

Appendix to:
Breeding biology and population dynamics
of a colonial seabird: The Razorbill

A long-term study of an expanding Razorbill colony on Græsholmen
in the central Baltic Sea, 1983-2011

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Appendix Tables	Page
Appendix Tab. 1	2
Appendix Tab. 2	3
Appendix Tab. 3	4
Appendix Tab. 4	5
Appendix Tab. 5	6
Appendix Tab. 6	7
Appendix Tab. 7	8
Appendix Tab. 8	9
Appendix Tab. 9	10
Appendix Tab. 10	11
Appendix Tab. 11	12
Appendix Tab. 12	13

Appendix Figures

Appendix Fig. 1	14
Appendix Fig. 2	14
Appendix Fig. 3	15
Appendix Fig. 4	14
Appendix Fig. 5	14

Græsholmen

Græsholmen	16
A note on fledging	22

Appendix Tab. 1

Ringed and measured Razorbills on Græsholmen, 1983–2011. FANs = found active nests.

Year	FANs	Measured eggs	Ringed chicks	Measured chicks	Weighed chicks	Ringed adults	Reringed adults
1983	197		60			6	
1984	248	16	108		37	13	
1985	316	35	192	202	194	16	3
1986	350	52	199	194	79	14	7
1987	356	35	224	48	47	12	4
1988	367	52	226	127	119	16	7
1989	376	55	244	70	69	8	2
1990	408	65	232	220	178	10	4
1991	459	133	274	278	275	7	6
1992	474	235	281	288	288	15	7
1993	569	332	383	387	381	4	1
1994	595	421	342	361	361	3	1
1995	573	413	325	336	262		
1996	608	300	396	407	345	4	4
1997	616	204	418	426	172	5	8
1998	612	122	402	430	430	8	19
1999	678	114	464	464	236	6	5
2000	738	101	507	522	103	12	11
2001	738	45	507	521	57	19	14
2002	737	26	469	482	34	1	
2003	765	29	460	462	19	2	1
2004	846	31	562	563	70		4
2005	883	27	345	347	37	1	4
2006	953	34	308	306	17	2	5
2007	892	34	252	251	20		
2008	219	39	111	104			
2009	44	45	51				
2010	41	32	41				
2011	52	49	84	11		1	
Total		3076	8467	7807	3830	185	117

Appendix Tab. 2

Resightings of Razorbills on Græsholmen, 1983–2011.

	Hours used for resighting	Resighted birds ringed as chicks	All resightings of birds ringed as chicks	Resighted birds ringed as adults	All resightings of birds ringed as adults
1983				2	2
1984				2	2
1985		1	1	3	3
1986				7	7
1987	1	1	1	7	7
1988		4	4	10	10
1989		11	11	11	11
1990	15	54	56	16	20
1991	38	206	311	42	76
1992	58	338	661	51	119
1993	135	587	1387	79	217
1994	195	575	1207	68	151
1995	156	693	1879	61	185
1996	246	801	2334	46	163
1997	215	642	1173	46	90
1998	102	807	1771	40	92
1999	146	1028	2603	49	172
2000	168	886	1760	38	123
2001	120	872	1744	45	140
2002	117	675	1357	44	207
2003	97	495	959	34	155
2004	69	918	1695	45	146
2005	114	301	546	29	79
2006	41	297	572	30	78
2007	42	486	738	29	66
2008	43	403	755	26	102
2009	59	94	343	13	74
2010	49	108	342	12	42
2011	29	127	419	13	51
Total	2254	11410	24629	898	2590

Appendix Tab. 3

Egg volume (cm³) in relation to female age: 337 eggs laid by 85 females of known age in K30, Græsholmen, 1990–2011.

Age (year)	Mean egg volume	SD	Median egg volume	N =	Egg volume increase (%)
3	154.1	14.2	156.9	8	
4	167.2	14.4	165.0	23	8.5
5	168.1	12.0	168.5	33	0.5
6	173.4	11.3	170.7	34	3.2
7	175.1	13.0	174.8	41	1.0
8	177.2	12.6	175.7	35	1.2
9	178.8	13.2	178.1	31	0.9
10	181.6	12.1	179.9	25	1.6
11	180.6	14.5	178.8	22	-0.6
12	182.6	10.8	180.6	19	1.1
13	181.5	11.4	185.7	17	-0.6
14	182.6	14.2	182.4	12	0.6
15	183.6	15.7	182.8	13	0.5
16	183.2	11.7	179.6	7	-0.2
17	190.1	7.5	191.3	5	3.8
18	185.9	11.3	190.0	5	-2.2
19	193.0	9.0	196.3	5	3.8
20	190.4	5.8	190.4	2	-1.3

Appendix Tab. 4

Hatching dates for Razorbills on Græsholmen, 1985–2008 (N = 8192).

Year	Earliest	Mean	Latest	Span (d)	N =
1985	16-06	02-07	04-08	49	209
1986	10-06	26-06	06-08	57	247
1987	12-06	26-06	06-08	55	181
1988	04-06	23-06	27-07	53	209
1989	27-05	17-06	18-07	52	183
1990	23-05	12-06	17-07	55	241
1991	28-05	19-06	05-08	69	281
1992	31-05	19-06	06-08	67	286
1993	03-06	20-06	02-08	60	385
1994	06-06	21-06	19-07	43	384
1995	28-05	15-06	26-07	59	358
1996	06-06	23-06	30-07	54	399
1997	25-05	19-06	29-07	65	428
1998	29-05	16-06	22-07	54	407
1999	31-05	20-06	29-07	59	466
2000	28-05	16-06	27-07	60	510
2001	07-06	20-06	25-07	48	508
2002	30-05	16-06	19-07	50	473
2003	05-06	24-06	25-07	50	463
2004	28-05	14-06	20-07	53	566
2005	01-06	15-06	01-08	61	343
2006	09-06				309
2007	03-06	15-06	27-07	54	251
2008	02-06				105
Mean	02-06	19-06	27-07	56	
Min.	23-05	12-06	17-07	43	
Max.	16-06	02-07	06-08	69	

Appendix Tab. 5

Species and number of fish brought to Razorbill chicks on Græsholmen, 1985–2009.

Year	Observed		Goby	Found in nest		Total	Clupeid %
	Clupeid	Sandeel		Sprat	Sandeel		
1985				10	1	11	91
1986		1		17	2	20	85
1987							
1988							
1989				13		13	100
1990				3		3	100
1991	1		3	19		23	87
1992	2			7	3	12	75
1993	1	1		6	1	9	78
1994				8		8	100
1995	3			10		13	100
1996	19	3		16	4	42	83
1997	8		2	5	3	18	72
1998	14			5		19	100
1999	13			6		19	100
2000	12			5	1	18	94
2001	10		2	8		20	90
2002	8		1	6		15	93
2003	7	1		6	2	16	81
2004				15	3	18	83
2005							
2006	6	1				7	86
2007	47			3		50	100
2008	1		2	1		4	50
2009	1					1	100
2010							
2011							
Total	153	7	10	169	20	359	90

Appendix Tab. 6

Age of Razorbill chicks fledging in different periods of the breeding season, Græsholmen 1984–2005 (N = 202).

Age (d)	Late Jun - early Jul	Mid-Jul	Late Jul	Aug
13				3
14				3
15	1	1	2	4
16	3	4	2	3
17	4	4	4	11
18	7	11	4	11
19	11	10	12	5
20	7	6	1	3
21	6	5	4	2
22	8	2	3	1
23	6	3	2	
24	6	2	2	
25	3	2	1	1
26	3			
27	2		1	
Median	21	19	19	17
SD	2.9	2.4	2.8	2.4
N =	67	50	38	47

Appendix Tab. 7

Recoveries and resightings of Razorbills ringed as chicks on Græsholmen, 1986–2011.

	Ringed	Recovered	Recovered %	Resighted	Resighted %	Not reported	Not reported %
1986	199	15	6.7	85	42.7	99	49.7
1987	224	8	3.5	119	53.1	97	43.3
1988	226	7	2.9	118	52.2	101	44.7
1989	244	8	3.4	146	59.8	90	36.9
1990	232	13	4.7	128	55.2	91	39.2
1991	274	18	6.4	146	53.3	110	40.1
1992	281	13	3.4	136	48.4	132	47.0
1993	383	13	3.8	159	41.5	211	55.1
1994	342	14	4.3	184	53.8	144	42.1
1995	325	10	2.5	174	53.5	141	43.4
1996	396	9	2.2	213	53.8	174	43.9
1997	418	9	2.2	221	52.9	188	45.0
1998	402	20	4.3	178	44.3	204	50.7
1999	464	14	2.8	178	38.4	272	58.6
2000	507	23	4.5	162	32.0	322	63.5
2001	507	8	1.7	129	25.4	370	73.0
2002	469	19	4.1	106	22.6	344	73.3
2003	460	15	2.7	94	20.4	351	76.3
2004	562	29	8.4	93	16.5	440	78.3
2005	345	7	2.3	45	13.0	293	84.9
2006	308	2	0.8	41	13.3	265	86.0
2007	252	8	7.2	17	6.7	227	90.1
2008	111	0	0.0	11	9.9	100	90.1
2009	51	1	2.4	6	11.8	44	86.3
2010	41	0	0.0	1	2.4	40	97.6
2011	84	1	1.2	0	0.0	83	98.8

Appendix Tab. 8

Breeding success in six study plots on Græsholmen, expressed as % fledging chicks per laying pair, 1987-2007.

	K83	K14	K206	K96	K5	K119	Mean
1987	71.4	75.0	66.7	90.9	60.0	85.7	78.8
1988	60.0	55.6	100.0	72.7	12.5	88.9	67.7
1989	77.8	66.7	100.0	70.0	42.9	88.9	68.8
1990	70.0	60.0	50.0	91.7	50.0	88.9	69.1
1991	63.6	100.0	60.0	78.6	44.4	77.8	67.1
1992	41.7	46.2	66.7	73.3	12.5	80.0	58.2
1993	61.5	80.0	66.7	88.9	75.0	100.0	77.4
1994	54.5	76.5	77.8	71.4	60.0	57.1	65.3
1995	54.5	78.9	80.0	58.3	30.0	66.7	64.0
1996	75.0	72.2	80.0	68.0	88.9	84.6	75.0
1997	75.0	77.8	66.7	66.7	36.4	100.0	72.0
1998	64.3	70.0	83.3	78.9	60.0	75.0	73.3
1999	64.7	81.0	92.3	78.3	77.8	100.0	79.1
2000	60.0	83.3	85.7	90.9	100.0	91.7	84.6
2001	92.3	85.2	73.3	84.0	81.8	60.0	78.8
2002	86.7	85.2	78.6	74.1	72.7	85.7	77.9
2003	76.5	85.2	92.3	74.1	83.3	83.3	79.6
2004	54.5	90.3	93.3	90.0	100.0	75.0	82.7
2005	94.4	94.1	83.3	94.1	91.7	100.0	93.1
2006	78.9	82.9	77.8		84.6	86.7	82.2
2007	73.3	88.6	94.7	84.2	75.0	50.0	78.1

Appendix Tab. 9

Breeding success in the main study-plot K30 expressed as success per laying pair, 1986–2008.

Year	Used nests (pairs)	Hatched eggs % (H)	Fledging chicks (FC)	FC as % of H	FC as % per pair
1986	12	83.3	5	50.0	41.7
1987	11	90.9	9	90.0	81.8
1988	12	91.7	11	100.0	91.7
1989	16	56.3	8	88.9	50.0
1990	17	64.7	9	81.8	52.9
1991	18	61.1	9	81.8	50.0
1992	15	73.3	11	100.0	73.3
1993	17	64.7	11	100.0	64.7
1994	16	62.5	9	90.0	56.3
1995	14	78.6	10	90.9	71.4
1996	13	100.0	9	69.2	69.2
1997	14	85.7	11	91.7	78.6
1998	18	94.4	14	82.4	77.8
1999	20	85.0	14	82.4	70.0
2000	22	90.9	19	95.0	86.4
2001	26	76.9	19	95.0	73.1
2002	28	82.1	19	82.6	67.9
2003	29	79.3	21	91.3	72.4
2004	31	87.1	25	92.6	80.6
2005	31	93.5	29	100.0	93.5
2006	35	85.7	29	96.7	82.9
2007	36	72.2	24	92.3	66.7
2008	42	90.5	37	97.4	88.1

Appendix Tab. 10

Razorbills ringed as adult breeding birds on Græsholmen
1989–2006 and resighted one or more years later.

	Adult ringed	Resighted	Resighted %
1989	8	8	100.0
1990	10	10	100.0
1991	7	7	100.0
1992	15	14	93.3
1993	4	4	100.0
1994	3	3	100.0
1996	4	4	100.0
1997	5	5	100.0
1998	8	6	75.0
1999	6	6	100.0
2000	12	11	91.7
2001	19	18	94.7
2002	1	1	100.0
2003	2	2	100.0
2005	1	1	100.0
2006	2	2	100.0

Appendix Tab. 11

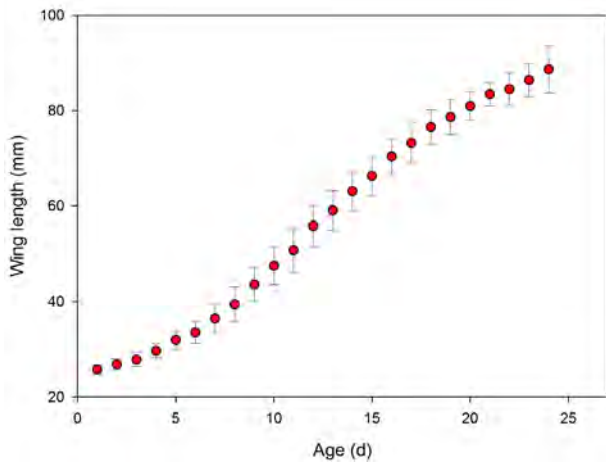
Resighting probability of adult breeding birds on Græsholmen 1987-2008 as calculated in program MARK. RP = Resighting probability, SE = Standard error, L CI = Lower 95% confidence interval, U CI = Upper 95% confidence interval, RH = hours used for resighting.

Year	RP	SE	L CI	U CI	RH
1987	0.1453	0.0951	0.0365	0.4328	1
1988	0.0837	0.0582	0.0202	0.2879	5
1989	0.2077	0.0708	0.1013	0.3787	15
1990	0.2526	0.0388	0.1843	0.3358	38
1991	0.4840	0.0318	0.4223	0.5463	58
1992	0.5938	0.0262	0.5416	0.6439	135
1993	0.8600	0.0172	0.8228	0.8904	195
1994	0.8079	0.0186	0.7688	0.8418	156
1995	0.8702	0.0151	0.8377	0.8970	246
1996	0.8872	0.0140	0.8567	0.9118	215
1997	0.7662	0.0175	0.7300	0.7988	102
1998	0.7370	0.0171	0.7022	0.7691	146
1999	0.8584	0.0130	0.8310	0.8820	168
2000	0.7601	0.0152	0.7291	0.7885	120
2001	0.6861	0.0159	0.6541	0.7165	117
2002	0.5574	0.0167	0.5244	0.5899	97
2003	0.4527	0.0168	0.4200	0.4858	69
2004	0.7863	0.0155	0.7544	0.8150	114
2005	0.3364	0.0184	0.3013	0.3734	41
2006	0.3467	0.0191	0.3103	0.3850	42
2007	0.5942	0.0264	0.5416	0.6446	43
2008	0.5340	0.0398	0.4558	0.6105	59

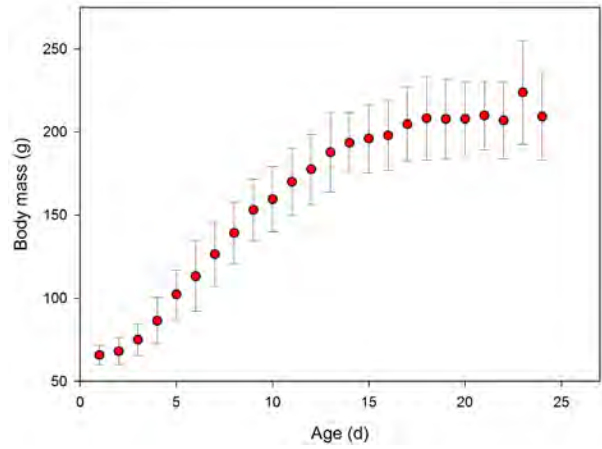
Appendix Tab. 12

Resightings on Græsholmen (1984–2008) of Razorbills ringed as chicks in other countries (N = 37).

	Visitors 1Y	Visitors 2Y	Visitors 3Y	Visitors 4-6Y	Breeders (3Y+)
Finland	1	8	1	4	7
Sweden	2	3	2	1	8
Total	3	11	3	5	15

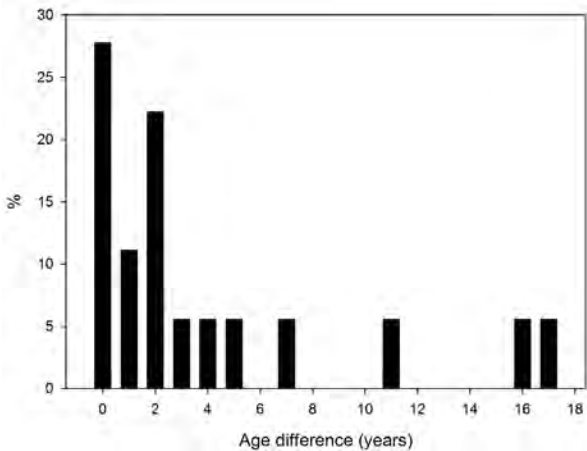


Appendix Fig. 1
 Mean daily increase \pm SD of wing length (mm) for 49 Razorbill chicks measured daily on Græsholmen, 1985–86 and 1994.

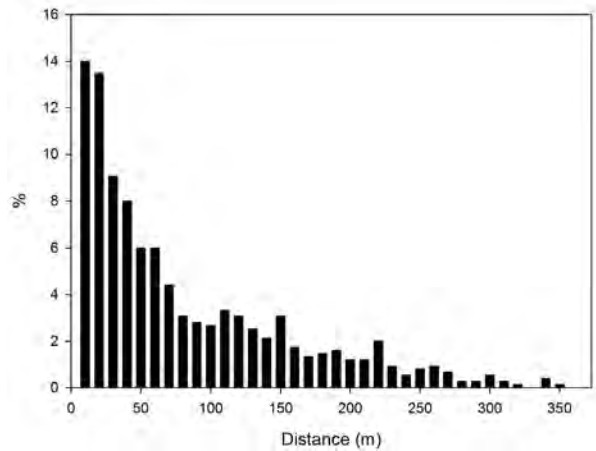


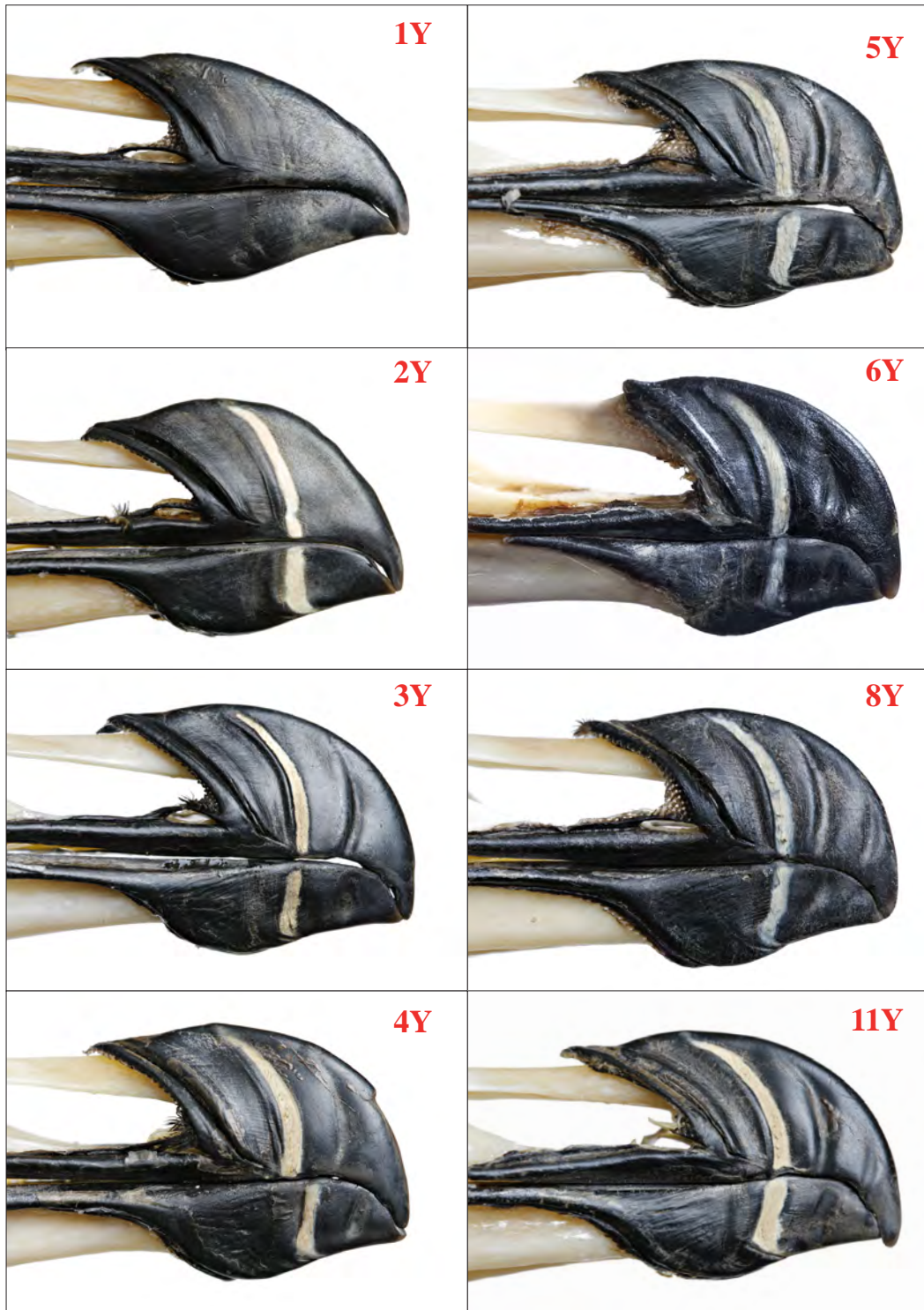
Appendix Fig. 2
 Mean daily increase \pm SD of body mass (g) for 49 Razorbill chicks measured daily on Græsholmen, 1985–86 and 1994.

Appendix Fig. 4
 Age difference between 18 pairs of ringed Razorbills breeding in the study plot K30, Græsholmen 2011.



Appendix Fig. 5
 Distribution of distance from hatching-nest to breeding-nest of 750 Razorbills hatched on Græsholmen and subsequently found breeding there.



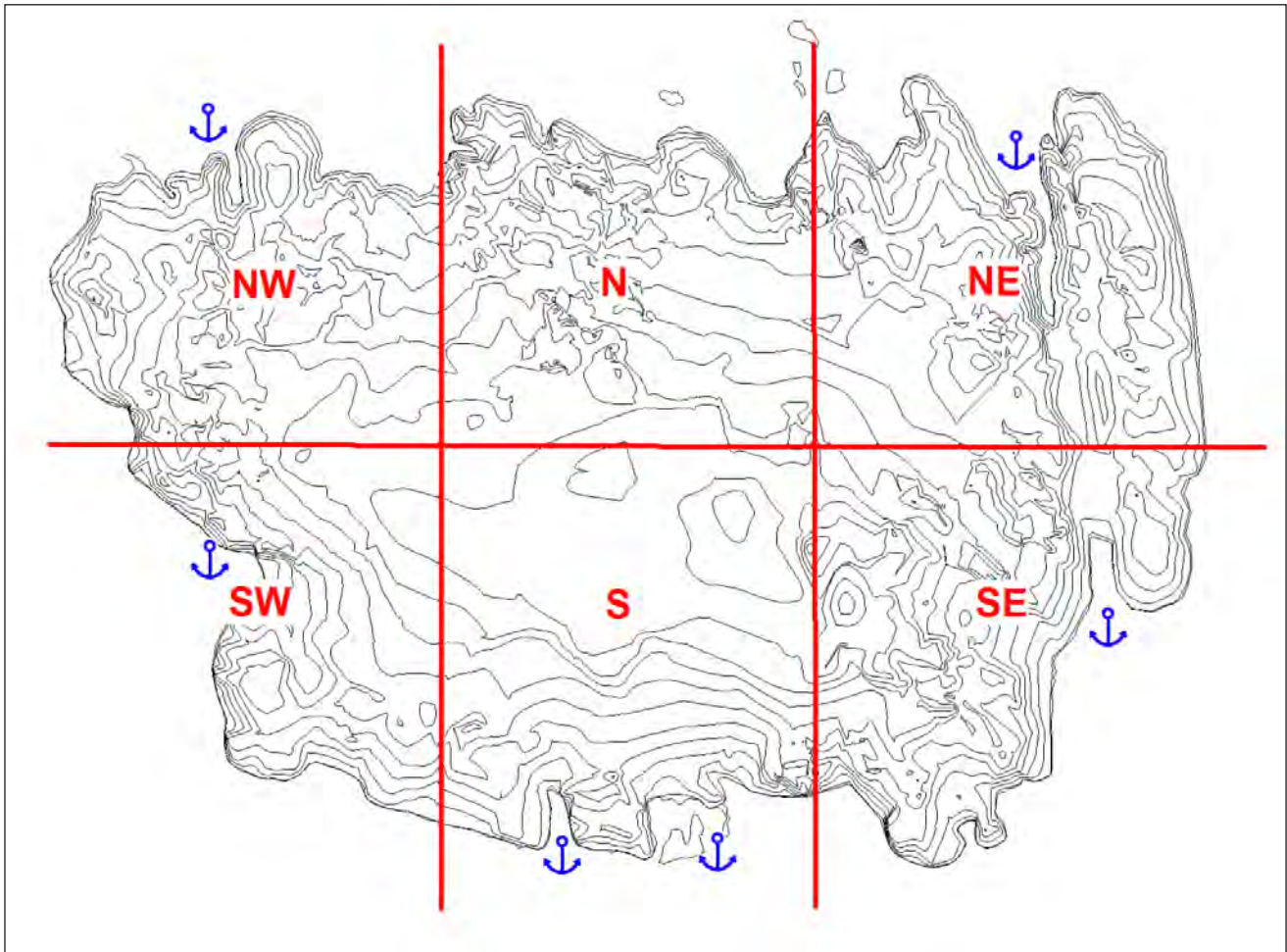


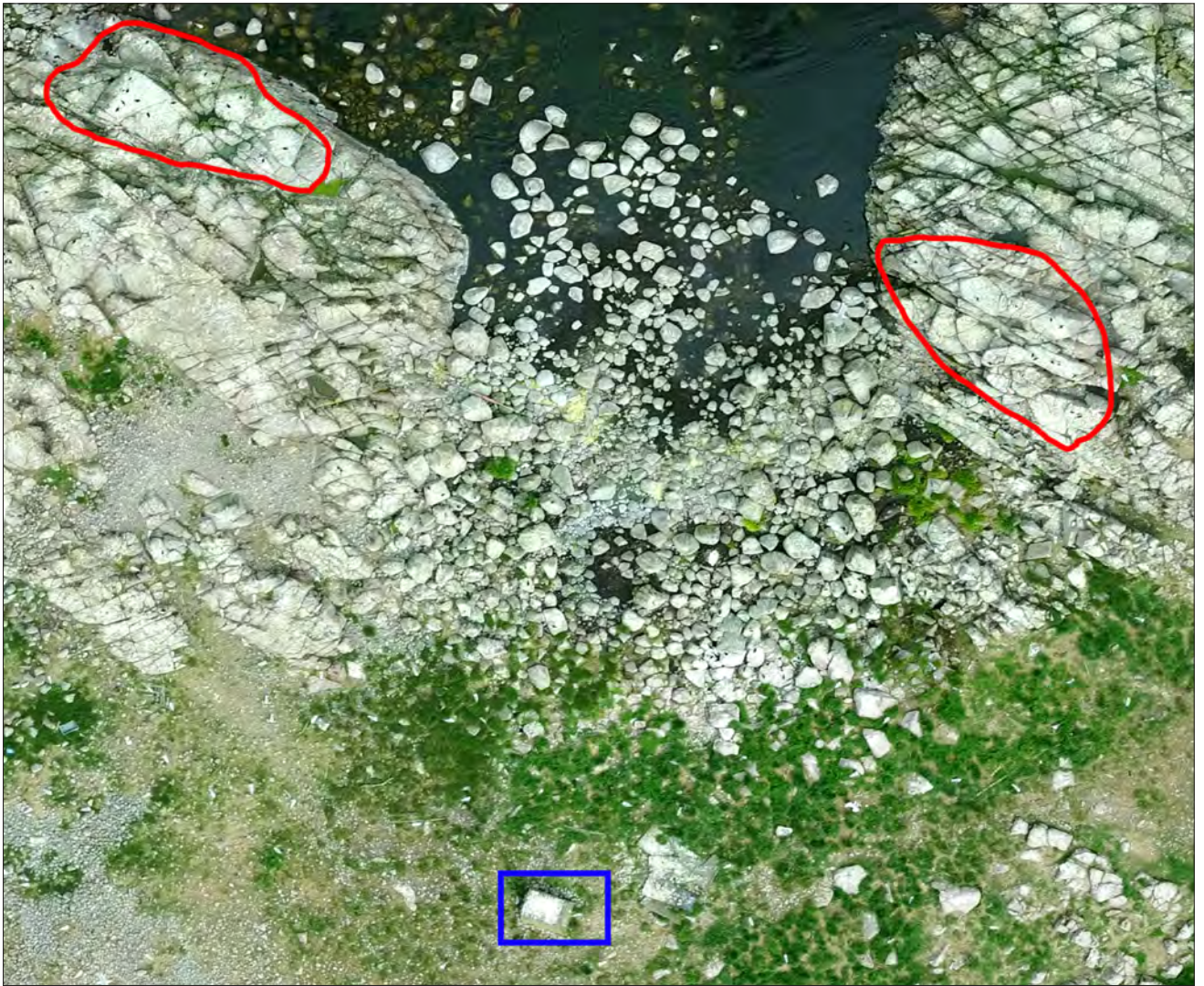
Appendix Fig. 3
Bills of 1Y–11Y old Razorbills from Græsholmen; all birds ringed as chicks and subsequently found dead there.

Græsholmen

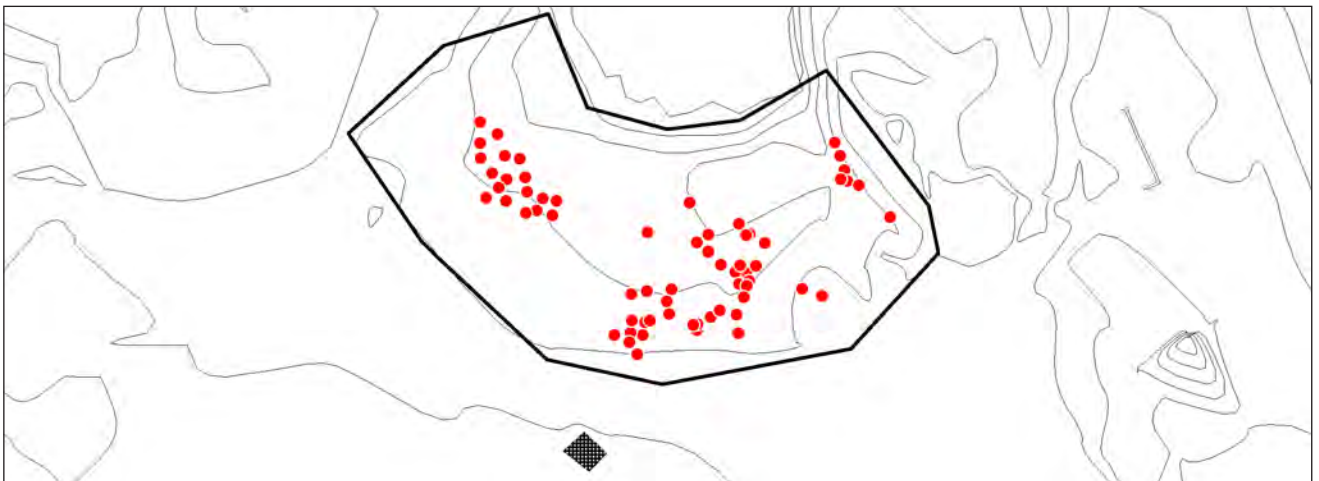


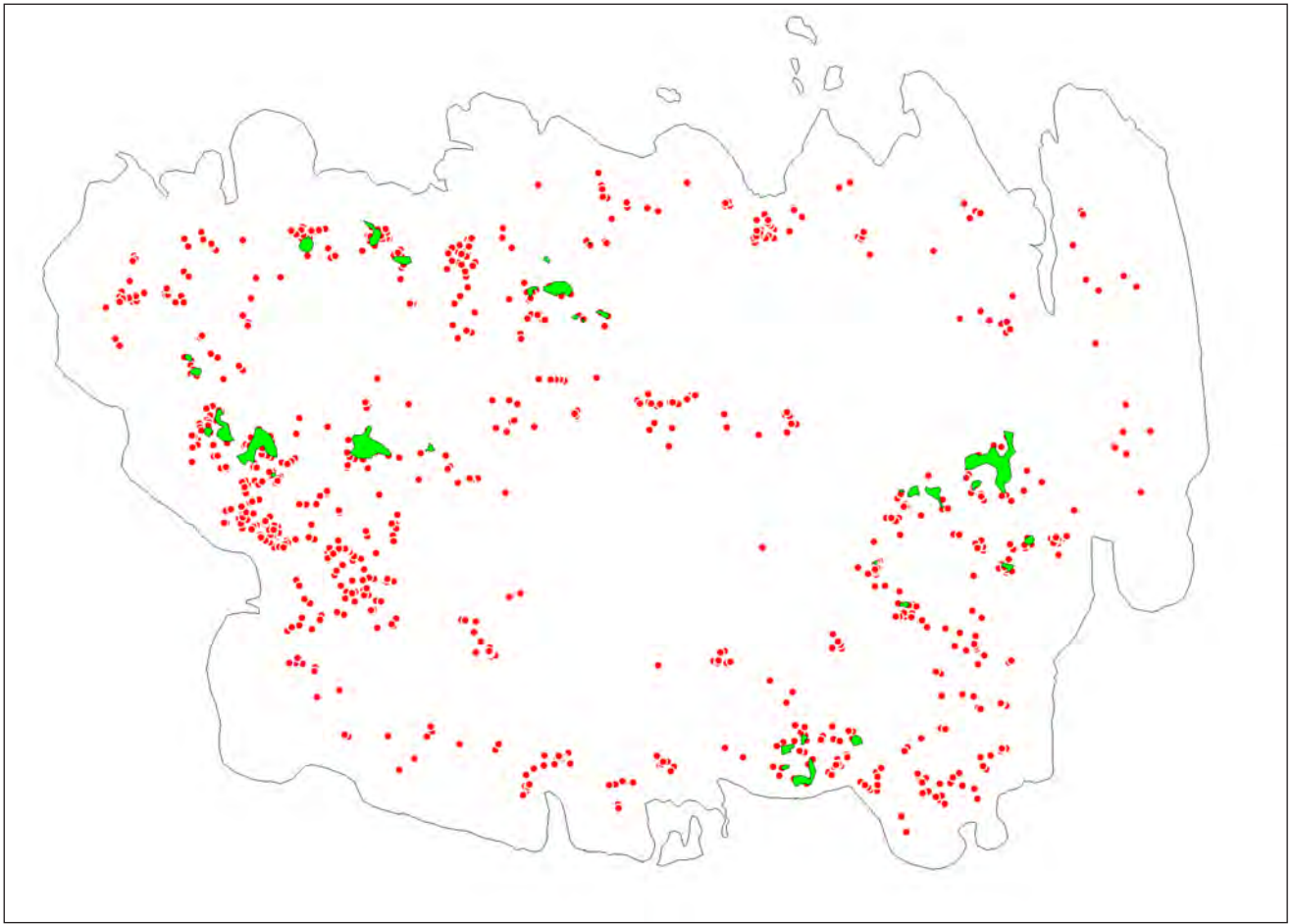
The division of Græsholmen used in some spatial analyses. The blue anchors denote the commonly used anchoring sites through the years. The anchoring place in the NE sector is by far the most used.



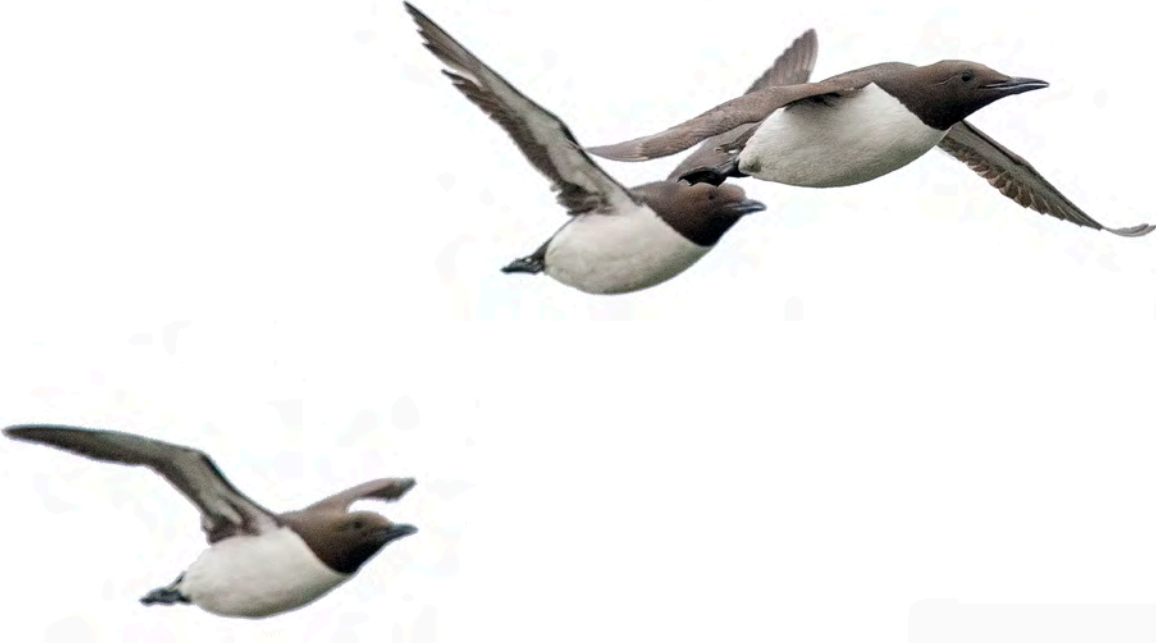


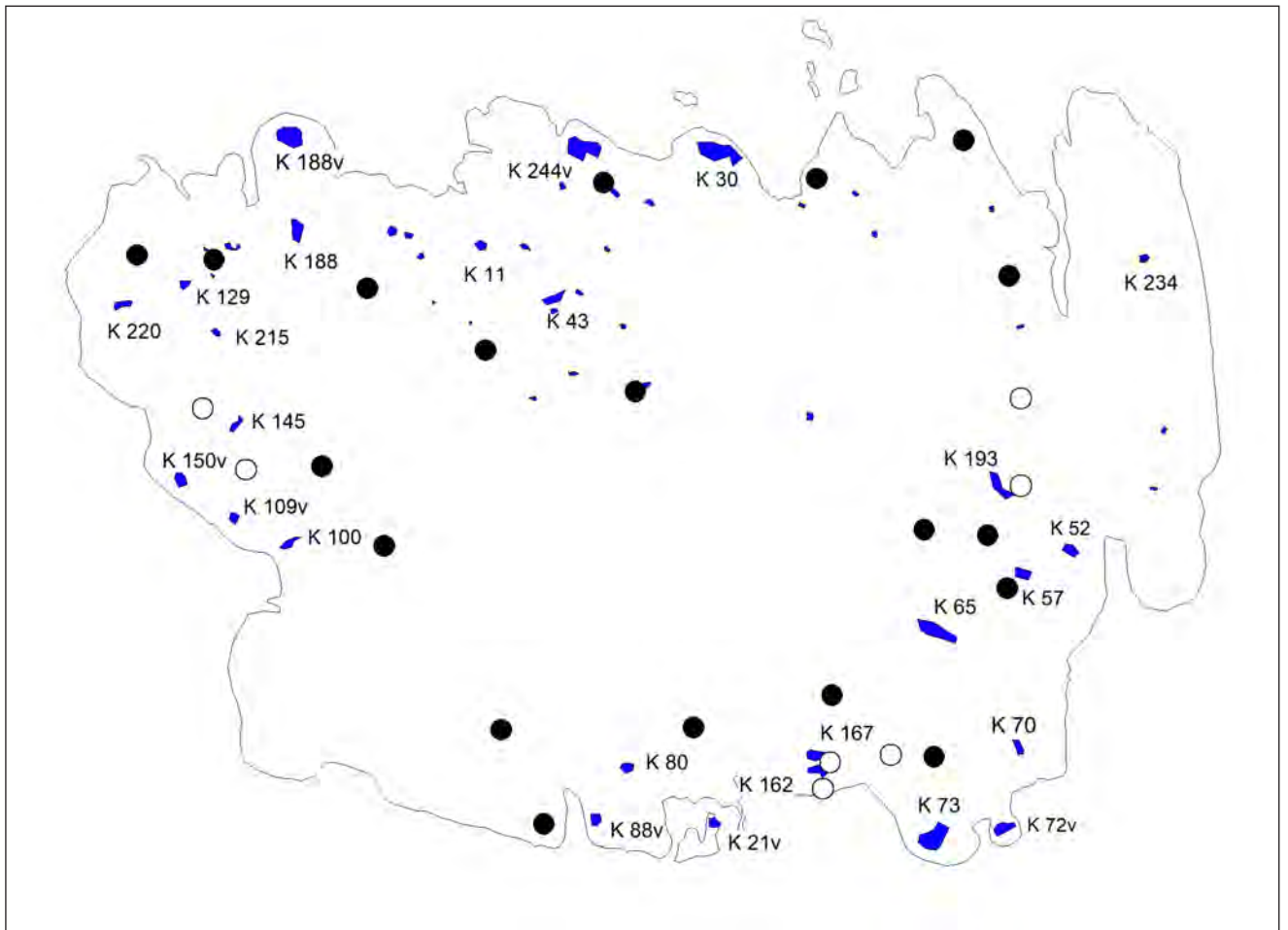
The study plot K30 with the much used loafing stones C30 (left) and C29 (right) marked by red lines and the permanent hide marked by blue (Photo: T. Nybirk, May 2018). Below, the K30 study plot marked with a black line and the Razorbill nests with red dots.





Razorbill nests (red dots) and Common Guillemot colonies (green areas), Græsholmen, 1996.

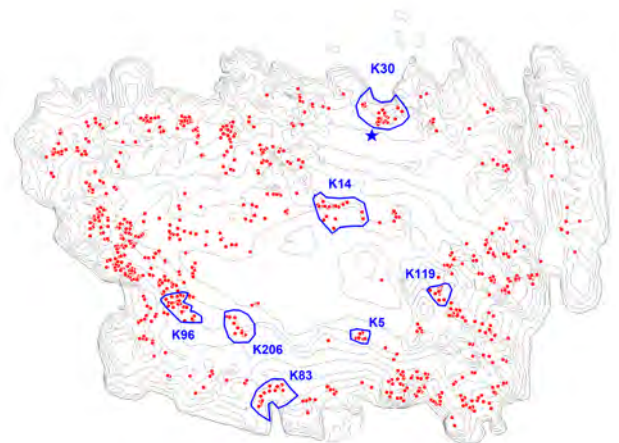
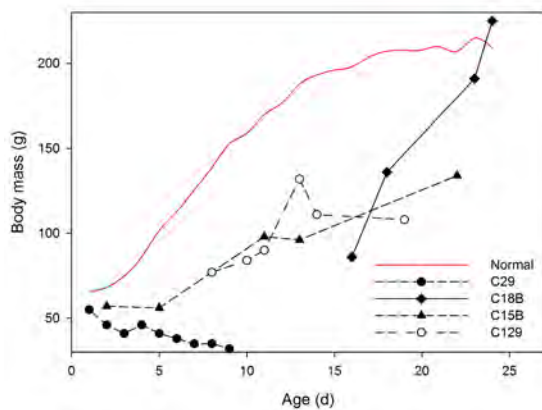




Major Razorbill loafing areas (blue) and often used spots for resighting with portable hides (black circles - white circles denote spots only used after the Common Guillemots had left their colonies).

Some examples of deviating development of body mass among chicks from Græsholmen.

Study plots on Græsholmen.





The Razorbill-team with Græsholmen in the background: Gitte Christensen Lyngs, Lars Abrahamsen and Peter Lyngs, June 1995. Note the the high-tech equipment ;-). Photo: Jeannie Jensen.

5AA48 6Y coming in for a resighting...





The eastern part of K30 as seen from the permanent hide, 7 May 2009. Birds sitting on the top rocks are using the loafing-area C29. Note human artefacts washed ashore – the Razorbills often nested below these.



PL checking nests in K30. 1 June 2011. Photo: GCL.





DK2438: cool, calm and collected – ready to fledge, 2 August 2004. Note the green wax, used to make sure that the metal ring did not rotate. This bird was subsequently resighted several times, first as a 2Y in July 2006.

A note on the fledging

We were regularly surprised how 'relaxed' some of the large pre-fledging Raxorbill chicks were when handled. Some were 'wild', biting and doing everything they could to escape - while many others (like DK2438 above) were very calm.

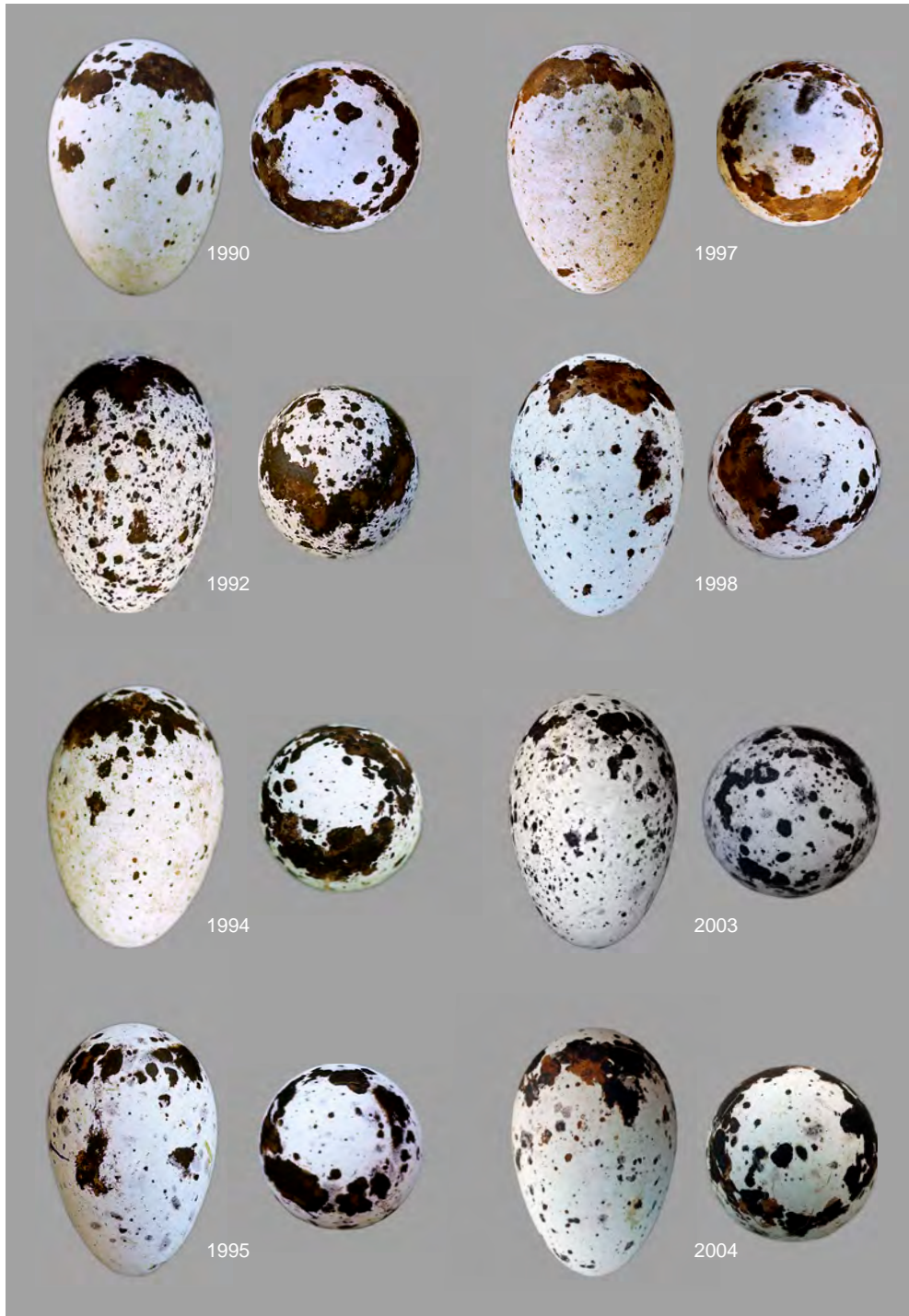
Through the years, we observed some 35 fledgings from start up to when the birds reached the sea. Most of these occurred around sunset, but we also observed a few fledgings in the morning, before 11 am, especially if the preceding days had been very windy. In all cases, the chick simply started to walk towards the sea, its adult male following close by. Of-

ten, the chick had been in and out of the nest on several occasions before it decidedly walked towards the sea. On some occasions, several very inquisitive 2Y birds followed the adult-chick pair en route. When reaching the sea, both the chick and the adult often appeared excited and frequently dived before swimming out to the open sea together. Usually both the adult and the chick were quiet, but if some serious interruption occurred (e.g. a gull attacking), the chick hid and the adult flew off. The adult then typically returned after some minutes, often locating the chick by its contact-call.

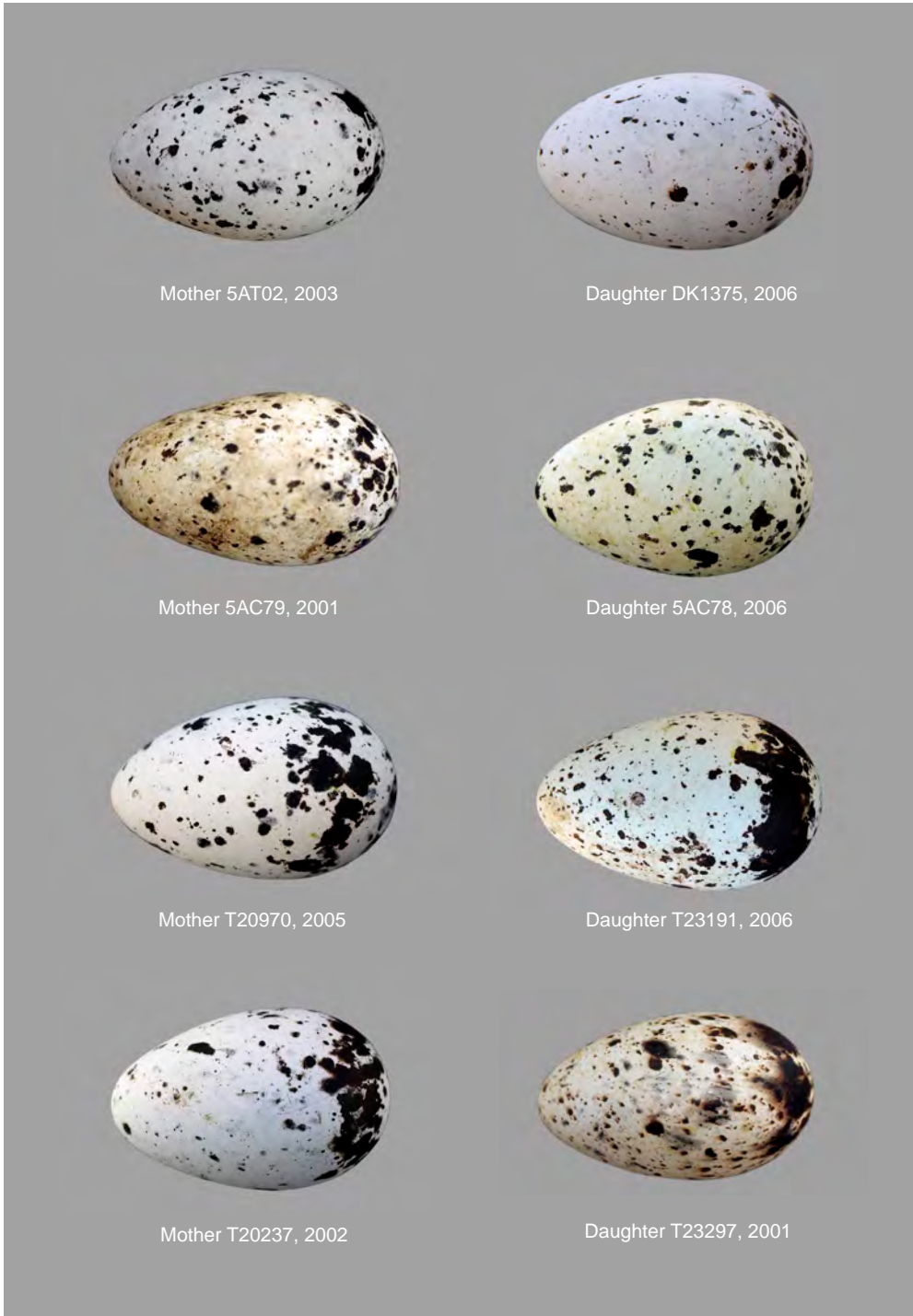


Other fledging chicks did not fare so well – remains of fledging Razorbill chicks found beside a nest of Great Black-backed Gulls, 29 July 2007.





Eggs from female 5037089 (hatched 1984), 1990–2004 (selected years, K30).



Eggs from mothers and their daughters (selected years, K30).