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Global Fisheries Enforcement Training Workshop
The Fourth Global Fisheries Enforcement Training Workshop: February 17-21, 2014

Time is running out! If you plan to attend the 4th GFETW and have not yet registered, please do so soon.

The International MCS Network and Costa Rica are working closely together in the organization of the fourth Global Fisheries Enforcement Training Workshop. The fourth GFETW will be held from February 17–21, 2014 in San Jose, Costa Rica at the Wyndham Herradura hotel. The theme of the conference will be “Protecting artisanal and regional fishing communities through the promotion of legal, reported and regulated fisheries.” The winners of the Stop IUU Fishing Award will be honored at the fourth GFETW and will share their MCS experiences to promote exchange of knowledge and inspirations. For more information on the Workshop, visit www.gfetw.org.

Wanted: Mesh Gauges

Under the framework of the operation “African Winds,” the IMCS Network recently sent two Vetted MCS Experts, Richard Thomasson and Alastair Beveridge, to assist with the training of authorities involved in Ghana and Benin’s fisheries enforcement. During this training, the MCS experts discovered that both countries’ fisheries inspectorates were in need of specialized equipment for fisheries inspections.

In West Ghana, one mesh gauge is shared among the entire region for measurement of mesh size. Among this, other basic equipment is also failing. After identifying the lack of basic equipment, the IMCS Network, in liaison with the Netherlands, has arranged to ship mesh gauges to Ghana and Benin. These gauges were no longer used by the Netherlands and therefore available for contribution.

The International MCS Network promotes the exchange of equipment between various country authorities. Please contact the Network secretariat when your authorities are in need of inspection and surveillance equipment or have equipment available which is no longer in use and written off from the books. The Network will take full responsibility for liaising with countries in need of such equipment.

On behalf of the countries in need of this equipment, we thank you in advance for making such equipment available.
Mr. Ralph summarized his experience at the meeting:

I attended the Interpol Fisheries Crime Working Group Meeting in two capacities; as Head of Fisheries and Marine Compliance in Scotland, and as the Chair of the Network. The conference was held at the headquarters of the UN Environmental Program, the United Nations center in Nairobi, Kenya. The facility covers an extensive and impressive campus type area on the outskirts of the city, and functions as their main base in the region. The meeting consisted of multiple conferences covering all aspects of Environmental Crime, and fisheries crime was only one aspect of the week-long event.

The Fisheries Crime Working Group sessions entailed presentations from delegates on various aspects of crime they had encountered. There were also sessions that dealt with the business aspects of the group, to set out its work for the next six months. Elections were also held during the meeting for the key office roles in the group.

On the first day I was one of a number of speakers covering specific investigations. I spoke about the large scale pelagic fraud investigations uncovered in Scotland a few years ago. Notably among the other presentations, there was a splendid demonstration on the work that had been done concerning a template for operational planning. On the second day I gave a presentation on the work of the Network, highlighting our role in capacity building and fostering informal contacts between national authorities, organizing the Workshop, and acting as a conduit for exchanges of equipment and experience. I sought to clarify the differences between the Network and the Fisheries Crime Working Group. I explained that we are not duplicating the work of the Fisheries Crime Working Group and that each organization had strengths that drove them to undertake different types of work. There were a significant number of questions asked during the session and a number of people approached me, including prospective new members, to discuss the Network. There were also many inquiries about organizing training similar to the recent exercises in Ghana and Benin. These requests are currently being taken forward.

During informal discussions, Gunnar Stølsvik, the Chair of the Interpol project, and I discussed the capacity building aspect of the project. We agreed that the project should be geared toward helping national authorities generate a capability to use the Interpol tools in order to share intelligence, as opposed to the Network's capacity building plans which assist member country's national authorities to train their front line officers in fisheries inspection techniques.

Throughout the Workshop, there was an impressive variety of speakers who gave presentations on their experiences relating to a wide range of fisheries crime issues. The conference agenda is available on the Network's website for those of you who would like to see the full extent of the meeting. If you would like to learn more about any of the presentations you can contact the Interpol team directly or contact me through the Network secretariat.

-Cephas Ralph, Chairman, IMCS Network
The RPOA Coordination Committee is a high level decision-making body providing strategic advice and direction to RPOA member countries. Since inception of the Coordination Committee in 2008, the visibility and significance of the RPOA in the global arena in combating IUU fishing in the region has been significantly raised. Representatives of ten participating countries to the Regional Plan of Action (RPOA) to Promote Responsible Fishing Practices including Combating IUU Fishing in the Southeast Asia Region (Australia, Brunei Darussalam, Cambodia, Indonesia, Malaysia, Papua New Guinea, Singapore, Timor Leste, Thailand and Vietnam) participated to the 6th RPOA Coordination Committee Meeting. The Philippines was unable to attend the meeting.

The Honourable Dato’ Ahamad Sabki Bin Mahmood, Director General of Fisheries, Department of Fisheries Malaysia welcomed all delegates to Sabah, Malaysia, on behalf of the Government of Malaysia. In the name of all participants, he extended sympathy to the people and Government of the Philippines that were recently struck by typhoon Haiyan, and sincerely wished for the Philippines quick recovery with help and support from all over the world.

At the occasion of the 6th Coordination meeting of the RPOA, the Honourable Dato’ officially launched Malaysia’s National Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (NPOA-IUU Fishing). After five years of adopting and implementing the actions agreed upon, the RPOA is now at the strategic point where countries must evaluate the RPOA’s achievements and assess further actions to address the emerging issues and challenges. Out of the eleven RPOA elements that were endorsed by Ministers responsible for fisheries in the region in Bali in May 2007, member countries commented on the implementation of five core elements that have guided RPOA countries during the last five years.

Co-chairs led a discussion on the regional outlook by highlighting development issues around the eleven elements contained in the RPOA Action Plan, the current situation in the region and ideas on developing an RPOA strategic plan of action. Co-chairs noted that the RPOA evaluation and assessment paper will provide guidance in the discussion on the RPOA’s achievements and future challenges. The discussion on the regional outlook identified achievements of the RPOA, including: Strengthening Monitoring, Control and Surveillance (MCS) systems to include: a draft matrix of national, sub-regional and regional MCS issues, needs and potential actions; establishment of a Regional MCS Network and three sub regional MCS forums; development of a Curriculum and Training Programme on fisheries MCS measures and techniques; and that the Coordination Committee has initiated greater MCS capacity building. Commissioned three RPOA studies: - MCS Curriculum and Training Programme; - Model Fisheries Legislation; - Net Returns: Human and institutional capacity building; Agreement to deny port access to IUU vessels; an advanced draft RPOA IUU Vessel Watch List.

Representing the IMCS Network, I highlighted the activities of the IMCS Network such as information exchange, raising awareness and strengthening technical capacity. He outlined IMCS Network’s experience on capacity building in Ghana and Benin as well as the exchange of MCS equipment. The IMCS Network also announced the upcoming 4th Global Fisheries Enforcement Training Workshop with the topic Protecting Artisanal and Regional Fisheries through the Promotion of Legal, Reported and Regulated Fisheries, which will be held on 17-21 February 2014 in Costa Rica. The IMCS Network invited RPOA countries to participate in the Enforcement Training Workshop as representatives from Southeast Asia. In response to this presentation, the matter of financial support for developing countries to participate in the IMCS Network activities was raised. It was concluded that further financial support would assist greater participation in community based MCS programs, such as in Indonesia and Vietnam who are members of the IMCS Network.
When in 1609, Hugo Grotius laid down the principle of the freedom to fish at sea; he argued that it was impossible to deplete the richness of the sea. Living marine resources would always replenish and therefore it was the right of every State and each legal subject to exploit these resources.

In modern times, this legal principle still underpins UNCLOS, but the argument that the richness of sea cannot be depleted, is overtaken. Technological development and economic opportunities have boosted exploitation of fish stocks to the point that many stocks are depleted and some species endangered.

For this reason, States are managing fisheries, trying to keep catches within the limits of total allowable catches; but their success is variable. Fishing mortality is often underestimated. IUU activities are to a large extent to blame for poor quality of data and even where countries have built up reliable landing control, misreported catches by area and discards are masking real fishing mortality impacting the natural environment. The result of poor data is poor scientific advice.

Currently, Maximum Sustainable Yield (MSY) is the guiding principle in fisheries policy worldwide. MSY means the largest possible annual catch that can be extracted without taking a toll on future catches. Going beyond MSY means not only that the stock declines but future catches as well. (A vicious circle of dwindling resources.) Many stocks are seriously depleted. The total catches from a depleted stock are only a fraction of the catches from a non-depleted stock; sometimes less than 10%. By pushing fishing mortality beyond MSY, the fishing industry is shooting in its own foot. Short term gain is long term pain!

Public opinion at large becomes increasingly concerned about the depletion of resources. Who wants to be responsible for depletion of living marine resources and destruction of the Ocean’s ecosystem? Retail chains are asking for guarantees from their suppliers assuring fishery products have been sustainably harvested. Meanwhile, a growing part of the industry is buying into schemes certifying that their catch has been sustainably harvested and is caught legally. Fully documented fisheries (FDF) and E-monitoring can support the fishing industry in achieving this objective.

Over the past years, E-monitoring pilot projects have been carried out within a clear MCS context. The experience obtained by these pilot projects should be shared between MCS professionals around the world. Therefore, this issue of the International Monitoring, Control and Surveillance Newsletter focuses on E-monitoring that has the potential to become an essential MCS tool and a pillar under FDF. FDF provides full accountability of the fishing industry for the total fishing mortality caused in the natural environment.

While fisheries enforcement authorities accurately monitor landings and fishing trips, traditional MCS tools such as inspection and aerial surveillance at sea, VMS and dockside inspections are not fully effective when it comes to the monitoring of discards and misreporting by area. So far, observer schemes were the only ways to monitor accurately fishing operations and catch at sea.

Fully documented fisheries (FDF) could breach the vicious circle of poor data, poor scientific advice and dwindling resources. FDF entails detailed recording of activities by the master together with E-monitoring. E-monitoring records and archives all activities of the vessel through closed circuit television (CCTV), hydraulic and movement sensors and GPS.

E-monitoring allows for the validation and auditing of the activities recorded by the master in the logbook through verification of CCTV footage and sensor data. E-monitoring records the whole fishing trip, each fishing operation, catch taken on board, by species, fish size and retention of all catch on board. In retrospect, the whole fishing trip can be recreated through CCTV footage, GPS and sensor data and may be audited at any time.

Real time transmission of partial data to inspection vessels and alarms may reduce the scope for tampering with the system.

Over the past decade E-monitoring has proven its qualities and reliability, although so far only a couple of countries have implemented the system and initially as a complement to observer schemes. In fact, many MCS experts were skeptical on the pertinence of E-monitoring as a MCS tool. (Scope for tampering, time consuming and no absolute compliance guarantees) MCS colleagues involved in the pilot projects have changed their minds. E-monitoring provides essential added value to current MCS tools as demonstrated in this Newsletter.
Electronic monitoring (EM) systems are already more than a decade in use in Canada complementing observer schemes and enforcement activities. The technology is well tested in practice and the technical reliability has been proven. Most countries participating in EM programs are using the EM Observe™ monitoring system from Archipelago Marine Research Ltd (www.archipelago.ca).

EM programs have successfully monitored fishing location, catch handling, by-catch, discards, enumeration, and protected-species interactions among other criteria. The primary piece of equipment is a metal, tamper-proof, control center that houses the digital data logger and video computer circuitry. The control center is typically mounted in the vessel wheelhouse. Recorded video and sensor data are stored on a removable hard drive that can be swapped out when the vessel is serviced so the fishing-activity data can be reviewed on shore.

The armored dome, closed-circuit television (CCTV) cameras are waterproof, with an industrial-grade camera design that has proven reliable in extreme environmental conditions for long-term deployments on vessels in a range of fisheries. A choice of lenses from fisheye to telephoto enables the installation technician to optimally adjust the field of view and image resolution on each vessel. Up to four cameras are installed on standard EM systems, although in some specialized large-vessel applications up to eight cameras have been used. Traditionally, analog cameras were standard, but digital cameras are now increasingly used for their flexibility and high-definition output. All cameras are configured and situated to reduce the effects of glare, water spray, or low light levels on image quality.

An independent GPS receiver is installed with the EM system. The GPS receiver and antenna are integrated into a single plastic dome that is wired directly to the data-logger; there is no attached display interface. The Archipelago EM software uses the GPS date/time information to chronologically stamp data records. A photoelectric rotation sensor is mounted at the hauling station or winch directed at a prismatic reflector which is attached to the hauler or winch. A hydraulic pressure sensor is attached to the line hauler or winch. Both sensors provide a record of hauling activity and can serve as a video trigger. GPS and sensor information are recorded in approximately 10 second intervals, allowing for a very high-resolution data set. An optional satellite modem and antenna (for example INMARSAT) can maintain a ship-to-shore data link that delivers regular updates of trip progress, fishing activity, system status and vessel location. A display screen and interface provides wheelhouse crew with a real-time view of all fishing activity on the vessel.

Once retrieved from the vessel, the fishing activity data can be reviewed using the EM Interpret™ software from Archipelago. The software integrates all the sensor, video and GPS data and presents it along a standard map and timeline so appropriate shore-based personnel can quickly view, interpret, and report on the EM data.

An EM program can be used as a standalone initiative, or alongside an existing vessel monitoring system (VMS) program. While VMS provides real-time information at the fleet level and supports two-way communication with individual vessels, an EM program can contribute high-resolution data of vessel cruise track and fishing gear activity to confirm specific fishing locations, dates, and times, and provide detailed activity reports on each fishing event. The addition of detailed EM equipment activity logs and high-resolution video footage opens up new possibilities in accurately accounting for all catch—including fish discarded at sea—and helping fisheries to verify quotas, eliminate waste, and support selective fishing practices fleet wide.
E–Monitoring in Australia

The Australian Fisheries Management Authority (AFMA) has trialed Electronic monitoring (EM) in a number of fisheries and plans to implement the technology more broadly in 2014. AFMA envisages significant benefits in the use of EM from a compliance perspective. The following are a few examples in which EM will enhance AFMA’s ability to ensure management arrangements are being followed in Commonwealth fisheries.

Closure Breaches

AFMA currently relies upon Vessel Monitoring System data to detect if boats are fishing inside closed waters. Under current arrangements, it can be difficult to prove whether a boat is fishing or was in an area with engine trouble, sheltering from weather or for some other non-fishing reason. AFMA relies on providing expert witness statements to court advising that VMS activity is consistent with fishing. AFMA introduced a new Regulation in 2010 to strengthen rules around entry into closures and to require boats to maintain speeds that are unsuitable for fishing when transiting these areas.

EM shows great potential in being able to prove fishing in closures from an evidentiary perspective. When boats are detected inside closures, VMS and the GPS logger within the EM unit can be corroborated to demonstrate that the boat was inside the closure (VMS is not a “notorious instrument” so the corroborating data is useful). Sensors on the EM system which detect fishing activity (usually hydraulic pressure and rotation sensors) indicate that the fishing gear is being used, and the CCTV footage shows the fishing activity occurring. This is compelling evidence to present to a court of law to prove an offence and may mean that regulations governing vessel speed and even presence in closed waters may be able to be reviewed, allowing boats to move and fish more efficiently.

More Accurate Reporting

Routine analysis of EM footage may show interactions with protected species. While it is not an offence to interact with protected species, it is an offence not to record these interactions. Compliance with reporting requirements can be checked by comparing EM and logbook data, and adherence to bycatch mitigation arrangements can also be verified using EM footage.

AFMA can also verify reporting of other information, such as the amount of fish that are discarded because they are not commercially viable or because the boat does not hold quota for that species. Accurately capturing discards is vitally important in stock assessments. Having EM on board encourages fishermen to become more accurate in filling out their logbooks to record this important information.

Detering other at Sea Offences

Electronic Monitoring footage allows AFMA to detect a number of at sea offences and encourages greater compliance with management arrangements. Shark finning, high grading of dead fish, marine pollution, transhipment and other offences could all potentially be detected with the prudent placement of cameras on boats.

Use of Mitigation Devices

Various fisheries have methods and devices for minimising interactions with protected and other species. For example long line fishing boats in Australia’s Eastern Tuna and Billfish Fishery must deploy tori lines when setting hooks in order to stop seabirds from taking the baits. Similarly, trawl boats must deploy large brightly coloured floats where the warp wire enters the water to stop birds from being injured or drowned. Measuring compliance with these arrangements can be difficult and expensive and is generally done by aerial surveillance and at sea patrols. Having cameras recording the boat allows AFMA to see these mitigation devices in action, and consider ways to continually improve their effectiveness in conjunction with the fishing industry.

Monitoring Offloads

There is potential to use EM to record the offload of catches. By placing cameras on the sides of the boat, it may be possible to record fish being unloaded from the boat, record any transport arrangements, observe any persons who approach the boat, count the number of boxes that come off the boat and corroborate against logbooks and other data. AFMA currently conducts physical inspections of offloads in ports using fisheries officers. There are a number of financial and logistical impediments to conducting mass inspections and AFMA uses an intelligence led, risk based approach to placing officers in ports for inspection at particular times. Offload analysis could be increased exponentially if all offloads were recorded and the footage sampled.
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North Sea Cod CQ Scheme

Since 2009, Marine Scotland has been trialing Fully Documented Fisheries (FDF) mainly in the North Sea Demersal fleet, with the aim of developing appropriate CCTV technology to monitor absolute catches and reduce cod mortality. During this time a great deal of experience and data has been gathered, resulting in continual improvement and refinement of CQMS.

In 2011, major advances were made following the detection of several non-compliance instances with the existing scheme rule. Weak points in the analysis process were identified and resulted in monitoring systems devised to cover the entire fish handling process on board. This process involved fitting as many as seven cameras on each vessel along with two control units (Archipelago 4.2). The scheme rules were also strengthened to include haul by haul logbook recording.

Cameras were placed to cover the fish handling process up to the point of gutting and sorting to ensure there was no tampering with catch prior to processing. All the cod then passed below the four cameras covering the sorting and processing belt where they were counted and measured in video and converted to weight for comparison against entries in the electronic logbook. Three continuous hauls for cod were taken at random from each trip for analysis and comparison against electronic logbook entries.

Of the twenty-two participating vessels in 2012, 10% of the video from hauls was analysed (730 of the 7,295 hauls). The analysis of cod seen in the images compared to that recorded in the electronic logbook and subsequently landed indicated that there was not any significant or systematic discarding of North Sea Cod from the vessels.

The requirement for a “land everything” obligation to be phased in is included with the agreement of the reformed Common Fisheries Policy (CFP) this year. The timetable provides a base for progressive introduction however successful implementation will still require substantial change by some sectors in their fishing behaviour.

Land All You Catch Trial (Landing Obligation)

Although the principles of the landing obligation are relatively clear, the way in which it will actually work in practice is unclear. To test the practice, Marine Scotland advertised the “Land All You Catch” trial in 2013.

Marine Scotland decided to run the discard ban trial with participating vessels receiving a quota uplift of the estimated average discards for 2012. This was the same manner in which the Fully Documented Fishery for cod trail was performed.

However, the Land All trail faced different challenges than that of the Fully Documented Fisheries trail. Rather than verifying weight of an individual species caught (cod), it was necessary to verify the weight of all fish caught, which would take more time than was available. For this reason, Marine

Conclusion

Electronic monitoring has the potential to increase AFMA’s capacity to demonstrate compliance with its management arrangements, collecting more information and different information in a cost effective way. It has the potential to improve reporting and accuracy of other data sources and this allows data to be used with greater confidence. In this way AFMA can demonstrate effective and transparent fisheries management and accountability to all stakeholders.

Schematic of typical cam positions for cod verification

Catch Quota Monitoring Scheme (CQMS), is a key objective of the Scottish Government in exploring how to better manage fisheries to minimize or stop discards brought about by mismatches in individual species quotas.

www.imcsnet.org
Scotland had to devise a verification process which would confirm that all the protected species caught were retained on board.

The verification system decided upon proved to be relatively simple. When the fish is taken on board i.e. into the hopper, it enters an enclosed area, usually within a water tight shelter deck, with exit points from these areas limited. As fish can only be discarded through these exit points, cameras were specifically focussed on these areas. The schematic from one of the trial vessels is shown below with the camera positions at the exit points marked in red.

Trial Results

Immediately after the first trial began, the skipper raised concerns about the amount of one particular species being caught. This species was relatively abundant but the total allowable catch was low. The problem proved insurmountable, and the trial was ended after just four weeks.

Nonetheless, a positive outcome was reached during this short period. Due to the highly selective construction of their fishing gear, removals that took place during the trial were comprised of less than 1% juvenile fish, indicating that the main issue is mature marketable fish in which abundance exceeds quota.

Although the trial has come to a close, the vessels have agreed to document all their discards in camera view. This documentation will allow for verification by the FDF unit analysis team that should result in valuable data that can be used to understand “choke” species ahead of 2016.

Firth of Forth TR2 Cod Scheme

In April 2013, the FDF unit set up a new EM trial, based in the Firth of Forth Estuary north of Edinburgh. The purpose of this trial was to verify cod catches by daily inshore Nephrops vessels. Four vessels agreed to take part in this trial to verify that the total weight of cod caught is below the 1.5% threshold for effort controls (days-at-sea limitations).

Although the trail is still ongoing, the data so far suggests that the inshore fleets do catch less than the threshold amount. This evidence may result in relaxing effort controls for this vessel class. The trial is in its sixth month, and the monitoring and verification of this small scheme is now run almost entirely from the local compliance port office and requires no additional staff resources.

Future Developments

Marine Scotland is currently working on trials with the intention of retrieving data on the weight of fish taken on board at each haul. If each catch is taken on board, then theoretically it is possible to verify logbook entries on a haul by haul basis. With this system, further analysis will only be necessary when significant differences are detected. Currently, there are two methods being tried for weight estimation:

- Load-cell shackle attached to the cod end recovery crane
- Volumetric measurement in video of cod-end as it is taken on board

The aim of these trails is to develop simpler, shorter and more effective analysis methodologies.
Pelagic Trials

The EU’s no-discard obligation will enter into force on 1 January 2015 for pelagic vessels. The no-discard obligation will bring enforcement challenges as there is currently evidence of slipping and discarding as vessels seek to retain the most valuable fish.

Voluntary trials (paid for by additional vessel quota) using CCTV and sensor data on one of Scotland’s largest pelagic vessels began in September 2013. Systems are being developed using high resolution, high frame rate video cameras and sensor feeds to record data from net sensors, fish pumps etc. Initial results seem to suggest that monitoring is possible, however much more analysis is required before conclusions can be drawn.

Applications are currently being sought from volunteer vessels in order to continue the trail through 2014.

Thanks to Norman Fletcher and Frank Higgins, Marine Scotland Compliance, for the contributions to this article.

E–Monitoring Trial in Denmark

In 2010 and 2011, the Danish AgriFish Agency (a fisheries enforcement authority) carried out trials in which fisheries enforcement aspects were put into context. By May 2010, Remote Electronic Monitoring (REM) systems were installed on board approximately seven vessels (trawlers), and by 2011, this number was extended to twenty-two vessels (fourteen trawlers, six Danish seiners and two longs line).

The trials focused on cod (Gadus morhua). Contrary to the normal rule in which the vessel has a landing quota from which all quantities landed are deducted, the trial required vessels to record the complete catches of cod including the amount discarded (discards of undersized cod = not legal to land) and to deduct the total quantity of cod caught from the vessel’s catch quota while, in exchange, participating vessels were issued with up to 30% extra cod quotas and exceptions for the authorized days-at-sea. Differing from the normal rule based on landing quota that allows the vessel to continue fishing after its cod quota is exhausted as long as any catches of cod are not landed and, therefore discarded, when trial vessels exhausted their cod quota, the vessel concerned was no longer allowed to engage in any fishery likely to imply catches of cod. Because, in practice, all viable alternative fisheries are likely to imply catches of cod, this rule means that in practice, the trial vessel has to stop fishing and stay in port.

The key objective of the trials was to assess Catch Quota Management (CQM) as management with full catch accountability (recorded catches = fishing mortality). Furthermore, the trial aimed to assess the hypothesis that CQM will incentivize fishermen to fish more selectively, reduce accidental catches and thereby optimize their economic gain and the ecological sustainability in the fishery.

The concept of a “fully documented fishery” (FDF) implies detailed recordings in the E-logbook as well as sensor data and video footage recorded by the REM system. In retrospect, through the data recorded by the REM system, it is possible to reconstruct the entire fishing trip and in turn, validate the master’s E-logbook recordings.

In the case of a management scheme where fish discarding is allowed it is necessary to establish procedures that ensure that REM effectively determines the amount of discarded fish. In the case of a discard ban, full documentation must ensure that fish have not been discarded. The precise weighing of non-legal fish may then take place ashore. In the framework of the trial, non-legal fish had to be discarded (discard obligation for undersized fish) and legal fish had to be retained on board (discard ban legal fish).

2010 and 2011 Trials

In order to be accepted as a trail vessel the following requirements had to be met:

- Use of VMS
- Maintain an electronic logbook (E-Logbook)
- Complete detailed recordings of catches for each haul including time and geographic positions of start and end of haul and discards
- Remote electronic monitoring system (REM) mounted on board
The REM system is comprised of a GPS, a hydraulic pressure transducer, a photo electric drum rotation (winch) sensor and four television (CCTV) cameras that provide an overhead view of the aft deck as well as closer views of the fish handling and discard chute areas for catch identification. Sensors and cameras are connected to a control box located in the wheelhouse. The control box consists of a computer that monitors sensor status and activates image recording. The computer is set to collect and store sensor data including GPS, hydraulic pressure and drum rotation. REM sensor data and image recordings are continuously recorded through the REM which is powered on during the entire fishing trip (port to port). No image recordings are taken in port.

The rules for the master are simple: REM must be turned on before the vessel leaves port and should not be turned off before the vessel is moored at port. In addition, the master must perform a daily functionality test of the REM system. This test includes cleaning the camera lenses whenever needed and checking that all blocking of the cameras’ views are avoided to ensure adequate free capacity on the hard disk for the fishing trip concerned.

The system functions as a closed circuit on a continuous basis while the integrity of the system is controlled. Any incidental or deliberate interruption or a malfunction of the system is detected and recorded. The memory in the system allows for data storage of approximately thirty days of activity. At the end of the trip, the REM hard disc drives are collected from the vessel by staff from the Directorate of Fisheries in the ports. Both sensor and image data are interpreted by staff at the Directorate of Fisheries using computer software developed by the manufacturer of the system.

**Collected Trail Data:**

<table>
<thead>
<tr>
<th>CCOM trial</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. Vessels</td>
<td>7</td>
<td>22</td>
</tr>
<tr>
<td>No. Trips</td>
<td>302</td>
<td>1114</td>
</tr>
<tr>
<td>Time at sea (hrs.)</td>
<td>20677</td>
<td>80166</td>
</tr>
<tr>
<td>No. Hauls</td>
<td>2973</td>
<td>9824</td>
</tr>
<tr>
<td>Fishing time (hrs.)</td>
<td>15389</td>
<td>44478</td>
</tr>
<tr>
<td>Time gaps in video (hrs.)</td>
<td>558</td>
<td>182</td>
</tr>
<tr>
<td>Time gaps (%)</td>
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<td>0.2</td>
</tr>
<tr>
<td>No. Hauls image analyzed</td>
<td>249</td>
<td>2177</td>
</tr>
</tbody>
</table>

Sensor data is used to validate fishing events including fishing time and position. The key vessel activities such as transit, gear setting and gear retrieval are identified by the REM system and can be compared with the recording of fishing events in the E-logbook.

CCTV footage is used to validate the recording of catches by the master of the vessel, particularly the amount of discarded cod recorded. The primary objective of CCTV footage examination is to determine the amount of fish caught compared to the catch amount recorded by the master. The secondary objective is to review the discard pattern in order to verify whether discards of cod are correctly monitored and recorded by the master.

**Data Integrity Check**

The REM system is designed to be powered on and collecting data for the entire duration of each fishing trip. When 100% of the data is successfully collected and stored, a complete reconstruction of the trip will be generated through the analytical tools provided by the manufacturer of the REM system.

A ‘time gap’ is a period of time where sensor data was expected to be collected but was not. Gaps within the data sets need to be categorized as either occurring within a fishing trip or not. Time gaps can be further categorized according to the risk involved relevant to project objectives. For example, time gaps that occur while fish are on deck are deemed critical, as this is the period when discards are most likely to occur, whereas small time gaps during vessel transit would be deemed of lower importance. The data record was nearly complete for most vessels during the two trails. In 2010, the overall data capture success was approximately 97.96% for 20,000 hours at sea. While in 2011, the overall data capture was approximately 99.8% for a total of more than 80,000 hours at sea.

Inconsistencies between the number of trips in the official E-logbook and the REM system were encountered in 2010 for two vessels in which one trip and two trips were missing from the E-logbook but were present in the REM system. The same situation but with trips being present in the E-log and not in the REM system was also encountered on a few vessels. In the first case the discrepancy was caused by a failure somewhere in E-log system or by the skipper forgetting to
fill out the correct data sheets. During the second case in which the REM system failed to detect trips the system was defect when the fishing trip was initially started.

**Validation of Fishing Events**

The fishing event analysis shows that the time difference between the E-logbook and REM system is less than fifteen minutes in 81% of the cases while the geographical location discrepancy is more than one nautical mile in 26% of the cases. Confusion regarding the definition of the geographical position of shooting and hauling of the gear cannot be excluded.

**Validation of Catch Records**

In general there was consistency between the E-logbook recording and the determination of the quantities discarded through the CCTV footage. Improvement is possible if the area around the discard skids/conveyor belt is adjusted to avoid large quantities (fish overlaying one another) passing at the same time.

Trial vessels must retain all legal fish on board. REM monitors compliance with this requirement. Assumptions concerning high grading are made by comparing the catch composition of trial vessels with the catch composition of the reference fleet. The proportion of the smaller size grade (size grade 4 and 5 – low market value) cod are a good indication as to whether and to what extent high-grading occurs (discarding with the aim of increasing the value of the landings). This analysis suggests that significant high grading is carried out by the reference fleet on a routine basis.

**Enforcement**

Two trial vessels were sanctioned due to violations of the rules and procedures. The Danish AgriFish Agency applied the following (administrative) sanctions:

One vessel’s registration in the logbook was not performed correctly as the actual discard of cod was evidently much larger than the discarded quantity recorded in the E-logbook. The Agency decided to increase the quantity to real level and to deduct this quantity from the vessel’s quota. In addition to under-recording of the quantity discarded, another vessel continued fishing for 10 days while aware that there was no available space on the REM system’s hard disk. The combined infringements were considered serious and led to the vessel’s exclusion from the CQM and withdrawal of premiums. As a consequence of the reduction of its quota, the vessel was forced to lease additional quota from the transferable quota market in order to compensate for overfishing.

The procedure leading up to an administrative sanctions includes a detailed investigation by a fishery inspector of which the conclusions are set out in a letter addressed to the owner who must be heard. The Director of the Agency adopts its decision on the basis all elements. The owner can appeal the decision of the Agency before a Court of Justice. The owner of the vessels did not appeal the Agency’s decision, based on the determination of the quantities discarded visible on the video footage recorded by the REM system.

**Resource Implication**

In 2011, the Danish AgriFish Agency spent approximately 3000 hours watching CCTV footage of fishing operations from the twenty-two participating vessels. On average, 10% of fishing voyages were monitored starting from the time the gear was hauled until the catch had been either stowed or discarded. The total expenses for monitoring are estimated at approximately $3,500 per vessel per year.

It is of course difficult to make a direct comparison with the existing resources used for inspection at sea. In general, it is however, safe to conclude that inspection at sea by inspection vessels is more costly than inspection done by watching CCTV footage. Moreover, risk analysis, including data from the REM system, would result in much better targeting of inspections at sea to cover real compliance risks and as appropriate fewer inspections at sea. Data from the REM system increase very significantly the level of resolution for risk analysis. Although some inspection presence at sea will always be required, certain scenarios, including E-monitoring, in which inspection and surveillance can be significantly reduced.

**Reliability of REM System**

The REM system has proven its technical reliability. Its records throughout the fishing trip contain very precise data
and images that enable validation of the data recorded by the master in the E-logbook. Although some modification to vessel deck setups and catch handling flow may be required, the experiences of the 2010/2011 project as well as the outcome of the previous CQM projects have shown that with tailor made mounting REM systems can be applied on nearly all vessels. The trail experience has shown that the quality of the detailed recordings made by some of the fishermen declined over time, and consequently constant feedback to the fishermen is essential. It should be stressed that feedback needs to be a fully integrated part of the programme allowing the REM system to compel the master to be precise.

The Danish CQM trial involves recordings from different fisheries and types of vessels, which leaves some variability in the quality of recordings. The position of the cameras on the vessels is of great importance to the quality of video recordings, e.g. camera views and water on the dome. When targeting certain species, larger total catches can be expected for different fisheries. As a result, too many fish on the conveyor belt makes it difficult to distinguish between species during video data analyzing.

There were few hardware and software mistakes in the functioning of the REM system observed. Human errors due to inappropriate use of the system on board, handling of data storage devices and transfer of data caused most of the system failure and loss of data. However, these problems can easily be resolved.

The software to analyze collected sensor data and images is extremely user friendly and easy to navigate. Differentiation between various vessel activities such as steaming, fishing, hauling or gear deployment can easily be done through the collected data. The data extracted from the system can be very precise, facilitating accurate comparisons with the data in the logbook. Comparisons should take into account the nature of full documentation as a continuous surveillance as opposed to alternative controls that rely on observations at the given time of control. The directorate has given priority to collect comparable monitoring and control results, and advantages of a risk based approach have not yet been tested.

Initial examining of logbooks and sensor data can give relevant information needed for further verification—e.g. if a given vessel has only registered large size grades. Similarly, results from vessels with full documentation can serve as a reference to comparable vessels. The trials have shown a change in behavior for the vessels involved as the skipper and crew pay more attention to where they are fishing in order to avoid areas with small cod.

Experience gained in the trial has shown that the estimate of discards of cod can be made with significant accuracy by viewing the images, particularly if the vessel has a sorting conveyor belt in which the discarded fish pass the discard chute individually. Unless the crew follows specific catch handling protocols, if large amounts of discards occur the accuracy of the estimate decreases. The trials were based on voluntary participation thus ensuring a smooth operation in which the fishermen work “with the system”. As initial implementation and running of the system needs close co-operation between the industry and the authorities to ensure maximum data security, this approach may have influenced the positive outcomes of the trails.

**Acceptance by the Industry**

In general the industry has accepted REM installation on board their vessels. The perception of the industry is that if the CQM system, including having REM systems installed, can revoke some of the very detailed regulations it would be beneficial to all. There has been no negative feedback on the issue of having cameras recording the vessels’ working areas. Some fishermen have expressed that it only takes one or two days before the presence of the cameras is forgotten. Most of the fishermen are of the opinion that it is very important to show what they are doing and what they are catching. The growing pressure from the NGO’s has strengthened this approach. For public opinion at large, fully documented fisheries would be a credible instrument to regain confidence in the sustainability of fishing industry activities. At any moment video images are available to demonstrate what is really happening at sea when fishing.

Furthermore, fully documented fisheries open the opportunity for some deregulation. This is interesting in relation to a simpler and coherent public management as it would consequently bring fewer rules to enforce. Regarding enforcement, the most interesting result of full documentation seems to be the consequential reduction in expensive seagoing inspection and surveillance. The development of technology and smart risk-based control should bring a continuous reduction in control costs. Finally, the transfer of costs to the industry for the on board documentation seems obvious.

With regard to wealth generation, it seems obvious that the fisherman is better served by the choices of fishing methods he can make in time and space than by generally applicable rules. Moreover, CQM and FDF, combined with traceability, will ensure both a traceable and validated fishery. Promoting fish can be done in good faith with an increasing inclusion of information that consumers are able to reward without having uncertainty.
In 2012 an expanded trial was enacted following the 2010 and 2011 North Sea cod scheme run in England. The trial was carried out from January 2012 through the end of December 2012. In total, ten otter trawlers, two gill netters and seven beam trawlers, operating in the North Sea and the Channel, participated to the trial (four more vessels than the previous year). The 2012 trial focused on mixed fisheries implying catches of cod, haddock, saithe and plaice.

Contrary to the normal rules according to which landing quota are allocated to vessels and discard of illegal fish is compulsory, catch quota were allocated to trial vessels while a discard ban applied. All quantities caught, including non-legal and non-marketable fish, were, therefore, counted against the relevant quota. In exchange the vessels benefitted from additional quota as well as additional flexibility in days-at-sea requirements. The additional quota was fixed at 75% of the expected discard rate for the fishery concerned. Trial vessels were allowed to lease or swap quota. When a quota was exhausted, the vessel was required to stop fishing and stay in port.

As usual, Masters of trial vessels were responsible for recording the activities of the vessel in the E-logbook while electronic monitoring systems were used to validate the data recorded by the master. Activities were recorded either per haul or per day. All trial vessels were equipped with VMS.

The main objectives of the project were:

- Investigate the potential of catch quota management and evaluate the use of catch quotas to reduce discard levels with a particular focus on how mixed fisheries will be affected
- Develop, where possible, effective audit methods that provide sufficient confidence in quantifying retained catches according to a specific method
- Enhance data collection to improve fisheries science and advice

**REM System**

The 2012 scheme continued to use the same remote electronic monitoring (EM) system with four or more cameras and hydraulic and drum rotation sensors as in previous years. The connection of a satellite modem compatible with the EM record system was added to test the potential for real time transmission of summarized sensor and system health check data. Testing of the transfer of still images would follow in the future along with the possibility to encrypt the recorded data and footage. Moreover, in 2012 digital caliper software was used for obtaining fish length-frequency data.

As in previous years, analysis of sensor data and CCTV footage was carried out using EM Interpret software.

It is important to understand that EM implementation should not be regarded as a 'plug and play' system. The operational requirements and data needs have to be fully understood and vary from one fishery to another.

The installation of the EM system on board and, in particular, the placement of the cameras is customized for the purpose of monitoring full retention of quantities caught and adapted to the chosen methodology.

Catch length-frequency data can be used in a number of ways to make comparisons between observed catch from CCTV and the actual catch on landing. The camera setup is critical in being able to make adequate observations and generally requires a camera looking directly down on the fish in order to avoid errors through image distortion (wide angle lenses). Two cameras were used to cover the full length of the sorting.

A crude method of calibrating different areas of the image was used in order to ascertain the possibilities using this method in the future. The figure below shows the sorting conveyor of a beam trawler split into six areas used to calibrate digital calipers according to the known width of the sorting conveyor.

The length-frequency data can be compared to the weight frequency of landed catches using market-grading data. This requires usage of a length to weight conversion factor. This factor may be variable on a seasonal basis and, therefore, subject to some error. The average weight data was then compared to market weight by grade bands. Frequency distribution samples were taken from random hauls throughout the trip.

After comparing the hauling of the gear and the conveyor to the hold, the CCTV footage can be used to verify that
the catch has been stowed in the fish room and not removed until landing. This can be achieved by viewing random sections of footage prior to landing.

An alternative method which involved a camera viewing a fish room pound in which sole was stowed, was also tested, and is shown in the figure below. Stock recovery regulations require sole to be stowed in an area of the fish room separate from other species therefore allowing for this type of monitoring.

The analyst can monitor the number of stowed boxes at any point in the trip and compare this to the cumulative logbook estimate. The footage can also be checked to ensure the boxes are only removed at the scheduled point of landing.

Three observer voyages were carried out in order to provide necessary control data to test the various methodologies used for estimating retained catch. Data was gathered using motion compensated weighing scales and the collection of onboard length-frequency data. Further control data was also collected from auction centers.

**Catch Estimation Methods**

Several methods have been tested to assess the quantities caught, ranging from rather crude to very precise methods. The placement of the cameras must be adjusted to the relevant estimation method used on the vessel. For vessel stowing quantities caught in bulk, it may be difficult to estimate the quantity caught by species.

In relatively clean single species fisheries such as saithe, the 2011 trails involved bulk catch estimates determined by estimating the total weight of each haul from the size of the codend or aggregate estimates from multiple codend lifts (where the volume of fish prevents stowage of all fish in one lift).

In 2012, two full trips were analyzed using this method and were compared against the total catch in live weight. This method was also tested against the master’s estimates on a haul-by-haul basis. The results for haul-by-haul estimates were not compared to control data. There was considerable variance between master and analyst estimates as might be expected from a crude method. There was reasonable correlation (within 20%) between the analyst’s estimate and total catch and more variation at a haul-by-haul level. This method is quick in terms CCTV footage review and may be appropriate in some clean fisheries where the bulk of the catch is one species.

When cameras are placed above conveyer belts, a precise fish count is dependent on the quantities passing the conveyer belt, as it is difficult when several fish are overlaying one another and thus the quantity estimate uses average length to weight ratios. Digital caliper length frequency data can be converted in weight using more precise length to weight ratios.

Volumetric assessment of multiple or part containers were relatively quick to achieve through CCTV analysis as counts of fish were lowered into the fish room during each fish processing event (shown in the figure below). The process typically took around 15 minutes depending on the volume of the fish.

Taking CCTV footage of the weighing scales display is a straightforward method. This method relies on the crew to weigh catches and requires a clear camera view of the weight readout from the scales. The ability to read the weight from motion compensated scales requires the co-operation of crew to ensure the view is not obscured and that a camera has a dedicated view of the scales readout.

The results for Camera Setup 1 with a view of the
scales reveals as might be expected, that there is a precise correlation between the control data and the scales readout. Camera Setup 2 did not allow for viewing of the scales readout. It should also be noted that the accuracy of the master’s estimates in this series of hauls was determined through the use of the scales.

**Real Time Transmission**

During the 2012 trial period one participant vessel was fitted with a satellite modem to test the ability to transmit hourly system health check data and summaries of sensor data.

The figure below shows a screen shot of the EM Lite software that provides hourly summaries of winch rotations, speed, position, and hard drive data storage remaining capacity as well as any outages of system functionality. This summary data was deemed useful inasmuch as regular checks allowed analysts to monitor data quality on a daily basis if necessary.

Throughout the trial a number of control box power outages (from BETA prototype units) were observed. This allowed staff to investigate and remedy earlier than would have otherwise happened. An analyst also identified recording trigger failures (rotation sensor fault) within hours of a particular trip commencing. In this case the vessel was contacted immediately and advised to trigger recording manually (Data was lost from only six hauls rather than the whole trip-eighty-two hauls) port.

In the future, the satellite modems may be also capable of transmitting still images. In terms of monitoring marine protected areas (MPAs), closed areas and geo-fencing applications this could be a highly effective tool. The data transmission speed and capacity through INMARSAT is limited.

**Data Collected and Audit Levels**

In total 456 trips and 14,985 fishing operations were monitored. The overall analysis rate was 9.3% of all fishing operations and included analysis of retained catch using a range of methods.

Apart from the method and the sample size, a number of factors influence the time it takes to audit a trip. These factors may include trip length, catch sorting time, number of hauls and number of species being examined. The gill net fishing operation (haul), for example, is typically an 18 to 24-hour activity, so a longer period is required to analyze one operation. The time taken to audit a trip depends on the type of fishery and varies from 2.4 to 7.8H on average for a single trip (the last figure concerns verification of CCTV footage from a beam trawler where several methods to estimate quantity were used simultaneously).

The data retrieved from hard drives was subject to three stages of audit:

- **Stage 1 – Data integrity and quality.** The hard drive data is checked for any gaps in the relevant period and the CCTV image quality is checked to ensure cameras are operating correctly and have been maintained to provide good image quality. The data from gear hydraulics and winch rotation sensors is annotated to allow for subsequent analysis of CCTV footage. This stage also allows for high-level auditing to check that the correct area of fishing has been recorded in the logbook and for fishing operations in relation to area restrictions.
- **Stage 2 – CCTV footage from a random selection of fishing operations is analyzed to estimate the level, if any, of discards for relevant discard prohibited stocks.** The total estimated discards for each trip are calculated by multiplying the observed discards by a raising factor determined by the sample rate, which is normally 10% of fishing operations.
  For this purpose standard weights are used for each species and may give rise to an over-estimate of actual discards.
- **Stage 3 – CCTV footage is analyzed to estimate retained catches for each fishing operation or for consecutive fishing operations for the purpose of checking the accuracy of the logbook.** This process may involve a simple count of fish containers, obtaining weights from length-frequency measurements or monitoring for discards beyond the point of sorting and stowage.

**Assessment of EM Audit Capability**

In order for an audit system to be effective there needs to be sufficient confidence in methodologies in order to assign a result, whether a score or a simple pass or fail. Such a system needs to give confidence and transparency both to regulators and vessel operators.

An effective audit system has been developed in the...
British Columbia hook and line fishery which compares counts of fish by CCTV analyst and vessel logbook. Comparing fish counts is clearly more definitive than comparing weight estimates. Nevertheless the process of agreeing on a trusted scoring system took over two years to develop (Stanley et al, 2011).

This trial has not sought to develop an audit system that would provide sufficient confidence to impose sanctions relating to catch estimates, however it does provide a baseline to work from, should such a system be developed with a sound statistical basis. The data does support sufficient confidence to provide feedback in an advisory capacity and to identify significant discrepancies between reported catch and observed catch. The ability to monitor length frequency of catch as it is processed shows potential as a means of monitoring for subsequent high grading.

Although retained catch audits have potential it should be considered that an operational programme should concentrate initially on higher level audits that relate to data integrity, discard events and catch records in respect to area of capture and effort. The results from full retention monitoring and length measurements also show potential for establishing whether discarding or high-grading takes place prior to landing.

The system is not tamper-proof. The risk of interference with EM systems needs to be assessed as well as what system of sanctions should be in place to provide sufficient deterrent from deliberate tampering or failure to maintain sufficient duty of care. It is, therefore, recommended that a regulatory framework be set to ensure sufficient data integrity.

A vessel-monitoring plan, which is customized to the vessel and agreed by the master, is considered to be an appropriate method of establishing a common understanding of monitoring requirements. This can detail any specific catch handling and reporting requirements according to the fishery.

EM sensor and CCTV data has demonstrated to provide a high degree of resolution and transparency, both for control purposes and for industry to demonstrate good practice.

**Operational Costs and Logistics**

The operational cost would be influenced by a number of parameters such as the level of audit required and the geographical spread of vessels in relation to operational and technical support. Nevertheless, the estimate from this trial is considered to be a useful guide for planning purposes. The cost assumes that all equipment has a lifespan of three years, although systems in use are now entering their fourth year. Assuming that analysis time can be brought to three hours per vessel or less and that equipment replacement is required at four-year intervals, it is estimated that annual costs could fall to around £8,000 (13 000 US dollar) per vessel.

There is also a need to consider whether potential savings could be made by replacing or reducing current MCS expenditures. Equally important, will be consideration of operational and technical support. This aspect may be relatively straightforward when vessels are based in one location but it is likely to become a logistical problem for dispersed fleets.

**Conclusions**

Electronic monitoring is considered an effective solution to monitoring of discards where it is proportionate and cost effective to do so. It is considered to be more effective, in the absence of an observer programme, than conventional surveillance methods, which have hitherto largely failed to police the high grading ban currently in force.

A variety of faults with the remote monitoring equipment have occurred and have been reported by masters for rectification in port. Loss of data and resolution of footage has given rise to concern, although improvements are considered possible both in terms of reliability and adherence to the duty of care placed on vessel crews.

Faults leading to loss of picture quality include camera lens or visor displacement, water ingress into camera housing, condensation and dirty lens covers. Loss of sensor data has resulted from loss of functionality of winch rotation sensors, usually from dirty or displaced reflectors.

**Acceptance by the Fishing Industry**

Collaboration with fishermen is fundamental in the detailed implementation of policy for a landing obligation (discard ban). While the implementation of a landing obligation is complex, there are foreseeable benefits such as greater flexibility from prescriptive regulation, quota uplifts, transparency and traceability and enhanced scientific data collection.

Electronic monitoring has been met with mixed reviews by the industry. The main driver for participation has been the incentive of additional quota and days-at-sea. However, industry representatives, vessel owners and masters engaged with the Marine Management Organization (MMO) and the Ministry during the course of the trial, recognizing that such dialogue is essential in moving towards fully documented fisheries and accountability of catches.

Exploring alternative approaches to fully documented fisheries (FDF) is an ongoing part of an industry and fisheries science partnership initiative. Some alternative approaches to FDF may be more appropriate and cost-effective in small-scale fisheries with large numbers of vessels.

Potential for improved data quality and quantity may also present potential benefits in terms of improved stock assessment and industry accreditation. Operating a level playing field among vessels that share EU fisheries will be critical in the successful implementation of fully documented fisheries and catch quota systems.
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