Chapter 10

Utilisation of time and space by harbour seals (*Phoca vitulina vitulina*) determined by new remote-sensing methods

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Abstract

Seals in the Wadden Sea are easy to study and count when they are exposed at haulout sites. However, our knowledge of seal activity at sea is limited. Consequently, in spring and autumn of 2002 and 2003, we equipped 19 seals with a logger/PTT-combined system to record at 15-second intervals, swim speed and direction, dive depths, water temperature and water turbidity. After a predefined time, the devices were automatically released to be washed ashore, where they could be located by satellite signal or found by beach walkers. The stored data showed that the seals did not forage in the Wadden Sea, but travelled to specific *hot spots* in the North Sea where they foraged on benthic prey[1], usually for several days, before returning straight back to their sandbank. Animals almost always dived to the seabed during both commuting and foraging. However, the dive profile was more irregular in the Wadden Sea compared to the deeper North Sea where the diving pattern was very regular, particularly with respect to depth and duration. Seals in the Wadden Sea not only rested on land at their haulout spots but also *slept* in the water, sinking down to the seafloor where they lay motionless for around 7 minutes, surfacing only for a short period to breathe before sinking back again. In deeper water (over 10 metres deep), the seals rested for up to 50 minutes at the surface, apparently drifting and showing no diving activity.

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1 Benthic prey: prey living in/on the seafloor.

1 Introduction

Harbour seals (*Phoca vitulina vitulina*), together with harbour porpoises (*Phocaena phocaena*), are the most numerous marine mammals along the coast of the North Sea and they may play an important role as top predators in this ecosystem.

In the 20th century, the seal population dropped continuously due to increasing disturbance, land reclamation, pollution and particularly overexploitation, until 1976 when the hunting of seals in the whole of the Wadden Sea area was prohibited. Supported by various governmental conservation schemes, the population size of harbour seals in that area rose steadily from about 3,800 animals in1976 to approximately 10,000 animals by 1988 (Reijnders et al. 1997). However, due to an epidemic caused by the *Phocine Distemper Virus*, almost 60% of the population died at this time. Subsequently, the surviving animals gained temporary immunity[2] and the population rose again at a yearly rate of 13.3% until 2002 when about 21,000 animals were counted. Since not all animals are hauled out on sandbanks or beaches during aerial surveys, a further 30% has to be added to that number to account for the animals at sea (Schwarz 1997). The total population size at that time was thus estimated to be over 25,000 animals.

In the same year, for unknown reasons, there was another outbreak of the distemper virus in a manner similar to that in 1988. This time the population size was reduced to about 12,000 counted seals in 2003. However, already by 2003 the abundance of harbour seals had begun to rise again. We expect a fast recovery to be made similar to that experienced after 1988.

The seal expert P. Reijnders from the Netherlands analysed historic data and estimated a population size of about 37,000 animals at the beginning of the 19th century (Reijnders 1992). Under present-day conditions, taking into account intense fishery, heavy boat traffic, and other factors such as the influence of tourism, this number is unlikely to be reached again. A further new impact can arise through offshore wind farms producing disturbing noises when they are built on or nearby the feeding grounds of the seals. The impacts of offshore wind farms on seals, harbour porpoises, and birds are under investigation by the research project MINOS, funded by the Federal Ministry for the Environment, Nature

[2] Regular tests of the antibody against the PDV-Virus by the Research and Technology Centre (FTZ) of the University of Kiel (Büsum, Germany) show that the immunity of the seals lasts only 3 to 4 years. (Personal communication by Dr. U. Siebert in 2005, FTZ)

Conservation and Nuclear Safety. Some of the preliminary results of this project are presented in this paper. Given undisturbed development, a population size of around 30,000 animals in the whole Wadden Sea area seems realistic. This could be calculated from the yearly counts, published by the Common Wadden Sea Sekretariat, Wilhelmshaven.

2 Materials and methods

To be able to characterise potential dangers to the seals, such as commercial fishing, pollution, the construction and maintenance of offshore wind farms and tourism, their needs and habitats have to be known better than they are at present. Direct observations of those animals are only possible when they are on land. In the water, where they spend most of their time, researchers depend on telemetric methods to record behavioural information.

For this purpose, different techniques have been developed. VHF- and satellite-telemetry, which are excellent in terrestrial studies, have a major disadvantage in an aquatic surrounding. They only transmit information when the antenna is out of the water. Therefore, only some information could be gained with the use of these technologies in seal studies. In contrast, the satellite-compensated *dead-reckoning system* used here provides continuous recordings of all important activities of the harbour seals over weeks and months, on land and in the water. This system has been developed together with the company Driesen & Kern GmbH in Bad Bramstedt (Germany). It records information from 12 different sensors at between 3- and 20-second intervals. The memory capacity provides enough space for data to be collected over a 2-month period if parameters are sampled at, for example, 20-second intervals.

This *dead-reckoning system* stores the information from the following sensors:

- channels 1–3: compass (3D)
- channel 4: pressure (depth)
- channel 5: pressure (speed)
- channels 6–7: light intensity (2 different wavelengths)
- channels 8–9: temperature (internal/external)
- channel 10: body orientation
- channel 11: pitch
- channel 12: roll.

Figure 1. Harbour seal equipped with telemetry unit

A primary drawback of this method for the seals is that the devices have to be retrieved to access the stored data. The equipped harbour seals cannot be caught a second time to take off the unit, so the devices are incorporated in a pressure-resistant positively buoyant body which releases itself automatically after a prescribed time from a base glued to the animal (figure 1). The device is then washed ashore. The base is made of neoprene and is stuck onto the fur of the animals with a fast-setting epoxy glue. This comes off during the annual moulting of the seals.

To monitor the movement of the equipped seals and to locate the units after their release, an ARGOS satellite tag (PTT) is also part of every unit. Due to the currents in the North Sea, which run parallel to the coast, the likelihood of the floating units being washed ashore somewhere is very high. Once they are washed on land, they can be located or found by beach walkers. The recovery rate over the last 2 years was 68%. After retrieval, the stored data can be downloaded and analysed with special software. After replacing the batteries, the devices can be used again.

3 Results

During the MINOS project (TP6), 19 harbour seals were equipped and, thus far, 13 units have been successfully recovered. The data sets stored in the devices recorded between 2 to 58 days of information about the animals' behaviour. Seventeen of the animals were caught and equipped on a sandbank northwest of the Eiderstedt peninsula, the *Lorenz Plate* (*Lorenzenplate*), in the spring and autumn of 2002/2003. In addition, in December 2003, 2 animals were tagged on the Danish island of Rømø, where one unit has so far been recovered.

We have analysed the diving behaviour of more than 159 days at sea from these 13 animals, and 25 routes from foraging trips made by 6 seals. Despite the relatively small number of equipped animals, the results show a very similar pattern of animal behaviour during these spring and autumn conditions.

Diving behaviour: our harbour seals left the Wadden Sea for foraging trips in the deeper North Sea, although the animals tended to spend more time in the shallow Wadden Sea in spring. They then headed straight for the deeper waters of the open North Sea during autumn and winter.

During these trips, they dived almost continuously down to the seafloor with their dive profiles mirroring the bottom topography along their swimming route (figure 2). A closer look at the dives of harbour seals indicates that it is possible to distinguish between different activities such as swimming and foraging in shallow or deep water and resting periods.

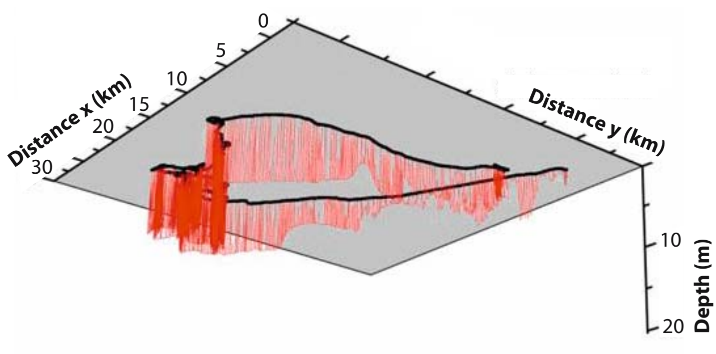


Figure 2. Route and dive profile of an equipped seal. The track to and from the foraging grounds is relatively straight, with the seal spending several days in the same area at sea.

Figure 3. Irregular dive patterns in the Wadden Sea

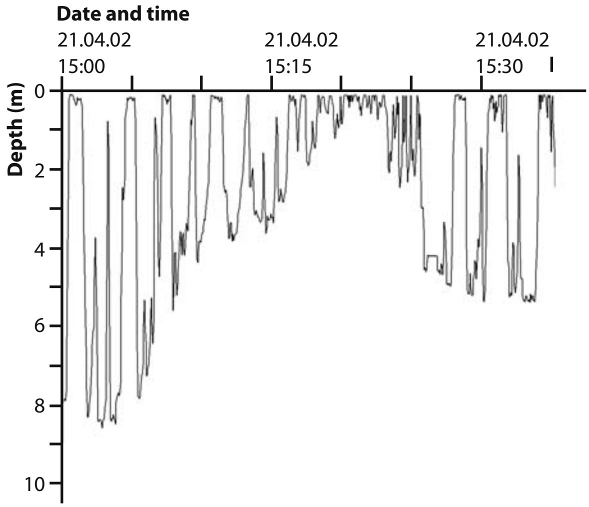
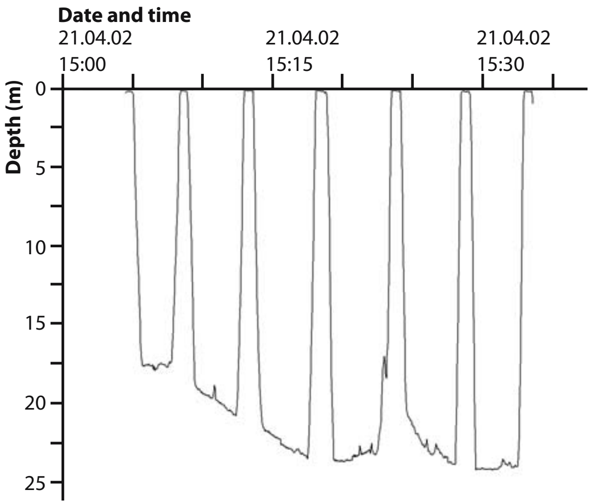


Figure 4. Dive profile at medium water depth



Swimming in the shallow water of the Wadden Sea is characterised by irregular dive patterns, independent of depth and with varying duration (figure 3).

However, foraging dives down to 20 metres, which occur mainly during the transit to deeper water, are very regular and show a clear U-shape, consisting of a vertical descent, a horizontal bottom and a vertical ascent phase. In addition, the dive profile is characterised by descent and ascent phases at a steep angle, while dive duration is around 4 minutes (figure 4).

Foraging dives become even clearer in deeper waters. Their duration is around 5 minutes, with an extended bottom phase and fast descent and ascent phases.

Apart from these 3 U-shaped dive types, other so-called *pelagic* dives occur. These have a V-shape and rarely go down to the seafloor. Animals may be searching for food during these dives.

The data also show resting periods both on land and at sea. On land, only the tilt sensors respond which show that the animals roll from one side to the other every now and then.

Astonishingly, extended resting or sleeping periods could also be found in water. In shallow areas, the seals let themselves sink down to the bottom and remain motionless for around 7 minutes, surfacing only for a short period to breathe before sinking back again.

The animals also rest from time to time while in deep water. These phases can take up to 50 minutes during which they drift to the surface without any diving activity. Such resting seals can easily be spotted from a plane during aerial surveys. Seals, diving normally, spend 79% of the time submerged at sea.

None of the presented activities was apparently influenced by the time of day or by the tides during the study period. Haul events were, however, only possible during low tide. In summer, during lactation and moulting, when no seals have ever been equipped, a higher frequency of hauling out on the sandbanks had been observed during low tide (Schwarz 1997).

Foraging trips: by using the compass, speed, depth and tilt data recorded by the device, the detailed swimming route of an equipped seal can be recalculated. This is done by starting from transmitted positions of the ARGOS-tag – while the seal is on land, before it goes into the water – and by using vectors (so-called *dead-reckoning*) for the period in water, until it comes back on land (indicated by good quality satellite fixes).

From the recorded dive data and the calculated positions, it could be presumed that the animals mainly search for food in deeper water.

One animal, which was equipped in April 2002 at the *Lorenz Plate*, swam almost directly out to the island of Helgoland the very next day. It took the seal about 16 hours to cover the distance of 57 km, while it was continuously descending, swimming along the bottom and ascending again.

Helgoland seems to be not only a permanent site for a larger population of seals in German waters, but also a temporary haulout site for seals from the mainland. In addition to the case cited above, we also detected (via satellite telemetry) another transfer to Helgoland by an adult harbour seal. Two pups equipped with ARGOS-tags upon their release from the Seal

Figure 5. Density distribution of transmitted satellite positions at the coastline of Schleswig-Holstein and the southern part of Jütland (Denmark) (The darker the colour the higher the density)

Figure 6. Density distribution of calculated route positions at the coastline of Schleswig-Holstein and the southern part of Jütland (Denmark) (The darker the colour the higher the density)

Centre in Friedrichskoog where they were raised, might also have swum to Helgoland (due to poor position quality this cannot be guaranteed) after spending considerable time on the west coast of Schleswig-Holstein.

The tagged seals primarily spent most of their time foraging in a relatively distinct area about 30 km west of the *Lorenz Plate*. It is important to mention here that quite different views on the seals' use of an area are obtained depending on whether the density calculations are based on the satellite positions (figure 5) or whether routes are calculated by dead-reckoning (figure 6). For technical reasons, only few reliable satellite data are transmitted while the seals are at sea, whereas during the haulout phases on the sandbank transmissions are not influenced. Therefore, the main seal distribution appears to be limited to that site if only the satellite telemetry data are considered. This is partly due to the positioning of the device on the back of the animal. In contrast, the continuously recorded data of the logger show that the harbour seals spend most of their time actually at sea.

Considering all analysed data, it becomes obvious that the Wadden Sea is of minor interest for hungry seals. They prefer certain *hot spots* in the

North Sea, sometimes spending days foraging out at sea, only interrupted by short resting periods.

Therefore, the seals sighted during the aerial surveys in the North Sea, which are part of the MINOS project dealing with possible effects of offshore wind farms (TP2, see chapter 14), are presumably primarily seals resting on the surface.

In the context of the offshore wind farms, harbour seals have to be given careful consideration because they obviously spend the major part of their lives foraging in the North Sea and not in the Wadden Sea.

4 Perspectives

The relevance of the results mentioned above is limited to spring and autumn. It is now important to find out if the seals' behaviour changes in the summer, during mating and moulting, and during the rest of the winter.

In addition, seal populations such as those on Helgoland and Rømø have to be examined for similar or different behaviours because they are very much influenced by their environment (Lesage et al. 1999, Fedak and Thompson 1993, Tollit et al. 1998). It would be unwise and premature to assume that the behaviour described here for seals from the *Lorenz Plate* typifies that of other populations.

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