Use of the North Sea by Harbour Seal with special emphasis on the Horns Reef area

Test of prototype GPS/GSM-transmitter on harbour seals in the Sealarium, Esbjerg.

Annual Status Report for 2003 to Elsam Engineering A/S

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Summary

A combined GPS-receiver and GSM mobile phone transmitter designed for deployment on wild seals was tested on a captive harbour seal. The unit has been under development in recent years and consists of a GPS-unit for positioning and a GSM mobile phone unit for transmission of logged positions to land.

The test took place in the Sealarium at the Fisheries and Maritime Museum, Esbjerg. The unit was glued onto the fur on the head of the seal, where it stayed on for 13 days. Only one position was acquired by the unit and it failed to connect to the GSM-net during the test. Technical information from the constructor of the unit is not available and it is thus not possible to conclude on the reasons why the unit did not function as intended. The behaviour of the seal can however, be ruled out, as close observation and registration of the seals dive behaviour during the first days of deployment showed that the unit was free of the water for sufficiently long periods for positions to be acquired.

Resumé

En kombineret GPS-modtager og GSM-sender beregnet til påsætning og sporing af vilde sæler blev afprøvet på en sæl i fangenskab. Enheden er udviklet gennem de senere år og består at en GPS-enhed til positionsbestemmelse og en GSM-mobiltelefonenhed til transmission af data til land.

Testen foregik i Sælariet ved Fiskeri- og Søfartsmuseet, Esbjerg. Enheden blev limet på hovedet af en sæl og sad på i 13 dage. Enheden opnåede kun at logge en position og fik aldrig forbindelse med mobilnettet i løbet af testen. Da teknisk information ang. forløbet af testen endnu ikke er tilgængeligt fra konstruktøren kan det ikke konkluderes hvorfor enheden ikke virkede som den skulle. Det kan dog udelukkes at det skyldes sælens adfærd. Denne blev fulgt tæt og dykkeadfærden registreret i de første dage af testen og disse data viser at enheden var fri af vandet tilstrækkeligt længe og tilstrækkeligt mange gange til at adskillige positioner burde være logget.

1 Introduction and background

In 2002, ten harbour seals from the Danish Wadden Sea island Rømø were equipped with satellite transmitters and followed over the first half of 2002. This was done as part of the environmental monitoring programs connected to Horns Reef wind farm. This wind farm was constructed in the summer 2002 and forms together with Nysted wind farm, Lolland, a national demonstration project aimed at assessing and developing the possibilities in offshore wind energy.

In the previous study an ARGOS transmitter (Wildlife computers SDR-T16) was used. The original plan for activities in 2003, as agreed by the Environmental Group (Miljøgruppen), included that additional 10 seals from Rømø should be equipped with ARGOS transmitters. These transmitters would be deployed in the fall and be active for the rest of the year, thus providing information on harbour seal activity in the area, in a period of the year that was not covered in the taggings in 2002.

The accuracy of ARGOS positions is not very high however, due to technical limitations in the satellite system, in the range from few hundred meters to several kilometres. This fact, combined with the lower than expected usage of the Horns Reef area makes it difficult to state strong conclusions on the seals use of the wind farm area. As a new type of telemetry-transmitter was under development by SEAS (now Energy E2) and National Environmental Research Institute (NERI), Roskilde as part of the environmental monitoring program at Nysted Offshore wind farm, it was recommended by the international expert panel (IAPEME) that this option should be considered also for Horns Reef. This new transmitter relies on GPS-positioning technology and has a much higher accuracy in positioning of the tagged animal.

The new unit was still under development at the time the decision to change transmitter was made. It was thus decided in early spring 2003 by the Environmental Group, that a test was to be conducted before production of four transmitters intended for deployment on wild seals in the Wadden Sea and at Nysted (two at each location). The test was to be carried out under controlled conditions on a seal in captivity at the Sealarium, Fisheries and Maritime Museum Esbjerg. Final decision regarding production and deployment of the transmitters and actions would then be made after evaluation of the test. According to the revised plan, the unit to be tested in the Sealarium would be delivered in late spring, allowing the test to be completed before moulting of the seals in July. This would allow for production of four units during summer and deployment in early fall 2003.

This report describes conduction of the test and evaluation of the behaviour of the tagged seal relevant for the test. Evaluation of the technical performance of the transmitter was left to the developer (LogicIO). The technical evaluation is not included in this report, as we did not have access to neither their data nor technical report.

Finally, we consider the future of the project and how the intentions of the demonstration project with respect to monitoring of effects on harbour seals can be fulfilled.

2 Methods

2.1 Transmitter

A combined GPS-receiver/GSM-transmitter was developed by LogicIO, Horsens, Denmark, in Cupertino with NERI/Arctic Environment and SEAS (now Energy E2). The current version was designed with input from Elsam Engineering and the Fisheries and Maritime Museum.

The unit consists of a GPS-receiver for positioning of the tagged animal, memory for storage of positions and a GSM-cell phone for transmission of stored information. In addition the unit has a saltwater switch and microprocessor, which controls the activation of GPS and GSM-subunits. Communication with the unit occurs either through the GSM-connection or by means of two magnetic switches. The unit is cast in hard epoxy resin with saltwater switch and GSM-antenna connected to the outside. See *Figure 1*.

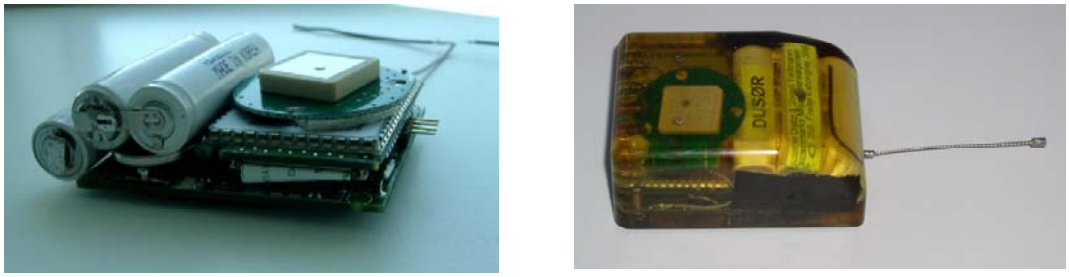

Figure 1 **GPS/GSM-transmitter (prototype) before and after encapsulation in epoxy resin. Length of transmitter (excl. antenna) 60 mm. Left photo: LogicIO.**

The unit was configured to attempt obtaining a GPS-position once every hour, whenever the saltwater switch was dry. The GPS-subunit was thus shut off most of the time in order to maximise battery life, and only turned on for 5 minutes once every hour. If the unit attempted to obtain a position more than 2 hours after the preceding position was obtained, the time required for positioning is estimated to be 38 seconds. During this time, the unit must be out of the water continuously.

If the transmitter was dry for 1 minute or more uninterrupted, it was assumed that the seal hauled out on land and the GSM-subunit would attempt to contact the GSM-net and transmit positions in the memory as SMS-messages.

The prototype tested was delivered from LogicIO in September 2003, to MacArtney A/S, Esbjerg, where the unit was encapsulated. The unit was delivered to the Fisheries and Maritime Museum ultimo September 2003, for final testing on a captive seal.

2.2 Tagging

The unit was mounted on a harbour seal in the Sealarium on October 1st, 2003. It was mounted by means of Velcro-strips glued to the fur of the seal and the base of the transmitter, to allow the transmitter to be taken off after the test was completed (see *Figure 2*). Mounting was done with a combination of a fast hardening 2-component glue (Sika-Fast) and epoxy (Araldit Rapid). However, the glue did not stick well and the transmitter fell off after only 45 minutes.

Following this, the transmitter was mounted on another harbour seal, this time glued directly onto the fur with fast epoxy (see *Figure 3*). This was done on October 7th, 2003.

2.3 Observation

Dive and haul out behaviour of the tagged seal was observed during the following two days after tagging. This was done in order to allow subsequent correlation of behaviour with information stored in the memory of the transmitter. Behaviour was recorded on video and the state of the animal was recorded continuously by means of a Psion Workabout computer. Behaviour was separated into three classes: submerged, at surface and hauled out. Observations and video recording was done by Susi Edrén, NERI.

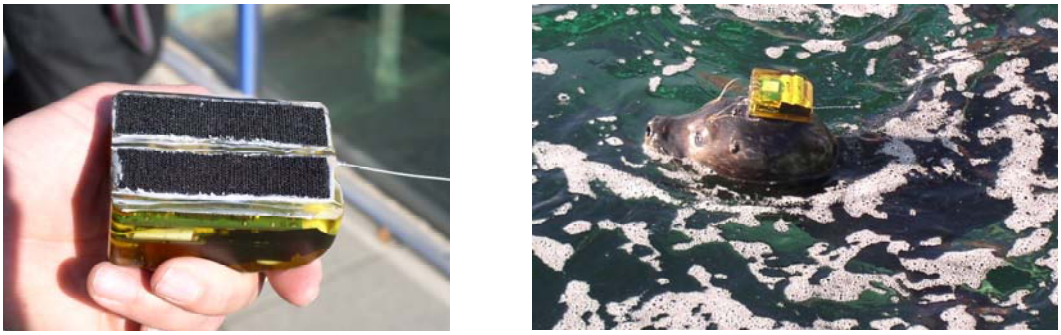

Figure 2 **Transmitter mounted on top of the head of a harbour seal by means of Velcro-strips glued onto base of transmitter.**

Figure 3 **Transmitter glued directly onto the fur of a seal.**

2.4 Termination of test

Few days into the test it became clear that the transmitter was not functioning properly as no SMS-messages were received from the GSM-subunit. Two attempts (on October 15th and 20th) were made at forcing the transmitter into "diagnostic mode", by catching the seal and activating two magnetic switches on the unit. In diagnostic mode it is possible to establish contact with the unit through the GSM-net, thereby gaining access to memory etc. As none of the two attempts resulted in establishing contact, the test was terminated. The seal was euthanised (planned in advance and for reasons unrelated to this project), the transmitter removed and handed over to LogicIO for inspection and fault finding.

3 Results and discussion

3.1 Observations

The behaviour of the seal was monitored mainly in the time around the time when the GPS was expected to turn on (5 minutes every hour). This gave a total observation time of 12 hours, 46 minutes, distributed over 2 days. Results are summarised in *Figure 4* and Table 1

Table 1 Summary of observations during 2 days of observation of the tagged animal.

Total time submerged	9:13 h		Dives	Surface
Total time in surface	2:56 h	n	656	651
Total time hauled out	0:36 h	n > 38 s	-	97
Observation time	12:46 h	Mean duration	50.6 s	16.3 s
Sum of surface periods > 38 s	1:25 h	25% percentile	2 s	3 s
Surface periods >38 s relative to total surface time	48.1%	50% percentile	11.5 s	8 s
Surface periods >38 s relative to total time in water	11.7%	75% percentile	88 s	23 s
Surface periods >38 s relative to total observation time	15.8%	90% percentile	165.5 s	45 s

3.2 Function of transmitter

During the 13 hours the seal was under observation, it hauled out five times, in total 36 minutes. These five events occurred within a short period, all right after one another.

There was large variation in duration of periods at the surface and periods submerged. Short intervals prevailed (median duration 11.5 s, and 8 s for dives and surface times, respectively). *Figure 4* shows the cumulated distributions.

3.2.1 GSM-unit

The GSM-unit neither transmitted messages on its own, as anticipated, nor responded to incoming calls when in diagnostic mode. Preliminary reports from LogicIO immediately after the termination of the test indicated a problem with the external antenna (an impedance mismatch), perhaps linked to unforeseen problems in the casting process. Subsequent correspondence from LogicIO to Elsam Engineering confirms this indication. Further conclusions await a final technical report from LogicIO.

3.2.2 GPS-unit

During the 13 days the transmitter was mounted on the seal and was active, only a single GPS position was logged in the memory (according to information from LogicIO). Seen in relation to the specifications wanted from the unit (several positions every day), this was clearly not satisfactory.

The view to the sky from the tank where the seals are kept was somewhat restricted by concrete edges etc, but this is not considered to impede the reception of GPS-signals to any large degree. This was tested with a standard hand-held GPS receiver, which had no problems acquiring positions at the water surface, even inside the corners of the pool.

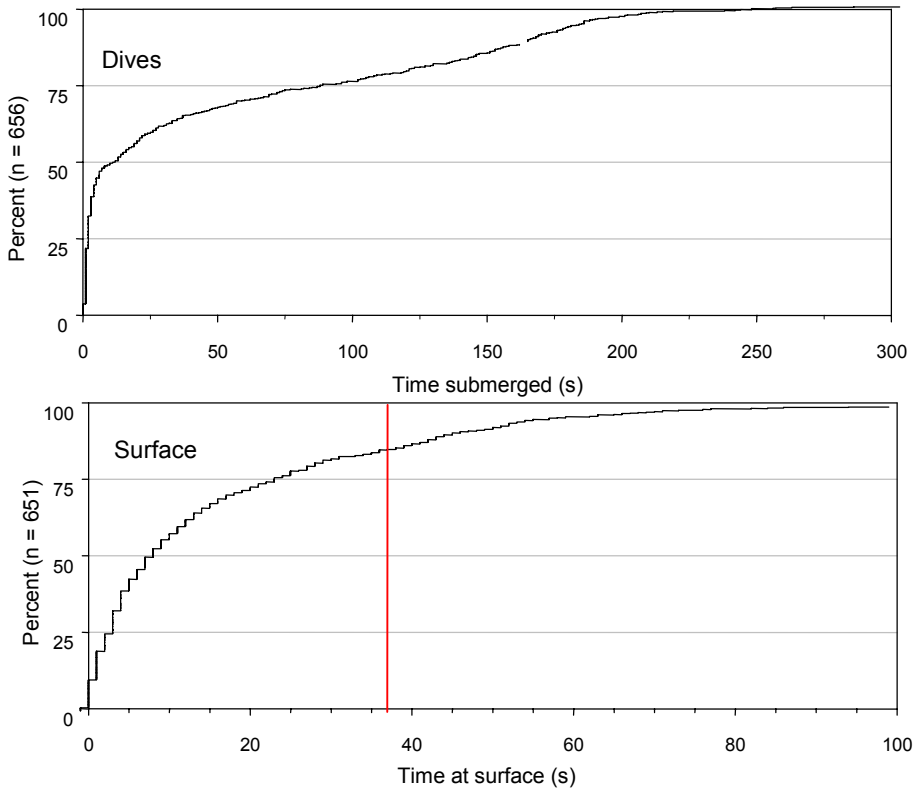

Figure 4 **Cumulated dive- and surface times. Vertical red line marks the 38 second limit of the GPS-unit.**

During the 13 hours the seal was under observation, the transmitter was dry for 38 consecutive seconds or more on 97 occasions (plus four haul out events > 38 seconds). This corresponds to 7.6 usable periods per hour on average, which should be sufficient to guarantee several positions per day. If we assume the 97 periods were randomly distributed in time we can, based on a Poisson distribution, calculate the probability that at least one usable interval falls into the 5-minute period each hour the GPS is on. This probability is roughly 0.5, which means that under these fairly crude assumptions, about half the times the GPS-receiver was on, it should have been clear of the water for sufficiently long time to obtain a position.

If we instead assume that the GPS-receiver needs 60 seconds to acquire a position, the number of usable periods is reduced to 2 every hour on average. Under the same assumptions as before, this translates into a probability of 0.15 for acquiring a position in each 5-minute period, or on average little more than 3 positions per day on average.

Even if the crude assumptions underlying these calculations are not completely fulfilled, the calculations nevertheless clearly shows that we should have expected to receive significantly more positions than the single one received in 13 days, had the unit worked according to specifications. As for the GSM-unit, final conclusions regarding cause of the poor performance awaits technical reports from LogicIO.

3.3 The future of the seal telemetry project

The test of the prototype GPS/GSM-unit clearly demonstrates at least two serious problems with the unit. The impedance mismatch problem with the GSM-unit is likely to be of technical nature and thus likely to have a technical solution. For the project as a whole, the problem with the GPS-unit is more critical. It is central for the evaluation of the unit to understand why only a single position was acquired in 13 days. Is this simply a malfunction of the GPS-unit, and thus something, which can be expected to be solved, or is the problem of a more fundamental nature, linked to the receiving conditions of the unit on to of the head of a seal? If the latter is the case, this problem must be thoroughly understood before it makes sense to continue development of this particular unit. As described below however, there are other, very promising new developments underway from other groups working with telemetry.

3.3.1 Alternatives

There are at present at least three alternatives to the GPS/GSM-unit, which are relevant for the project.

ARGOS

Using a standard Argos transmitter, either Spot-3 or the same unit as used in the first study, SDR-T16 form Wildlife Computers will provide data directly comparable to the previous collected data, but with the same weakness of the low accuracy in positions. Even with the low resolution in positioning, a doubling of the number of tagged animals (in relation to the ten already tagged) will provide additional power to conclusions, which can be reached regarding use of the Horns Reef area. If a SPOT-3 transmitter is used, a significantly higher number of positions can be expected compared to the previous deployments, due to a different design of the transmitter. This will also increase the power of conclusions. A significant advantage of the ARGOS transmitters is that it is a well-tested and thus reliable technology, which will give maximal chances for recovering useful data.

FTZ-unit

The Forschung und Technologie Zentrum (FTZ), Kiel University, Büsum use a transmitter type based on the Argos system, but supplemented with a datalogger, that integrates course and speed and thus allows for very accurate calculation of positions. The tag archives information in memory only and must be recovered once released from the animal. This unit was mentioned specifically as a promising option by the IAPEME panel in their evaluation of the 2003-program on the meeting between IAPEME, the Environmental Group and consultants in September 2003. In accordance with this recommendation, a collaboration between the Fisheries and Maritime Museum and FTZ on tagging of harbour seals in the Wadden Sea has been established.

Wildtrack FastLoc GPS

On the Marine Mammal Society conference in Greensboro, North Caroline, December 2003 a prototype of a GPS-receiver was demonstrated. This new type of receiver can acquire information for calculation of an accurate position in milliseconds, which makes it ideal for diving animals. This novel design takes advantage of the realisation that the receiving unit does not need to know the position itself, only acquire sufficient information for the position to be calculated

subsequently, exploiting additional almanac information not available to the unit. The very fast response of the unit is also energy conserving, which will greatly increase battery life. Units ready for deployment on marine mammals are not commercially available yet, but it is expected that they will be during 2004.

With the possibilities outlined above, the conditions for continuation of the project are thus good. With a proper choice of technical solutions, it is a realistic goal that improved conclusions on the impact of the Horns Reef wind farm on harbour seals can be obtained, fulfilling the recommendations given by the IAPEME panel.

Acknowledgements

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