REMOTE ELECTRONIC MONITORING

Why camera technology is a cost-effective and robust solution to improving UK fisheries management

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REM OFFERS THE UK THE CHANCE TO IMPROVE FISHERIES MANAGEMENT

FOREWORD

by Helen McLachlan
Fisheries Programme Manager, WWF

As the UK develops new fisheries policies that will come into force after Brexit, it is vital to the economic wellbeing of fishing communities and the long-term protection of our fish stocks and the marine environment, that the UK and devolved governments adopt the most effective, value-for-money tools for monitoring fishing activities, collecting data and assuring best practice.

This report provides clear evidence that Remote Electronic Monitoring (REM) with closed circuit television cameras (CCTV) should be a key component of a well-monitored fishery and supports the case for REM being made a condition for fishing in UK waters.

The UK is now preparing to leave the EU, which for the last 40 years has dictated our fisheries management regime. One of the key issues addressed by the most recent reform of the Common Fisheries Policy (CFP) was how to tackle the wasteful practice of discarding, leading to the introduction of the Landing Obligation. Tackling discards will remain a key priority for any new fisheries regime in the UK after leaving the CFP. In order to tackle this, there is a clear need to be able to monitor activities at sea, where discarding takes place. Without this, confidence in the supply chain can be damaged and there is a growing risk of losing track of fisheries mortality, which in turn could undermine the management regime to the point of overfishing. This must be avoided.

WITHOUT MONITORING AT SEA THERE IS A GROWING RISK OF LOSING TRACK OF FISHERIES MORTALITY

This report follows WWF's 2015 investigation into monitoring and control practices, which was commissioned in response to growing concerns over the failure of fisheries managers to introduce effective monitoring of, and compliance with, new fisheries legislation. It also looked at the use of REM and compared coverage and costings of both this and more traditional monitoring processes. The study revealed that REM with cameras offers by far the most cost-effective option for monitoring at sea and can offer 100% coverage levels at a fraction of the cost of more traditional methods, which provide less than 1% coverage. Our 2017 findings not only reinforce these conclusions, but also reveal that the cost of installing cameras on the UK fishing fleet has continued to fall, making the case all the more compelling.

The report also briefly explores the human cost of the current system of collecting scientific data using on-board observers. We hear from observers about the threats and intimidation they can face from vessel owners and crews, and the unsafe working conditions they are sometimes exposed to. While these incidents are thankfully rare and it appears that most of the fishing industry understands the need for data collection, they add weight to the argument that our current systems are not fit for purpose.

REM offers the UK the chance to improve fisheries management and lead the way in the adoption of progressive technology that delivers sustainability, accountability and confidence in the supply chain, as well as a level playing field across shared seas. Introducing it as standard practice makes clear economic and environmental sense.

EXECUTIVE SUMMARY

This report builds on previous research into the merits of using Remote Electronic Monitoring (REM) in fisheries management and provides some compelling arguments in support of the adoption of REM across the UK over-10-metre fleet.

Some of the key conclusions include:

- When compared to 2015, costs have reduced by 22% from £4,694 to £3,785 per vessel per year due to advancements in technology and greater efficiencies of analyst staff time.
- To provide 10% video review monitoring across the over-10-metre fleet across the UK would cost in the region of £5.01 million. This equates to roughly a quarter of the money spent on more traditional systems which deliver less than 1% at-sea coverage.
- Research revealed a lack of progress in adopting REM as a key monitoring and compliance tool despite the obvious benefits it offers over traditional methods since 2015. Interviews revealed a wider acceptance of REM by certain segments of the industry, and greater reluctance to install voluntarily in others.
- Some of the clear benefits of REM include the potential for improved data, more reactive data management and larger data sets to feed into fisheries management, and the ability to use the technology to support evidence for industry anecdotal claims.
- The use of REM also minimises the use of human observers and the sometimes unpleasant experiences they have.
- The use of REM would address concerns raised by supply chain representatives – those in the retail and processing sectors – over compliance with key fisheries legislation, and the potential for illegality in the supply chain if compliance is low.
- There can be no market without transparency; no level playing field without transparency; and no transparency without REM.
- The costs of using REM are falling because of greater efficiencies, while the costs of traditional monitoring and research methods are rising.
- A fisherman currently using REM believes that once the UK leaves the EU, non-UK vessels fishing in UK waters should abide by UK Regulations. If this includes the use of REM then non UK vessels should follow suit for the sake of transparency and to deliver a level playing field, as well as data collection for scientific and management use.

THERE CAN BE NO LEVEL PLAYING FIELD WITHOUT TRANSPARENCY

PREVIOUS REPORT

The 2015 WWF report *Remote Electronic Monitoring (REM) in Fisheries Management* looked at how the new and partially introduced Landing Obligation (Landing Obligation) was being monitored using current traditional monitoring methods and compared this with the use of REM with cameras and sensors, and reviewed the costings for both. The results revealed that REM with cameras offers the cheapest option for monitoring at sea, and can offer 100% monitoring for less money than other methods which provide a fraction of the coverage.

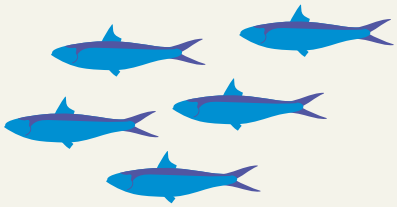
The report concluded that if 25% of the UK's current compliance and scientific observer monitoring budget was diverted to REM equipment and monitoring, then all vessels over 10m in length could have REM equipment installed; and that 100% of the sensor data and 8% of the collected video imagery could be reviewed. This gave an estimated total cost of approximately £5.5m. It was also found that REM could increase traditional monitoring coverage levels from less than 1% to 8% video and 100% sensor (activity, time and position).

The report generated discussion into using REM as a routine monitoring tool, at both national and international level.

PHOTO: GRANT COURSE

BACKGROUND

Patrol vessels, boardings at sea, dockside and landings monitoring, and aircraft patrols have been the main methods used to monitor whether UK fisheries are adhering to regulations and allocated fish quotas. In addition, onboard observers are the main method used for collecting scientific fisheries data from commercial fishing vessels.



Over the last decade satellite technology has been introduced on larger vessels in the form of Vessel Monitoring Systems (VMS), which show the position, speed and course of a vessel. This information is sent to a shore-based monitoring station, usually every two hours. Assumptions are then made on the activity of the vessel at the time of sending the data, based on its calculated speed. For example, if a trawler is travelling at >7 knots, the assumption may be that it is sailing between grounds or towards port, whereas at 4 knots it may be assumed that it is fishing.

FISHERMEN CAN DEMONSTRATE A SUSTAINABLE APPROACH TO FISHING

However, new REM systems combine this satellite technology with sensors that can determine exactly when a vessel is fishing, and therefore the need to make assumptions over activity is removed. Couple this with CCTV and the sensor data can be fully verified. CCTV also captures video footage of the crew's behaviour and imagery of the fish catches, and this can be reviewed for both compliance and scientific purposes.

No other method of monitoring is able to record the 'decision point' where a crewman decides whether to retain or discard a fish. REM can monitor this process and also provide a recorded evidence base in any further discussions or investigations. Careful video review and well-designed and agreed catch handling procedures can also allow the amounts of fish retained and discarded to be quantified or even measured, thus removing the need to have human observers go to sea gathering these data. Examples of well-designed REM projects include the Scottish and English Catch Quota trials, which have illustrated that REM allows accurate data to be gathered, ensures good compliance with fisheries regulations, and has additional benefits as a monitoring tool (e.g. fishermen can demonstrate a sustainable approach to fishing, or provide evidence to management to support previously anecdotal claims).

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 satellite. The imagery can then be used to obtain information on catch handling, discarding practices and catch composition; to gather scientific data; to verify self-reported information; or in monitoring for compliance with regulations.

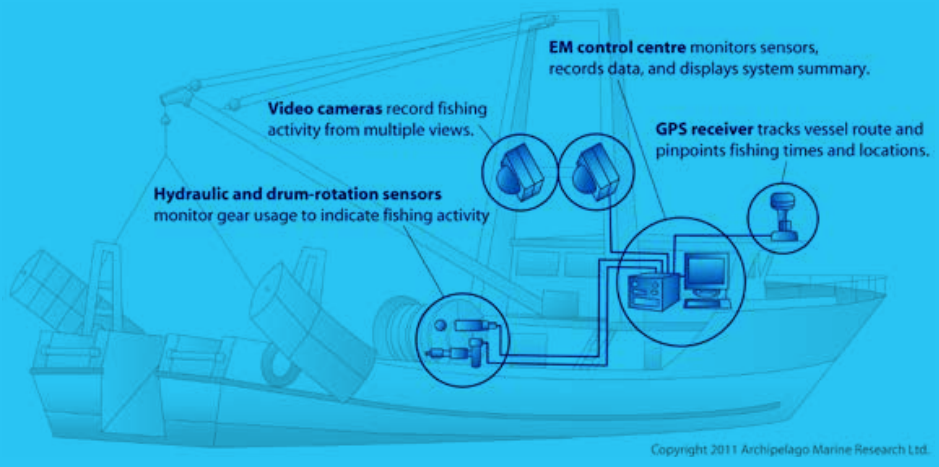


Figure 1. Diagram of a remote electronic monitoring system (REM) installed on a fishing vessel (Courtesy of Archipelago Marine Research Ltd.).

Figure 2. Cameras installed on fishing vessels

Current UK REM projects

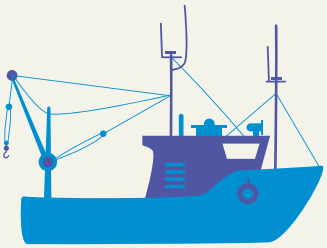
REM projects have been conducted within the UK since at least 2009 when Pasco *et al* (2009) carried out preliminary CCTV trials aboard an Irish Sea nephrops trawler. This was done using a portable 'briefcase' system, and since then the UK has trialled systems in several different fisheries from various suppliers from all round the world. These systems generally use sensors to indicate activity (e.g. winch rotation or hydraulic pressure sensors), GPS to provide temporal and spatial data, and CCTV to provide imagery for later review. The results from all these trials have been very promising, and REM has been shown to be able to fully monitor fishing vessel activity and crew behaviour in regard to a discard ban, as well as provide large quantities of catch data over a long time period for management and scientific purposes. All reports can be found on the Marine Management Organisation (MMO) website.

Table 1 shows the number of vessels that have participated in trials in England and Scotland over the last eight years. The information in Table 1 was obtained through Parliamentary Questions (PQs), English Catch Quota Trials publications, and personal communications with fishery managers at Marine Scotland and MMO. The overall coverage rate of REM aboard UK fishing vessels is <1%, and has fallen between 2014 and 2017 (PQ 70005). In Scotland this rate was higher at approximately 3.7% between 2014 and 2016, however REM equipment is not deployed there for compliance purposes but only as part of the Fully Documented Fisheries (FDF) scheme investigating the use of REM aboard fishing vessels. Participation in the FDF scheme is voluntary and primarily focused on scientific data-gathering in collaboration with Masters and crew (PQ S5W-08258). Participation levels in 2017 are expected to be low.

Table 1. Number of vessels participating in UK REM trials and the number of fishing trips completed.

	ENGLAND		SCOTLAND		TOTAL	
YEAR	NO. VESSELS	NO. TRIPS	NO. VESSELS	NO. TRIPS	NO. VESSELS	NO. TRIPS
2009	1	5	NA	NA	1	5
2010	6	104	16	658	22	762
2011	12	281	23	684	35	965
2012	19	456	23	686[3]	42	1,142
2013	25[1]	418	22	689	47	1,107
2014	17	426	32	1,123	48	1,498
2015	18	638	21	786	39	1,424
2016	17	720	22	709	39	1,429
2017	16[4]	-	4[2]	-	20	-

1 Includes vessels participating under four different REM projects.
2 Potentially up to 10 additional scallop dredging vessels to participate under the new Scallop Standing Order.
3 This is an estimate based on surrounding years' effort, as the actual number of trips was unavailable.
4 This includes 11 North Sea vessels and 5 otter trawls fishing in the southwest undertaking gear trials to reduce haddock catches.



THE CONCLUSION OF ALL THESE TRIALS WAS THAT REM WITH CCTV CAN ALLOW FISHING EFFORT TO BE MONITORED, CATCHES TO BE VERIFIED AND DISCARDING TO BE DETECTED

Although there was an initial trial in England in 2009, the full UK REM trials did not begin until 2010. Participation was voluntary and vessels were incentivised to participate by having an additional quota made available to them. Initially the REM trials were aimed at the North Sea fleet which targeted cod (nearly 40% of cod catches in 2016 were from vessels equipped with REM (PQ70005)), but both Scotland and England have now trialled systems on a range of vessels and in different fisheries including nephrops trawlers, gillnetters, longliners, beam trawlers, pelagic trawlers (both freezer and refrigerated seawater), under-10-metre vessels, shellfish creeling vessels (in a separate European Fisheries Fund (EFF) funded study, Course *et al*, 2015), and scallop dredgers. The conclusion of all these trials was that REM with CCTV can allow fishing effort to be monitored, catches to be verified and discarding to be detected.

In short REM is an effective compliance and scientific tool that is capable of providing the observations required to monitor adherence to the Landing Obligation and supply large quantities of good-quality scientific and management data. It also acts as a deterrent to any non-compliant activity and creates a level playing field for all vessels that use it within a fishery.

However, unless all vessels within a specific fishery or fleet are equipped with REM systems, there is the potential for the opposite to occur. An uneven playing field would be created, with vessels without REM able to continue with potential bad practices, while the REM-equipped vessels would need to abide by all rules and may then be at a commercial disadvantage.

If REM was introduced to a fishery using a reference fleet then there would need to be a way to ensure that the collected data represented the whole fleet, and that the vessels with REM were not 'punished' for their responsible approach by being put at a commercial disadvantage. Scientists and the fishing industry should work to ensure that the data collected is useable, representative and non-biased, and that those carrying the cameras are not disadvantaged.

As of March 2017, overall participation levels have reduced from previous years, from a high in 2014 of 48 vessels down to a combined total of 20 vessels. In England, the MMO have stated that 16 vessels are participating (although four of these still need to be installed in the southwest haddock otter trawl fishery), compared to 17 in 2016; while in Scotland there has been a significant reduction from 22 to four trawl vessels.

A new scallop conservation and management regulation was introduced in June 2017 (Marine Scotland, 2017a), and this could potentially lead to more scallop dredgers installing REM. As of 1 June 2017, fishing with 10 dredges per side in the 6-12 nautical mile zone is only permitted if a vessel has installed REM equipment, otherwise they must reduce the number of dredges to 16 in total. This equipment will have to be purchased and installed at the vessel owner's expense, and it will be used by Marine Scotland to monitor the number of dredges in operation in the different fishing zones within Scottish waters (Marine Scotland, 2017b). This is the first commercial fishery in UK waters to propose the use of REM as a statutory requirement, outside of a trial and at the vessel's (partial) expense. Marine Scotland have estimated that about 10 vessels may install REM equipment in line with the new scallop order.

The most notable difference in participation levels this year is the reduction from 22 to four vessels in the Scottish REM demersal whitefish and nephrops fishery projects. This reduction in participation is likely due to the introduction of additional whitefish such as whiting and cod in the North Sea, which have been subject to the Landing Obligation as of January 2017. This has reduced the opportunities to provide additional cod quota to participating vessels. Previously quota top-ups have been provided to vessels to account for fish which would have been discarded but which now must be retained. If the stock is healthy and lots of cod are being caught, then vessels will need to have access to enough quota to allow them to continue to fish, and land all cod caught whether they are above or below the Minimum Conservation Reference Size (MCRS). Otherwise they will have no choice but to stay tied to the quay or move to a different fishery or area. If vessels are not monitored then there is the potential for vessels to discard the smaller cod and high-grade the catch for the larger size classes. This is an understandable and tempting reaction: abide by the Landing Obligation and risk being tied up, or high-grade and be able to continue making a living.

Issues around the Landing Obligation are not without challenges, and one of these is availability of quota to cover catches that would normally have been discarded. Part of this can be addressed by improving selectivity of gear and behaviour, but for some species there are deeper issues of quota availability which need to be addressed by Member States.

Under a Landing Obligation management systems arguably need to be flexible enough to respond to fluctuations in stock size, large year class sizes and changes in fleet dynamics. Data gathered via REM will support such a management regime if used effectively.

PHOTO: SHAUN DORAN

Changes in UK fleet size

The size of the UK fleet is never static. Vessels are continuously being added to or removed from the registered vessel list, or sold within the list to other UK owners. It is important to keep this list up to date if undertaking any review or research project, as the fleet list represents the full sample population. The UK registered vessel lists have been split into under or over 10m in length, and can be found on the MMO website (MMO, 2017). They are usually updated on a monthly basis. However, for the purposes of this report and to be consistent with the previous 2015 report, the numbers and size of vessel data will be extracted from the published fleet report, UK Sea Fisheries Statistics 2015 (MMO, 2016).

Table 2 shows the size of the fleet in 2015 split by size class of vessel. A total of 6,187 vessels were registered, of which 1,324 (21%) were of a registered length of more than 10m. Scotland has the highest number of vessels in the >10m fleet with 573, England has 541, while Wales, Northern Ireland and the Islands have a combined total of 207 vessels >10m.

When this is compared to the 2013 fleet size used in the 2015 report (Course, 2015), it can be seen that the >10m fleet has reduced in size by 34 vessels from 1,358 to 1,324, and that the overall fleet has reduced by 190 vessels from 6,377 to 6,187. This continues the year-on-year trend of reducing numbers of vessels in the UK fleet. Overall the percentage contributions from each vessel length group have remained the same, although England's fleet share has increased from 49% in 2013 (Course, 2015) to 51% in 2015, mainly due to a reduction in the number of vessels registered to the Islands (see Table 3).

Table 2. Number of registered fishing vessels in the UK fleet, by nationality and length class, in 2015 (MMO, 2016).

COUNTRY OF ADMINISTRATION	8M AND UNDER	8.01 - 10M	10.01 - 15M	15.01 - 18M	18.01 -24M	OVER 24M	TOTAL
England	1,801	797	368	34	55	84	3,139
Scotland	956	478	217	109	127	120	2,007
Wales	317	95	25	1	1	5	444
Northern Ireland	120	81	45	28	57	18	349
Islands*	150	32	15	10	2	0	209
Total**	3,370	1,493	672	182	243	227	6,187

* Islands include Guernsey, Jersey and Isle of Man;
** Includes vessels that are registered but not administered by a port; typically, new vessels and vessels changing administrations.

Table 3. The number of registered fishing vessels in the UK fleet by nationality and length size, shown as a percentage of the fleet.

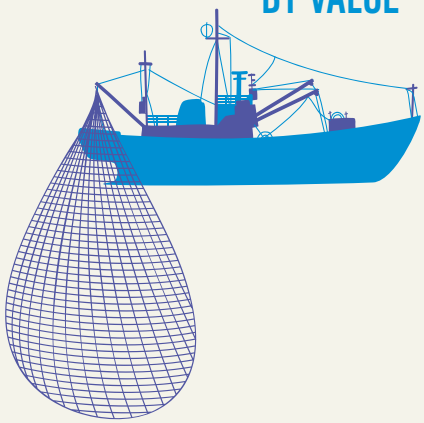
COUNTRY OF ADMINISTRATION	8M AND UNDER	8.01 - 10M	10.01 - 15M	15.01 - 18M	18.01 -24M	OVER 24M	% OF UK TOTAL
England	57	25	12	1	2	3	51
Scotland	48	24	11	5	6	6	32
Wales	71	21	6	0	0	1	7
Northern Ireland	34	23	13	8	16	5	6
Islands*	72	15	7	5	1	0	3
Total**	54	24	11	3	4	4	100

* Islands include Guernsey, Jersey and Isle of Man;
** Includes vessels that are registered but not administered by a port; typically, new vessels and vessels changing administrations.

Scale of REM roll-out

If a large-scale REM programme was introduced in the UK vessels longer than 10m should be a first priority for installation, as argued in the 2015 report. In 2015 the UK fleet landed 708,000 tonnes of fish worth a total of £775m (see Table 4 (adapted from MMO, 2016)). The >10m vessels account for 94% of the total UK fleet catch by weight and 88% by value.

>10M VESSELS ACCOUNT FOR 94% OF THE TOTAL UK FLEET CATCH BY WEIGHT AND 88% BY VALUE



The majority of the <10m fleet's landings were of shellfish species (72% by value (MMO, 2016)), generally caught in creels and not subject to the Landing Obligation. The exception to this is *Nephrops norvegicus*, which is a quota species and became subject to the Landing Obligation in 2016. Survivability exemptions will likely continue to apply for creel-caught nephrops as the discards are usually returned alive. Therefore, electronic monitoring of shellfish creeling vessels would be useful for collecting scientific data for fisheries management issues, but may not be necessary for enforcing compliance measures because the majority of discarded creel-caught shellfish are thought to survive.

Creeling vessels do occasionally catch a bycatch of finfish (e.g. cod, conger eel, wrasse species), but generally the quantities are not large and if the fish are not returned alive they are reused as bait for the creels. From an environmental management perspective it would be useful to gather this data (especially for wrasse or rare species), but in relation to the Landing Obligation this is not necessary as these species are not the main target, catches are minimal and they are usually not quota-managed stocks.

Table 4. The weight and value of UK fish landings by fleet segment in 2015 (MMO, 2016).

SEGMENT	WEIGHT ('000 TONNES)	VALUE (£M)
8m and under	9	26.1
8.01 – 10m	33.5	64.1
10.01 – 15m	55.5	85.5
15.01 – 18m	22.6	44.3
18.01 – 24m	67.25	116.8
Over 24m	520.25	438.3
Total	708.1	775.1

It is difficult to identify creel-only vessels from the UK fleet because vessels participate in several fisheries and with a variety of gear types. These multi-purpose vessels are often termed 'polyvalent', and it is generally the smaller vessels (<10m length) that operate in this way. Therefore, although removing the <10m fleet from an REM programme would 'miss' some trawling or netting activity and exclude 78% of the fleet (by number of vessels) from being monitored, the contribution to the overall catch these vessels make is low at 6% by weight – so the risk to the fishery of not monitoring these vessels should also be low. Once a roll-out of cameras on >10m vessels is underway, risk assessment could be used to identify additional requirements for the <10m fleet, should this be thought necessary.

PHOTO: GRANT COURSE

COSTS OF USING REM

The estimated costs of using an REM system include full installation, the purchase of the hardware and analysis software, and the review of 10% of the video footage.

Since the 2015 report, there have been developments in the REM marketplace, with new suppliers and equipment options becoming available. There has also been a move towards using additional cameras to enable greater transparency. Marine Scotland now install two REM systems aboard each demersal trawl vessel, with up to seven cameras to monitor the progress of the captured fish through the sorting process. Some system manufacturers now supply systems that can use up to eight or even 12 cameras, depending on the needs of the programme. A revision of the estimated costs to reflect system developments and changes in best practice is therefore appropriate.

THE 90% CONTRIBUTION THAT WOULD BE MADE THROUGH THE EUROPEAN MARITIME AND FISHERIES FUND (EMFF): SHOULD BE AVAILABLE UNTIL 2020

Table 5 summarises the 2015 costs (Course, 2015). These still include the 90% contribution that would be made through the European Maritime and Fisheries Fund (EMFF): this should be available until 2020, but thereafter it is unclear whether UK governments will continue to offer this level of financial support once the UK leaves the EU. The total cost was estimated at £4,697 per vessel per year based on the assumptions included in the table footnotes.

Table 5. Summary of costs associated with a REM programme, as presented in Course, (2015).

ITEM DESCRIPTION	UNIT COST (£)	90% EMFF CONTRIBUTION (£)	ACTUAL COST TO UK AND DEVOLVED GOVERNMENTS (£)	COST PER VESSEL PER YEAR[1] (£)
REM hardware – 4 camera system[2]	6,000	5,400	600	120
Installation costs[3] (Dinsdale, 2013)	2,400	0	2,400	480
2 additional hard drives per vessel	90	81	9	2
Hard drive swapping (courier service)[4]	NA	NA	NA	120
Maintenance costs[5] (Dinsdale, 2013)	NA	NA	NA	1,200
Video analyst salary[6]	NA	NA	NA	2,500
Review software licence[7]	NA	NA	NA	275
Total				4,697

1 Assumes a five-year lifespan.
2 Includes four digital cameras, GPS assembly, rotation laser sensor assembly, hydraulic pressure sensor assembly, POE switch, vessel software, 300m Cat5 cable, power cables, two 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.
4 Assumes monthly hard drive swap at £10/month per vessel.
5 Includes annual service and regular checks of system as well as any ad hoc repairs.
6 Based on a salary of £20,000 per year and one analyst being able to undertake 10% video review, data entry and reporting for eight vessels per year, does not include overheads and other staff costs.
7 Annual cost of £2,200 per licence and eight vessels per analyst.

These costs have been revised to the latest costs of a digital system fitted with six cameras, to more accurately reflect current practices. The revised costs have been based on average estimates received from three leading REM technology suppliers, who have been kept anonymous to protect commercial confidentiality (see Table 6). The costs for reviewing video footage have been revised with a higher salary of £25,000 (from £20,000 in 2015), and the number of vessels each analyst can review at 10% of video analysis has been increased from eight to 15. The number has been increased because changes in the technology (digital imagery) and software now available have made it easier to detect the appropriate viewing periods (catch-sorting activity) and reduce the time required to review each vessel. The increase in cameras has reduced the opportunities to discard out of view, meaning less in-depth scrutiny of the video footage is required, so more vessels can be managed by one analyst.

It should also be noted that some REM suppliers now have systems that can store larger quantities of data – sensor data can now be downloaded through mobile phone networks, and video imagery (selected clips) through the internet. However, all three suppliers used in this report still have a removable storage device option to enable full sensor and video data to be transferred to analysts. Therefore, the cost of swapping out the hard drives remains. Similarly, although it is likely that these newer systems are more reliable, no data was available on breakdown rates, so the maintenance cost estimated by Dinsdale (2013) will continue to be used.

Table 6. The average costs, update to 2017, of operating a REM programme, based on costs obtained from three market leading suppliers.

ITEM DESCRIPTION	UNIT COST (£)	90% EMFF CONTRIBUTION (£)	ACTUAL COST TO UK/ DEVOLVED GOVERNMENT (£)	COST PER VESSEL PER YEAR[1] WITHOUT EMFF (£)	COST PER VESSEL PER YEAR[1] WITH EMFF (£)
REM hardware – 6 camera system[2]	8,269	7,442	827	1,654	165
Installation costs[3] (Dinsdale, 2013)	2,400	NA	2,400	480	480
2 additional hard drives per vessel	90	81	9	18	2
Hard drive swapping per year (courier service)[4]	120	NA	120	120	120
Maintenance costs[5] (Dinsdale, 2013)	1,200	NA	1,200	1,200	1,200
Video analyst salary[6]	25,000	NA	25,000	1,667	1,667
Review software licence[7]	2,271	NA	2,271	151	151
Total				5,290	3,785

1 Assumes a five-year lifespan.
2 Includes six digital cameras and associated activity sensors.
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.
4 Assumes monthly hard drive swap at £10/month per vessel.
5 Includes annual service and regular checks of system as well as any ad hoc repairs.
6 Based on a salary of £25,000 per year and one analyst being able to undertake 10% video review, data entry and reporting for 15 vessels per year, does not include overheads and other staff costs.
7 Annual average cost of £2,271 per software licence and 15 vessels per analyst.

The majority of costs associated with the REM system and conducting video review have remained the same. The hardware (system) cost has increased from £6,000 to £8,269. Although the price of technology constantly reduces, the specifications of the technology available increase. The cost of the REM system used in 2015 was based on a system that used four analogue cameras, whereas the new cost is based on a system that uses six digital cameras. This increase in cameras reflects the current preferred usage rates of the main UK users (Marine Scotland, MMO, Cefas, SeaScope). Digital cameras cost more than the analogue cameras and more are being used, so, as specifications increase to meet the user's requirements, so does the cost. As this new technology becomes older and more commonly used, these costs will reduce.

It should also be remembered that the costs used in the 2015 report were based solely on estimates provided by the leading supplier at the time. The updated costs are based on the average of estimates from three leading suppliers, so if one company has a relatively expensive system it will make the average cost higher. In addition, it should be noted that all technology suppliers used in this report are based outside the UK and the foreign exchange rates have changed during the last two years, with the British pound becoming weaker (e.g. 18 April 2015 £1 = US$1.5, 18 April 2017 £1 = US$1.28 *X-Rates, 2017*), so some price changes may be purely due to exchange rate differences.

EFFICIENCY SAVINGS ARE LIKELY TO INCREASE AS ADVANCEMENTS ARE MADE

The analyst software is also based on an average cost as supplied by these REM technology providers. Because of exchange rate differences, the unit cost for a single licence for a single analyst has increased slightly from £2,200 in 2015 to £2,271 in 2017. The improvements in both software and hardware, as well as increased experience of using REM, have increased the number of vessels that each analyst is able to manage and review from eight to 15.

The salary cost for an analyst has been revised to an estimated £25,000 per year, from £20,000 in 2015. This increase in cost is offset by the increase in the number of vessels that an analyst can review, and therefore the cost per vessel per year has decreased from £2,500 in 2015 to £1,667 in 2017.

The overall cost of an REM system – software, staffing, installation, maintenance etc – with 90% EMFF funding on hardware items has reduced from £4,697 per vessel per year in 2015 to £3,785 in 2017. This is a reduction of approximately 19% overall (see Table 7). Although the hardware costs have increased by 38% due to increased specifications, averaging costs over three different suppliers and foreign currency exchange rate fluctuations, the increased staff efficiency brought about by software and technology advances has reduced the overall cost of using REM. These efficiency savings are likely to increase as advancements are made in computer vision and image recognition software.

Table 7. A comparison of the 2015 and 2017 REM programme costs.

ITEM DESCRIPTION	2015 COST WITH EMFF (£)	2017 COST WITH EMFF (£)	% DIFFERENCE
REM hardware – 6 camera system	120	165	+38
Installation costs	480	480	0
2 additional hard drives per vessel	2	2	0
Hard drive swapping per year	120	120	0
Maintenance costs	1,200	1,200	0
Video analyst salary	2,500	1,667	-33
Review software licence	275	151	-45
Total	4,697	3,785	-19

When these costs are combined with the revised fishing fleet numbers (Table 2), it would cost approximately £5.01m to equip and monitor the UK >10m fleet of 1,324 vessels, reviewing 10% of the video and 100% of the sensor data.

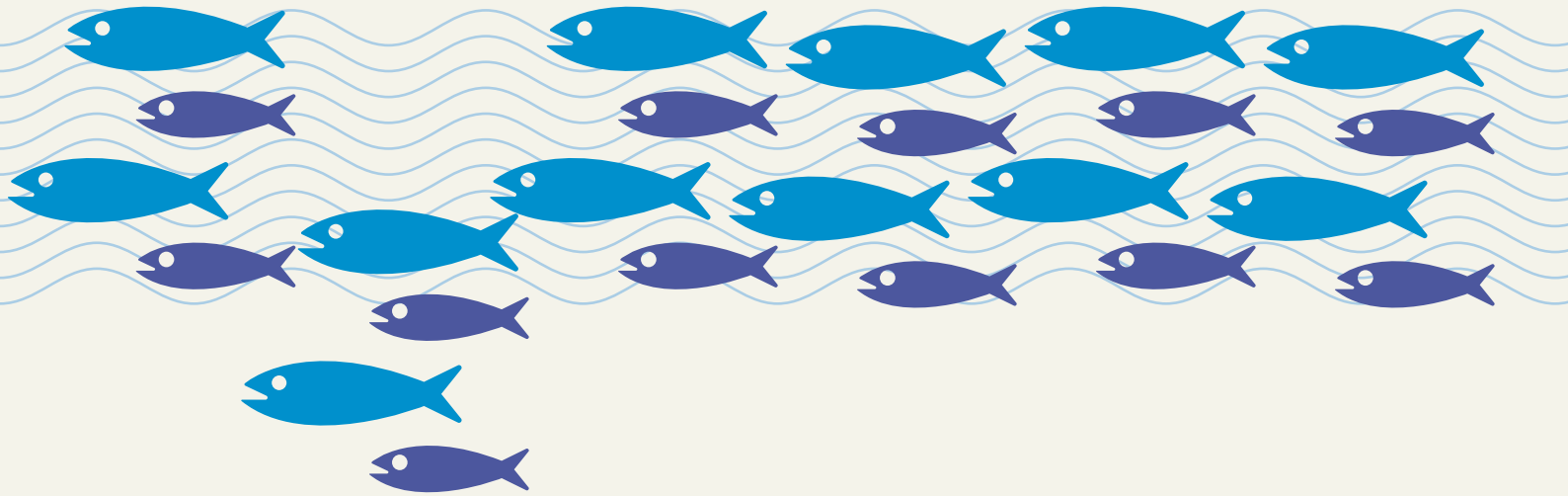


PHOTO: ADOBE

WHAT CAN REM DELIVER?

The benefits of using REM to monitor and manage fisheries were discussed fully in the 2015 WWF report, in brief they include:

- Improved compliance and transparency
- Improved data collection to support stock assessments
- An ability to demonstrate that a vessel is operating in accordance with best practice
- An ability to ground truth and support management revisions
- A reduced need for human observers to go to sea
- Effective monitoring at sea incentivising selectivity
- A cost-effective alternative to traditional monitoring and control methods

Effective: REM is the only monitoring method currently available that can effectively monitor the Landing Obligation because of its ability to view and record crew behaviour at sea. The fact that no high-grading regulations were ever properly enforced before the introduction of REM in fisheries but that there are now three cases pending in Scotland based on REM data, supports this (PQ S5W-04367).

Delivers more for less money: Financially, the 2015 report illustrated that every UK vessel over 10m in length could be installed with REM and have 100% of the sensor data and 8% of the video reviewed for a cost of £5.5m (including the EMFF contribution for hardware). This was equivalent to 25% of the 2015 monitoring, enforcement and observer programme budget. With a rate of 10% video review this cost rose to £6.38m. The revised 2017 costs now show that it would cost approximately £5.01m to monitor 10% of the collected video for the >10m UK fleet, a reduction of £1.37m

The financial argument clearly shows that REM is a viable option. However, there are other potential benefits to using REM in fisheries management that are not linked to compliance or enforcement costs.

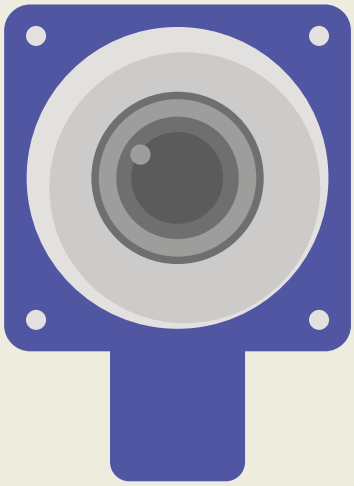
Increased and improved data: REM has allowed data to be collected over a longer period, and it is being used in several UK research projects such as the 2016 Fisheries Science Partnership (FSP) Bristol Channel elasmobranch survival project, and the MMO /industry southwest haddock gear selectivity trials. Rather than sending observers to sea for one or two research trips and obtaining a 'snapshot' of results, the fishermen themselves can collect the data over a longer period, record the data and imagery using REM, and have the data and results verified by an onshore video analyst. This removes any potential bias introduced by seasonal variations or from having an observer on board. It increases the timescales of a project, increases available data and reduces the costs of collecting the data.

Article 25 of the revised CFP regulation (Council Regulation 1380/2013) states that "the collection, management and use of data shall be based on accuracy and reliability, and collection in a timely manner" and that it shall be carried out in a "cost-effective manner". The use of REM allows both these criteria to be met, in contrast to traditional scientific data-gathering methods.

Faster access to data: Currently observer coverage for scientific research purposes is low but costs are relatively high; and the data takes time to be manually entered on to a database, checked and then formatted for annual stock assessment purposes. This process can take up to a year to complete. REM sensor and positional data can be available in near-real time, while video review data can be completed and uploaded within two weeks of receipt of the raw data. This in turn can allow managers to respond more quickly to events on the fishing grounds and so give fishermen the best opportunities based on what they are currently (or very recently) experiencing, rather than historical events.

Legal compliance: Article 15 of the CFP states that for the purposes of "monitoring compliance with the landing obligation, Member States shall ensure detailed and accurate documentation of all fishing trips and adequate capacity and means, such as observers, CCTV and others." Having an observer programme that can effectively monitor the Landing Obligation is expensive and requires large numbers of observers; while REM will be less expensive and less intrusive, and will produce data that can be used for multiple purposes.

NEW ZEALAND COMMITS TO REM WITH CCTV



The New Zealand government recently announced its intention to require fishing permit holders to use electronic catch reporting, geospatial position reporting and electronic (camera) monitoring of commercial fishing activity.

Integrated Electronic Monitoring and Reporting System (IEMRS) is expected to provide important contributions to Future of our Fisheries strategic proposals. The New Zealand government identified a range of benefits that such a policy will have, including:

Reduction of wastage in commercial fisheries: Camera monitoring of commercial fishing operations by IEMRS will encourage full catch reporting and eliminate discarding of unreported catch.

Improvement of the information base to support fisheries management: Timely catch reporting and monitoring via IEMRS will improve the information base for setting sustainable catch limits. This presents a significant opportunity to improve the value realised from commercial fisheries, particularly for those stocks for which there is currently limited information.

More responsive decision-making: The availability of more comprehensive, timely and fine-scale information on fishery interactions with fish stocks and the environment will enable a decision-making framework that is more responsive to risk, and better able to assure the sound environmental performance of New Zealand fisheries.

IEMRS will provide verifiable, accurate, integrated and timely data on commercial fishing activity to inform decisions of fisheries managers in government and industry. Better and verifiable information from commercial fisheries will contribute to significant improvements in fisheries management.

In addition to enabling significant improvements in fisheries management, IEMRS is expected to generate economic benefit for New Zealand. The cost/benefit analysis undertaken for the Ministry's 2017 Budget bid to support IEMRS identifies monetised costs of NZ$83.2m over 15 years (2018-32), compared to monetised benefits of NZ$158.6m in the same period. Monetised benefits result from, for example, securing and increasing access for New Zealand's wild-caught seafood to premium markets that require assurance of sustainable fish production and 'boat to plate' tracking.

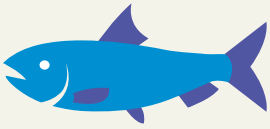
IEMRS also delivers substantial non-monetised benefits. The introduction of IEMRS will increase public confidence in New Zealand's fisheries and fisheries management system, strengthen the nation's international reputation and help minimise the impact of commercial fishing on the aquatic environment.

Source: Paper from the New Zealand Office of the Ministry of Primary Industry

WHAT THE USA IS SAYING

It is interesting to note that at the IFOMC 2016, Jane Dicosimo, a representative of the United States government and manager of the US National Observer Programmes, stated that they "would no longer fund REM pilot projects". This was because they acknowledge that the technology providers and operators have demonstrated that the REM systems are advanced and reliable enough to be used in nearly all fisheries, and that all future REM-allocated funding would be used in making full monitoring programmes operational in US fisheries. In short, REM works, so there is no need to test anymore and REM should be introduced wherever appropriate.

COLLABORATIVE SCIENTIFIC APPROACH USING REM



THERE WERE REPORTS OF LARGE QUANTITIES OF HADDOCK BEING DISCARDED AT SEA

Background

In 2013, David Stevens, skipper of the FV Crystal Sea, volunteered to participate in an REM trial investigating the catches of western haddock (ICES Area VIIb-k) in the southwest of England. The aim was to try and quantify haddock catches using REM and verify skipper self-reported catch data. At the time there were reports of large quantities of haddock being discarded at sea because of large year classes coupled with low quota availability. This was thought to be mainly due to the UK having only a small share of the haddock quota due to relative stability, and fishermen were selecting only the most valuable fish for retention. Observers were reporting discards of up to 62% of the catch on the Data Collection Framework (DCF) catch sampling programme (Roberts *et al*, 2014), but reports from industry were that haddock stocks were abundant and virtually unavoidable, and that all discards were as a result of a Total Allowable Catch (TAC) share that was too low.

REM was installed on the vessel and video from 10% of the hauls fished was reviewed. Roberts *et al*, (2014), found that accidental discards (discards where a crewman failed to select off haddock for retention in accordance with the terms of the trial) were less than 0.01%, and that less than 1% of the catch was below the minimum landing size (MLS). This supported the skipper's claims that his gear was fishing selectively and that all discards were TAC generated. However, there was the possibility that the vessel was not catching small haddock because they were not encountered.

Two months before the end of the trial, the vessel ran out of haddock quota completely and the discard rate rose to 100%, of which 99% was estimated to be higher than the MLS. Had additional quota been available nearly all of this haddock could have been landed for human consumption rather than discarded back into the sea dead or dying. However, on a positive note the skipper agreed to keep collecting data and allowing the REM to operate throughout this period: this allowed the data gathered to be fully verified, and led to research trials on gear selectivity in this fishery.

AN INDUSTRY VIEWPOINT

As part of this report, an interview was conducted with the owner of the FV *Crystal Sea*, David Stevens. The following is a summary of this discussion.

As we moved into 2015 to 2017 the UK was working towards Maximum Sustainable Yield (MSY) principles, and the haddock quota was cut by 70% during this period. This made the continued catch quota trial (CQT) impossible to continue with as it required us to land all haddock, but of course we couldn't because there was so little quota. But we decided to continue to fully record the entire catch to help provide data to MMO. However despite not towing at night (25% of fishing time) and introducing 120mm SQMP, cut back headlines and agitators in the net we found it impossible to make the haddock quota last all year and would have run out of quota by April in 2016 if fully engaged in the CQT.

Throughout this period the vessel was seeing greater volumes of this species year on year, suggesting something was seriously wrong with the management approach.

To give an overview of what we were up against, we usually catch between 1-2% of each species quota amount for the UK in area 7, and we have access to 10% of the haddock TAC plus the 5% uplift from the CQT trials, but this is nowhere near the amount of quota we need to continue in this mixed fishery. Then in 2016 the EU discontinued the quota uplifts for CQT schemes in area VII due to the insistence of other Member States and their fears of REM.

The purpose of accepting the REM aboard the vessel was to help bridge what we saw as gaps in the scientific data. We were being told that the stocks were threatened and that due to limited data the scientists had to take a precautionary approach to stock management. This advice and approach did not seem to fit with what we were seeing when we went to sea. We knew that there was an observer programme but were concerned that sampling levels were extremely low compared to the fishing effort in the area, and that if the 'wrong' trips at the wrong time were used to represent the whole fleet then there was the chance it would be completely different to what the rest of the fleet was seeing, and totally unrepresentative. This was especially the case when the observer sampling effort was spread over such a wide range of vessels and gear types and the whole of England.

PHOTO: DAVE STEVENS

> We wanted to show the scientists what was really going on and help them make well-thought-out management decisions

PHOTO: DAVE STEVENS

> The cameras and REM systems gave us the chance to collect data and prove we were telling the truth but also help managers at the same time. We want a healthy well-managed stock and that can only be achieved through good data collection at high enough levels

PHOTO: ADOBE

> "Now REM has given us a chance to prove what we are reporting and claiming in almost real time"

For example, in area VII, our fishing area, only eight trips were conducted for one year in our metier (Bottom Otter Trawl – OTB), and many of these trips were only of one day at sea in duration. One of the biggest issues in the recording of data for haddock in area 7 is that most of our haddock catches are caught at night, and the way in which the observer programme is conducted means very little night fishing is properly observed. So we fear that the scientists are completely missing the data for haddock by only undertaking day trips, and we think this has led to a mismatch with the quota share for haddock in our fishery. Compound this with the UK's poor relative share from the EU (UK 10% of TAC, France 60% of TAC) and factor in that the majority of haddock swim close to the UK coast and can be caught as bycatch, we have a huge choke species scenario for this stock.

So, to help inform the process we wanted to participate and help reverse the burden of proof. In other words, we wanted to show the scientists what was really going on and help them make well-thought-out management decisions based on higher quantities of good quality data. The cameras and REM systems gave us the chance to collect data and prove we were telling the truth but also help managers at the same time. We want a healthy well-managed stock and that can only be achieved through good data collection at high enough levels. We also wanted the chance to experiment with the fishing gear and try and remove the smaller grades caught to allow them to reach spawning size – again, the REM could allow long-term trials to be undertaken without the need to accommodate an observer.

This was a huge leap of faith by us, but we wanted to be completely transparent and be part of the solution. There was and still is the chance that this data could be used against us, or even worse is never used at all. But over the last four years we have built up an excellent relationship with the MMO who are leading on these trials, as well as with Cefas who are interested in the data and are also undertaking REM projects elsewhere.

We have basically helped remove this 'silo' mentality of us and them, between ourselves and compliance and science. This has led to us being able to show other vessels in our local fleet that there is nothing to fear from the systems and that it can only help the situation by having the right data.

Cooperation between scientists, managers and fishermen is key to a well-managed fishery, and fishermen are in a position to contribute the most data at the lowest cost through the use of REM. We are also able to investigate new gear developments over long periods and finally able to think of innovations for ourselves and to help ourselves. The top-down approach by both scientists and managers has stifled this innovation and strict technical conservation measures have limited what we can trial. In the past we have taken scientists to sea, taken any incentives on offer (like charter fees), carried out their instructions – then when they have left we have gone back to whatever we were doing before because we didn't think what was being trialled was very effective and was unlikely to work all the time. Plus, there was no real need to change what we were doing.

But now REM has given us a chance to prove what we are reporting and claiming in almost real time. Observer data and research trials can often take years to be inputted and written up and are very seldom acted on. We now have a chance to show video and data from our last trip that is indisputable, and the managers should put in place systems that allow them to act on that information as quickly as possible. We know it won't be an immediate reaction, but if decisions could be made in weeks instead of months and years it would be a vast improvement.

From an ambition point of view, we think that REM will give us the chance to prove our claims and challenge management decisions based on poor data in a positive way, through improving and increasing data sets.

"Now that we are leaving Europe there is the chance for us to shape our own fisheries management structure"

There is no reason why the fishing industry cannot undertake its own surveys and assessments if the data is transparent and available for scrutiny. Arguments will be reduced because the evidence will be available for all to see, and there is no real reason why the industry should not be the owners of that data.

Now that we are leaving Europe there is the chance for us to shape our own fisheries management structure. We can set the bar high and ensure a responsible and transparent approach by all who want to fish in UK waters. It should be a UK fisheries ambition to have REM coverage in all fisheries, even if it is not on 100% of the vessels. This will still allow comparisons to be made between the grade structures of fish caught between REM and non-REM vessels to ensure that the two fleets are operating in a similar pattern.

Above all we need a share of the quota that reflects what we catch and not what we land, especially if the UK continues with a management measure similar to the Landing Obligation after Brexit. If a Landing Obligation is monitored through REM we will be forced to land unwanted fish and made to stop fishing once the quota is used up. The science needs to reflect what we are experiencing on the ground and we need to ensure that the UK gets the quota that it is due. If not, we could be tied up within months, and the industry – and all supporting infrastructure and related industries – could run the risk of collapse. Quota management post-Brexit needs to be able to address this challenge and avoid disastrous consequences for the industry.

If foreign vessels wish to fish UK waters after we leave the EU then they must abide by the rules set by the UK government, and prove that they are not high-grading or illegally discarding or doing any other illegal activity. They should be monitored to the standards set by the UK, and if we have REM then so should they. Their data should be sent to the UK authorities for review and action, just as ours is.

If not then they should not have the right to fish. Transparency and effective monitoring will ensure that it is a level playing field, that the fishery is sustainable, and that monitoring is of the same standard and not subject to different national funding levels or attitudes.

Through the recent gear trials, we have shown that we are able to think of our own technical solutions for reducing unwanted catch. We have discovered that haddock react differently to escape panels depending on the time of fishing and the size of the fish. Larger more mature fish tend to escape from the panels placed at the front of the net, while the smaller immature fish escape near the codend. We have almost eliminated undersize haddock and the smaller marketable grades from the catch, with virtually no fish below 37cm being caught (Figure 1, Catchpole *et al*, 2014), with the MLS being 30cm. Unfortunately, we are also losing other valuable species at certain times of the year, so we need to balance when we use this gear. But this is a really positive start and through our participation we have encouraged other vessels in the area to take part and carry REM. This cooperative approach is the way to ensure the data being used is correct, that innovation in gear design is encouraged and that we have a healthy sustainable fishery in the future.

Instead of complaining, we can be a major part of the solution and argue our case with facts and evidence. To gain the much-needed flexibility in the mixed fisheries we have in the UK, we as an industry need to add transparency into the system. REM gives you that ability. It reverses the burden of proof.

This positive approach by David Stevens has helped build healthy relationships between the enforcement, science and commercial sides of the fishing industry. Instead of the usual approach of dictating a policy, rigid enforcement, attempted circumvention of rules and voluntary (but often reluctant) accommodation of observers, there has been a completely new and cooperative approach. There is the realisation that all parties want the same thing: a healthy and profitable industry based on well-managed, sustainable stocks. This has led to greater quantities of data being collected at a fraction of the cost, an enthusiasm to solve gear selectivity issues by those who use the equipment every day and have the in-depth knowledge to solve these challenges, and a pragmatic approach by compliance agencies that has allowed greater flexibility to experiment and provided the right incentives to do so.

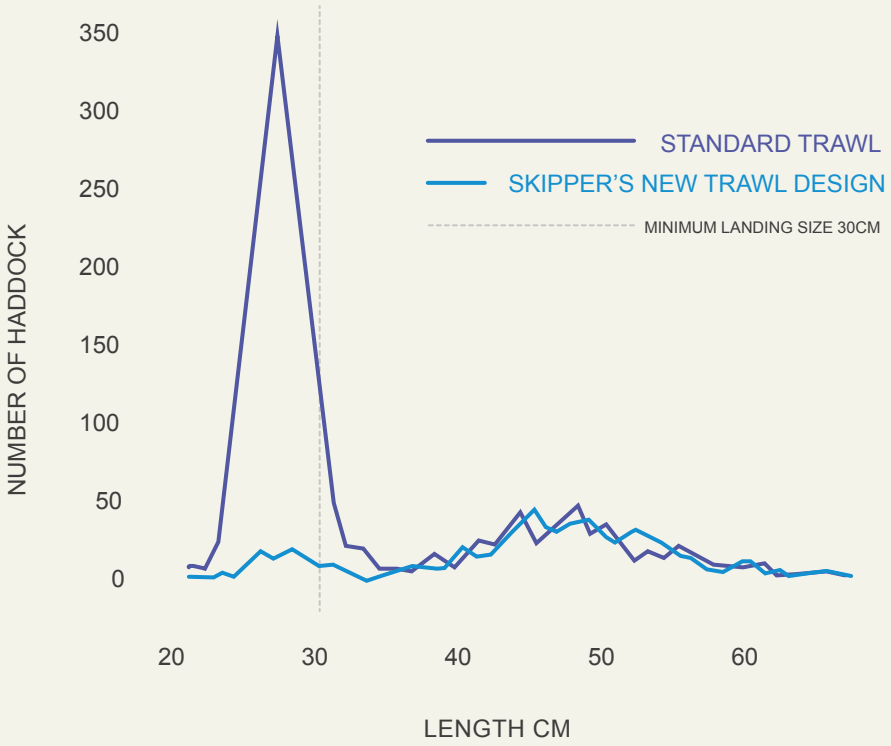
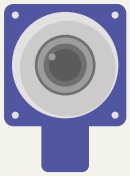


Figure 3. Length frequency distribution for haddock caught during gear trials as part of the ASSIST project in 2014.

A STALLED PROCESS

There is no disputing REM's usefulness as a compliance monitoring tool, as it is now being used in this way in several major fisheries worldwide. In the UK trials have been conducted for both compliance and scientific purposes, yielding useful verified data.

Yet there still seems to be a reluctance to move to the next step of a fishery roll-out. A small step has been taken in the inshore Scottish scallop fishery with the introduction of the optional use of REM for improved fishing opportunities, but no real introduction has occurred.



WHAT IS HOLDING UP ADVANCEMENT OF REM IN THE UK, FROM A TRIAL BASIS TO NORMAL PROGRAMME STATUS?

On the 26th of June 2017 the Scottish Fisheries Minister Fergus Ewing noted that Control experts for the Scotland and elsewhere in the EU have advised that for large scale, directed pelagic fisheries monitoring can best be achieved with the use of cameras and sensors, more commonly referred to as Remote Electronic Monitoring (REM). He further noted that the Scottish Government agree with this and that they would be content to see cameras installed where appropriate on all relevant vessels fishing in EU waters. He also noted that for some sections of the demersal fleet a similar approach may apply, although this should be contingent on solutions to "choke species" being in place.

This is a positive statement and one to be welcomed. There is however a clear argument for REM not to be adopted on a piecemeal basis but for a comprehensive commitment to be made in order to create the much needed level playing field, introducing it as standard practice across the over ten fleet.

At the time of going to press there has been no such positive commitment from the UK minister and it is difficult to understand the reason for apparent reluctance.

It is unlikely to be cost, as REM provides a cheaper and more effective alternative for monitoring the Landing Obligation. It allows large quantities of data to be collected over a long time-scale for scientific purposes, without the need to send observers to sea in harsh, unfamiliar and potentially life-threatening environments. Again, it is cheaper than observers or using research vessels. Certain parts of the industry are becoming fully aware of how REM can benefit them and have admirably volunteered for all REM trials and projects so far. So, what is holding up advancement of REM in the UK, from a trial basis to normal programme status? It can only be one of two things: culture or politics.

Arguments are often made about the use of CCTV being an invasion of privacy, and several European countries have used the argument that it is "against their culture" to be monitored using CCTV. This may well be the case in some countries, but here in the UK and in many other countries it has become standard practice to safeguard property and people using CCTV. It is used in supermarkets, banks, public transport, streets, houses, in most work spaces, road junctions, in fact almost anywhere there is a perceived need.

So this argument cannot be the issue in the UK, otherwise the population would be protesting at such widespread usage already. This suggests that the issue must be political.

Certain segments of the industry have shown that they are not afraid of REM, and it could actually equip them with the tools and evidence they need to prove their assertions. If all vessels were operating on a level playing field through the use of REM then no one would have an unfair advantage. So the issue must lie with governments, and a lack of will to monitor the Landing Obligation and a lack of willingness to invest in the technology that will allow a better evidence base to make marine planning and fisheries decisions.

Or is the real issue that having the real data will upset the convenience of a precautionary approach, and that stock assessment models would need to be redesigned?

Reference fleet approach

"IT CAN ONLY BE CONCLUDED THAT HIGH-GRADING TAKES PLACE IF FISHING IS NOT FULLY MONITORED AND DOCUMENTED"

The use of reference fleets is one option often suggested, but it comes with challenges and does not offer an alternative to an effectively implemented REM programme. In 2012, Dalskov *et al* analysed the catches of cod landed by grade for vessels before they joined the catch quota scheme (2009) and after they joined the scheme (2011), and installed REM with CCTV. They found that the grade 5 (smallest grade) cod landings for the North Sea vessels was less than 5% of the total landings in 2009, and that this rose to 13% in 2011 for the vessels fitted with REM. However, the vessels that did not have REM installed only had 7% of their landings at grade 5 size in 2011. In the Skagerrak, a similar pattern occurred where vessels installed with REM were landing 27% grade 5 cod compared to 10% for those without REM. Dalskov *et al* (2012) stated that "it can only be concluded that high-grading takes place if fishing is not fully monitored and documented."

Similar differences in the size grades of cod landed by REM and non-REM vessels were noted in the UK by Sandeman *et al*, (2016) during the MMO Catch Quota Trials. Those vessels installed with REM had 30% of their cod landings at Grade 5 size, whereas the non-REM vessels had only 12% Grade 5 cod in their landings. When the Grade 4 cod were also included the percentages rose to 48% Grade 4 and Grade 5 cod in the landings for REM vessels and 25% for non-REM vessels. The conclusion was that this was indicative of high-grading in the non-REM monitored fleet. They also suggested that when considering a reference fleet approach instead of a 100% monitored fleet, the number of vessels chosen for monitoring must provide confidence of a level playing field and ensure that unfair commercial advantage does not arise from not having REM installed.

The ability to fund a 100% coverage REM project is likely to be the main reason why a reference fleet approach may be considered. However it is clear from the above studies that those vessels with REM installed will be placed at a commercial disadvantage compared to those without REM in a reference fleet scenario. The vessels without REM will likely continue to discard undersize fish as well as high-grade the less valuable smaller grades of marketable catch and will therefore be able to maximise the returns on their limited quota by ensuring that only the larger more valuable fish are landed against it. Given that the main costs associated with REM tend to be staff costs related to video review, a fairer solution would be to install REM on all vessels within a fishery but reduce the video randomly selected for review. That way vessels will all be operating to the same conditions because none will know if they will be selected to have their catch declarations verified by video and so will not risk non-compliant activity.

THE COST OF NOT IMPLEMENTING

What would be the cost of not effectively monitoring a discard ban or having the correct data to improve stock assessments? Stock assessments are usually based on the official landings data.

If we allow discarding to occur unmonitored and unreported, then there is a proportion of the fishing mortality that is unaccounted for. Scientists can assign this a figure based on best available knowledge, but at best this is an educated guess and management decisions will be made on this approach.

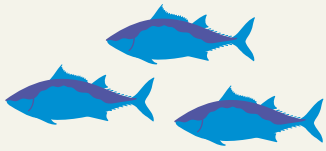
The restrictions on the UK bass and elasmobranch fisheries is a good example of where management measures are now solely based on the assumption that what is landed represents the fishing mortality. A landing ban is in place and therefore the assumption is that none are being killed (or at least have been limited to low level incidental bycatch). Yet a quick search of social media platforms such as Facebook will show that fishermen are still catching large quantities of these species and being forced to discard them at sea, and this information is not currently being recorded or accounted for. The fish are still being killed but now the problem is hidden at sea and the unaccounted fishing mortality could increase dramatically. The use of REM on these vessels would have allowed this discarding to be detected and quantified and appropriate management measures to be put in place. Now there is a situation where the assumption is that mortality has dramatically decreased due to a ban on landing and that all future assessments are based on this new mortality/landings data, whereas the reality is that the fishing mortality may be exactly the same as it was before the landing ban was introduced.

THE PROBLEM IS HIDDEN AT SEA AND THE UNACCOUNTED FISHING MORTALITY COULD INCREASE DRAMATICALLY

The reality is that there is already a fully documented fishery (FDF) policy in the UK and this has been the case since recording catches in logbooks was required. Recording of discards of 50kg or more is mandatory, but how accurate is this self-declaration? It would be interesting to compare self-declared discard information from the logbook entries to those collected by fisheries observers. It would give a good indication of the accuracy of logbook discard data. Without verification, it is quite possible that the values recorded for retained or discarded catch could be completely unrepresentative of the catches actually caught, especially discards. If there is no monitoring then the decision to record this information accurately becomes a personal choice, and misreporting of catches may give one vessel an unfair commercial advantage over another. But the new Common Fisheries Policy (CFP) clearly states that it will "contribute to an efficient and transparent internal market… ensuring a level playing field for fisheries products", and it is difficult to see how this can be achieved without REM being used as a compliance tool on all vessels. Even if catches are being fully recorded accurately by all vessels, if there is no verification then there will still be suspicion and caveats placed on the use of self-declared data.

FISHERIES OBSERVERS: THE HUMAN COST

The monetary cost of using on-board observer schemes has been well documented, but little has been said of the cost to the observers from a non-financial perspective.



HUMAN OBSERVERS WOULD BE BEST USED TO COLLECT CERTAIN BIOLOGICAL DATA AND PHYSICAL SAMPLES

At the International Fisheries Observer and Monitoring Conference (IFOMC) in San Diego in 2016 this was a major discussion topic and was prompted by the tragic loss at sea of a well-respected and highly experienced fisheries observer. Over the last five years two US observers and three Pacific Island observers have been lost in suspicious circumstances, or murdered at sea.

The conference also heard reports of physical assault, sexual assault, intimidation, attempted bribery and discrimination, along with details of the mental and physical demands placed on observers due to the harsh environment and isolation. All discussions agreed that being an observer was a highly skilled and dangerous career, and that many enforcement duties would be better served by the use of REM. Human observers would be best used to collect certain biological data and physical samples (Kennelly, 2016). Thankfully these extreme examples are rare, and it is important to note that these all involved compliance observers. These are different from observers used in UK fisheries, who are not used for compliance but instead to collect scientific data. However, with the introduction of the Landing Obligation any data collected by government seagoing observers on discarding practices could be used to identify infringements.

In essence, the observer's role could change from one of scientific observer to an observer whose data could be used in compliance – and this new role could create conflict with the industry and corrupt the non-biased data they are trying to collect. In addition, because they are government employees, any confidentiality is removed and the observers would have a duty to report any infringements. Given that vessels are only required to accept observers on a voluntary basis, this may reduce levels of acceptance and with it the levels of data collected for management purposes.

Even scientific observers can face conflict, aggression and intimidation, plus the remoteness of their role can leave them feeling isolated and removed from reality. In addition to this there is also still the risk of accidental injury or even death given the dangers associated with life on a fishing vessel. The following are actual examples from UK observers.

Case 1 – "Whilst operating on a small trawler in the North Sea, I was taking samples of catch in a basket and measuring these whilst sitting on the lid to the fish hold. I had done this for several baskets of fish and went to do it again but had not noticed that the hatch had been removed to gain access. I fell backwards into the hold and landed on my back. This was a fall of about 8-10 feet and it caused severe pain. I was lucky not to have been more severely or permanently hurt."

Case 2 – "I was supposed to conduct a series of research voyages with the same vessel over several weeks. During the first trip the weather was severe and water often poured into the accommodation. On returning ashore I refused to do another trip because I thought the vessel was not suitable for research this far offshore. This had been a frightening experience in itself but on top of this I was then threatened with violence ashore by one of the crew because losing the contract was going to cost the vessel and crew lots of money."

Case 3 – "I had been deployed on a foreign vessel working in deep waters. I was the only English speaking person on board and it was difficult to communicate with anyone. The conditions on board were appalling and the trip was long. It was scheduled to be 4-6 weeks long but whilst out there they extended by another 4 weeks, so we started to run out of basic food and water. The isolation and conditions nearly broke me mentally."

The following quotes are from five different scientific observers who encountered threatening attitudes and intimidation. To avoid offence, some of the wording has been slightly altered.

Most of these examples stem from the fishermen somehow perceiving the observer as an annoyance, or as a spy, or as an inconvenience or cost to them and their industry in some way. Others concern the observers being asked to lie or be complicit in a deception, while others are just born from frustration at government legislation or that a trip is going poorly. These are all real examples from within the UK. Very few of the examples below or the cases above are ever documented because the observers are worried they may not be able to go to sea for safety reasons and because the bureaucracy involved with reporting these near misses and incidents is great. It is easier to pretend they never happened and carry on regardless.

1. "They defecated on my measuring boards."
2. "They threw my measuring boards over the side."
3. "I was thrown down the wheelhouse steps."
4. "They stuck the deck hose inside my oilskins when I was working to humiliate me."
5. "They refused to let me sample at night because they were misreporting these catches."
6. "They asked me to record the fish as a different species so they could land them."
7. "They told me to record the retained cod as discarded because they had no quota and were landing them illegally."
8. "They would not take me to sea because I was a woman."
9. "I had to check my boots every haul as they kept putting dead fish or live crabs in them as a joke."

It should be remembered that the UK observer programmes have been operating for over 20 years with 100% voluntary participation from the industry. The majority of fishermen are courteous, polite, helpful and understanding of the need to collect data. They are highly professional businessmen and highly skilled crewmen and seagoers. But it takes just one person to spoil this reputation, or just one momentary lapse of reason or sobriety for a tragedy like those experienced in the USA to occur. If seagoing observers are used as compliance officers in the UK, it is likely that these incidents of ill-will or conflict could become more frequent and perhaps more serious, as the scientists may be unable to observe illegal activity (e.g. high-grading) without recording and reporting it.

It is expected that the scientific DCF observer programme will be undertaken on approximately 0.3% of the UK fleet. This may be a useful level of sampling for some purposes (e.g. to collect otoliths for aging fish), but given that this sampling effort is spread over all fisheries, all gear types, all regions, all seasons and all vessel length classes, there is a risk that the sampling coverage will be spread extremely thinly. If the collected data is then raised to fleet level, the data for a particular metier could be heavily influenced by a very low number of sampled trips. This is not in anyone's interest, so there are three choices:

1. Increase the observer monitoring budgets to allow higher coverage levels;
2. Switch completely to REM for scientific data collection to increase sampling levels and to reduce potential sampling level bias, but without increasing costs; or
3. Combine both programmes to allow data to be gathered from large numbers of vessels over all seasons and regions using REM, but with quality assurance sampling and physical sample collection being undertaken by the observers.

USING REM ALLOWS THE DATA COLLECTED TO REMAIN NON-BIASED BY AN OBSERVER PRESENCE OR SEASONALITY

If observer programme budgets were to be increased it is likely that it would need to be at least 10-fold, which would make it expensive and would also lead to the 'friendlier' fishing vessels being targeted by observers. Therefore any increase would need to include a change in participation from voluntary to mandatory to ensure that data from all types of vessels is included.

With the developments in REM technology, the need to send government scientific observers as compliance officers could be considered unnecessary. Is sending observers to sea a risk that is worth taking when a safer alternative is available? Scientists should be allowed to collect data confidentially to ensure it is representative of what the industry routinely does when not being monitored, and using REM allows the data collected to remain non-biased by an observer presence or seasonality. Observers will always be necessary for some tasks such as collecting physical samples or for gathering fine-quality data sets, but it is important to ensure that the data is collected safely, is independent of bias, is representative and – above all – is usable.

CONCLUSION

The efficacy of REM is well tested, and trials have established that it can be employed for both compliance and scientific purposes. Trials have mainly been government-driven, with incentive-led industry participation. But the industry is now realising how REM could work for them, and that it would allow them to demonstrate that they are endeavouring to fish not just legally but sustainably and responsibly.

RELUCTANCE TO USE REM FOR FINANCIAL REASONS IS NOT VALID

It would also allow them to build partnerships with scientists and compliance agencies, as well as with retailers to market their product positively. The industry can also see that REM is just another tool, and it is up to the user to determine how that tool is used and what the outputs from it could or should be.

The cost issue has been well and truly addressed, and the reluctance to use REM for financial reasons is not valid. It is cheaper and more effective than some other methods of monitoring and in the collection of some scientific data sets, and is becoming cheaper all the time. The updated costs have shown that new technology is becoming the most affordable and efficient option for monitoring catches and collecting scientific data. The estimated cost of reviewing the whole UK >10m fleet at 10% video review rate has dropped from £6.4m to £5.01m from 2015 to 2017 (a 22% reduction), despite the fall in value of the UK pound against foreign currencies. Conversely the costs associated with traditional monitoring and scientific data-gathering methods are increasing. Salary costs have risen, so the costs of using observers has risen. Oil prices have risen so deploying monitoring assets – e.g. aircraft or patrol vessels – has increased. The maintenance and running costs associated with ageing assets will also rise as they become older, or alternatively millions of pounds will need to be invested to replace them. In addition, reductions in government spending mean that departments are being asked to provide the same level of service with less resource, which in turn could lead to reduced monitoring levels or scientific research. So, REM is cheaper and more efficient than traditional methods for monitoring fisheries regulations or collecting long-term data sets; and it will become more effective as government departments are forced to prioritise spending on services.

PHOTO: ADOBE

REM also helps to reduce bias introduced through observer presence, 'snapshot' seasonal sampling, and low collection rates due to low scientific budgets. To achieve a similar level of coverage using observer schemes would cost considerably more, and the numbers of observers required would be in the hundreds. With this number of onboard observers operating in the fishing fleet fishermen would soon become saturated with calls to take an observer, patience with unwelcome guests would be tested, and observer accident rates would increase. It would only be a matter of time before there was a serious or even fatal observer accident. Observers have a role to play going forward, but that is to obtain the high-quality data and physical biological samples required to inform science. REM can obtain the necessary metadata, more safely and more efficiently than an observer.

In order to monitor a ban on discarding, when activity at sea is what needs to be monitored, it is difficult to understand how government can claim compliance without a means of monitoring this activity effectively.

Other countries have clearly seen the benefits. UK fisheries management is about to enter a new era, and a progressive approach would be to embrace the use of REM at the heart of any new system in order to demonstrate that UK fisheries can be synonymous with sustainable fisheries.

It could also look at making the use of REM and cameras a condition of operating in UK waters, and in doing so set positive trends that will in time create level playing fields across shared seas.

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£3,785

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

0 DAYS

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

£5M

Estimated annual cost of using REM to monitor 10% of the UK over-10m fleet's activity

100%

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