WWF

REPORT

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# ELECTRONIC MONITORING IN FISHERIES MANAGEMENT

WWF commissioned this report as a contribution to the ongoing discussions surrounding the introduction of new CFP regulations including the Landing Obligation and in the interests of addressing some of the potential misconceptions around the use of Remote Electronic Monitoring systems using cameras.



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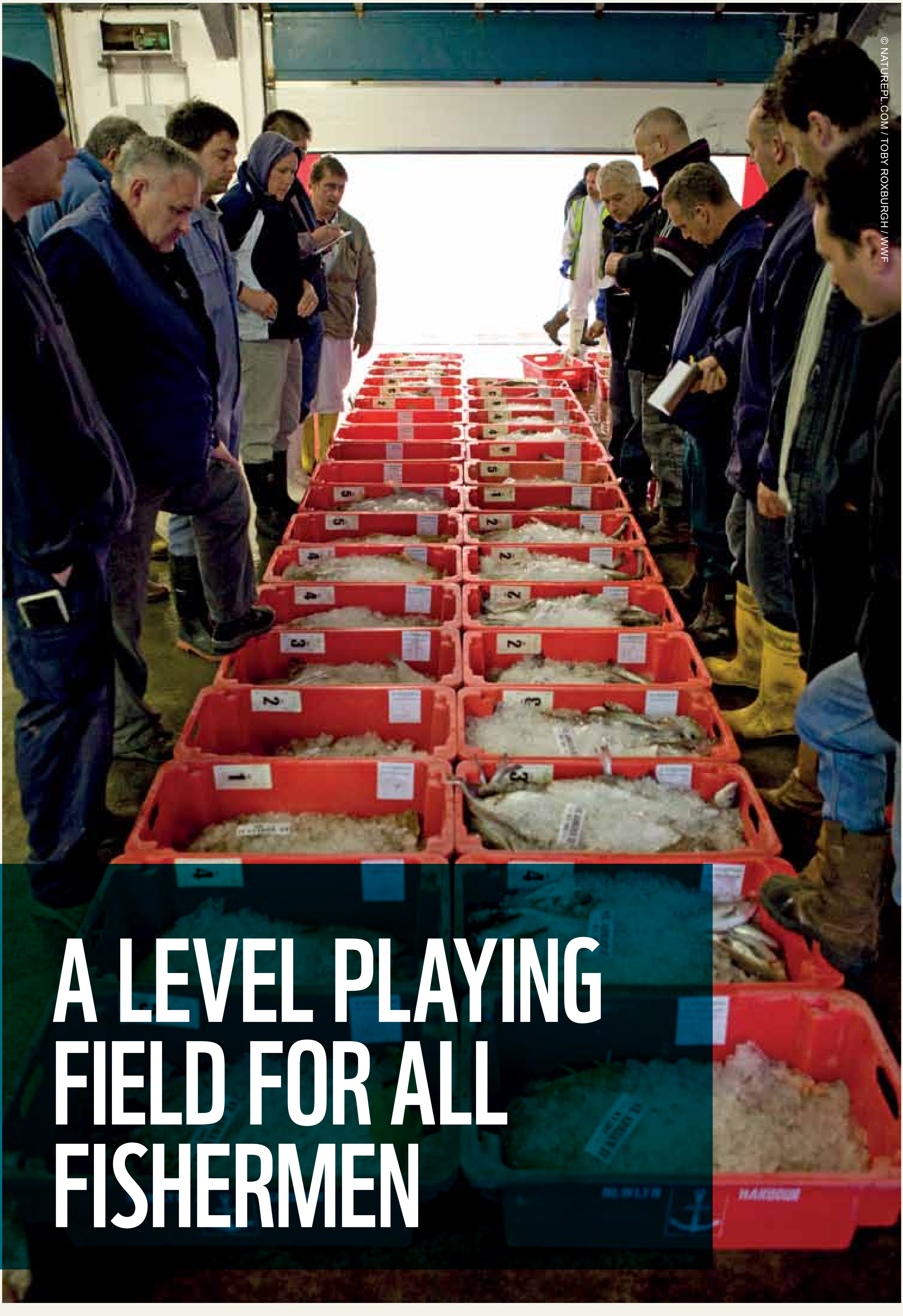


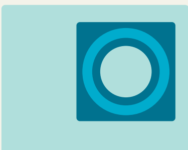

# A LEVEL PLAYING FIELD FOR ALL FISHERMEN

# EXECUTIVE SUMMARY

**The landing obligation described in Article 15 of the reformed Common Fisheries Policy requires fishers to land all catches of specified species so that they count against their quota and are fully documented and accounted for. This new measure will present a number of challenges including the details of how it is applied, and then monitored for effectiveness.**

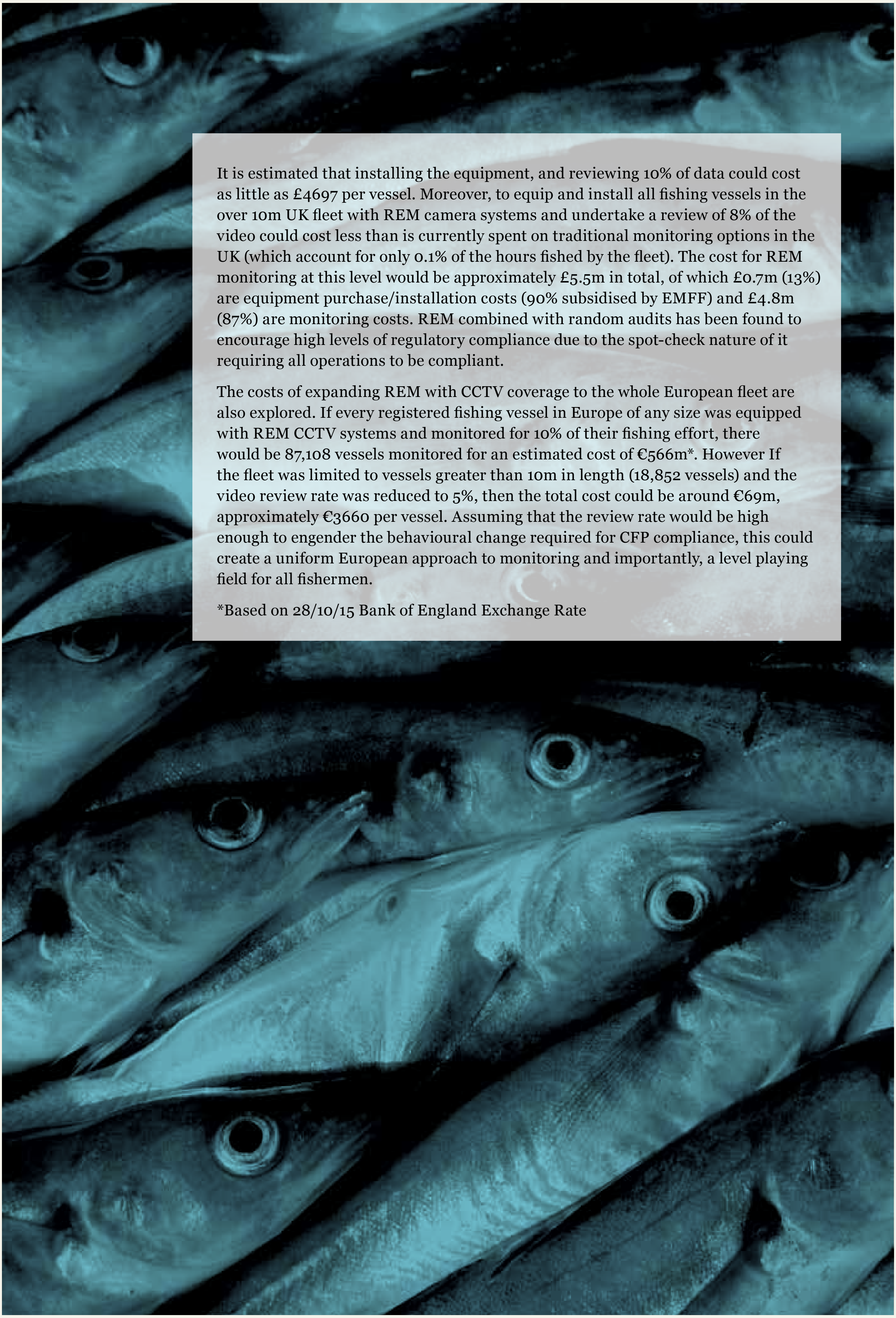
Both will be key for the landing obligation to be successful. It may be that adaptations are required, in which case the monitoring system needs to be able to support this process – in providing evidence of where things are working, or not.

This report explores the alternative methods available for monitoring and concludes that only a Remote Electronic Monitoring system (REM) equipped with video technology (CCTV) can provide assurance of effective monitoring of activities at sea. Trials have been conducted worldwide for over 15 years and video technology is constantly improving with new digital cameras and improved sensor development. It represents a transparent, proportionate and risk based approach to monitoring and control as it reviews a small percentage of at sea footage to look at how vessels are operating. Such a system would not only allow a snap shot of how compliance is working but also provide a tool with which to support all the operators that are working responsibly and with integrity in what is a challenging set of circumstances. For example using REM technology to demonstrate best practice and using camera footage to substantiate potential implementation problems.



Electronic monitoring with video techonology represents a transparent, proportionate and risk based approach to effective monitoring and control

The costs of monitoring – using the UK as a case study – are explored and it is concluded that using electronic monitoring systems equipped with cameras is the cheapest option for monitoring at sea and that this method can offer higher coverage levels than other methods at a reduced cost. This is confirmed by other studies worldwide. In addition, the alternative, traditional options currently being considered by the UK administrations to monitor compliance with the landing obligation do not ensure that the observed behaviour continues when the surveillance platform (vessel/aircraft) has left the vicinity. This reduces the confidence in the information and will limit the usefulness of the data collected for both science and compliance.



It is estimated that installing the equipment, and reviewing 10% of data could cost as little as £4697 per vessel. Moreover, to equip and install all fishing vessels in the over 10m UK fleet with REM camera systems and undertake a review of 8% of the video could cost less than is currently spent on traditional monitoring options in the UK (which account for only 0.1% of the hours fished by the fleet). The cost for REM monitoring at this level would be approximately £5.5m in total, of which £0.7m (13%) are equipment purchase/installation costs (90% subsidised by EMFF) and £4.8m (87%) are monitoring costs. REM combined with random audits has been found to encourage high levels of regulatory compliance due to the spot-check nature of it requiring all operations to be compliant.

The costs of expanding REM with CCTV coverage to the whole European fleet are also explored. If every registered fishing vessel in Europe of any size was equipped with REM CCTV systems and monitored for 10% of their fishing effort, there would be 87,108 vessels monitored for an estimated cost of €566m*. However If the fleet was limited to vessels greater than 10m in length (18,852 vessels) and the video review rate was reduced to 5%, then the total cost could be around €69m, approximately €3660 per vessel. Assuming that the review rate would be high enough to engender the behavioural change required for CFP compliance, this could create a uniform European approach to monitoring and importantly, a level playing field for all fishermen.

*Based on 28/10/15 Bank of England Exchange Rate

# BACKGROUND

A reform of the Common Fisheries Policy (CFP) was agreed between European Member States in December 2013 and entered into force in January 2014. Within this reform package was the introduction of a ban on discarding of fish at sea. This is referred to as the Landing Obligation under Article 15 of the CFP basic regulation (Council Regulation No 1380/2013).

In 2015 the EU applied the landing obligation to fishing vessels fishing for pelagic species where there is a Total Allowable Catch (TAC) (e.g. herring, mackerel, and sprat). This will be extended to all TAC controlled demersal species (e.g. cod, haddock, plaice, and sole) between 2016 and 2019. This is likely to be undertaken using a phased approach with the details of implementation and enforcement currently being considered by Member States.

The landing obligation will require fishermen to bring all catches of the specified species ashore and the total catch will count against their quota, rather than just the marketable landed proportion of the catch as has previously been the case. The aim of this management strategy is to gradually eliminate the wasteful practice of discarding fish at sea, to fully document all fishing mortality and to improve the data going into the scientific stock assessments. It will also encourage fishermen to fish more selectively so that their quota is not being used to account for fish they cannot sell i.e. fish that are caught and landed but are below the Minimum Conservation Reference Size (MCRS) as these cannot be sold for human consumption.

The EU definition of discards is catches that are returned to the sea. This includes any fish returned after being brought on board a vessel or any release of catch from fishing gear whilst it is still in the water (sometimes described as “slipping”). In addition the landing obligation will also apply to non-Union waters which are not subject to a third countries’ jurisdiction, in other words Union vessels operating in international waters.

The majority of discarding occurs at sea, so it is essential that the activities of fishing vessels are effectively monitored at sea.

The success of the landing obligation will largely depend on the ability of Member States to effectively implement, monitor and enforce the regulation. The majority of discarding occurs at sea, so it is essential that the activities of fishing vessels are effectively monitored at sea. Using the UK as a case study this paper focusses on the options for monitoring fishing practises and the tools that could be used, with a particular focus on using Remote Electronic Monitoring (REM) equipment that utilise video camera technology.

# TRADITIONAL MONITORING SYSTEMS

There are several different ways to monitor commercial fishing operations. The traditional approach to monitoring includes undertaking dockside compliance and fish market visits; using aircraft (including unmanned aircraft) to overfly fishing vessels; using patrol vessels to undertake at sea boardings or surveillance; using Vessel Monitoring Systems (VMS) that use satellite positional data to work out location and speed of vessel; sending observers to sea for the duration of a sea trip to collect scientific data or evidence gathering for compliance; and using self-reported data (E-log, paper logbooks, salenotes, landing declarations). Here we look at how REM systems that utilise CCTV cameras compare to these traditional approaches.

## COMPLIANCE

**Dockside monitoring**

Monitoring for compliance purposes generally involves the use of several of the methods described above. The most commonly used method is to inspect vessels when they land their catches in port, and cross check catches on the vessel against those declared in logbooks. If discrepancies are discovered then investigation and enforcement action is usually taken. This is sometimes referred to as dockside monitoring. This is a good way to check that the amount of fish that has been declared for landing is actually what is going to be landed; or to check for fishing gear infringements. However it cannot check for any high grading activity at sea or any illegal discarding that may occur contrary to the requirements of a landing obligation.

Counting vessels is not equivalent to policing them.

**Aerial Surveillance**

Aircraft are mainly used to overfly vessels and determine if they are fishing in an area where fishing is prohibited. This is done by checking to see if the fishing vessel has gear deployed in the water or not and the activity can then be filmed or noted for evidence purposes by the fishery officer aboard the aircraft. Under a landing obligation, discarding at sea of some species will be prohibited and there is the potential that aircraft would be able to view vessels discarding larger quantities of fish over the side of the vessel. However this can only be seen if the discarding operation occurs above sea level, the quantities are large and when a vessel is unaware of the presence of the aircraft. It would also be extremely difficult to distinguish the species being discarded to determine if it was subject to the landing obligation or not. It is likely that vessels would adhere to a landing obligation whilst the aircraft was in the vicinity but once the aircraft had departed there would be no deterrent to discarding at sea if this was something that a skipper was interested in actioning.

Aerial surveillance is also used as a rapid response to intelligence that suggests illegal activity is occurring at sea, often linked to international fleets. Using overflight inspections may be considered a high cost option and flight times are limited by fuel, which can make range and duration of coverage low. Marine Management Organisation (MMO, UK)states in its 2014 annual report that "aerial surveillance has provided a visual deterrent with over 2,338 sightings of vessels at sea" in financial year 2013/14 (MMO, 2014). However, it is unclear from the report whether this represents good value for money or not as it is impossible to determine whether these vessels were deterred from fishing illegally by the presence of the aircraft, whether they then went on to commit an infringement after the aircraft had departed, or continued to fish in a responsible and legally compliant way, or whether the aircraft would have been able to detect an infringement in the first place. Counting vessels is not equivalent to policing them.

Although 2,338 sightings are equivalent to observing approximately 1.2% of the days at sea (the UK 2013 fleet total of 187,307 days at sea was used to give an approximation of fleet coverage by aircraft in 2013/14 because 2014 days at sea data is not yet available) this isn't an accurate way of assessing/observed fishing effort because the aircraft usually only overfly the vessel for a few minutes and note its position and registration. The amount of time that can actually be spent in the air is limited by fuel load, so it is likely that viewing time will not exceed half an hour duration for an individual vessel. In reality, the sightings achieved above may be equivalent to viewing approximately 0.026% of fishing effort (hours at sea) if the assumption that a maximum of half an hour was spent observing each vessel is factored into the equation.

However it should be noted that there is an obligation to undertake surveillance operations, using aerial or marine assets to monitor fleet activity, especially foreign vessels entering national waters. Aircraft and patrol vessels are a highly visible monitoring method and therefore should act as a deterrent when they are observed by fishing vessels and for the time they are visible.

**At-Sea Surveillance**

Patrol vessels are used in a similar way to aircraft but they have an added advantage in that they can also deploy enforcement officers to board a vessel and check that the catch onboard and in the fish hold, matches that which is declared in the logbooks (or E-logs). The enforcement officers can also check for any infringements with the gear being used as it is hauled back on board the vessel. The patrol vessel can remain in an area for a longer duration than an aircraft as it is not limited by fuel in the same way. Patrol vessels could also use high resolution long distance surveillance equipment which could allow them to view activity from a distance, limited to line of sight. However, the main limitations of patrol vessels in relation to monitoring a landing obligation are that the boardings are limited by weather; discarding of fish needs to occur above the waterline to be viewed from distance; the fishing vessels are usually fully aware that the patrol vessel is nearby and can adjust their behaviour if desired; and there are safety implications for enforcement staff carrying out these boardings. It is likely that whilst the patrol vessel is in the vicinity and weather is calm it will act as a deterrent for any illegal activity, but once the vessel has departed so too does the deterrent.

In 2013, the Royal Navy carried out 587 inspections at sea on behalf of the Marine Management Organisation (MMO). There were 142 infringements identified, and most of these resulted in oral advice being offered to achieve compliance (MMO, 2014). This would suggest that these infringements were minor and may have been caused by an oversight by the skipper rather than a conscious decision to commit an offence.

In 2013, the UK fishing fleet carried out 187,307 days at sea so it is reasonable to assume that in 2014 fishing effort would be of a similar amount. Therefore the Royal Navy figures suggest they were able to inspect approximately 0.3% of the days spent at sea. However, as was the case with aircraft surveillance, this is not actually 0.3% of the fishing effort because although the patrol vessel inspected on 0.3% of the days they would only have inspected the vessels for a maximum of approximately 4 hours. So in reality you would need to divide this effort by 6 (4/24 hours), giving a percentage coverage of fishing effort of approximately 0.05%.

It should be noted that some countries may own their own vessels for undertaking fisheries enforcement work rather than subcontracting to other suppliers. For example, Scotland have 3 fisheries patrol vessels each with between 15-17 crew, which are used to monitor inshore and offshore activity. Maintaining and operating a fleet of naval class vessels can be an expensive undertaking with each vessel needing several days per year of maintenance as well as permanent and reserve crews. Owning the patrol vessels may give more flexibility and greater control of when and where patrols should take place, compared to leasing the service from a navy. It may also allow the vessels to be deployed at short notice in response to intelligence reports.

**Vessel Monitoring Systems (VMS)**

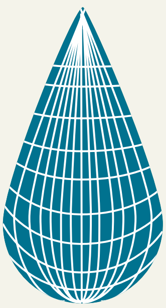
Current VMS provides a summary of data every 2 hours to a shore based database via satellite communications. This data set contains position, date, time and speed. The data is then interpreted using software that determines whether a vessel is fishing or traversing an area, based on its speed and duration at that speed. It can therefore detect when a vessel is operating in a closed area and make an assumption, based on speed, as to whether the vessel is fishing or not. However it could be argued that this assumption is not conclusive evidence of fishing activity because a vessel may just have slowed down to save fuel or be sailing against a strong tide. It also does not provide any information on the catch aboard a vessel or whether the crew have been discarding fish at sea or not. VMS is an effective tool for giving an overview of where vessels have been during a sea trip and can give an indication of “likely” fishing activity. All vessels greater than 12m length have been required to have a working VMS system on board since 1st January 2012 (in line with Council Regulation (EC) No 1224/2009 and Commission Implementing Regulation (EU) No 404/2011 Vessel Monitoring System and E-logbooks).

**Observer Programmes**

At sea observer programmes are used throughout the world to monitor for compliance and for gathering scientific data. These usually require an observer to be at sea for the duration of a full trip due to the safety, costs and logistical issues associated with transferring staff at sea. It is likely that whilst a vessel has an observer on board and undertaking their observer duties, that it will comply with regulations. Therefore to ensure regular compliance, coverage levels need to be high. In some fisheries the vessel is required to carry an observer for 100% of their fishing trips and the observer is paid for by the vessel (Stebbins et al, 2009). This can be an effective way to ensure compliance, assuming that the observer can observe every fishing activity and all stages of the fish sorting, handling and processing stages. This is possible but unlikely because observers will require rest time and cannot observe all stages of the handling process at the same time when on larger vessels. There is also the potential that the observer will come into conflict with the crew given that the observer may be curtailing the crew’s financial returns. In addition, observers are usually deployed on different vessels and gear types, which could increase the risk to their own personal safety, given that every trip on a new boat will be like their first trip to sea as they get accustomed to that particular vessel and its operating procedures.

**Self-Reported Declarations**
Self-reporting of catches has been required for several years using different methods and legislation. These include E-logbooks, paper logbooks, landings declarations, and sales notes. However in reality this has not been self-reporting of catches, but a self-reporting of landings. Although there is space on E-logs and logbooks for the reporting of discarded fish, and a legal requirement to document discards of over 50 kg's for certain species, these are seldom, if ever, completed. This is likely to change under a landing obligation, with fishermen required to declare and land fish that they would currently legally discard. In addition there is a requirement to log interactions with and discarding of those species where landing is prohibited (protected species). However given that this information has not been recorded in the past, it is unclear how consistently this information will be provided in the future, especially with no adequate means of verifying the information supplied. This will limit the uses of this data if some catch records are recorded inconsistently or not at all. These methods of self-reporting catches can only be compared against the catches that come ashore, so if discarding continues to occur at sea undetected and unrecorded, there will be no way to account for this fishing mortality. Therefore by itself, self-reporting does not equate to a fully documented fishery or encourage compliance. It needs to be coupled with the other methods detailed above (e.g. dockside monitoring) so that the self-reported landings can be verified and with at-sea checks (e.g. using 100% sea going observer coverage or REM with CCTV) to ensure that no discarding at sea has occurred, for every fishing event or haul.

**Reference fleets**
In some countries reference fleets have been used to obtain data on fisheries and discards. Generally these have been used to collect scientific data (e.g. Norway) but there are discussions within the UK regarding using reference fleets for compliance purposes. The suggestion is that REM camera systems or observers could be used on a small proportion of the fleet and that these vessels could be used as a benchmark to judge the performance of those vessels without on board monitoring and any discrepancies between catch compositions of these different vessels could indicate potential illegal activity. For example, if a vessel with a camera system on board has a 25% undersize fish catch rate for a particular species, but a vessel without a system has only a 15% undersize catch rate, then the assumption is that the vessel without a system is discarding fish at sea. However it is possible that the vessel without a monitoring system could be fishing more selectively or not encountering the same quantity of undersize fish. Fish move and aggregate in different ways often dependent on size; the ability of the skipper can affect the catch rates; different nets fish differently; identical nets can also fish differently and be affected by local conditions such as tides, weather, swell, wind, substrate type and local features.



If discarding continues to occur at sea undetected and unrecorded, there will be no way to account for this fishing mortality.

With all of these parameters it is difficult to see how a reference fleet for compliance would actually work in practise or how it could be used to detect illegal activity and provide fact based evidence in a prosecution case for the non-monitored vessels. So why are reference fleets being considered as an option? The main reason is to provide a cost saving over sending observers or installing electronic systems on all vessels. However the investment required to investigate all of the potential influencing factors on a case by case basis would be enormous and extremely unlikely to successfully prove that a vessel was discarding fish at sea.

The reference fleet also removes the level playing field as some fishermen will be fully monitored whilst the rest of the fleet will not. Even if the systems/observers are swapped between different vessels this could arguably in some instances encourage only temporary compliance by the vessel carrying the monitoring tool. It would also increase the running costs per vessel of the monitoring programme due to the removal and reinstallation of a system, or the need to have a greater number of observers available and on standby.

## SCIENCE

**Stock assessments**

Self-reported landings data has traditionally been used to calculate stock sizes. However this data did not include information on discarded fish and it is generally accepted that in the past there may have been issues with the misreporting of some landings data. The data for these unaccounted fishing mortalities are necessary to obtain accurate stock assessments and therefore values were estimated based on anecdotal evidence. In addition, if some data is collected by some vessels but not by others it can make the data skewed or even unusable.

**Aerial, Patrol Vessel and VMS Surveillance**

Aerial and patrol vessel surveillance generally do not provide any data for scientific purposes other than a recording of vessel location at time. VMS data can be used to calculate some effort data for use in scientific programmes, e.g. days at sea and number of trips, but number of tows/hauls/sets is less accurate due to interpretation assumptions, as discussed in the Compliance section.

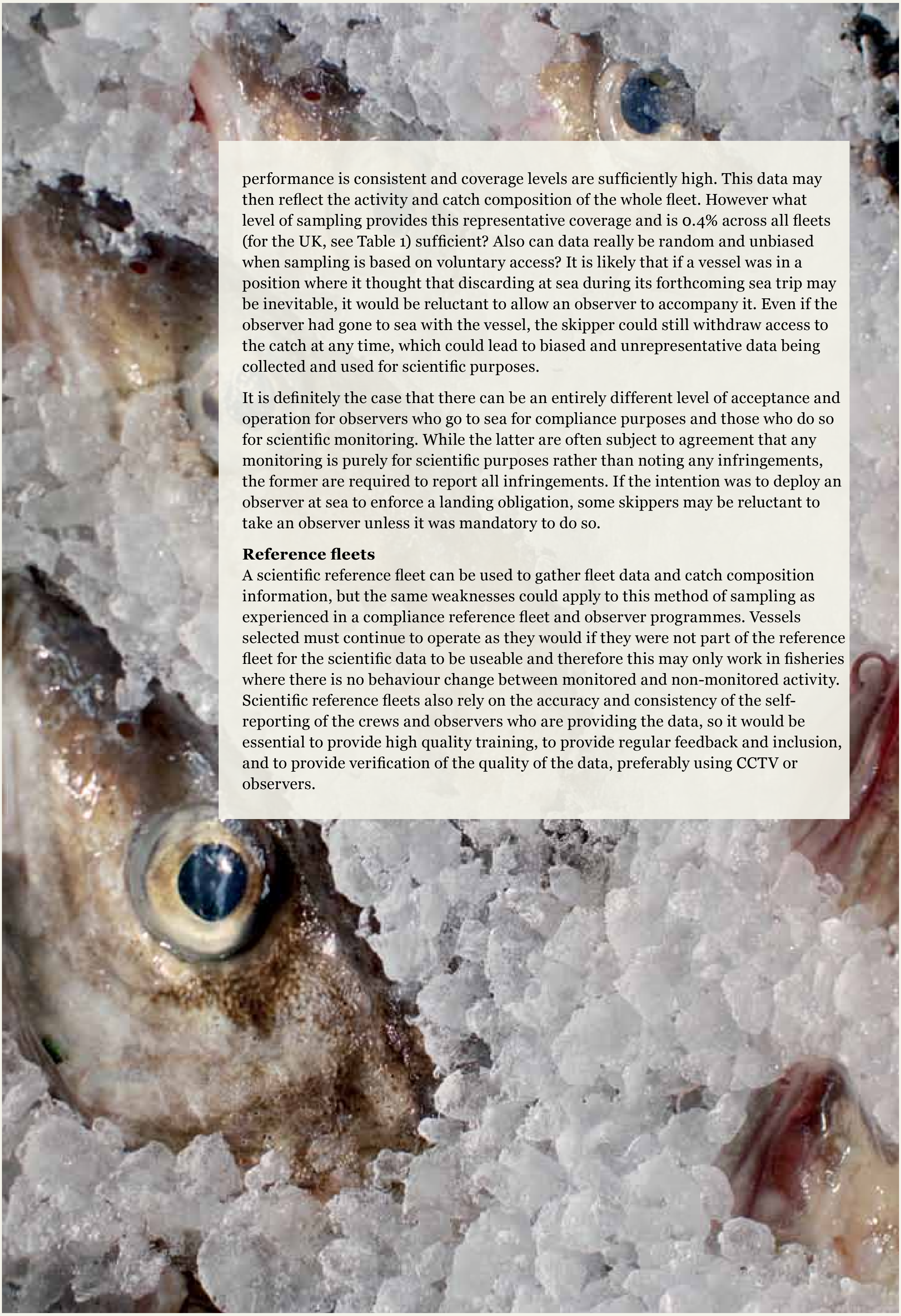
A total of 574 sea trips were undertaken in 2012 by observers which represented 0.4% of the UK total fleet's fishing activity

**Observer programmes**

Scientific observers have been used worldwide to obtain scientific data and to monitor catch rates. In Europe the Data Collection Framework (DCF) details how this should be undertaken and reported. The UK DCF programmes have been operating since 2002, sampling the important fisheries and observers are sent to sea to subsample the catch from as many of the individual fishing activities as they can. Table 1 (in Appendice) shows the sampling levels in 2012 by the UK under the DCF programme. A total of 574 sea trips were undertaken by observers which represented 0.4% of the UK total fleet's fishing activity. The highest level of sampling was by the Northern Irish who sampled 1.9% of the total fishing trips, with England and Scotland each sampling 0.3% of their fishing fleet's sea trips. All countries had fisheries where sampling levels were lower than 0.5% of trips and in some cases no sampling occurred, e.g. Scottish pelagic fleets. This was because the DCF monitoring programme is based on voluntary access and permission to sample this fleet was denied.

If observers were being used to monitor a landing obligation, then access would likely be mandatory and sampling levels would be increased if additional funding was available. However to ensure a level playing field for all fishermen, observer coverage would need to be 100% across all MS involved in a fishery, otherwise some vessels would have all activities monitored whilst others did not.

The data collected from a scientific observer programme is very detailed and observers are usually able to provide catch data for all species caught through the sub sampling of catches, as well as additional biological data such as length, sex, and maturity. They can also collect tissue samples and otoliths/scales for aging purposes. Most observers are extremely able and dedicated professionals although of course these attributes will vary between individuals, which could affect the consistency of a data set and there would be no opportunity to check an individual's observations to detect this. Observer sampling programmes can provide very useful data as long as sampling programmes are designed around a random sampling plan, observer



performance is consistent and coverage levels are sufficiently high. This data may then reflect the activity and catch composition of the whole fleet. However what level of sampling provides this representative coverage and is 0.4% across all fleets (for the UK, see Table 1) sufficient? Also can data really be random and unbiased when sampling is based on voluntary access? It is likely that if a vessel was in a position where it thought that discarding at sea during its forthcoming sea trip may be inevitable, it would be reluctant to allow an observer to accompany it. Even if the observer had gone to sea with the vessel, the skipper could still withdraw access to the catch at any time, which could lead to biased and unrepresentative data being collected and used for scientific purposes.

It is definitely the case that there can be an entirely different level of acceptance and operation for observers who go to sea for compliance purposes and those who do so for scientific monitoring. While the latter are often subject to agreement that any monitoring is purely for scientific purposes rather than noting any infringements, the former are required to report all infringements. If the intention was to deploy an observer at sea to enforce a landing obligation, some skippers may be reluctant to take an observer unless it was mandatory to do so.

**Reference fleets**

A scientific reference fleet can be used to gather fleet data and catch composition information, but the same weaknesses could apply to this method of sampling as experienced in a compliance reference fleet and observer programmes. Vessels selected must continue to operate as they would if they were not part of the reference fleet for the scientific data to be useable and therefore this may only work in fisheries where there is no behaviour change between monitored and non-monitored activity. Scientific reference fleets also rely on the accuracy and consistency of the self-reporting of the crews and observers who are providing the data, so it would be essential to provide high quality training, to provide regular feedback and inclusion, and to provide verification of the quality of the data, preferably using CCTV or observers.

# USE OF CAMERA SYSTEMS

Most camera systems used on commercial fishing vessels for fisheries management include more than just CCTV cameras. A system will usually combine a GPS receiver, a hydraulic pressure sensor, winch rotation sensor, a user interface (e.g. keyboard and display screen), and digital CCTV cameras (Figure 1).

## A BRIEF DESCRIPTION OF A REMOTE ELECTRONIC MONITORING (REM) SYSTEM

Most camera systems used on commercial fishing vessels for fisheries management include more than just CCTV cameras. A system will usually combine a GPS receiver, a hydraulic pressure sensor, winch rotation sensor, a user interface (e.g. keyboard and display screen), and digital CCTV cameras (Figure 1). With these the system is able to determine the activity of a vessel, determine where that activity occurred, accept inputs and comments from the skipper, and record video images of that activity for verification and other purposes. If a satellite communication device is also added to the system, then there is no reason why the GPS and sensor data cannot be sent to shore for near live monitoring. However, video data files are prohibitively large to stream live, so gathered data is usually stored on a removable hard drive which is swapped over at suitable intervals, rather than sent via the satellite option. The imagery can then be used to obtain information on catch handling, discarding practises and catch composition; gather scientific data, verify self-reported information, or to monitor for compliance with regulations.

**Figure 1. Diagram of a remote electronic monitoring system (REM) installed upon a fishing vessel (Courtesy of Archipelago Marine Research Ltd.).**

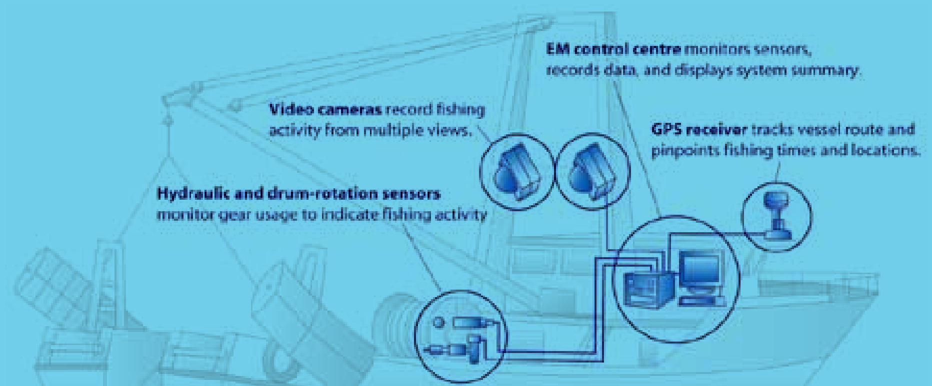



**Figure 2. Cameras installed on fishing vessels**

# USE OF REM WITH CCTV IN COMPLIANCE AND SCIENCE

## USE OF REM SYSTEMS FOR COMPLIANCE

Effective monitoring and recording of activites at sea: Current REM systems available on the market combine video and sensor technology to provide a full picture of fishing activity and catch handling. The sensor data alone can be used to determine exact fishing activity at time and location which can be transmitted ashore using satellite communication devices if required.

However the sensors alone cannot monitor for illegal discarding of fish at sea. By integrating video cameras with the system it is possible to check that the sensors are detecting fishing activity correctly, as well as monitor how the crew sort and handle the catch. REM with CCTV can therefore monitor and record discarding of fish at sea.

**Continuous presence:** The video collected can be brought ashore using portable hard drives and reviewed to quantify the catches which can be compared against the fishermen's logbooks and to ensure that no discarding at sea has occurred. The system can work continuously as long as the hard drives are changed regularly. Sensor data are always recorded whilst the system is switched on and cameras can either run continuously or be triggered to switch on and off based on geographical location or by a fishing related event, such as an increase in hydraulic pressure or winch activity. The cameras are always present and will record the normal catch handling activity of the fishermen. This will encourage compliance and the use of better sorting and handling processes as a normal part of the working process and act as a deterrent to any potential non-compliant activity, all of the time. Camera systems also record information for the full catch and not just the landed portion, which will provide evidence that fishermen land all that they catch under a landing obligation regulation, rather than discarding fish at sea.

This addresses one of the major shortcomings of aerial and sea patrols – that there is no way to determine whether or not non-monitored fishing effort is operating in the same way as monitored activity. Fishermen can often detect patrol activity in advance of any 'surprise' boarding or presence which means that any non compliant activity could be stopped when the patrol was in the vicinity. This is also the case for observer monitoring programmes for compliance purposes. Moreover there is no way to verify that at sea observers have correctly identified and reported what they have encountered at sea or that non-observed fishing events (during observer rest periods) are compliant. REM systems can verify this data and the video from non-inspected fishing operations could be reviewed if required. Alternatively REM could be used instead of an at sea observer because all fishing activity could be reviewed ashore if desired.

Table 2 reviews the different data gathering and monitoring options to determine the most suitable method for monitoring compliance with a landing obligation.

**Not influenced by weather or other seagoing conditions:** Unlike at-sea and aerial surveillance, camera systems do not cease if the weather is bad or if fuel is limited and they don't rely on fishermen being unaware of them to detect non-compliance or fully aware of them to encourage full compliance.

**Efficient and accurate data gathering:** Using an REM camera system to monitor a fishery or fleet allows accurate and near real time (if required) sensor data to be gathered and provided to enforcement agencies on fishing time, position and activity. REM system sensors do not rely on an interpretation of speed to determine fishing activity (unlike VMS) and they do not rely on self-reported fishing effort (logbooks), which can often generalise such things as fishing time (e.g. all hauls always reported as 4 hours tow time), or have the possibility of introducing human error during inputting of information. The camera systems of REM provide video imagery that can be used to gather information on catch quantities which can either be compared to self-reported data or used in their own right.

For self-reported catch data to be trusted and used it needs to be checked for compliance and accuracy.

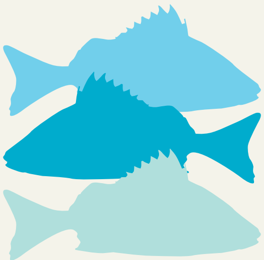
**Potential to incorporate catch weights:** If a REM system also incorporated a weighing system it would remove the need to estimate catch weights as these could be digitally stored as part of the dataset. REM systems can be used cost effectively to verify self-reported data such as logbooks (as in Canada) and also provide video for all fishing operations undertaken.

**Risk based monitoring:** If the REM systems are installed on every vessel in a fishery or fleet, then reviewing of the video can be undertaken on a random or targeted audit, in line with available budgets. This would introduce a "spot check" effect where fishermen would not be able to predict which fishing events are going to be reviewed. The percentage of video footage reviewed can be varied depending on how high a risk the potential infringement level of an operation is considered to be.

**High quality evidence:** Where required the sensor and video data can be used as evidence in prosecution cases and can be reviewed as often as is required by different reviewers to ensure consistency of interpretation and quality assurance of analysis. It can also be used to demonstrate cases where, despite best efforts, problems remain in terms of regulatory implementation. For example taking a case to the European Commission or other Member states regarding ongoing implementation problems can use video technology to provide evidence, depending on the nature of the case.

Most importantly none of the other methods of monitoring provide an opportunity to view 100% of a vessel's at sea activity in order to review implementation or detect potential infringements. This is evidenced by the fact that neither England or Scotland (the countries reviewed in this report) have caught or prosecuted a vessel high grading fish at sea despite the existence of a high grading ban and despite high levels of discarding above the MLS being reported through scientific observer programmes (European Commission, 2011).

**Operational efficiency savings:** Using an REM system could also present significant efficiency savings by removing the need to carry out some of the other monitoring procedures detailed above. For example, where aerial surveillance is used to check vessels are not fishing in a closed area, REM can replace this need by automatically plotting the fishing positions as generated by sensor data and if illegal activity is suspected in this area then video footage can be reviewed. Also, if the total catch (including the quantities to be landed or retained as undersize) can be determined by reviewing the video footage and the opportunity to discard at sea unobserved is removed from a vessel by having cameras observing the sorting processes, then there would be little or no need for any aerial or at sea patrols because these checks could be undertaken in an office whilst reviewing the video footage. There could still be a requirement to have aerial and patrol vessel monitoring if visiting vessels are not monitored with REM, however this effort could be reduced and targeted where required. In addition if the patrol vessels and aircraft are owned assets and there is now spare capacity, then these could also be made available for other work streams or outsourcing to other agencies/countries.REM systems can provide 100% monitoring of fishing effort unaffected by sea conditions or human error. Dockside monitoring programmes could also be reduced significantly as there would be no need to inspect catches during landing. Instead these resources and visits could be reduced and effort redirected to REM video review. Or they could be used to gather biological samples for length and age determination (scales and otoliths) or to check that the correct fishing gears are being used.



REM systems with cameras can provide full monitoring of a landing obligation for up to 100% of the fishing effort

REM systems can even be used by the skipper to help observe the activity and performance of the crew for safety reasons or performance issues. The only area where aerial and at sea patrols have an added benefit is in being able to monitor those vessels not able to operate REM or visiting vessel that are nationals of a country where REM is not being used. But if all vessels in Europe adopted REM there would be a reduced need for these other surveillance methods.

**Added value:** Fishing vessels with REM systems aboard may also be able to use the information gathered for economic benefit. Many fish buyers and food processors are conscious of and respond to the public's demand for traceability and sustainability. Although current requirements to complete logbooks is technically a fully documented fishery (FDF) there is little or no verification that what is documented is accurate. Using a REM system with CCTV provides a tool to verify all declared catches as well as document bycatch interactions. It allows transparency that can be verified at any time. Vessels that carry these systems can demonstrate best practise at sea and provide evidence that supports all self-declarations. They are able to demonstrate that they are fishing in a responsible and verifiable way by providing evidence of full product traceability. A good example is given by Kindt-Larsen et al., 2012, which states that Danish gillnet fishermen are volunteering to have video monitoring systems on board to demonstrate limited levels of harbour porpoise bycatch, with no financial incentive. By doing this, these vessels should be the preferred raw product supplier to those merchants and processors who wish to show the public that they are listening to their demands and to demonstrate sustainability.

Accreditation schemes may take account of fishers operating with REM and CCTV equipment as they are showing that they are doing everything possible to fish sustainably and fairly. If all vessels in a fishery have a system on board it provides a level playing field and could help a fishery attain accreditation to an internationally recognised standard such as the Marine Stewardship Council (MSC), which in turn could lead to an increase in value for this product over alternative suppliers.

## USE OF REM SYSTEMS – SCIENCE

**Scientific data collection:** REM systems can be used to gather useful scientific data. The sensors provide independent data on position and track of the vessel during a voyage, the exact fishing location, the number of fishing events and the duration of fishing effort, without the need to use data supplied by the vessel's crew. In addition, the stored video imagery allows the shore based analyst to estimate the total volumes, weights or counts of catch retained aboard the vessel.

This type of data is essential for use in stock assessments as it can provide catch per unit effort information. It also allows the analyst to view discarding activities at sea and quantify the amount of fish being discarded by species.

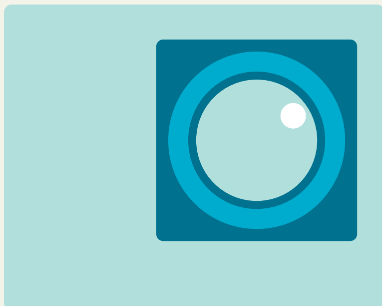
Some REM systems also have an imbedded measuring tool which can allow species to be measured for length, although there can be limitations to this tool's use. For example, each individual fish needs to be presented in the correct orientation and with the whole of the fish viewable and available for measuring. However, if the presentation of the fish can be managed by altering handling procedure or deck machinery, then length frequency data should be achievable. There are other limitations to using REM systems with cameras for scientific sampling though. It is not always possible to identify every individual fish and species (e.g. distinguishing between spotted and reticulated dragonet, or sand sole and Dover sole, would be nearly impossible); you cannot collect physical biological samples; visual sexing of some species (e.g. elasmobranchs, brown crab) can be achieved but not for all individuals caught; you cannot change the presentation of the fish to obtain a better observation or measurement; the interaction with the crew and skipper is removed thus reducing anecdotal evidence gathering and feedback; and you cannot undertake physical measurement checks of the fishing gear deployed in fishing gear selectivity trials.

It is possible however to gather information for the full duration of a trip, for all trips undertaken, which can then be subsampled according to the financial resources available. The data and video stored on the hard drives are also available for review by several different analysts to ensure correct interpretation and results. Additional information can also be gathered on interactions with protected or prohibited species, birds and sea mammals, which, as discussed earlier may not normally be provided by the vessel. Combining an REM camera system with a fully documented fishery and/or landing obligation, it is possible to ensure that all portions of a catch are reported, accounted for and verified. Having accurate and independently verified data for all parts of a catch, can only improve stock assessments.

**Key advantages:** There are many reasons where a video REM system with cameras would be a preferable method of collecting scientific data over other methods. If long term or large scale monitoring is a requirement of the research project then a camera system would be far cheaper than sending observers to sea to monitor all trips. If the programme involves fishermen self-reporting information, then the accuracy of this data can be checked using REM system and thus remove any accusations of falsifying records due to a vested interest in the results. In addition, REM systems do not get seasick, they don't rely on skippers to provide data, they don't cost as much as sending observers to sea long term, they don't require training or need to be provided with safety equipment, they don't get injured, they can't be influenced, bribed or threatened, and they don't need rest periods. The sensors can capture data without the need for human input or transcribing information, which helps to eliminate a potential source of error. One of the main advantages of using a REM system with CCTV cameras over other methods of collecting fisheries data, is that the video and sensor data can be reviewed as many times as is required. Once the data is captured one can decide what review coverage levels are adequate without having to redo the whole experiment if you have not gathered enough information. It is possible to have different shore based staff review the video footage to ensure that observer bias is detected and eliminated. Research projects can also be extended to monitor long term effects independently, rather than rely on one or two scientifically observed sea trips followed by unverified skipper self-reporting. Sensors can also be tailored to the experiments to help automate the data collection process as much as possible. There may even be the opportunity to re-use the video collected for more than one project, for example, monitoring compliance, discard observing, bird bycatch monitoring, cetacean bycatch monitoring, or logging and validating rare species encounters.

**Addressing observer safety:** One of the main concerns with observer programmes is staff safety. Before being allowed to go to sea for solo sampling, most observers are provided with comprehensive safety training and personal protective equipment, as well as being trained in fish identification and sampling techniques. Equipping and maintaining staff with these skills and equipment is expensive and time consuming. Most certificates require updating, most equipment needs regular servicing, changes in staff leads to additional training and equipment needs, and there needs to be comprehensive emergency response plans and communication procedures in place and monitored. Very little of this is required if the observer is based in an office reviewing video footage and sensor data. With this electronic alternative available it is difficult to justify why an observer would be sent to sea as a first choice monitoring option.

**Potential limitations:** There are currently some limitations to using REM for science. These mainly centre on collection of physical samples and getting fine detailed data, such as distinguishing some of the smaller non-commercial species (e.g. gobies or dragonets) or obtaining exact length and weight measurements. Biological sampling could be achieved through dockside sampling programmes, additional electronic equipment could be added to a REM system (e.g. motion compensated scales, electronic measuring boards, inbuilt on-screen measuring tools), or even through fisher self-sampling with camera verification of the activity. Scientists should regard REM systems as another data gathering tool and determine if the data these systems collect are sufficient for the needs of their project.



**REM SYSTEMS DON'T GET SEASICK, THEY CAN'T BE INFLUENCED, BRIBED OR THREATENED, AND THEY DON'T NEED REST PERIODS**

**Table 2. Comparing the benefits and shortcomings of the different monitoring options.**

| System | Main benefits | Main shortcomings | What can be addressed by REM |
|---|---|---|---|
| **AERIAL SURVEILLANCE** | 1. Can observe non-national vessels.<br>2. Can observe vessels not suited to REM monitoring.<br>3. High visibility deterrent whilst in the vicinity | 1. Short time spent in vicinity of vessel and therefore only a short term deterrent.<br>2. Unlikely to pick up discarding event.<br>3. Cannot identify species readily.<br>4. Affected by poor weather.<br>5. Behaviour change - effective communication between vessels meant they can be forewarned and change behaviour.<br>6. Not a major disincentive to discard.<br>7. High cost for low quality data returns. | 1. REM 24/7 coverage.<br>2. REM is capable of identifying and recording non-compliant behaviour.<br>3. REM provides video to allow species identification by shore based observers.<br>4. REM still functions in poor weather conditions.<br>5. Acts as an effective deterrent to illegal activity as present and recording 24/7.<br>6. Constant and effective monitoring by REM provides an incentive to be compliant and not discard.<br>7. Provides for high quality monitoring for less cost. |
| **PATROL VESSEL SURVEILLANCE** | 1. Can observe non-national vessels.<br>2. Can observe vessels not suited to REM monitoring e.g. vessels with no suitable power source.<br>3. Can check that fishing gear being used is compliant.<br>4. High visibility deterrent whilst in the vicinity | 1. Short time spent in vicinity of vessel and therefore only a short term deterrent.<br>2. Unlikely to pick up discarding event.<br>3. Cannot identify species readily.<br>4. Affected by poor weather.<br>5. Behaviour change – effective communication between vessels meant they can be forewarned and change behaviour.<br>6. Not a major disincentive to discard.<br>7. Safety risk to compliance boarding officers. | 1. REM 24/7 coverage.<br>2. REM is capable of identifying and recording non-compliant behaviour.<br>3. REM provides video to allow species identification by shore based observers.<br>4. REM unaffected by weather conditions.<br>5. REM acts as effective deterrent to illegal activity as present and recording 24/7.<br>6. Constant and effective monitoring by REM provides an incentive to be compliant and not discard.<br>7. No boarding of vessel required so the safety risk is eliminated. |
| **AT-SEA COMPLIANCE OBSERVERS** | 1. Detailed information can be gathered.<br>2. Biological sampling can be undertaken at sea. | 1. Observers can be influenced or intimidated whilst at sea.<br>2. Personal safety risk to observers.<br>3. Can seldom sample all hauls on a trip due to tiredness, poor weather, and illness.<br>4. To sample every vessel and every trip would be extremely costly.<br>5. Sub-sampling vessels, trips and hauls may not be representative of normal activity because crew are fully aware of the observer presence.<br>6. Sub sampling of the catch with haul may not be representative.<br>7. No opportunity to quality assure the data gathered at sea. | 1. REM cannot be intimidated or influenced.<br>2. REM removes the safety risk to staff.<br>3. REM can record data and imagery for all hauls and trips undertaken by a vessel.<br>4. The cost of sampling every vessel, every trip and every haul is less using REM than at-sea observers.<br>5. Sub-sampling is likely to be more representative as crew will not know which hauls or trips are to be reviewed.<br>6. Generally reviewers will monitor the whole haul and not subsample within a haul.<br>7. The data is available for subsequent quality assurance reviews. |
| **SELF-REPORTING BY VESSELS** | 1. Data can be gathered by ALL vessels.<br>2. Generally low cost to governments. | 1. Data needs to be input if paper records.<br>2. Generates an additional task for fishermen to perform.<br>3. Records cannot be verified for accuracy.<br>4. Potential for bias due to self interest in results. | 1. REM does not require data to be manually input.<br>2. REM collects all necessary information automatically.<br>3. Allows verification of any declarations.<br>4. No self-interest if data is independently reviewed. |

## EXAMPLES OF FISHERIES THAT UTILISE REM AND CCTV

### The use of cameras as part of a REM system is not new and this technology has been successfully employed worldwide for nearly 15 years, to ensure compliance with regulations that require vessels to land the whole catch.

Zollett et al. (2011) states that "where 100% retention of catch is required, at-sea monitoring may be less complicated and more easily accomplished through the use of technology (e.g. a camera system)". Camera systems are being trialled worldwide as a serious alternative to using at sea observers or more traditional monitoring techniques and in some fisheries REM has been successfully used in operational programmes to ensure compliance with regulations for several years. Mangi et al. (2013), states that there were 33 pilot trials to date and operational systems in 8 countries. Some of the examples named include;

**•The British Columbia Hook and Line Groundfish fishery** – The hook and line fishery and trap fishery requires fishermen to self-report catch data and vessels are monitored using REM systems with cameras and it mainly targets halibut. 10% of the video collected is reviewed to ensure compliance with regulations and if an anomaly is observed then up to 100% of a vessel's video can be reviewed, at the vessel's expense. In 2013, the entire fleet of approximately 200 vessels, 1200 sea trips and 10,000 days at sea were fully monitored. In comparison the offshore trawl fisheries associated with the Groundfish fishery are required to carry an observer on 100% of all trips at the expense of the vessel. This observer cost is higher than the REM system option. These fisheries have been successfully monitored in this way since 2006. A fuller review of this fishery is provided in Stebbins (2009) and McElderry et al. (2003).

**•Alaskan Rockfish Fishery** – The Alaska region has had success with the use of REM for compliance monitoring in several fisheries including the Alaskan pollock fishery, Rockfish, and Pacific cod freezer longline fishery in the Bering Sea. In 2008, Bonney and McGauley, tested electronic monitoring in the Kodiak-based rockfish fishery to estimate quantities of at sea halibut discards, and concluded that using video monitoring is sufficiently accurate and precise for management needs when compared to estimates obtained from the current observer sampling methods. In all of these cases, EM is being used to verify compliance with regulations for catch sorting and weighing. REM has also been trialled on the West Coast trawl fishery for hake to successfully ensure compliance with a discard ban (Loefflad, et al., 2014). In this project, the video appears to be able to detect most discard events although some occurred outside of the camera views and estimating quantities of slippage or drop-outs was not possible (also termed "operational discards"). On smaller vessels additional cameras could be set up specifically to observe drop outs, perhaps by mounting the camera on an outboard pole which is swung inboard during docking operations and to avoid collision. Intentional slipping of the catch is more difficult to quantify but weights could be estimated by linking net sensor information (if the vessel has these installed and usually only applicable to trawlers) to the REM system to estimate weights. Accidental slipping through net damage could also be quantified in this way but perhaps in this situation escaped catches should not count against quota because it was an unintentional loss.

**•Australia** – Trials have been undertaken on gill net fisheries, in particular to assess the performance of REM systems against at sea observers (Evans and Moloney, 2011). It was concluded that with additional tuning and regular maintenance of the EM equipment (particularly the camera), it is likely that the identification of all catch to the appropriate taxonomic level could approach 100%. The study also concluded that EM was cheaper than using at sea observers but that the data collected was less detailed. It has also been recently announced (2nd March 2015) that electronic monitoring will be installed to monitor all vessels participating in the Australian Gillnet Hook and Trap (GHAT) and the Eastern and Western Tuna and Billfish fisheries (ETBF and WTBF), to provide greater insights into Australia's fishing operations, effective management and fishery sustainability (AFMA, 2015).

**•Denmark** – The Danish were the first country to undertake trials using REM systems with CCTV cameras in Europe in 2008 (Ulrich et al., 2015) operating on their demersal trawl fisheries. Between 2010-12 these became coordinated with the trials in the UK and Germany (also on demersal trawlers) with a focus on cod as a catch quota species. In 2011 trials were conducted on over 20 vessels, for 80,000 hours at sea, in excess of 1,100 fishing trips and approximately 9,800 fishing operations (Dalskov et al., 2012). During these trials the REM system performed very well with only a 0.2% video data loss due to power failures on board the vessel although the highest risk of data loss is through mailing of completed hard drives and the robustness of some sensors (e.g. the winch rotation sensor) (Dalskov et al., 2012). These could be reduced by redesigning the sensors or using a tracked courier service for hard drive exchange. Trials have also been undertaken to test the efficacy of using REM to monitor incidental bycatch of cetaceans in Danish gill net fisheries. Results obtained using REM with CCTV were more reliable than results provided by fishermen because in many cases, crew did not observe the bycatch at deck level as it had already dropped out of the net before coming on board. They also concluded that REM use on these vessels allowed very high coverage at a low cost, and was approximately 6.7 times cheaper than using observers (Kindt-Larsen et al., 2012). Ulrich et al., (2013) showed the different landings of demersal trawlers before and after joining the catch quota scheme. With cameras on board it landed more small (grade 5) cod than it did without cameras. This would suggest that the opportunity to discard the smaller less valuable grade 5 cod (sometimes referred to as high grading) at sea without detection, was removed by installing a camera system and operating under a discard ban situation. Ulrich et al., (2015) found that the use of REM as a control and documentation tool for obtaining accurate reporting of discards in logbooks has great potential as a cost-effective and wide-covering monitoring programme. Additionally they state that counting discards against quota increases the incentive to underreport undersize fish if there are not proper controls in place and discards need to be estimated accurately.

**•New Zealand** – Several trials have been conducted in New Zealand using REM systems with cameras to collect fishery data and monitor protected species interactions. These include trials on set net vessels and trawlers (McElderry et al., 2007; McElderry et al., 2011). These studies demonstrated that EM systems operated very reliably on inshore set net and trawl vessels and could be used to effectively monitor dolphin encounters in both fisheries. The set net imagery could also be used to identify the majority of fish catch to species or species group (McElderry et al., 2007). McElderry et al., 2011), found that using electronic monitoring was approximately 40% of the cost of using at sea fishery observers during its comparative trials. The report also suggested that the results of REM programmes can be better improved through monitoring agencies carefully determining their monitoring needs and establishing good working relationships with the fishing industry.

**•The United Kingdom** – In the UK trials using REM systems with cameras have been carried out in England and Scotland since 2009, on different fleet segments and fisheries. In Scotland the main focus has been on the offshore otter trawl fisheries that target mixed gadoid species with a requirement to land all cod caught, as well as in the Refrigerated Sea Water (RSW) pelagic trawl fishery. In addition Scotland has investigated using the cameras to capture scientific data that can be used in stock assessments and to gather data on discard rates and fish length (Needle et al., 2015). Trials are also underway to test the use of REM on small shellfish potting vessels operating in inshore waters off the North West of Scotland to provide scientific data and verify self-reporting (Seafish, 2014). England also focused on North Sea cod initially but they extended their Catch Quota Trials to include gillnet caught North Sea cod, sole and plaice in the English Channel beam trawl fishery, Celtic Sea haddock in the otter trawl fishery, and under 10m vessel trials in the Irish Sea otter trawl fisheries (Roberts et al., 2015; Roberts et al., 2014; Course, 2012). There were also limited trials in an inshore longline fishery, a pelagic freezer trawl and on an offshore scallop dredger. One English pelagic freezer trawl is now operating under the landing obligation with a fully operational REM system with cameras. It was found that obtaining counts of fish discarded and landed was extremely successful for most species, especially on the lower volume high value fisheries e.g. gill net cod, longlines, beam trawl fisheries with a conveyor fish handling system. Converting these counts to weight was more problematic. On larger volume fisheries counts of baskets of fish retained and discarded could provide good estimates of weights. Good correlation was found between skipper estimates of catch and estimates obtained from video review. In addition the catch quota trials showed that fishermen were prepared to use more selective gears to reduce the catches of unwanted small fish. So far no trials are known to have been carried out in Wales or Northern Ireland.

## THE USE OF CAMERAS AS PART OF A REM SYSTEM IS NOT NEW AND THIS TECHNOLOGY HAS BEEN SUCCESSFULLY EMPLOYED WORLDWIDE FOR NEARLY 15 YEARS

# COSTS OF MONITORING A LANDING OBLIGATION

Most fishermen agree that the success of any regulation is ensuring that all fishing vessels operating in a fishery are governed by the same rules and level of monitoring, to ensure that there they are operating on a level playing field.

Many of the fisheries that UK fishermen are engaged in for example are also prosecuted by other Member States. For the landing obligation to be implemented effectively and fairly across Member States it will therefore be critical to address European fleets and fisheries in a consistent manner. Here we look at what the potential cost implications of introducing REM systems could look like using the UK as a case study.

## THE UK FISHING FLEET

One option for the application of electronic monitoring for the landing obligation would be to focus on fleet segments based on vessel size. The benefit of this approach is that even if a vessel switches location or fishery due to such things as the seasonality of a fishery or because it has been sold, the vessel's activity is still able to be monitored and recorded using the camera systems. For example, a 16m North Sea otter trawler may wish to target cod and saithe in the winter but carry out pipeline guard work in the summer from time to time. By having a REM system with cameras on board, regulators can check that the vessel was undertaking guard work as stated and concentrate video review to the fishing activity only, without the need to install or remove the hardware. Similarly, the same situation would apply if the vessel was fishing in a different sea area or for a different species.

The information provided in Table 3 and Table 4 has been adapted from the UK Sea Fisheries Statistics – 2013 (MMO, 2014).

**Table 3. The UK fishing fleet by country of administration and split into vessel length class, in 2013.**

| Country of Administration | 8m and Under | 8.01 – 10m | 10.01 – 15m | 15.01 – 18m | 18.01 -24m | Over 24m | Total |
|---|---|---|---|---|---|---|---|
| England | 1777 | 825 | 380 | 38 | 56 | 80 | 3156 |
| Scotland | 978 | 469 | 226 | 107 | 131 | 136 | 2047 |
| Wales | 324 | 118 | 25 | 3 | 1 | 6 | 477 |
| Northern Ireland | 137 | 97 | 38 | 33 | 55 | 19 | 379 |
| Islands[1] | 249 | 45 | 14 | 8 | 2 | 0 | 318 |
| Total[2] | 3465 | 1554 | 683 | 189 | 245 | 241 | 6377 |

1 Islands includes Isle of Man, Guernsey and Jersey.
2 An additional 22 vessels are currently not administered because they are new or changing administrations.

**Table 4. The UK fishing fleet by country of administration and split into vessel length class, shown as a percentage contribution to each fleet segment along with an overall contribution to the whole UK fleet, in 2013.**

| Country of Administration | 8m and Under | 8.01 – 10m | 10.01 – 15m | 15.01 – 18m | 18.01 -24m | Over 24m | % of UK Total |
|---|---|---|---|---|---|---|---|
| England | 56 | 26 | 12 | 1 | 2 | 3 | 49 |
| Scotland | 48 | 23 | 11 | 5 | 6 | 7 | 32 |
| Wales | 68 | 25 | 5 | 1 | 0 | 1 | 7 |
| Northern Ireland | 36 | 26 | 10 | 9 | 15 | 5 | 6 |
| Islands[1] | 78 | 14 | 4 | 3 | 1 | 0 | 5 |
| Total[2] | 54 | 24 | 11 | 3 | 4 | 4 | 100 |

1 Islands includes Isle of Man, Guernsey and Jersey.
2 An additional 22 vessels are currently not administered because they are new or changing administrations.

# COST OF REMOTE ELECTRONIC MONITORING (REM) WITH CCTV

It is unlikely that all registered vessels in the European fishing fleet will be equipped with electronic monitoring. Some vessels will not have a reliable power supply to run the system, others may not be commercially active, and some may not present a risk to the fish stocks covered by the regulations. However, there may be certain fisheries or class of vessels where high levels of monitoring should be considered and where the use of REM with CCTV will be the most cost effective approach. To try and illustrate the possible costs associated with electronic monitoring, the UK fleet will be used as an example.

**System Costs**

Table 5 shows the typical costs associated with the supply and installation of a typical REM system and is based on recent quotes (September 2014) received from an internationally renowned supplier. In relation to hardware costs it is also important to note that Defra has stated in their recent Demersal Species Landing Obligation Consultation Document (Defra, 2015) that the European Maritime and Fisheries Fund (EMFF) is likely to supply 90% of the funding associated with the purchase of electronic monitoring systems. In addition it also states that all video review, hard drive management and system maintenance would be provided by the MMO out of current resources. For the purposes of this exercise it is assumed that EMFF grant funding will only include hardware costs. Installation, running costs, video review costs or software licences are not covered. However should these items also be included or provided out of current compliance agency resources, then the final costs will be at least 90% less than those shown in Table 5 and 6.

**Table 5. Purchase and installation costs of an REM system with CCTV per vessel.**

| ITEM Description | Cost (£) | 90% EMFF Contribution (£) | Actual Additional Cost (£) To UK Government | Cost per Year[1] (£) |
|---|---|---|---|---|
| REM hardware - Camera System[2] | 6000 | 5400 | 600 | 120 |
| Installation Costs[3] (Dinsdale, 2013) | 2400 | 0 | 2400 | 480 |
| 2 Additional Hard Drives per Vessel | 90 | 81 | 9 | 1.80 |
| Total | 8490 | 5481 | 3009 | 601.80 |

1 Assumes a 5 year lifespan. 2 Includes 4 x digital cameras, GPS assembly, rotation laser sensor assembly, hydraulic pressure sensor assembly, POE switch, vessel software, 300m Cat5 cable, power cables, 2x 1TB Hard drives).
3 Assumes this cost is not included in the normal running costs, is not to be paid by the owner and is not eligible for EMFF funding.

In addition to the purchase and installation costs shown in Table 5, there are running costs associated with a REM system which include hard drive swapping, system maintenance, video review and monitoring, data handling and storage and reporting of results (although Defra's Consultation document states that the MMO will meet these costs from existing monitoring and enforcement budgets for the English fleet). No EMFF funding is thought to be available for these additional costs. Table 6 shows associated costs with running each REM system.

**Table 6. Running costs associated with maintaining a REM system with CCTV and reviewing gathered data.**

| ITEM Description | Cost per Year (£) Per Vessel |
|---|---|
| Hard Drive Swapping (Courier Service)[1] | 120 |
| Maintenance Costs[2] (Dinsdale, 2013) | 1200 |
| Video Analyst Salary[3] | 2,500 |
| Review Software Licence[4] | 275 |
| Total | 4095 |

1Assumes monthly hard drive swap at £10/month per vessel. 2Includes annual service and regular checks of system as well as any ad hoc repairs. 3Based on a salary of £20,000 per year and one analyst being able to undertake 10% video review, data entry and reporting for 8 vessels per year, does not include overheads and other staff costs. 4Annual cost of £2200 per licence and 8 vessels per analyst

By combining the costs shown in Tables 5 and 6 it can be calculated that the cost of buying and installing a REM camera system and reviewing the data for a year at a 10% of effort review rate, without a contribution from EMFF, is approximately £5793 per vessel per year. This is calculated by dividing the total of £8490 (Table 5) by 5 years (lifespan of system) and adding the annual running costs of £4095 (Table 6). If EMFF provides 90% of the hardware purchase costs, as expected by the UK government (MMO Demersal consultation Document), then the cost reduces to approximately £4697 per vessel per year (Table 7). Table 8 shows the estimated cost to monitor all of the vessels described in Table 3 for the 2013 UK fleet and using the EMFF subsidised cost. This gives a total cost of approximately £30m to monitor all segments and nations and review 10% of the video. However it is unrealistic to include the under 8m fleet because they contribute very little to the UKs total landings by weight, yet make up more than 54% of the costs shown. This would revise the cost down to approximately £13m. If the under 10m fleet was also excluded, the estimated cost to monitor 10% of the >10m UK fleet's fishing effort would be approximately £6.4m, half of which is attributed to the 10.01 – 15m fleet. And if these were removed (leaving only the over 15m vessels) the cost would be approximately £3.17m (see Table 7). Even if there was no contribution by EMFF, the total cost for monitoring the >10m fleet would be approximately £7.87m (1358 vessels at £5793/vessel) per year. These costs include purchase of equipment, installation and maintenance of equipment, software licences, hard drive management, video review at 10% of fishing effort and data entry/reporting of results.

**Table 7. Estimated costs to monitor (at 10% video review rate) the over 10m UK fleet and the over 15m UK fleet**

| | Cost per Vessel per Year | Cost for >10m UK fleet | Cost for >15m UK fleet |
|---|---|---|---|
| Number of Vessels | 1 | 1358 | 675 |
| Without 90% EMFF | 5793 | £7.87m | £3.91m |
| With 90% EMFF | 4697 | £6.38m | £3.17m |

*90% EMFF covering hardware purchase costs only.

**Table 8. The estimated cost required to purchase, install, maintain and monitor (at 10%) each segment of the UK fleet and the individual national totals (£'000s), with EMFF providing 90% of the hardware cost.**

| Country of Administration | 8m and Under | 8.01 – 10m | 10.01 – 15m | 15.01 – 18m | 18.01 -24m | Over 24m | Total |
|---|---|---|---|---|---|---|---|
| England | 8347 | 3875 | 1785 | 178 | 263 | 376 | 14824 |
| Scotland | 4594 | 2203 | 1062 | 503 | 615 | 639 | 9615 |
| Wales | 1522 | 554 | 117 | 14 | 5 | 28 | 2240 |
| Northern Ireland | 643 | 456 | 178 | 155 | 258 | 89 | 1780 |
| Islands[1] | 1170 | 211 | 66 | 38 | 9 | 0 | 1494 |
| Total[2] | 16275 | 7299 | 3208 | 888 | 1151 | 1132 | 29953 |

1Islands includes Isle of Man, Guernsey and Jersey. 2An additional 22 vessels are currently not administered because they are new or changing administrations.

As an additional cost to fisheries monitoring programmes for compliance and science, the £6.4m to introduce REM as an additional monitoring tool on all UK vessels >10m may be an unaffordable burden. But using the camera systems instead of other traditional monitoring tools could provide the financial savings required to equip the fleet with REM and undertake the 10% video review. It should also be remembered that although 10% coverage has been used as the example, there may be no need to undertake this level of sampling because the camera systems should act as a deterrent to non-compliance and there may be little risk of discarding in some fisheries. Available resources could be directed at high risk fleets or overall percentage coverage could be reduced. For example, dropping to 5% video review would increase the number of vessels managed by an analyst and reduce the cost per vessel to £2649, which to monitor the >10m fleet would result in a revised cost of approximately £3.6m, a 44% cost saving.

**The European Fleet**

For monitoring of the landing obligation to be successful, it is essential that a "level playing field" approach is taken, otherwise some vessels will feel unfairly subjected to monitoring and may try to circumvent any monitoring measures imposed on them whilst other vessels in the same fishery avoid them.

Table 11 (in the Appendix) shows the number of vessels in the European fishing fleet broken down in to fleet segment by length. This includes the UK fleet. The total fleet size is 87,108 vessels, of which 68,256 (78%) are below 10m in length. Countries with high numbers of smaller vessels in their fleet include Italy, Greece and Croatia in the Mediterranean, and Portugal, Spain and France in the Mediterranean and elsewhere. Spain and Italy have the highest number of over 24m vessels with a combined total of 37% of the total of >24m EU fleet. Overall there is a total 18,852 vessels greater than 10m of which 8443 vessels are >15m length.

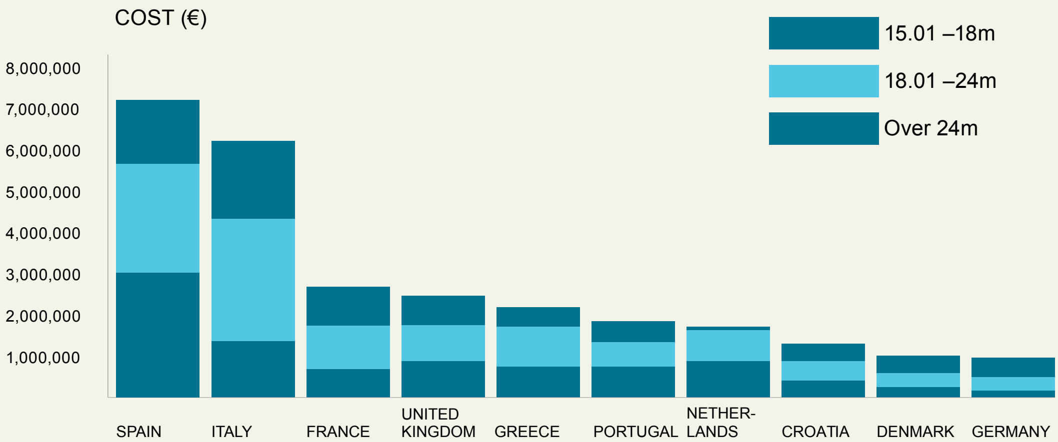
## Costs of Monitoring the European Fleet with REM and CCTV

Using the costs detailed earlier for the UK fleet it is possible to provide an estimate of the total cost to install and monitor the whole European fleet (including the UK). It should be noted that this is a simplistic estimate based on an average cost and number of vessels and it is acknowledged that there will be large fluctuations in local costs due to a range of factors, including national standards of living, remoteness of some fishing fleets, vessel distribution and travel costs, and local expertise. It is also recognised that large numbers of the smaller vessels will not be equipped with suitable and reliable power sources and therefore will not be able to support a REM with CCTV monitoring system.

*Based on Bank of England exchange rate of £1 = 1.3847 euro

To install and undertake 10% analysis of video on a fishing vessel the cost was estimated at £4697 (equivalent to 6504 euros per vessel* – see Table 7). If this cost was applied to the whole European fleet of 87,100 vessels then the total cost would be approximately £409m (566m euros – see Table 12 in Appendix). However if the systems were only installed on the >10m fleet the cost would be reduced to around £88m (122m euros), or on the >15m fleet only it would be further reduced to around £39m (54m euros). If the video review rate was reduced to 5% then the costs are further reduced to £50m (69m euros) for the >10m fleet and £22.4m (31m euros) for the >15m fleet, based on the estimated cost of £2649 per vessel (3668 euros – see Table 13 in Appendix). These estimated costs are shown for the top 10 countries with the highest number of over 15m vessels in Figure 3.

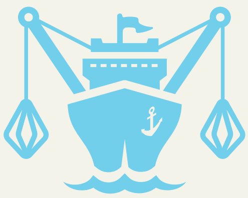
**Figure 3. The cost of installing REM systems and reviewing 5% video for the top 10 European countries with the most >15m vessels**




It can be seen that if the REM systems were installed on all vessels >15m length, then the highest costs would be incurred by Spain and Italy, as their >15m fleets are the largest in Europe. At 5% video review the total costs would be £5.2m and £4.5m (7.2m euros and 6.2m euros) respectively. All other 8 countries would incur an estimated cost of less than £2m (2.8m euros) per country, with 3 countries (Croatia, Denmark and Germany) all being less than £1m (1.4m euros).

Where fisheries are shared between countries the vessels that prosecute the stocks are generally greater than 15m in length. How much is currently spent monitoring these fisheries using patrol vessels, aerial surveillance and other traditional means by each of the top 10 countries is not readily available. However if these monitoring options were scaled down and REM with CCTV was used instead, it could allow 5% of video to be reviewed for all vessels, for approximately £2m (2.8m euros) per year. This would seem to be a reasonable cost, especially as it is the only monitoring tool that can effectively monitor a landing obligation at sea and one which will create a level playing field within an internationally shared fishery.

## COMPARING THE COSTS OF OTHER MONITORING METHODS



REM systems could save fishermen money and increase monitoring coverage more than 10-fold for a similar cost to the government as now.

**Aerial, Patrol Vessel and VMS Surveillance**
In the financial year 2013/14, the cost to the MMO to undertake aerial, surface (patrol vessels) and satellite (VMS) surveillance was £3.63m, a reduction from 2012/13 when the total cost was £8.39m. This surveillance concentrated on vessels fishing in English waters. These methods achieved 100% coverage of the >15m fleet using VMS to plot positons of vessels and estimate fishing positions; 2,338 sightings by aircraft equating to approximately 0.026% of the fishing effort (as a proportion of hours spent at sea, or 1.2% of part days at sea); and 587 boardings of vessels at sea (by the Royal Navy) equating to approximately 0.05% of fishing effort (as a proportion of hours spent at sea, or 0.3% of part days at sea). In contrast the REM system with cameras will provide 100% sensor coverage and 5% video review of all UK vessels greater than 10m length, for a cost similar to that spent on aerial/ patrol vessel/ VMS surveillance just by England (£3.6m compared to £3.63m). So replacing aerial, at-sea and VMS surveillance with an REM system that has video cameras and an in-built VMS system would provide approximately 100% sensor coverage and 5% video review coverage of all hours spent at sea by the UK >10m fleet, compared to less than 0.1% of fishing effort currently being observed by these traditional methods, and for a fraction of the price. Especially if the video can be reviewed based on a risk based approach e.g. when sensors show a vessel has entered and fished in a closed area, or when there is a known high risk of non-compliance by a particular fleet or vessel.

It should also be noted that a VMS system currently costs £2,400 to install, £2000 of this is paid by grant funding and the remaining costs are met by the fishermen. So combining VMS within a REM system also saves each vessel greater than 10m (or grant funding bodies) up to £2,400 purchase cost plus additional running costs of transmitting the data. REM systems could therefore save the fishermen money and increase monitoring coverage more than 10-fold for a similar cost to the government as now. In addition the cameras are the only option that have the ability to provide point of capture monitoring at sea and provide recordings for evidential purposes.

**Dockside Monitoring**
As discussed earlier, port based inspections are unable to observe discarding at sea and are of little value in monitoring a discard ban other than to ensure that what has been declared for landing is actually landed which should include any undersized catches. If all vessels greater than 10m were required to have REM and cameras aboard and self-report catches (preferably haul by haul), the shore based analyst would review the video for 5% of a vessel's fishing effort and determine if these self-declared records were accurate or not. If there were discrepancies the video review rate could be increased and the discrepancies further investigated. This would virtually remove the need for dockside monitoring, other than to collect biological samples and to interact with the industry. By changing to REM catch verification methods there would be additional financial savings or staff resource savings, which could be redirected to REM monitoring. The current cost of undertaking dockside landings monitoring is unavailable, however if there were say 100 fishery officers in

the UK and this could be reduced to half the number then savings would be in excess of £1.5m per year based on a £30,000 salary cost per officer. This is thought to be a conservative estimate because the salary cost does not reflect the full economic cost of a member of staff (accommodation, overheads, pensions etc.) and perhaps more than a 50% saving in number of staff could be made. The remaining fishery officers could then be available to continue monitoring the under 10m fleet if it was decided that this fleet segment was exempt from REM monitoring with cameras or concentrate efforts on high risk fisheries and investigating cases rather than routine monitoring.

Based on the costs obtained and estimated above, the total enforcement costs for English fisheries are approximately 5.16m. In Scotland the total costs are higher, approximately £15m per year (per.comms MS) due to their larger offshore fleet (England having 817 vessels >15m and Scotland having 1757 vessels >15m).

**Observer Programmes**

In 2012, the UK declared a reclaim cost of £535,000 for the combined Data Collection Framework (DCF) at sea monitoring programme to the EU (see Table 9) and it provided catch data for 574 trips at sea at a fishing effort (by trip) coverage level of approximately 0.4% of the UKs fishing effort (see Table 1). This cost does not include the stock assessment surveys or biological market sampling programmes also undertaken through DCF. These would still need to continue under a landing obligation to ensure that biological samples continue to be collected and that the stock assessment surveys continue to collect annual comparative data. It should also be noted that only the actual salary costs could be recovered under the DCF and therefore the actual costs to the UK were higher. The salary costs are thought to be approximately 60% of the full economic cost (FEC) of a member of staff, which includes costs associated with accommodation, insurance, pensions, other overhead costs (Elliot, 2015) and therefore a more accurate cost would be approximately £786,000 (adapted from DCF 2012 financial statement tables supplied by MMO (Elliot, 2015)).

**Table 9. Current costs associated with undertaking the UK's discard observer programme in 2012 (data adapted from the DCF technical and financial tables as supplied by MMO (Elliot, 2015))**

| Country | Cost[1] of At Sea Discard Sampling (£) | Trips Sampled | Days At Sea Sampled[2] | Cost per Trip (£) | Cost per Day[3] (£) |
|---|---|---|---|---|---|
| England | 257388 | 232 | 253 | 1021 | 1017 |
| Scotland | 264296 | 152 | 407 | 1739 | 649 |
| Northern Ireland | 264237 | 190 | 54 | 1390 | NA[4] |
| Wales | 0 | 0 | 0 | 0 | 0 |
| Total | 785921 | 574 | 714 | 1369 | |

1This includes the adjusted salary rate to take into account the FEC of employing staff, where salary is 60% of the FEC. 2Adapted from the DCF financial statements that provide number of days the sea allowance was paid, however this may not include day trips or other trips where this allowance was not paid to staff. 3This is based on the days at sea calculated from paid sea allowances and may not include day trips. 4No value is presented for Northern Ireland because the number of Trips exceeds the number of Days when a sea allowance was paid which would suggest an error in the DCF tables or a significant number of sea trips where no sea allowance was paid e.g. day trips or overtime allowances.

With the introduction of a landing obligation the discarding of certain species will be prohibited and instead, this portion of the catch will be landed for non-human consumption use. Therefore these species will now be available to be sampled ashore for length and collection of aging samples, which if undertaken will reduce the need for sampling at sea in fisheries where the named landing obligation species are predominantly caught. It is acknowledged that observer programmes provide considerable data on non-commercial species and that video review may find it difficult to distinguish between species which are very similar. Therefore it is likely that observer programmes could still be a useful tool in monitoring the impact of fishing practises and adherence to a landing obligation but perhaps at a much reduced rate. If we assume that sampling levels were reduced by 50% this would present a saving of nearly £400,000 which could be used to help fund the REM camera systems and video review and this may still be a conservative estimate.

**Reference fleets**

The main reasons that reference fleets are being considered as a monitoring option are that it is thought that they could provide a cost saving to monitoring the whole fleet and because it is assumed that the data would be representative of the whole fleet. However these assumptions may be flawed. Table 5 shows that one of the highest item costs of operating REM camera systems is the installation cost. If a reference fleet approach was chosen this cost would increase and there would be the additional cost of removing the equipment intact and reusable, which is likely to cost about the same as the installation costs (80% of install cost has been used for comparison exercise). Also, if the data that is acquired through reference fleet monitoring is unrepresentative of the non-monitored segment of the fleet, then all of the data is unusable and the whole exercise could potentially be a waste of money.

If REM camera systems are installed on all over 10m vessels in the UK fleet it will cost

**£6.4M**

per year to monitor 10% of the fleet's activities

To try to assess the cost of a reference fleet compared to a whole fleet approach, an example using 25% fleet coverage with annual rotation of systems and 10% video review has been used. Table 10 and Figure 4 (both in Appendix) shows that to install on 25% of a fleet would cost approximately 45% of the total cost to monitor the whole fleet of 100 vessels. If fleet coverage was 55% of the fleet it would cost approximately the same as monitoring the whole fleet. So the savings expected from using reference fleets are not necessarily as large as would first be anticipated. The coverage level chosen is critical for both the potential cost savings, but more importantly to gather representative information about the whole fleet operating under a landing obligation. What level of coverage would be accepted as providing meaningful coverage and ensuring that the whole fleet is compliant? If it was 30%, is there really much point in creating an un-level playing field, a potential opportunity to discard, reduced confidence in the data and limiting its potential usage in stock assessments, for a 45% cost saving, with little or no knowledge of what is happening in the remaining 70% of the fleet. Thus, the use of reference fleets would be a balance between risk and savings. The risk of creating data errors, compliance issues and having vessels operating in the same fishery but under different restrictions, against a monetary saving. There is also the risk that the rest of Europe and their scientists will judge the monitoring and data unreliable. If the data is unusable and vessels adhere to the legislation differently, then any resources associated with implementing a reference fleet approach will be wasted.

**Potential Efficiency Savings**

If REM camera systems are installed on all over 10m vessels in the UK fleet it will cost £6.4m per year to monitor 10% of the fleet's activities or £3.6m per year at 5% monitoring rate (assuming 90% EMFF funding for equipment). From the arguments detailed in previous sections there could be opportunities to save money from other monitoring techniques currently used, which could be redirected into REM camera monitoring. If REM systems could output their positional data to shore based VMS control rooms then REM systems could technically replace the need for a separate VMS system as the data being collected is identical and would meet the requirements of article 9.2 of the Control Regulation. In addition there is no reason why REM systems cannot be developed to have an inbuilt E-log system which would allow catch data to be sent whilst the vessel is at sea. Removing the duplication of electronic equipment and the need to collect the same information twice, would provide a saving to fishermen as they would not need to pay for a VMS or E-log system as well as an REM system (if these are required on board).

Aerial surveillance for discard infringements would not be required because the REM system provides time, position and activity data, which is recorded or can be sent to shore via satellite. At sea patrols could be greatly reduced and would primarily be used to monitor foreign fishing vessel activity if these vessels did not have REM systems on board. Dockside monitoring would be greatly streamlined as there would be little need to inspect the catches because this could be done by verifying skippers' self-reported catches using video review. Alternatively dockside inspections could concentrate on monitoring the under 10m fleet, which may not have monitoring systems aboard, checking fishing gear or collecting biological sampling. Observer programmes for monitoring discards of commercial species would not be required at the same level, although some scientific observing should continue to obtain data for non-commercial species, but the programme could probably be reduced to at least half of its current size. Again this would provide funding available for REM systems. In addition some of the costs associated with REM may also be recouped through the DCF programme, as this allows electronic monitoring to be used as an eligible option. Competition between REM suppliers will reduce hardware prices. Compliance and science organisations will become more efficient when using the REM and camera systems, thus increasing the number of vessels that a shore based analyst can review and lowering programme costs.

**LONG-TERM, LARGE-SCALE PROGRAMMES CAN PRODUCE EFFICIENCY SAVINGS**

It is also important to note that for this costing exercise, it was estimated that a single analyst could review the video (10% of effort) and manage approximately 8 vessels (this is based on previous experiences with pilot projects). However in Canada where REM has been used for nearly 15 years and on 200-300 vessel programmes, a single observer is responsible for reviewing the video (at a 10% review rate) for approximately 25-30 vessels. This demonstrates how long-term, large-scale programmes can produce efficiency savings.

Summarising the current available cost information for the UK for fisheries enforcement activities the MMO spent £3.63m on aerial/VMS/surface surveillance and approximately £1.5m on shore based inspections and staff (English total of £5.13m) and in Scotland approximately £15m is spent on fisheries enforcement. This is a combined total of £20.13m. Reducing the enforcement coverage by 25% and reducing observer programme coverage by 50% (a saving of £400,000), would allow enough funding (approximately £5.5m) to install REM equipment aboard all >10m vessels in the UK, monitor 8% of their video footage and 100% of sensor data.

The coverage rates of the observer programme and the aerial/surface surveillance, monitors less than 0.1% of the over 10m fishing effort and find it difficult to observe non-compliant behaviour at sea and in addition dockside inspection rates are difficult to undertake in some areas due to the remoteness of the locations. This would suggest that using REM with CCTV to provide 8% coverage (80 times more than the other methods combined) for the same price, represents excellent value for money.

It is acknowledged that these savings would not be available overnight and that there would be an element of duplication until all systems and changes were properly embedded in a new enforcement programme. However if funding was made available REM could clearly be a valuable tool for both science and compliance purposes.

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# APPENDIX

**Table 1. DCF at-sea sampling levels and fleet activity in 2012, for the UK by country.**

| MEMBER STATE | REGION | SAMPLING FRAME FISHING ACTIVITY | TOTAL NO. OF TRIPS BY FLEET DURING YEAR | NO. SAMPLED TRIPS AT SEA | % NO. FLEET TRIPS SAMPLED |
|---|---|---|---|---|---|
| Scotland | North Sea and Eastern Arctic | Demersal finfish | 4107 | 50 | 1.2% |
| Scotland | North Sea and Eastern Arctic | Pelagic finfish | 110 | 0 | 0.0% |
| Scotland | North Sea and Eastern Arctic | Shellfish | 21119 | 29 | 0.1% |
| Scotland | North Atlantic | Demersal finfish | 599 | 26 | 4.3% |
| Scotland | North Atlantic | Pelagic finfish | 68 | 0 | 0.0% |
| Scotland | North Atlantic | Shellfish | 32395 | 47 | 0.1% |
| **Scotland Total** | | | **58398** | **152** | **0.3%** |
| England | North Sea and Eastern Arctic | Demersal trawlers, netters + liners | 31310 | 83 | 0.3% |
| England | North Sea and Eastern Arctic | Beam trawlers | 1872 | 5 | 0.3% |
| England | North Sea and Eastern Arctic | Mollusc dredgers | 331 | 7 | 2.1% |
| England | North Atlantic | Demersal trawlers, netters + liners | 31343 | 101 | 0.3% |
| England | North Atlantic | Beam trawlers | 1580 | 25 | 1.6% |
| England | North Atlantic | Mollusc dredgers | 444 | 11 | 2.5% |
| **England Total** | | | 66880 | 232 | 0.3% |
| Northern Ireland | North Atlantic | Demersal finfish | 256 | 8 | 3.1% |
| Northern Ireland | North Atlantic | Shellfish | 7935 | 167 | 2.1% |
| Northern Ireland | North Atlantic | Pelagic fish | 27 | 3 | 11.1% |
| Northern Ireland | North Atlantic | Mollusc dredgers | 777 | 8 | 1.0% |
| Northern Ireland | North Atlantic | Shellfish pot & trap vessels | 1081 | 4 | 0.4% |
| **Northern Ireland Total** | | | 10076 | 190 | 1.9% |
| **Overall UK1 Total** | | | 135354 | 574 | 0.4% |

[1]No DCF sampling information was presented for Wales. Prior to devolved administration, sampling of the Welsh fleet was undertaken by Cefas as a combined English and Welsh fleet (between 2002 and 2009).

**Table 10. Comparing the costs (£) of full REM coverage with 10% video review for a fleet of 100 vessels and using a reference fleet where the REM systems are transferred to different vessels annually.**

| ITEM Description | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Total |
|---|---|---|---|---|---|---|
| REM Camera System | 600 | 0 | 0 | 0 | 0 | 600 |
| Installation cost | 2400 | 0 | 0 | 0 | 0 | 2400 |
| Additional Hard Drives | 9 | 0 | 0 | 0 | 0 | 9 |
| Hard Drive Swapping | 120 | 120 | 120 | 120 | 120 | 600 |
| Maintenance Costs | 1200 | 1200 | 1200 | 1200 | 1200 | 6000 |
| Video Review Cost (at 10% review rate) | 2500 | 2500 | 2500 | 2500 | 2500 | 12500 |
| Licence Cost Per Vessel | 275 | 275 | 275 | 275 | 275 | 1375 |
| Total Per System | 7104 | 4095 | 4095 | 4095 | 4095 | 23484 |
| 100 vessels fully installed at 10% video review | 710400 | 409500 | 409500 | 409500 | 409500 | 2348400 |
| Additional costs associated with reference fleet | | | | | | |
| ITEM Description | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Total |
| Installation cost | 2400 | 2400 | 2400 | 2400 | 2400 | 12000 |
| Removal costs (estimated at 80% of install costs) | 1920 | 1920 | 1920 | 1920 | 1920 | 9600 |
| Total | 9024 | 8415 | 8415 | 8415 | 8415 | 42684 |
| 25% Reference Fleet | 225600 | 210375 | 210375 | 210375 | 210375 | 1067100 |
| 50% Reference Fleet | 451200 | 420750 | 420750 | 420750 | 420750 | 2134200 |

**Figure 4. The costs (£) associated with monitoring different sized reference fleets**

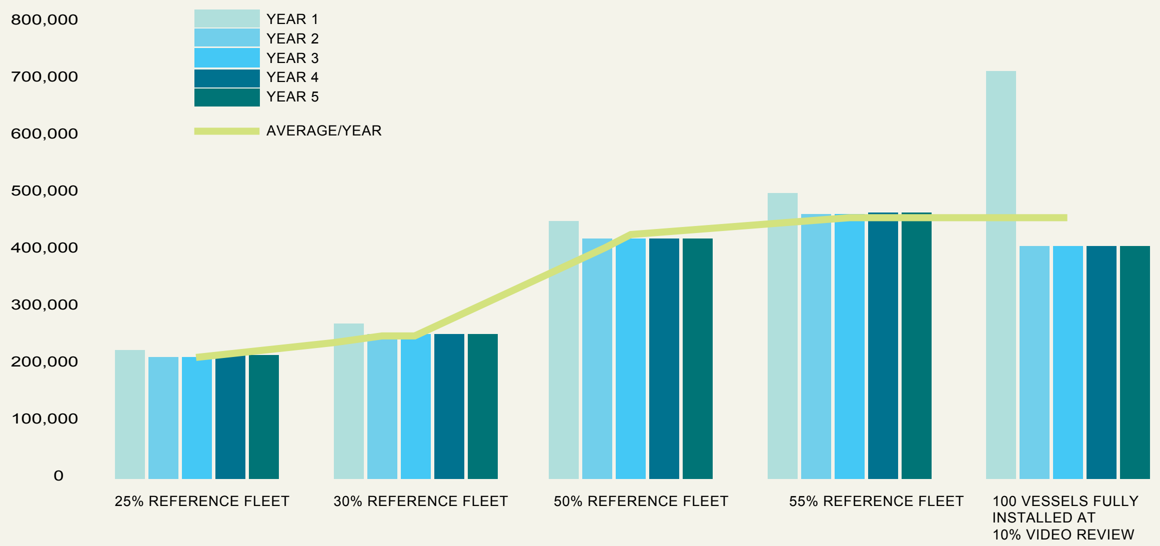

**Table 11. European Fishing Fleet in 2013 split by vessel size (Source: Eurostat through MMO website).**

| Country of Administration | 8m and Under | 8.01 – 10m | 10.01 – 15m | 15.01 – 18m | 18.01 -24m | Over 24m | Total |
|---|---|---|---|---|---|---|---|
| Belgium | - | - | 4 | 3 | 36 | 37 | 80 |
| Bulgaria | 1,717 | 161 | 103 | 28 | 22 | 12 | 2,043 |
| Croatia | 5,850 | 712 | 632 | 117 | 122 | 121 | 7,554 |
| Cyprus | 580 | 234 | 65 | 6 | 3 | 7 | 895 |
| Denmark | 1,675 | 421 | 286 | 118 | 90 | 71 | 2,661 |
| Estonia | 1,081 | 239 | 91 | 3 | 5 | 26 | 1,445 |
| Finland | 2,370 | 577 | 214 | 14 | 15 | 21 | 3,211 |
| France | 3,663 | 1,549 | 1,184 | 251 | 301 | 185 | 7,133 |
| Germany | 967 | 166 | 136 | 121 | 89 | 54 | 1,533 |
| Greece | 10,984 | 3,408 | 860 | 130 | 260 | 205 | 15,847 |
| Ireland | 1,274 | 368 | 327 | 24 | 93 | 111 | 2,197 |
| Italy | 6,444 | 1,449 | 3,100 | 504 | 814 | 380 | 12,691 |
| Latvia | 560 | 55 | 13 | 11 | 3 | 61 | 703 |
| Lithuania | 87 | 10 | 11 | - | 2 | 36 | 146 |
| Malta | 815 | 92 | 71 | 8 | 33 | 12 | 1,031 |
| Netherlands | 225 | 94 | 62 | 22 | 197 | 246 | 846 |
| Poland | 298 | 211 | 187 | 41 | 51 | 50 | 838 |
| Portugal | 6,418 | 718 | 592 | 136 | 162 | 206 | 8,232 |
| Romania | 154 | 11 | 27 | - | - | 2 | 194 |
| Slovenia | 128 | 17 | 20 | 4 | 1 | - | 170 |
| Spain | 5,187 | 1,273 | 1,448 | 422 | 724 | 819 | 9,873 |
| Sweden | 644 | 334 | 290 | 29 | 44 | 45 | 1,386 |
| United Kingdom | 3,479 | 1,557 | 686 | 190 | 246 | 241 | 6,399 |
| **Total** | **54,600** | **13,656** | **10,409** | **2,182** | **3,313** | **2,948** | **87,108** |

**Table 12. The cost of monitoring the European fishing fleet with REM CCTV systems and at an approximate 10% video review rate (€m).**

| Country of Administration | 8m and Under | 8.01 – 10m | 10.01 – 15m | 15.01 – 18m | 18.01 -24m | Over 24m | Total |
|---|---|---|---|---|---|---|---|
| Belgium | - | - | 0.0 | 0.0 | 0.2 | 0.2 | 0.5 |
| Bulgaria | 11.2 | 1.0 | 0.7 | 0.2 | 0.1 | 0.1 | 13.3 |
| Croatia | 38.0 | 4.6 | 4.1 | 0.8 | 0.8 | 0.8 | 49.1 |
| Cyprus | 3.8 | 1.5 | 0.4 | 0.0 | 0.0 | 0.0 | 5.8 |
| Denmark | 10.9 | 2.7 | 1.9 | 0.8 | 0.6 | 0.5 | 17.3 |
| Estonia | 7.0 | 1.6 | 0.6 | 0.0 | 0.0 | 0.2 | 9.4 |
| Finland | 15.4 | 3.8 | 1.4 | 0.1 | 0.1 | 0.1 | 20.9 |
| France | 23.8 | 10.1 | 7.7 | 1.6 | 2.0 | 1.2 | 46.4 |
| Germany | 6.3 | 1.1 | 0.9 | 0.8 | 0.6 | 0.4 | 10.0 |
| Greece | 71.4 | 22.2 | 5.6 | 0.8 | 1.7 | 1.3 | 103.1 |
| Ireland | 8.3 | 2.4 | 2.1 | 0.2 | 0.6 | 0.7 | 14.3 |
| Italy | 41.9 | 9.4 | 20.2 | 3.3 | 5.3 | 2.5 | 82.5 |
| Latvia | 3.6 | 0.4 | 0.1 | 0.1 | 0.0 | 0.4 | 4.6 |
| Lithuania | 0.6 | 0.1 | 0.1 | - | 0.0 | 0.2 | 0.9 |
| Malta | 5.3 | 0.6 | 0.5 | 0.1 | 0.2 | 0.1 | 6.7 |
| Netherlands | 1.5 | 0.6 | 0.4 | 0.1 | 1.3 | 1.6 | 5.5 |
| Poland | 1.9 | 1.4 | 1.2 | 0.3 | 0.3 | 0.3 | 5.5 |
| Portugal | 41.7 | 4.7 | 3.9 | 0.9 | 1.1 | 1.3 | 53.5 |
| Romania | 1.0 | 0.1 | 0.2 | - | - | 0.0 | 1.3 |
| Slovenia | 0.8 | 0.1 | 0.1 | 0.0 | 0.0 | - | 1.1 |
| Spain | 33.7 | 8.3 | 9.4 | 2.7 | 4.7 | 5.3 | 64.2 |
| Sweden | 4.2 | 2.2 | 1.9 | 0.2 | 0.3 | 0.3 | 9.0 |
| United Kingdom | 22.6 | 10.1 | 4.5 | 1.2 | 1.6 | 1.6 | 41.6 |
| **Total** | **355.1** | **88.8** | **67.7** | **14.2** | **21.5** | **19.2** | **566.6** |

Based on Bank of England exchange rate of £1 = 1.3847 euro

**Table 13. The cost of monitoring the European fishing fleet with REM CCTV systems and at an approximate 5% video review rate (€m).**

| Country of Administration | 8m and Under | 8.01 – 10m | 10.01 – 15m | 15.01 – 18m | 18.01 -24m | Over 24m | Total |
|---|---|---|---|---|---|---|---|
| Belgium | - | - | 0.0 | 0.0 | 0.1 | 0.1 | 0.3 |
| Bulgaria | 6.3 | 0.6 | 0.4 | 0.1 | 0.1 | 0.0 | 7.5 |
| Croatia | 21.5 | 2.6 | 2.3 | 0.4 | 0.4 | 0.4 | 27.7 |
| Cyprus | 2.1 | 0.9 | 0.2 | 0.0 | 0.0 | 0.0 | 3.3 |
| Denmark | 6.1 | 1.5 | 1.0 | 0.4 | 0.3 | 0.3 | 9.8 |
| Estonia | 4.0 | 0.9 | 0.3 | 0.0 | 0.0 | 0.1 | 5.3 |
| Finland | 8.7 | 2.1 | 0.8 | 0.1 | 0.1 | 0.1 | 11.8 |
| France | 13.4 | 5.7 | 4.3 | 0.9 | 1.1 | 0.7 | 26.2 |
| Germany | 3.5 | 0.6 | 0.5 | 0.4 | 0.3 | 0.2 | 5.6 |
| Greece | 40.3 | 12.5 | 3.2 | 0.5 | 1.0 | 0.8 | 58.1 |
| Ireland | 4.7 | 1.3 | 1.2 | 0.1 | 0.3 | 0.4 | 8.1 |
| Italy | 23.6 | 5.3 | 11.4 | 1.8 | 3.0 | 1.4 | 46.6 |
| Latvia | 2.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.2 | 2.6 |
| Lithuania | 0.3 | 0.0 | 0.0 | - | 0.0 | 0.1 | 0.5 |
| Malta | 3.0 | 0.3 | 0.3 | 0.0 | 0.1 | 0.0 | 3.8 |
| Netherlands | 0.8 | 0.3 | 0.2 | 0.1 | 0.7 | 0.9 | 3.1 |
| Poland | 1.1 | 0.8 | 0.7 | 0.2 | 0.2 | 0.2 | 3.1 |
| Portugal | 23.5 | 2.6 | 2.2 | 0.5 | 0.6 | 0.8 | 30.2 |
| Romania | 0.6 | 0.0 | 0.1 | - | - | 0.0 | 0.7 |
| Slovenia | 0.5 | 0.1 | 0.1 | 0.0 | 0.0 | - | 0.6 |
| Spain | 19.0 | 4.7 | 5.3 | 1.5 | 2.7 | 3.0 | 36.2 |
| Sweden | 2.4 | 1.2 | 1.1 | 0.1 | 0.2 | 0.2 | 5.1 |
| United Kingdom | 12.8 | 5.7 | 2.5 | 0.7 | 0.9 | 0.9 | 23.5 |
| **Total** | **200.3** | **50.1** | **38.2** | **8.0** | **12.2** | **10.8** | **319.5** |

Based on Bank of England exchange rate of £1 = 1.3847 euro

## 0%

Amount of time REM systems are affected by poor weather, seasickness or lack of sleep

## £4697

Estimated annual cost of installing equipment and reviewing 10% of vessel activity

## 100%

Level of fishing activity that can be monitored by Remote Electronic Systems using cameras

## €122m

Estimated cost of using REM to monitor 10% of the over 10m fleet activity across Europe

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