

## Long-term decline in egg size of Atlantic puffins *Fratercula arctica* is related to changes in forage fish stocks and climate conditions

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**Supplement.** Annual means of measurements of eggs, adults and laying dates of Atlantic puffins at 2 North Norwegian and 1 Scottish colony.

Table S1. *Fratercula arctica*. Mean size measurements ( $\pm 1$  SE) of Atlantic puffin eggs and adults on the 2 study sites and Isle of May, SE Scotland in 1973–2011 (the latter are referred to in the ‘Discussion’ of the main article). Sample sizes are indicated in parentheses. See Table 1 for results of linear regressions against year

Year	Egg volume (ml)			Wing length (mm)		Head+bill length (mm)	
	Hornøya	Hernyken	Isle of May	Hornøya	Hernyken	Hornøya	Hernyken
1973			57.5 $\pm$ 1.0 (14)				
1980	65.8 $\pm$ 0.8 (26)		56.4 $\pm$ 0.9 (31) <sup>2</sup>	176.2 $\pm$ 0.3 (161)	172.8 $\pm$ 0.3 (216)		
1981	66.6 $\pm$ 0.7 (62)			177.4 $\pm$ 0.3 (197)	171.7 $\pm$ 0.2 (735)	82.7 $\pm$ 0.2 (196)	
1982	66.8 $\pm$ 0.7 (60)	61.8 $\pm$ 1.0 (4) <sup>1</sup>	53.8 (1) <sup>1</sup>	176.3 $\pm$ 0.6 (63)	172.7 $\pm$ 0.2 (457)	82.2 $\pm$ 0.3 (53)	
1983		63.4 $\pm$ 0.4 (121)			172.7 $\pm$ 0.1 (863)		
1984			59.5 $\pm$ 2.5 (8)		173.4 $\pm$ 0.6 (60)		
1987			58.6 $\pm$ 2.1 (4) <sup>1</sup>				
1988	66.0 $\pm$ 0.7 (53)				170.7 $\pm$ 0.3 (174)		
1989	66.9 $\pm$ 0.8 (37)	61.3 $\pm$ 1.7 (11)	50.3 $\pm$ 0.5 (3) <sup>1</sup>		170.7 $\pm$ 0.4 (105)		80.6 $\pm$ 0.8 (13)
1990	67.6 $\pm$ 0.9 (34)	61.2 $\pm$ 0.6 (109)			171.8 $\pm$ 0.3 (211)		80.7 $\pm$ 0.2 (107)
1991	66.3 $\pm$ 0.8 (40)	62.7 $\pm$ 0.4 (164)	58.1 $\pm$ 2.2 (3) <sup>1</sup>		171.4 $\pm$ 0.2 (314)		80.0 $\pm$ 1.0 (2) <sup>1</sup>
1992	66.2 $\pm$ 0.8 (42)	61.6 $\pm$ 0.4 (147)			171.8 $\pm$ 0.2 (309)		81.0 $\pm$ 0.1 (294)
1993	65.5 $\pm$ 0.8 (39)	62.5 $\pm$ 0.4 (149)			171.7 $\pm$ 0.3 (207)		81.0 $\pm$ 0.2 (195)
1994	66.1 $\pm$ 0.7 (40)	62.2 $\pm$ 0.3 (163)		179.2 $\pm$ 0.3 (243)	171.7 $\pm$ 0.3 (241)	82.1 $\pm$ 0.1 (243)	81.2 $\pm$ 0.1 (239)
1995	64.9 $\pm$ 0.6 (42)	60.9 $\pm$ 0.3 (283)			171.5 $\pm$ 0.6 (31)		81.1 $\pm$ 0.4 (29)
1996	65.9 $\pm$ 0.6 (48)	61.7 $\pm$ 0.3 (153)	56.1 $\pm$ 1.2 (21)		171.6 $\pm$ 0.2 (258)		81.0 $\pm$ 0.1 (257)
1997	65.6 $\pm$ 0.6 (43)	61.9 $\pm$ 0.4 (128)			171.3 $\pm$ 0.4 (137)		81.0 $\pm$ 0.2 (130)
1998	65.8 $\pm$ 0.7 (32)	61.3 $\pm$ 0.4 (116)			171.4 $\pm$ 0.3 (232)		81.1 $\pm$ 0.1 (222)
1999	66.1 $\pm$ 0.9 (37)	61.8 $\pm$ 0.9 (38)			172.3 $\pm$ 0.3 (223)		81.3 $\pm$ 0.1 (275)
2000	64.9 $\pm$ 0.7 (45)	61.0 $\pm$ 0.5 (56)	57.1 $\pm$ 0.3 (175)		171.7 $\pm$ 0.3 (190)		80.8 $\pm$ 0.2 (189)
2001	67.0 $\pm$ 0.6 (40)	61.8 $\pm$ 0.5 (62)			172.1 $\pm$ 0.2 (262)		80.8 $\pm$ 0.1 (262)
2002	65.6 $\pm$ 0.7 (39)	61.3 $\pm$ 0.6 (33)			171.1 $\pm$ 0.3 (218)		81.0 $\pm$ 0.2 (218)
2003	64.2 $\pm$ 0.8 (44)	60.9 $\pm$ 0.5 (70)		180.1 $\pm$ 0.4 (152)	171.9 $\pm$ 0.3 (189)	82.5 $\pm$ 0.2 (151)	81.2 $\pm$ 0.1 (222)
2004	64.6 $\pm$ 0.7 (44)	61.4 $\pm$ 0.8 (32)		179.2 $\pm$ 0.9 (28)	172.2 $\pm$ 0.4 (290)	82.4 $\pm$ 0.4 (28)	81.2 $\pm$ 0.1 (290)
2005	64.1 $\pm$ 0.7 (46)	60.9 $\pm$ 0.9 (27)		178.2 $\pm$ 0.4 (81)	171.5 $\pm$ 0.3 (162)	82.2 $\pm$ 0.2 (81)	81.2 $\pm$ 0.2 (160)
2006	64.4 $\pm$ 0.7 (49)	60.8 $\pm$ 1.2 (17)		177.7 $\pm$ 0.7 (47)	171.6 $\pm$ 0.3 (162)	81.8 $\pm$ 0.3 (47)	81.0 $\pm$ 0.2 (162)
2007	63.5 $\pm$ 0.6 (57)	60.8 $\pm$ 0.7 (59)			172.7 $\pm$ 0.6 (46)		81.9 $\pm$ 0.3 (46)
2008	63.7 $\pm$ 0.6 (51)	61.8 $\pm$ 0.7 (52)			173.7 $\pm$ 0.9 (26)		81.8 $\pm$ 0.5 (25)
2009	65.3 $\pm$ 0.6 (49)	61.1 $\pm$ 0.8 (29)	55.8 $\pm$ 0.8 (26)	178.9 $\pm$ 0.7 (39)	172.0 $\pm$ 1.1 (18)	83.0 $\pm$ 0.3 (39)	81.3 $\pm$ 0.6 (18)
2010	64.5 $\pm$ 0.6 (56)	61.2 $\pm$ 0.8 (39)					
2011	65.1 $\pm$ 0.7 (55)	62.1 $\pm$ 0.6 (34)					

<sup>1</sup> Omitted from further analysis because of insufficient sample size

<sup>2</sup> Approximate year for data lost in fire, with estimate reconstructed from published means and SEs of length and breadth of 54 eggs measured in 1973–1984 that included the 23 eggs measured in 1973, 1982 and 1984 (M.P. Harris pers. comm.).

Table S2. *Fratercula arctica*. Mean size measurements ( $\pm 1$  SE) of adult Atlantic puffins taken during the breeding season on Herykyen in 1980–2009 in addition to those included in Table S1. Sample sizes are indicated in parentheses. See Table 2 for results of linear regressions against year

Year	Culmen length (mm)	Bill depth at gonys (mm)	No. of bill grooves	Body mass (g)
1980	46.0 $\pm$ 0.2 (80)	36.3 $\pm$ 0.2 (80)	3.34 $\pm$ 0.03 (216)	450.9 $\pm$ 2.5 (197)
1981	46.3 $\pm$ 0.1 (292)	35.8 $\pm$ 0.1 (292)	3.28 $\pm$ 0.01 (801)	459.1 $\pm$ 1.8 (537)
1982	47.0 (1) <sup>1</sup>	36.0 (1) <sup>1</sup>	3.45 $\pm$ 0.02 (584)	462.9 $\pm$ 1.2 (999)
1983	46.4 $\pm$ 0.3 (28)	36.5 $\pm$ 0.3 (28)	3.38 $\pm$ 0.01 (1044)	457.7 $\pm$ 1.0 (1124)
1984			3.43 $\pm$ 0.03 (257)	455.2 $\pm$ 2.3 (253)
1985				435.8 $\pm$ 3.1 (87)
1986				451.5 $\pm$ 14.0 (10)
1988			3.12 $\pm$ 0.03 (161)	431.7 $\pm$ 2.4 (166)
1989	45.4 $\pm$ 0.8 (8)		3.26 $\pm$ 0.05 (123)	444.8 $\pm$ 2.8 (125)
1990			3.44 $\pm$ 0.03 (223)	440.8 $\pm$ 1.9 (221)
1991	46.9 $\pm$ 6.0 (2) <sup>1</sup>	28.1 $\pm$ 6.5 (2) <sup>1</sup>	3.48 $\pm$ 0.03 (334)	445.4 $\pm$ 1.7 (327)
1992	45.6 $\pm$ 0.1 (294)	36.6 $\pm$ 0.1 (266)	3.35 $\pm$ 0.02 (508)	451.7 $\pm$ 1.5 (443)
1993	46.0 $\pm$ 0.1 (196)	37.1 $\pm$ 0.1 (196)	3.54 $\pm$ 0.03 (208)	447.4 $\pm$ 2.3 (206)
1994	46.0 $\pm$ 0.1 (240)	36.9 $\pm$ 0.1 (223)	3.40 $\pm$ 0.03 (258)	452.1 $\pm$ 2.4 (241)
1995	45.7 $\pm$ 0.3 (29)	37.0 $\pm$ 0.2 (29)	3.52 $\pm$ 0.09 (31)	443.7 $\pm$ 5.2 (30)
1996	45.6 $\pm$ 0.1 (257)	36.7 $\pm$ 0.1 (254)	3.47 $\pm$ 0.03 (257)	451.3 $\pm$ 2.3 (239)
1997	46.0 $\pm$ 0.2 (134)	37.0 $\pm$ 0.1 (134)	3.44 $\pm$ 0.04 (138)	445.2 $\pm$ 3.3 (131)
1998	46.0 $\pm$ 0.1 (225)	37.1 $\pm$ 0.1 (224)	3.45 $\pm$ 0.03 (225)	450.3 $\pm$ 1.8 (346)
1999	45.9 $\pm$ 0.3 (180)	37.2 $\pm$ 0.1 (215)	3.43 $\pm$ 0.03 (279)	460.9 $\pm$ 2.2 (219)
2000	45.9 $\pm$ 0.1 (189)	37.0 $\pm$ 0.1 (189)	3.42 $\pm$ 0.03 (189)	454.4 $\pm$ 2.7 (190)
2001	45.6 $\pm$ 0.1 (259)	36.4 $\pm$ 0.2 (259)	3.48 $\pm$ 0.03 (262)	452.9 $\pm$ 2.3 (230)
2002	45.4 $\pm$ 0.1 (218)	36.5 $\pm$ 0.1 (218)	3.48 $\pm$ 0.03 (218)	450.2 $\pm$ 2.0 (194)
2003	45.9 $\pm$ 0.1 (189)	36.7 $\pm$ 0.2 (189)	3.68 $\pm$ 0.03 (222)	454.5 $\pm$ 2.4 (172)
2004	45.6 $\pm$ 0.1 (290)	36.4 $\pm$ 0.1 (290)	3.55 $\pm$ 0.03 (277)	442.1 $\pm$ 2.1 (217)
2005	45.8 $\pm$ 0.1 (162)	36.7 $\pm$ 0.1 (161)	3.42 $\pm$ 0.03 (165)	443.5 $\pm$ 2.8 (130)
2006	45.1 $\pm$ 0.4 (162)	36.6 $\pm$ 0.1 (161)	3.46 $\pm$ 0.04 (162)	441.9 $\pm$ 2.6 (131)
2007	46.5 $\pm$ 0.2 (46)	36.6 $\pm$ 0.2 (46)	3.47 $\pm$ 0.06 (46)	455.7 $\pm$ 39.4 (3) <sup>1</sup>
2008	46.9 $\pm$ 0.5 (25)	37.2 $\pm$ 0.3 (25)	3.46 $\pm$ 0.10 (25)	
2009	47.2 (1) <sup>1</sup>	38.5 (1) <sup>1</sup>	3.47 $\pm$ 0.10 (18)	483.0 (1) <sup>1</sup>

<sup>1</sup> Omitted from further analysis because of insufficient sample size

Table S3. *Fratercula arctica*. Mean laying date (mean May date  $\pm$  1 SE) of Atlantic puffins on Hornøya and Hernyken in 1978–2011, calculated as hatching date minus incubation period of 42 d (Myrberget 1962). Sample sizes are indicated in parentheses. n.d. = no data. See Table 3 for results of linear regressions against year

Year	Hornøya	Hernyken
1978		15.1 $\pm$ 0.4 (25)
1979		12.2 $\pm$ 0.4 (31)
1980	19.3 $\pm$ 1.1 (38)	7.3 $\pm$ 2.1 (7)
1981	26.8 $\pm$ 0.8 (40)	5.5 $\pm$ 2.6 (11)
1982	18.0 $\pm$ 0.9 (41)	2.3 $\pm$ 1.5 (18)
1983		-0.4 $\pm$ 0.7 (66)
1984		9.0 $\pm$ 1.1 (37)
1985		17.6 $\pm$ 0.8 (43)
1986		11.8 $\pm$ 0.6 (59)
1987		
1988	24.9 $\pm$ 0.8 (41)	19.2 $\pm$ 1.3 (24)
1989	10.2 $\pm$ 0.9 (35)	17.2 $\pm$ 0.8 (84)
1990	15.8 $\pm$ 1.6 (24)	13.3 $\pm$ 0.7 (131)
1991	16.5 $\pm$ 1.6 (37)	14.0 $\pm$ 0.3 (138)
1992	17.6 $\pm$ 1.0 (32)	18.5 $\pm$ 0.5 (138)
1993	19.8 $\pm$ 0.9 (30)	13.8 $\pm$ 0.4 (131)
1994	16.9 $\pm$ 0.7 (56)	10.5 $\pm$ 1.1 (63)
1995	20.9 $\pm$ 0.8 (36)	17.0 (1) <sup>1</sup>
1996	18.2 $\pm$ 0.7 (33)	40.5 $\pm$ 0.8 (69)
1997	24.2 $\pm$ 1.1 (37)	19.7 $\pm$ 0.3 (144)
1998	18.8 $\pm$ 0.9 (36)	19.5 $\pm$ 0.5 (129)
1999	17.8 $\pm$ 1.1 (36)	10.7 $\pm$ 0.6 (121)
2000	20.7 $\pm$ 1.0 (34)	10.0 $\pm$ 0.5 (99)
2001	17.6 $\pm$ 1.1 (33)	17.0 $\pm$ 0.5 (103)
2002	9.2 $\pm$ 0.8 (38)	14.1 $\pm$ 0.4 (104)
2003	22.7 $\pm$ 0.9 (35)	10.4 $\pm$ 1.0 (90)
2004	15.9 $\pm$ 1.1 (42)	12.8 $\pm$ 0.6 (75)
2005	19.5 $\pm$ 0.8 (40)	6.1 $\pm$ 0.5 (61)
2006	21.3 $\pm$ 0.9 (45)	8.6 $\pm$ 0.5 (85)
2007	16.7 $\pm$ 1.4 (45)	13.4 $\pm$ 0.4 (33)
2008	25.5 $\pm$ 1.0 (32)	n.d. <sup>1</sup>
2009	16.8 $\pm$ 0.9 (42)	9.7 $\pm$ 0.7 (28)
2010	18.0 $\pm$ 1.2 (49)	19.4 $\pm$ 1.7 (9)
2011	15.6 $\pm$ 0.7 (37)	11.3 $\pm$ 3.2 (4) <sup>1</sup>

<sup>1</sup> Years of almost complete hatching failure. Data omitted from further analysis because of insufficient sample size

#### LITERATURE CITED

Myrberget S (1962) Undersøkelser over forplantningsbiologien til lunde (*Fratercula arctica* (L.)) egg, ruging og unger. Medd St Viltunders 2:1–51 (in Norwegian with English Abstract)