Feeding behaviour of Weddell seals
in relation to 3-dimensional diving activities

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Objectives

The Weddell seal, a fish predator, is adapted to exploit coastal shelf waters which are largely covered by fast ice for most of the year. Previous (1998) studies at Drescher Inlet provided detailed information on diurnal variations in the seals' foraging depths. Trawling with RV "Polarstern" confirmed that *Pleuragramma antarcticum* were by far the most abundant fish in the pelagial and near the seabed (Plötz *et al*. 2001). However, directly measuring where feeding actually takes place has remained problematical. We therefore conceived a system of data recorders to obtain new insights into the seals' spatial and temporal variations in diving behaviour and foraging success.

First Results

Presented are the foraging activities of two Weddell seals. Figure 1 illustrates the horizontal components of their (black and red) tracks recorded during two consecutive nights under dim-light conditions of the midnight sun. Both seals often foraged under the ice shelf. Their vertical movements adjacent to the underwater ice cliffs and their foraging below the ice shelf is evident from the striking progression of dive tracks presented in Figures 2 - 5.

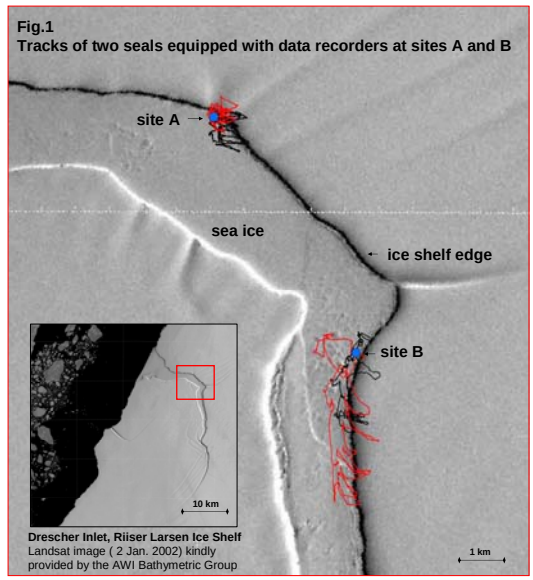
Figures 2 and 3 provide two of many scenarios of diving behaviour and concomitant feeding events. The seal (Fig. 2) primarily foraged at depths around 100 m where hunting was successful. The seal (Fig. 3) foraged within two depth layers, these being from the surface to around 50 m, and near the bottom at 420 m, where feeding events were most abundant. By contrast, the midwater layer from about 150 to 350 m appears to be prey-deficient, as the seals just commuted through this zone to reach the seabed.

Enlargements of single dive tracks show greater distances covered during benthic foraging (Fig. 5) compared to the dive track in the pelagial (Fig. 4), even though higher speeds were recorded during pelagic diving (Figs. 6/9).

Pitch angles (Fig. 7) during the deepest phases of pelagic dives are wider, indicating the body of the hunting seal pointed upwards.

Feeding events mainly occurred during the deepest phases of pelagic and benthic dives shortly after slight rises in swim speed (Figs. 7/8). In benthic dives feeding events tend to consist of more peaks and to last longer. The Area Interest Index (explained below) peaks during minimum horizontal displacement, like steep descents and ascents (Figs. 7/8). During pelagic dives the index shows irregular patterns, whereas during benthic diving constant maximum values appear in conjunction with feeding events indicating the seal's area-intensive and effective foraging near the seabed.

Fig.1
Tracks of two seals equipped with data recorders at sites A and B



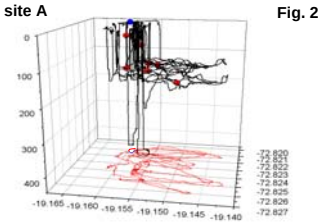
Drescher Inlet, Riiser Larsen Ice Shelf
Landsat image (2 Jan. 2002) kindly provided by the AWI Bathymetric Group

Materials & Methods

The field campaign was conducted at the Drescher Inlet (72°50'S, 19°02'W) from 4 Dec. 2003 to 3 Jan. 2004. Seven non-lactating adult female Weddell seals were equipped with Multi Channel Loggers (MCL) and Inter Mandibular Angle Sensors (IMASEN). The MCL records swim heading by compass, swim speed, dive depth and body orientation (pitch) at 1Hz. The IMASEN records jaw opening angles by a Hall sensor reacting to the field strength of a magnet. Sensor and magnet are glued on the hair-covered parts of the upper and lower jaw, respectively. Sensor data are sent via cable to a logger glued on the seal's head and are typically recorded at 10Hz. Sensor-perceived magnetic field strength was calibrated for jaw angle by photographing the head from the side and then relating angles derived from the photos to the sensor output at that time. The synchronous link between the dive- and jaw-data information was achieved using the program Multi-Trace (Jensen Software Systems, Laboe, Germany).

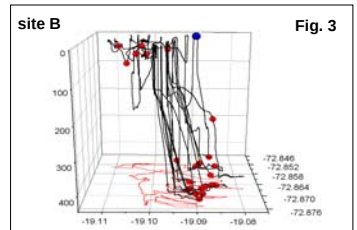
Calibration of IMASEN

site A **Fig. 2**



Dive tracks (black line) of the seal tagged at site A, same tracks projected to the bottom (red line), start/stop of record (blue dot), feeding events (red dots).

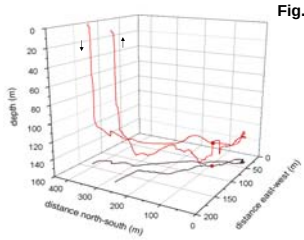
site B **Fig. 3**



Dive tracks (black line) of the seal tagged at site B, same tracks projected to the bottom (red line), start/stop of record (blue dot), feeding events (red dots).

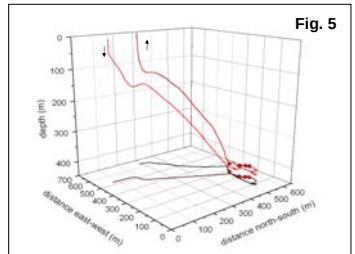
MCL on the back and IMASEN unit on the head of an immobilised Weddell seal

Fig. 4



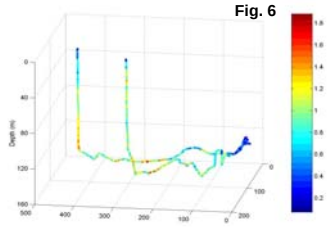
A single pelagic dive track selected from Fig. 2, now with relative positions given in meters, feeding event (red dot).

Fig. 5



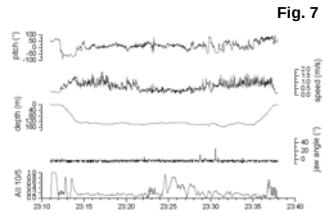
A single benthic dive track selected from Fig. 3, now with relative positions given in meters, feeding events (red dots).

Fig. 6



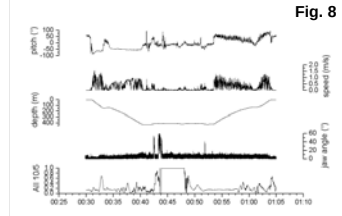
Pelagic dive track from Fig. 4 with speed (m/s) added in colour.

Fig. 7



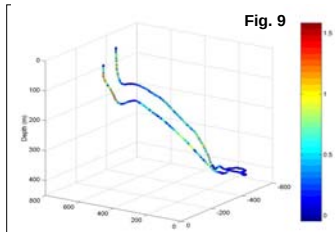
Pitch angle, swim speed, dive depth, jaw-opening-angle and Area Interest Index (AII) over time for the pelagic dive shown in Fig. 4/6.

Fig. 8



Pitch angle, swim speed, dive depth, jaw-opening angle and Area Interest Index (AII) over time for the benthic dive shown in Fig. 5/9.

Fig. 9

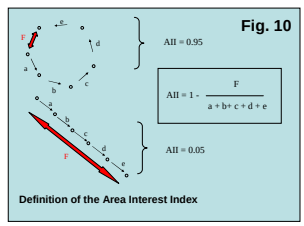


Benthic dive track from Fig. 5 with speed (m/s) added in colour.

Area Interest Index (AII)

The AII (Fig. 10) is a measure of the directionality of the movement. It relates the sum of distances of a certain number of successive positions to the distance between the first and the last position. A high AII indicates convoluted movement, whereas a low AII indicates directional movement. Depending on sampling frequency and numbers of positions used to calculate the AII, it can be adjusted from fine- to large-scale movements.

Fig. 10



Definition of the Area Interest Index

Conclusions

- **The study documents that Weddell seals forage below the ice shelf.**
- **The underside of the ice shelf and the seabed beneath represent food horizons.**
- **Prey distribution in these horizons differs necessitating different hunting strategies.**
- **Trawling conducted during the present study again confirmed that the fish fauna near the Drescher Inlet was predominated by *Pleuragramma antarcticum* (Knust pers. com.). This leads us to conclude that the seals fed primarily on this fish.**

Reference: Plötz J, Bornemann H, Knust R, Schröder A, Bester M (2001) Foraging behaviour of Weddell seals, and its ecological implications. Polar Biol 24:901-909.

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