Agenda Item 5.1.1

Implementation of the ASCOBANS Triennial Work Plan (2007-2009)

ASCOBANS Baltic Recovery Plan (Jastarnia Plan)

Implementation

**Document 53**

# Pilot study of Electronic Monitoring (EM) system for fisheries control on smaller vessels

**Action Requested**

- Take note of the information submitted
- Comment

Submitted by

Sweden

***NOTE:***
**IN THE INTERESTS OF ECONOMY, DELEGATES ARE KINDLY REMINDED TO BRING THEIR OWN COPIES OF DOCUMENTS TO THE MEETING**

# Pilot study of Electronic Monitoring (EM) system for fisheries control on smaller vessels.

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## Summary

The cetacean by-catch programme set up in response to EU council regulation no. 812/2004 requires the monitoring of fisheries by-catches by independent observers. The purpose of this pilot study was to see if remote Electronic Monitoring (EM) using onboard cameras could meet the requirement more effectively than maintaining fisheries personnel onboard the fishing vessels. The regulations only require monitoring of vessels over 15m length, for both practical and economic reasons, but they encourage member states to carry out pilot studies on smaller vessels as well. This is exactly what the Swedish Board of Fisheries has now done, with trials involving two gillnetters in the central Baltic Sea during the summer of 2008.

EM is well established in Canada, so two complete systems with 3 cameras for each boat were hired from the Canadian company Archipelago Marine Research Ltd. The way the system works is that sensors detect when the vessels leave port and when the nets are being hauled, and a computer controls when the cameras start and stop filming, depending on the previously chosen programme settings. Both video and sensor data recordings, including GPS coordinates, are stored on a removable hard drive, which can hold many weeks' worth of data and can be removed later in order to check for by-catches. The time needed for analysing the recordings on dry land was somewhat less than the actual time spent hauling nets, and considerably less than an at-sea observer would have had to spend on board. The system was tested for 4 months, including 71 days of fishing operations, and proved to be reliable, with only a few days of data lost due to technical problems. The same set-up lends itself to recording bycatches of seabirds and seals; to the documenting of seal-induced damage to catches; and even to monitoring by-catches of non-target fish species.

During the study, no porpoises were by-caught, one seal was reported as by-caught but falling out of the net before it could be filmed and 19 seabirds were by-caught. Results from the monitoring system correlated very closely with the control data obtained from fishermen's log books.

The study was carried out in active co-operation with commercial fishermen A rough projection based on this pilot study suggests that the cost of implementing a full scale EM monitoring programme should approach as little as one third of the cost of maintaining an onboard observer programme, and possibly even less. With this in mind we conclude that the EM system should be an effective and relatively cheap way of monitoring by-catches.

## The EM system: description

The EM system (Fig.1) consists basically of from one to four analogue video cameras with variable recording quality, linked to a Windows computer (Control Box) with a flexible data storage facility (Data Storage). This comprises both a swappable inbuilt hard drive and the facility to attach an external hard drive via a USB port. There is also a sensor fitted to the

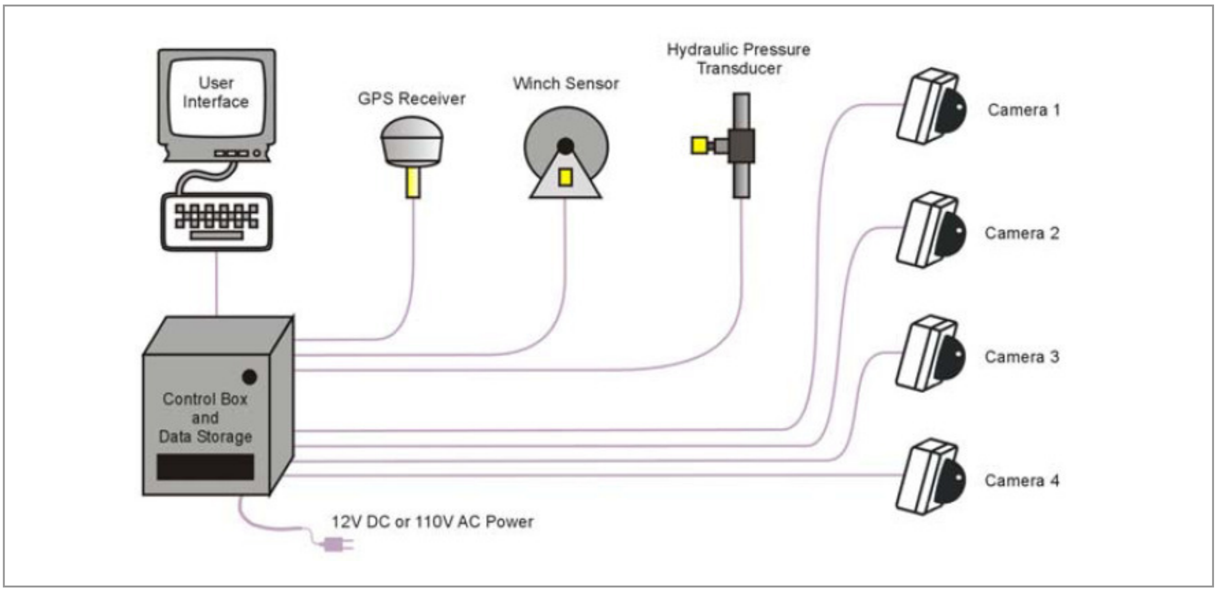


Fig 1. Schematic diagram of the EM system and its components.

hauler which reads the hydraulic pressure, a motion sensor (photocell) on the winch/hauler drum and a GPS receiver. The latter records the vessel's movements while the sensors on the fishing gear indicate the progress of any fishing activity. All these inputs enable the triggering of recording at the appropriate times according to the settings chosen. A keyboard and screen are also linked to the computer to enable control and management of the hardware and software.

The system runs off the vessel's electricity supply and records video and ancillary data for each fishing trip. Sensor data is continually recorded whenever the vessel's engine is running: at ten second intervals, the date, time, position, speed and course as well as any signals from the pressure and movement sensors are saved in special text files. The video cameras can also be set to record continuously, but more typically the aim is to record only when there is fishing activity going on. This is achieved by pre-setting suitable parameters for the sensor readings, which then trigger the cameras appropriately, for example when the nets are being hauled. The data is stored on high capacity hard disks which can suffice for anything from several weeks to several months usage, depending on the size of the disks chosen, how much fishing activity takes place, how long before and after hauling the system is set to record, the number of cameras used and the number of frames per second recorded. In the event of an interruption to the power supply while the system is in operation, whether accidental or deliberate, it starts up again automatically when the power is restored and returns to its functions as programmed. Any interruption in the data flow from the sensors will be visible in the read-out from the system when the data is analysed.

## Overview

The fishing boats used for the study (Plate 1) were mainly engaged in the turbot (*Psetta maximus*) and flounder (*Platichthys flesus*) fisheries, with some cod (*Gadus morhua*) also targeted. On each boat, three cameras were mounted, recording video from different angles (Plate 2) in order to cover all the relevant fishing operations. The systems were installed and put into use at the end of May and beginning of June 2008 and data collection continued until the beginning of October, i.e. for four months. Both vessels' skippers also kept a detailed fishing journal for the duration of the project, with records of fishing activities, catches and by-catches, seal and bird damage and disturbance etc according to the protocols already in use by the Institute of Coastal Research in its Voluntary Logbook Scheme.


Plate 1. The two Gotland fishing boats "Boat 1" (left), 10.6m, and "Boat 2"(right), 11.6m, on which the EM systems were installed.

During the course of the study, Archipelago Marine Research Ltd processed the raw data from the sensors and supplied results in the form of Excel spreadsheets, graphs and maps. One member of staff at the Swedish Board of Fisheries was employed full-time on data collection, analysis and evaluation of the project data. Another member of staff acted as control for the study by independently analysing a sample of the material.

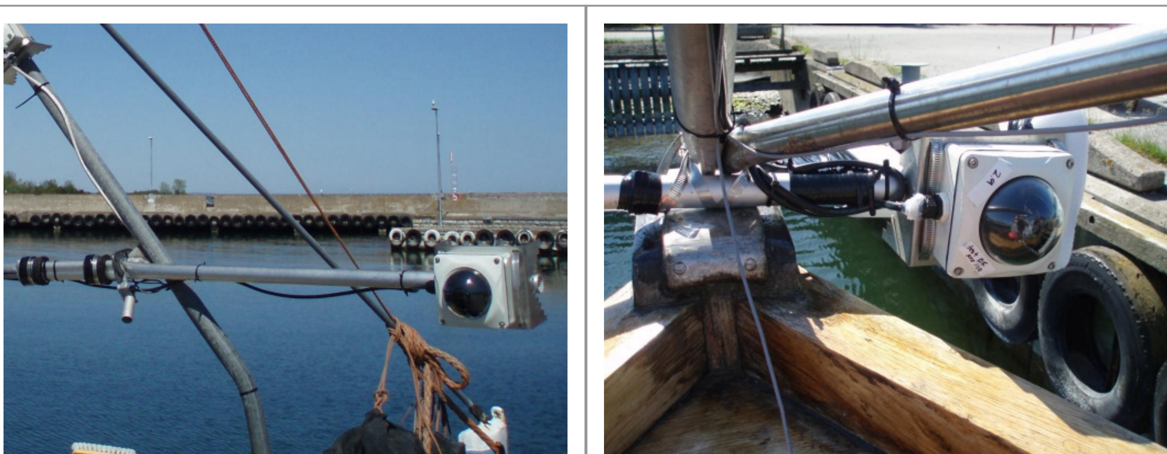

Plate 2. Temporary constructions for mounting 'outrigger' cameras in order to document any by-catches which might fall out of the nets before arriving at the hauler; on 'Boat 2' (left) and 'Boat 1' (right).

## Operation and security

The EM system automatically collects sensor data whenever the power supply is on, which effectively means whenever the boat's engine is running. Video recording on the other hand is triggered by the settings pre-programmed into the computer. The system can be set to record constantly, whenever the vessel is moving, whenever the hauler is in use, only in certain geographic areas and so on, and time margins can be added to the recording phases to cover the completion of fishing operations.

The EM system is designed to function without any involvement on the part of the fishermen. The computer is password protected, and the casing is padlocked, so once the data is recorded it should be proof against tampering. However, the system is not impossible to interfere with, in that the power can be cut off at any time. In this case it will not operate at all until the power is restored. Any interruption in operation during a trip will nevertheless show up in the recorded data and lead to subsequent investigation, so the only way of cheating the system would be to disconnect the power before leaving port. In this case the logbook data would also have to be falsified in order to conceal the whole fishing trip.

If any video sequences should appear to be missing, whether interrupted during recording or totally missing compared with log book data, the problem can be investigated and measures taken to correct it. Possible causes might include inappropriate recording settings, accidental damage or the fisherman in some way interfering with the system, but the most likely problem is some sort of power outage.

The data can be downloaded from the system either by swapping hard disks or by transferring it to a portable external hard drive (Plate 3). The optimal interval for collecting the data can depend of course on how quickly the hard disk fills up but also on how often one wants to inspect and adjust the system in general. On the vessel in our study which fished the most days, it would have been enough to collect the data every other month, but it would also have been possible to use hard disks of at least twice the capacity and so extend the operational period to four months, assuming the same fishing effort throughout that period. Intervals between data collection should be set after taking into consideration the risks of errors going undetected for long periods as well as the economic and practical aspects. There is also a function whereby the fishermen can check how much hard disk space is left and notify the Fisheries Board that the data needs to be collected soon, assuming there exists the desired level of co-operation.


Plate 3. The EM box, with the cover removed and a portable external hard drive attached for downloading of data.

## Data analysis

***Analysis of data from the sensors***

The text files with sensor data provide a detailed record of the start and finish times of the fishing trip, the vessel's speed and heading and the operation of the hauler. This, together with the video recordings and log book records give a detailed history of the fishing trip. The text files can also be used to generate graphic visualisations for interpreting the vessel’s activities. An example of this is shown in Figure 2 (Fig 2)

As part of the study, the fishermen were also asked to participate in the Voluntary Log-Book scheme which the Fisheries Board has built up in recent years in order to document catch damage and by-catches involving either seals or seabirds. The fishermen are compensated for keeping this detailed log-book. The purpose of including this in the study was to check both whether all by-catches and damaged catches reported by the fishermen were also recorded by the monitoring system, and whether the fishermen remembered to note all such events that were recorded by the system.

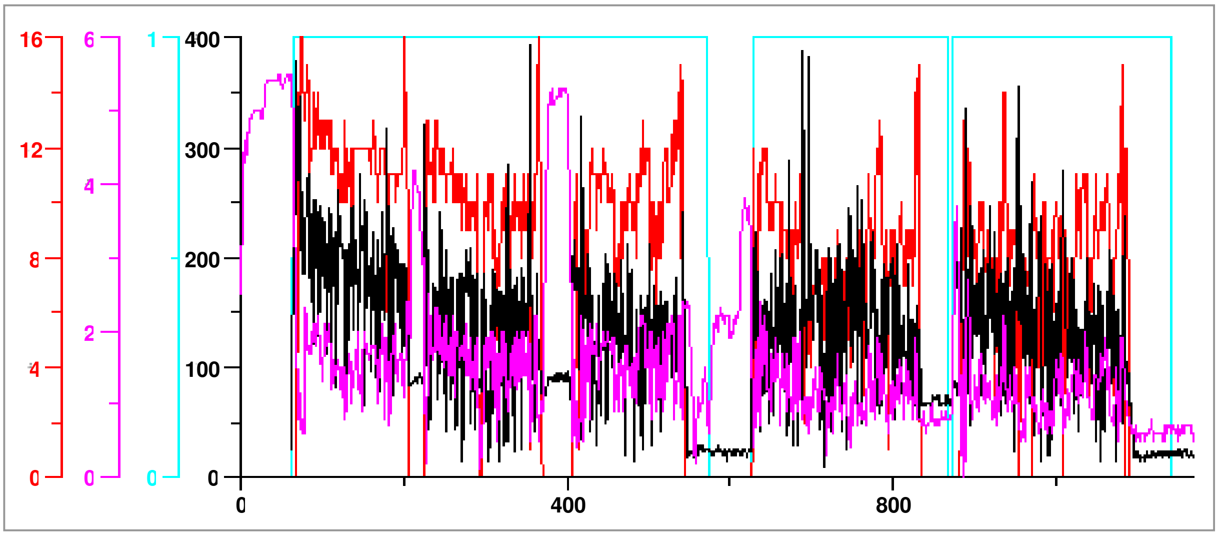


Fig 2. Fishing activities in graph form, showing five net haulings in one trip. On the y-axis, red represents the hauler drum rotations per 10 seconds, pink shows the vessel's speed in knots, light blue indicates when video data is recorded (=1) and black gives the hydraulic pressure in the hauler system (bar). The x-axis is time in 10 second units. In this sample, recording was programmed to start when the hydraulic pressure reached a certain threshold value.

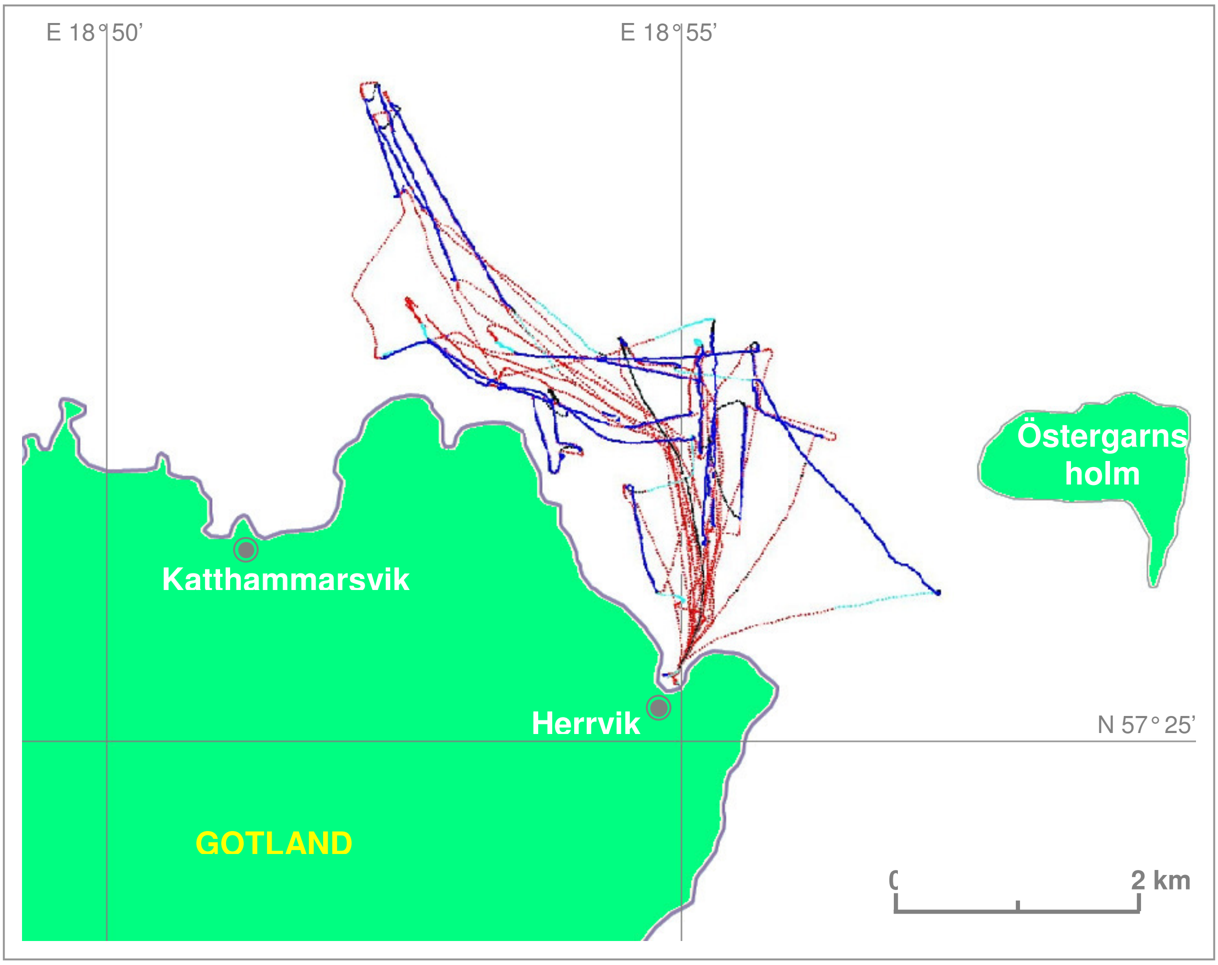


Plate 4. Sensor data shown in map format with each fishing activity shown in a different colour as defined by the vessel's velocity and other data. Solid dark blue shows net hauling, dotted red lines are transports between fishing operations and light blue is the time after hauling when the system is still recording. This map shows a few trips with Boat 2 in early June.

The maps (Plate 4) already show quite precisely where the nets are set, but the base data can also be used with a GIS application to analyse other geographic factors such as sea depth, bottom profile etc. which might be influencing the likelihood of by-catches in a certain area.

### *Analysis of video data*

The film sequences were analysed by Fisheries Board staff using a proprietary software programme, Video Analyzer (Plate 5), supplied by Archipelago Marine Research Ltd.  This programme can replay the same sequence from all camera angles simultaneously and offers simple and precise controls for slow motion, freeze frame and fast forward, so that one can speed through uninteresting sequences without missing anything. At the same time it is easy to register the location of any by-catch with the boat's position, using different code numbers on the keyboard for each species. There is also an image capture function so that one can save still pictures without having to pause the analysis.


Plate 5.  Screen shot from the Video Analyzer programme showing footage from all camera angles on 'Boat 1'.

## Results

### *Quantity of data*

Altogether the two boats produced 160 hours of recorded video data in 71 fishing days (Table 1). Of this, 107 hours were actually of nets being hauled. The remaining 50-odd hours consisted of recordings of, for example, the hauler being used to wind on the net from the quayside, as well as lots of short clips triggered by faulty recording settings during one period. Initially there was also a problem with the system on 'Boat 2' which created a number of corrupt files when the power was switched off. The cause of all this was again traced to recording settings which didn't fit with the boat's activities, and both problems were solved with the new settings. We were able to repair all the corrupted files and no data was lost.

| Vessel | Fishing days | Fishing effort | Total recorded video (hh:mm) | Total time spent on analysis (hh:mm) | Fishing activities filmed (hh:mm) | Time spent analysing fishing activity |
|---|---|---|---|---|---|---|
| Boat 1 | 15 | 31 125 | 21:56 | 8:37 | 15:48 | 6:35 |
| Boat 2 | 56 | 494 167 | 138:26 | 79:48 | 91:22 | 62:58 |
| Total | 71 | 525 292 | 160:22 | 88:25 | 106:10 | 69:33 |

Table 1. Fishing activity during the study period (number of days and net.metre.days), amount of recorded video data (hh:mm) and time taken for analysis (hh:mm).

***Time spent on analysis***

About 90 hours were used on the analysis of the 160 hours of video (Table 1), including all time spent actually viewing film sequences, but not ancillary tasks such as record-keeping, comparing sequences with sensor data and making back-ups.

The time taken for analysis of the fishing sequences varied both by boat and by fishing period. For 'Boat 2' the analysis took on average 40 minutes per hour of film, while for 'Boat 1' the corresponding figure was about 25 minutes per hour of film (see Fig 3 below).

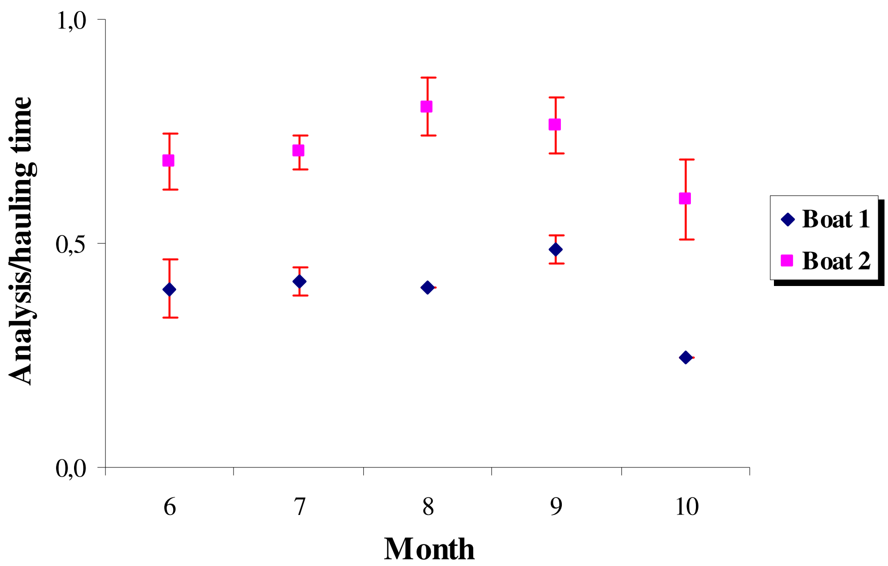


Fig 3. Relationship between film analysis time and time spent hauling nets. Error bars indicate the s.e.

***Quality of data***

The quality of the recordings and thus the time spent analysing them was to a large extent dependent on how the net hauling and catch handling was set up on the boat. When the net was hauled over an aluminium sorting table, as in 'Boat 1' (Plate 5), it was very much easier to be confident in identifying and documenting by-catches of seabirds.

In order to test the reliability of detecting by-catches, a whole month's video data from 'Boat 2' was independently analysed by two different members of staff, without reference to each other or to the by-catch data in the fisherman's log-book. The result was that both researchers noticed and identified the same three by-caught seabirds (two cormorants and an eider duck). However, a by-caught seal had also been noted in the log-book which did not show up on the films. According to a verbal report from the fisherman, the cadaver had fallen out of the net as it came to the surface, but was apparently hidden from the outrigger camera by the hauler itself, so all that showed up on the film was a minor commotion amongst the crew members standing at the railing. The angle of this camera (camera 3) was later adjusted slightly to avoid this problem arising again.

The only currently available way of checking how well the system has worked as a record of what actually happened during fishing operations is via the daily log-books for boats over 10m (8m in the case of the cod fishery).  For smaller boats than this, there is only the monthly journal, which is no help as it does not include daily entries. Therefore the trials with the EM system benefited from a high degree of willingness to collaborate on the part of the fishermen so that the data collected could be judged to be complete and unbiased

***By-catches***
In total, the recordings from Boat 2 showed 19 by-caught seabirds: 14 eider ducks, 2 cormorants and 3 guillemots. These numbers dived from the log-book records were the total number was 16. On the recordings from boat 1, no by-catches were detected and none were reported by the fisherman either.

***Damage by seals***
The fishermen were asked to show any damaged fish to the cameras so that these could be recorded by the EM system. During the trial period there was very little seal interference. No damage at all was reported from Boat 1. On Boat 2 the fishermen reported 6 damaged fish in the log-book, of which 5 were shown to the camera. The monitoring system also detected a further 2 fish which were clearly seal-damaged. There may have been others but the picture quality was not good enough to detect minor damage.

## Cost effectiveness

In order to judge the cost effectiveness of EM monitoring we need to compare it with the traditional monitoring method, i.e. using on-board observers. The only available point of reference for this is the pelagic fisheries monitoring scheme operated by the Fisheries Board in accordance with EU council regulation 812/2004 concerning accidental by-catch of small cetaceans. The situation here is of course somewhat different in that the observers stay on board for week-long trips on a much larger vessel, as opposed to day trips on a smaller boat. Parallels nevertheless exist in terms of the unpredictability of weather conditions and other factors affecting fishing opportunities, which makes it hard to predict fishing operations in advance.

The pelagic monitoring scheme ran for 5 months during 2006 and can be considered to have largely overcome its teething problems by the 2007 season, so if we take the data from that year, the observer effort constituted 34 man-months or the equivalent of 2.83 full-time positions. 201 days were spent at sea, of which 160 involved observing fisheries operations. The total cost for 2007, excluding the project director's salary and expenses, was about €290,000, so the cost per observed fishing day was about €1800.

The EM monitoring study cost about €85,000 (again excluding the project director's salary and expenses) and monitored 71 days of fishing activity. This works out at about €1,200 SEK per observed fishing day. However, this figure includes many additional costs due to it being a pilot study. Moreover one of the participating fishermen only spent 15 days fishing in 4 months, so we did not get the best 'value for money' out of the equipment on his boat. We therefore judge that it is easily possible to reduce costs to one half of those of an at-sea observer scheme and not difficult to get them down even less.
Even if EM is a cheap method in relative terms, it would still take significant sums of money to implement a full-scale monitoring programme nationally. During 2007, in the Swedish coastal fisheries as a whole, 567 vessels spent 39,080 days fishing with nets. With 5% coverage of the fishing effort and an estimated cost of about €560 per day, the total would run to about €1,090,000. Moreover, with only a 5% coverage, it is unlikely that any of the few instances of porpoise by-catch which are believed to occur annually would be detected, while any data which was recorded would have a very wide coefficient of variation.

If on the other hand by-catch studies were directed to areas where by-catch is thought to be a bigger problem, then statistically meaningful figures as regards trends could be obtained. In the Kattegatt and Skagerrak, which are the only sea areas where one might expect any significant porpoise by-catches, there were 7,900 days of net fishing operations during 2007. A 20% coverage of these areas at our estimated cost levels would involve a total cost of about €890,000.

The fishermen's union was initially unenthusiastic about the idea of at-sea monitoring, but there is now an understanding that collecting evidence that by-catches are actually rare, and that seal damage is much more of a problem, could actually help to restore the fishermen's reputation as responsible custodians of the marine environment. We see continued collaboration with fisheries interests as an essential ingredient in any practical resolution of the problems of enforcing fisheries policies without threatening the survival of our fishing industry.

## Conclusion

The EM system worked with relatively little maintenance for the four months of the trials. Once it is installed it looks after itself and the main job is to get to the harbour when the boat is in port in order to pick up the recorded data and to carry out system functionality tests. Analysis of data is easy and much less time consuming than having observers on board a fishing vessel for the duration of a fishing trip. The quality of data produced was high and we have no reason to believe that we would have missed any by-catches of porpoises if these had been present in the area during fishing operations. The system lends itself equally well to monitoring by-catches of seals and seabirds.