

# Foraging Ecology of Emperor Penguins

Ilka Zimmer<sup>1</sup>, Rory Wilson<sup>2</sup>, Joachim Plötz<sup>1</sup>, André Ancel<sup>3</sup>

<sup>1</sup> Alfred-Wegener-Institut für Polar- und Meeresforschung in Bremerhaven (AWI), Germany

<sup>2</sup> University of Wales Swansea, UK

<sup>3</sup> Département Écologie, Physiologie et Éthologie / Centre National de la Recherche Scientifique à Strasbourg (DEPE/CNRS), France

## Introduction

Emperor penguins, *Aptenodytes forsteri*, play an important role as top predators in high Antarctic marine ecosystems. Being central place foragers they execute foraging trips to remote locations and consistently return to a central place, the colony, to deliver food to the chick. The present study focuses on the critical two month-period before fledging, when maximum growth of chicks occurs and food demand is high at the Pointe Géologie emperor penguin colony of about 3000 breeding pairs (Fig. 1).

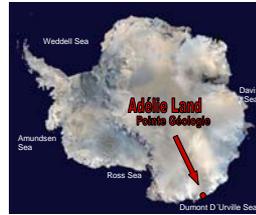


Fig. 1. Study site at 66°40'S, 140°00'E

Objectives were to:

- identify the foraging distribution and feeding grounds during late chick-rearing and before the adult moult by satellite tracking.
- determine the length and duration of feeding trips.
- describe the extent of horizontal and vertical movements during single foraging trips.
- reconstruct the foraging time/activity budget by the calculation of an Area-Restricted-Search index (ARS).

## First results

### Foraging distribution

Trips during the late chick-rearing period (Fig. 5a):

- Birds centred foraging over the shelf north-east of the colony.
- Median trip duration was 8.1 days (range 1.8 - 19.3 days).
- Median trip length was 396.5 km (range 81 - 858.7 km).

Trips prior to the moulting period (Fig. 5b):

- Birds dispersed widely to forage over deep water up to 600 km off the coast, and then moved back to the coastal shelf to moult.
- Median trip duration was 42.2 days (range 31 - 54 days).
- Median trip length was 3056.4 km (range 1762.3 - 3686.1 km).
- Last transmission occurred in the end of January.

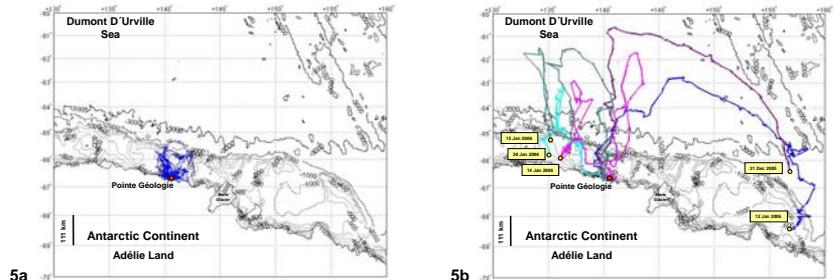


Fig. 5. Bottom topography off Adélie Land as calculated from ETOPO1 minute gridded evaluation database. Foraging trips (n=10) in Nov/Dec 2005 (a). Pre-moult trips (n = 5) between Nov 2005 – Jan 2006; the last at-sea positions are shown by date (b).

### Diving activity

To examine how emperor penguins allocate their time to foraging in certain areas, we examined location and depth data recorded for full foraging trips (n = 5) and show an example (Fig. 6) for a single trip conducted during late chick-rearing. Trips were cut into sections and the effort put into vertical movement (derived from diving depths) and the horizontal tortuosity (derived from the straight line distance travelled between two points versus the total horizontal distance swum underwater between these points) examined for each section. Horizontal tortuosity appeared to change out of phase with vertical movement effort (Fig. 6a). Two overall measures for the foraging activity over a trip were the "Area-Restricted-Search Index" (ARS) (derived from the total distance spent travelling underwater over a defined time interval divided by the straight-line horizontal distance travelled during that period) and the "Catch Per Unit Effort" (CPUE) (derived from the putative number of prey caught using points of inflections in the dive trace divided by the time spent underwater) (Fig. 6b). Both indices indicate that maxima tend to occur in the middle of the foraging track and minima at the start and end (Fig. 6c) auguring for rapid movement away from the colony to distant sites where prey concentrations are higher and best exploited by area-restricted search at depth.

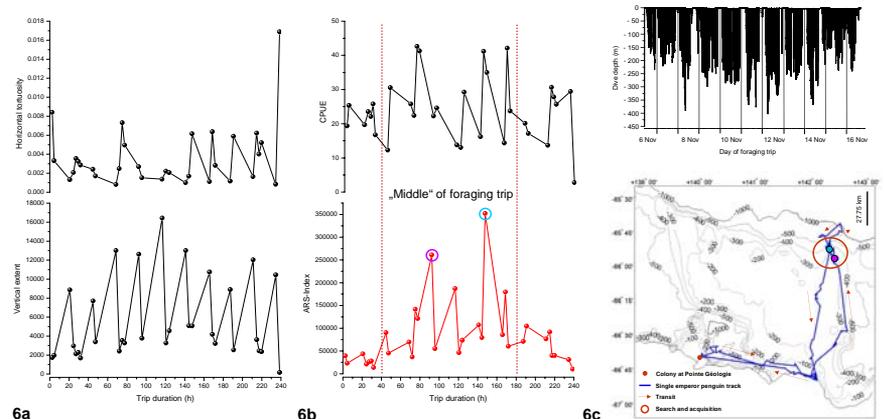


Fig. 6. (a) Horizontal tortuosity and effort allocated to depth for a foraging trip made by an emperor penguin to elucidate prey search strategies (b) The area-restricted search index and catch per unit effort data (derived from counting irregularities in the depth profile) shows how these vary with time into the foraging trip (c) This example shows a foraging trip of 10 days duration, 667 km length with n = 1763 dives > 2 m over the Antarctic shelf.

## Conclusions

- The relatively high provisioning rates necessary during chick-rearing result in emperor penguin foraging close to the colonies and over the Antarctic Shelf at this time.
- The pre-moult foraging period allows extended periods at sea and the movements of birds indicate that this concession results in a different choice of foraging area to that observed during chick-rearing, with birds exploiting deep water far from the Antarctic shelf.

- Preliminary data indicate that during foraging in the late chick-rearing period, emperor penguins display both highly directed travelling and area-restricted search according to locality and this is likely to be due to maximizing the rate of net energy gain according to prey distribution and the costs of transport.

## Methods

- Study period: From end October 2005 to end of January 2006.
- Cooperation between the AWI and the DEPE/CNRS.
- Equipped adult penguins: n = 18
- Devices: Two types of ARGOS transmitters (Fig. 2).
- Attachment: Tape-method (Fig. 3).
- Parameters measured: At-sea locations, dive depth, temperature and light.

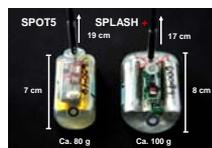


Fig. 2. Satellite Transmitter Wildlife Computers, USA.

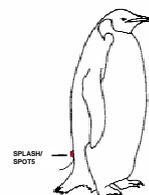


Fig. 3. Devices attached on the lower back feathers of an adult emperor penguin.



## Acknowledgements

We thank the Alfred Wegener Institute for Polar and Marine Research, the Institut Polaire Français (IPEV) and Terres Australes et Antarctiques Françaises (TAAF) for their financial help and logistics support in realizing this project. Many thanks to C. Gilbert, M. Beaulieu, T. Raclot and A. Dervaux for help in field data collection and their advice.