The following supplement accompanies the article

Prey density in non-breeding areas affects adult survival of black-legged kittiwakes *Rissa tridactyla*

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Supplement. This supplementary material includes a detailed description of how the covariates used in the CMR analyses were selected. The yearly temporal trends of the covariates used are shown in a figure. All covariates were tested for yearly linear trends and the results for this test are shown. In addition, a correlation matrix of all covariates and a total overview of all CMR models are given.

SELECTION OF COVARIATES USED IN THE CAPTURE-MARK-RESIGHTING ANALYSES

We gathered information from the literature on the diet of kittiwakes throughout the year and compared this with their non-breeding distribution to identify potentially important prey species covariates. Knowledge of what the kittiwakes feed on during the non-breeding season is rather poor, but a study of stable isotopes by González-Sólis et al. (2011) of birds equipped with geolocators on Hornøya in 2008 (also included in the present study) indicated that kittiwakes during the non-breeding season fed at a lower trophic level than when they were in their breeding area. Unfortunately, we do not have access to temporal data of any zooplankton taxa from east of Svalbard (EOS). However, capelin, their main food source in the breeding season (Barrett 2007, A. Ponchon et al. unpubl.), moves northwards in the Barents Sea in late summer and autumn (Gjøsæter et al. 2011), and it may well be that the kittiwakes follow the capelin after having completed their breeding. Polar cod is also highly abundant in these areas. Herring, which is more abundant in the warmer waters further south in the Barents Sea, were very scarce, and in some years absent, in these waters. We therefore used acoustic data of capelin and polar cod from the yearly joint Norwegian–Russian ecosystem surveys as diet covariates from EOS (for a detailed description, see Skern-Mauritzen et al. 2011).

In winter, when kittiwakes from Hornøya are in the Grand Banks/Labrador Sea (GBLS), they probably also feed on a lower trophic level (González-Solís et al. 2011), and there is some indication that kittiwakes feed on a variety of large zooplankton species, amphipods and euphausiids (Mehlum & Gabrielsen 1993, Lewis et al. 2001, Frederiksen et al. 2012). A study from the North Water Polynya (Karnovsky et al. 2008) found that kittiwakes' stomachs in the autumn contained large amounts of the pteropod *Limacina helicina*. For GBLS, we therefore used data from the Continuous Plankton Recorder survey (CPR data) from the winter period (November–February) from 1990 to 2010 on Euphausiaceae, Hyperiidae, *Calanus finmarchicus* and Thecosomata. The CPR survey is a monitoring programme of the upper-layer plankton, sampled by using a high-speed sampler towed behind merchant ships on their regular trading routes. This method has provided regularly collected samples in the North Atlantic and adjacent seas that is presented at monthly intervals since 1946. A detailed description of the sampling routine is provided by Lindley (1982).

A study of stomach contents of kittiwakes from the Barents Sea during the pre-breeding period (Erikstad 1990) indicated that polar cod was an important component of their diet. This data set was, however, collected in a year with very low abundance of capelin after a stock collapse in the mid-1980s (e.g. Gjøsæter et al. 2009). Barrett (2007) showed that kittiwake diet at Hornøya in the breeding season mostly consists of capelin and 1 yr old (1-group) herring and that kittiwakes switch to the latter when capelin availability is low.

We also included climatic covariates in the models. Since lagged effects of temperature are due to indirect effects of prey abundance, we only considered un-lagged effects of climate. Since adult survival following a year of low breeding success could be low, according to the cost of reproduction hypothesis (Williams 1966), we also used breeding success in the previous breeding season as a covariate.

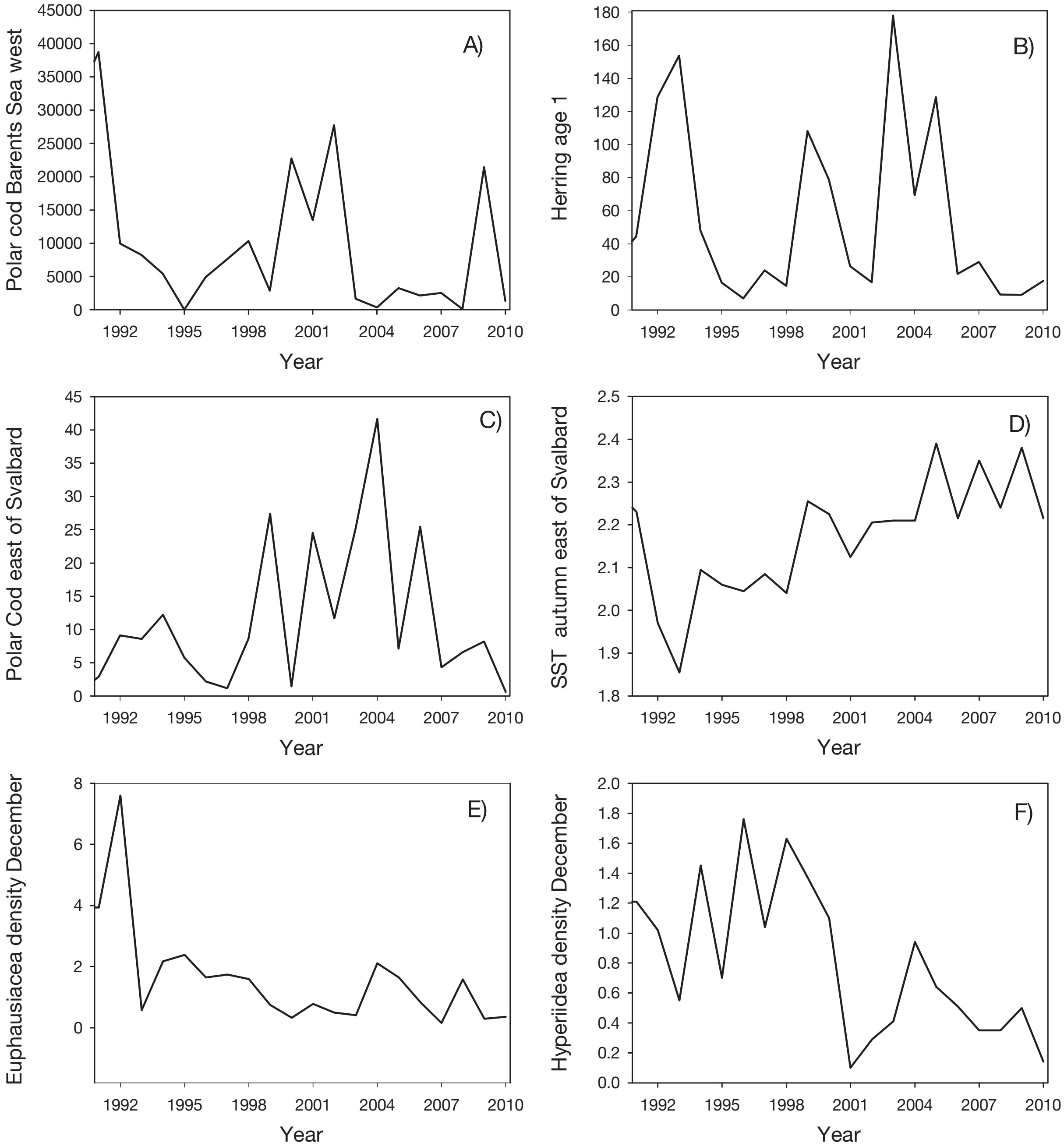

Fig. S1. Yearly temporal trends for (A) polar cod in the western Barents Sea, (B) 1 yr old herring, (C) polar cod east of Svalbard, (D) sea surface temperature east of Svalbard, (E) Euphausiacea density from Grand Banks/Labrador Sea area in December, and (F) Hyperiidea density in Grand Banks/Labrador Sea in December used in the most important CMR models

Table S1. Colinearity (correlation matrix) between explanatory variables used to model the survival of kittiwakes. Significance levels are indicated by red (p < 0.01) and **bold** (p < 0.05) All prey covariates were log-transformed, and covariates with yearly trends were detrended before analyses. For details about description and selection of covariates, see the ‘Material and methods’ and Table 2 in the main text

	Capelin Tot	Capelin EOS	Herrring 1Y	Pcod West	Pcod East	Pcod EOS	Theco Dec	Theco Nov	Euph Dec	Euph Nov	Hyp Dec	Hyp Nov	Cal Dec	Cal Nov	SST aut EOS	SST winter GBLS	SST spring Horn	SST summer Horn	NAO PC
Year	0.14	0.26	–0.30	–0.26	0.04	0.08	–0.13	–0.13	0.04	0.20	–0.03	0.18	–0.14	0.05	0.14	0.05	0.03	0.39	**–0.44**
CapelinTot		**0.88**	–0.10	**0.44**	0.37	–0.25	–0.38	–0.23	0.08	–0.06	–0.05	0.29	–0.09	0.17	0.16	0.05	0.17	–0.09	–0.03
CapelinEOS			–0.26	0.24	0.14	–0.18	–0.41	–0.32	0.04	–0.02	–0.17	0.28	–0.26	0.09	–0.02	–0.03	0.44	0.02	0.03
Herring1Y				0.14	0.17	0.33	–0.02	0.12	–0.10	0.24	–0.12	–0.25	0.19	0.11	0.12	0.05	–0.01	0.25	0.42
PcodWest					0.65	–0.14	–0.04	0.13	–0.34	**–0.44**	0.03	–0.19	0.41	0.09	0.19	–0.30	–0.07	–0.27	0.01
PcodEast						–0.03	–0.06	0.26	–0.25	**–0.46**	0.34	–0.04	0.20	0.23	0.17	–0.15	–0.13	–0.22	–0.12
PcodEOS							–0.03	–0.22	0.06	0.35	–0.07	0.08	0.28	0.41	–0.02	–0.12	–0.02	0.33	0.04
ThecoDec								**0.65**	0.32	0.11	0.42	0.27	0.21	–0.13	–0.13	–0.19	–0.42	0.19	–0.30
ThecoNov									0.00	–0.10	0.30	0.29	0.06	0.22	–0.26	0.10	–0.43	–0.05	–0.35
EuphDec										**0.51**	0.17	**0.48**	0.08	0.01	0.11	0.01	–0.14	0.21	–0.05
EuphNov											–0.28	0.35	0.01	0.22	0.11	0.09	–0.18	0.31	0.05
HypDec												0.35	0.23	0.08	0.29	–0.04	–0.06	–0.26	–0.07
HypNov													0.02	**0.64**	–0.01	0.08	–0.09	–0.06	–0.25
CalDec														0.14	0.32	–0.26	–0.27	–0.20	–0.05
CalNov															0.07	0.22	–0.21	–0.07	–0.20
SSTautEOS																–0.14	–0.02	–0.05	0.12
SSTwinterGBLS																	–0.34	–0.12	–0.37
SSTspringHorn																		–0.04	**0.68**
SSTsummerHorn																			–0.10

Table S2. Tests for yearly linear trends between 1991 and 2010 in covariates used to investigate the relationship between kittiwake adult survival on Hornøya and environmental factors. Bold indicates covariates with yearly linear trends ($p < 0.05$), which were detrended using the residuals from the regression between the parameter and year. For details about description and selection of covariates, see 'Material and methods' and Table 2 in the main text

Covariate	Slope (±SE)	R^2	p
CapelinTot (ICES data)	0.03 (0.04)	0.02	0.57
CapelinEOS	0.06 (0.05)	0.07	0.27
Herring1Y	–0.05 (0.04)	0.09	0.20
PcodEast	0.02 (0.10)	0.002	0.87
PcodWest	–0.08 (0.07)	0.07	0.27
PcodEOS	0.01 (0.04)	0.006	0.75
ThecoDec	**–0.08 (0.03)**	**0.35**	**0.005**
ThecoNov	–0.002 (0.04)	0.02	0.57
EuphDec	**–0.06 (0.01)**	**0.45**	**0.0008**
EuphNov	**–0.06 (0.02)**	**0.41**	**0.003**
HypDec	**–0.03 (0.008)**	**0.42**	**0.002**
HypNov	0.01 (0.01)	0.03	0.46
CalDec	–0.02 (0.03)	0.02	0.56
CalNov	0.008 (0.04)	0.002	0.85
SSTautEOS	**0.02 (0.004)**	**0.52**	**0.0003**
SSTwinterEOS	**0.06 (0.01)**	**0.51**	**0.0004**
SSTspringHorn	**0.02 (0.005)**	**0.53**	**0.0003**
SSTsummerHorn	**0.03 (0.006)**	**0.60**	**<0.0001**
NAOPC	–0.09 (0.04)	0.19	0.05

Table S3. An overview of all models of kittiwake adult survival rates tested against different environmental covariates. Phi is the survival rate and *p* is the re-sighting rate. The notation *t* indicates time-dependent, *f* indicates the transition between 2 states and is a model where the re-sighting rate has been corrected for trap-happiness and transient, *i* indicates a constant model. The notations and explanations for the covariates are explained in Table 2 in the main text. Models are sorted by ascending $QAIC_c$ (quasi-likelihood Akaike's information criterion corrected for small sample size and overdispersion) and $\Delta QAIC_c$ (the difference between the $QAIC_c$ of a given model and the $QAIC_c$ of the best model) is given for covariate models only. AIC_{wt}: AIC weight

	k	Deviance	$QAIC_c$	$\Delta QIAC_c$	AIC_{wt}	*F*	p	R^2
phi(*t*)*p*(*f*+*t*)	42	10349.93	10434.58					
phi(CapelinTot+Thecodec)*p*(*f*+*t*)	25	10405.13	10455.36	0	0.97	9.17	0.002	0.52
phi(CapelinTot+PcodEOS)*p*(*f*+*t*)	25	10412.01	10462.24	6.87	0.03	7.21	0.005	0.46
phi(CapelinTot+EuphDec)*p*(*f*+*t*)	25	10417.54	10467.77	12.41	0.00	5.93	0.01	0,41
phi(Herring1Y+HypDec)*p*(*f*+*t*)	25	10421.28	10471.51	16.15	0.00	5.17	0.016	0.38
phi(PcodWest+EuphDec)*p*(*f*+*t*)	25	10421.73	10471.96	16.59	0.00	5.08	0.017	0.38
phi(PcodEOS+HypDec)*p*(*f*+*t*)	25	10422.29	10472.52	17.16	0.00	4.98	0.018	0.37
phi(PcodEOS+EuphDec)*p*(*f*+*t*)	25	10422.97	10473.21	17.84	0.00	4.85	0.02	0.36
phi(PcodWest+HypDec)*p*(*f*+*t*)	25	10425.66	10475.89	20.53	0.00	4.38	0.027	0.34
phi(CapelinTot+CalDec)*p*(*f*+*t*)	25	10426.17	10476.41	21.04	0.00	4.29	0.029	0.34
phi(CapelinTot+HypDec)*p*(*f*+*t*)	25	10427.20	10477.43	22.07	0.00	4.12	0.033	0.33
phi(ThecoDec+SSTautEOS)*p*(*f*+*t*)	25	10427.61	10477.84	22.48	0.00	4.06	0.034	0.32
phi(ThecoDec+PcodEOS)*p*(*f*+*t*)	25	10429.32	10479.55	24.19	0.00	3.78	0.041	0.31
phi(Herring1Y+PcodEOS)*p*(*f*+*t*)	25	10430.32	10480.55	25.19	0.00	3.63	0.046	0.30
phi(PcodEOS)*p*(*f*+*t*)	24	10432.47	10480.68	25.32	0.00	7.02	0.016	0.28
phi(PcodEOS+CalDec)*p*(*f*+*t*)	25	10431.11	10481.34	25.97	0.00	3.51	0.05	0.29
phi(CapelinTot)*p*(*f*+*t*)	24	10433.87	10482.08	26.71	0.00	6.61	0.019	0.27

	k	Deviance	$QAIC_c$	$\Delta QIAC_c$	AIC_{wt}	F	p	R^2
phi(CapelinTot+SSTwinterGBLS)*p*(*f*+*t*)	25	10432.12	10482.35	26.99	0.00	3.37	0.056	0.28
phi(CapelinTot+SSTautEOS)*p*(*f*+*t*)	25	10433.79	10484.02	28.66	0.00	3.13	0.067	0.27
phi(PcodWest+SSTautEOS)*p*(*f*+*t*)	25	10434.60	10484.83	29.47	0.00	3.02	0.073	0.26
phi(Herring1Y+SSTautEOS)*p*(*f*+*t*)	25	10434.61	10484.85	29.48	0.00	3.02	0.073	0.26
phi(ThecoDec+PcodWest)*p*(*f*+*t*)	25	10436.35	10486.58	31.22	0.00	2.79	0.087	0.25
phi(PcodWest+CapelinEOS)*p*(*f*+*t*)	25	10437.78	10488.01	32.65	0.00	2.60	0.1	0.23
phi(PcodWest+CalDec)*p*(*f*+*t*)	25	10438.52	10488.75	33.39	0.00	2.51	0.108	0.23
phi(PcodWest)*p*(*f*+*t*)	24	10440.80	10489.02	33.65	0.00	4.73	0.042	0.21
phi(Herring1Y+EuphDec)*p*(*f*+*t*)	25	10439.73	10489.96	34.59	0.00	2.36	0.121	0.22
phi(PcodWest+SSTwinterGBLS)*p*(*f*+*t*)	25	10440.35	10490.58	35.21	0.00	2.29	0.081	0.21
phi(Herring1Y+SSTwinterGBLS)*p*(*f*+*t*)	25	10442.11	10492.34	36.98	0.00	2.08	0.152	0.20
phi(HypDec)*p*(*f*+*t*)	24	10444.15	10492.37	37	0.00	3.92	0.062	0.18
phi(CapelinEOS+HypDec)*p*(*f*+*t*)	25	10444.06	10494.29	38.93	0.00	1.86	0.183	0.18
phi(Herring1Y+CapelinEOS)*p*(*f*+*t*)	25	10446.52	10496.75	41.38	0.00	1.60	0.228	0.16
phi(ThecoDec+Herring1Y)*p*(*f*+*t*)	25	10448.44	10498.67	43.31	0.00	1.40	0.271	0.14
phi(Herring1Y)*p*(*f*+*t*)	24	10450.59	10498.80	43.44	0.00	2.52	0.129	0.12
phi(EuphDec)*p*(*f*+*t*)	24	10451.51	10499.72	44.36	0.00	2.33	0.143	0.11
phi(CapelinEOS+EuphDec)*p*(*f*+*t*)	25	10449.65	10499.88	44.52	0.00	1.28	0.301	0.13
phi(Herring1Y+CalDec)*p*(*f*+*t*)	25	10449.95	10500.18	44.82	0.00	1.25	0.309	0.13
phi(SSTautEOS)*p*(*f*+*t*)	24	10453.00	10501.21	45.85	0.00	2.04	0.169	0.10
phi(HypNov)*p*(*f*+*t*)	24	10455.91	10504.12	48.76	0.00	1.49	0.237	0.08
phi(ThecoDec+CapelinEOS)*p*(*f*+*t*)	25	10454.22	10504.45	49.09	0.00	0.85	0.443	0.09
phi(ThecoDec)*p*(*f*+*t*)	24	10458.36	10506.58	51.21	0.00	1.05	0.318	0.05
phi(SSTwinterGBLS)*p*(*f*+*t*)	24	10458.39	10506.60	51.24	0.00	1.04	0.321	0.05
phi(CalNov)*p*(*f*+*t*)	24	10459.81	10508.03	52.66	0.00	0.79	0.385	0.04
phi(EuphNov)*p*(*f*+*t*)	24	10461.16	10509.37	54.01	0.00	0.57	0.46	0.03
phi(PcodEast)*p*(*f*+*t*)	24	10461.78	10509.99	54.63	0.00	0.46	0.506	0.03
phi(SSTsummerHorn)*p*(*f*+*t*)	24	10462.34	10510.55	55.19	0.00	0.37	0.55	0.02
phi(*i*)*p*(*f*+*t*)	23	10464.66	10510.86	55.49	0.00	0.00	0	0
phi(CalDec)*p*(*f*+*t*)	24	10463.70	10511.91	56.55	0.00	0.15	0.703	0.01
Phi(BSL1)*p*(*f*+*t*)	24	10463.86	10512.07	56.71	0.00	0.12	0.733	0.01
phi(SSTspringHorn)*p*(*f*+*t*)	24	10463.97	10512.19	56.82	0.00	0.11	0.743	0.01
phi(ThecoNov)*p*(*f*+*t*)	24	10464.21	10512.42	57.06	0.00	0.07	0.794	0
phi(CapelinEOS)*p*(*f*+*t*)	24	10464.66	10512.87	57.51	0.00	0.00	0.986	0
phi(*t*)*p*(*t*)	41	10866.89	10949.50	494.14	0.00	0.00	0	0
phi(*i*)*p*(*f*)	3	10952.34	10958.34	502.98	0.00	0.00	0	0
phi(*i*)*p*(*t*)	22	11004.44	11048.62	593.26	0.00	0.00	0	0
phi(*i*)*p*(*i*)	2	11649.80	11653.80	1198.4	0.00	0.00	0	0

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