ASSESSING AGE AND BREEDING ORIGIN OF WRECKED LITTLE AUKS *ALLE ALLE*: THE USE OF BIOMETRICS AND A VARIABLE UNDERWING PATTERN

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Camphuysen, C.J. 2006. Assessing age and breeding origin of wrecked Little Auks *Alle alle*: the use of biometrics and a variable underwing pattern. Atlantic Seabirds 7(2): 49-70. *Biometrics and plumage characteristics of Little Auks* Alle alle *were evaluated to assess possibilities for the external ageing of individual birds. Age is important when biometrical data are used to assess the subspecific identity or probable breeding origin of the birds. Standard biometrics included bill length (feathers to tip), distance from nostril to tip, bill depth, head, wing (maximum flattened chord), and tarsus length, and body mass. The presence or absence of white or white-tipped feathers was checked in seven feather groups of the (grey) underwing. Bill depth and wing length were the most useful measurements to separate adult and juvenile Little Auks (when combined, classification accuracy 83%). In combination with body mass (only emaciated birds were used), the age was assigned correctly in 88% of the examined birds. White or white-tipped feathers in the lesser primary coverts (LPC) occurred more frequently in juveniles than in adults, while the reverse was true for the greater secondary coverts (GPC). Only 74% of the Little Auks were properly aged on the basis of a combination of LPC and GPC pigmentation. With body mass being a 'difficult' measurement (an assessment of physical condition is required and incomplete corpses cannot be weighed), the combination of bill depth, wing length and white in LPC and GPC was evaluated (87% correctly assigned). A review of biometrics collected in breeding areas indicated that birds wrecked in The Netherlands were of the subspecies* A. alle alle, *with an overall size similar to for example birds of Bjørnøya (Bear Island) in the Barents Sea. It is recommended to use bill depth and wing length for ageing in combination with pigmentation patterns of LPC and GPC in future studies of wrecked birds. For comparisons with breeding populations, bill length and wing length are the most widely available and therefore useful measurements.*

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INTRODUCTION

The smallest of the Atlantic Alcidae, the Little Auk *Alle alle*, is a common offshore winter visitor in the North Sea area (Skov *et al.* 1989; Stone *et al.* 1995). In recent years, influxes and wrecks occurred in all countries around the

North Sea at irregular intervals (Camphuysen & Leopold 1996). The latest wreck on record coincided with a relatively small influx in the SE North Sea in early 2003 (Camphuysen 2003). Substantial flights of Little Auks were seen in Denmark and The Netherlands in autumn 2005 (Van Bemmelen & Wielstra 2005).

Mass-strandings are common in most of the auks and during systematic beached bird surveys it is often tried to obtain an idea of the age-composition of the casualties using external features in the plumage and/or soft parts (beak development in Puffin *Fratercula arctica* and Razorbill *Alca torda*, plumage characteristics in Common Guillemots *Uria aalge*; Kuschert *et al.* 1981; Jones *et al.* 1982; Camphuysen 1995). Information on the age of birds is important when biometrics are used to collect information on subspecies level or on the probable breeding origin of the casualties (cf. Jones 1988). Only for adult birds is sufficient baseline information in breeding areas available.

Ageing auks, or at least separating juveniles from older birds, is fairly easy in most species, but not in Little Auks. Characteristics as "brownish-black" versus "glossy black" upperparts in juveniles and adult respectively (Witherby *et al.* 1941; Glutz von Blotzheim & Bauer 1982; Cramp 1985; Gaston & Jones 1998; Svensson & Grant 2000) are not particularly helpful when examining wet, decomposed and often incomplete carcasses. Even after drying the remains, the results are not consistent between observers. It would therefore be useful if other ageing characteristics could be identified, on the basis of which adults and juveniles could be separated with a high degree of reliability, but without the need to investigate the (internal) gonads and bursa (Jones 1985). Plumage characteristics or biometrics with a potential to correctly 'predict' the age of an individual bird are needed, preferably on the wings and/or head (parts that remain when corpses are heavily scavenged).

In this paper the standard biometrics were compared with autopsy results in order to find measurements that may be of use for ageing Little Auks. The plumage of the birds was the next point of attention. The underwing of Little Auks is described in handbooks and fieldguides as "dark", "grey" or even "blackish-looking". Glutz von Blotzheim & Bauer (1982), however, noted that "*Die im Feld meist dunkel wirkende Flügelunterseite ist im Bereich der Handdecken und des Apikalteils der mittleren Armdecken fleckig oder flächenhaft weiß aufgehellt.*" In fact, the underwing pattern is rather variable, with white feather tips or entirely white feathers occurring in variable amounts in several of the main feather groups of the underwing. Following the useful observations of Kuschert *et al.* (1981), as a result of which we can now easily separate first-year Common Guillemots from older birds on the basis of white tips on the greater secondary underwing coverts, it was hoped that a careful examination and dissection of a sufficiently large sample of Little Auk wings

might provide similar clues. A study of underwing patterns was therefore undertaken using 42 freshly stranded individuals during the 2003 wreck in The Netherlands and this paper reports the results.

A larger sample of wrecked Little Auks, collected in The Netherlands over the last 30 years, were used to elucidate the probable breeding origin of the birds and their subspecific identity. The purpose of this paper is to prioritise certain measurements and plumage observations that are useful for the ageing of Little Auks in the hand. Secondly, the available baseline data are reviewed to find biometrics that are particularly useful when the subspecies or the probable breeding origin are to be assessed.

METHODS

Little Auks were collected opportunistically since 1975. If possible, the following measurements or observations were made: (a) bill length (tip to feathers and tip to nostril), (b) bill depth (at the base, Snh1), (c) head length, (d) wing length (maximum flattened chord), (e) tarsus length, (f) body mass, (g) sex and age by dissection (development and size of gonads, presence and size of bursa *Fabricii*), and (h) physical condition (subcutaneous fat, deposited fat and breast muscle) (see Jones 1985, Camphuysen 1995). Sometimes, probably as a result of severe emaciation, the condition of the gonads and bursa were such that sexing and ageing was difficult. In case of doubt, the birds were left unaged/unsexed.

In February 2003, 42 Little Auks were collected to examine the plumage in more detail. Preferably the right, and otherwise the "best" wing was collected, stretched and dried. The pattern of the underwing was documented by a description (a score) and digital photography. The wings were photographed with a HP scanjet 2200c scanner at 300 dpi and examined at actual pixels level in Photoshop 5.0 in a slideshow presentation on a 17" NEC screen. Feather groups of the underwing were evaluated one at the time and without indications of the age and sex of the birds at hand: greater (GPC), median (MPC) and lesser (LPC) primaries coverts and greater (GSC), median (MSC) and lesser (LSC) secondary or underwing coverts and the axillaries or inner median underwing coverts (Axil; Fig. 1). These seven sets of feathers were categorised and scored using the following criteria:

All grey	score 1
Grey, partly with faint white edges	score 2
Faint white tips	score 3
All or mostly faint white	score 4
Clear white tips	score 5
All or mostly bright white	score 6

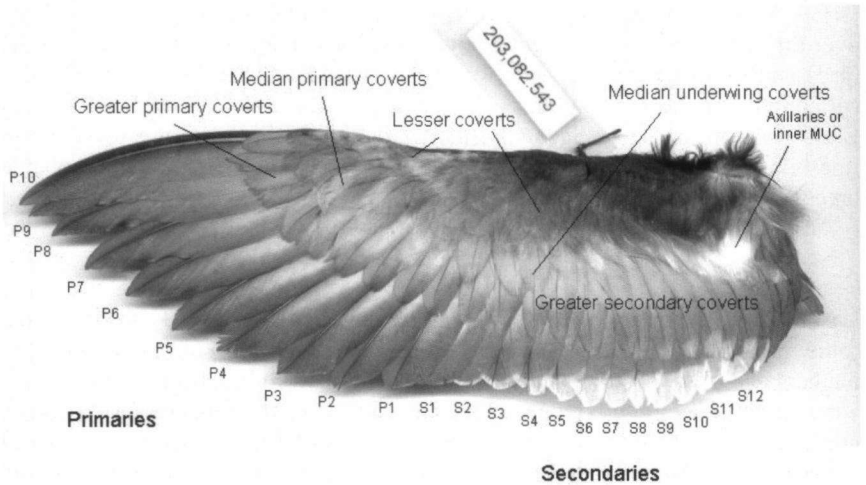

Figure 1. Topography of a Little Auk underwing and terms used in this paper. Note white tips on the inner greater secondary coverts, a bright white patch in the area between axillaries and inner median coverts, and vaguely white fringed lesser primary coverts in this example (coll.# 203082.543).

Figuur 1. Topografie van de ondervleugel van een Kleine Alk, inclusief begrippen die in dit artikel worden gebruikt. Let bij dit voorbeeld (coll.# 203082.543) op de witte toppen op de binnenste grote armpendekveren, de helder witte vlek tussen de okselveren en middelste armpendekveren, en de vage witte randjes op de kleine handpendekveren.

A minimum score of 7 would describe an all grey underwing, whereas a maximum score of 42 would result from an all white set of underwing coverts. The scores were later linked in the database with the dissection results. The birds were aged and sexed on the basis of gonadal development and the presence (and size) or absence of a *bursa Fabricii* (*cf.* Jones *et al.* 1982; Camphuysen 1995). Four categories were the used in the analysis: male and female, adult (no bursa, developed gonads, including immatures; n = 2) and juvenile Little Auks (large bursa, non-developed gonads).

Biometrics were compared with the z-test (Fowler & Cohen 1986), testing between adults (n = 41) and juveniles (n = 50), between unaged males (n = 33) and females (n = 63), between adult males (n = 13) and adult females (n =

28), and between juvenile males (n = 31) and juvenile females (n = 17). Specimens identified as "immature" (birds with a very small bursa and partly developed gonads, n = 6) were excluded from the tests between age classes. Discriminant functions and a jackknife test were calculated to assess the classification accuracy of ageing characteristics (biometrics and plumage) using classical discriminant analysis in SYSTAT 11 (Systat Software Inc. 2006).

RESULTS

Biometrics Mean bill length (± 95% confidence limits), tip to feathers, of all Little Auks measured was 14.3 ± 0.17 (11.7-16.1 mm, n = 104). Adults (14.4 ± 0.26, n = 41) were similar in bill length to juveniles (14.2 ± 0.23, n = 47; z = 0,74, n.s.; Table 1), but unaged males (14.6 ± 0.24, n = 32) were significantly larger than unaged females (14.1 ± 0.24, n = 61; z = 2.57, P< 0.05). When the sexes were split into adults and juveniles, although the tendency of males being larger than females remained the same, the difference was not significant.

The mean distance between nostril and tip of the bill in all Little Auks amounted to 10.9 ± 0.14 (9.5-12.1 mm, n = 82). Neither between sexes nor between ages were significant differences found and the range was so small that the value of this measurement may be questioned (mean ranged between 10.8 and 11.0 mm in any age/sex category).

The mean bill depth measured at the base in all Little Auks amounted to 7.9 ± 0.25 (5.8-13.4 mm, n = 82). Excluding two outliers (13.4 in an adult female and 13.0 in a juvenile male), mean bill depth amounted to 7.8 ± 0.17 (5.8-9.7 mm, n = 80). Excluding outliers, the difference between adults (8.1 ± 0.28, range 6.6-9.7 mm, n = 26) and juveniles (7.6 ± 0.22, range 5.8-9.5 mm, n = 41) was close to significance (z = 2.41, n.s.; Table 1). Otherwise, neither between sexes nor between a combination of age and sex could significant differences be found.

Mean head length of all Little Auks measured was 52.3 ± 0.36 (48-57 mm, n = 95). Adults (52.4 ± 0.56, n = 36) were similar in head length to juveniles (52.1 ± 0.50, n = 45; z = 0.83, n.s.; Table 1), but unaged males (52.7 ± 0.68, n = 30) were significantly larger than unaged females (51.8 ± 0.42, n = 55; z = 2.80, P< 0.01). A difference in head length between the sexes was even more obvious in adult birds (adult males 53.6 ± 1.04, n = 12, adult females 51.8 ± 0.53, n = 24; z = 3.93, P< 0.01), but non-significant in juveniles (juveniles males 52.0 ± 0.90, n = 16, juvenile females 52.1 ± 0.63, n = 27, z = 0.34, n.s.).

The mean tarsus length in all Little Auks amounted to 20.9 ± 0.17 (19-23 mm, n = 87). Neither between sexes nor between ages were significant differences found and the overlap in range was such that the value of this measurement may be questioned.

Table 1. Basic biometrics for Little Auks collected in winter in The Netherlands and Belgium, 1975-2003. Selected individuals were aged during autopsies (presence/absence cloacal bursa and gonadal development).

Tabel 1. Biometrische gegevens van Kleine Alken die 's winters in Nederland en België zijn verzameld, 1975-2003. Geselecteerde individuen werden op leeftijd gebracht bij autopsies (aan/afwezigheid van bursa en ontwikkeling van geslachtsorganen).

	Bill length		Nostril to tip		Bill depth		Head		Tarsus		Wing		Mass	
	Ad	Juv	Ad	Juv	Ad	Juv	Ad	Juv	Ad	Juv	Ad	Juv	Ad	Juv
Mean	14.4	14.2	11.0	10.8	8.1	7.6	52.4	52.1	20.8	21.0	125.5	121.2	117.2	115.7
SD	0.9	0.8	0.6	0.6	0.7	0.7	1.7	1.7	0.8	0.9	4.2	3.5	9.8	11.1
SE	0.1	0.1	0.1	0.1	0.1	0.1	0.3	0.3	0.1	0.1	0.6	0.5	2.0	1.9
95% c.i.	0.3	0.2	0.2	0.2	0.3	0.2	0.6	0.5	0.3	0.3	1.3	1.0	3.8	3.6
Min	12.1	12.4	9.9	9.5	6.6	5.8	48	48	19	19	116	114	105	90
Max	15.8	15.9	12.1	12	9.7	9.5	56	55	22	23	135	130	138	135
Sample	41	47	27	42	26	41	36	45	27	43	41	50	25	36

Mean wing length of all Little Auks measured was 123.1 ± 0.76 (114-135 mm, n = 117). Adults (125.5 ± 1.27, n = 41) had significantly longer wings than juveniles (121.2 ± 0.97, n = 50, z = 10.30, P< 0.01; Table 1). Unaged males (123.7 ± 1.38, n = 33) and females (122.9 ± 1.07, n = 63), as well as adult males (125.5 ± 1.82, n = 13) and adult females (125.5 ± 1.68, n = 28) were similar. A difference in wing length between the sexes was found in juveniles (males 122.3 ± 2.03, n = 17; females 120.8 ± 1.04, n = 31; z = 2.53, P< 0.05).

Body mass ranged from 90-150 grams in 71 Little Auks that could be weighed (116.7 ± 2.72, n = 71). Clearly, body mass is influenced by the physical condition of the animal when it died. On a condition index scale ranging from 0-9, two birds scored 4 (some fat remaining) and 6 (moderately fat) respectively, and these birds had a body mass of 147 and 128 grams. The remainder of the sample, all severely emaciated birds (condition index 1.1 ± 0.6 SD), had a body mass of 116.1 ± 2.64 (90-150, n = 69). In these emaciated corpses, adults (117.2 ± 3.84, 105-138, n = 25) were slightly heavier than juveniles (115.7 ± 3.63, 90-135, n = 36; z = 1.78, n.s.; Table 1), males (117.2 ± 5.26, 90-138, n = 21) heavier than females (115.0 ± 2.81, 95-135, n = 46; z = 2.48, n.s.), but the overlap was enormous and the differences were not significant.

Jackknife tests of classification accuracy suggested that approximately between 76% and 88% of the Little Auks used would have been properly aged on the basis of either just bill depth, or a combination of the measurements bill depth, wing length and lean body mass (Table 2).

Table 2. Discriminant functions for Little Auks arranged in order of increasing classification accuracy according to jackknife tests. Measurements of bill depth, wing length and body mass were used of 25 adult and 33 juvenile Little Auks.

Tabel 2. Discriminant functies voor Kleine Alken, gesorteerd op toenemende nauwkeurigheid volgens jackknife-toetsen. Gegevens gebaseerd op snavelhoogte, vleugellengte en lichaamsgewicht van 25 adulte en 33 juveniele Kleine Alken.

Discriminant coefficients				Wilks'			% correct
Bill depth	Wing	Mass	Constant	lambda	*F*	*df*	jackknife
1.665			-12.80	0.77	16.66	1, 56	76
	0.291		-35.76	0.70	24.52	1, 56	78
1.115	0.230		-36.88	0.56	21.74	2, 55	83
4.006	0.117	-0.198	-22.18	0.33	37.14	3, 54	88

Summarised, bill depth (measured at base) and wing length seemingly are the most promising biometrics to separate adults from juveniles. Bill length, head, and wing were most useful to discriminate between the sexes in unaged birds, but only the head produced significant results. Lean body mass was useful for ageing and sexing, but in this case the body condition should be assessed first. Only emaciated individuals were available for the analysis presented here. In the sample examined here, head length was a useful measurement to discriminate between adult males and females, but not juveniles. Wing length was inconclusive to separate the sexes in either adults or juveniles. The material evaluated suggests that on the basis of bill depth and wing length alone, 17% of the birds would not be aged correctly. Adding body mass would improve the accuracy of classifications (88% correct; Table 2), but an internal inspection of the physical condition of the animals is required to make sure that lean body mass is used. During that inspection, a visual check of the presence or absence of a cloacal bursa would give a more definite answer regarding the age of the bird in hand.

Plumage characteristics Of 42 corpses of Little Auks examined for the underwing pattern, 33 could be sexed and 35 were aged during dissection (see Appendix). Age composition was rather even, with 17 adults (or non-juveniles) and 18 juvenile birds, but sexratio was biased towards females (21 females, 12 males). Underwing pattern scores ranged from 7 to 25 out of a theoretical range from 7 to 42 (Appendix 1). Examples of the extremes found are shown in Figure 2 (score 7) and Figure 3 (score 25). Both the greater primary coverts (GPC) and the lesser secondary coverts (LSC) were all grey in all examined specimens (Table 3). Such feather groups may be ignored in future studies. The other feather groups were more variable. Since the birds were examined to investigate

Figure 2. Score 7, not a single white feather in any of the underwing coverts (juvenile female).

Figuur 2. Score 7: geen enkele witte veer op de ondervleugeldekveren (juveniel vrouwtje).

Figure 3. Score 25, white tips or largely white feathers in median and lesser primary coverts, greater and median secondary coverts and a bright white inner secondary coverts/axillaries region (adult female).

Figuur 3. Score 25: witte toppen op of grotendeels witte veren tussen de middelste en kleine handpendekveren, grote en middelste armpendekveren en helder witte okselveren en binnenste dekveren (adult vrouwtje).

*Table 3. Colour scores in seven feather groups on the underwing of aged Little Auks (*n = *35).*

*Tabel 3.Kleurscores van zeven onderscheiden veergroepen op de ondervleugel van op leeftijd gebrachte Kleine Alken (*n = *35)*

Code	Colour of feathers \ feather group	GPC		MPC		LPC		GSC		MSC		LSC		Axil	
	Age	A	J	A	J	A	J	A	J	A	J	A	J	A	J
1	All grey	17	18	11	9	8	4	11	16	11	11	17	18	3	1
2	Grey, partly with faint white edges			5	8	5	3			2	6			2	5
3	Some faint white tips					2	7	2	2	3	1			1	
4	All or mostly faint white			1	1	1	1			1				7	7
5	Clear white tips					1	2	4							
6	All or mostly white						1							4	5
	Sample	17	18	17	18	17	18	17	18	17	18	17	18	17	18

the possibilities for ageing on the basis of external characteristics, only the successfully aged individuals were used in the analysis (Table 3, Fig. 4). More or less completely white feathers were most frequent in the axillaries (Table 3), but with no difference between adults and juveniles (Fig. 4). The median primary and secondary coverts had highly variable amounts of white, but again, with no difference between the two age categories. White tips of the lesser primary coverts (LPC) and greater secondary coverts (GSC) seemed more promising, with a more frequent occurrence of white-tipped LPC in juveniles and the reverse in GSC in adults (Fig. 2, 3, and 4).

Examples of dull grey or faintly white-tipped GSC are shown in Figure 5, examples of clear-cut white tipped GSC are shown in Figure 6. Note that all examples were collected in February, so that differences in feather wear should theoretically be negligible. All wings were dried prior to inspection and it should be realised that the assessment of white tips and fringes on wet wings may be more difficult.

Mean (± SD) LPC score amounted to 1.9 ± 1.2 (n = 17) in adults and to 2.8 ± 1.4 (n = 18) in juveniles. While white tips on the greater secondary coverts (GSC) occurred in 35% of the mature birds, some 10% of the juveniles had faint white tips. Mean (± SD) GSC score amounted to 2.2 ± 1.7 (n = 17) in adults and 1.2 ± 0.6 (n = 18) in juveniles. A jackknife test of classification accuracy suggested that approximately 74% of the Little Auks used would have been properly aged on the basis of a combination of LPC and GSC pigmentation (Discriminant coefficients LPC = 0.654, GSC = -0.707, constant -0.376, Wilks Lambda 0.705, F = 6.7, df = 2, 32, $P< 0.004$). In the other feather groups, the amount of white observed was similar in both adults and juveniles.

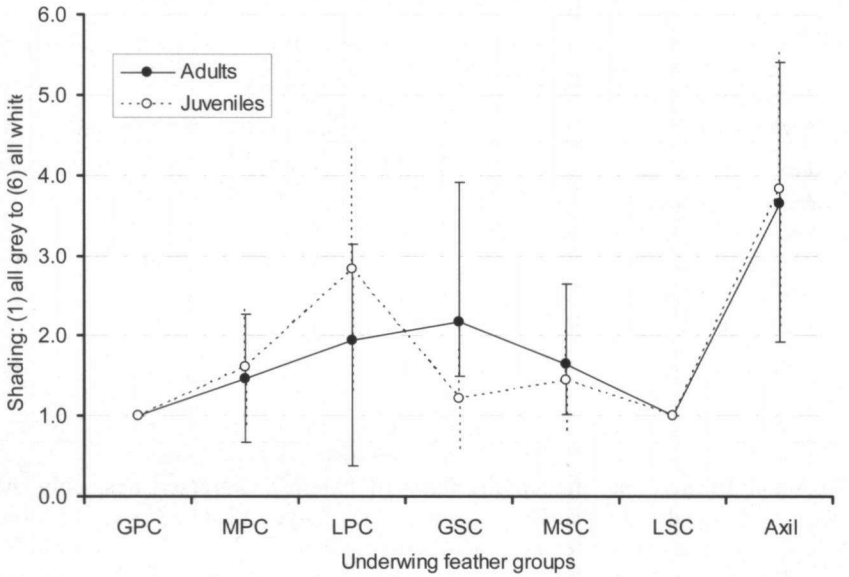

Figure 4. Mean (± SD) score on the grey-scale for the major feather groups in the underwing of adult (n = 17) and juvenile (n = 18) Little Auks.

Figuur 4. Gemiddelde (± SD) score op de 'grijsschaal' voor de veergroepen op de ondervleugel van adulte (n = 17) en juveniele (n = 18) Kleine Alken.

DISCUSSION

When studying stranded birds following wrecks and oil incidents, three main questions are put forward: what (sub)species were involved, what was the sexratio and age-composition, and from where did the birds originate? Little Auks are polytypic with the nominate subspecies *alle* nesting in Canada, Greenland, northern Iceland, Jan Mayen and Spitsbergen and with *polaris* nesting on Franz Josef Land (not certainly known which race breeds on Severnaya Zemlya and in the North Pacific; BWP*i* 2004). Breeding populations are very large in more northern areas (many millions) and also the colonies in Franz Josef Land are said to be vast, with some colonies of over 100 000 birds (Norderhaug *et al.* 1977). To allow for a valid comparison of biometrical data (wintering birds and birds in breeding populations or vice versa), adults and immatures should be separated. The first step, therefore is to age the collected birds.

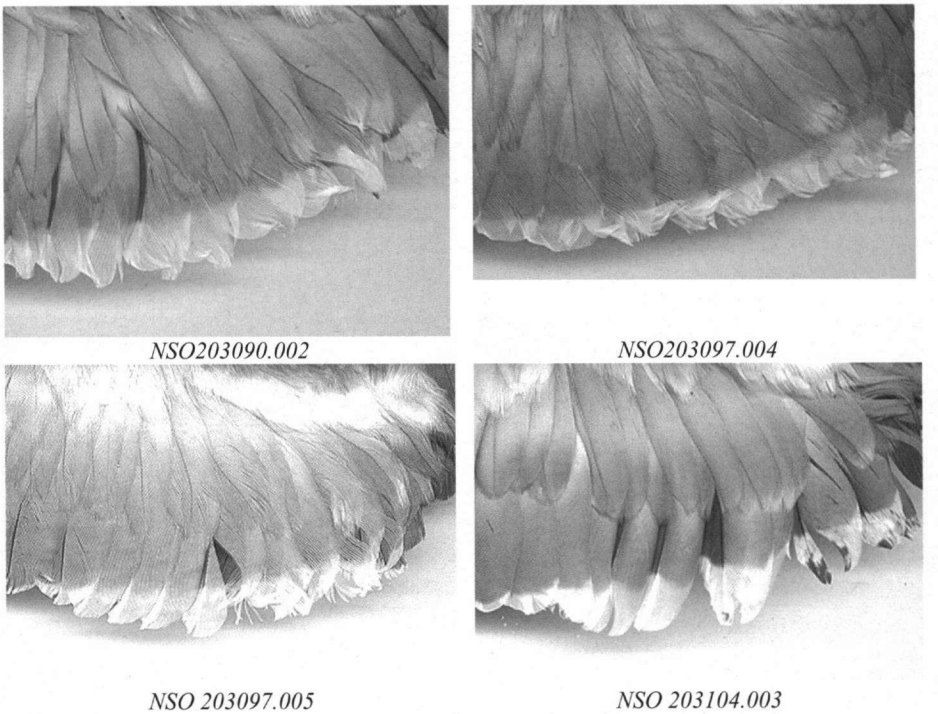

Figure 5. GSC score 3 in two juvenile (top row) and two adult (bottom row) Little Auks.
Figuur 5. GSC-score 3 van twee juveniele (boven) en twee adulte (onder) Kleine Alken.

Ageing Little Auk gonads are small and emaciated birds are sometimes very difficult to sex during a simple visual internal inspection. The presence of a bursa is an important feature, but a small proportion of birds combines a small bursa with partially developed gonads (possibly immatures rather than juveniles). When autopsies can be avoided, much larger samples can be checked. More importantly, when many corpses are partly scavenged, autopsies may not even be an option. From the external ageing characteristics, biometrics are the first to be evaluated. The most promising biometrics for ageing were bill depth and wing length. Body mass was potentially useful, when the condition index was taken into account. Figure 7 reveals a clear split in juveniles and adults on the basis of two measurements, but there is considerable overlap, making individual judgements unreliable (expected accuracy 83%, Table 2).

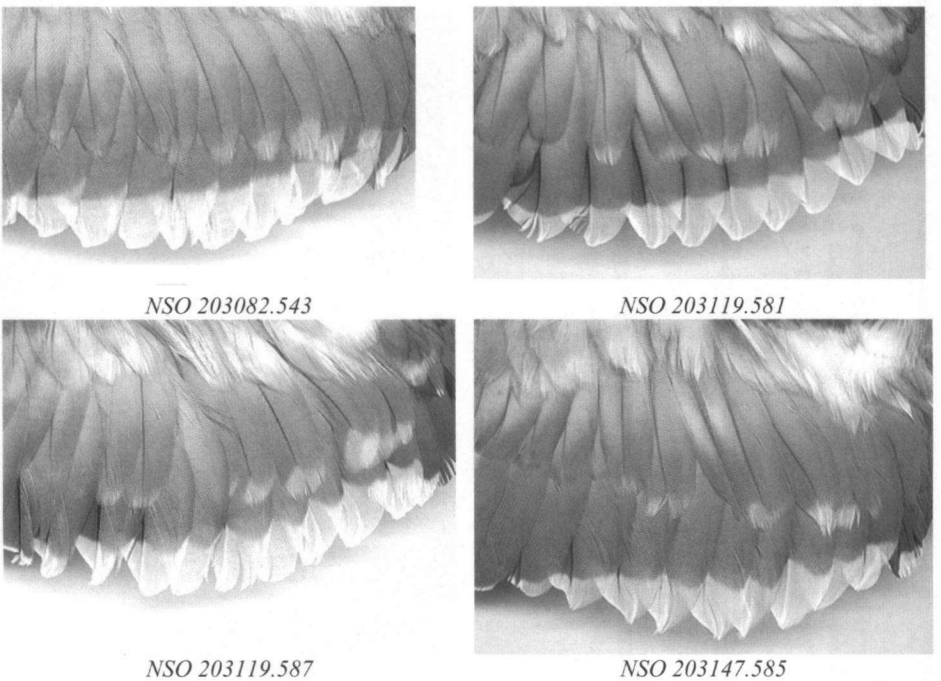

Figure 6. GSC score 5 in four adult Little Auks.
Figuur 6. GSC-score 5 van vier adulte Kleine Alken.

The prospects for a reliable external judgement of age based on plumage characteristics are not very good either. Despite considerable variation in the amount of white in the underwing feather groups, observed patterns were far from consistent. The most promising feather groups, white-tipped lesser primary coverts (LPC) were indicative of young animals (11 out of 18 birds, 61%), but nearly a quarter of the 17 adults had at least some faint white tips (23%; Table 3). While white tips on the greater secondary coverts (GSC) occurred in 35% of the mature birds, some 10% of the juveniles had faint white tips. The expected accuracy of ageing on the basis of these plumage characteristics was only 74% (jackknife test, see above).

A logical next test was to combine the most promising biometrics (bill depth and wing length) with the most clearly different feather groups (LPC and GSC) in a discriminant analysis. Unfortunately, only 15 aged birds were available for the test (7 adults, 8 juveniles), all the others had at least one of the required parameters missing. A jackknife test of classification accuracy still

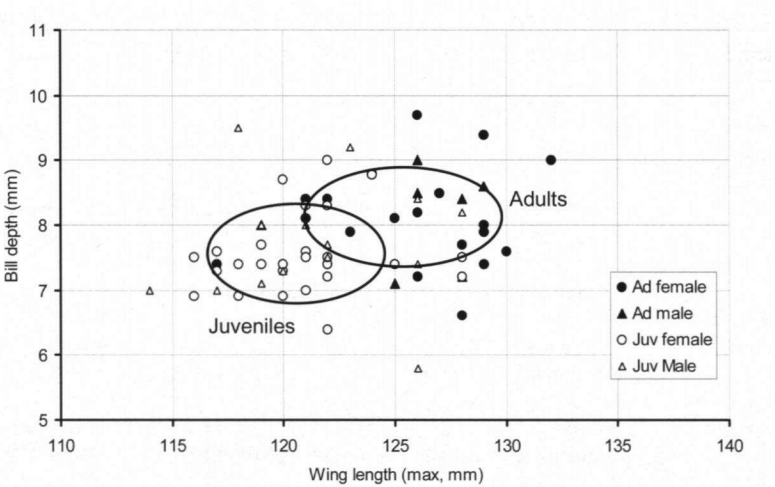

*Figure 7. Wing length (maximum flattened chord) and bill depth relationship in adult and juvenile Little Auks found dead in The Netherlands (*n *= 66) The ovals contain mean values and standard deviation ranges.*

*Figuur 7. Relatie tussen vleugellengte (maximum flattened chord) en snavelhoogte bij adulte en juveniele Kleine Alken, die dood in Nederland zijn gevonden (*n *= 66). De ovalen bevatten gemiddelden en en standaarddeviaties.*

suggested that approximately 87% of the Little Auks used would have been properly aged on the basis of a combination of LPC and GSC pigmentation, bill depth and wing length (Discriminant coefficients LPC = 0.349, GSC = -0.618, wing length 0.066, bill depth -2.439, constant 11.660, Wilks Lambda 0.150, F = 14.14, df = 4, 10, $P< 0.001$). In the other feather groups, the amount of white observed was similar in both adults and juveniles. It is therefore recommended to keep scoring LPC and GSC in future dissections, to enlarge the sample, and to re-analyse underwing pigmentation as an ageing characteristic in future. Of the basic measurements, wing length and bill depth deserve the highest priority.

Detecting the origin of birds Despite comprehensive research programmes and considerable ringing effort in some colonies (e.g. Norderhaug 1968, Bakken *et al.* 2003), ringed Little Auks are extremely rare in Europe (none in the Dutch beached bird survey since the early 1960s; n = 534 checked corpses). Birds from Spitsbergen were recovered in Iceland and Greenland. Colonies east of Svalbard have received relatively little attention in terms of ringing. Biometrics, if at all

Table 4. Wing length in Little Auks found in winter in the North Sea.
Tabel 4. Vleugellengte van Kleine Alken die 's winters in de Noordzee zijn gevonden.

Sample	Sex and age	mean (mm)	SD (*n*)	Range	Source
Netherlands, Winter	Adults	125.5	4.15 SD (41)	116-135	this study
	Juveniles	121.2	3.51 SD (50)	114-130	
Shetland, winter	Ad males	130.2	2.82 SD (13)	124-134	Heubeck &
	Ad females	127.0	3.02 SD (23)	119-131	Suddaby 1991
	All males	129.7	3.06 SD (15)	124-134	
	All females	127.0	3.77 SD (32)	117-134	
Skagerrak, winter	All males	126.4	(65)	117-135	Anker-Nilssen *et al.* 1988
	All females	125.9	(66)	120-132	
Britain, east coast winter	Adults	122.7	4.6 SD (71)	112-135	Jones *et al.* 1985
	Immatures	120.7	3.0 SD (26)	112-130	

different between populations, are therefore the only means of assessing the origin of stranded Little Auks. The main distinguishing feature seems to be the wing length (Anker-Nilssen *et al.* 1988). Heubeck & Suddaby (1991), evaluating the biometrics of Little Auks found in Shetland in December 1990, were able to compare wing length with birds measured live at Jan Mayen colonies (from Camphuysen 1990), measured live at Spitsbergen colonies (Norderhaug 1980, Stempniewicz 1981), and measured as museum skins of adults collected in Franz Josef Land (Vaurie 1965; also prior to assumed shrinkage of 1.5%; Table 4-5). Anker-Nilssen, comparing measurements of Little Auks found dead in an oiling incident in 1981 in the Skagerrak with those from breeding populations, used the same measurements by Vaurie (1965) for Franz Josef Land and Norderhaug (1980) for Spitsbergen (Table 4-5), but also data from museum skins by Vaurie (1965) for Greenlandic specimens. The study of Heubeck & Suddaby (1991) as well as measurements by Anker-Nilssen *et al.* (1988) were representative of the larger end of wing length measurements reported for the form *alle*, but in fact intermediate between birds measured alive in Jan Mayen and Spitsbergen and those measured as skins for the race *polaris* where a shrinkage of 1-2% is likely to have occurred.

Since these studies and overviews, an important new paper was published, reporting fresh measurements of adult birds captured in colonies from Spitsbergen, Bjørnøya, and Franz Josef Land (Stempniewicz *et al.* 1996; Table 5). Birds from Bjørnøya and Franz Josef Land could be separated with

Table 5. Wing length in Little Auks in breeding populations. Note that measurements labelled with an (*) were naturally folded wings rather than maximum flattened chord. Measurements labelled with (†) were dried skins. Norderhaug (1980) did not specify the measuring technique.

Tabel 5. Vleugellengte van Kleine Alken in verschillende broedpopulaties.. NB maten met (*) betroffen natuurlijk gevouwen vleugels in plaats van maximiuaal gestrekte vleugels (maximum flattened chord). Maten met (†) betroffen balgen. Norderhaug (1980) specificeert de gebruikte meetmethode niet.

Sample	Sex and age	mean (mm)	SD (*n*)	range	Source
Franz J. Land	Males †	131.9	(27)	124-138	Vaurie 1965
	Females †	131.6	(7)	129-137	
Franz J. Land	live, unsexed	133.3	3.73 SD (59)	122-141	Stempniewicz *et al.* 1996
Spitsbergen	Adults *	120.5	3.2 SD (97)	114-128	Stempniewicz 1981, 1982
	Fledglings *	97.9	3.6 SD (31)		Stempniewicz 1982
Spitsbergen	live, unsexed	118.5	(185)	106-129	Norderhaug 1980
Spitsbergen	live, unsexed	124.6	2.51 SD (5)	121-127	Stempniewicz *et al.* 1996
Bjørnøya	live, unsexed	124.8	2.64 SD (217)	118-134	Stempniewicz *et al.* 1996
Jan Mayen	live, unsexed	118.4	3.69 SD (20)	112-124	Camphuysen 1990
NW Greenland	Ad males	123.1	2.73 SD (117)	?	Roby *et al.* 1981
	Ad females	122.4	2.95 SD (92)	?	
	first year	117.2	2.20 SD (18)		

confidence on the basis of (combined) body mass and wing length, or bill length and wing length. Multivariate analysis showed that any set of variables measured in the field (mass, wing, tail, bill or tarsus) clearly discriminated the Little Auk populations from Svalbard and Franz Josef Land. An interesting confounding factor, however, was that apparently some of the data sets used previously have included 'naturally folded wing' rather than 'maximum flattened chord'! Stempniewicz in his 1981 paper (data copied in Cramp 1985 and BWP*i* 2004) reports a "flattened wing" according to "Svensson 1975" for Spitsbergen birds: 120.5 ± 3.2, range 114-127.5 (n = 97). Stempniewicz *et al.* (1996), however, report a "naturally folded wing" for Spitsbergen birds of 120.9 ± 3.27, range 114-129 (n = 94), as well as a 'maximum flattened chord' of 124.6 ± 2.51, range 121-127 from only 5 individuals! Their 'second' mean is 4 mm larger than the much larger sample based on naturally folded wings and it is the maximum flattened chord that they use in subsequent analysis and testing. Because most of their 99 Spitsbergen birds were "captured in five expeditions

between 1975 and 1992" there is likely to be overlap between the material published in 1981 and that in the overview paper published in 1996. The earlier comparison with *A.a. alle* from Spitsbergen by Heubeck & Suddaby (1991) based on Stempniewicz's material, suggesting that Shetland's birds are extremely large (Table 4), is therefore misleading. Birds from Shetland are still representative of the larger end of wing length measurements reported for the form *alle*, however.

Stempniewicz (1980) failed to find sexual dimorphism from measurements taken on Little Auks. This is corroborated by most results in this study and in Little Auks measured after a wreck along the British east coast (Jones *et al.* 1985) and during the 1981 oil spill in the Skagerrak (Anker-Nilssen *et al.* 1988). Heubeck & Suddaby (1991), however, tested significant differences between males and females in wing length, gonys bill depth, and bill length. Significant differences in bill length and head length were found between the sexes, if the age of the birds was ignored, in data reported in this study. British east coast birds, as well as birds in the present study, showed significantly different measurements with age in some biometrics, such as wing length. Similar differences were found in studies in breeding areas, for example when adult breeders were compared with first year individuals (Roby *et al.* 1981). Because so few birds measured alive in colonies were sexed, a comparative data set from breeding areas with age and sex of the birds known is difficult to obtain. With age differences being considerably larger than the sexual dimorphy, ageing Little Auks in post-mortems is of higher priority than sexing. The combination of body mass and wing length to separate different populations, as proposed by Stempniewicz *et al.* (1996) is not very useful for studies of wrecked and oiled individuals in winter areas. Such birds are either oiled (and cannot be weighed) or severely emaciated and therefore low in body mass irrespective of structural size.

Adult Little Auks measured live in NE Atlantic colonies (Table 5) can now be compared with measurements of birds collected in the North Sea. Using a combination of wing length (maximum flattened chord!) and bill length, selecting adult birds from the Dutch sample regardless of their sex (n = 41 where both measurements were available), a comparison with individuals classified as *A.a. polaris* from Franz Josef Land and *A.a. alle* from Bjørnøya is shown in Figure 8. The results suggest that winter birds in The Netherlands were consistent with *alle* rather than *polaris*, and that birds from Bjørnøya are similar in size, but with relatively longer beaks. The difference in beak size would call for future attention, but possibly, just as in several of the other auks, are winter beaks in Little Auks smaller than summer beaks.

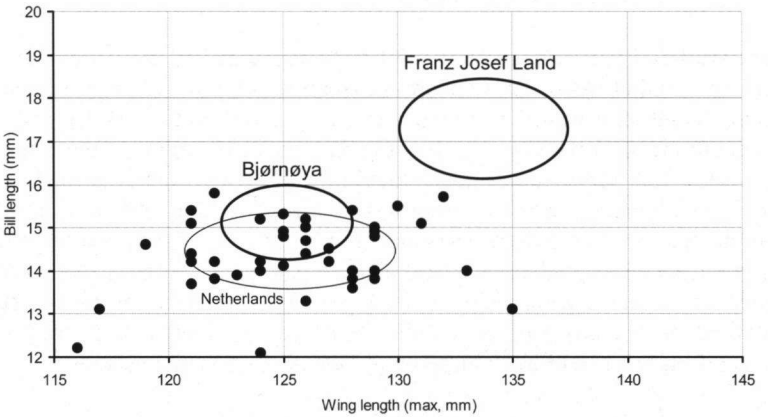

Figure 8. Wing length (maximum flattened chord) and bill length relationship in adult Little Auks found in The Netherlands (black dots and thin oval; n = *41) in comparison with adult birds measured in breeding colonies at Bjørnøya and Franz Josef Land (ovals). Ovals contain mean values and standard deviation ranges.*

Figuur 8. Relatie tussen vleugellengte (maximum flattened chord) en snavelhoogte bij adulte Kleine Alken, die in Nederland gevonden zijn (zwarte stippen en dunne ovaal, n = *41) vergeleken met adulte vogels die gemeten waren in de broedkolonise op Bjørnøya en Franz Josef Land (ovalen). De ovalen bevatten gemiddelden en en standaarddeviaties.*

Body mass The (recent) papers on Little Auk biometrics in breeding areas provide useful information also on body mass of fit, adult individuals. Stempniewicz (1981) reported a mean body mass of 163.1 ± 12.0g (134-193g, *n* = 96) for adult breeding birds in Spitsbergen. Roby *et al.* (1981) reported a body mass of 150.5 ± 8.81g (no range, *n* = 209) for adults from NW Greenland. Stempniewicz *et al.* (1996) reported a mass of 157.8 ± 10.5g (range 133-196g, *n* = 212) for adults from Bjørnøya, and 202.3 ± 12.5g (174-230g, *n* = 56) for *polaris* in Franz Josef Land. With biometrics clearly suggesting the *alle* subspecies (Fig. 8, Table 4-5), the emaciated (adult) birds found in The Netherlands had lost on average a quarter (24.5%) of their body mass (Table 1). This is a very similar result in comparison with other emaciated auks found in the Southern North Sea, where 278 emaciated adult Common Guillemots *U.a. (albionis/aalge)* were 28% below an expected body mass of 975g, 132 adult Razorbills *A.t. islandica* were 25% below an expected body mass of 620g, and 9

adult Atlantic Puffins *Fratercula arctica grabae* were 26% below an expected body mass of 390g (C.J. Camphuysen, unpubl. data).

Future studies From this study, it can be recommended to always include bill depth (measured at base) as a standard measurement. On the other hand, the use of tarsus length and nostril to bill tip length may be omitted. Bill length and wing length are vital parameters when the subspecies or origin of the birds has to be assessed. A follow-up project, studying wing patterns as described in this paper, in combination with the appropriate measurements and dissections to reveal the age from the presence/absence of a bursa is recommended to confirm or even enhance the predictive value of these parameters. Finally, we have no information on underwing patterns in Little Auks in each of the breeding populations and colony workers should therefore be stimulated to study wing patterns during their field work or perhaps studies of skins in museums.

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BEPALING VAN DE LEEFTIJD EN DE HERKOMST VAN GESTRANDE KLEINE ALKEN *ALLE ALLE*: DE BETEKENIS VAN BIOMETRISCHE GEGEVENS EN EEN VARIABEL PATROON OP DE ONDERVLEUGEL

Bij massale strandingen van zeevogels is het een goed gebruik om de achtergronden en de mogelijke oorzaak te onderzoeken. De vogels worden dan gemeten, een indruk wordt opgedaan van de leeftijdsverdeling en de sexratio, en zo mogelijk wordt nagegaan waar de gestrande vogels vandaan zijn gekomen. In het ideale geval zijn alleen uitwendige bepalingen noodzakelijk, liefst aan onderdelen waardoor ook aangevreten, incomplete kadavers nog bruikbaar zijn. Voor de herkomst van vogels zijn ringgegevens het meest betrouwbaar, maar helaas zijn er zelden voldoende geringde exemplaren voorhanden om een uitspraak te kunnen doen. In dergelijke gevallen worden de genomen maten vergeleken met biometrische gegevens uit de broedgebieden. Behalve dat zo een eventuele ondersoort kan worden vastgesteld, geven dergelijke gegevens vaak ook een aanwijzing welk deel van de populatie betrokken was, omdat er binnen een soort vaak regionale verschillen in biometrie bestaan.

Kleine Alken Alle alle *zijn dikwijls betrokken bij massastrandingen en invasies. Helaas zijn bij deze soort de uitwendige verschillen tussen volwassen en juveniele vogels onduidelijk. De invasie van 2003 werd benut om 42 exemplaren nader te onderzoeken. Daarnaast werden de dissecties die gedaan werden aan Kleine Alken die sinds 1975 'opportunistisch' werden verzameld, gebruikt om een wat grootschaligere analyse te kunnen doen. De vogels uit 2003 werden gebruikt*

om de patronen op de ondervleugel in detail te bestuderen, vanwege een vermelding in de handboeken dat hier "variabele hoeveelheden witte veertjes" aanwezig zouden zijn. Alle andere exemplaren werden gemeten en zo mogelijk inwendig onderzocht. Bij dissectie werden leeftijd en geslacht bepaald, waardoor achteraf kon worden uitgerekend in hoeverre de verzamelde biometrische gegevens van nut zouden zijn geweest bij het 'voorspellen' van leeftijd en geslacht.

De standaardmaten die bij Kleine Alken werden genomen waren snavellengte (veerrand tot punt), afstand van neusgat tot snavelpunt, snavelhoogte aan de basis, koplengte, tarsuslengte, vleugellengte en totale massa, inclusief een bepaling van de conditie van de vogels. Bij de analyse van de vogels uit 2003 werden zeven verschillende veergroepen aan de ondervleugel onderzocht en werd de hoeveelheid wit aan de veren gescoord op een schaal van 1 (geheel grijs) - 6 (helderwit). Geheel grijze ondervleugels behaalden zo een score van 7 (7x1); theoretisch zou een score van 42 (7x6) haalbaar moeten zijn. Het bleek dat op grond van een combinatie van de snavelhoogte en de vleugellengte zo'n 83% van de vogels correct op leeftijd zou zijn gebracht. In combinatie met 'vermagerd gewicht' (vrijwel alle onderzochte vogels hadden volkomen uitgeputte vet- en spierreserves) kon de betrouwbaarheid worden opgevoerd tot 88%. Sommige andere maten konden worden gebruikt om de sexen te scheiden. Twee maten, de afstand tussen neusgat en snavelpunt en de tarsuslengte, gaven noch tussen de sexen, noch tussen de leeftijdsklassen verschillen aan en het nut van deze maten wordt daarom betwijfeld.

Witte veertjes, of veertjes met witte toppen, kwamen relatief vaak voor in de kleine handpendekveren (LPC) van juveniele Kleine Alken, het omgekeerde was het geval bij de grote armpendekveren (GPC) van adulte vogels. De gemiddelde LPC score (± SD) bij juveniele Kleine Alken bedroeg 2.8 ± 1.4, bij adulten 1.9 ± 1.2. De gemiddelde GSC score (± SD) van bij juveniele Kleine Alken bedroeg 1.2 ± 0.6, bij adulten 2.2 ± 1.7. De overlap was aanzienlijk en op basis van een combinatie van deze beide veergroepen kon slechts 74% van de Kleine Alken correct op leeftijd gebracht worden.

Omdat het lichaamsgewicht een 'moeizame' maat is, omdat er dan toch ook een dissectie (en een compleet kadaver) nodig is om een uitspraak te kunnen doen over de leeftijd op grond van de afmetingen, werd gezocht naar een combinatie van biometrie en ondervleugelpatronen. Helaas was het monster van vogels waarbij zowel de vleugel was onderzocht, als de juiste maten waren genomen maar klein. Evengoed bleek op grond van een combinatie van snavelhoogte, vleugellengte en de aan-/afwezigheid van witte veertjes op LPC en GSC 87% correct op leeftijd gebracht te kunnen worden.

*Vervolgens werd gekeken, na een nieuwe analyse van de literatuur, welke afmetingen Kleine Alken in de broedgebieden hadden en in hoeverre Nederlandse vogels daarmee overeenkwamen. Over de biometrie in de gebieden van herkomst, in vergelijking met de gegevens die van gestrande vogels in de Noordzee, waren enkele verwarrende analyses gepubliceerd. Uit de literatuur was een groot verschil bekend tussen de broedvogels van Franz Josef Land (*A.a. polaris*) en de broedvogels van Spitsbergen en Groenland (*A.a. alle*). Gestrande vogels op de Britse eilanden hadden maten opgeleverd die feitelijk inzaten tussen de beide populaties, en gespeculeerd werd al over 'nog onontdekte broedgebieden' waar dergelijke vogels zouden kunnen broeden. Uit een vergelijking van drie publicaties van dezelfde auteur over de vogels van Spitsbergen, bleek echter dat de gepubliceerde vleugellengtes niet op een vergelijkbare manier waren gemeten. Na correctie (ongeveer 5% langere maten door de vleugel bij het meten goed te strekken) waren de Noordzeevogels al een stuk minder ongewoon, ofschoon nog steeds relatief groot in vergelijking met de op Spitsbergen gemeten individuen. Nederlandse vogels bleken afmetingen te hebben die prima overeenkwamen met broedvogels van de westelijke Barentszee, zals de broedvogels van Bereneiland of Spitsbergen (Fig. 8, Tabel 5). Met nieuwe gegevens uit de broedplaatsen in de hand kon bovendien preciezer worden ingeschat hoeveel lichaamsgewicht de hier gestrande vogels verloren hadden. Uitgaande van een 'gezond gewicht' van ongeveer 155 gram, hadden de Nederlandse vogels gemiddeld 24.5% van hun lichaamsgewicht verloren.*

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Appendix. Age, sex, colour pattern on underwing feather groups, overall colour score, wing length, bill length, bill depth, and body mass in 42 corpses of Little Auks selected for a plumage analysis in 2003. Bijlage. Leeftijd, geslacht, kleurpatroon op de veergroepen op de ondervleugel, totale kleurscore, vleugellengte, snavellengte, snavelhoogte en lichaamsgewicht van 42 kadavers van Kleine Alken die in 2003 geselecteerd zijn voor een analyse van het verenkleed.

Coll number	Age	Sex	GPC	MPC	LPC	GSC	MSC	LSC	Axil	Score	Wing	Bill	Depth	Mass
203079.596	J		1	1	3	1	1	1	4	12	119	14.1	7.50	
203080.533	J	M	1	2	3	1	1	1	4	13	128	16.1	8.00	
203081.550			1	1	1	1	1	1	1	7	119	13.1	6.70	
203082.542	J	M	1	1	1	1	2	1	6	13	119	14.2	8.00	
203082.543	A	F	1	2	2	5	2	1	6	19	124	15.5	8.30	115
203090.002	J	M	1	1	3	3	2	1	4	15	122	15.2		
203090.003	A	F	1	1	1	1	1	1	1	7	124	14.2		
203090.004	A	M	1	1	1	1	1	1	1	7	122	14.2		
203090.005	J	F	1	1	1	1	1	1	1	7	124	14.3		
203096.569	J	M	1	2	2	1	1	1	6	14	119	13.8	7.10	120
203097.002	A	F	1	1	1	1	1	1	4	10	133	14.0		
203097.004	J	F	1	2	4	3	3	1	4	18	119	13.4		
203097.005	A	F	1	1	2	3	4	1	4	16	116	12.2		
203098.001	A	M	1	1	1	1	1	1	2	8	127	14.2		
203098.002			1	2	4	1	2	1	2	13	119			
203100.572			1	2	3	1	3	1	5	16	129	14.9	7.40	
203100.573	J	F	1	2	3	1	1	1	6	15	122	13.7	6.40	
203100.574			1	2	3	1	1	1	4	13	121	14.4	8.80	
203104.001	A	M	1	2	3	1	1	1	4	13	121	15.4		
203104.003	A	F	1	2	3	3	3	1	6	19	124	15.2		
203105.001	J		1	1	3	1	1	1	2	10	117	14.9		
203105.002	A	F	1	1	1	1	1	1	4	10	121	13.7		
203106.001			1	1	1	1	1	1	2	8	125	15.5		

Coll number	Age	Sex	GPC	MPC	LPC	GSC	MSC	LSC	Axil	Score	Wing	Bill	Depth	Mass
203119.578	J	M	1	2	5	1	1	1	2	13	126	14.7	8.40	130
203119.581	A	F	1	1	1	5	3	1	3	15	124	12.1	8.80	120
203119.587	A	M	1	2	4	5	2	1	6	21	126	13.3	8.50	120
203119.588	J	F	1	2	2	1	1	1	4	12	125	14.3	7.40	125
203119.589	J	F	1	2	3	1	2	1	4	14	122			
203119.590	A	M	1	1	1	1	1	1	4	10	126	15.2	9.00	120
203119.591	J	F	1	4	6	1	2	1	6	21	116	14.6	7.50	120
203119.592	J	M	1	2	5	1	1	1	2	13	126	13.5	7.40	100
203122.001	A	M	1	1	2	1	1	1	2	9	131	15.1		
203144.621			1	2	2	1	1	1	6	14	124			
203146.582	A	F	1	1	1	1	1	1	1	7	121	14.2	8.10	105
203147.579	J	F	1	1	3	1	1	1	4	12	122	13.3	7.20	115
203147.580	A	F	1	1	2	1	1	1	4	11	130	15.5	7.60	
203147.583	J	F	1	1	1	1	2	1	6	13	128	14.3	7.20	115
203147.584	A	F	1	2	2	1	1	1	4	12	129	14.0		
203147.585	A	F	1	4	5	5	3	1	6	25	126	14.7	8.20	120
203147.586	J	F	1	1	2	1	2	1	2	10	117	13.4	7.30	120
203147.618	J	F	1	1	1	1	1	1	2	8	118			
203170.530			1	2	6	1	5	1	6	23	126			
						Summarised								
- Sample 21		F	1.0	1.6	2.2	1.9	1.8	1.0	3.9	13.4	123.1	14.0	7.6	117.2
- Sample 12		M	1.0	1.5	2.6	1.5	1.3	1.0	3.6	12.4	124.4	14.6	8.1	118.0
- Sample 17	A		1.0	1.5	1.9	2.2	1.6	1.0	3.6	12.9	125.0	14.3	8.4	116.7
- Sample 18	J		1.0	1.6	2.8	1.2	1.4	1.0	3.8	12.9	121.6	14.2	7.5	118.1