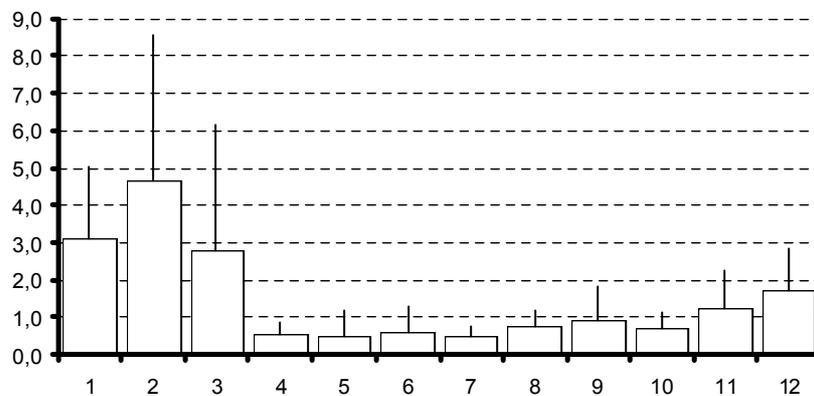


Figure 1. Deposition rates of dead birds (mean number of carcasses per day, \pm SD) along an 8 km stretch of North Sea coast in Noord-Holland (The Netherlands) between January and December.

Figuur 1. Aanspoelsnelheid van dode vogels (gemiddeld aantal kadavers per dag \pm SD) op een traject van 8 km in Noord-Holland, januari-december.

The uninterrupted series of 195 months of data showed a substantial variability in deposition rates between months, but normally with a peak between November and March (Fig. 1), with a maximum of 4.6 ± 3.9 corpses per day (0.57 ± 0.49 per km per day) in February. Between years, the number of corpses washing ashore averaged 553.5 ± 196.0 (69.2 ± 24.5 per km). Extrapolating these figures to the entire Dutch North Sea coast line would result in an estimate of nearly $27,000 \pm 9500$ corpses washing ashore per annum.

HET AANTAL DODE VOGELS DAT DAGELIJKS AANSPOELT AAN DE NEDERLANDSE KUST

Er bestaan maar weinig betrouwbare schattingen van de aantallen vogels die op de kust aanspoelen. Aaseters en weer en wind doen kadavers verdwijnen voordat de tellers er bij gekomen zijn en alleen op basis van een uitermate intensieve survey is een schatting te maken van de dagelijkse aanvoer. In Noord-Holland is door medewerkers van voorheen Natuurvereniging "De Windbreker" sinds maart 1988 een intensief programma uitgevoerd waarbij de 6 km lange Hondsbossche Zeewering en 2 km aansluitend strand vrijwel dagelijks worden onderzocht. Uit deze ononderbroken serie van 195 maanden gegevens blijkt dat er een flinke variatie bestaat in de dagelijkse aanvoer van kadavers, maar met een duidelijke piek in de winter (Fig. 1), en met een maximum van 4.6 ± 3.9 kadavers per dag (0.57 ± 0.49 per km per dag) in februari. Van jaar tot jaar bedroeg het aantal gevonden lijken gemiddeld 553.5 ± 196.0 (69.2 ± 24.5 per km). Wanneer dit getal wordt gebruikt om een schatting voor de gehele Nederlandse Noordzeekust te maken, dan spoelen hier naar schatting bijna $27,000 \pm 9500$ kadavers per jaar aan.

This overview could only have been written as a result of the incredible enthusiasm through the years of "De Windbreker" team, Arnold and Rineke Gronert, Ruud Costers, and Peter Spanenburg. The results are part of the Dutch beached bird surveys scheme, subsidised by the Ministry of Transport, Public Works and Waterways since 1999.

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*Kees (C.J.) Camphuysen, NZG/NSO,
c/o Royal Netherlands Institute for Sea Research,
P.O. Box 59, 1790 AB Den Burg, Texel*