

Pursuit-diving seabird endures regime shift involving a three-decade decline in forage fish mass and abundance

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Supplement 1. Capelin and murre offspring sampling

Table S1. Dates and sample sizes of capelin collected from the food loads of parental Common Murres and of condition measurements of chicks and fledglings, and adult masses on Funk Island, 1980 – 2017.

Year	Capelin collection	N	Chick (C) /fledgling (F) condition	N	Adult mass	N
1980			C/Aug4	1		
1980			F/Jul30-Aug8	83		
1982			F/Aug9,11-12	40		
1983			F/Aug5,8	14		
1984			F/Aug8,12-13	38		
1990	Aug10-12	55	_a		Aug7-8	31
1991	Aug13-15	48	C/Aug14	40		
1992	Aug4-10	158	C/Aug7	37		
1993	Aug5-12	150	C/Aug11	43		
1994	Aug12-16	98	C/Aug15	28		
1995	Aug4,5,8,11	151	C/Aug8	41		
1996	Aug5-6,8-9	81	-a			
1997	Aug 1-3,5,7-9	323	C/Aug7	33		
1998	Aug 4-6,8,14,16	96	C/Aug15	24		
1999	July27,29,31-Aug 5	61	-a			
2000	Aug5-7,10, 13	159	F/Aug6,10,12	47	Aug13	3
2001	Aug1-6	117	F/Aug1,6	30		
2002	Aug6-9,11, 13	270	F/Aug10,12	30		
2003	Jul28-30, Aug 2,7	79	F/Aug1,6b	54		
2004	Jul26,28-31, Aug1-2	161	F/Jul27,30-31	40		
2005	Aug2-3,8-9	110	F/Aug2,6	30	Aug2	25
2006	Aug7-8,11-13	28	a			
2007	Jul27-28,30-31, Aug2-3	150	a		Jul24,26-31, Aug1-2	67
2008	Jul21,24,26-29	101	a		Jul 21-31	102
2009	Jul30-Aug 6	70	F/Aug4-6,8	13	Jul29-31, Aug1-6	209
2010	Aug2,4-5	34	F/Aug1-5	38	Aug1-5	26
2011	Aug2-6,9	126	F/Aug2-4,6-8	31	Aug1-6,9	164
2012	Jul28-30-Aug1-2	113	F/Jul27-29	69	Jul28-30, Aug1-2	180
2013	Jul30-31, Aug,1, 4	75	F/Jul30-31, Aug1	52	Jul30-31, Aug1,4-5	67
2014	Aug2-3,6	92	F/Aug1-4,7	71	Aug2-3,6	85
2016	Aug10-12	40	F/Aug9,10	23	Aug10-12	70
2017	Aug5-8,10-11	209	F/Aug8-11	19	Aug5-11	244

^aChicks were not measured in these years due to inclement weather and time constraint.

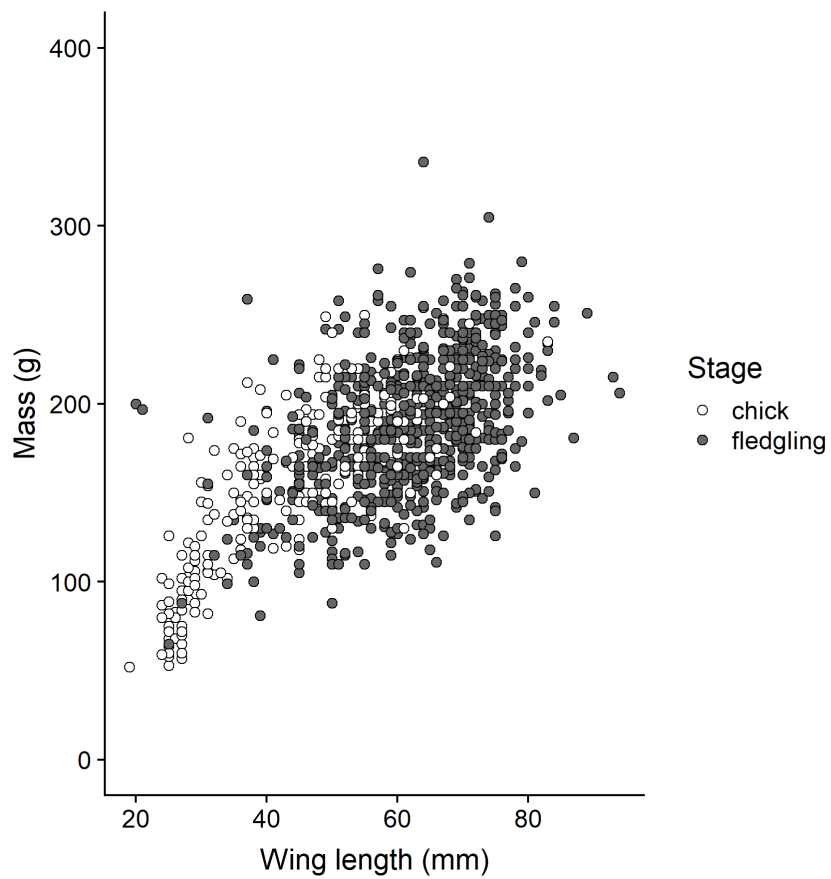
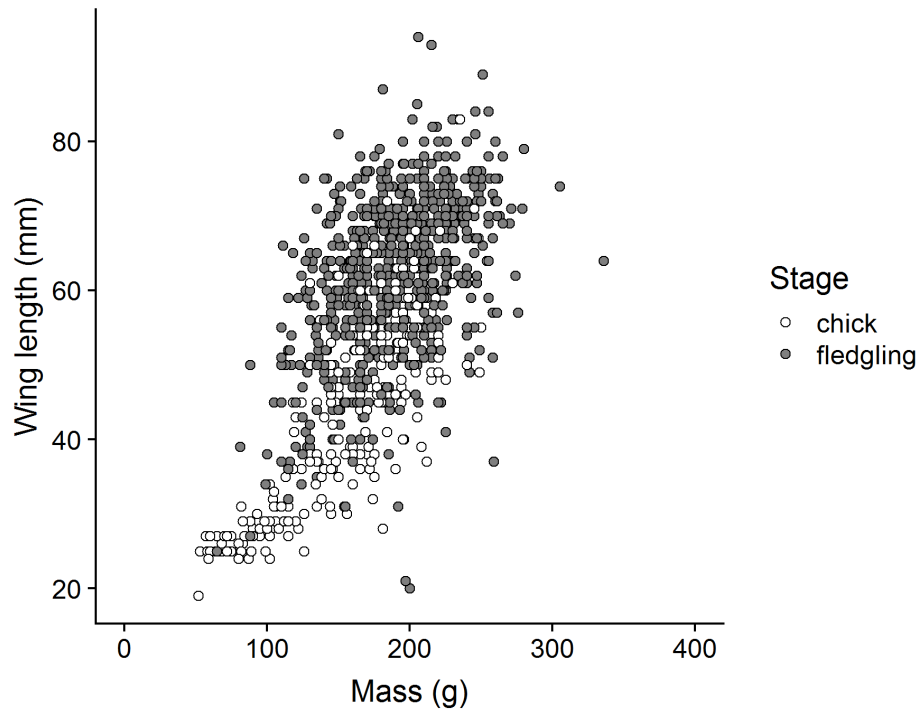


Fig. S1. Relationship between mass and wing length of Common Murre chicks and fledglings on Funk Island, Newfoundland, 1990 - 2017.

Supplement 2.

While maturity stage and reproductive condition contributes to variation in the energy content of capelin, the largest source of variation is capelin mass. The somatic condition of capelin peaks in the fall in preparation for overwintering and spawning the following year. Condition steadily worsens through the winter and spring reaching a minimum just prior to spawning. This pattern holds in waters off Newfoundland (Montevecchi & Piatt 1984), and in Icelandic waters (see Figure 4 in Engilbertsson 2014).

Montevecchi & Piatt (1984) reported mean energy density for capelin during the spawning season in Newfoundland:

- Male: 3.8 kJ/g
- Spent female: 3.9 kJ/g
- Gravid female: 4.6 kJ/g

Thus, if we consider the observed range in capelin mass (~ 10 g to ~18 g) delivered by parental murres, the expected energy contents of capelin as a function of mass and maturity stage are shown in Fig. S2 below.

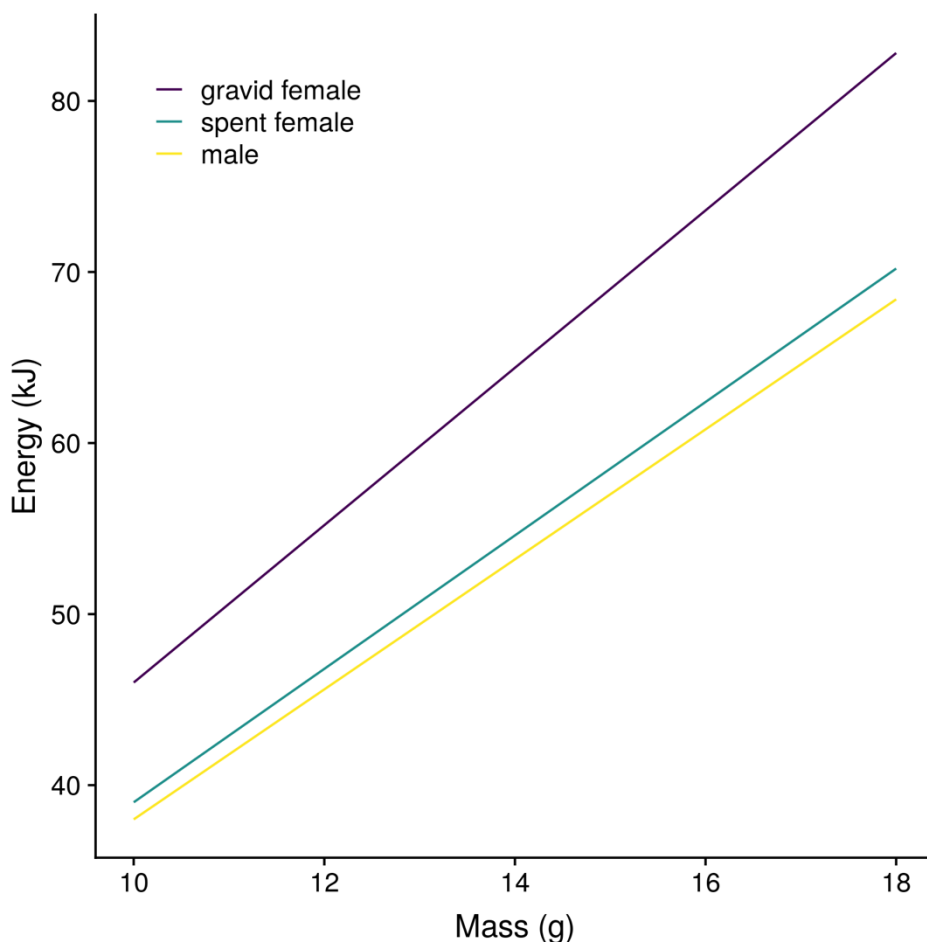


Fig. S2. Expected energy content of gravid and spent female and male capelin as a function of mass.

The largest source of variation in energy content is mass, while maturity stage accounts for less of the expected variation in energy contents.

The same analyses presented in the ms was carried out for A) Fulton's K condition factor, B) fish mass and C) fish fork length (the two components of Fulton's K condition factor; Figure S3). The decreasing trend in condition factor as a function of year resulted from the decreasing trend in mass, although it was confounded by an increasing trend in capelin length.

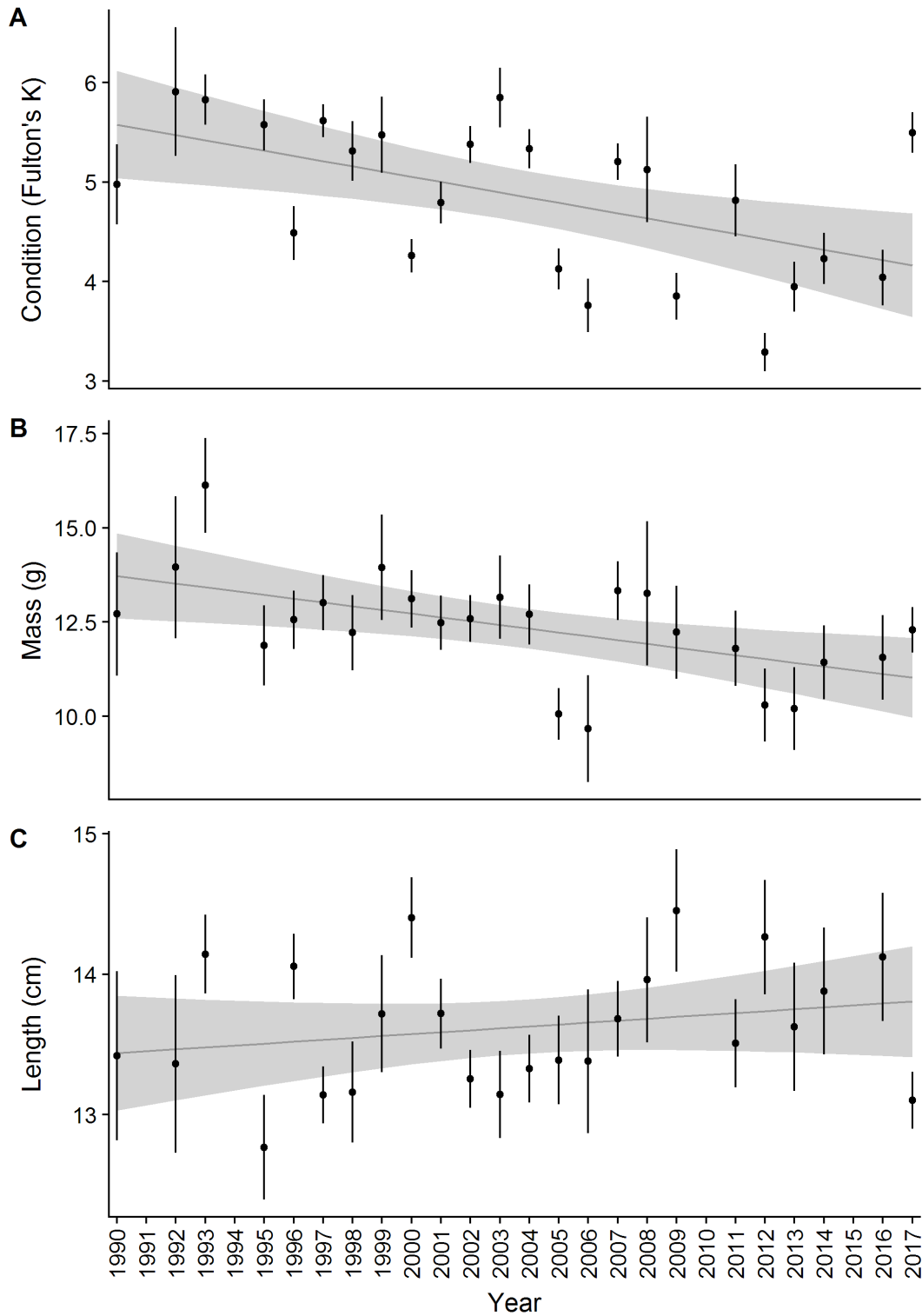


Fig. S3. Fulton's K condition factor (A), capelin mass (B), and capelin length (C) on Funk Island, NL.

The calculation of Fulton's condition factor assumes that fish grow isometrically, i.e. the exponent $b = 3$ in the following relationship;

$$\text{Weight} = aL^b$$

However, reported values of b are highly variable, and most of them are well above 3 (<http://fishbase.org/popdyn/LWRelationshipList.php?ID=252&GenusName=Mallotus&SpeciesName=villosus&fc=80>)

Therefore, to avoid the introduction of biases due to the violation of the assumption of isometric growth, we decided that it would be best not to report trends in condition, and given that most of the variability in energy content of capelin delivered to murre chicks is due to the mass of the fish delivered, we focused the analyses on capelin mass.

LITERATURE CITED

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Montevecchi WA, Piatt JF (1984) Composition, energy content of inshore spawning capelin: Implications for seabird predators. *Comp Biochem Physiol A* 78:15–20