

The following supplement accompanies the article

Decadal changes in blood $\delta^{13}\text{C}$ values, at-sea distribution and weaning mass of southern elephant seals from Kerguelen Islands.

Julie Mestre^{1,2*}, Matthieu Authier^{3,4}, Yves Cherel¹, Rob Harcourt⁵,

Clive R. McMahon^{5,6,7}, Mark A. Hindell⁷, Jean-Benoît Charrassin⁸, Christophe Guinet¹

¹ Centre d'Etudes Biologiques de Chizé (CEBC), UMR 7372 du CNRS- La Rochelle Université, 79360 Villiers-en-Bois, France.

² Sorbonne Université, Collège Doctoral, F-75005 Paris, France.

³ Observatoire PELAGIS, UMS 3462 La Rochelle Université & CNRS, La Rochelle, France.

⁴ ADERA, Pessac Cedex, France.

⁵ Department of Biological Sciences, Macquarie University, North Ryde, NSW, Australia.

⁶ IMOS Animal Tagging, Sydney Institute of Marine Science, Sydney, NSW, Australia.

⁷ Institute for Marine and Antarctic Studies, University of Tasmania, Hobart, TAS, Australia.

⁸ LOCEAN/IPSL, Sorbonne Université-CNRS-IRD-MNHN, UMR 7159, Paris, France.

*Corresponding author: julie.mestre@cebc.cnrs.fr; j.mestre@hotmail.fr

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Supplementary Materials S3: Mixture model set up on pup blood $\delta^{13}\text{C}$ values

1) Code of mixture model taking into account $\delta^{13}\text{C}$ trend

```
data {  
  
  int<lower = 1> n_obs;           // n_obs = number of data points  
  
  int<lower = 1> n_year;         // n_year = number of years  
  
  vector[n_obs] DELTA13C;       // DELTA13C = observations  
  
  int<lower = 1, upper = n_year> YEAR[n_obs];  
  
                                 // YEAR[n_obs] = indicator of year  
  
  vector[n_year] STDYEAR;  
  
}  
  
parameters {  
  
  ordered[2] unscaled_mu;  
  
  vector<lower = 0.0>[2] sigma;  
  
  real<lower = 0.0> sigma_year;  
  
  real unscaled_intercept; // intercept of logistic regression  
  
  real unscaled_slope; // slope of logistic regression  
  
  vector[n_year] unscaled_epsilon; // residuals for year effect  
  
}  
  
// mu = locations of mixture components  
  
// sigma = scales of mixture components  
  
transformed parameters {  
  
  real intercept;  
  
  real slope;  
  
  vector[2] mu;  
  
  vector[n_year] epsilon;
```

```

vector[n_obs] theta;

vector[2] mu_year[n_year];

vector[2] prop[n_year];

vector[2] log_npdf[n_obs];

vector[2] marginal_proba[n_obs];

real R_sq;

mu = rep_vector(-20, 2) + 5.0 * unscaled_mu;

intercept = 1.5 * unscaled_intercept;

slope = log(2) / 2 * unscaled_slope;

epsilon = rep_vector(intercept, n_year) + slope * STDYEAR + sigma_year *
unscaled_epsilon;

theta = inv_logit(epsilon[YEAR]);

for(j in 1:n_year) {

  prop[j, 2] = inv_logit(epsilon[j]);

  prop[j, 1] = 1 - inv_logit(epsilon[j]);

  mu_year[j, 1] = mu[1] - 0.09 * (j - 1);

  mu_year[j, 2] = mu[2] - 0.09 * (j - 1);

}

for (i in 1:n_obs) {

// decrease of 0.09 permill per year

  for (k in 1:2) {

    log_npdf[i, k] = normal_lpdf(DELTA13C[i] | mu_year[YEAR[i], k],
sigma[k]);

    marginal_proba[i, k] = exp(log_npdf[i, k]);

  }

  marginal_proba[i] = marginal_proba[i] / sum(marginal_proba[i]);

}

R_sq = 1 - square(sigma_year) * variance(unscaled_epsilon) /
variance(epsilon);

```

```

}

// mu_year = year specific d13C value (per strategy, per year)

// prop = proportion of mixtures (per mu, per year)

// R_sq = R2 of a linear regression adjusted on probability to belong to a
foraging strategy

model {

  unscaled_mu ~ normal(0.0, 1.0);

  sigma ~ normal(0.0, 1.0);

  sigma_year ~ normal(0.0, 1.0);

  unscaled_intercept ~ normal(0.0, 1.0);

  unscaled_slope ~ normal(0.0, 1.0);

  unscaled_epsilon ~ normal(0.0, 1.0);

  // individual likelihoods, as sum of component contributions
  for (i in 1:n_obs) {
    target += log_mix(theta[i], log_npdf[i, 2], log_npdf[i, 1]);
  }
}

generated quantities {

  vector[n_obs] log_lik;

  int G[n_obs];

  vector[n_obs] y_rep;

  for(i in 1:n_obs) {

    log_lik[i] = log_mix(theta[i], log_npdf[i, 2], log_npdf[i, 1]);

    G[i] = categorical_rng(marginal_proba[i]);

    y_rep[i] = normal_rng(mu_year[YEAR[i], G[i]], sigma[G[i]]);

  }
}

```

2) Distribution of raw data and the fitted model

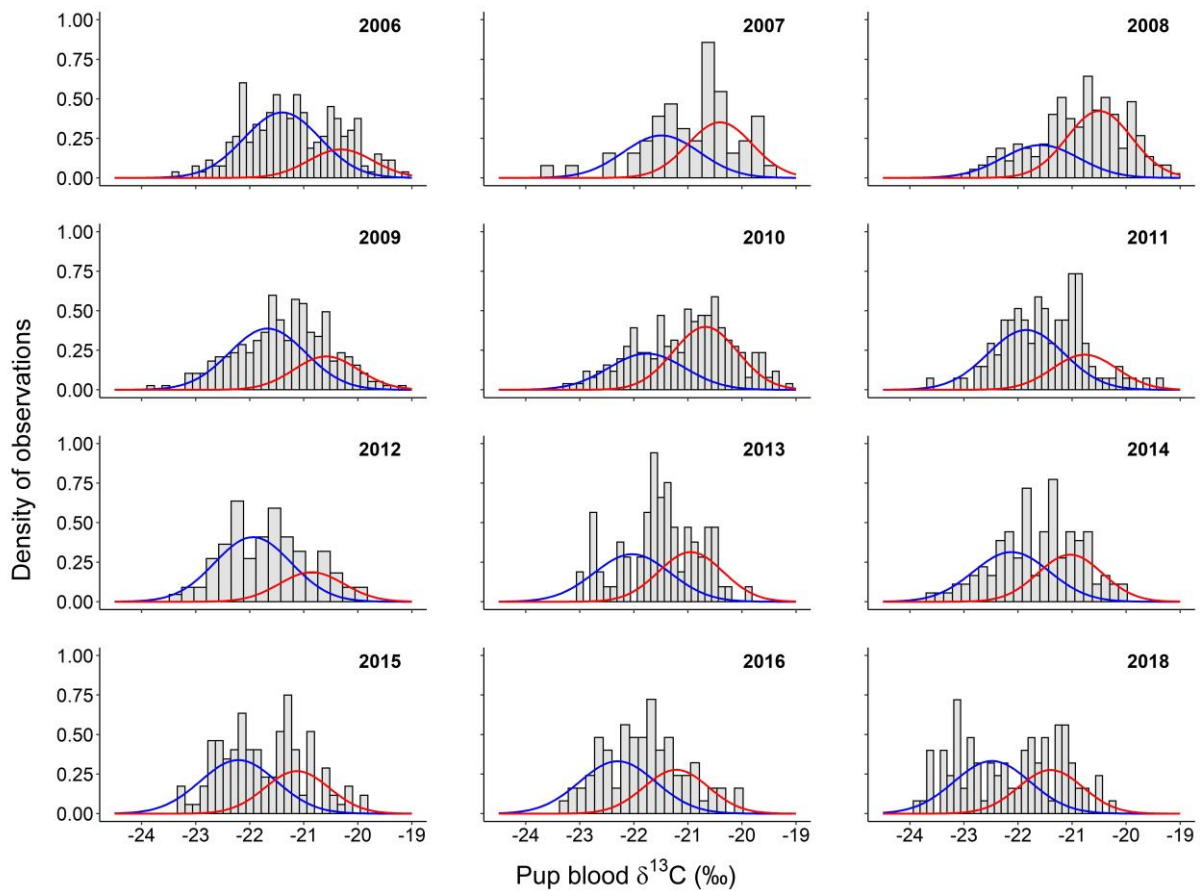


Figure S5. Empirical distribution of the blood $\delta^{13}\text{C}$ values of pups superimposed with the probability density functions of the mixture model. The blue curve represents the probability density function of pups assigned to the Antarctic habitat, whereas the red one corresponds to individuals assigned to the sub-Antarctic habitat.

3) Annual proportions of the two estimated groups

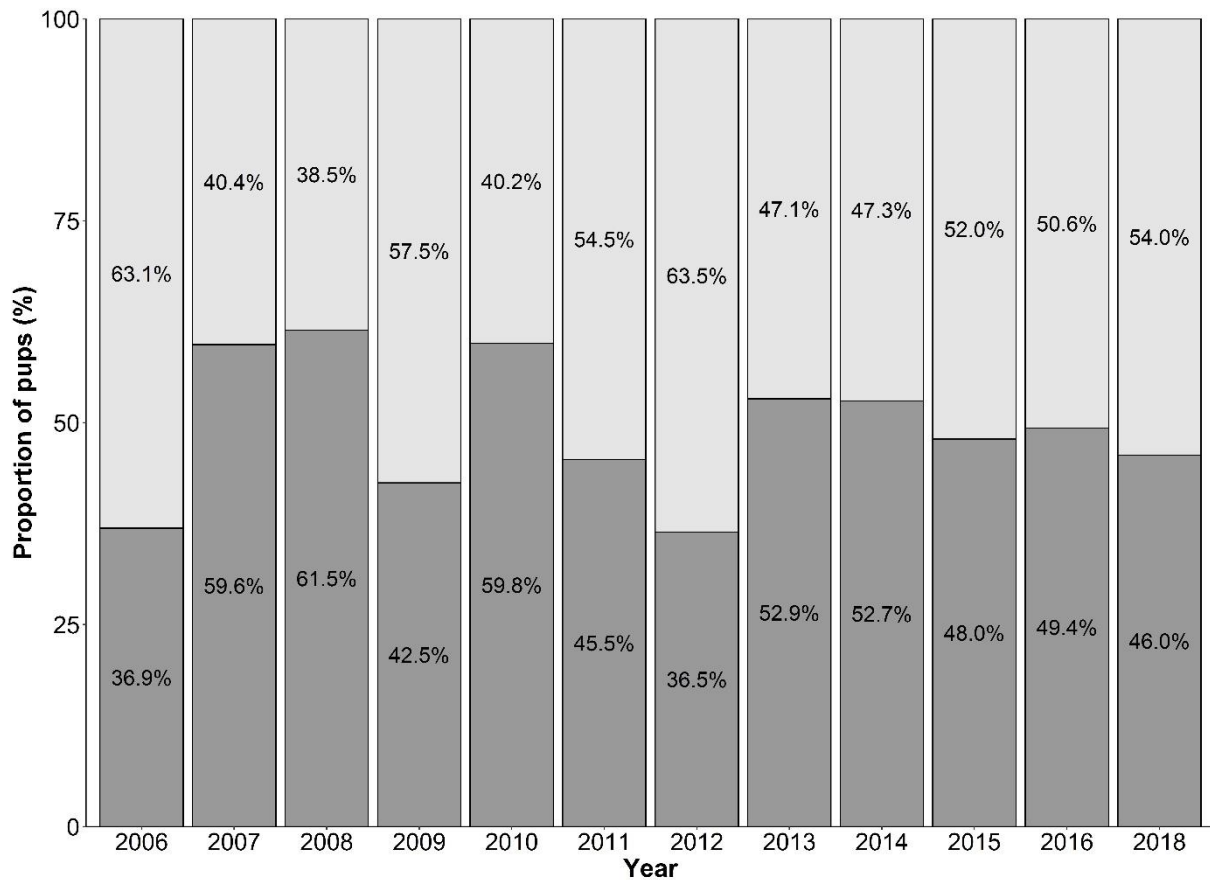


Figure S6. Annual percentages of pups presumably born from female southern elephant seals that foraged either in the Antarctic (light grey) or in sub-Antarctic (dark grey) zones. Groups of pups were established based on a mixture model taking into account the temporal trend in blood $\delta^{13}\text{C}$.

No significant change has been detected in the annual proportion of females' foraging strategies, suggesting that the balance between the two foraging habitats remained unchanged over the study period. We should however be cautious with this interpretation, as our results suggest that the two foraging strategies displayed by females whose pups were blood-sampled on southeast Kerguelen Island are of similar importance within the population. Tracking data at the opposite suggest that more females forage in the sub-Antarctic habitat. This is subjective and "data-biased", depending on thresholds set up to split the two foraging

strategies. Datasets thus do not have the same sample sizes, and we have to keep in mind that sampled individuals are not necessarily representative of the whole population. We therefore tried to get rid of subjectivity by implementing non-informative priors in our mixture models. However, and regardless of the relative importance of the two foraging habitats, our mixture models showed that the percentage of individuals assigned to a given foraging strategy stays relatively stable over time.