

## Keep the course: travelling penguins consistently orient toward the destination

Kozue Shiomi<sup>1</sup>, Katsufumi Sato<sup>2</sup>, Yves Handrich<sup>3,4</sup>, Charles A. Bost<sup>5</sup>

<sup>1</sup>*National Institute of Polar Research, Japan*

<sup>2</sup>*Atmosphere and Ocean Research Institute, University of Tokyo, Japan*

<sup>3</sup>*Université de Strasbourg, France*

<sup>4</sup>*CNRS, Strasbourg, France*

<sup>5</sup>*Centre d'Etudes Biologiques de Chizé, France*

Orientation of animals during long-distance movements can be affected by internal and external factors such as navigational ability, wind and water current, and local movements for other purposes (e.g. searches for food and refuges). King penguins *Aptenodytes patagonicus* breeding on sub-Antarctic islands travel hundreds of kilometres through the sea to commute productive foraging areas. During the long-distance transit, they also perform deep dives to >100 m depth for foraging: this would reduce speeds of the horizontal travel to the final goal as well as may temporarily disorient themselves. The focus of the present study is on dive-by-dive and at-surface orientations of king penguins at sea, investigating their orientation ability and movement strategy. Headings, which were estimated for each second using magnetometer and accelerometer, were generally maintained toward the south, i.e. the direction of their main foraging area (the Polar Frontal Zone), in outward journeys, while toward the north, i.e. the direction of the breeding colony, in inward journeys. These were consistent during dives and even when staying at the water surface. Concentration of heading distributions were particularly high in shallow dives and at surface, and the variances were not significantly different between the day and night. Meanwhile, in deep dives, heading concentrations were relatively low probably due to foraging movements, but overall movement directions were still kept toward the destination of the trips. These results indicated that king penguins have compass mechanisms reliable both underwater and at the water surface and both in the day and at night. Consistent orientation to the distant destinations should support achievement of long-distance movements within limited time.