Final Report on the Danish Catch Quota Management Project 2010

DTU Aqua Report No 235-2011

By Jørgen Dalskov, Kirsten Birch Håkansson and Hans Jakob Olesen

DTU Aqua
National Institute of Aquatic Resources

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in co-operation with the Danish Directorate of Fisheries

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Executive summary

Catch-quota management (CQM) is a result based management where targets (catch quotas, where all fish count on the fishers quota) are set, and the choice of method in harvesting is left to the exploiter together with the obligation to document (by E-log and CCTV) that targets are observed. At present management needs time to prepare and legislate and it regulates with rigid and uniform rules. This is problematic in an environment where the ideal harvesting pattern is highly complex and variable, and it often leads to conflict between regulation and fishermen's perception of the best practice. In contrast a result based management incentivizes the exploiter to continuously adapt and improve his fishery against the targets, which in fisheries policy coincides with the main objective, namely the observance of removals of fish according to the MSY principle.

Denmark started trials with CQM and full documentation in a scientific project from September 2008 to September 2009 gathering extensive data from 6 vessels, 17.000 hours at sea. The report can be found at www.fvm.dk/yieldoffish together with video demonstrations and other documentation on CQM.

In 2010 a new trial was carried out where the operational aspects were put into a management and control context by the Danish Directorate of Fisheries (FD). The National Institute for Aquatic Resources, DTU Aqua, installed Remote Electronic Monitoring (REM) systems onboard the trial vessels and acted as supervisor to the FD and the skippers and crew onboard the trial vessels.

Seven vessels have participated in the trial and were mainly fishing in the North Sea and the Skagerrak and in the Baltic Sea. The scheme started April/May 2010 and ended by the end of December 2010.

The main focus has been made on cod (Gadus morhua) the amount of cod retained and the amount discarded. Participating vessels were issued with up to 30% extra cod quota and exceptions for the days-at-sea programmę. The participating vessels have counted all cod caught against their allocated quota including undersized cod that had to be discarded. In addition if a trial vessel reached its cod catch-quota is reached – the vessel must stop fishing which may catch cod.

A requirement for entering into the new catch quota scheme is that the fishers operating under the scheme must have comprehensive, complete and reliable documentation of all their catches including discards. The remote electronic monitoring (REM) system used in the trial consisted of up to four closed circuit television cameras, a GPS receiver, a hydraulic pressure sensor, a gear rotation sensor and a system control box.

The REM system has been collecting sensor data and images throughout the trial period and according to the vessel electronic-logbooks the vessels were at sea for app. 27,000 hours, carried out app. 270 fishing trips, and conducted app. 2,600 fishing operations during the project period.

The analysis of the sensor data (GPS, hydraulic pressure and rotation of the winches) compared to the skippers recording in the e-logbook showed that the skippers needs to keep their focus on accurate reporting as determination of where and when a fishing operation takes place can be made with a high degree of accuracy. Feed back to the skippers on the accuracy on their reporting in the e-logbook should be made regularly.

Based on review of the video footage of the catch handling onboard it has been possible to estimate the amounts of discards of cod with high accuracy, especially if the vessel had a sorting conveyor belt where the discarded fish passed the discard chute individually. If large amounts of discards occur the accuracy of the estimated discard amounts decreased unless specific onboard catch handling protocols were followed.

If large quantities of small cod were caught the fisher would change fishing grounds and according to one of the outcome of interview with the participating fishers they actively have trying avoiding catches of small cod. Furthermore, there has been a positive reaction from the fishers and they have shown an increased awareness of their fishing patterns. An incentive driven CQM system where all catches (retained and discarded part) are counted against the quota and the fisher is responsible for documenting his fishery seems to reduce discards and seems to be a way forward toward sustainable fishing where the catches are utilized optimal.

The electronic monitoring system has proven its reliability. The experiences obtained during this project and the preliminary outcome of a project having REM installed onboard smaller gill-netter (length less than 14 m) have shown that the EM system can be applied on almost all types of vessels. Onboard some vessels it may be necessary to modify vessel deck setups and interior catch handling flow in order to obtain appropriate image coverage for the full documentation processes.

It is very important that the fishers are given information and guidance regarding recording the vessel activities such as the time of deployment and retrieval of gears. Experience from the trial has shown that the quality of the detailed recordings made by some of the fishers declined over time. Therefore, constant feed back to the fishers is essential and it should be stressed that this should be a fully integrated part of the programme. It is probably needed that some kind of “penalty” system is implemented as the skipper then in advance knows the consequences for not living up to the terms and conditions for the trial.

It could be considered whether a score card system or system to graduate how accurate the skipper/crew comply with the terms and conditions for a CQM system. The more accurate skipper recordings is made the lower review frequency and the less accurate recording of when and where the fishing has taken place and the recordings on what and the amount of fish caught the higher frequency of reviewing. In addition it could be considered whether lower compliance with the terms and conditions should give lower quota bonus. It should be possible to set up an objective and transparent set of rules for such a bonus/penalty system.

1. Introduction

In 2008 the Danish Government suggested that the utilization of the marine resources in the EU in the revised Common Fisheries Policy (CFP) should follow a result based approach with the simple requirement that the fisher accounts for his total removal of fish from the resource. By introducing full accountability through catch-quotas instead of landing quotas the fishers' incentive to optimize his value by discarding less valuable fish would be exchanged by his incentive to use selective fishing methods to optimize the value of his total removals from the stock.

To achieve this objective the fisher should receive increased catch-quotas to reflect that all fish was accounted for and he should be given the freedom of choice of method in conducting his fishery in order for him to make his own methods work for the best result.

A scientific trial was carried through in 2008 and 2009. In 2010 the trial continued in a concrete management context.

The purpose of the project was to assess the catch-quota system's running in a fisheries management environment and its potential to account for all catches, reduce discards, provide better scientific data and incentivize fishermen to fish more selectively through catch-quotas, full observation using sensor and camera technology. Evidence from this trial will inform us on how this potential management system could work for cod (Gadus morhua) in the North Sea, the Skagerrak and the Baltic Sea.

The principle of a catch quota management system (CQM) is to align the amount of caught fish with the fishing mortality that is being decided for the given stock as well as reducing discards (Kindt-Larsen et.al. 2011). By defining and being able to record exactly how much cod is caught, there should be no need for any other restrictions, including effort restrictions. An incentive driven management system (Pasco. et al. 2010) can have a positive effect on the will to live up to terms and conditions for a management system.

The present CFP where there are quota and effort restrictions, high-grading ban and restrictions that contributes to a complex management system with a considerable incentive. A catch quota management system with fully documented fishery gives opportunities gives assurances that quotas can actually be administered with an absolute limit, so that catch limits becomes an exact expression of the set fishing mortality.

2. Scientific project 2008 – 2009

From September 2008 to September 2009 DTU Aqua conducted a trial with fully documented fishery. The objective was to evaluate the reliability and functionality of Remote Electronic Monitoring (REM) as a tool to monitor fishing in a catch-quota management scheme. During this project period the 6 participating vessels were at sea for 16,955 hours, carried out 561 fishing trips and 1,558 fishing operations.

The experiences obtained during the trial showed that the electronic monitoring system used during the scientific trial could be operated on most types of vessels and give close to 100% documentation of the fishing activities.

The full report (Dalskov & Kindt-Larsen, 2009) can be found at www.aqua.dtu.dk or at www.fvm.dk/yieldoffish.

The very promising results contributed to the decision in EU that a catch quota management could be tried on an explicit legal basis, namely in the form of the introduction of a limited catch-quota option in the TAC/Quota regulation for 2010.

3. Danish Catch Quota Management project in 2010

The catch quota management project conducted in 2010 is an extension of the scientific trial that was carried out in 2008-2009. 7 trawlers with a length overall between 17 and 40 meters participated in the project.

In addition 6 smaller gillnet vessels participate in the CQM in a scientific trial with the aim to test whether the present electronic remote sensing equipment can be used on smaller vessels and whether collected imagery can be used to verify incidental by-catches of marine mammals. This project also tests whether an automate image recognition to detect catches of marine mammals can be developed. This project runs for 18 months and reporting is expected by the end of 2011.

3.1 Political and legal basis

At the council meeting 19th October 2009 The Council and the Commission in a Joint Statement recommended experiments and development on CQM based on fully documented fishery as it might offer a real alternative to the present CFP.

Following the negotiations with Norway COUNCIL REGULATION (EU) No 219/2010 of 15th March 2010 made provisions for a CQM in EU Member States. The regulation i.a. states, that:

“Member States may allow vessels participating in initiatives regarding fully documented fisheries to make additional catches within an overall limit of an additional 5 % of the quota allocated to that Member State, provided that:

- the vessel makes use of closed circuit television cameras (CCTV), associated to a system of sensors, that record all fishing and processing activities on board the vessel,
- all catches of cod with that vessel are counted against the quota, including those fish below the minimum landing size,
- the additional catches are limited to 30 % of the normal catch limit applicable to such a vessel"

3.2 Implementation in Denmark

National rules for a Danish CQM trial were established in December 2009, and the rules were further elaborated on February 1st 2010 with a description of the more specific requirements that a vessel would have to meet to participate in the trials. It was also specified what the criteria were for selection of the participants in the trials. The Danish Fishermen’s Associations were consulted prior to the issuing of the

regulations, and changes were made according to their proposals. REM equipment for the vessels was ordered and installed onboard in April and May 2010.

3.3 Selection of vessels to participate

In the selection process it was attempted to recruit vessels in the Western and Eastern Baltic, Kattegat, Skagerrak and the North Sea. It was also the aim to recruit vessels both smaller and larger than 18 meters, and vessels using different kind of gears such as trawl and gillnets. In 2010 a total of 7 vessels took part in the trial, all demersal trawlers. 6 of the vessels have their main fishery in the North Sea and Skagerrak, and 1 vessel has its main fishery in the Baltic Sea. The first vessels started the trials in April 2010, and all the vessels were part of the trials by early May 2010.

FN 226 Andrea Klitbo 	Homeport: Østerby Vessel type: Trawler Building year: 1986 Length over all: 35.4 m BT: 314 Engine: 634 kW Power: 220 AC	**HG 306 Tobis** 	Homeport: Hirtshals Vessel type: Trawler Building year: 2009 Length over all: 39.95 m BT: 574 Engine: 721 kW Power: 220 AC
HG 350 Luna 	Homeport: Hirtshals Vessel type: Trawler Building year: 1998 Length over all: 28.44 m BT: 306 Engine: 735 kW Power: 220 AC	**HM 555 Kingfisher** 	Homeport: Hanstholm Vessel type: Trawler Building year: 2007 Length over all: 31.3 m BT: 467 Engine: 736 kW Power: 220 AC
RI 427 Mette Helene 	Homeport: Hvide Sande Vessel type: Trawler Building year: 2009 Length over all: 27.16 m BT: 243 Engine: 736 kW Power: 220 AC	**RI 468 Juli-Ane** 	Homeport: Hvide Sande Vessel type: Trawler Building year: 2000 Length over all: 21.4 m BT: 210 Engine: 749 kW Power: 220 AC
R 254 Katrine-Kim 	Homeport: Neksø Vessel type: Trawler Building year: 1978 Length over all: 17.3 m BT: 39.1 Engine: 219 kW Power: 220 AC		

Source: www.fiskerforum.dk

The vessels participating in cod catch-quota scheme 2010				
Registration No.	**Vessel name**	**Type of fishing vessel**	**Catch- quota premium in kg**	**Date joining the trial**
FN226	ANDREA KLITBO	TR 1 (trawler)	26.216	27-04-2010
HG306	TOBIS	TR 1 (trawler)	47.674	28-04-2010
HG350	LUNA	TR 1 / TR 2 (trawler)	49.385	15-04-2010
HM555	KINGFISHER	TR 1 (trawler)	56.688	06-04-2010
RI427	METTE HELENE	TR 1 (trawler)	23.031	22-04-2010
RI468	JULI-ANE	TR 1 (trawler)	45.228	05-05-2010
R254	KATRINE-KIM	TR 2 (trawler)	41.552	11-05-2010

3.4 Licenses, Terms and Conditions

The rules for participating in the trials were specified in February 2010. The requirements to be met included REM equipment to be installed on the vessels, the vessels deck-arrangement, the processing of catches of cod, and reporting of catches.

A vessel participating in the trials has to cease fishing with a gear for which cod is recognized as a target species when its quota for cod has been exhausted. This follows from the basic principle of CQM, that all catches must be covered by quota holdings.

Equipment requirements

1. The vessel should be equipped with a Remote Electronic Monitoring system (REM) which consists of a control box, hydraulic pressure sensor, rotation sensor, GPS and an adequate number of cameras.
2. The REM should be turned on before the vessel leaves port and should not be turned off before the vessel is moored at port.
3. The vessel master should use the REM according to the guidelines for the system.
4. The vessel should be equipped with a functioning VMS system.
5. The vessel should be equipped with a functioning electronic logbook.
6. The vessel should fill out the electronic logbook haul by haul, and information should be sent to the Directorate of Fisheries as soon as the processing of the catch is finished.

Requirements for vessel design

1. The vessel should be arranged in such a way that it is possible to place a camera that is able to film the area where the vessel is shooting and retrieving the gear.
2. The vessels working deck should be arranged in such a way that it is possible by using an adequate number of cameras to overview the whole working deck and the cargo hatches.
3. Fish which are discarded should only be discarded through a specially designed skids/conveyor belt, which can be monitored by a camera.

Requirements for catch processing

1. All cod – above or below the minimum size – should be sorted out from the rest of the catch.
2. Cod over the minimum size should not be discarded.
3. Both the weight of cod above and below the minimum size should be registered haul by haul.
4. Catches of fish restricted by a quota should not be discarded, if they are above the minimum size. If the vessel does not have a vessel quota of that particular species, it should lease it or obtain it from other vessels participating in a quota pool.
5. The weight of the total discard should be recorded.

Reporting requirements

1. In the electronic logbook the position where the vessel is shooting the gear and the position for where the vessel is retrieving the gear should be recorded haul by haul.
2. The amount of cod that is kept onboard and the amount of cod that is discarded should be recorded in the electronic logbook.

3. The recording of other species should be done according to normal procedure, however it should be performed haul by haul, and also the weight of the total discard should be recorded.
4. Any problem with or breakdown of the VMS, REM or electronic logbook should immediately be reported to the Danish Directorate of Fisheries.

3.5 Catch Quota premium

The 7 vessels were awarded a catch quota premium of maximum 30 % on top of the vessel quota available after the functioning of the documentation system had been approved. If the initial quota had been partly fished at the time the vessels entered the project the premium was reduced accordingly. The premium is fixed on the basis of calculated discards in 2010 but limited according to the maximum of 30% set out in the TAC/Quota regulation.

Total amount of quota for cod, for the 7 vessels participating in the trial						
	North Sea	Skagerrak	Kattegat	Baltic IIId west	Baltic IIId east	Total
Vessel quota	744.292	147.506	2.561	250.799	603.239	1.705.386
Quota premium	179.085	40.031	484	22.179	53.716	282.189
Total quota	**923.377**	**187.537**	**3.045**	**272.978**	**656.955**	**1.987.575**

4. Remote Electronic Monitoring System

Archipelago Marine Research Ltd. (Archipelago), Victoria, BC, Canada has successfully developed and deployed video based remote electronic monitoring (REM) on a variety of gear and vessel types (McElderry et al., 2005; 2006; 2008) and DTU Aqua decided to use this REM system for the scientific pilot project carried out in 2008-2009 (Dalskov & Kindt-Larsen, 2009). The same system was used during 2010 CQM trial.

The system comprises of a GPS, hydraulic pressure transducer, a photoelectric drum rotation (winch) sensor (Figure 1) and four television (CCTV) cameras providing an overhead view of the aft deck and closer views of the fish handling areas and discard chute areas for catch identification. Sensors and cameras were connected to a control box located in the wheelhouse. The control box consists of a computer that monitored sensor status and activated image recording.

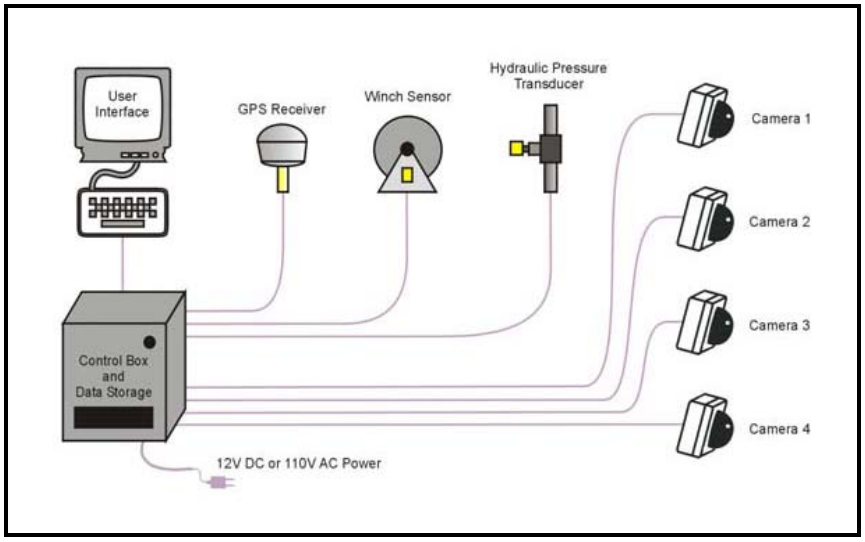

Figure 1. Schematic diagram of the electronic monitoring system, which can record video data from up to four cameras per vessel.

The control box contained data storage capability for about 30 days of vessel fishing activity, and the computer was set to collect and store sensor data (GPS, hydraulic pressure and drum rotation). REM sensor data and image recording were recorded continuously while the REM system was powered which, in principle, was constantly during the entire fishing trip (port to port). No image recording was taken place in port.

5. Reporting, Monitoring and Validation

The skippers on the participating vessels reported additional information in addition to the official logbook requirements. For each individual fishing operation the following information was recorded:

Date, time and position of shooting the gear, time and position of hauling the gear, total catch in weight, weight of retained part of the catch by species, total weight of discarded cod, length measurement of discarded cod, weight of discard of other species.

Monitoring

The REM hard disc drives from the vessels has been collected by staff from the Directorate of Fisheries for data storage and interpretation. Both sensor and image data has been interpreted by staff at the Directorate of Fisheries using computer software developed by Archipelago Marine Research Ltd. Sensor data is used to validate fishing time and position and imagery to validate the fishers recording of catches and especially recording of the amount of discards of cod.

Sensor Data Analysis

The purpose of sensor data (GPS, hydraulic and winch rotation) interpretation is to determine the spatial and temporal parameters for start and end of each fishing trip and each fishing event. The key vessel activities including transit, gear setting, and gear retrieval were identified and compared with the logbook recordings. Figure 2 is showing a spatial plot and sensor time series illustrating part of a typical fishing trip.

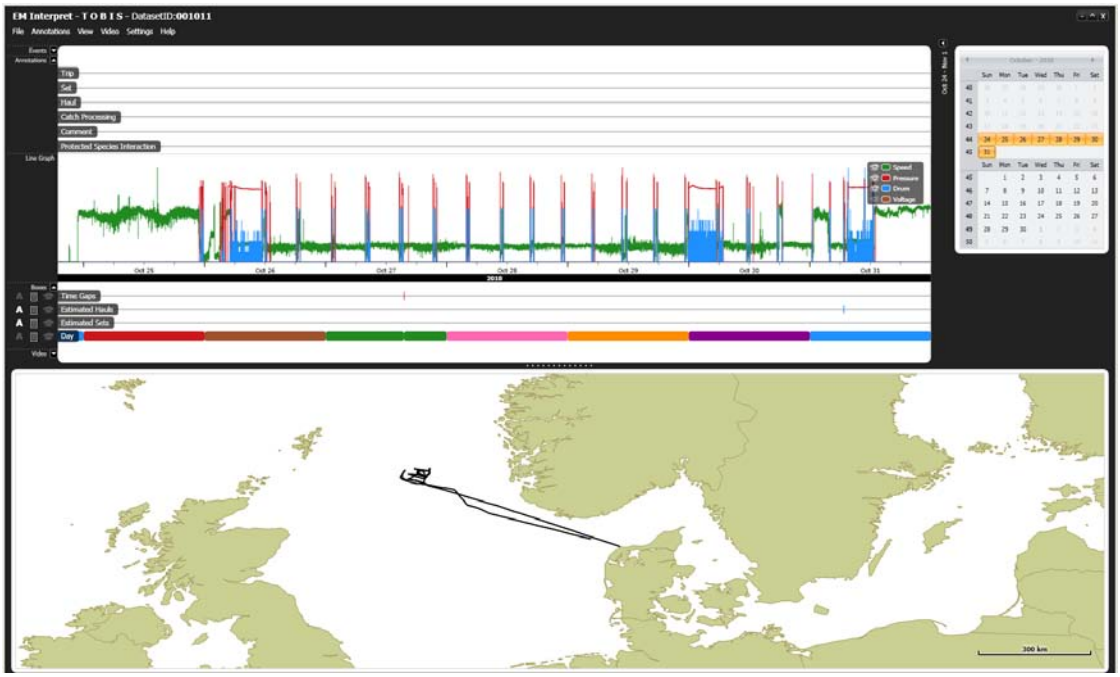

Figure 2. Spatial plot and sensor time series illustrating part of a typical fishing trip.

Image Data Interpretation

The primary objective of image interpretation is to examine and assess the amount of fish caught for comparison with the catch amount recorded by the crew. The secondary objective is to document catch handling and review the discard pattern to verify whether discards of cod are correctly monitored and recorded by the crew. Figure 3 gives an example of the images that are reviewed.

Figure 3. Example of the images that are monitored by the image reviewer.

6. Results

As most of the vessels started the trial period during April 2010 the result given covers the period May 2010 to ultimo December 2010. It should also be mentioned that the skippers should follow the rules of condition given in the CQM trial license but the fishery was carried out according to the skippers and vessel owners own fishing plans without any interference neither by the Directorate of Fisheries nor DTU Aqua. The total catch – landings for the whole 2010 plus discards for the trial period – for the seven CQM vessels is given in table1.

Table 1. Total quota for 2010 for the 7 trial vessels and their total catch (landing and discard) of cod in kg by management area.

	North Sea	Skagerrak	Kattegat	Baltic IIId west	Baltic IIId east	Total
Vessel quota	744,292	147,506	2,561	250,799	603,239	1,705,386
Quota premium	179,085	40,031	484	22,179	53,716	282,189
Total quota	**923,377**	**187,537**	**3,045**	**272,978**	**656,955**	**1,987,575**
Landing	915,058	81,941	0	311,055	721,752	2,029,646
Discard	6,272	880	0	8,071	6,686	21,909
Total catch	**921,330**	**82,821**	**0**	**319,126**	**728,438**	**2,051,555**
Catch less than quota	-2,047	-104,716	-3,045	46,148	71,483	-63,990

According to the official e-logbooks the vessels have during the project period been at sea for app. 27,700 hours, carried out 274 fishing trips, and conducting 2,588 fishing events. Data for individual fishing vessels are presented in Table 1.

Table 2. Number of hours at sea, number of fishing trips, number of fishing operations and fishing hours according to the official logbooks per trial vessel since entering the trial and until the end of December 2010.

Vessel	# of trips	Hrs at sea	# of hauls/sets	Fishing hrs
0	*68 (43)*	*1096 (845)*	*96 (73)*	*429 (352)*
1	39	5134	475	2845 (n = 452)
2	32	4426	392	2337 (n = 369)
3	41	5460	537	2719 (n = 475)
4	38	5143	375	2349 (n = 305)
5	34	2239	136	416 (n = 88)
6	47	4212	600	2118 (n = 544)
Total	231	26614	2515	12784

EMI data only collected for vessel 0 until November (values in brackets). Vessel 0 is not included in Total. Calculation of Fishing hrs were not possible for several hauls in the Electronic logbooks because of missing start time. N = no. of hauls used to calculate Fishing hrs.

Sensor data has been collected throughout the period from the data the individual vessel has entering the trial and until the end December 2010.

Table 3. Number of trips and number of fishing operations recorded using sensor data and used for this report.

Vessel	# of trips	Hrs at sea	# of hauls/sets	Fishing hrs
0	n.a.(43)	n.a. (869)	n.a.(96)	n.a.(567)
1	39	5118	539	3265
2	34	4514	458	3163
3	41	5423	516	2954
4	41	5121	498	3024
5	31	2039	214	787
6	47	4202	609	2281
Total	233	26417	2834	15474

For vessel 0 data was only available until November 2010 (in brackets). For vessel 5 there are 2 trips missing fromDecember (not processed).Vessel 0 is not included in Total.

Differences between numbers of trips in the official E-log and the EM system are encountered for two vessels where one and two trips respectively are missing from the E-log but are present in the EM system (table 4). The same situation but with trips being present in the E-log and not in the EM system is also seen for a few vessels. The mismatch is in the first case either caused by a failure somewhere in E-log system or by the skipper forgetting to fill out the correct data sheets. In the second case where the EM system fails to detect trips the system has been defect when starting out on a fishing trip.

Table 4. Comparable numbers of trips and fishing operations for each vessel for time and position comparisons.

Vessel	# Trips (time and position)	# Time (start)	# Time (end)	# Position (start)	# Position (end)
0	42	53	67	53	67
1	39	300	297	300	297
2	27	219	221	218	238
3	30	117	134	117	134
4	38	104	106	104	106
5	28	31	32	31	32
6	46	458	501	457	501
Total	250	1282	1358	1280	1375

The mismatch in numbers of fishing operations in the E-log and the EM system (table 4) is due to the same problems that were mentioned regarding the trips but here it is likely that single operations during a trip could be lacking in the E-log due to forgetfulness from the skipper. The same lack in the EM system arises from time gaps and the interpretation during data processing of when a fishing operation is carried out.

However the mismatch between numbers of trips and fishing operations reduces the amount of comparable data from the two systems only by a fraction.

6.1 Collected data

The EM systems were set up to be powered and collecting data for the entire duration of each fishing trip. A 'time gap' is a period of time where sensor data was expected to be collected but was not. When 100% of the data is successfully collected for a trip, a complete reconstruction of the trip can be created using the sensor and imagery data. As the level of time gaps increase, the system loses the ability to meet the program objectives as determining the total fishing effort, catch composition, and ensuring compliance issues such as catch retention and area restrictions are followed.

Gaps within the data sets need to be categorized as occurring within a fishing trip or not. Since the EM data were collected after several fishing trips, some gaps are expected in the data set, and ignored during analysis, when the vessels were at port between fishing trips. Time gaps can be further categorized according to the risk involved relevant to project objectives. For example, time gaps that occur when fish are on deck are deemed critical, as this is the period when discards are most likely to occur while small time gaps during vessel transit would be deemed of lower importance. Table 5 provides a summary of data set completeness for the participating vessels. The data record was nearly complete for most vessels and the overall data capture success was 97.96% for a total of more than 26,000 hours of recorded data.

Table 5. Sensor data collected in number of hours, the percentage of data completeness and the estimated number of hours fished.

Vessel	Sensor data (hrs)	Time gaps (hrs)	Data loss (%)	Fishing data (hrs.)
0	n.a. (869)	0	0	n.a.(567)
1	5118	0,2	0,0	3265
2	4514	377,0	8,4	3163
3	5423	1,4	0,0	2954
4	5121	0,3	0,0	3024
5	2039	172,9	8,5	787
6	4202	8,6	0,2	2281
Total	26417	560,5	2,1	15474

Definitions:
Sensor data (hours): This is the time calculated between departure and return for each trip.
Time gaps (hrs): The hours where the REM should have collected sensor data but did not.
Data loss %: =Sensor data hours - Time Gaps/Sensor Data hrs
Fishing data collected (hours): This is the time calculated between start and end for each set (as defined in No. of hauls).

Data loss for vessel 2 and 5 was primarily caused by vessels going to sea when REM systems were defect.

6.2 Fishing event analysis

Since the beginning of the trials in early April fishery control personnel and students have been employed in the Directorate of Fisheries to review the video material from the vessels. During this trial each reviewer has the responsibility to monitor the same vessels in order to grow familiar with the routine patterns on the particular vessel. Irregularities in the handling of fish and reporting are easier to discover if the reviewer is familiar with the vessels routines.

Various review approaches can be used auditing census REM data (Stanley et. al 2011). The Directorate of Fisheries has been reviewing video footage of app. 10 % of the hauls carried out. This has been done simply by reviewing every tenth haul made by the vessels. Analyzing all the sensor data stored on the REM system data hard drive that are collected from vessels has easily been done and then every tenth haul has been selected for video footage reviewing.

When reviewing the selected hauls the Danish Directorate of Fisheries has examined the time of departure and the time of arrival to port, and compared that information with the information provided by the vessel master in the logbook. The information from the REM system on the first and final hauls has also been compared with the information provided by the vessel master in the e-logbook. During the review it has also been checked if there was a discrepancy between the catch area recorded by the vessel master in the logbook, and the catch area that was observed from the data collected by the REM systems. In addition comparisons between the sensor data from the REM system and the VMS system and the data from the vessels e-logbook have from time to time also been made for all 7 participating vessels.

Sensor data registration of fishing events versus fishers' e-logbook registrations

The REM sensor data for start of fishing events was compared with logbook records in order to evaluate the event monitoring capability of the REM system. The difference in minutes between recorded start of fishing event and time reported in the logbooks was calculated. Table 6 shows the relative distribution in time

intervals of the differences. The results of this comparison show that in 81% of the recorded fishing events, the time difference was less than 15 minutes. In 5% of the fishing events the time difference was more than 60 minutes. This indicates that the skippers should have focus on correct e-logbook reporting on fishing event start and stop. It is believed that these time difference issues would be minimal when the fishers become more accustomed to the routine notation of fishing event times.

Table 6. Time difference given in % between the notations of fishing event made in the fishers' extended logbook and fishing notation notated using sensor data.

Vessel ID	<15min	15-30min	30-45min	45-60min	>60min	Total no.
0	69	15	3	3	9	120
1	96	2	1	1	0	595
2	94	2	1	0	3	440
3	54	25	11	3	6	251
4	77	16	1	1	5	210
5	86	10	0	0	5	63
6	89	3	3	1	4	959
Mean	**81**	**10**	**3**	**1**	**5**	**Total 2638**

Difference in fishing events positions recorded by fishers in the extended logbook compared with positions derived from the sensor data is shown in Table 7. In 34 % of the events the positions noted by the fishers and derived from the sensor data lied within a distance of 0.5 nm (nautical mile). For 26 % of the events the difference was larger than 1 nm. The reason for this difference was likely the uncertainty of definition and determination of when a fishing event actually started and ended. The skipper has to do boat handling when setting and hauling the gear and therefore may not have the time to record the position and time when the setting and hauling actually took place. The recording of position and time was therefore made later. The time differences are not acceptable and the skipper have to be trained to be more accurate.

Table 7. Distance difference given in % between the notations of fishing event made in the fishers' extended logbook and fishing notation notated using sensor data

Vessel ID	< 0.5 nm	0.5 - 1.0 nm	> 1.0 nm	Total no.
0	31	48	22	120
1	40	38	22	597
2	29	44	27	456
3	52	27	22	251
4	30	35	35	210
5	21	43	37	63
6	35	44	21	958
Mean	**34**	**40**	**26**	**Total 2655**

6.3 Catch data analysis

As mentioned in section 6.2 10 % of the hauls have been selected for video footage reviewing. The amounts of cod discarded and reported in the e-logbook have been estimated by reviewing the video footage. When monitoring the selected hauls the amount of cod discarded is estimated and recorded. The amount of discard of other species is also estimated and recorded.

Discards of cod

One of the purposes of this project was to examine whether it was possible to estimate the amount of cod discarded by viewing the image records of the catch handling onboard the trial vessels. When the analysis of the discard practises started it was planned to analyse all catch events. It was, however, realized during earlier projects that it was not possible to follow that approach with the available resources. It was therefore decided for the vessels to analyse at minimum 10% of the catch events. The total numbers of catch events processed are presented in Table 8 below.

Table 8. The total number of catch events which are processed from each vessel.

Vessel	0	1	2	3	4	5	6	Total
Events	12	45	34	48	38	25	47	249

Table 9 shows the fishing events given as the percent of situations where the image viewer either had estimated less, more or the same amount of discard as the fishers. In 72% of cases the viewer and the fisher estimated the same amount of cod discard. There was however 22% of the occasions where the fishers estimated a larger discard amount than the image viewer. Looking at the results more closely, e.g. vessel 0, there were 50% cases where the fisher's estimate was larger than the viewer.

Differences between the image viewer's estimate of discard quantity and the amount reported by the vessels were more common when the discard volume was large. The results suggest that it was difficult for the viewer to estimate with accuracy when a large number of fish were discarded and there was a clear tendency for the viewers to underestimate discards in these situations. A new catch handling protocol regarding discard could improve the accuracy of the viewers estimate on the amount of discard.

The results show that image recording of catch sorting can with a high degree accuracy be used to verify the actual amount of fish and shell fish that are discarded if the catch sorting working area onboard is arranged in a optimal way for image recording. This result may be of less interest if EU moves to a policy of 'all fish landed'

Table 9. The percentage of fishing events where the image viewer either had estimated less, more or the same amount of discard cod as the fishers.

Vessel ID	**Fisher < Viewer**	**Fisher = Viewer**	**Fisher > Viewer**	**Total no.**
0	16,7	33,3	50,0	12
1	0,0	83,7	16,3	43
2	0,0	96,0	4,0	25
3	0,0	93,2	6,8	44
4	10,5	89,5	0,0	38
5	13,0	43,5	43,5	23
6	2,1	66,0	31,9	47
Mean	**6,1**	**72,2**	**21,8**	**Total 232**

Discard of other fish

Discard of cod was the main focus area in this project although when analysing the images, discards of other fish species were also noted. No analysis of this has been made. Viewer data shows that it has been possible to identify other species and to estimate their weight.

6.4 Spatial distribution of the trial fishery

The fishery carried out by the REM vessels has been analysed and a number of vessels that could form a group of vessels to be used as a reference fleet has been selected. The spatial distribution of those two vessels groups has been plotted for the period January-April 2010 and for the period May-December 2010 is shown in figure 6.

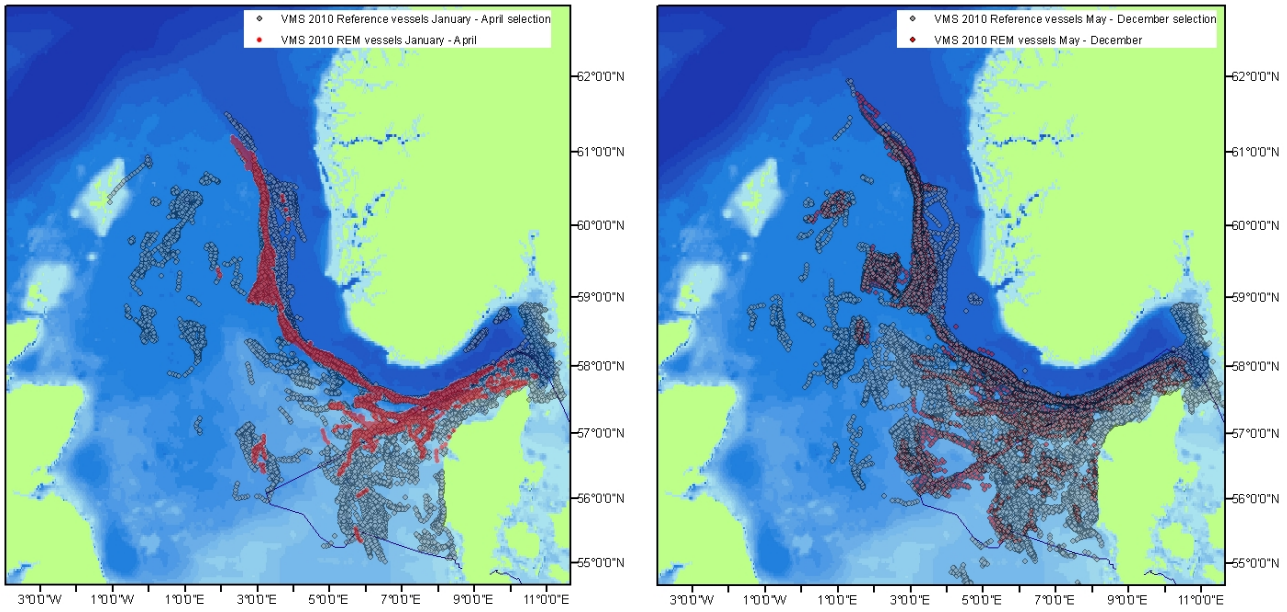

Figure 4. Spatial distribution carried out by the REM vessels and the reference vessels for the period January – April (left) and May –December (right) 2010.

As it appears from figure 4 there is some overlap between the two vessel groups. It would have been possible to select individual fishing trips where the fishery had taken place at the exact same fishing grounds. It has though been decided to include all fishing trips for the reference vessels when using the same gear and mesh size as the REM vessels and for fishery in the North Sea and the Skagerrak.

6.5 Size grade distribution and discards

The vessels participating in the CQM project have according to the terms and conditions for participation (see section 3.4) to retain and land all fish above the minimum landing size. For most species the price per kg increases with fish size and it is possible for a vessel to optimize the value of a quota by only retaining large fish and discarding small ones. This type of illegal discard known as “high grading” often occurs for species and areas where catch opportunities and quotas do not match.

Six of the trial vessels have been fishing in the North Sea and the Skagerrak and a comparison between these vessels with a group of vessels (128 reference vessels) fishing in the same areas with the same gear type and mesh size and the rest of the fleet fishing in the same areas can be made. Figure 4 shows the proportion of landings of cod per size grade (size grade 1 are the large fish and 5 are small) for the period before the trial start (Jan-Apr) and after the trial start (May-Sep) 2010 for the trial vessels (REM vessels), Reference vessels and for all other vessels that have landed cod caught in the North Sea. Figure 5 shows

this comparison for fishery carried out in the Skagerrak. A difference of the proportion of size grade 4 and 5 can be seen.

A similar comparison has not been made for the Baltic Sea as only one trial vessel was operating there. All data collected by this Baltic Sea vessel is of course monitored and reviewed.

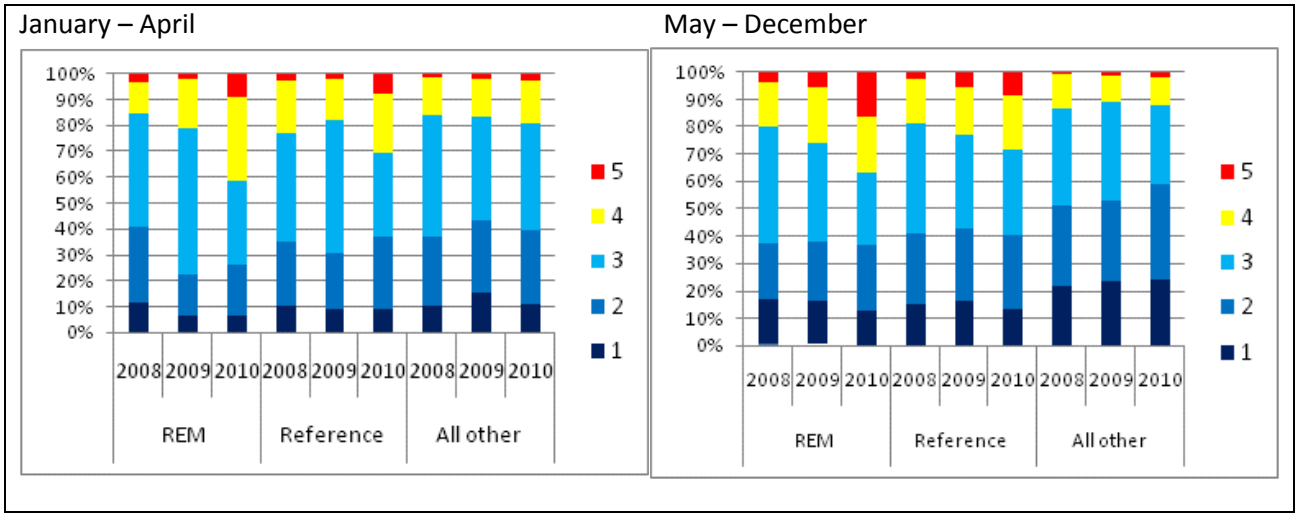

Figure 5. Size grade distribution of landed cod given in % for fishery carried out in the North Sea for 2008-2010.

Figure 5 shows the size grade of the landed fish for 3 vessel categories and two seasons for the three years (before and during full documentation). The REM vessels have almost the same landing pattern for 2008 and 2009 even though one may expect more size grade 4 and 5 landed in 2009 compared to 2008 as the cod quota was increased for 2008 to 2009 by 30% in the North Sea and the Skagerrak. The figure for the period May-December show that the share of size grade 5 by the REM vessels is double the share of the Reference vessels. This indicates some high grading among vessels without full documentation. When fishing without the full documentation scheme the fishers may not be that accurate when sorting the fish just above or below the minimum landing size. This may have an influence in the difference in size distribution of cod landings between the three vessel groups. It should also be mentioned that the minimum landing size for cod caught in the North Sea is 35 cm and the main mesh size used in the trawl gears is 120-130 mm.

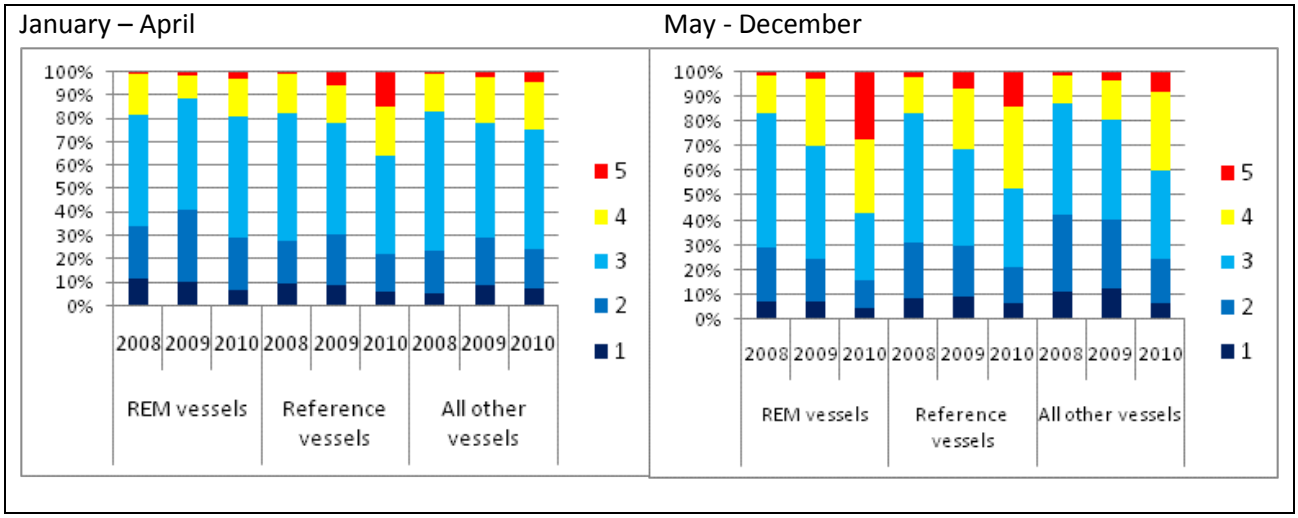

Figure 6. Size grade distribution of landed cod given in % forfishery carried out in the Skagerrak for 2008-2010.

Figure 6 shows the size grades of the landed fish for 3 vessel categories and two seasons for the three years (before and during full documentation). The REM vessels have almost the same landing pattern for the period 2008-2010 for the season January to April. The share of size grade 5 for the REM vessels for the period May to December increases from app. 3 % in 2008 and 2009 to app. 28% after entering the CQM trial. If comparing the REM vessels with the Reference vessels for the May-December period the REM vessels land double the share of size grade 5 than the Reference vessels. This indicates high grading among vessels without full documentation. The minimum landing size for cod caught in the North Sea is 30 cm and the main mesh size used in the trawl gears is 90-100 mm.

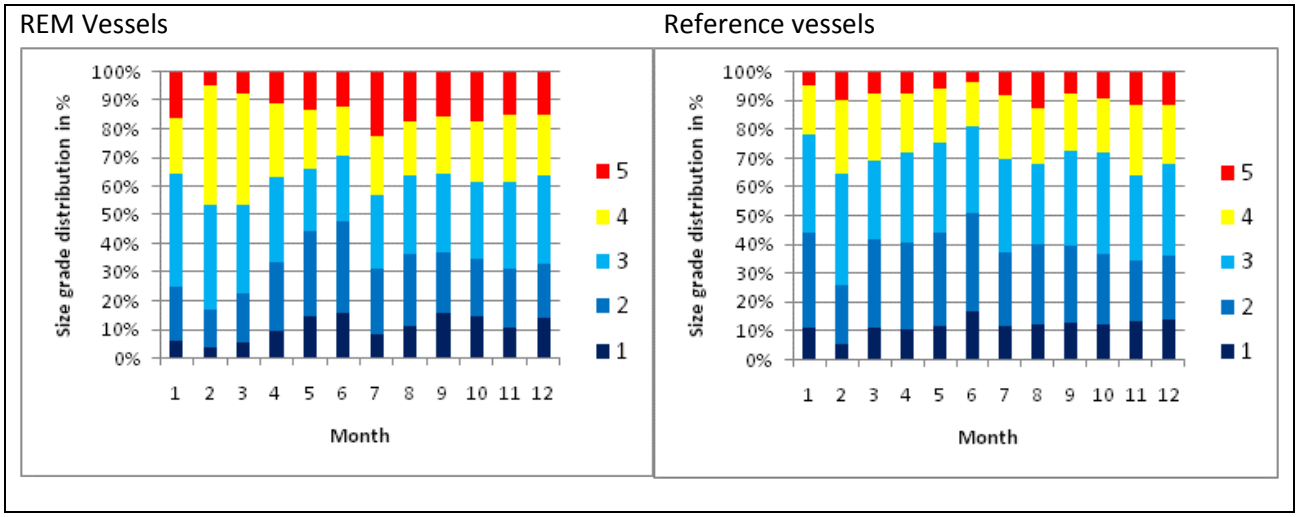

Figure 7. Size grade distribution of cod in % landed by month caught in the North Sea for the REM vessels and the Reference vessels for 2010.

Figure 7 is showing the size grade distribution of cod in % landed by month caught in the North Sea for the REM vessels and the Reference vessels for 2010. As mentioned in section 3.3 the REM vessels (6 vessels) were equipped with the REM system in mid-late April 2010. It can be seen in figure 6 that the proportion of size grade 5 increases from May 2010 and amounts to app. 15-20 % per month and compared to the Reference vessels (57 vessels) where the size grade 5 only amounts to 5-10% per month. This difference

cannot be explained by increased availability of smaller cod (stronger year-class). If so both vessel groups should have the same proportion of the smaller size grades. The difference can only be explained by high grading for the reference vessel group.

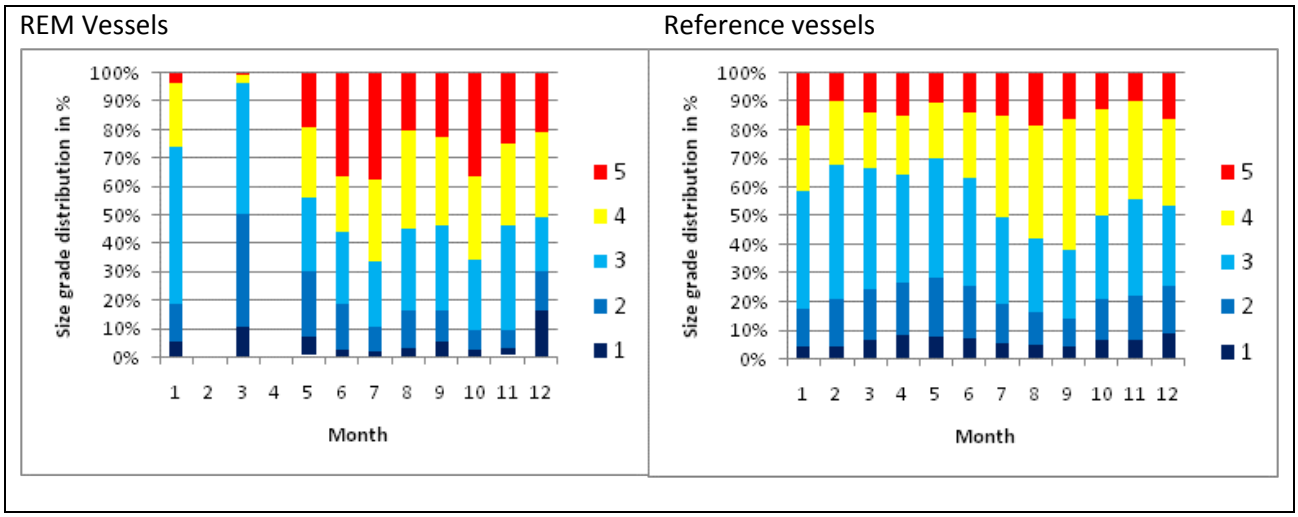

Figure 8. Size grade distribution of cod in % landed by month caught in the Skagerrak for the REM vessels and the Reference vessels for 2010.

Figure 8 shows the size grade distribution of cod in % landed by month caught in the Skagerrak for the REM vessels and the Reference vessels for 2010. For the Skagerrak the proportion of size grade 5 increases from May 2010 and amounts to app. 20-35 % per month and compared to the Reference vessels (113 vessels) where the size grade 5 only amounts to 10-15% per month. As for the North Sea fishery this difference cannot be explained by increased availability of smaller cod (stronger year-class). The difference can only be explained by high grading for the reference vessel group.

Change in size grade distribution may be caused by several factors such as the species viability in relation to the set quota, change in prices per kg. per size grade (less differences between size grade 3 - 4 and especially between size grade 4 and 5) and change in selected fishing ground as most demersal fisheries are mixed fisheries and therefore catch opportunities of other species have to be taken into account. But as data used for the analysis is data for a large number of vessels it may be concluded that high grading takes place if all fishing event is not fully monitored and documented.

6.6 Fisher behaviour and change of fishing pattern

The Danish Directorate of Fisheries has been in continuous contact with the vessel owners participating in the trials. The participants have stated that they now pay more attention to where they are fishing in order to avoid areas with small cod. When doing the catch handling the crew measures the smallest cod in order to determine whether the cod is below or above the minimum landing size. Before entering the trials the size determination of the cod was just done by eye, which meant that fish just above the minimum size most often were discarded. Those vessel owners who chose to participate in the trials have a positive opinion towards the project and the CQM approach. The incentives to participate in the trial have been partly the opportunity to gain a premium of cod, but also a desire to document their fishery and to provide reliable data. There are also some fishers that believe that their participation will be an advantage in relation to MSC certification.

6.7 Possible circumvention of the REM system

Observations have shown that the participating vessels accept the REM system as a condition for the participation in the scheme, and no direct tampering of the systems has occurred.

To achieve a mutual understanding of which information and routines that are essential in making the trials as useful as possible, the Directorate of Fisheries visited all vessels after the REM system had been functioning for a couple of months. When discussing any irregularities of the recordings in the logbook that may have occurred the vessel owners and masters have subsequently followed the instructions of the Directorate which have implied that the standard of the incoming information has improved. Information regarding recording the vessel activities such as the time of deployment and retrieval of gears has especially been improved. It was though experienced that the quality of the detailed recordings made by some of the fishers declined over time. Therefore, constant feed back to the fishers is essential and it should be stressed that this should be a fully integrated part of the programme. It is probably necessary to implement some kind of "penalty" system so the skipper in advance knows the consequences for not living up to the terms and conditions for the trial. It could also be considered how often the hard drives should be exchanged because irregularities preferably should be detected as soon as possible in order to give feed back to the fisher.

It should be mentioned that the REM system has not been tested or verified as a complete tampering free system.

6.8 The use of REM from a control and enforcement perspective

The preliminary assessment of the use of REM to verify the recording of discards in the logbook looks very promising. Given the incentive and a conscious adherence to the requirements for verification of the discard, it can be made with high accuracy.

Also it is the opinion of the Directorate of Fisheries that the use of the REM system is a very efficient control instrument towards eliminating misreporting of fish from areas where fishing is not taking place.

The experiences gained so far show that REM cannot at this stage replace all control mechanisms. The main objective of full documentation is to ensure that discards are recorded with a reliable weight, and that no other discards takes place. The exact weight of the contained catch must be weighted by landing.

In addition to use REM data to verify the fishers recording of catches and discard the REM sensor data and imagery is used to test whether and how this type of information can be used as a control and enforcement tool. The various present control and enforcement possibilities can be tested at the various control duties that should be carried out in order to live up to e.g. the EU Control regulation. An overview is given in table 10 below.

Table 10. The table show the use and the reliability of various ways of verifying how, where, when and what has been done during a fishing trip where multiple fishing events have been carried out.

	At-Sea observers	Remote electronic monitoring	At-Sea control	VMS (satellite control)	Landing control
Spatial and temporal location of the fishery	An at-sea observer can verify fishing event with high accuracy but it is not possible for one observer to work 24/7.	All individual fishing events can be verified with high accuracy.	Only if control vessel is in vicinity of a fishing vessel and only the single fishing event carried in that timeframe can be verified.	It can be verified when a fishing vessel is having a speed that usually is used when fishing (eg. trawling). Though it cannot be verified if a gear is deployed.	Not possible.
Justification of correct quota area reporting	An at-sea observer can verify fishing event with high accuracy but it is not possible for one observer to work 24/7.	Not possible exact to justify the total catch in kilo per species per haul. But by reviewing the imagery compared with the fisher catch recording high precision can be made.	Only for the individual fishing event controlled.	Not possible.	Not possible.
Exact recording of fishing effort	An at-sea observer can verify fishing event with high accuracy but it is not possible for one observer to work 24/7. Departure and call of port can be exact recorded.	All fishing events can be verified with high accuracy. Departure and call of port can be exact recorded.	Not possible.	Not possible.	Not possible.

Verification of discarding and slipping	An at-sea observer can verify if discarding or slipping takes place but it is not possible for one observer to work 24/7.	Verification of discarding and slipping can be verified with high accuracy.	Only if control is boarding a fishing vessel twice. When the fishing vessel is hauling the gear and few hours after the catch handling has taken place.	Not possible.	Not possible.
Catch weight estimate	An at-sea observer can verify total catch per fishing event with high accuracy but it is not possible for one observer to work 24/7.	Only a rough estimate can be given. The estimate can be given for all fishing events analysed.	Only for the individual fishing event controlled.	Not possible.	Not possible.
Landing weight estimate	Not possible.	Not possible.	Not possible.	Not possible.	Precise recording can be made.
Fishing gear rules compliance	Can be done by observer	Not a relevant function of CQM and it will require additional set-up of the REM system.	Can be done by boarding fishing vessels for inspection.	Not possible.	As the rules for the use of a gear applies to the gear on board control can be made in port.

6.9 REM costs – installation of equipment and data analysis

The 2010 has been carried out in cooperation between FD and DTU Aqua. Before installation of REM systems FD staff visited the vessels and decided where the CCTV cameras should be places. The installation of the REM system onboard the vessels have been carried out by DTU Aqua staff and subsequently FD staff approved the installations.

Setting up the operational system for running a fully documented fishery monitoring programme is resource demanding. There is no doubt that all the work processes can be optimized and that the land based organization can be organized, trained and specialized in the different work processes. The more precise the terms and conditions for fishers that participate in CQM with full documentation are the easier and more correct the review process would be and consequently less resource demanding.

7. Discussion and Conclusions

The conclusion of the trials is that the REM system is satisfying the requirements for a fully documented fishery in the sense that the system is technically very reliable, it records catch events with high precision and it is in context of a management regime generally accepted among fishermen. It is likely to give valuable information even under a fisheries management regime not considered legitimate among fishermen, however, the system is not tested against this situation. It is possible through the REM system to estimate the amount of discard of cod and other species. The system also has the potential to improve the existing control mechanisms, especially regarding cases of area misreporting.

The experiences gained when analyzing the data collected have shown that close contact with the participating vessels master and crew is of importance especially in the initial phases of an implementation of full documentation. Both the staff at the Danish Directorate of Fisheries and the participating vessel master and crew had to get familiar with the routines and how to solve any irregularities that arose. It should be stressed that the initial face of running a CQM system and fully documented fishery is important and that all the operational conditions should be in place.

It could be considered whether a score card system or another system to evaluate how accurate the skipper/crew complies with the terms and conditions for a CQM system should be included. The more accurate skipper recordings are made the lower review frequency and the less accurate recording the higher frequency of reviewing. This should include all the types of recordings stated in terms and conditions for the vessels participating in the CQM system i.e. GPS positions, times, species composition, amounts, etc. In addition it could be considered whether lower compliance with the terms and conditions should give lower quota bonus. It should be possible to set up an objective and transparent set of rules for such a bonus/penalty system.

The assessment of the software to analyze collected sensor data and images is that it is very user friendly. It is easy to navigate. Differentiation between various vessel activities such as steaming, fishing, hauling or gear deployment can easily be done from the collected data. The data that can be extracted from the system is very precise, which facilitates accurate comparisons with the data in the logbook.

The directorate has not at this stage made a cost efficiency comparison between full documentation and other means of control such as landing control, VMS, control at sea or control by observers. Such a

comparison should take account of the nature of full documentation as a continuous surveillance as opposed to other controls that rely on observations at the given time of control.

The directorate has given priority to obtain comparable monitoring and control results, and advantages of a risk based approach have not yet been tested. Initial analyzing of logbooks and sensor data can give relevant information in relation to need of further scrutinize – 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 of behaviour for the vessels involved and 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 by viewing the images can be made with significant accuracy, especially if the vessel has a sorting conveyor belt where the discarded fish pass the discard chute individually. If large amounts of discards occur the accuracy of the estimate of the discard amounts decreases unless specific catch handling protocols are followed by fishers.

It is considered that the voluntary participation ensure acceptance of legitimacy of the documentation thus ensuring a smooth operation where the fishermen work “with the system”. The incentive effect and possible relevance market requirements affects the operational integrity of REM as a reliable tool for documenting catches. The initial implementation and running of the system needs close co-operation between the industry and the authorities to ensure maximum data security.

These results are very much in line with those from the scientific trial in 2008/2009 but it should be stressed that constant feedback to the skippers or vessel owners is essential as there is a tendency over time to be less accurate in e-logbook recordings.

8. Acknowledgement

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9. References

Dalskov, J. & Kindt-Larsen, L., 2009. Fully documented fishery. DTU Aqua report. Available at: http://www.aqua.dtu.dk/upload/dfu/kameraforsoeg/final%20rapport%20300809%20v3.pdf

Kindt-Larsen, L, E. Kirkegaard and J. Dalskov, 2011: Fully documented fishery – a tool to support a Catch Quota Management System. In press. ICES Journal of Marine Science.

McElderry, H. 2008. At-Sea Observing Using Video-Based Electronic Monitoring. Report prepared for the Electronic Monitoring Workshop held by The North Pacific Fishery Management Council, The National Marine Fisheries Service and The North Pacific Research Board, July 2008.

McElderry, H, R. Reidy, D. Pahti, 2006. A Pilot Study to Evaluate the Use of Electronic Monitoring on a Bering Sea Groundfish Factory Trawler. Unpublished report prepared for the International Pacific Halibut Commission by Archipelago Marine Research Ltd., Victoria BC, Canada.

McElderry, H., A. Crumpacker, R. Wright and D. McCullough. 2005. Electronic Monitoring for the 2005 U. S. Shore-based Pacific Hake Fishery--A Pilot Study. Unpublished report prepared for the National Marine Fisheries Service, Northwest Fisheries Science Center, National Oceanic & Atmospheric Administration, Department of Commerce by Archipelago Marine Research Ltd., Victoria BC, Canada.

Pascoe, S., J. Innes, D. Holland, M. Fina, O. Thébaud, R. Townsend, J. Sanchirico, R. Arnason, C. Wilcox, and T. Hutton: Use of Incentive-Based Management Systems to Limit Bycatch and Discarding. International Review of Environmental and Resource Economics, 2010, 4: 123–161

Stanley, R., H. McElderry, T Mawani and J. Koolman. The advantages of an audit over a census approach to review of video imagery monitoring. In press. ICES Journal of Marine Science.

Colophon

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