

## THE FORAGING RANGE OF ADELIE PENGUINS AT BECHERVAISE ISLAND, MAC. ROBERTSON LAND, ANTARCTICA, AND ITS OVERLAP WITH THE KRILL FISHERY

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### Abstract

The foraging ranges of six female and four male Adélie penguins breeding at Béchervaise Island near Mawson Station (Mac. Robertson Land) were determined by satellite tracking using the ARGOS system. Birds were tracked over four foraging trips (two females and four males) during the incubation period (November to December 1991) and 17 trips (four females and two males) throughout January 1992 when birds were feeding chicks. Most birds made foraging trips to the continental shelf break (1 000 m isobath) approximately 110 km distant at its closest point. Birds feeding chicks also made journeys of one to two days ranging up to 12 km after 17 January when the sea became ice free to the coast. Concentrations of krill, *Euphausia superba*, which have in the past been the subject of a fishery, occur along the shelf break zone where the birds were foraging. There is potential for overlap between the foraging range of Adélie penguins breeding along the Mac. Robertson Land Coast (approximately 150 000 pairs) and any future harvest of krill in the region. The foraging range of the birds at Béchervaise Island considerably exceeds the 15 to 50 km determined for birds in the South Shetland and South Orkney Islands and reflects the distance offshore of krill, one of their major food sources.

### Résumé

Les secteurs d'alimentation de six femelles et quatre mâles de manchots Adélie se reproduisant à l'île Béchervaise, près de la base Mawson (Terre Mac. Robertson) ont été déterminés par suivi par satellite grâce au système ARGOS. Les oiseaux ont été suivis lors de quatre sorties alimentaires (deux femelles et quatre mâles) pendant la période d'incubation (de novembre à décembre 1991) et 17 sorties (quatre femelles et deux mâles) pendant tout le mois de janvier 1992 alors que les oiseaux élevaient des poussins. Les sorties alimentaires de la plupart des oiseaux les ont menés jusqu'à la rupture de pente du plateau continental (isobathe 1 000 m) distante d'environ 110 km en son point le plus proche. Les oiseaux élevant des poussins ont également effectué des sorties d'un ou deux jours et d'un maximum de 12 km après le 17 janvier quand la mer s'est libérée des glaces jusqu'à la côte. Des concentrations de krill, *Euphausia superba*, qui par le passé ont fait l'objet d'une pêcherie, sont présentes le long de la zone de la rupture de pente, là où les oiseaux se sont alimentés. Il est possible qu'à l'avenir le secteur d'alimentation des manchots Adélie se reproduisant le long de la côte de la terre Mac. Robertson (environ 150 000 couples) et une exploitation de krill dans la région se chevauchent. A l'île Béchervaise,

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le secteur d'alimentation des oiseaux, dépassant considérablement l'intervalle de 15 à 50 km déterminé pour les oiseaux des îles Shetland du Sud et des Orcades du Sud, reflète la distance du krill, l'une de leurs principales sources d'alimentation, par rapport à la côte.

#### Резюме

Нагульные ареалы шести самок и четырех самцов пингвина Адели, размножающихся на о-ве Бешервез около станции Моусон (Земля Мак-Робертсон), были установлены с помощью спутникового слежения, используя систему "Аргос". Слежение за птицами велось в ходе четырех походов за пищей (две самки и четыре самца) в течение периода насиживания яиц (ноябрь-декабрь 1991 г.) и 17 походов (четыре самки и два самца) в течение января 1992 г., когда птицы вскармливали своих птенцов. Большинство птиц совершило походы за пищей на границу континентального шельфа (изобата 1 000 м), ближайшая точка которой расположена приблизительно 110 км от берега. После 17 января, когда море стало свободным ото льда до берега, птицы, вскармливающие своих птенцов, совершали одно- двухдневные походы на расстояние до 12 км. Концентрации криля (*Euphausia superba*), которые в прошлом являлись объектом промысла, встречаются вдоль границы шельфа, где птицы искали корм. Существует возможность частичного совпадения между нагульным ареалом пингвина Адели, размножающегося вдоль побережья Земли Мак-Робертсон (приблизительно 150 000 пар), и будущим промыслом криля в данном районе. Нагульный ареал птиц на о-ве Бешервез намного превышает 15-50 км, установленных для птиц на Южных Шетландских и Южных Оркнейских о-вах, и отражает расстояние от берега местонахождений криля, который является одним из основных компонентов рациона пингвинов.

#### Resumen

Se determinó la zona de alimentación de seis hembras y cuatro machos adelia durante la reproducción en isla Béchervaise cerca de la base Mawson (Territorio de Mac. Robertson) mediante el seguimiento por satélite con el sistema ARGOS. Se siguió el curso de cuatro viajes de alimentación (dos aves hembras y cuatro machos) durante el período de incubación (noviembre y diciembre 1991); y 17 viajes (cuatro hembras y dos machos) realizados durante el mes de enero de 1992, cuando las aves estaban alimentando a sus polluelos. La mayoría de las aves se desplazaron al borde continental (isóbata 1 000 m) el cual queda a unos 110 km de distancia en su punto más cercano. Aquellas aves que estaban alimentando a sus polluelos realizaron viajes de uno a dos días de duración hasta una distancia máxima de 12 km después del 17 de enero, fecha en la cual el mar está libre de hielo hacia la costa. Los cardúmenes de kril, *Euphausia superba*, que en el pasado han sido el objetivo de la pesquería, se encuentran a lo largo del borde continental que es donde las aves se estaban alimentando. Por lo tanto, existe la posibilidad de que se produzca una superposición entre la zona de alimentación de los pingüinos adelia, cuyas colonias se encuentran a lo

largo de la costa del Territorio de Mac. Robertson (alrededor de unas 150 000 parejas), y cualquier recolección de kril que se pudiera realizar en el futuro en la zona. La extensión de la zona de alimentación de las aves de isla Béchervaise excede en gran medida los 15 a 50 km determinados para las aves de los archipiélagos de las Shetland del Sur y Orcadas del Sur y refleja la distancia costa afuera a la que se encuentra el kril, una de sus fuentes de alimento más importante.

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## 1. INTRODUCTION

The foraging range of Adélie penguins is limited during the breeding season by the time they must remain in the colony to brood, guard and feed their chicks and the frequency of feeding visits required. During the incubation period birds make foraging trips of between two and three weeks. Later in January/February both parents are required to forage to feed the chick and each bird must provide food every one to three days. It is during this time that the greatest pressure is placed upon the birds to nourish themselves and their chicks and thus when they are most vulnerable to the impacts of a fishery on their food source.

The probable overlap of the foraging range of 50 to 100 km of Adélie (and chinstrap and gentoo) penguins with the krill fishery in the South Shetland and South Orkney Islands was highlighted by Agnew (1991). He pointed out the theoretical possibility of the existing krill fishery taking an amount of krill up to 50% of that required by these krill predators to successfully raise their chicks.

The krill catch in the Indian Ocean sector of the Southern Ocean (Statistical Area 58) has in the past been significant, with fishing being undertaken by a number of nations, particularly the Soviet Union, Korea and Japan. The Soviet Union was most active in the region during the early 1980s, taking a maximum annual krill catch of 119 381 tonnes in 1982 (CCAMLR, 1992). The location of these catches has not been reported. Fishing by Japan has taken place intermittently and at a lower level since 1973 (Ichii, 1990); Korea has also been fishing for krill since 1982 (Anon., 1982). Reports of these fisheries show that much of their catch occurred in the Prydz Bay region (Division 58.4.2). The Soviet Union has also conducted limited fishing in this subarea since 1988 and it is likely that a large proportion of their earlier catches also took place here.

Although there has been no significant harvest of krill in Division 58.4.2 since 1988 it is likely that further harvests will take place. A CCAMLR Ecosystem Monitoring Program (CEMP) site has been established at Béchervaise Island (67°35'S, 62°48'E), offshore from the coast of Mac. Robertson Land near Mawson Station, in order to monitor krill predators in this subarea. As part of the program the foraging range of Adélie penguins during all stages of the 1991/92 breeding season was determined by satellite tracking. We report here data that show for the first time an overlap occurring in the Prydz Bay region between the foraging range of Adélie penguins and the locations of previous krill fisheries.

## 2. METHODS

The study was commenced in November 1991. Birds in good condition were selected from breeding birds with eggs or chicks and were marked at the nest. They were caught as they departed the breeding colony and a Platform Transmitter Terminal (PTT) attached; they were then sexed by cloacal examination and given an implanted electronic tag (Tiris, Texas Instruments).

The birds were tracked by the ARGOS satellite system using either Telonics ST-6 or Toyocom 2038 PTT set on a 50s repeat transmission cycle. These were packaged together with their batteries in epoxy resin. The packages weighed approximately 160 g and were slightly negatively buoyant in sea water. They were virtually identical to those used in the study by Davis and Miller (1992), both being packaged by Sirtrak in New Zealand. The number of satellite passes capable of detecting the PTTs averaged 22 per day. Few passes occurred between 0900 to 1300 hours solar time.

Each PTT was attached to the bird using a Velcro™ patch and cable ties which were glued to the middle of the bird's back; the corresponding half of the Velcro™ was glued to the PTT. The PTT was then placed on the bird's back and the cable ties tightened over the package. When required the PTT could be removed after cutting the ties. The Velcro™ patch remained on the bird to be moulted off later. This system of attachment allowed the bird some flexing of its back. Birds were logged in and out of their colony by an automated monitoring system (Kerry *et al.*, 1992).

The location of the fast ice was determined from AVHRR images obtained from NOAA 11 and NOAA 12 satellites and relayed to Hobart from the receiver at Casey Station. The ice front was determined for each 0.2° longitude at various dates throughout the summer.

### 3. RESULTS AND DISCUSSION

Ten birds were instrumented utilising seven PTTs. Twenty-one foraging trips were recorded ranging in duration from 1 to 34 days between 25 November 1991 and 1 February 1992 thus covering the period from early laying to early fledging. The periods over which each bird was tracked, the stage of the breeding cycle and the distance and the direction of travel are given in Table 1. The tracks, together with the position of the continental shelf break and the locations of previous krill fisheries, are shown in Figure 1.

During the incubation period the off-duty birds travelled in a northwesterly direction; the two females reached distances of 341 and 243 km and the two males 161 km and 164 km from the colony. All four birds travelled in a generally northwesterly direction until the edge of the fast ice was reached and then two (a male and a female) travelled in westerly direction along the edge of the continental shelf at approximately the same speed (1 km/hr) as the prevailing currents. All four birds appeared to forage at leisure as they travelled away from the colony. Once the birds started to return they did so directly and quickly following along the edge of the fast ice to a point north-northwest from the colony and then walking.

The pattern of foraging changed after hatching (24 December onward). The journeys were less than seven days duration and appeared more purposeful than those made during the incubation period. Birds travelled directly to points between north-northeast and north-northwest from the colony and usually spent less than two days at the northern most point before returning again directly. Journeys were made to the edge of the fast ice, up to 80 km distant, with some reaching the edge of the continental shelf approximately 110 km from the colony. Once the sea-ice had blown out from the coast (17 January) penguins spent time within a few kilometres of the colony before suddenly departing out to the edge of the continental shelf. Others made short journeys of up to 12 km range and then returned briefly to land before making the longer journeys just described.

Numerous research cruises and fishing operations have shown the occurrence of krill *Euphausia superba* in considerable concentrations at the shelf break along the coast of Mac. Robertson Land (Higginbottom *et al.*, 1988; Ichii, 1990). This study suggests that the penguins specifically travel to this region to forage throughout the breeding season. The long distances of up to 135 km travelled to forage even when feeding chicks are thus in marked contrast to the suggested foraging range for Adélie penguins in the Antarctic Peninsula region of 50 km (Trivelpiece *et al.*, 1987) and 15 km (Wilson *et al.*, 1989) although similar to 83 to

119 km determined by Lishman (1985). The shorter foraging range for birds in the Antarctic Peninsula region (Trivelpiece *et al.*, 1987; Wilson *et al.*, 1989) reflect the closer proximity of *E. superba* to shore and hence to the breeding colony. Since all birds in the present study carried an instrument package causing considerable drag in water it is expected that unencumbered penguins would be able to decrease the time necessary for foraging and probably extend the foraging range.

There is a clear overlap, as Figure 1 shows, between the foraging range of penguins from Béchervaise Island and the locations of areas where fishing has been undertaken by Korea (Anon., 1982), Japan (Ichii, 1990) and the Soviet Union (CCAMLR, unpublished data). Breeding colonies of Adélie penguins with an estimated breeding population of 150 000 pairs (Horne, 1983; Woehler *et al.*, 1989) including those on Béchervaise Island are found scattered along the coastline of Mac. Robertson Land between 56°E and 65°E. These birds forage in the same region and their range presumably also extends into the same fishing grounds.

The foraging range of the birds from Béchervaise Island extends only into the southern end of the fishing grounds. This may be due however to the fishing vessels staying to the north of the pack-ice. It would appear at present that the penguins are able to obtain sufficient food without having to extend their range much beyond the continental shelf break. Considerably more overlap could occur in those years where ice conditions allow the fishing fleet to operate further south or in poor krill seasons when the penguins are forced to forage further north.

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Table 1: Details of each foraging trip by Adélie penguins as determined by satellite tracking. The bearing is given in degrees true from Béchervaise Island. Each PTT was used twice as designated by A or B after the PTT number. Where the PTT failed the point of failure is recorded as the furthest distance; in each case the PTT failed on a north bound track.

PTT No.	Sex	Date Departed	Days Away	Latitude	Longitude	Distance (km)	Bearing	Approx. Position of Fast Ice Front	Stage of Breeding Cycle	Notes
1396A	F	25 November 1991	34	S 65.7°	E 56.8°	341	307	S 66.8°	first foraging trip post laying	travelled along continental shelf
8402A	F	26 November 1991	21	65.9°	59.2°	243	319	66.8°	first foraging trip post laying	travelled along and to north of continental shelf
1397A	M	11 December 1991	23	66.2°	62.0°	164	347	67.0°	long foraging trip after first incubation shift	travelled north of continental shelf before PTT failed
1399A	M	18 December 1991	15	66.7°	59.8°	161	307	67.2°	long foraging trip after first incubation shift	travelled along ice edge south of continental shelf
8404A	F	3 January 1992	3	67.0°	63.0°	62	11	67.2°	feeding young chick	travelled to ice edge
		9 January 1992	6	66.5°	62.0°	128	344	67.4°	feeding young chick	travelled to continental shelf
		16 January 1992	5	66.5°	61.5°	135	335	67.5°	feeding young chick	travelled to continental shelf
1398A	M	4 January 1992	1			2		67.2°	feeding young chicks	only 1 to 2 km from colony
		7 January 1992	1			2		67.4°	feeding young chicks	only 1 to 2 km from colony
		11 January 1992	4	66.9°	63.3°	76	15	67.4°	feeding young chicks	travelled to ice edge before PTT failed
1396B	M	19 January 1992	1			5	275	none	feeding growing chick	only 1 to 5 km from colony
		20 January 1992	1			5	263	none	feeding growing chick	only 1 to 5 km from colony
		23 January 1992	1			5	263	none	feeding growing chick	only 1 to 5 km from colony
		26 January 1992	1			4	148	none	feeding growing chick	only 1 to 5 km from colony
		27 January 1992	4	67.2°	62.9°	43	5	none	feeding growing chick	travelling north when PTT failed
8402B	F	18 January 1992	7	66.5°	62.2°	125	348	none	feeding small chick	travelled to continental shelf
1399B	M	17 January 1992	1			3	357	none	feeding small chick	only 1 to 2 km from colony
		19 January 1992	45+	67.5°	62.5°	20	318	none	feeding small chick	travelling northwest when PTT failed
8404B	M	27 January 1992	1	67.5°	62.9°	12	11	none	feeding large chick	short foraging trip
		28 January 1992	3	66.7°	63.8°	114	23	none	feeding large chick	travelled to continental shelf
		1 February 1992	1	67.6°	62.3°	6	286	none	feeding large chick	short foraging trip

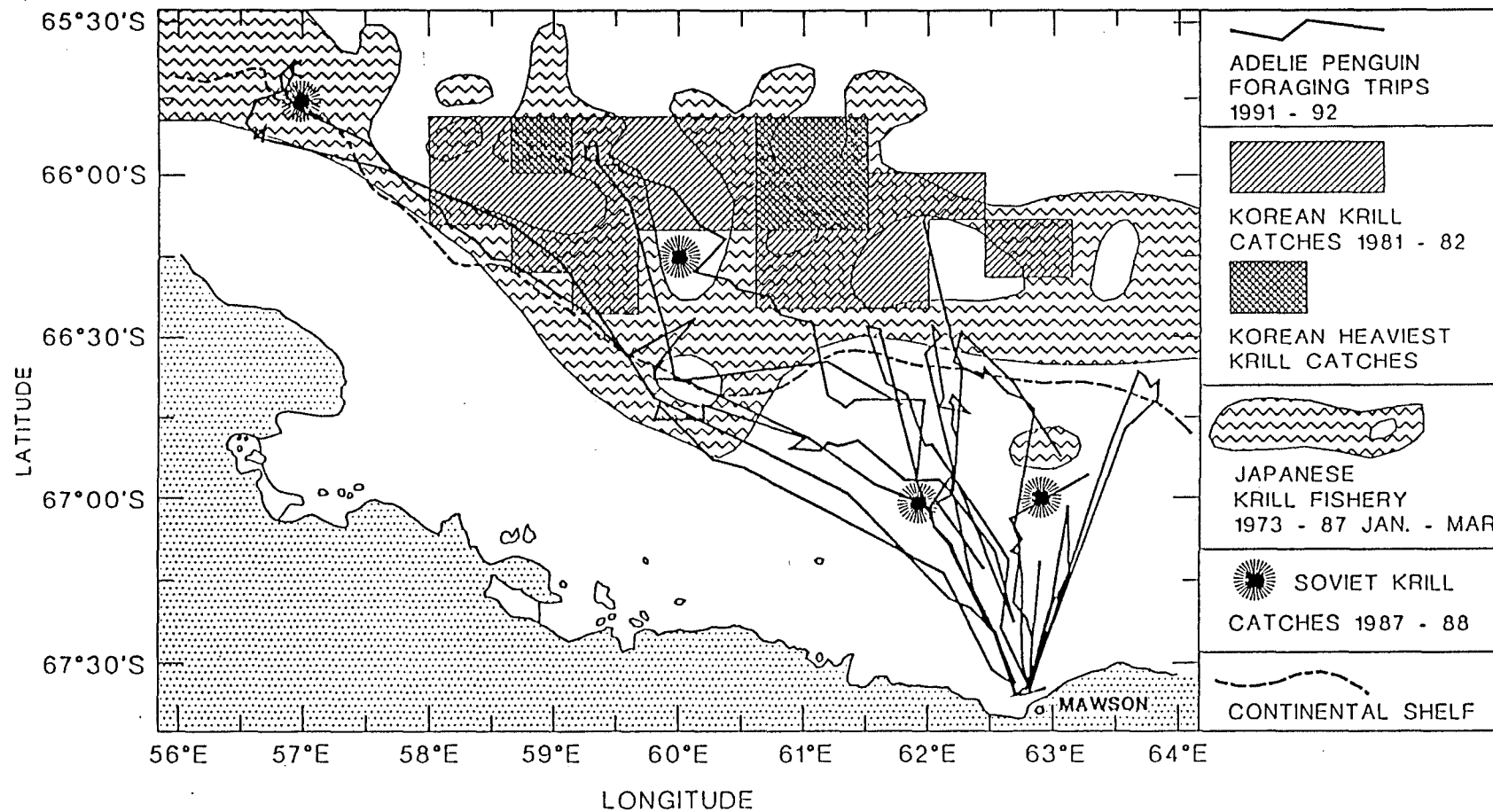


Figure 1: Tracks of all penguins and the position of the continental shelf break (1 000 m isobath). The locations of the Korean and Japanese fisheries and the positions of single commercial hauls made by the USSR in the 1987/88 season, (CCAMLR, unpublished data) are shown.

### Légende des tableaux

- Tableau 1: Détails de chaque sortie alimentaire des manchots Adélie, déterminés par suivi par satellite. L'orientation est donnée en degrés actuels à partir de l'île Béchervaise. Chaque plate-forme de terminal de transmission (PTT) a été utilisée deux fois comme l'indiquent les lettres A et B après le numéro de la PTT. Lorsque la PTT n'a pas fonctionné, le point d'échec est enregistré comme étant l'emplacement le plus distant; chaque fonctionnement défectueux de la PTT s'est produit sur une piste se dirigeant vers le nord.

### Légende des figures

- Figure 1: Pistes de tous les manchots et position de la bordure du plateau continental (isobathe 1 000 m). La position des pêcheries coréenne et japonaise et l'emplacement des traits commerciaux isolés effectués par l'URSS pendant la saison 1987/88 (CCAMLR, données non publiées) sont indiqués.

### Список таблиц

- Таблица 1: Детали каждого похода за пищей пингвинов Адели, определенные с помощью спутникового слежения. Курс дается в истинных градусах от о-ва Бешервез. Каждый передатчик (РТТ) использовался дважды, что обозначено буквами А или В после номера РТТ. В случае прекращения работы РТТ, точка прекращения регистрировалась самая дальняя точка похода за пищей. В каждом случае РТТ переставал работать при продвижении на север.

### Список рисунков

- Рисунок 1: Курсы всех пингвинов и граница континентального шельфа (изобата 1 000 м). Показаны метоположения промыслов Кореи и Японии и позиции отдельных коммерческих тралений, проведенных СССР в течение сезона 1987/88 г. (неопубликованные данные АНТКОМа).

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- Tabla 1: Detalles de cada viaje de alimentación de los pingüinos adelia, según lo indica el rastreo por satélite. La dirección se expresa en grados geográficos desde la isla Béchervaise. Cada transmisor se utilizó dos veces, representado por A ó B, siguiendo al número de PTT. Cuando el PTT falló, la posición del fracaso se registra como la distancia más lejana; en cada ocasión el PTT dejó de funcionar durante la trayectoria norte.

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- Figura 1: Trayectorias de todos los pingüinos y la posición del borde continental (isóbata de 1 000 m). Se muestra la ubicación de las pesquerías japonesa y coreana y las posiciones de lances comerciales individuales realizados por la URSS en la temporada 1987/88 (datos inéditos de la CCRVMA).