



Article (refereed) - postprint

Harris, Mike P.; Heubeck, Martin; Newell, Mark A.; Wanless, Sarah. 2015.
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This is an Accepted Manuscript of an article published by Taylor & Francis Group in *Bird Study* on 30/03/2015, available online: <http://www.tandfonline.com/10.1080/00063657.2015.1017444>

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1 **The need for year-specific correction factors (k values) when converting counts of individual**
2 **Common Guillemots *Uria aalge* to breeding pairs**

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10 **Capsule** Long-term studies at two Scottish colonies show that the k value used to convert counts of
11 individual Common Guillemots *Uria aalge* to pairs has changed substantially in the last 15 years due
12 to decreases in survival and colony attendance. Any future wide-scale census of this species needs to
13 collect concurrent k values if counts of individual birds are to be used to determine changes in
14 breeding populations since the previous survey.

15 For most seabirds the counting unit is something tangible such as a nest, apparently occupied site,
16 apparently occupied territory or burrow. However, for the Common Guillemot *Uria aalge* (hereafter
17 Guillemot) the counting unit is the individual bird. This is a pragmatic solution to a difficult problem
18 since the birds often breed at very high densities (sometimes >70 pairs per sq m; Birkhead 2010)
19 where it is not possible to determine how many breeding sites or eggs are on a ledge. There are
20 guidelines in place as to how and when counts of individuals should be made to reduce the variation
21 due to time of day, weather etc. and hence increase the usefulness of such counts to detect changes
22 in the numbers of individuals from year to year (Birkhead 1978, Hatch & Hatch 1989, Burger & Piatt
23 1990, Walsh *et al.* 1995).

24 Counts of individuals include incubating and brooding adults, some of their mates, failed and
25 non-breeders, and immature birds that visit the colonies for 3–4 years before they recruit. Such
26 counts should always be presented as the number of individuals bearing in mind that such totals
27 integrate abundance and attendance behaviour at the colony. However, when comparing population
28 trends of Guillemots with other seabirds or for use in population models, there is a need to convert
29 these counts to the numbers of breeding pairs. This is done by the use of a correction factor k
30 defined as the number of pairs that bred in an area determined by daily checks throughout the
31 laying period divided by the number of individuals counted in the same area at the time that the
32 colony census is made (Birkhead & Nettleship 1980). Determining this value is time-consuming since
33 the laying period can span six or more weeks and so is not normally done. In the 1980s, a six-year
34 study at a single colony and a review of the literature suggested that a figure 0.67 was generally

35 applicable and this has subsequently been widely used including during the censuses of the
36 Guillemot populations of Britain and Ireland undertaken in 1985–88 and 1998–2002 (Harris 1989,
37 Lloyd *et al.* 1991, Walsh *et al.* 1995, Harris & Wanless 2004). Elsewhere, other values have been used
38 e.g. 0.61 in mainland Norway (Bakken 1986, Barrett *et al.* 2006) and 0.67–0.83 in California (Carter *et al.*
39 *et al.* 2001, McChesney *et al.* 2013). Most estimates of k have come from populations that were stable
40 or increasing but numbers and breeding success at some British colonies have declined substantially
41 this century (JNCC 2014). Here we report on k values recorded during two long-term studies and
42 draw attention to the need to obtain such values concurrently with any large-scale survey of
43 Guillemot numbers, as is currently being planned for Britain and Ireland.

44 Information was collected at two Scottish colonies — the Isle of May (56°11'N, 02°33'W),
45 Firth of Forth and 400 km north at Sumburgh Head (59°51'N, 01°16'W), Shetland. On the Isle of
46 May, the numbers of individual Guillemots at the colony were counted during the late incubation
47 and chick-rearing period 1–20 June each year 1981–2014 except for 1982. The colony was counted
48 section-by-section between 08:00 and 16:00 BST over a period of several days. To allow for
49 differences in attendance between and within days, immediately before or after a section count
50 (that would normally last 2–3 hours) a count was made of the numbers of individuals present in a
51 fixed plot of broken cliff containing 100–250 breeding pairs (depending on the year) where there
52 was plenty of room for colony expansion (Area 3 in Harris & Wanless 1988). This area typical of the
53 Guillemot colony on the Isle of May is not disturbed for ringing and it seems reasonable to assume
54 that it is representative of the colony. It is part of a long-term intensive study and all breeding sites
55 in it were checked at least three times a day during the laying period so that the number of breeding
56 pairs (hereafter pairs) was known each year (Harris & Wanless 1986). Each section count of
57 individuals was converted to pairs using the k value at the time and section totals later combined to
58 give a total population estimate for that year. An average k value for each year was then obtained by
59 dividing the number of calculated pairs by the number of birds counted. Additional data on breeding
60 and demography were available as part of the long-term studies (details in Harris & Wanless 1988,
61 Lahoz-Monfort *et al.* 2013, 2014).

62 At Sumburgh Head, the laying of 108–154 pairs breeding on a large ledge with room for the
63 colony to expand (Heubeck 2009) which was assumed to represent the colony as a whole was
64 followed by twice-daily checks each year 2000–2014 and the numbers of individuals present were
65 counted 12:00–14:00 BST on the same five dates in early and mid-June (i.e. late incubation and early
66 chick-rearing) each year that numbers were counted in population monitoring plots.

67 The annual count of individual Guillemots on the Isle of May declined during the 1980s,
68 increased during the 1990s to a peak in 2001 before declining to a 30-year low in 2013 (Fig 1.).
69 Despite considerable differences between years, the annual value of k fluctuated around 0.67
70 between 1981 and 2000 (mean $0.678 \pm se\ 0.01$, 95% CI 0.657, 0.699, $n = 20$ years) before increasing
71 rapidly to 0.95 in 2011 (Fig. 2). The average value of k over the 33 years was 0.743 ± 0.017 (0.708,
72 0.772) with a range of 0.592–0.953. The use of a k value of 0.67 would thus have approximated year-
73 specific values until about 2001 and accordingly the numbers of pairs estimated by using year-
74 specific k or $k = 0.67$ were similar (Fig. 1). However, subsequently the use of 0.67 would have given
75 estimates that progressively diverged from year-specific values and by the end of the period the
76 number of pairs would have been underestimated by 20-30%.

77 Sample counts at Sumburgh Head indicated that numbers of individuals decreased between
78 2000 and 2014 by more than 50%. Over this period k values varied markedly but, on average,
79 became higher (Fig. 2). The mean value was 0.816 ± 0.029 (95% CI 0.753, 0.879) with a range of
80 0.600 – 1.05. The k value >1.0 in 2011 was the result of there being fewer birds present than the
81 number of pairs that bred that year due to some pairs having failed and others leaving their young
82 unattended. The mean k value for the Isle of May over the same period was almost identical at 0.818
83 ± 0.023 (95% CI 0.769, 0.867); the k values at the two colonies were significantly and positively
84 correlated (Fig. 2, $r^2 = 34\%$, $P = 0.013$, $n = 15$ years) suggesting that the factors influencing the
85 attendance of birds at the colonies was acting over a wide area.

86 The detailed studies on the Isle of May shed light on why k values have become markedly
87 lower since about 2000. First, breeding success declined significantly from c. 0.85 chicks fledged per
88 pair up to 1995 to 0.28 in 2007 (Lahoz-Monfort *et al.* 2013). Second, first-winter survival of fledglings
89 declined steadily from c.80% in 1996 to near zero in 2006 and 2007 (Lahoz-Monfort *et al.* 2013,
90 2014). Thus there were fewer immatures to return to the colony in later years. Third, studies of birds
91 colour marked as chicks showed that starting about 1991, two- and three-year olds spent much less
92 time at the colonies (details in Lahoz-Monfort *et al.* 2014). For instance, the resighting rate at the
93 colony of birds in their second year of life (the youngest that birds are seen at this colony) has
94 declined from 30% in 1991 to near zero since 1998. The resighting rate of birds in their third year

95 (when most immature birds visit the colony) declined from 80% in 1992 to 10% in 2004 and this rate
96 explains 18% of the variation in the value of k (ANOVA: $F_{1,22} = 5.81$, $P = 0.025$). Together these
97 changes resulted in there being many fewer immatures in the population towards the end of the
98 period and those that had survived spent less time at the colony compared to the 1980s and 1990s.
99 Changes in the attendance of breeding birds were also apparent. Mates not brooding chicks spent
100 less time at the colony. For instance, annual daily checks of 100–200 chicks at mid-day through the
101 chick-rearing period found that the percentage with both parents in attendance declined from 28.1%
102 in 1997 to 0.8% in 2007 and, whereas no unattended chicks were seen up until 2003, by 2007 the
103 proportion of unattended chicks had reached 13% (Ashbrook *et al.* 2008). After this, parental
104 attendance rates improved but even in 2014 only 7.5% of chicks had both adults present. The
105 proportion of chicks with both adults in attendance t at mid-day explained 37% of the variation in k
106 (ANOVA: $F_{1,26} = 17.1$, $P < 0.001$). The resighting rate of Guillemots in their third year of life and the
107 frequency of both adults being present were highly correlated ($r = 0.70$, $P < 0.002$, $n = 19$ years) so it
108 was not possible to determine the relative importance of attendance of adults or immatures on the
109 value of k . Colony attendance by adult Guillemots has been shown to be positively correlated with
110 food when their prey fish occurred at poor to moderate densities but not when the density was
111 higher (Harding *et al.* 2007); in theory, k might be used as index of prey availability but in practice it
112 would be difficult to separate the effects of poor conditions 3–5 years before from poor conditions
113 during the season in question. However, if the proportion of chicks with both adults present was
114 routinely recorded at the same time as the counts of individuals were made for a k value, this would
115 help interpret the underlying causes in the annual variation in k .

116 A k value of 0.67 was used to convert counts of individuals at British and Irish colonies in
117 1985–88 and 1998–2002 to pairs and our results indicate that such estimates were likely to have
118 been robust. However, application of this value to surveys in eastern and northern Britain at present
119 would not be appropriate. For instance, the count of 16,691 individuals on the Isle of May in 2011
120 would have been converted to 10,513 breeding pairs instead of 14,955 – an underestimate of 42%.
121 Similarly, the number of pairs at Sumburgh Head in 2007–2014 were underestimated each year by
122 between 12% (2014) and 34% (2011) using 0.67 instead of the year-specific value.

123 Although we found close agreement between year-specific k values at two colonies that are
124 400 km apart and experience contrasting trophic interactions (Frederiksen *et al.* 2007), it is likely
125 that there will be considerable variation in k values between colonies as well as years. Thus where
126 counts of individuals need to be converted to pairs, it is highly desirable to have concurrent values of
127 k . However, obtaining even a single value is very time consuming and even for our studies, k values
128 were based on data from a single study plot assuming that this value was representative of the

129 colony. Birkhead & Nettleship (1980) considered that it needed three hours of observations each day
130 of a plot containing c. 80 breeding pairs for at least 40 days and a count of all birds present on 5–10
131 dates during the normal census period to get an acceptable value for that breeding season. Hence, it
132 may be unrealistic to expect k values to be collected on a regular basis.

133 It is now 15 years since the last full survey of the numbers of British and Irish Guillemots and
134 another is scheduled. While the only feasible counting unit is the individual bird, the value of the
135 survey will be greatly enhanced if the results can be used to assess long-term regional changes in
136 Guillemot breeding populations. Our results suggest that this is best done by ensuring that k values
137 at a sample of geographically representative colonies are collected concurrently with the survey
138 period.

139

140 **ACKNOWLEDGEMENTS**

141 We thank the members of the Institute of Terrestrial Ecology (1981–1994) and Scottish Natural
142 Heritage (1995–2014) who made the annual whole-island counts on the Isle of May NNR and Harry
143 Carter and an anonymous reviewer for improving the manuscript. Studies at Sumburgh Head were
144 funded by Sullom Voe Association Ltd.

145 **References**

- 146 **Ashbrook, K., Wanless, S., Harris, M. P. & Hamer, K. C.** 2008. Hitting the buffers: conspecific
147 aggression undermines benefits of colonial breeding under adverse conditions. *Biol. Letters*
148 **4**: 630-633.
- 149 **Bakken, V.** 1986. A method for assessing changes in the breeding population of guillemots *Uria*
150 *aalge* on Vedøy, Røst. *Fauna norvegicus. Ser. C, Cinclus* **9**: 25-34.
- 151 **Barrett, R. T., Lorentsen, S.-H. & Anker-Nilssen, T.** 2006. The status of breeding seabirds in mainland
152 Norway. *Atlantic Seabirds* **8**: 97-126.
- 153 **Birkhead, T. R.** 1978. Attendance patterns of Guillemots *Uria aalge* at breeding colonies on Skomer.
154 *Ibis* **120**: 219-229.
- 155 **Birkhead, T. R.** 2010. *Great Auk Islands*. T. & A.D. Poyser, London.
- 156 **Birkhead, T. R. & Nettleship, D. N.** 1980. Census methods for murrens *Uria* species - a unified
157 approach. *Canadian Wildlife Service Occasional Paper* **43**: 1-25.

- 158 **Burger, A. E. & Piatt, J. F.** 1990. Flexible time budgets in breeding Common Murres as buffers against
159 variable prey abundance. *Studies Avian Biol.* **14**: 71-83.
- 160 **Carter, H. R., Wilson, U. W., Lowe, R. W., Rodway, M. S., Manuwal, D. A., Takekawa, J. E. & Yee, J.**
161 **L.** 2001. Population trends of the Common Murre (*Uria aalge californica*). In Manuwal, D. A.,
162 Carter, H. R., Zimmerman, T. S. and Orthmeyer D. L. (eds) *Biology and conservation of the*
163 *Common Murre in California, Oregon, Washington, and British Columbia. Volume 1: Natural*
164 *history and population trends* 33-132. U.S. Geological Survey, Information and Technology
165 Report USGS/BRD/ITR-2000-0012, Washington, D.C.
- 166 **Frederiksen, M., Furness, R. W. & Wanless, S.** 2007. Regional variation in the role of bottom-up and
167 top-down processes in controlling sandeel abundance in the North Sea. *Mar. Ecol. Progr. Ser.*
168 **337**: 279-286.
- 169 **Harding, A. M. A., Piatt, J. F., Schmutz, J. A., Shultz, M. T., Van Pelt, T. I., Kettle, A. B. & Speckman,**
170 **S. G.** 2007. Prey density and the behavioral flexibility of a marine predator: The common
171 murre (*Uria aalge*). *Ecology* **88**: 2024-2033.
- 172 **Harris, M. P.** 1989. Variation in the correction factor used for converting counts of individual
173 Guillemots *Uria aalge* into breeding pairs. *Ibis* **131**: 85-93.
- 174 **Harris, M. P. & Wanless, S.** 1988. The breeding biology of guillemots *Uria aalge* on the Isle of May
175 over a six-year period. *Ibis* **130**: 172-192.
- 176 **Harris, M. P. & Wanless, S.** 2004. Common Guillemot *Uria aalge*. In Mitchell, P. I., Newton, S. F.,
177 Ratcliffe N. & Dunn, T. E. (eds), *Seabird populations of Britain and Ireland*, 350-363. T. &
178 A.D.Poyser, London.
- 179 **Hatch, S. A. & Hatch, M. A.** 1989. Attendance of murres at breeding sites - implications for
180 monitoring. *J. Wildlife Manage.* **53**: 483-493.
- 181 **Heubeck, M.** 2009. Common Guillemot *Uria aalge* chick diet and breeding performance at Sumburgh
182 Head, Shetland in 2007–09, compared to 1990–91. *Seabird* **22**: 9-18.

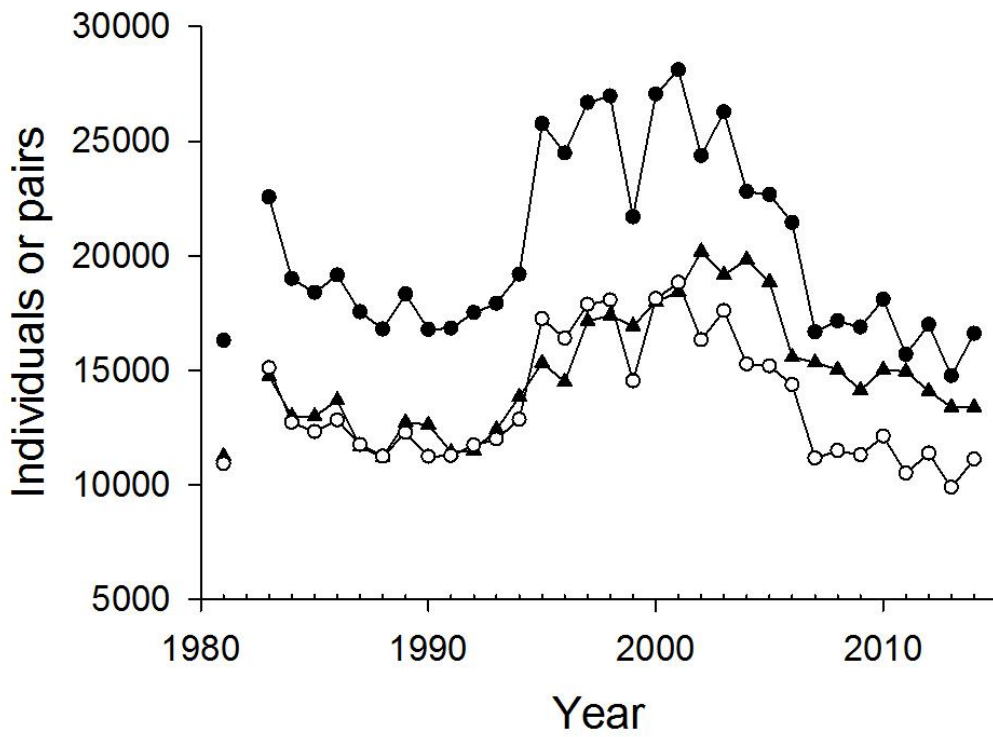
- 183 **JNCC.** 2014. Seabird Population Trends and Causes of Change: 1986-2013 Report
184 (<http://www.jncc.defra.gov.uk/page-3201>). Joint Nature Conservation Committee. Updated
185 August 2014. Accessed 20 November 2014.
- 186 **Lahoz-Monfort, J. J., Harris, M. P., Morgan, B. J. T., Freeman, S. N. & Wanless, S.** 2014. Exploring
187 the consequences of reducing survey effort for detecting individual and temporal variability
188 in survival. *J. Appl. Ecol.* **51**: 534-543.
- 189 **Lahoz-Monfort, J. J., Morgan, B. J. T., Harris, M. P., Daunt, F., Wanless, S. & Freeman, S., N.** 2013.
190 Breeding together: modelling synchrony in productivity in a seabird community. *Ecology* **94**:
191 3-10.
- 192 **Lloyd, C., Tasker, M. L. & Partridge, K.** 1991. *The Status of Seabirds in Britain and Ireland*. T. & A.D.
193 Poyser, London.
- 194 **McChesney, G.J., Carter, H.R., Bechaver, C.A., Rhoades, S.J., Bradley, R.W., Warzybok, P.M.,**
195 **Golightly, R.T. & Capitolo, P.J.** 2013. Seabird breeding population sizes within the North
196 Central Coast Study Region of the California Marine Life Protection Act Initiative, 2010-2012.
197 In McChesney G.J. & Robinette, D. (eds.) *Baseline characterization of newly established*
198 *marine protected areas within the North Central California Study Region - seabird colony and*
199 *foraging studies*, 78-110. U.S. Fish and Wildlife Service, San Francisco Bay National Wildlife
200 Refuge Complex, Fremont, California, and Point Blue Conservation Science, Petaluma,
201 California.
- 202 **Walsh, P. M., Halley, D. J., Harris, M. P., del Nevo, A., Sim, I. M. W. & Tasker, M. L.** 1995. *Seabird*
203 *monitoring handbook for Britain and Ireland*. JNCC / RSPB / ITE / Seabird Group,
204 Peterborough.

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208 **Figure 1.** Counts of birds (filled circles) and the calculated number of breeding pairs of Guillemots on
209 the Isle of May 1981-2014 using a year-specific value of k (triangles) and a value of 0.67 (open
210 circles).



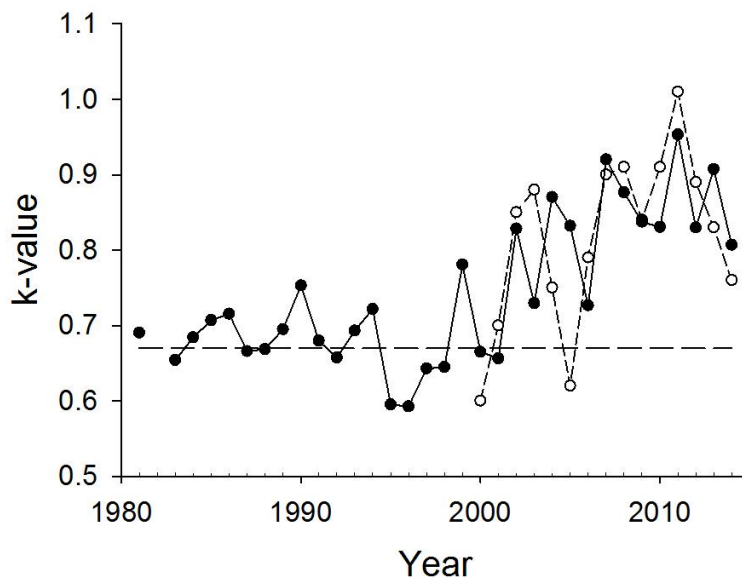
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214 Figure 2. Changes in the k values obtained on the Isle of May in 1981-2014 (solid circles and solid
215 lines) and at Sumburgh Head in 2000-14 (open circles, dotted lines. The horizontal line indicates a k
216 value of 0.67.

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