The following supplement accompanies the article

Forecasting ocean warming impacts on seabird demography: a case study on the European storm petrel

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Supplement 1.

Details of the Principal Component Analysis on sea surface temperatures.

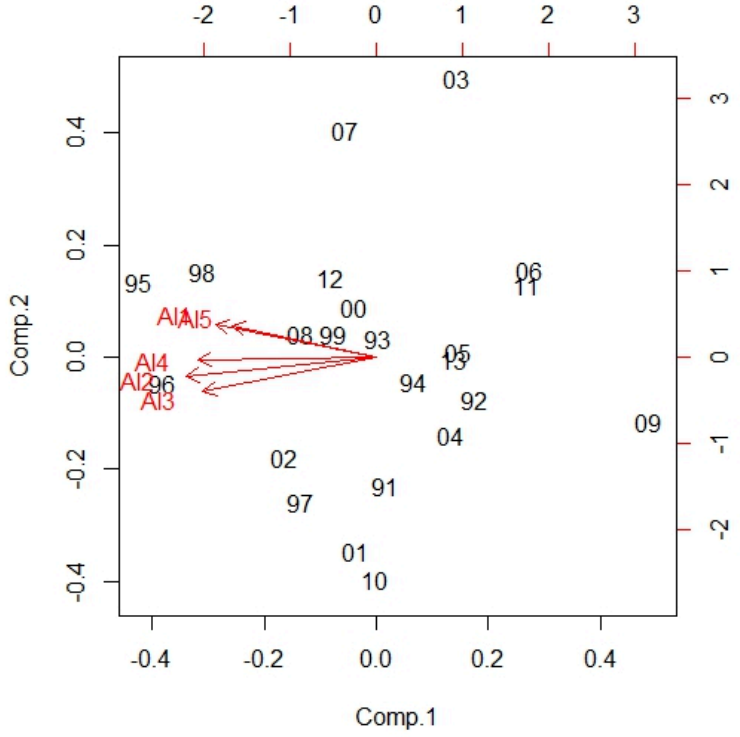

Figure S1: Biplot of the PCA with principal component scores and directions of the variable considering winter period SST in the Alboran sea, the potential wintering area for the species. Each Al vector corresponds to temperature recorded in one of the 5 random sampling points.

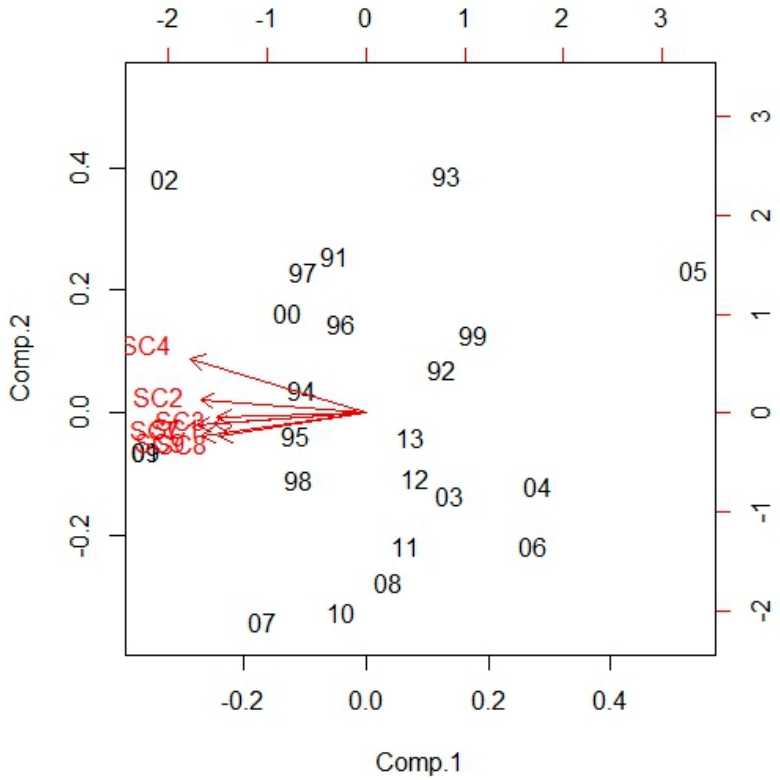

Figure S2: Biplot of the PCA with principal component scores and directions of the variable considering pre-breeding period SST in the Sicilian Channel. Each SC vector corresponds to temperature recorded in one of the 13 random at-sea sampling points in the Sicilian Channel..

Table S1: First factor of PCA on SST of the 5 sampling points in the Alboran sea (Fig. 1b in the main article).

year/point	Al1	Al2	Al3	Al4	Al5	PC1
91	14.85	15.19	15.63	15.38	15.29	0.081
92	14.75	14.80	15.04	14.99	14.75	0.967
93	15.14	15.24	15.43	15.43	15.24	0.018
94	14.90	15.14	15.24	15.33	15.09	0.358
95	16.16	16.31	16.45	16.65	16.16	-2.330
96	16.01	16.35	16.50	16.26	16.06	-2.096
97	15.33	15.72	15.92	15.77	15.38	-0.742
98	15.77	15.97	16.21	16.31	16.11	-1.708
99	15.33	15.53	15.63	15.53	15.43	-0.417
00	15.38	15.33	15.58	15.43	15.29	-0.217
01	15.14	15.53	15.72	15.43	15.09	-0.204
02	15.43	15.92	15.82	15.87	15.43	-0.900
03	15.08	14.72	14.80	15.14	15.06	0.792
04	14.77	14.87	15.27	15.06	14.92	0.728
05	14.70	14.69	15.20	15.12	15.06	0.795
06	14.49	14.64	14.64	14.57	14.85	1.503
07	15.45	15.29	15.44	15.50	15.58	-0.307
08	15.51	15.70	15.74	15.75	15.48	-0.748
09	13.94	13.95	14.25	14.26	14.13	2.675
10	14.92	15.29	15.70	15.53	15.07	-0.019
11	14.56	14.42	14.82	14.69	14.80	1.467
12	15.49	15.57	15.61	15.45	15.43	-0.454
13	14.87	14.94	15.20	14.85	14.98	0.759
			Proportion of Variance			98.34%

Table S2: First factor of PCA on SST of the 7 sampling points in the Sicilian Channel (Fig. 1c in the main article).

year/point	SC1	SC2	SC3	SC4	SC7	SC8	SC9	PC1
91	14.90	14.97	14.82	15.12	14.97	14.90	14.97	-0.279
92	14.53	14.68	14.61	14.53	14.61	14.61	14.61	0.668
93	14.31	14.75	14.53	14.75	14.53	14.53	14.61	0.707
94	15.19	15.12	14.97	15.04	14.97	15.04	15.12	-0.568
95	15.12	15.12	15.19	14.97	15.12	14.97	15.12	-0.620
96	14.97	14.97	14.90	14.97	14.90	14.90	14.90	-0.213
97	15.04	15.12	14.97	15.19	14.97	15.04	15.04	-0.547
98	15.04	15.12	14.97	14.97	15.04	15.19	15.19	-0.593
99	14.46	14.46	14.39	14.53	14.53	14.53	14.53	0.938
00	14.90	15.19	15.04	15.19	15.19	15.12	15.12	-0.689
01	15.48	15.55	15.48	15.55	15.77	15.48	15.70	-1.926
02	15.41	15.63	15.48	15.77	15.48	15.41	15.41	-1.764
03	14.43	14.60	14.64	14.37	14.64	14.71	14.61	0.733
04	14.25	14.18	14.28	14.15	14.24	14.59	14.31	1.505
05	13.82	13.75	13.85	13.74	13.77	13.66	13.72	2.877
06	14.36	14.23	14.26	14.05	14.35	14.35	14.48	1.463
07	15.25	15.15	15.17	14.94	15.22	15.27	15.41	-0.915
08	14.75	14.83	14.69	14.50	14.78	14.85	15.02	0.197
09	15.48	15.55	15.48	15.55	15.77	15.48	15.70	-1.926
10	14.81	14.90	14.93	14.66	15.09	15.15	15.02	-0.223
11	14.71	14.75	14.76	14.45	14.82	14.79	14.75	0.355
12	14.78	14.69	14.70	14.51	14.72	14.74	14.67	0.437
13	14.78	14.61	14.83	14.62	14.65	14.71	14.75	0.383
					Proportion of Variance			94.43%

Supplement 2.

Deterministic model with constant parameters.

Scenario A (accounting for senescence)
According to the estimated age-specific survival from the age dependent model, seven age classes were considered with the following annual survival probabilities:
from age 0 to 1: s0 = 0.222
from age 1 to age 16: s1115 = 0.949
from age 16 to age 17: s16 = 0.674
from age 17 to age 18: s17 = 0.745
from age 18 to age 19: s18 = 0.494
from age 19 to age 21: s1921 = 0.247
from age 21 onwards: s22 = 0.247

The proportion of breeding females at age 1 is m1 = 0.233, then increasing at age 2, 3 and 4 (m2 = 0.477, m3 = 0.593, m4 = 0.865) and for older females it is m = 0.999.
Each breeding female produces one chick per year, with a balanced sex-ratio at birth.

```
A <- matrix(c(
  0,
s0*m1*f,s0*m2*f,s0*m3*f,s0*m4*f,s0*m*f,s0*m*f,s0*m*f,s0*m*f,s0*m*f,s0*m*f,s0*m*f,s0*m*f,
s0*m*f,s0*m*f,s0*m*f,s0*m*f,s0*m*f,s0*m*f,s0*m*f,s0*m*f,s0*m*f,s0*m*f,
  s115, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
  0, s115, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
  0, 0, s115, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
  0, 0, 0, s115, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
  0, 0, 0, 0, s115, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
  0, 0, 0, 0, 0, s115, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
  0, 0, 0, 0, 0, 0, s115, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
  0, 0, 0, 0, 0, 0, 0, s115, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
  0, 0, 0, 0, 0, 0, 0, 0, s115, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
  0, 0, 0, 0, 0, 0, 0, 0, 0, s115, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, s115, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
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  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, s16, 0, 0, 0, 0, 0, 0,
  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, s17, 0, 0, 0, 0, 0,
  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, s18, 0, 0, 0, 0,
  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, s1921, 0, 0, 0,
  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, s1921, 0, 0,
  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, s1921, s22),nrow=22, byrow=T)
```

Scenario B (not accounting for senescence)
According to the estimated survival from the general survival model, three age classes were considered with the following annual survival probabilities:
from age 0 to 1: s0 = 0.222
from age 1 to age 2: s1 = 0.90
from age 2 onwards: s2 = 0.949

The proportion of breeding females at age 1 is m1 = 0.233, then increasing at age 2, 3 and 4 (m2 <- 0.477, m3 <- 0.593, m4 <- 0.865) and for older females it is m = 0.999.

```
A <- matrix(c(
  0,
s0*m1*f,s0*m2*f,s0*m3*f,s0*m4*f,s0*m*f,s0*m*f,s0*m*f,s0*m*f,s0*m*f,s0*m*f,s0*m*f,s0*m*f,
s0*m*f,s0*m*f,s0*m*f,s0*m*f,s0*m*f,s0*m*f,s0*m*f,s0*m*f,s0*m*f,s0*m*f,
  s1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
  0, s2, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
  0, 0, s2, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
  0, 0, 0, s2, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
  0, 0, 0, 0, s2, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
  0, 0, 0, 0, 0, s2, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
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  0, 0, 0, 0, 0, 0, 0, s2, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
  0, 0, 0, 0, 0, 0, 0, 0, s2, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
  0, 0, 0, 0, 0, 0, 0, 0, 0, s2, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, s2, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, s2, 0, 0, 0, 0, 0, 0, 0, 0, 0,
  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, s2, 0, 0, 0, 0, 0, 0, 0, 0,
  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, s2, 0, 0, 0, 0, 0, 0, 0,
  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, s2, 0, 0, 0, 0, 0, 0,
  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, s2, 0, 0, 0, 0, 0,
  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, s2, 0, 0, 0, 0,
  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, s2, 0, 0, 0,
  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, s2, 0, 0,
  0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, s2, s2),nrow=22, byrow=T)
```

Model with environmental stochasticity, the 9 scenarios:
In some years ‘catastrophic events’ occur, strongly reducing fecundity and observable in high skipping propensity. On average, such catastrophes occur every 5 years. We considered environmental variability using a Bernoulli distribution to implement the frequency of catastrophes and catastrophic levels of fecundity. We also used a pseudo-extinction threshold of 100 individuals in order to estimate extinction probability at 100 and 200 years.