

## **A bioenergetics model for estimating prey consumption by an Adélie penguin population in East Antarctica**

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### **SUPPLEMENT**

**Field data collection:** Data in the energetics model from Béchervaise Island include mass changes, foraging probability, breeding success, proportion of prey types in their diet, population size and phenology. Each of these are described briefly below with reference to detailed studies if they were used for parameter estimates.

**Body mass:** Body mass of male and female breeders at key phenological dates (i.e. arrival, hatching, crèche, fledging) were extracted from an Automated Penguin Monitoring System (APMS), installed at Béchervaise Island. Values were used from across breeding seasons presented in Emmerson et al. (2003) and specifically extracted for 1998/99 and 2000/01 for this study. The APMS consists of a weighbridge, a tag detector, direction sensors and computer microprocessor and records the direction of travel, sex and body mass of tagged breeders that arrive to and from the colony (Kerry et al. 1993, Clarke et al. 1998). Data on body mass at the start and of molt was not recorded by the APMS and was taken from the literature (Penney 1967). Body mass changes are shown in Figure 1a, b in the main article.

**Foraging probability and phenology:** The probability of male and female breeders being on and off nests and the phenology of different breeding events were attained from daily nest census data. Nest censuses on up to 300 nests began from 13<sup>th</sup> November when females departed their nests after egg lay until 5<sup>th</sup> February when chicks had crèched and were no longer present on the nest and adults departed in preparation for moult. Daily records of the presence of males, females, eggs and chicks at each study nest were recorded.

To determine the probability that a male or female breeder was at-sea for each day of the breeding cycle  $F_d$  (equation 4 in the main article), we fitted generalized additive models (GAMS) (Hastie & Tibshirani 1990) to nest attendance data collected at Béchervaise Island during two breeding seasons. In this dataset, the attendance of males and females was recorded at 268 nests in 1998/99 and 318 nests in 2001/02.

To determine the probability that a male or female breeder was at-sea for each day of the breeding cycle  $F_d$  within the dates of the survey, we fitted generalized additive models (GAMS) (Hastie & Tibshirani 1990) to the nest attendance data (Figure S1). Figure S1 shows the results of model fitting. The solid line represents the probability of a female being at-sea, while the dotted line represents the probability of a male foraging at-sea. The vertical dotted lines represent the start and end of the nest attendance surveys. To extend our model to the start of November, before the start of the attendance surveys, we assumed that the probability of adults being at-sea was 0. This assumption is reasonable since breeders participate in courtship and mating activities during this period. To extend our model past the last day of nest attendance data (5<sup>th</sup> February), we assumed that males and females forage at-sea with a probability of 1 until the start of molt, which occurs on 20<sup>th</sup> February (SD = 5). Adults are then assumed to remain on land with a probability of 1.

Breeding phenology events were taken from Emmerson & Southwell (2011), except for the data for 1998/99 and 2000/01 which were calculated separately for this model.

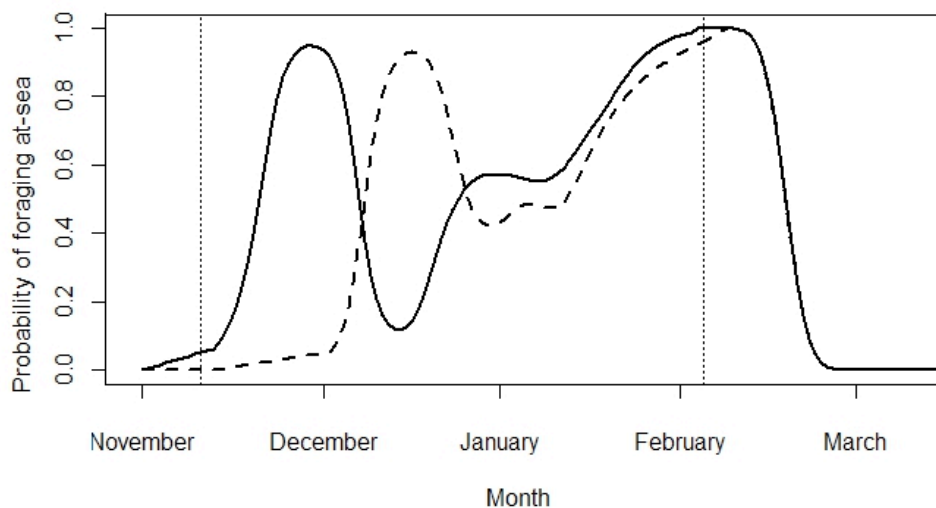


Figure S1: The probability of a male (dashed line) and female (solid line) at-sea for each day of the breeding season. The models were developed by fitting two seasons of nest attendance data with generalized additive models (GAMS). The two vertical dashed lines represent the start and end of the survey period.

**Breeding success and population size:** Breeding success was measured as the number of chicks surviving to the time when two-thirds of the chicks have crèched (around mid-January) in relation to the number of nests occupied by breeding adults at the commencement of incubation (in early December). Population size related to the number of occupied nests at the commencement of incubation.

**Proportion of prey type in diet:** Approximately forty stomach content samples were collected during the guard and crèche stages of the chick rearing period in each year (except 1994/95) using the water-offloading technique described in Tierney et al. (2009). Stomach samples were stored in 70% ethanol for later analysis. Each sample was drained and excess liquid gently squeezed out before being weighed. Samples were sorted and prey species identified to the lowest taxonomic level possible (Tierney et al. 2009). Generally, krill (*E. superba* and *E. crystallophias*) were identifiable to species level (unless highly digested). The wet mass of each component of the diet including krill was weighed separately. Total proportion of krill and fish in the diet were determined across years and in the 1998/99 and 2000/01 breeding seasons separately. Penguin diet at Béchervaise Island is summarized in Tierney et al. (2009).

**Estimates of error associated with parameters:** We specified probability distributions wherever possible to account for uncertainty in model parameters using normal distributions where means and standard deviation of measurements were available, or from a uniform distribution representing the maximum and minimum of published estimates. We were able to specify probability distributions for all of the parameters in our model, with the exception of foraging success *FS* (equation 2 in the main article).

#### LITERATURE CITED

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