The Innovative Application of Vessel Monitoring Systems for the Effective Fisheries Monitoring Control and Surveillance,

Brendan O'Shea
Sylvia Thompson

Disclaimer: The interpretations, analysis and views are those of the authors and do not purport to represent the position of the European Commission.
ABSTRACT

Vessel monitoring systems (VMS) became a practical reality for the Common Fisheries Policy, from its introduction on 30 June 1998. The development of VMS was seen, by all the parties concerned, as having the potential to increase the cost effectiveness and impact of traditional fisheries monitoring, control and surveillance methods by facilitating a more targeted deployment of these resources. In addition, VMS was also to be considered appropriate for the direct application to control measures such as effort management and closed fishing areas.

VMS is of huge potential practical importance to fisheries control and management. Where it is properly applied, VMS results in significant cost savings and improved returns accruing to the Community’s enforcement and conservation efforts. This in turn helps in the development of a unified strategy for the better management of the Community’s valuable fish resource in order to ensure a viable fishing industry into the future.

To date, although the introduction of VMS has been an unquestionable technical success, it is arguable that VMS still has considerable untapped potential. In order to reap the full benefits of VMS and to secure the maximum return on the Community’s investment in the system, it is necessary to explore and exploit the system’s untapped potential.

This paper will argue that only through the innovative application of the VMS to fisheries management and control will it be possible to tap into and realise all of the system’s potential benefits. This claim will be illustrated by examining
practical applications of VMS, such as geo-fencing and time-fencing, which if implemented would represent a move towards an innovative application of VMS. In the context of this discussion, the possibility of extending the legislative mandate of fisheries monitoring centres (FMC), in order to fully articulate the application of VMS data in the enforcement context, will also be discussed and the advantages assessed. Lastly, the prospect of extending the applicability of VMS to fishing vessels of 10 metre or more in length will also be examined. Through such measures, it is argued, the full potential of VMS can be tapped and the benefits realised for the Community.
The Innovative Application of Vessel Monitoring Systems for the Effective Fisheries Monitoring Control and Surveillance

Sylvia Thompson,
Brendan O’SHEA
European Commission,
Directorate General for Fisheries and Maritime Affairs,
Regulation and Monitoring Fisheries Inspection
B-1049 Brussels;
Belgium

Disclaimer: The interpretations, analysis and views are those of the author and do not purport to represent the position of the European Commission.

Keywords: Vessel Monitoring System (VMS), Fisheries Management, Fisheries Monitoring, Fisheries Control, Fisheries Surveillance

1. INTRODUCTION

The proposal outlining the development of Vessel Monitoring Systems (VMS) was first presented by the European Commission in 1992. VMS would advance inter alia the effectiveness of fisheries management, particularly in the framework of Monitoring Control and Surveillance (MCS). The European Community adopted legislation, which sets out the legal framework concerning the equipping of fishing vessels with satellite tracking devices in June 1998. Since that time the experience has demonstrated that VMS has provided an enormous potential and capacity to gather, analyse and retain data on fishing vessel activity, for the control authorities and fisheries managers of the Member States of the European Community.


In the European Community VMS was introduced in two phases. The first phase commenced on the 30 June 1998 requiring vessels exceeding 20 meters between the perpendiculars or 24 meters overall length to be fitted with VMS except for vessels in the Mediterranean Sea and for vessels fishing for fish for reduction to fish meal and oil. The second phase commenced on the 1 January 2000. It obliged all vessels covered in phase one to operate VMS regardless of area or type of fishery.
Community. However, the same experience has also demonstrated that VMS has considerable untapped MCS potential which has not yet been fully explored or exploited.

In order to determine the true level of operational effectiveness of VMS in the framework of MCS, it is necessary to analyse the available data on the level of utilisation of these systems. Based on the data gathered to date, both inside and outside the European Community, it is confirmed that the information gathered by VMS on fishing vessel activity could be used more effectively and accordingly, there is potential in the system that has not yet been explored or exploited.

Against this background, the questions that need to be addressed are (1) what steps need to be taken to explore and realise for MCS the full benefits of VMS. And (2), would the expansion of VMS to include all vessels equal to or greater than ten meters, contribute to this goal?

The purpose of this paper therefore is to demonstrate, through the use of practical examples, that the innovative application of VMS, in the context of MCS and fisheries management generally, will indeed achieve the goal of identifying and maximising the benefits of such VMS for MCS and fisheries management.
2. **VMS: WHAT DOES IT DO TODAY?**

Establishing VMS as an operational tool for MCS enabled the Fisheries Monitoring Centres (FMC) of a Flag State to remotely monitor fishing vessel activity (vessel identification, geographical position, the date and time of the position, vessels course and speed) within certain geographical boundaries and in particular within the EEZ of the Member State in question at least every hour. Furthermore this information also allows Coastal States and relevant Regional Fishery Organisations to monitor all vessels fitted with transponders within its area of control.

By providing automated surveillance VMS provides cost effective and efficient support to control authorities allowing the rapid identification of potential infringements, which can then be targeted for further investigation.

Initially VMS was mainly seen as an additional tool that would complement traditional surveillance methods as it comprises a relatively inexpensive method of continually monitoring fishing activities. Because FMCs form an integral part of the VMS system, the individual data of large numbers of fishing vessels often deployed over a significant geographic area, can be monitored by a relatively small staff of controllers at the FMCs.

The centralised monitoring of the VMS data, which is then collated by the FMC on the activities of fishing vessels in its operational zone provides the means for more targeted surveillance and allows inspection resources to be deployed more effectively.
Despite the potential of VMS for gathering and retaining data on fishing vessel activity, experience has shown that national authorities have been slow to exploit the MCS possibilities arising from the application of the data provided by the system, particularly the analyses of the VMS data gathered at the FMC. Part of the current difficulties can be attributed to the fact that the full functionality and interconnectivity of the system represented in Figure 1 is dependant on the simultaneous development of the three elements that constitute the system.

- **The Satellite Transponder (Satellite Tracking Device) fitted on board the Fishing Vessel.**

  Between 1998 and 2003 the regulatory framework describing the technical requirements of the transponder was rudimentary in terms of security of transmission and operation. Fishing vessel operators had, in certain cases, a wide range of transponders from which to choose from.
Some of the transponders were basic in their functionality and had very few built-in safeguard mechanisms in order to prevent the manipulation of the VMS data. The transponders ranged from: the open system, which comprised an open supply from the Global Positioning System (GPS) to the satellite transmitter to a totally closed tamper proof blue box, which incorporated tamper proof alarms and backup data recording and power supply.

In 2003 an improved regulatory framework adopted by the European Commission providing for *inter alia* greater tamper proofing of the transponder, which in turn reduced many of the problems related to tampering and provided for a more reliable on board transponder. Nonetheless, some additional enhancements still remain to be addressed in order to counterbalance any benefits to fishing vessel operators that can currently be gained if they switch off the transponder. Such improvements could include the requirement that the transponder continue to record and save GPS data for a period of about thirty days following switch off, power failure or a satellite transmission failure.

Against this background Member States could consider developing new VMS systems which are trans-European. Such developments would ensure harmonisation of operation and facilitate greater cooperation.

- **Communication Pipeline linking the data transmission from the fishing vessel to the FMC.**

In real terms very few difficulties have been experienced concerning the communications pipeline. The system comprises a satellite communication function from the vessel to the earth station via a communication satellite and communication between the earth station and the FMC via landline, (X-25, X-

---

400). The redundancy of the X-25, X-400 system has required that this part of the system change to internet and email applications.

Fisheries Monitoring Centre comprising the necessary computer hardware and software for the collection storing and possible analysis of VMS data.

The legislative framework describing the operational role of the FMC has changed very little since 1998. The prescribed principle function of the FMC is to collate and monitor the VMS data on the activities of fishing vessels in its operational zone and advise the relevant control authorities on the results of the monitoring. In this regard Member States should *inter alia* routinely verify the catch, effort and deployment activity of their vessels in the framework of a range of fisheries management and conservation measures in force\(^4\).

Analysis of Member States Control and Management measures provided for in Community legislation and presented in *Figure 2* (present performance indicators) demonstrate that there is a disappointing use of the data collated by FMCs. For the most part the process of verification of fishing vessel activities being carried out by most Member State authorities is manually applied and sporadic.

Because the VMS system is automatic and provides for the automatic transmission of VMS at regular intervals to an FMC, where the position and identity of the vessel is displayed, it ensures that large numbers of fishing vessels deployed over a significant geographic area could be monitored automatically by a relatively small staff of controllers at the FMC. However, because the FMC measures on the monitoring of catches, fishing effort and are not explicitly laid down by most Member States have adopted a minimalist interpretation of the VMS rules.

---

In the future, the Community Fisheries Control Agency (CFCA) could undertake to develop enforcement and operational best practices procedures to enhance the use of VMS. Such measures could include more extensive use of geo-fencing and time-fencing for control purposes. Moreover, the CFCA could undertake to advance procedures for more extensive sharing of VMS data between Member States.
3. **REALISABLE BENEFITS OF VMS?**

The consensus amongst all Member States is that VMS has the potential to be a very effective and management tool. To this end it is also recognised that a lot more could be done in real terms to expand the application and role of VMS data in order to advance the effectiveness of MCS.

Should the current situation prevail, with VMS data continuing to be underutilised, this will effectively constitute the squandering of the investment in VMS and the forfeiture of the untapped benefits that would in due course accrue to MCS. To rectify this situation the application of VMS needs to be more proactive and the operational mandate of the FMCs enhanced to allow for the automatic enforcement for infringements and follow-up of control issues.

**Realisable benefits of the current VMS system include:**

- Greatly facilitate transparency through the exchanges of real time information (catch and effort activity) between the national authorities responsible for enforcement. The availability of real time information on fishing activity particularly for vessels that are fishing and landing in the ports of another coastal state would facilitate greater transparency and cooperation between flag states and coastal states and would in turn help to eliminate the reporting delays provided for in the current legislative framework.

- **Advance developments in electronic catch reporting.** Although logbooks and other catch registration documents should already be entered into a computerised data base system, most cross checks are being carried out by time consuming manual procedures. Linking the data structures employed by VMS will simplify the data structure necessary for electronic catch reporting. Moreover, the use of electronic logbooks would increase the security of such a system as they would not be capable of subsequent falsification. Electronic
logbooks would have a further benefit for the establishment of the evidentiary probity of VMS data in the enforcement context. Electronic logbooks would therefore facilitate the cross referencing of VMS data with logbook entries by the deployment of automated techniques.

- **Enhance the efficiency of inspection authorities.** Real time activity and catch data together with automated reporting will greatly reduce the burden of control at sea and in port. Satellite monitoring can be of immense help to the operational efficiency of inspection resources deployed, in particular where the system can be used to establish in real time the position of a vessel as it nears the coast. Inspection departments can then, at reasonable cost, ensure a sufficiently high probability of an inspection when the catch is landed and, thereby, make fisheries control much more credible.

- **Significantly reduce the administrative and reporting burden of fishermen.** Effort reports, pre-notification reports, obligations on designated ports, hail messages, trans-zonal fishing reports could be replaced by the VMS report.

- **Would advance the Evidential Value of VMS.** The use of VMS data strengthens the evidential case of prosecution cases, particularly in non criminal prosecutions. Moreover experience has shown that in certain cases there has been no problem with the courts of one jurisdiction accepting VMS data provided by the FMC of another Member State. The types of fishery cases in which VMS data has been accepted are as follows:
  - Unlawful entry into a restricted area
  - Failure to maintain properly the logbook
  - Illegal Fishing
  - Tampering with VMS equipment
  - Provision of false information
However, in order to realise the full potential of VMS in the context of the measures listed above, there is a need for greater cooperation and understanding of on the one hand controls and the other hand management criteria. In this context, scientists and policy makers should take into account, when developing management measures, the technical advantages and disadvantages of VMS data.

- **A reduction of expenditure on control by increased automation and verification.** Automatic verification and monitoring of vessels activities by FMC would free up time for inspection resources in the ports to concentrate on more targeted inspections.
Figure 2: Possible Control and Management Requirements of VMS in the Future

<table>
<thead>
<tr>
<th>Control And Management Requirements</th>
<th>Present Performance Indicators</th>
<th>Description of Potential Uses Of VMS</th>
<th>Future Performance Indicators</th>
</tr>
</thead>
</table>
| VMS Systems and Functions           | ![Green](state_green)           | • Real time control analysis of vessel activity  
• Automated alarm systems to monitor  
  ➢ Geo-fencing and Time-Fencing areas.  
  ➢ Data Quality Control.  
  ➢ Tampering and falsification of data  | ![Green](state_green) |
| Inspections                         | ![Yellow](state_yellow)         | • Remote access to VMS data.  
• Cost efficiencies for control services.  | ![Red](state_red) |
| Relational Data Bases               | ![Red](state_red)               | • Cost efficiencies for control services.  
• Automated alarm system  
• Fully integrated and relational data base systems  
• Integrated control system with the capacity to control and monitor all the fishing possibilities of a vessel.  | ![Yellow](state_yellow) |
| Fishing Area / Biologically Sensitive Areas | ![Yellow](state_yellow) | • Cost efficiencies for control services  
• Automated control and monitoring of geographically remote areas.  
• Automated alarm systems for geo-fencing and time-fencing.  
• Direct response to infringements.  | ![Yellow](state_yellow) |
| Pre-Notification                    | ![Yellow](state_yellow)         | • Cost efficiencies for control services  
• Automated alarm systems  
• Automated on-board mechanisms that detect a vessel leaving port  | ![Green](state_green) |
| Designated Ports                    | ![Yellow](state_yellow)         | • Automated alarm systems  
• Cost efficiencies for control services  | ![Green](state_green) |
| Effort Management and Control       | ![Red](state_red)               | • Real time monitoring of effort scheme, based upon fishing vessels in specific areas.  
• Fully automated effort management.  | ![Green](state_green) |
| Catch Reporting Verification        | ![Yellow](state_yellow)         | • Integrated with an electronic logbook there would be real time accounting of quota utilisation.  
• Fully automated verification and quality control procedures  
• Fully integrated and relational data base systems  | ![Green](state_green) |

- **Red**: Requirement is not explored or explored unsatisfactorily
- **Yellow**: Requirement is explored, but only sporadically
- **Green**: Requirement is explored satisfactorily

15
4. EXAMPLES OF POTENTIAL USE OF VMS

Stock recovery measures are defined in line with conservation and resource management measures. These measures may include factors such as days at sea schemes, fisheries closures, specific landing and reporting obligations and prior notifications. All these defined measures can be implemented by automated procedures, provided for in the framework of VMS.

Against this background, this chapter aims at demonstrating examples for the implementation of control measures by innovative use of VMS data.

4.1. Geo-fencing and Time-Fencing

Geo-fencing and time-fencing are techniques that can be deployed for the monitoring and control of closed fisheries areas, and for the control of specific landing obligations such as landings that are subject to prior notifications to the inspection services of the port of landing.

**GEO-fencing** refers to a geographically defined area or location, where the defined area or location is predetermined in legislation and which can be monitored and enforced using an automatic reporting system such as VMS. Community legislation defines the following closed areas: Biologically Sensitive Areas, Temporary Fishing Closures and Geographical Fishing Closures. Entry and exit of a vessel into or from such an area can be automatically monitored by a system of alarms installed on the GIS monitoring system at the FMC.

A ship can be geo-fenced in an area, for example, with an alarm signal in both the FMC and on the fishing vessel which is transmitted if the vessel is unexpectedly moved outside a pre-determined zone within a certain time period. Conversely, the system can be programmed to transmit a heads-up signal when the ship has reached a particular location or has not reached a prescribed location within a defined window.
**Time-fencing** refers to a geographically defined area or location where the defined area or location is predetermined by legislation and which can be then monitored and enforced using an automatic reporting system such as VMS. Entry and exit of a vessel into or from that area during predetermined periods are automatically monitored by a system of alarms installed on the GIS monitoring system at the FMC.

Other applications of time fencing refer to time spent away from port by a fishing vessel or groups of vessels.

The principle of monitoring and controlling these two types of closures is the same.

*Figures 3 and 4* demonstrate examples where geo-fencing and time-fencing techniques are deployed.

*Figure 3* depicts a geographical closure applicable throughout the year. VMS coordinates in yellow depict instances where the vessel’s speed implied possible fishing activity occurred. VMS coordinates that are depicted in blue depict instances were possible fishing activity occurred within the closed area. These incidents are identified by geo-fencing and time-fencing techniques.

The simulated example of *Figure 4* considers any ports that are depicted in the map as designated ports. The principle of geo-fencing is applied. Around every port, a buffer area\(^5\) of a radius representative of the area is defined. An alarm notifies the approach to land, which can in turn be cross-checked to pre-notification requirements. The alarm also signals landings at designated ports and non-designated ports.

---

\(^5\) A buffer is an area defined around a point with a fixed defined radius. In the case of ports, the radius may vary in accordance to the geography of the ports.
Community legislation obliges Member States to use VMS data for the effective monitoring of the fishing activities of vessels. It does not provide the national FMC with the necessary mandate to use VMS as an enforcement tool. Accordingly, geo-fencing and time-fencing techniques are rarely employed by the national FMC.

A clear regulatory framework could provide the national FMC with the obligation as well as the mandate to apply automated geo-fencing and time-fencing techniques in order to meet its monitoring and control obligations.

---

4.2. Data Quality Control Procedures, Cross-checking and Effort Management

Community legislation establishes a framework and system for the control of fishing effort by Member States. In particular this applies to fishing effort by Member States whose fishing vessels are authorised to carry out fishing activities in areas to which fishing effort limitation schemes apply pursuant to Community regulations. More specifically, it obliges these Member States to establish a validation system comprising reports, recordings, cross-checks and verification of effort data.

Fishing effort is calculated from logbook information. Most Member States calculate fishing effort in Microsoft Excel by manual procedures. As a consequence, the accuracy of the calculated effort figures is directly related to the accuracy of the logbook data. In addition, experience has shown that data verification and cross-checking procedures, as warranted by Community regulations are sporadic and inefficient.

As a result, underestimated fishing effort figures are a consequence of omitted logbook entries and incorrect logbook declarations regarding factors such as the time spend at sea and the areas fished. Using VMS, such discrepancies could be identified by automated procedures.

A simple example is portrayed in Figure 5, where the vessel owner had not declared any fish catches during the season for the Senegalese and Cape Verde waters. The VMS track of the vessel clearly indicates fishing activity in Senegalese and possibly Cape Verde waters, which are deduced from the vessel speed.

---

7 Title IIA of Council Regulation (EEC) No 2847/93 of 12 October 1993, establishing a control system applicable to the common fisheries policy.
8 Article 19 of Council Regulation (EEC) No 2847/93 of 12 October 1993, establishing a control system applicable to the common fisheries policy.
In such a case, an FMC could again deploy automated methods such as geo-fencing and time-fencing, combined with simple algorithms that would for instance consult the vessel speed, in order to control the reported fish catches of a vessel.

In terms of cross checking VMS data with catch registration data, geo-fencing techniques, as well as other statistical tools could be deployed to compare catches per statistical area with declared figures in the logbook. Accordingly, any attempts to convey incorrect data would be identified as a statistical anomaly and addressed.

**Figure 5: Vessel Track depicting Fishing Activity.**

Member States currently do not deploy automated procedures for data verification and cross-checking. Such procedures warrant fully integrated and relational data base systems.

In this case, it is again neither practical nor feasible to deploy manual methods to control and monitor the fishing activity of a country’s vessels, in order to efficiently meet the MCS obligations. Data quality control and verification procedures can only be deployed effectively and efficiently by systematically applying algorithms to the
fleets fishing activity reports, be they VMS data or catch registration data. This in turn warrants automation.
5. EXPANSION OF VMS TO VESSELS BETWEEN 10 AND 15 METERS

It has been clearly demonstrated that VMS is very effective for monitoring the activities of fishing vessels and for implementing the targeted application of inspection resources, even in light of the fact that there is considerable scope for expanding the application of VMS and realising the additional potential benefits of the system.

However, it must be recalled that pursuant to the current legislative framework, VMS is mandatory only for vessels greater than 15 meters in length. Given the current strength of the Community fishing fleet, this means that less than half of the Community fleet is required to carry a transponder with the consequence that such vessels are not subject to measures that could be monitored by VMS such as effort management effort management, recovery plans and catch legislation Figure 6.

Figure 6: Percentage of Vessels fitted with VMS Transponders in the EU

<table>
<thead>
<tr>
<th>Category</th>
<th>LOA 10 – 15 meters</th>
<th>LOA &gt; 15 meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of vessels⁹</td>
<td>11040 vessels</td>
<td>11250 vessels</td>
</tr>
<tr>
<td>Vessels not fitted with VMS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vessels fitted with VMS</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

⁹ European Commission Fleet Register as in August 2006
Part of realising the full potential benefits of VMS, includes the expansion of the legislative framework to include the monitoring of vessels between 10 and 15 meters, which are capable of conducting fishing trips of between 36 hours and 5 days.

By doing so the number of vessels subject to VMS coverage would double. The situation is such that in most Member States there are rather few vessels in the 15-24 meter and plus class currently covered by Community legislation, when compared to the 10 meter class. Accordingly, by extending VMS to include vessels between 10 and 15 meters in length, the effect on control for vessels subject to recovery plans would be greater and efficiencies in the framework of MCS could be achieved.

Other possible expansion of VMS to an overall length threshold below 15 m could also be specific to the monitoring of certain fleets or types of fisheries. In this regard, for instance, a specific recovery plan for a specific type of fisheries or type of vessel could prompt the expansion of VMS to the relevant fleet size threshold.
6. **THE WAY FORWARD.**

(1) The technical implementation of VMS has been a technical success. It is clearly demonstrated that VMS is of huge potential practical importance to fisheries control and management, with the potential benefits including more cost effective application of resources, which should lead in turn to more effective management of fishery resources.

(2) It has been demonstrated that VMS is very effective for monitoring the activities of fishing vessels. VMS provides FMCs with information on the identity of individual vessels, their geographical position, course and speed. This information when used in conjunction with other databases and analytical tools makes it possible to remotely monitor one or a number of vessels and to collate information on their activities in respect of a given area and/or a given time in a cost effective and efficient manner.

(3) The full economic and operational value of VMS can only be realised by mandating either FMCs or other relevant authorities to act and enforce independently, by establishing a legal framework that recognises the evidential probity of the data collated by these systems in the enforcement context.

(4) The existing legislative framework which defines control measures for conservation and resource management dictates and provides incentives for the potential use of VMS. However, future legislative frameworks should give clear guidelines for the use of VMS and furthermore, oblige the use of automated procedures, geo-fencing and time-fencing by the FMC.

(5) An extension on the obligation to have vessels with an overall length between 10 and 15 meters fitted with a satellite-tracking device will advance the evidential value of VMS for the MCS of control measures such as effort management, catch registration and recovery measures.

(6) A clear and well defined European dimension would give added value to ensure a reliable synergy for the implementation and safe guarding of VMS. Amongst others, the Community Fisheries Control Agency (CFCA), which will represent a joint European interest for the European Union, and for the management of data, could facilitate a dimension of good practice, by promoting tools for ensuring the reliability, accuracy and integrity of VMS data. Accordingly, Member States should consider further technological and system developments in VMS in the context of community projects. A harmonisation of project development would bring synergy to the systems employed in the Member State.

(7) Continued research in SAR in the framework of Vessel Detection Systems\(^{10}\) (VDS) have demonstrated that VDS records correlated with VMS records can bring efficiencies in support of control and enforcement tasks. VDS outputs give the possibility to visualise and analyse in a web-based mapping application such as GIS the detected vessels position of SAR in an automatic fashion and in Near Real Time (NTR).

---

\(^{10}\) Guido Lemoine; Vessel Detection System; A blueprint for an Operational System; February 2005. The report provides the system blueprint for future implementation of an operational Vessel Detection Service.
(8) The use of VMS data to develop fisheries management plans could be of benefit to scientists. Hence, such management plans should bear in mind the technical parameters of VMS.

(9) The use of VMS tools for fisheries management in the implementation of future regulatory frameworks, and in response to the decline of specific fish stocks, as proposed by the scientific cadre, should be promoted in order to ensure enforceable and successful regulatory frameworks.