Marine Mammals as Ocean Explorers

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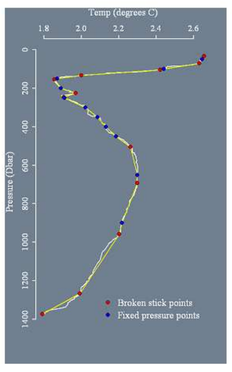
Animal-borne sensors

CTD-Satellite Relay Data Loggers

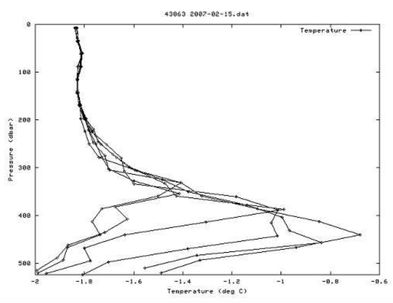
New instrumentation developed by the NERC Sea Mammal Research Unit (SMRU) can provide an important observation technique which compliments more commonly used observational approaches. Unique oceanographic samplers linked to Satellite Relay Data Loggers (SRDLs) are attached to marine mammals. SRDLs can provide temperature only or conductivity, temperature and depth (CTD-SRDLs) profiles from key areas.



Data Collection

When submerged CTD-SRDLs measure depth every 4 seconds. When the seal ascends and the deepest point of the dive is deeper than a predefined value, the CTD-SRDL also samples temperature, salinity and depth every second. This full resolution CTD profile is then compressed before transmitted to the Argos system. A hybrid compression method is used: 7 CTD points selected by 'broken stick' algorithm and 8 CTD points at pre-defined pressures (left).

The figure on the right shows temperature profiles from beneath the Antarctic pack ice. Note the cold surface water close to the freezing point of seawater.



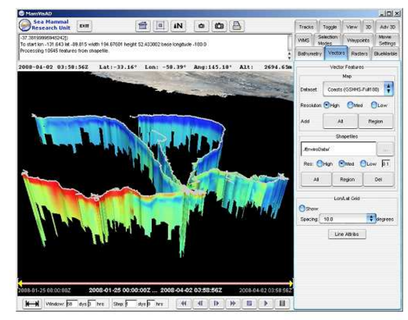
Data Transfer

Every time the seal surfaces, the full resolution CTD profile is compressed, encoded and transmitted to the Argos satellite system. The transmissions are picked up by satellites, which relay the data to ground stations. A position is calculated and all data are stored in the SMRU database. The time lag between the measurements and the availability from the SMRU database is usually less than 24 hours.

Data Accessibility

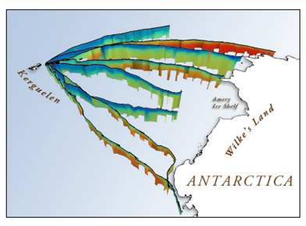
Data stored in the SMRU database can be accessed in four different ways:

1. *Simple internet based access: simple figures allow easy and fast access even with slow internet connections.*
2. *Download of tracks only into Google Earth: quick way to visualize the migration patterns.*



3. *Download of database to be used with SMRUs Marine Mammal Visualisation Software (MamVisAD): to visualize tracks and measurements alongside bathymetry, SSTs and sea-ice fields (see figure).*
4. *Download of Microsoft Access database: this provides researchers with the complete dataset.*

An unequalled dataset!

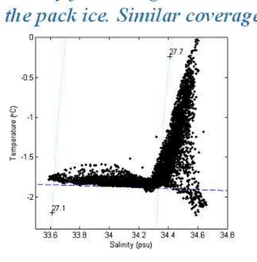


Spatial and Temporal Coverage

The instruments provide between 2 and 5 CTD profiles per day during the deployment. The station spacing ranges from less than 50km during travelling to less than 1km during feeding phases.

Eight southern elephant seals travelled simultaneously from Kerguelen to the Antarctic Continent (left) and operated deep in the pack ice. Similar coverage using ships would be all but impossible.

By choosing the appropriate species, the data collection effort can be directed. The figure on the right shows a temperature vs. salinity diagram of CTD data collected by Weddell seals in the wintertime deep in the pack ice (up to 1500km from the ice edge). The blue line indicates the surface freezing conditions.



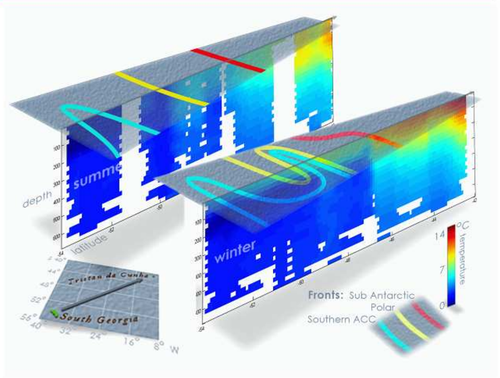
e-Seals in e-Science

During the Southern Elephant Seals as Oceanographic Samplers (SEaOS) project more than 22,000 hydrographic profiles were collected in the Southern Ocean (left), exceeding the number of 'traditional' profiles (ship-based or Argo floats) by a factor of more than two during 2004 and 2005.

Northern Hemisphere

SRDLs measuring temperature only and CTD-SRDLs were deployed on a range of marine mammals. The map on the right shows the locations of SRDLs in the North Atlantic during past deployments.

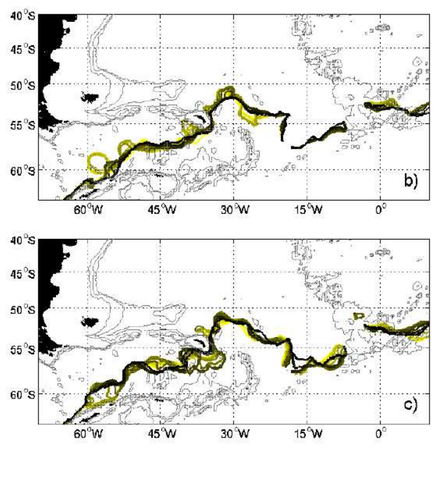
Environmental research



Wintertime Data

Seals can direct sampling effort to particularly interesting and productive regions as they adaptively sample their environment based on previous experience. This also has the added benefit that individuals are likely to retrace previous tracks, and can therefore provide repeat sections.

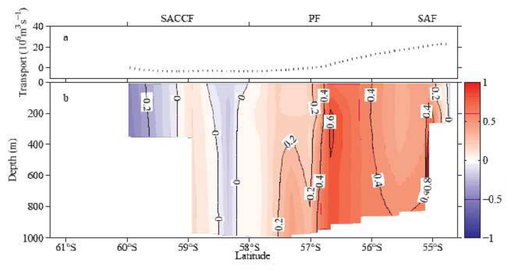
Two temperature sections collected by one animal about 6 months apart are shown in the left figure.



Interannual Variability

Combined with other data sources (e.g. Argo floats), data coverage in space and time is good enough to look at interannual or even interseasonal variability in previously data sparse regions.

The figures on the left show the monthly positions (yellow to black) of the Southern Antarctic Circumpolar Front (SACCF) in 2004 (top) and 2005 (bottom) (Boehme et al., 2008a).



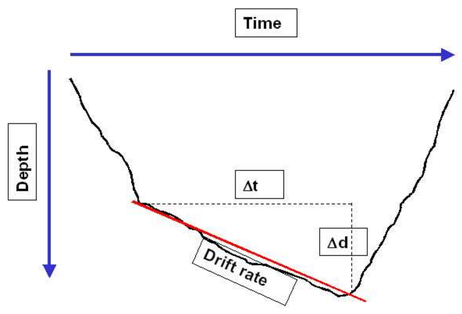
Drake Passage Transports

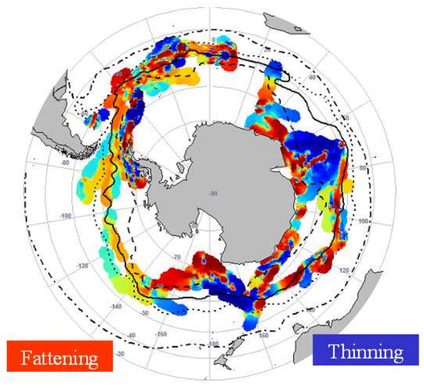
Animal-borne data were combined with altimetry data to calculate absolute geostrophic velocities across Drake Passage (Boehme et al., 2008b).

Interdisciplinary research

Behavioural Data

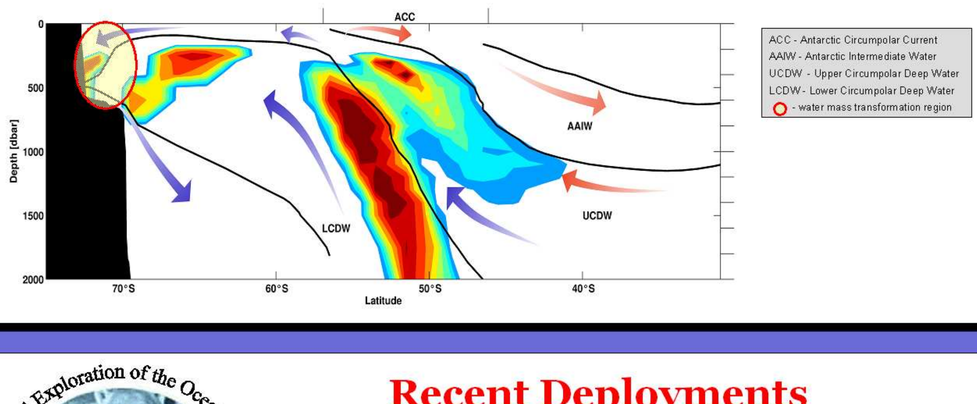
The instruments provide also behavioural data, e.g the shape of the dive. Some dives include a drift phase. The direction and slope (drift rate) are dependent on the animal's body condition (fat content). A change in drift rate is an indirect measure of the animal's condition change over time.





Body Condition

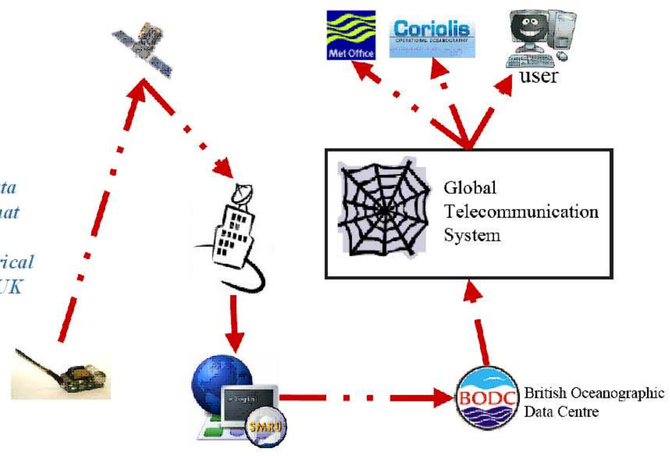
The change in drift rate on a horizontal map (left) shows areas, where southern elephant seals get fatter or thinner. This can highlight areas were seals find food. A generalized section of the Southern Ocean (bottom) highlights areas with a positive change in drift rate (fattening). Coloured contours represent the accumulated number of matches between in situ values obtained from seals, and corresponding values in the schematic hydrographic section (Biuw et al., 2007).

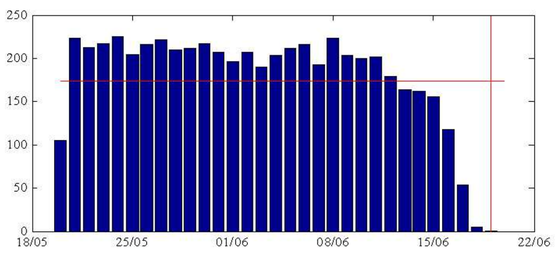


Freely available real-time data

Real-Time Data Stream

New deployments are underway and the oceanographic data received at SMRU are decoded and transferred to the British Oceanographic Data Centre once a day. Data are then converted into an appropriate format and put on the Global Telecommunication System (GTS), i.e. providing data for numerical weather and ocean prediction centres (e.g. UK Met Office).

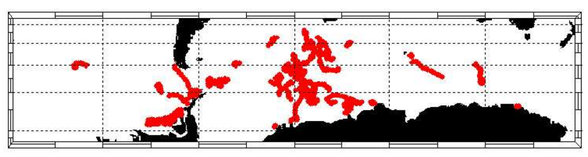


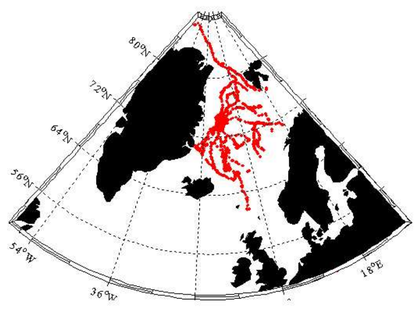


30 Days of Data

The figure on the left shows the numbers of CTD profiles served to the BODC within 30 days (picture generated on 19th June). On average 173 CTD profiles a day are received within MEOP at the moment, excluding some not freely available profiles). These data are forwarded onto the GTS.

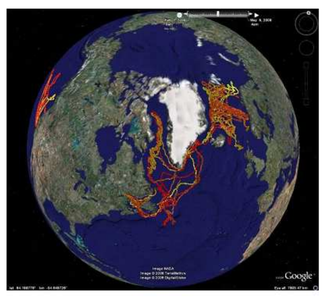
Data coverage in the last 30 days in the Southern Ocean (bottom) and the Arctic (right). These data were served onto the GTS.



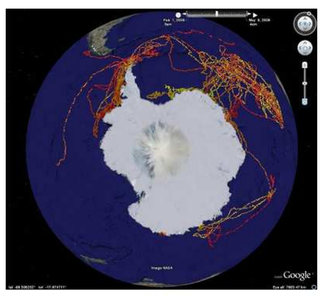


Recent Deployments

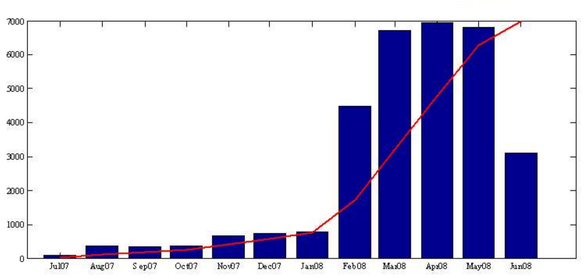
The Marine Mammal Exploration of the Oceans – Pole to Pole (MEOP) project is part of the International Polar Year and started in March 2007. Within this project CTD-SRDLs will be deployed on a range of marine mammals in both hemispheres.

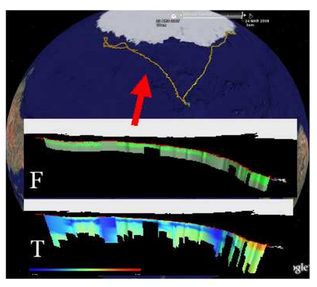


The figures show the locations of CTD-profiles on the southern(right) and northern (left) hemispheres collected so far during the MEOP project. CTD-SRDLs were deployed on Southern elephant seals on the Antarctic Peninsula, South Georgia, Bouvet Island, Marion Island and Kerguelen and on Hooded seals in the Arctic.



More than 31000 CTD profiles were collected from MEOP's start in July 2007 until mid June 2008.





Recent Developments

A prototype CTDF-SRDL is currently deployed in the Southern Ocean south of Kerguelen. A miniature fluorometer is connected to the CTD-SRDL. The CTDF profile is then transmitted as usual.

CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE

UV MINItracka
In-situ Miniature Fluorimeter