Report on Catch Quota Management using Remote Electronic Monitoring (REM)

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Fisheries Division

marinescotland

Summary

This report builds on the interim report published by Marine Scotland in September 2010 and is intended to focus on the scientific, economic and compliance aspects of Catch Quota Management using Remote Electronic Monitoring (REM).

Marine Scotland invited 26 vessels to participate in the 2011 Catch Quota Management Scheme (CQMS), 25 vessels accepted. While these vessels are operating a fully documented fishery for North Sea Cod they gather important data. As we learn more about the scientific capabilities of the REM system in the complex fishery of the North Sea, we can look at the economic impact of operating a discard free cod fishery and how that impacts on the individual skipper's business. Perhaps most importantly we learn more about the control aspect of the CQMS, strengthening our processes and analyses to give policy makers the confidence in the compliance of a fully documented fishery.

While we aim to evaluate the work to date, there are difficulties with scientific work results not being available immediately, we can, however, see vessels that participate in the CQMS are more profitable as a result and compliance continue to improve and adapt their processes to increase confidence in a fully documented fishery and observance of the CQMS rules.

Conclusion

One question often raised in relation to a move to a catch quota scheme, is that it may be difficult to control and enforce, because total catches cannot be verified at 100%. However rather than simply saying for example, that there is a discard ban in place with no means of proper verification, we have full confidence that these control and observation challenges can and are already, being resolved to a level of acceptable confidence in most fisheries by the use of REM.

The biggest challenge remains one of allocating appropriate fishing opportunities to those in the scheme and dealing with the so called "choke species", experience to date, is highlighting this as one of the most difficult challenges we face. The historical records used for allocation keys will normally only reflect landings data, with no factoring or consideration on levels of discarding that takes place, a particularly enhanced issue in complex mixed fisheries such as the North Sea. It is quite apparent there have been, and continue to be, major changes in the dynamics and spatial distribution of stocks, and more generally in fishing practices. The allocation of quotas either at a national level or to individual vessels often bear little or no resemblance to the current circumstances and activities of vessels in the various fisheries.

The costs of this approach are equally cited as a concern, particularly during the current economic climate that we operate within. However a move to management of removals or a discard ban in some fisheries will only be accepted by managers and the general public alike if they have the necessary confidence that fish are not really continuing to be thrown dead back into the sea and that we do have accurate records on actual removals.

To have an observer on board a vessel costs in the region of £400 per day and covering 250 to 300 days equates to a cost for a single vessel of between £100,000 and £120,000. The REM system has the ability to deliver an analysis of much of the same data apart from recorded discard weights for a fraction of the costs. Indeed at a time when there is so much demand for additional scientific research and analysis, the REM systems have the most unusual problem of almost providing too much information to be able to handle.

The catch forecasts provided in scientific advice should, in principle, cover total catches and not just landings. We do know, however, that in numerous circumstances discards are not recorded or reported properly and the uncertainty around the volume is often substantial and, as such, the information is not properly considered. The introduction of REM systems will not change the way in which advice is delivered. However it may result in different advice as the confidence levels on knowledge of total removals is enhanced greatly.

An early and recognisable feature of the catch quota trials is that it clearly provides the incentives for skippers to optimise their gear selectivity to maximise the economic return of their catches and indeed the areas of the sea that they go to accommodate such changes. The economic drivers, highlighted in this report, are amongst the most powerful ones at our disposal.

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INTRODUCTION

Principles of a Fully Documented Fishery

In September 2010 Marine Scotland published an interim assessment of its Catch Quota Management Scheme (CQMS). That report outlined the design of the CQMS using Remote Electronic Monitoring (REM) in the North Sea. A copy of the interim report can be viewed at:

http://www.scotland.gov.uk/Topics/marine/SeaFisheries/17681/CQSinterimreport

The interim report introduces the concept of a fully documented fishery in the North Sea that allows participating skippers to land what they catch. Chapter 2 of the interim report details how REM works and Chapter 3 explains how the CQMS trial was designed and is recommended for those who are not familiar with the earlier trials undertaken by Marine Scotland. Overall, the aim of CQMS is to reduce cod discards. The early results of Marine Scotland's trials have been encouraging both from a control and from a scientific perspective, and have given Marine Scotland sufficient confidence to pursue negotiations with an expanded scheme for 2011.

Marine Scotland has gathered a lot of experience of CQMS using REM since its original pilot in 2009. In many ways we are continually improving, adapting and refining the management of CQMS. There is still much to learn and apply. Two key improvements to the operation of CQMS in 2011 have been the involvement of the Producer Organisations in the management of cod quota uptake and the centralisation of logistical support in the North East of Scotland under the management of Marine Scotland Compliance. Marine Scotland believes that CQMS is a viable fisheries management option that can tangibly reduce discarding in the North Sea.

CQMS using REM

Participants in CQMS are provided with extra North Sea cod of up to 30%. In return they agree to: (1) land all the cod they catch; (2) carry cameras; and, (3) stop fishing altogether in the North Sea when they reach their (augmented) cod quota. The additional quota provided is less than the discards that would otherwise take place. In 2010, the trial involved 17 vessels using the equivalent of 5% of the 2010 TAC (for Scotland this equated to 535 tonnes). In 2011 the UK was allocated 12% of the 2011 UK cod quota for the CQMS. This was agreed in the EU/Norway negotiations. Scotland pressed for open access to all vessels meeting the conditions, but Norway resisted and the Commission gave only limited support. Scotland has 997 tonnes of cod which could be provided for the 2011 scheme if open access were allowed – 79.5% of the UK allocation. Although 58 vessels applied for the scheme, only 26 could be offered a place with 25 accepting. It is disappointing that we were unable to allocate a place on the scheme to every applicant but with the quota available this was not possible. Marine Scotland will continue to press the

Commission for further catch quota opportunities for the Scottish fleet. Marine Scotland believes that any whitefish vessel that wants to participate should have the opportunity.

Problem of discards in the North Sea

In the North Sea in 2009, 60,000 tonnes of whitefish worth £68m were landed in Scotland, whilst the total catches were 88,000 tonnes worth an estimated £101m. This means that almost 28,000 tonnes - and a third of the value of the Scottish cod, haddock, whiting, saithe, plaice and hake catch - was thrown back into the sea last year; £33m of fish wasted economically and environmentally in one year. Overall in the North Sea, one in three cod caught is still wastefully being discarded (approx. 14,600 tonnes); this means that more cod is discarded in the North Sea than can be landed in the UK. This position is unacceptable and must be addressed.

Estimated figures for the key North Sea species by Scottish vessels in 2009

Species	Amount discarded	Value of discards	Value of landings
Cod	6,867t	£12,356,517	£16,296,633
Haddock	8,627	£8,180,203	£24,883,493
Whiting	2,418t	£2,397,242	£7,418,031

- Estimates are based on data from the Observer programme

Discards is one of the biggest challenges that we face, particularly in the complexities of a mixed fishery in the North Sea, and while CQMS is not the complete solution it presents fisheries managers and industry with a way of reducing discards. We require several tools to tackle discards and deliver stock recovery. However, alongside the use of selective gears and real time closures, CQMS can make a real difference.

Evaluating CQMS

CQMS is an innovative approach. Its success must be measured against three areas: science, economic benefit to participants; and, compliance with the rules. In order to develop a robust case to demonstrate that CQMS can reduce discards and in turn improve the stock, we must show that it can gather better **scientific data** on discards. To make CQMS attractive to skippers it must provide an **economic incentive** for participation. Economic modelling suggests that vessels participating (with an uplift limited to 30%) will be in a better position commercially than non-participants, even after taking into account the lower average prices achieved because they must land small fish, because of their ability to land greater volumes. They will also benefit

from being exempt from effort control (days at sea). Finally, Marine Scotland must ensure that the participants are operating a fully documented fishery; the rules of CQMS and the code of conduct must be adhered to. Vessels are receiving additional quota and are exempt from effort restrictions and in return they are not allowed to discard North Sea cod and must have access to cod quota in order to keep fishing in the North Sea. Therefore, **compliance with the rules** of a fully documented fishery are of the upmost importance. To date, Marine Scotland has expelled three vessels for non-compliance with the scheme terms and conditions. Terms and Conditions are contained in Annex 5. While this is disappointing, it does demonstrate that enforcement of this scheme and adherence to its principles are the highest priority.

CQMS is a key Scottish Government policy objective in influencing reform of the Common Fisheries Policy and how we can better manage our fisheries. It delivers a level of confidence to both managers and consumers alike that has not been possible before.

Working in partnership with others

Marine Scotland and DEFRA have worked closely together on CQMS, although they do operate their schemes on a slightly different basis. A report of the English scheme is being published in tandem with this report. It has been particularly useful to have collaboration with other Member States on the progression of CQMS. On 17 May 2011 a second workshop was hosted in Copenhagen by the Danish Ministry. The workshop focussed on many ways forward for CQMS, how it can be used to improve fisheries management; how to develop common standards for processing and reporting more reliable data; innovative methods and technologies and develop cost efficiencies; and, intelligent and simplified control and regulation. Marine Scotland was able to share its experiences with CQMS and in particular report back on the views of Scottish skippers who have participated in the trials. A report of the workshop can be found on the Danish Ministry of Food, Agriculture and Fisheries webpage at:

http://www.fvm.dk/conferences%20and%20hearings.aspx?ID=42787

Marine Scotland and DEFRA are keen for other Member States who are pioneering CQMS to work together to develop cohesive standards that can be applied consistently across European fisheries. To this end, we would wish to see further technical meetings take place with a focus on agreeing common standards of application and monitoring techniques as well as the amount of footage that is viewed either randomly or on a risk based approach.

We acknowledge that there will be multiple ways in which to manage a discard free fishery or to manage on the basis of total removals from the sea rather than, as currently, on landings. However we are also very keen to see catch quotas acknowledged throughout the EU and by the Commission itself, as a central tool in moving towards such objectives and we look forward to

sharing our experiences and further enhancing the levels of participation both at fleet and country level.

CHAPTER 1 – CQMS - SCIENTIFIC EVALUATION

Introduction

REM data consists of video footage of fish discards from strategically placed cameras on fishing vessels, along with high resolution readings of vessel position, speed and trawling activity. REM data has been used extensively by Marine Scotland Compliance (MSC) during 2008 and 2011 as part of the management and enforcement measures in the Conservation Credits and Catch Quota schemes. However, the scientific analysis of such data is at a much earlier stage of development. Globally, REM systems have generally been implemented in long line fisheries, in which fish pass cameras individually, which facilitates identification and counting. The use of REM to monitor mixed species trawl fisheries is a more recent development, and the capabilities of the system in this context are not yet fully understood. Therefore, there is a pressing need for scientific analysis of REM data, both to evaluate what can be learned of the fish stocks and the fishing industry from these data, and to help inform best practice in compliance monitoring operations.

This chapter briefly summarises the scientific analyses of Scottish REM data that has been conducted by Marine Scotland Science (MSS) at the Marine Laboratory during 2008 and 2011, along with proposals for future work. The work covered includes:

- Full species composition estimates and appropriate sub-sampling rates for video footage.
- Comparisons of length distributions of landings of commercial species from comparable vessels with and without REM systems.
- Comparisons of discard rates on comparable REM fitted vessels with and without physical observers onboard.
- Comparisons of discard estimates from CCTV footage and onboard observers.
- Comparisons of CCTV-based species counts from different video viewers.
- Comparisons of Vessel Monitoring System (VMS) and REM location and activity data.
- Computer vision based automated species recognition and measurement.
- Method exploration using systems installed on RV Scotia.

Estimating discarding rates onboard Scottish trawlers using CCTV: what is the minimum proportion of footage needing to be analysed?

The estimation of discard rates in commercial fisheries has historically been difficult to do, due to the limited availability of onboard observers. The introduction of REM systems has enabled monitoring on each vessel to be increased, as data can be analysed at a later date onshore. Although it holds the potential to provide 100% monitoring, this would require too much time

and therefore sub-sampling of footage is required. The aim of this study was to examine how much footage is required to be sampled, to estimate correctly the level of discarding on a vessel.

The study used data recorded from a trip conducted by a demersal trawler, fishing at Rockall during March and April 2010. All discarded fish of all species were recorded to the highest taxonomic level possible for the whole trip, which was divided into 10 minute segments to facilitate processing. Random sampling of the segments was then carried out to examine the proportion of footage that would need to be viewed in order to get an estimate of the discards from the entire trip without a significant difference from the true observed value. Sampling was carried out at increments of 5%, from 5% of the footage up to 100%. The sums of the samples of each species were raised up to produce an estimate for the full trip and sampling was repeated 1,000 times giving a distribution of sampled estimates. Sampling was carried out in different categories of species of particular interest to examine how the required proportion changes with individual species and groups of species.

The results showed that the level of sampling required varies depending on the particular species or groups of species that is of interest. A sampling level of 10% was found to be significantly underestimating discarding for the majority of species. It was found that 40% of footage needed to be sampled to get accurate estimates of all discarded species, with yet higher sampling rates required for estimates of non-commercial species (Figure 1). Alternatively, if monitoring was focused on specific species that are commonly discarded lower values could be sampled (for example, 20% for haddock). Figure 1 also summarises the probability of missing all the discards of haddock or the non-commercial species subset, which would probably be of more interest to Compliance officials monitoring a discard ban. On the sampled trip, at least some haddock discards were always seen, whereas there was a moderate probability (~50%) of missing non-commercial species discards if only a few periods of footage were viewed.

Therefore this study suggests that, if REM systems are monitored using human viewers, the technology may be more suitable for monitoring discarding of a certain species rather than monitoring discards of all species.

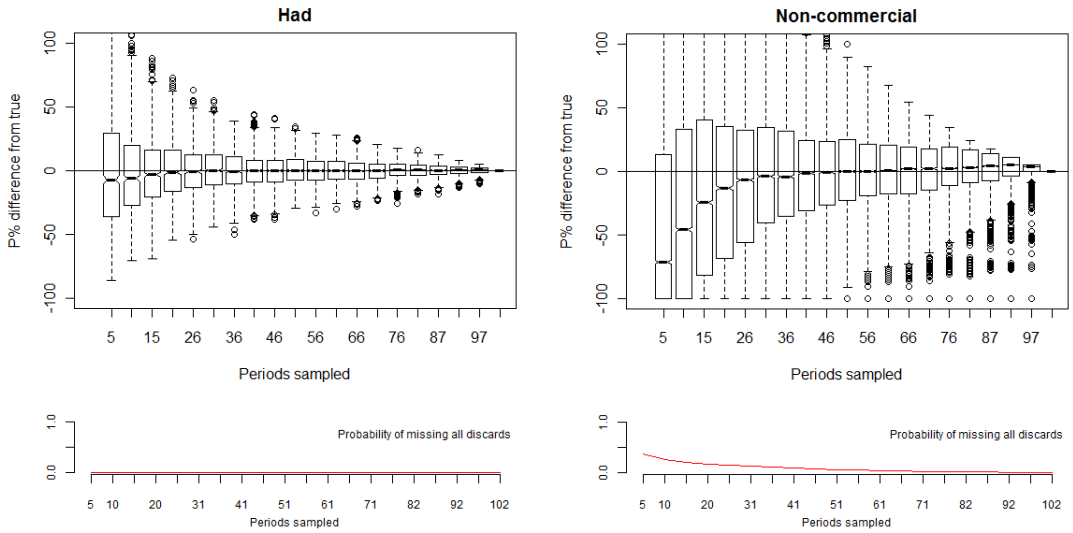


Figure 1. Upper plots: Boxplot summaries of sampled values of haddock (left) and grouped non-commercial species (right), calculated as a percentage difference from the true observed value at each sampling rate of 5% increments over 102 sampled periods. Each boxplot summarises 1,000 samples for that sampling rate. The notch of the boxplot overlaps the x-axis at 20 periods sampled (for haddock), indicating no significant difference from the actual observed value. This is roughly equivalent to a 20% sample rate. Notch overlap occurs at a much higher sample rate (around 40%) for the group of non-commercial species. Lower plots: measures of the probability of missing all discards in the trip, for different sample rates, for haddock (left) and non-commercial species (right).

Comparisons of length distributions for comparable vessels with/without cameras.

In theory, vessels with the same characteristics (gear, power, quota availability, etc), fishing at the same time and in the same area, should generate similar catches (although factors such as skipper experience and luck can also be very influential). However, REM vessels are subject to different regulations and are not allowed to discard cod. All else being equal, a REM vessel should land more smaller cod than a matched non-REM vessel. In this analysis, we tested this hypothesis using observed length distributions of cod landings.

In order to be able to compare two vessels, they needed to be:

- Fishing in the same area (no more than a stat square distant);
- Fishing roughly at the same time (no more than a week apart);
- Using the same gear; and,
- Cod landings from both vessels needed to have been sampled for length.

From our database (FMD), we identified vessels which are part of the scheme and were sampled by our teams either by the means of an observer onboard or by market sampling. Having identified these, we matched them with other vessels that are not part of the scheme and that fulfilled the above criteria, allowing us to make a valid comparison.

When matches were identified, we plotted the cod length frequency for both the REM vessel and the matching non-REM vessels. From the plot, we looked for obvious differences in the landings composition. Ideally, one should compare multiple vessels fishing in the same area which would make the analysis and the interpretation of the results more robust.

So far, analysis has been performed on eight cases where size compositions from landed cod could be compared between REM vessels and non-REM vessels. In each case, the area, time of fishing and gear type were matched between the vessels in the comparison. Three examples are shown below illustrating different results in the comparison. Figure A shows a pair trawl result in which the REM vessel did land smaller fish than the two other vessels.

Figure A

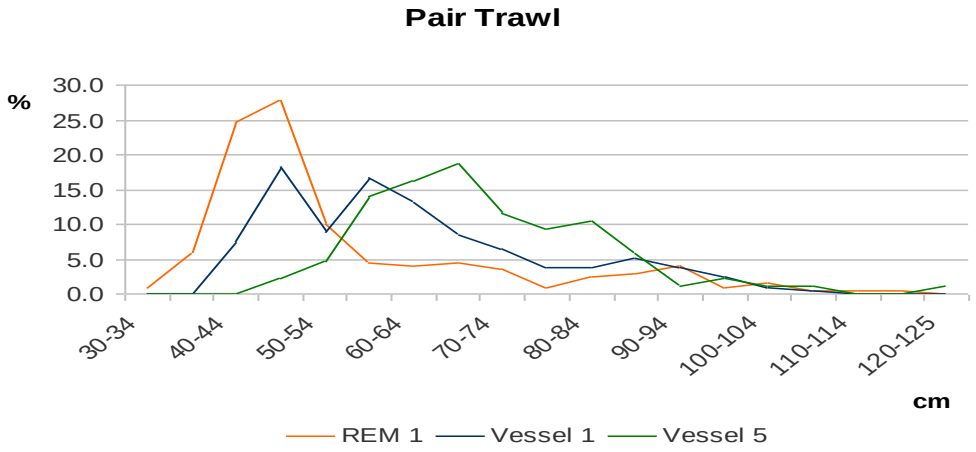
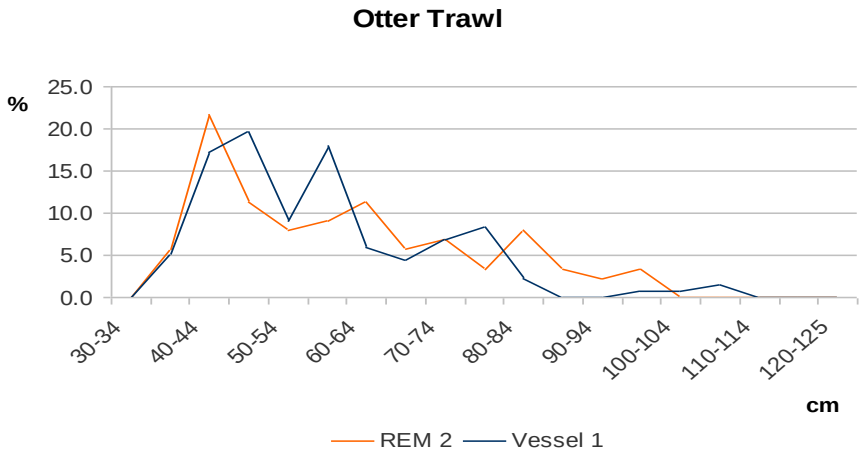


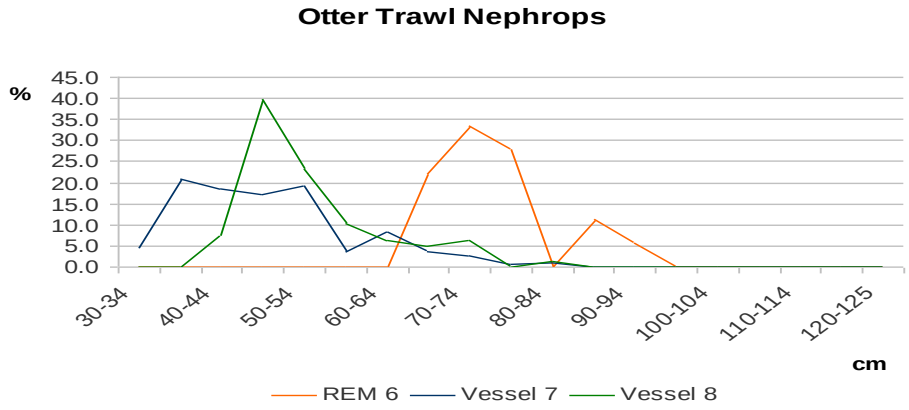
Figure B is an example where the landings size composition was roughly the same in the two groups of vessels.

Figure B



In contrast, Figure C is an example where the REM vessel landed noticeably larger sizes of fish than the two other vessels sampled from the same area, time and gear. Such a result would prompt an additional inspection of the vessel's practices to determine whether discarding had in fact taken place.

Figure C



Early results indicated that REM vessels exhibiting behaviour consistent with the regulation were the biggest group and only one vessel showed behaviour inconsistent with regulation. More analyses are needed for this to become a robust conclusion.

Changes in discarding rates for a given vessel when cameras are installed.

One of the first questions to arise as soon as the first system was installed was whether the discarding practices of the vessels was going to change. In other words, would the discard rates be any different due to the cameras being on board?

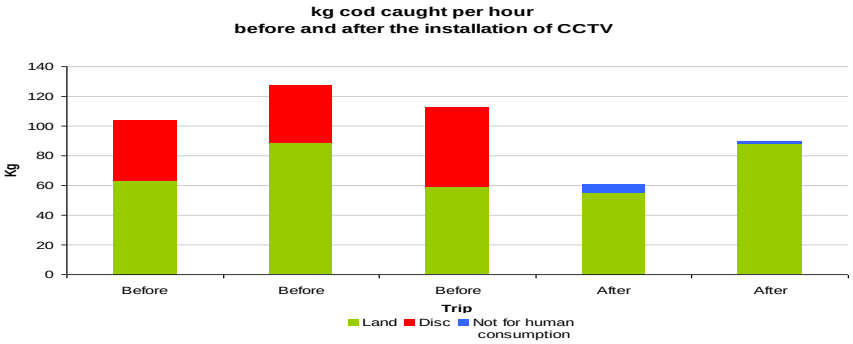
To try to answer this question, we compared discard rates from trips on specific vessels before and after the REM systems had been installed onboard.

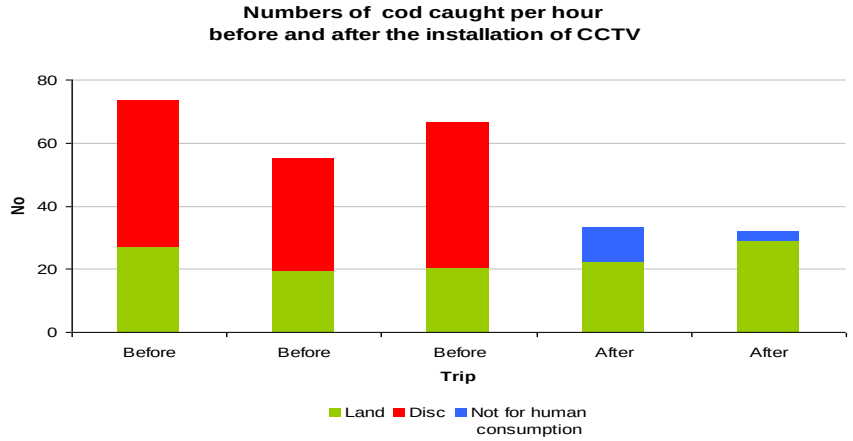
The only time that we can measure discards is when an observer is present onboard the vessel. So we identified, in our database, vessels that joined the scheme in 2010 and took observers on board both in 2009 (before having cameras on board) and during 2010 when the cameras were present. In our analysis, the observer is present for all the trips considered and any influence of the onboard observer on discarding practices should therefore be constant. By comparing the discard rates in both trips for three of the main species (cod, haddock and whiting), we can look for changes in the discard patterns. Is the vessel discarding less fish or did behaviour not change?

Screening of the available data for observer trips on the same vessels in both 2009 and 2010 where the vessel was taking part in the REM scheme in 2010,

produced a rather limited sample set to work with, consisting of four vessels. Analysis of the available data is ongoing and confounded by the fact that in some cases the vessels were operating in different sea areas during the sample periods before and after the REM technology was fitted. Two examples of the outputs are provided below.

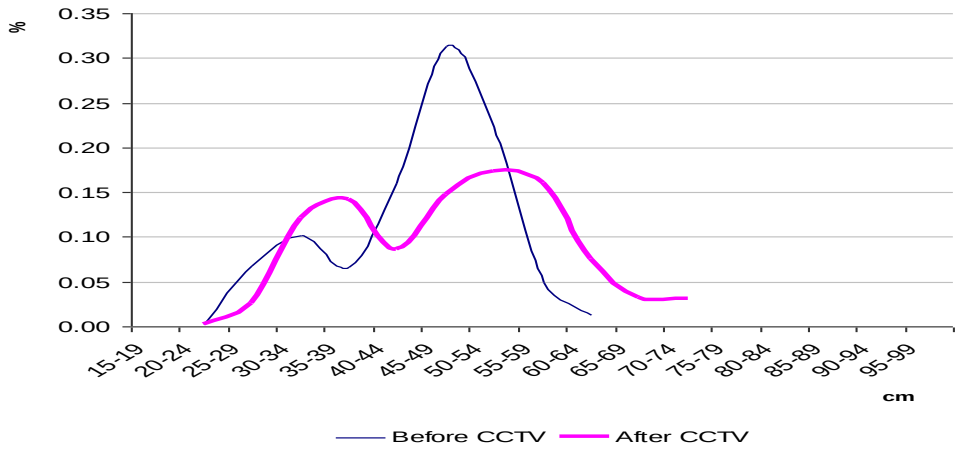
In the first example, a comparison is made of the overall catch rate of cod (kg/hour fishing) with the catch broken down into landings and discards (before REM) and landings and undersized landed but 'not for consumption' (after REM). Note that a condition of using REM is that all cod are landed. The figure below effectively shows a marked reduction in discards between the two time periods and a reduction in the quantity of unwanted fish. It should be borne in mind that this is against a background of increasing biomass of cod which might be expected to push catch rates higher. Weight and numbers per hour landed are broadly similar before and after REM. Given the limited sampling, it is too early to report conclusively on the full extent of discard reduction but early indications are encouraging.





The second type of analysis looks more closely at the size composition of the catches before and after the introduction of REM. A drive to maximise the commercial component of the REM catch so as to avoid having to bring ashore large quantities of undersized fish would be expected over time to lead to improved selectivity and catches of small fish to decline. Examination of figures of the type shown below, provide a first indication of whether this is happening. In the cod example below, there is slight evidence of a reduction

in the smallest size categories in the REM catch but it is difficult to comment on the significance of this and conclusions will not be possible until further analysis is completed and, indeed, after more observer sampling has been completed.



Different counts when different people watch the footage.

Analysing and interpreting CCTV footage from REM vessels is not a straightforward task, as fish are often occluded by other fish or fish entrails from earlier in the fish-processing sequence. Small fish can be difficult to distinguish. Training is required before a full species analysis can be undertaken.

The purpose of this analysis was to determine the extent to which different viewers estimated different species compositions from the same footage. The footage used came from CCTV images taken from a single trip of a demersal trawler fishing at Rockall during March and April 2010. To organise the counts of different species, a list of the most common species that occur in the study area was made:

Monk stomachs	Blue whiting	Rays
Unidentified round	Blue mouth	Conger Eel
Unidentified pouting	Megrim	Mackerel
Unidentified flat	Ling	Dogfish
Norway haddock	Whiting	Chimera
Lemon sole	Haddock	Witch
Grey Gurnard	Grenadier	Lesser argentine
Monkfish		

In a similar approach, as used in other analyses presented here, the video footage from this trip was subdivided in 10 minute segments (called “slots”). These slots were then watched by three different viewers (A, B and C), all of whom had received training but who had differing levels of experience. In total, 15 slots were analysed in this way.

Figure 2 gives the total numbers of discarded fish (all species) in each of the 15 slots, as estimated by each viewer. It is clear that the lines follow similar trends for all viewers, although it can also be seen that the viewer with the most experience (Viewer C) had higher counts for almost all slots.

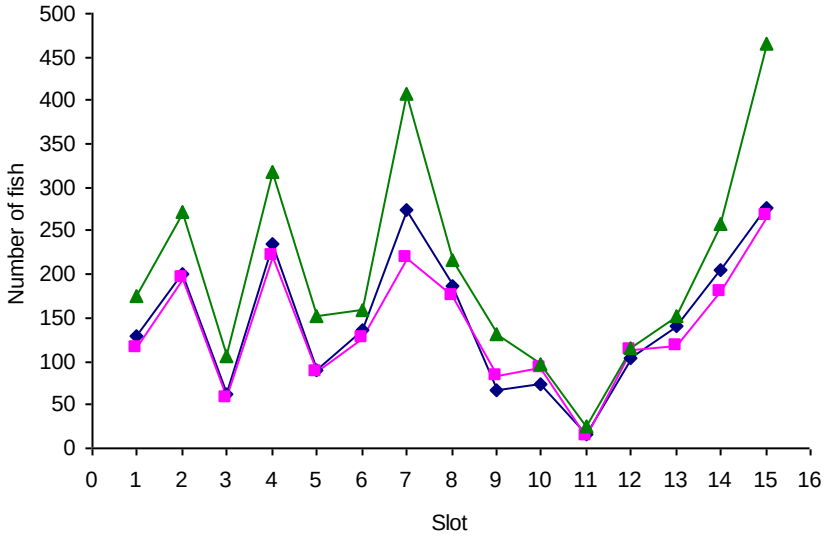


Figure 2: The total number of discarded fish per time slot, as estimated by viewers A (blue), B (pink) and C (green).

In Figure 3, the number of fish counted per species group (summed across all slots) is shown for each observer. Overall, the three observers had similar results regarding the species they identified in the footage, although again the most experienced observer (viewer C) saw the most fish of each species and had the fewest unidentified fish.

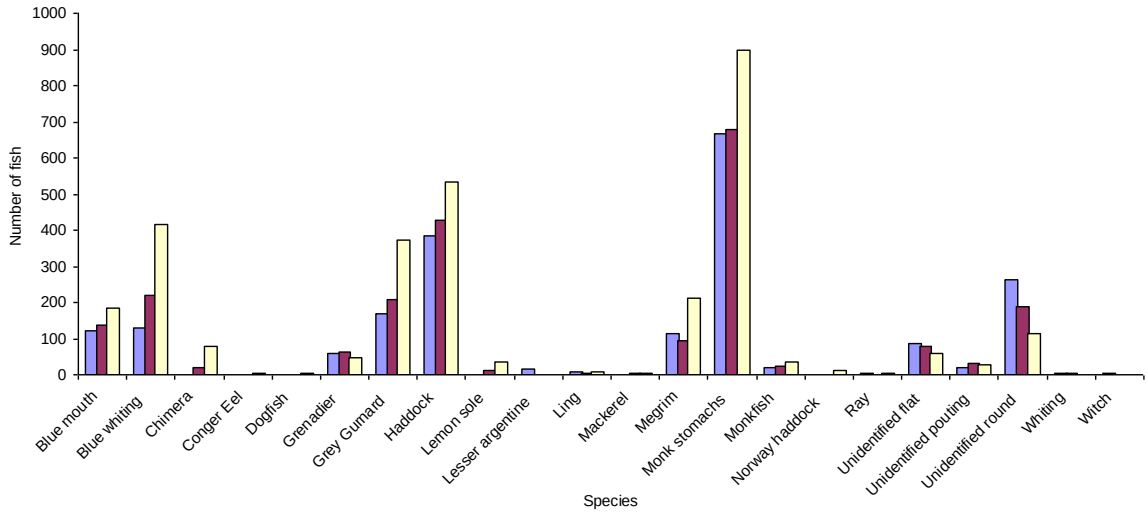


Figure 3: Total number of fish counted per species, for viewers A (blue), B (maroon) and C (yellow).

In order to determine if the counts of numbers of fish varied significantly with each observer, an ANOVA was performed, using two different models:

1. Explanatory variables: observer and species
   Model: Number of fish = observer + species + observer*species
   The interaction effect (observer*species) was tested and was not significant (p-value=0.077*),* therefore was removed form the model.

2. Explanatory variable: observer
   Model: Number of fish = observer

The R package was used for the analyses. For model 1, the ANOVA table was as follows:

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
observer	2	1745	872.3	4.0723	0.01733 *
species	21	141299	6728.5	31.4130	< 2e-16 ***
Residuals	966	206913	214.2		

The observer has a significant p-value (0.0173), meaning that there are significant differences in the counts of fish by the three different observers. The variable species is highly significant, (which means that there are differences in the species due to the intrinsic variability within each frame).

For model 2, the ANOVA table was as follows:

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
observer	2	1745	872.27	2.4724	0.0849 .
Residuals	987	348212	352.80		

In this model, only the observer is used as explanatory variable, and the p-value obtained (0.0849) is not significant, meaning that there are no significant differences in the counts of number of fish between the three observers.

In conclusion, this brief study has demonstrated that different observers will produce significantly different species counts when viewing CCTV footage (although their estimates of the overall numbers of fish of all species do not differ significantly). If human observers are to continue to be used in CCTV monitoring and analyses, these differences could be important and need to be accounted for.

Fishing activity confirmation.

All Scottish vessels greater than 15 metres in length are required to have Vessel Monitoring Systems (VMS) installed. This is a system that uses satellites to transmit information on vessel position and speed every two hours. VMS data have principally been used in the past for compliance and search-and-rescue purposes, but they have recently become available to Marine Scotland Science.

In order to determine where a vessel has been fishing, VMS pings need to be categorised as "fishing" or "non-fishing". This has been done on the basis of speed, following a study by Borchers and Reid (2008): essentially, a vessel moving at less than 4.5 knots is assumed to be fishing. On the other hand, REM data (which is recorded every 10 seconds) enables us to determine very precisely if a vessel is fishing or not, using a combination of video and sensor data. This allows us to test the assumption that 4.5 knots must imply fishing activity.

To demonstrate this, we compared REM and VMS data for a Scottish demersal whitefish trawler fishing at Rockall between 21st September 2009 and 24th October 2009. Due to the commercially-sensitive nature of these data, it would be inappropriate to name the vessel: we will refer to it as Vessel A. REM sensor data were downloaded from the hard-drive data generated during the relevant Scottish REM trials run during 2009. VMS data were taken from the Scottish Government FIN database. The drum rotation counter had not been working on this particular trip, so the principal source of information regarding fishing activity was the winch pressure sensor. Full camera coverage was also available, but was reserved to be used to check the conclusions from the sensor analysis.

The winch pressure levels that signify when the winch is or is not being used vary from vessel to vessel, so the first task was to determine what these levels were for Vessel A. Figure 14.4 (upper plot) reproduces the winch pressure readings for the whole trip (Figures in this section are taken from Needle, in prep). These are highly variable and to facilitate interpretation a loess curve (span = 0.01) was fitted through the observations. The lower plot of Figure 14.4 gives the frequency distribution of the fitted loess curve points. The distribution was split into two sub-distributions at its minimum (which we denote by P_{split}), and the maxima of both sections were determined. These maxima were denoted by P_{off} and P_{on} for the left and right sub-distributions

respectively, and indicate average winch pressure for ”fishing" (when the winch is working; P_{on}) and ”not fishing" (for when it is not; P_{off}). For Vessel A:

P_{off} = 12.22
P_{split} = 388.12
P_{on} = 1338.54

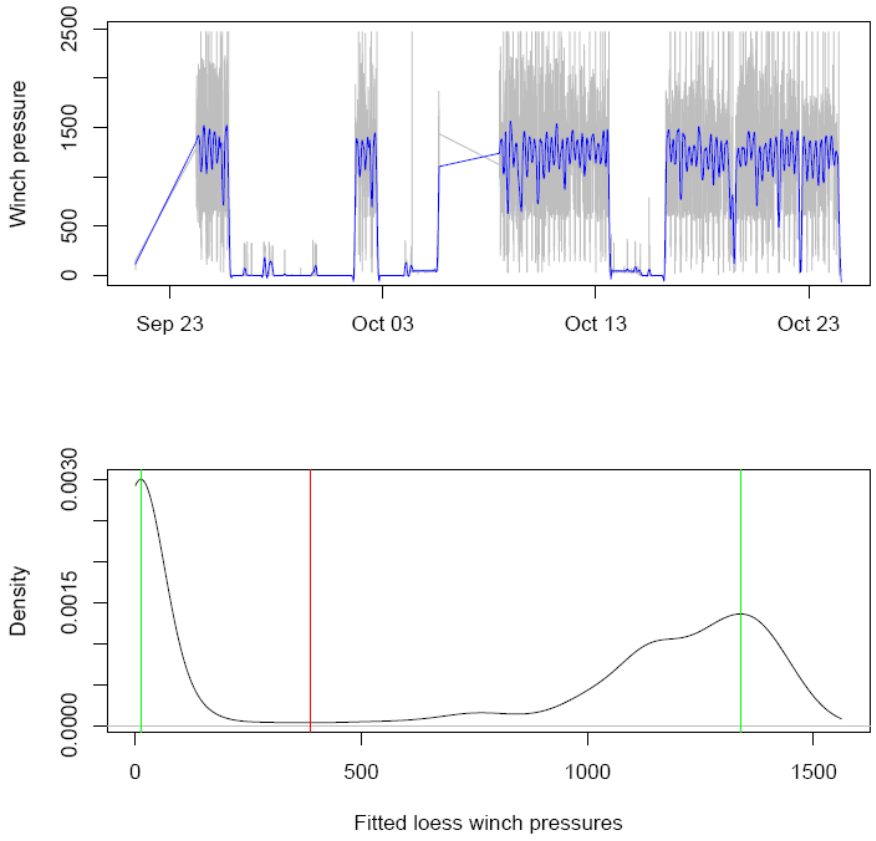


Figure 14.4: Upper plot: REM winch pressure time series from Vessel A (grey line) with fitted loess curve (blue line). Lower plot: frequency distribution of fitted loess curve values from upper plot. The red vertical line indicates the minimum P_{split} of the distribution, while the green vertical lines (P_{off} and P_{on}) give the maxima of the sub-distributions formed by partitioning the full distribution at the minimum.

Each day of data from the time series for Vessel A was analysed separately and the results combined to allow conclusions for the time series as a whole. Figure 14.5 summarises the available information from Day 1 of the time series, during which the vessel was fishing on the Rockall Bank. The correlation between REM and VMS speed measures appears to be quite poor (R^2 = 17.35%), although the REM speed data are very variable and a direct correspondence with the VMS speed data is not always evident. For example, the average speed comparison R^2 over all days from Vessel A for which both VMS and REM data are available is only 63.62%.

REM winch pressure data for each day were categorised as follows. To reduce the effect of high variability in pressure data, a loess curve P_{loess} was fitted to the raw winch pressure time series, using local polynomial regression

fitting and a small span (0.05). Each point on P_{loess} was then categorised as fishing or not fishing by comparison with the estimated split value (P_{split}) calculated via Figure 14.4: all times for which $P_{loess} \geq P_{split}$ were deemed to be fishing times, otherwise the vessel was assumed to be not fishing. The resultant time series are indicated in Figure 14.5: this suggests good agreement between the REM derived indicator of fishing activity and the VMS speed derived indicator, save for two points in mid-morning and late evening when the VMS speed was greater than 4.5 knots but the REM winch pressure indicated fishing activity. These points are also highlighted in the contingency table plot of VMS speed against REM loess winch pressure, both appearing in each of the upper-right quadrant (indicating disagreement between the two measures). For Day 1, VMS and REM fishing indicators agree for 7 (77.8%) out of 9 available time points.

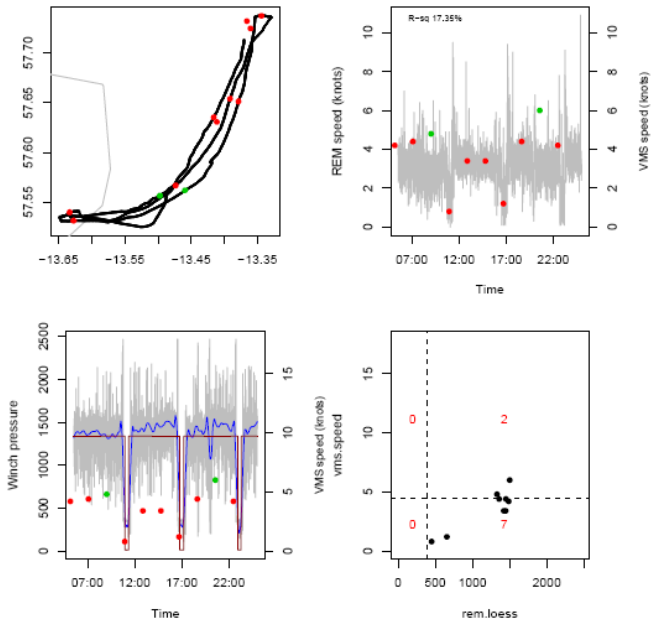


Figure 14.5: Comparison of VMS and REM sensor data for Day 1 of REM time-series from Vessel A. Upper left plot: vessel position. Black line gives REM position data: points give VMS position data, categorised as fishing (red) or not fishing (green). Grey lines show bathymetry contours in 100-m intervals. Upper right plot: time-series of REM (lines) and VMS (points) speed data, along with the R^2 value from a linear model fit to REM against VMS data. Lower left plot: winch pressure time series (grey line), with loess fit (blue line) and blocked equivalent (red line). VMS speed data (points) are given as before. Lower right plot: scatterplot and contingency table of VMS speed data against the loess fit to REM winch-pressure data. Vertical line is at P_{split}, while horizontal line is at 4.5 knots. The number of points in each quadrant is also indicated.

This analysis was repeated for all 31 days of the trip. Summing the daily contingency tables comparing REM and VMS fishing indicators results in the following overall contingency table:

	REM not fishing	REM fishing
VMS not fishing	90	10
VMS fishing	7	114

In other words, over the full time series, REM and VMS fishing indicators agreed for 204 out of 221 time points (92.3%). A simple χ^2 test applied to the table above indicates strong support ($p < 2.2e\text{-}16$) for the hypothesis that the measures are not independent: in other words, that REM and VMS fishing indicators agree. Needle (in prep) gives further statistical tests which confirm this conclusion.

Hence, if we assume that REM winch pressure data accurately indicates fishing activity, then VMS speed data is a reasonably good proxy which agrees with REM indicators on over 90% of observations. This supports the use of VMS data as a marker of fishing activity, as suggested by Borchers and Reid (2008) and implemented in recent years by enforcement authorities in Scotland and elsewhere.

Future work.

Plans for future work with REM data have been outlined in four main contexts: a wide-ranging research project (or ROAME) to be carried out by Marine Scotland Science; a summer placement to continue work on observer effects, funded by the Fisheries Society of the British Isles (FSBI) and the Scottish Fishermen's Trust (SFT); a studentship on fisheries economics at the University of Aberdeen; and proposed studentships on image recognition at the Robert Gordon's University, Aberdeen. These are outlined below.

ROAME: "Electronic Documentation of Scottish Commercial Fisheries"
Policy rationale

One of the key elements of Scottish Government fisheries policy, now and for the foreseeable future, is the phased replacement of the current European fisheries management structure with a system of catch quotas. These have been in place for a limited number of Scottish vessels for cod only during 2009 to 2011 but it is likely that the scheme will be greatly expanded by 2015. The principal feature of catch quotas is that all fish which are caught must be landed, which necessitates a demonstrable discard ban and which, in turn, requires full observance and monitoring of fishing vessels at sea. Scotland has proposed that this can be achieved through (REM) systems.

Following pilot projects in Scotland and Denmark, and building on extensive experience in Canadian fisheries, Canadian-designed Archipelago REM systems have been installed on a number of Scottish whitefish vessels and are currently being used by Marine Scotland Compliance to detect infringement of discard regulations. The systems record high resolution position data alongside data from ancillary sensors such as hydraulic pressure sensors on the winch systems and winch rotational speed sensors. Simultaneous images are recorded from (currently) four *in situ* TV cameras recording scenes from the net recovery deck area, the catch receiving hopper, the internal fish processing area and the discard point. The system, therefore, potentially supplies a wealth of varied physical data with integrated imagery of

a vessel's detailed activities. However, little is known about the full scientific and monitoring potential of REM systems and there is an urgent need to provide advice to Marine Scotland Policy and Compliance on this aspect. Work is proceeding on an *ad hoc* basis but a formal analysis structure is lacking.

Scientific rationale

The science of REM as applied to European trawl fisheries is currently underdeveloped. Denmark has carried out a number of short term studies but, while valuable, these have been too restricted in scope for wider conclusions to be drawn (Dalskov and Kindt-Larsen 2009). The most complete studies of the scientific utility and efficacy of the systems, have been conducted over a number of years at Archipelago, the company that produces the systems now being used in Scotland. These are also very important studies (see, for example, McElderry 2008), but have focussed on the long line fisheries in British Columbia and elsewhere in North America, and thus have reduced relevance to European trawl fisheries. There is therefore an urgent need to analyse, understand and document the application of REM systems to Scottish vessels, and explore the subsequent use of the information in a catch quota management system.

We propose that this work is done via four work packages (WP):

WP1: REM system design and implementation. This WP will consider how best to install and use REM systems on Scottish vessels, seeking to answer questions such as: How many cameras are needed to fully document a vessel's activity and where should they be placed? Can (and should) fish processing systems be changed to facilitate the use of REM? Do modifications need to be made to the Archipelago systems to meet the needs of Scottish fisheries?

WP2: REM data. Here we will consider the data that are produced by the REM systems. What quantitative estimates can be derived from the system including catch and discard composition by species, fish lengths, and absolute quantities of total catch and discards? What is the magnitude of uncertainties in any quantitative estimate derived from the system? How do electronically recorded data compare to *in situ* observer data, market sampling data, RV data? Importantly, we will consider the statistical power of video sub-sampling, so as to determine how much video footage needs to be viewed before a representative sample is obtained. In a more exploratory vein, we would also consider questions such as: What information can be derived for non-commercial species by-catch, e.g. benthic fauna? Can information be obtained for research use in Scottish deepwater fisheries? Can biodiversity indicators be derived from the system?

WP3: Operationalisation. In this WP we will investigate how REM data can best be used in an assessment and advisory context. For example: What is the best way to merge market sampling, observer sampling and electronic

sampling data into a coordinated data gathering scheme? How is the data generated by electronic monitoring to be used in the formal fish stock assessment process? Can the analysis process be automated in any way? A key part of this WP will be an analysis of potential of existing image analysis approaches to be applied to CCTV data from REM systems, as relying on human viewers will be very limiting in time and resources.

WP4: Fleet behaviour. It is not yet known what the likely response of the fully documented fishing fleet will be to catch quota management. Bioeconomic, spatio-temporal models of vessel and fleet responses to management measures are under development in a number of forums (two PhD studentships, collaborative work with University of Washington, and two other ROAME proposals), and these will be modified (if necessary) and applied to the question of determining catch quota related effects on fleet dynamics.

The ROAME started in April 2011 and will conclude in March 2014.

FSBI and SFT placement: "Evaluating observer effects in discard sampling"

This placement has been granted to Rosanne Dinsdale, who carried out the Vessel A CCTV-footage analysis during the summer of 2010 and has been funded by the FSBI and the SFT for four months during 2011. The project outline on which the funding applications were based is as follows.

The Marine Laboratory in Aberdeen has operated a fisheries observer sampling programme with the Scottish fishing industry since 1978. On roughly 75 trips (on average) each year, samples of discarded fish are taken and used to generate estimates of the total number and weight of all discarded fish from the Scottish fleet. These are combined with similar estimates from other countries, where available, to produce discard estimates for the international fishery, which, along with landings and survey data, form the basis of fisheries stock assessments carried out for advisory and scientific purposes. The Scottish sampling programme is the longest running and most extensive observer programme in Europe.

The annual assessment of the state of the North Sea cod stock is undertaken by ICES in Copenhagen, with input from all of the nations participating in the fishery. The current assessment method allows for a modelled discrepancy between the observed catches (landings plus discards) and total annual removals from the stock. This discrepancy, referred to as "unallocated removals", can be substantial each year, but its cause is not clearly known. It could be due to model problems, changes in natural mortality or survey catchability, problems with landings data, or potential discard under estimation. The latter issue may arise as the result of an observer effect, in which fishermen reduce the extent to which they discard fish as a direct consequence of having an observer on board. This is clearly a possibility but opportunities to test for the existence of such an effect have been scarce.

The catch quota management scheme currently under development in Scotland and elsewhere provides such an opportunity. Under catch quotas, qualifying vessels have CCTV cameras and other sensors fitted at key points in catch processing areas. The vessels are banned from discarding cod in the first instance and are provided with extra cod quota as compensation. The intention is that they will be able to catch less cod (as over quota fish cannot be discarded), while landing more cod (as they have an increased quota entitlement) with the result that overall mortality will be reduced. The CCTV cameras provide a means for Compliance officers to ensure that the discard ban is being observed.

Information from CCTV systems is also made available to scientists in the Marine Laboratory and has been used over the past year in studies of appropriate sampling rates to detect discarding, analyses to confirm fishing locations and comparisons of discard composition estimates from cameras and onboard observers.

The intention of this project is to use this CCTV source to evaluate the likelihood of observer effects in discard sampling. Specifically, discard estimates obtained from CCTV footage from a trip with an onboard observer will be compared the estimates from a trip without an observer, both on the same vessel (and consecutively, if possible). Over a number of such comparisons, it is hoped that it will be possible to detect whether or not the discarding practices are significantly altered by the presence of the observer. Cod cannot be used for this purpose, as CCTV equipped vessels are not permitted to discard any cod, so other commercial species (perhaps haddock and whiting) will be used. This methodology will be augmented further by comparisons between the length distributions of landed fish from observed and unobserved vessels, although this is a less detailed source than CCTV. The restriction to one or two commercially important species will reduce the time required for viewing CCTV footage and enable several trips to be compared. The results of the project will have a direct effect on improvements to the assessment and management of North Sea cod and other stocks, and will contribute valuable data to studies of fishermen's at sea decision making.

Fisheries economics studentship

The following is taken from Little (2011), with references removed for brevity:

Do fisheries management tools such as quota regulations create incentives to discard fish?

Whilst the economic theory, management and incentives to discard have been discussed, little in the way of empirical modelling has been carried out. Consequently much uncertainty surrounds the response of fishers to quota regulations. Under certain circumstances, quota regulations may encourage discarding and may even be socially optimal. One may expect economic (e.g. market price, cost of harvesting or cost of discarding) and technological

constraints (e.g. hold capacity) to have an effect on discarding. Are any of these factors binding and under what conditions do these factors create an incentive to discard under single species quota management in a mixed fishery?

Theoretical models of economic discard behaviour will form the basis of our discard model. Participating Scottish whitefish vessels trialling CCTV cameras and sensors creates a unique opportunity to remotely monitor discard behaviour which will be integrated into the fleet ABM. Rather than examine economic grade (size), we will model species discards and incorporate fishing location. This model will describe discarding in the Scottish North Sea mixed whitefish fleet and under what conditions quota creates incentives to discard in this mixed fishery when managed with single species quota.

Image recognition studentships

One of the main drawbacks of a video-based monitoring and analysis system, such as REM, is that a great deal of time and effort is required to view, analyse and interpret the footage. Rosanne Dinsdale's analysis of the Vessel A trial, described above, took several months to complete. As a rough guide, 10 minutes of video footage requires between 30 and 60 minutes to analyse if full species identification is being attempted. The required time will be less if only a few species are being considered but it still represents an unsustainable resource burden for Marine Scotland that will only get worse as the catch quota scheme develops. Further analyses, such as length measurements, are even more difficult at present.

The development of automated image recognition and analysis software should therefore be considered a priority for the medium to long term future. Several systems are available internationally and are under consideration by Marine Scotland Science but they generally require specific layouts and configurations of both cameras and fish processing areas, these are not always possible with Scottish fishing vessels.

To address this need, plans for close collaboration with image recognition experts at the Department of Computing at Robert Gordon's University (RGU) (Aberdeen) are being developed. The first stage of this is an MSc summer project planned for June to September 2011, which will develop algorithms to detect and recognise (*inter alia*) haddock from representative REM derived images. Prospects for progress with this are good, as images of fish appear to be relatively straightforward to identify in comparison with the much more intractable problem of human face recognition with which RGU staff are familiar. This initial project will be followed by a PhD studentship to develop and implement the fish recognition algorithm.

Our intention with this work is to produce a system that, when applied to video footage from a fishing trip, will be able to identify, count and measure all the fish of a given subset of the available species. We envisage that this will be

done in a probabilistic way and that human intervention and further analysis will be suggested when the uncertainty exceeds a preset threshold as there will be sections of footage in which identification will be very difficult due to occlusion. The timescale of development for this system should be thought of in terms of years rather than months but once complete, it will reduce dramatically the pressure on resources of a catch quota management scheme, with a corresponding increase in accuracy.

RV Scotia

Much of the methodological work described above would benefit from being tested in a controlled environment where the true values of species counts to be estimated were known. To achieve this, an REM system has been installed on RV *Scotia* and is undergoing testing. Once fully operational, this will provide excellent controlled footage for image analysis work, as well as good test cases for observer counts since the true numbers of all fish caught by RV *Scotia* are counted and recorded.

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CHAPTER 2 – CQMS: THE ECONOMIC IMPACT

Summary Findings

- Participation in the 2010 catch quota trial appears to have increased the volume of landings of all species in comparison to a control group. However, this was at the expense of a small relative decrease in the price received for such landings.

- Overall, this led to an estimated increase in net fishing revenues of approximately £114,000 per participating vessel.

- However, this increase in fishing revenues should be set against an increase in operating costs, including both the potential leasing in of cod quota and greater effort. For example, it is estimated that the average vessel spent an additional eight days at sea through participating in the trial.

- Taking a narrower focus on the value of the additional quota allocated through the trial, this is estimated to be approximately £57,000 per vessel once the impact of a greater proportion of small and undersized fish being landed is taken into account.

- Analysis conducted on the direct value of the additional quota suggests that all vessels participating in the trial should have increased net fishing revenues, with the average increase being 5% of the total landings value throughout the year.

- There appears to be provisional support for the scheme from skippers who are participating in the trial. In particular, nearly all felt that catch quotas could be a useful management tool. In contrast, the skippers interviewed who were not taking part in the trial felt generally negative about its impacts.

- There is some evidence that fishers have adapted their fishing techniques in order to maximise the benefit they receive from participating in the trial. In particular, this includes an increase in gear selectivity and spatial/temporal measures.

- There is mixed support for expanding the scheme to other species, with a clear warning that this would need to be managed with care.

- There is also a strong suggestion that the operation of the trial has led to an increase in leasing costs for cod quota and that this may have a strong detrimental impact on some sectors of the whitefish fleet.

Introduction

The aim of this chapter is to evaluate, where possible, the impacts of the catch quota (CQ) trial on the fishing industry. In particular, consideration is given to economic indicators such as the change in landings volumes and value, any changes to business practices and potential impacts upon operating costs. Because it is an evaluation of the trial, there is explicitly no speculative modelling or conjecture about future scenarios, i.e. the potential impact of further roll out of the scheme or widening it to an increased range of species.

The chapter consists of two main components:

- Financial analysis from official landings data; and,
- Evidence obtained directly from the industry itself – including both participants and non-participants.

It is hoped that drawing evidence from these two complementary sources will provide as comprehensive a picture as possible regarding the full range of impacts that the scheme has had on both participating and non-participating vessels.

Financial analysis from official landings data

We can use official landings data to estimate how participation in the scheme may have affected vessels performance with regards to volume, price and, ultimately, value. Two possible methods with which to do this have been identified:

- Double-difference - assess the change in volume, price and value for CQ vessels and a control group between the trial period and the pre-trial period (both lasting approximately six months). Such an approach enables us to attribute any differences in the rate of change of such indicators between the two groups to involvement in the scheme; and,
- Multiple regression analysis – calculate the average price of large, small and undersized cod and then compare the volume of each category
- landed for vessels within the scheme with a control group.

These two approaches each have their own strengths and weaknesses. For example, the former method estimates the **total** change in landings volume and value between the two groups. As such, it demonstrates the gross impact of the CQ trial on fishing revenues but it should be remembered that much of this is associated with significant concurrent changes to operational costs. For example, if volume and value has increased due to the leasing in of additional quota, this methodology shows the gross revenue but does not reflect the fact that there are increased costs associated with this. As such, it represents something approaching a maximum estimate of the change to fishing revenues but must be treated with some degree of caution.

In contrast, the second methodology does not pick up any changes to behaviour such as exploiting the removal of restrictions in effort, in order to catch more of other species. This means that it represents a **direct** impact of the CQ quota allocation in terms of the value of the additional quota, net of the 'opportunity cost' of having to land more small and undersized cod. It does not include the change in landing volumes of any other species and, as such, it is likely to be a lower estimate of the change to total fishing revenues.

In terms of reconciling these two alternatives, the approach taken here is to present both in order to give an indicative range of the impact of the CQ trial on fishers. This, coupled with the fact that we do not have comprehensive quantitative data on how participation in the trial has affected fishing costs, means that we are unable to provide a definitive figure on the net impact of the trial on fishing profitability.

Method 1 – Double-difference

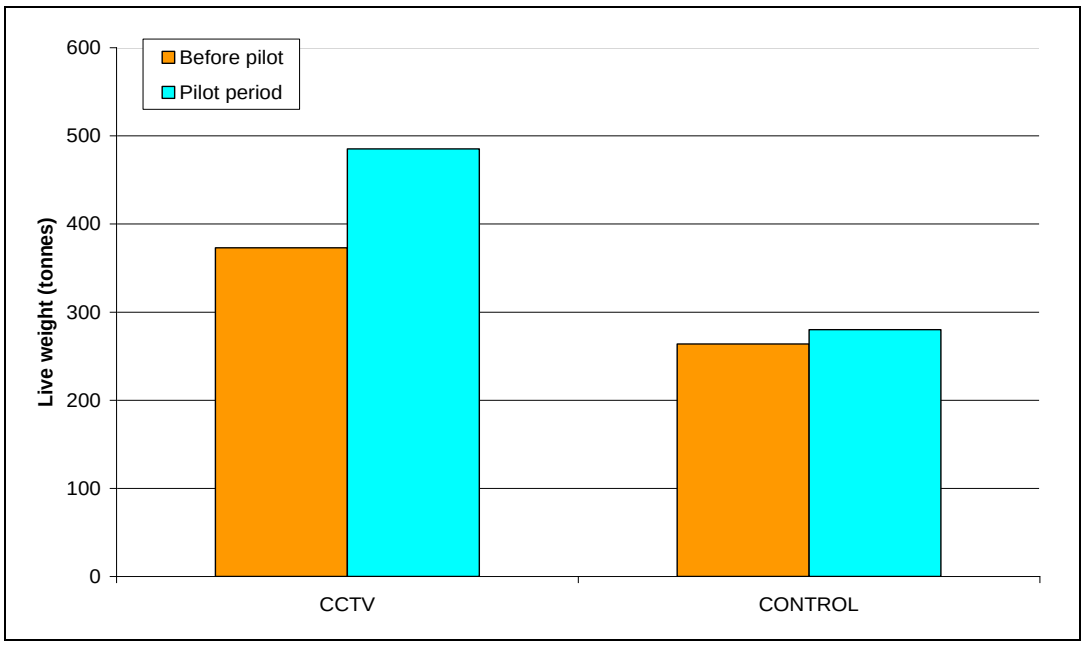
The analysis focussed on 16 participating vessels and compared their performance with a representative control group that consists of 116 other vessels, landing key whitefish species. Taking a standard 'double-difference' approach, we can see how the performance of the CQ vessels altered between the pre-trial period and the trial period (both lasting approximately six months[1]) and then compare this change to the change in performance of the control group across the same time period. The theory suggests that this technique should isolate purely the impacts of the CQ trial.

Starting by looking at changes to the average volume of total landings per vessel, the data suggests that, despite an overall background to land a greater volume during the trial period (a 6% increase for the control group), the CQ vessels still saw a proportionately greater increase (30%)[2].

[1] To be precise, the pre-trial period dated from 1 January to 13 June 20?? and, therefore, consisted of 164 days. The trial period lasted from 14 June to 31 December 20?? and so lasted for 201 days. For reference, this means that the trial period is 37 days, or 23%, longer than the pre-trial period.

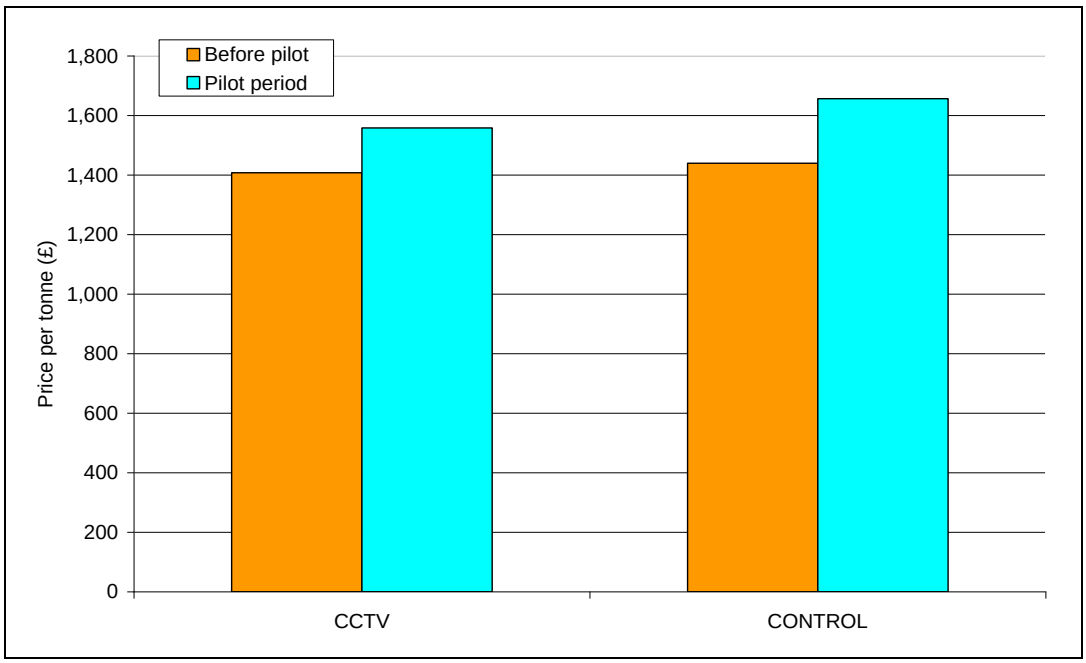
[2] Although total landings per vessel increased for both groups between the two periods, it should be remembered that the trial period is longer than the pre-trial period. Therefore, the change in landings per day at sea between the two periods is smaller for both groups and is actually negative for the control group.

Figure 1: Change to the average volume of total landings per vessel



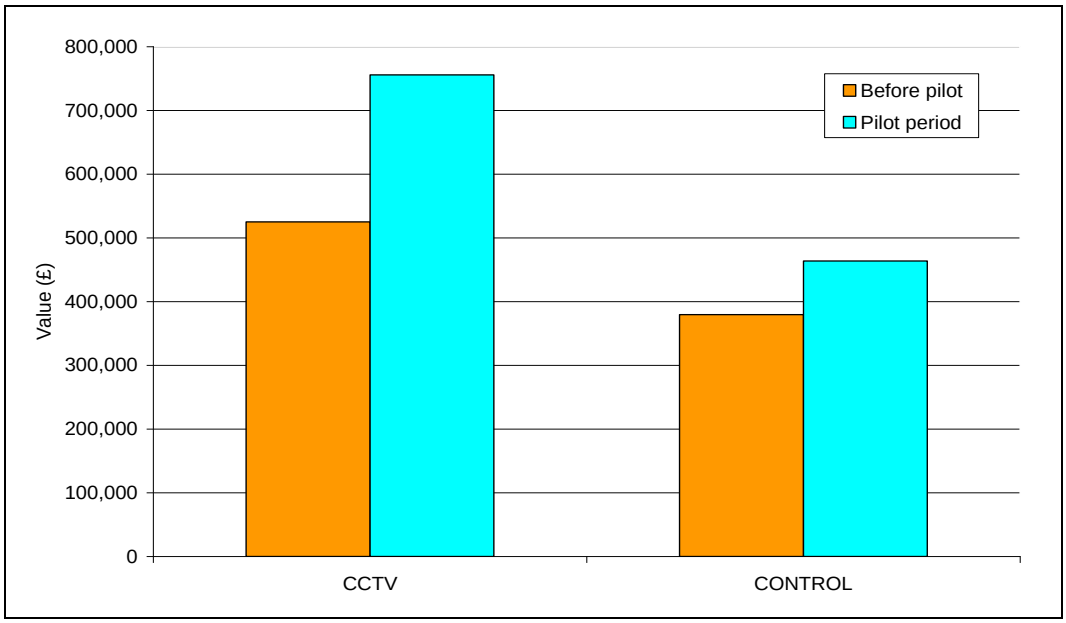
However, as might be expected, this increase in landings came with a relative reduction in the average price per tonne in comparison to the control group. Figure 2 demonstrates that the CQ vessels already received a marginally lower price per tonne on average than the control group. However, although the CQ group saw an 11% increase in the price per tonne over the two periods, the fact that this was still less than the 15% increase experienced by the control group meant that, overall, the gap between the two widened.

Figure 2: Change to the average price per tonne



When we combine the opposing impacts of the lower increase in the average price, compared to the control group, and the greater increase in volume, we observe that, on balance, the CQ vessels achieved a greater increase in value than the control group across the two periods. In absolute terms, this difference equates to a 44% increase for the CQ vessels in comparison to a 22% increase for the control group, or a 15% and 5% increase respectively for value per day at sea.

Figure 3: Change to the average value of total landings per vessel



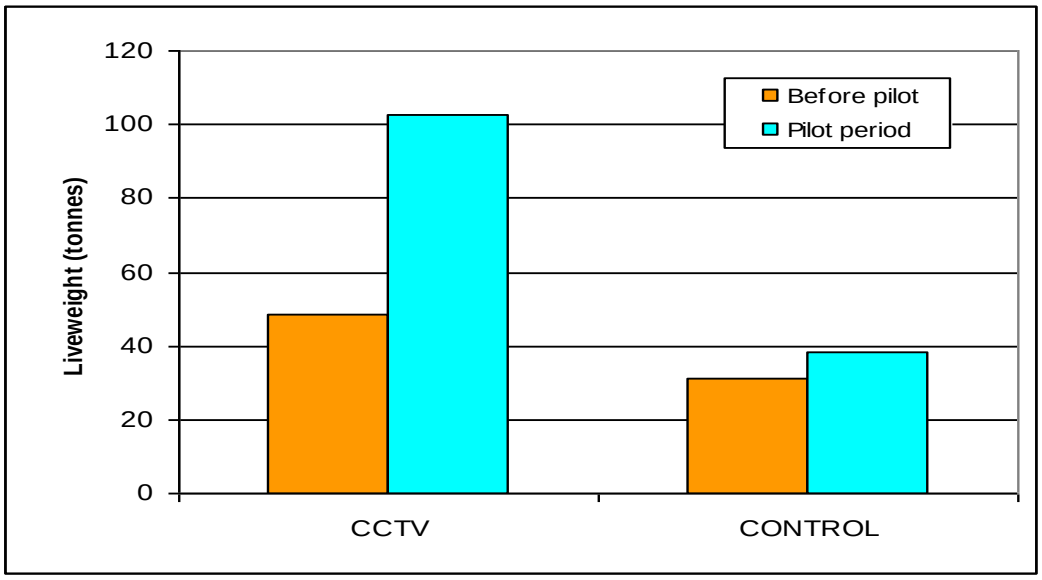
Analysing these figures in greater detail, a 44% increase in value for the CQ vessels equates to earning a total of £12.1m of fishing revenues in the trial period. In contrast, had they seen the same 22% increase in value as the control group, it is estimated that they would have made £10.2m in the period. The implication is that participation in the trial enabled the CQ vessels to generate an additional £1.8m in total, or an **average of £114,000 each**[3]**.**

However, in order to generate this additional revenue, there is also data to suggest that there were potentially significant business costs incurred as a result. For example, although we would naturally expect the CQ vessels to increase their landings of cod by more than the control group due to the award of additional quota for participating in the trial – as borne out by Figure 4 below – the data tells a further story. In the pre-trial period, the CQ vessels landed 776 tonnes of cod and in the trial period they landed 1,640 tonnes. This represented an increase of 864 tonnes, or 111% per vessel. In comparison, the control group landed 202 tonnes more during the CQ trial than in the preceding period, which is a 23% increase per vessel. However, an equivalent 23% increase for the CQ vessels would have equated to an extra 181 tonnes and this, plus the total of 445 tonnes allocated to these

[3] All figures are rounded to the nearest £1,000 to avoid spurious accuracy.

vessels through participating in the trial, are still 238 tonnes less than the observed 864 tonnes increase the CQ vessels actually experienced between the periods. The implication of this would appear to be that there is some other activity, potentially the leasing in of further quota, occurring simultaneously.

Figure 4: Changes to average cod weight landed per vessel

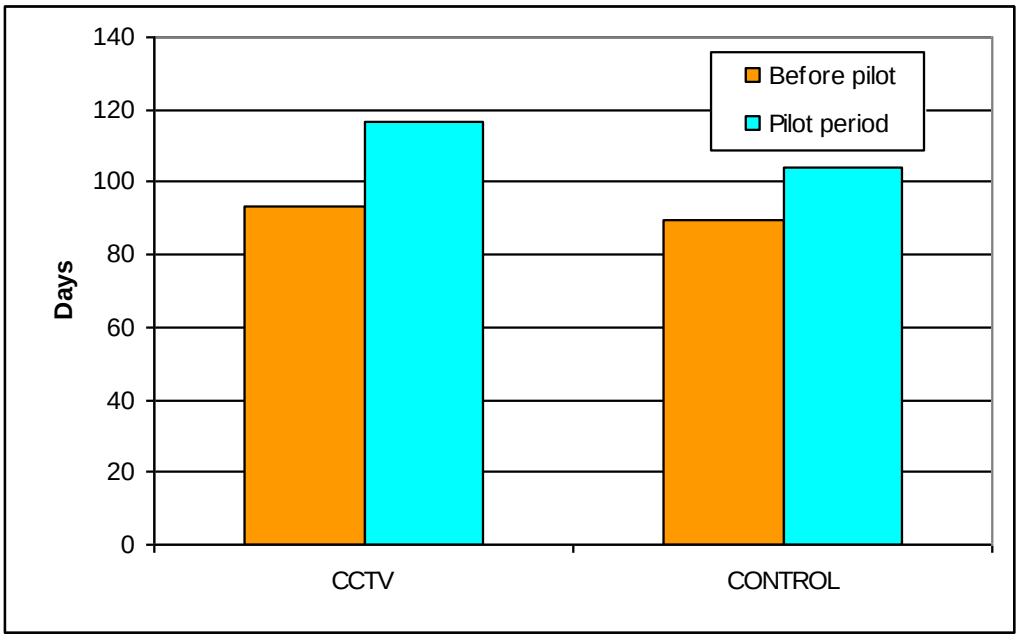


More generally, even discounting the additional cod that was caught by the CQ vessels during this period, the CQ vessels still observed a 18% increase in catch of non-cod stocks between the periods, in comparison to an equivalent 6% increase for the control group. So, the increase in activity and landings is not confined purely to cod stocks. It is unclear as to what extent this difference occurs due to an increase in leasing in of quota or because the removal of days at sea restrictions allows them to increase the efficiency of their catch with regards to utilisation of existing quota.

This apparent differential in overall activity by those vessels taking part in the trial in comparison to those that are not, is supported by data on the numbers of days spent at sea. The trial period was 23% longer than the pre-trial period and vessels in the scheme increased effort between the periods by an average of 25% (i.e. a very marginal increase in terms of the proportion of calendar days spent at sea). In comparison, those in the control group showed only a 17% increase (i.e. a slight decrease in terms of the proportion of calendar days spent at sea)[4]. This equates to the trial vessels spending an additional 121 days at sea in total due to participating in the trial. In terms of individual vessels, those participating spent, on average, an additional eight days at sea each, taking their total up to an average of 117 days in comparison to an estimated 109 in the absence of the trial.

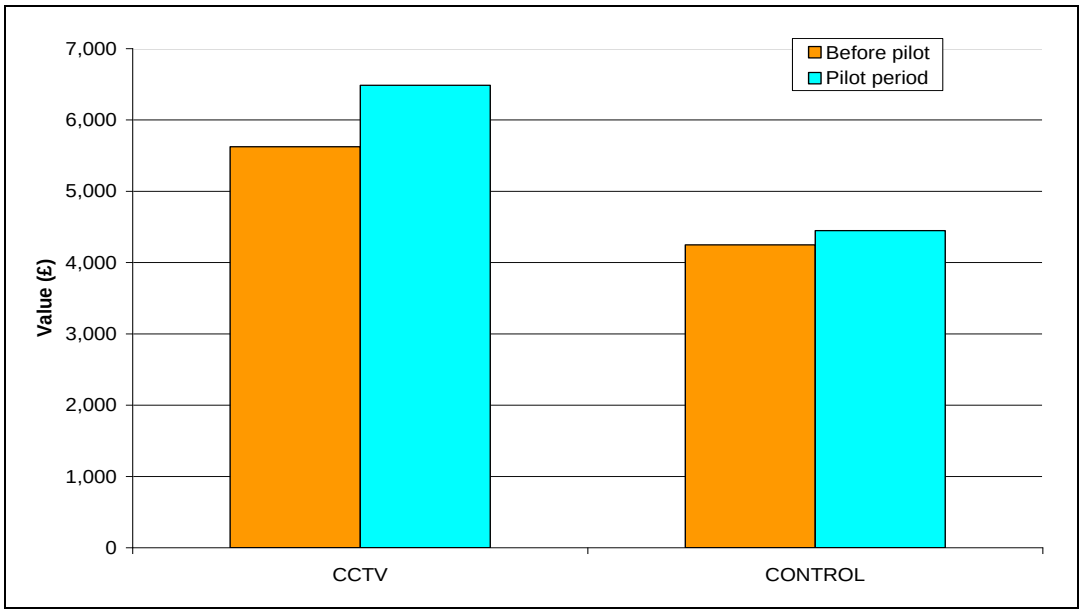
[4] In terms of days spent at sea as a proportion of calendar days, the CQ vessels saw a 2% increase from an average of 57% to 58%, whilst the control group saw a decrease of 5% from 54% to 52%.

Figure 5: Change to average numbers of days at sea per vessel



We can convert this information into an efficiency indicator in terms of the value of landings per day at sea. As shown in Figure 6 below, the CQ vessels appear to already receive a greater value for each day at sea than the control group, predominantly due to a higher volume of landings, and this differential increases across the two time periods. However, the 15% increase the CQ vessels saw in value per day at sea, from £5,624 to £6,486, between the two periods is predictably less than the 44% increase they saw for the value of landings in total in the same period. Had the CQ vessels experienced the same 5% increase in value per day at sea as the control group, they would have received an average of £5,888 per day at sea during the trial period. This suggests that they earned a premium of £598 per day at sea through participation in the trial. This figure is presumably a result of keeping and landing all cod that is caught that would previously have been discarded.

Figure 6: Change to average value per day at sea



Finally, we can estimate the potential value realised through this additional activity of the CQ vessels by multiplying the additional eight days spent fishing each, as a result of participating in the trial, by the average value per day at sea of £6,486. Doing so gives a total increase in fishing revenues from this extra activity of approximately £49,000 on average per vessel. In addition, multiplying the £598 that participating vessels increased their average value per day at sea, by the 109 days they would have spent at sea in the absence of the trial, i.e. their total effort net of the eight days referred to above, gives a value of £65,000. Aggregating the two figures gives the total increase in fishing revenues of £114,000, of which the analysis implies that:

- £65,000 or 57% originates from greater value per day at sea – presumably through landing all cod that is caught; and,
- £49,000 or 43% comes from extra days at sea enabling a greater level of catch of all species.

Although the data above gives us a lot of information, it does not allow us a definitive picture of the balance between costs and benefits to fishers of participating in the trial. We might assume that rationale fishers would only participate if they believed they would benefit overall and it is clear that there are significant gross benefits in terms of increased fishing revenues. However, there are also indications that there may be significant costs incurred through leasing of extra quota that should be used to offset these in order to develop a picture of the true net benefit.

A significant cost incurred by fishers is fuel costs. Although we cannot estimate fuel costs for these selected vessels specifically, Table 1 below gives us an indication of their average fuel consumption per day at sea.

Table 1: Fuel consumption per day at sea[5]

	Demersal - Over 24m segment	Demersal - Pair trawl seine
No of vessels in the CQ trial[6]	3	9
Fuel consumption per DaS – High estimate	5,000 litres	1,900 litres
Fuel consumption per DaS – Average	**3,900 litres**	**1,350 litres**
Fuel consumption per DaS – Low estimate	2,500 litres	1,250 litres

Assuming an approximate fuel cost of 40p per litre[7], the cost of fuel consumption is, therefore, between £500 and £2,000 per day at sea. A weighted average of the figures above gives an average consumption of 1,988 litres per day at sea at a cost of £795 per day. If we multiply this by the assumed extra eight days spent at sea by the CQ vessels as outlined above, then additional fuel costs may be approximately £6,000 per vessel as a result of participating in the trial. This is likely to constitute a part, but not all, of the additional costs incurred through participating in the trial. Other costs will inevitably be incurred through expenditure on items such as boxes, ice and paying crew.

Method 2 – Multiple regression

An alternative methodology to assess the impact on fishers for participating in the trial is based upon multiple regression analysis to assess the change to price of all stocks[8]. This analysis is based upon 15 CQ vessels landing into Peterhead and compares these with a control group of other whitefish vessels landing into Peterhead[9]. It estimates the average price for large fish received by the CQ group, taking account of a number of other explanatory variables such as freshness of the fish and time of landing, and multiplies it by the additional quota awarded through participation to estimate a theoretical maximum level of value that could accrue to participating fishers. However, it then offsets this by taking account of the fact that participating vessels land more undersized and small cod, and calculating what this might entail in terms of an 'opportunity cost' through lower prices for such categories

[5] Seafish (2010) 2008 Economic Survey of the UK Fishing Fleet
[6] 12 of the 15 vessels fall into these two categories and, therefore, we have restricted analysis to these two for simplicity.
[7] The Seafish (2011) 2011 UK Fleet Forecasts report states that "average annual fuel price is set at 40 pence per litre (excluding duty), which is the average UK fuel price for January to September 2010".
[8] The analysis suggests that only prices for cod and hake are effected, with the latter impact being almost negligible.
[9] Vessels landing into Peterhaed are looked at because Peterhead is the only port for which we have sufficiently detailed data to be able to distinguish the price differential between the categories of large and small fish.

The analysis suggest that CQ vessels landed 12 tonnes of undersized cod, for which we make the simplifying assumption that it has no resale value, and 42% of small cod in comparison to 35% for the control group (with a price differential of £458 per tonne). They also landed slightly more small hake in comparison to the control group. The affect of this, although minimal, is included in the analysis to ensure an appropriate degree of caution. As a result, it is estimated that participating in the scheme provided the vessels with a £851,000 increase in net fishing revenues in total, or an **average of £57,000 per vessel**. This net revenue can be disaggregated across the separate vessels and Table 2 below shows a more detailed distribution of this level of benefit. It should be noted that **all** participating vessels are estimated to have increased their net fishing revenues as a result of participating in the trial, with this increase ranging from 1.7% to 9.7% of total landings value.

Table 2: Net change to fishing revenues

	Net change to fishing revenues	Net change to fishing revenues as a proportion of total landings value
Average	£57k	5.0%
Minimum	£11k	1.7%
Maximum	£97k	9.7%

This alternative methodology gives us a more direct picture of the impacts of participating in the trial but excludes any impacts that may have been induced through changed business models. However, such impacts remain an important part of the calculation if the existence of such impact has a significant influence on the net benefit of participating in the trial.

So, in summary, we have two separate estimates for the change in net revenue to vessels participating in the CQ trial depending on the scope of impacts that are assessed. The double-difference' methodology produces an estimate of net benefits, including indirect impacts, of an average of £114,000 per vessel. This is our preferred approach as it provides estimates of both the direct and indirect revenue impacts. It also estimates that approximately £65,000 of this total benefit per vessel can be attributed to the direct effects of catching more cod. In addition we use multiple regression to validate / test these estimated direct effects, which provides estimates of a similar magnitude (an average of £57,000 per vessel). The relatively large difference between the estimates of direct and total effects within the 'double-difference' methodology implies that there is a significant amount of indirect affects that contribute to the overall impact of participating in the trial. Indeed, the value of this additional fishing activity is estimated to be £49,000 per vessel. Neither approach included any associated cost estimates, although these are likely to be greater for the latter.

The reason for the absence of definitive cost data is due to an evidence gap around the associated costs that are incurred in realising such benefits. In addition, official landings data cannot provide us with information on the extent that the CQ trial has acted to alter operational techniques which change fishing costs, including gear selectivity and an increase in spatial measures. Nonetheless, in order to develop this picture further, we have acquired some information on these issues through conducting a survey of skippers. The results of this are presented in the following section.

Skipper Survey

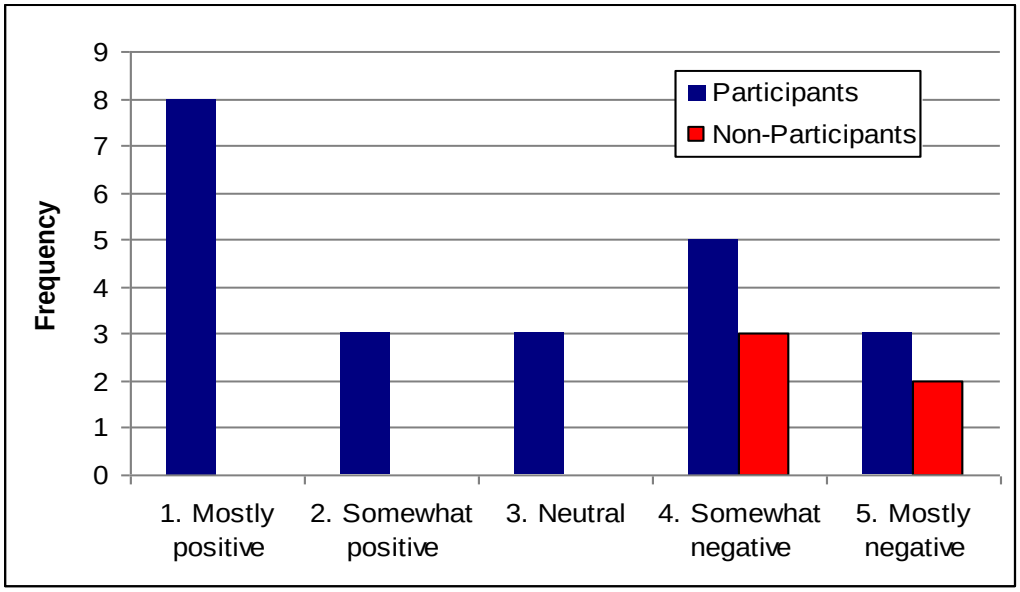
Marine Scotland commissioned Seafish to design and conduct a survey of skippers who had participated in either the 2010 or 2011 CQ trials. This concluded with 22 out of a possible 27 participating skippers agreeing to be interviewed. In addition, Seafish also surveyed five skippers who had not been involved in either trial, in order to provide an alternative view (two of whom had applied to join the scheme at some stage over the last two years, whilst three had never applied to join). Although the small sample size of the latter group precludes any results being statistically significant, the responses are useful in highlighting any immediate areas of concern that may warrant further investigation. Copies of the two surveys are presented in Annexes 2 and 3. The results of the survey are summarised below.

Attitudes towards and opinions of the CQ scheme and its current format

The primary reason skippers stated for joining the scheme, was to get more cod quota (17 mentioned this as a reason). This was followed by access to more days at sea (mentioned by 10). It is also noticeable that five skippers mentioned that helping to improve scientific knowledge was one of their reasons for joining the trial.

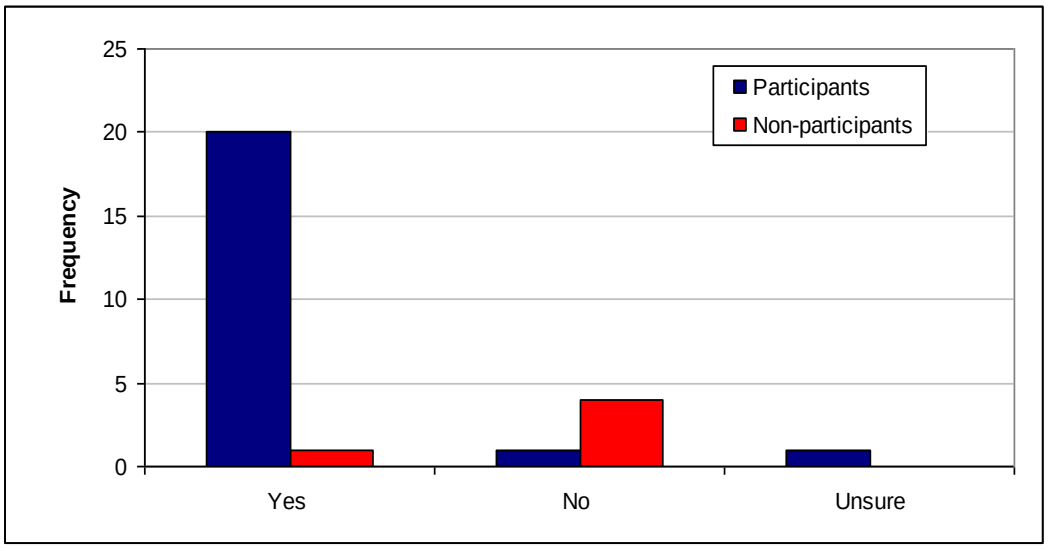
Regarding opinion of the scheme in general, there appears to be a strong division between those skippers participating and those who are not. As shown in Figure 7 below, 50% of participating skippers felt mostly or somewhat positively about the scheme whereas all of the non-participants felt mostly or somewhat negatively towards it.

Figure 7: Tell me your thoughts about the trial in general?



This is echoed the fact that nearly all participating skippers believe that catch quotas are a useful management tool in comparison to most non-participants who do not.

Figure 8: Do you think Catch Quotas are a useful management tool?



There was a wide range of reasons listed as to what people thought were the main positive and negative elements of the scheme. Some of these are shown in Table 3.

Table 3: Thoughts on the scheme to date and as a management tool

Positive	Neutral	Negative
No discards	Use of data should improve the science but hasn't done yet	Division of the fleet – has been bad for those not selected.
Increased quota	Need large quota to make it work	Increase in leasing costs
Removal of Days at Sea restrictions	Works on the East coast but won't on the West.	Have to steam away from profitable fishing grounds
High levels of management control		Would not work if extended to all species
Helps make fishing more responsible		Potential to catch dead cod discarded from vessels not on the scheme
Will help stocks recover more quickly		

In terms of the operation of the trial, the results were broadly positive, with most participating skippers suggesting that the trial had worked out as expected. The rules were easy to understand and the trial was well designed. These are shown in Figures 9 to 11 below.

Figure 9: Has the trial worked out as you expected?

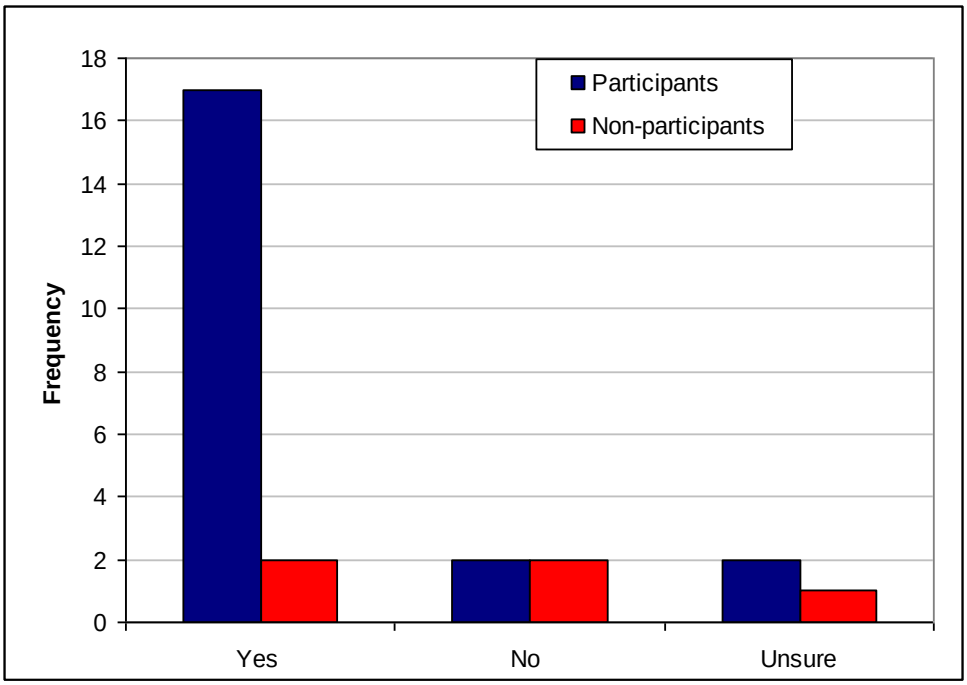


Figure 10: How easy or difficult were the trial rules to understand?

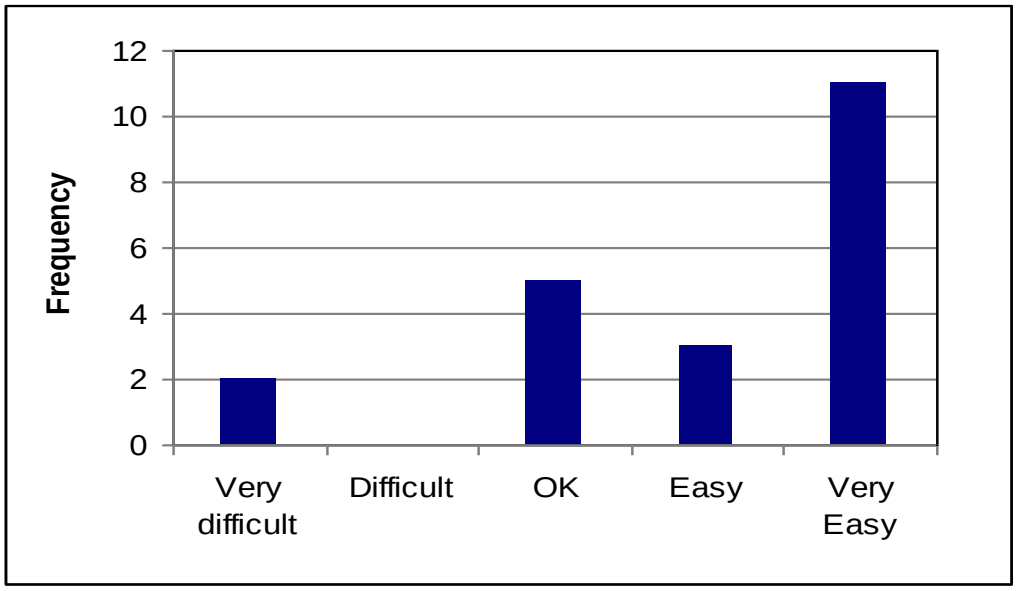
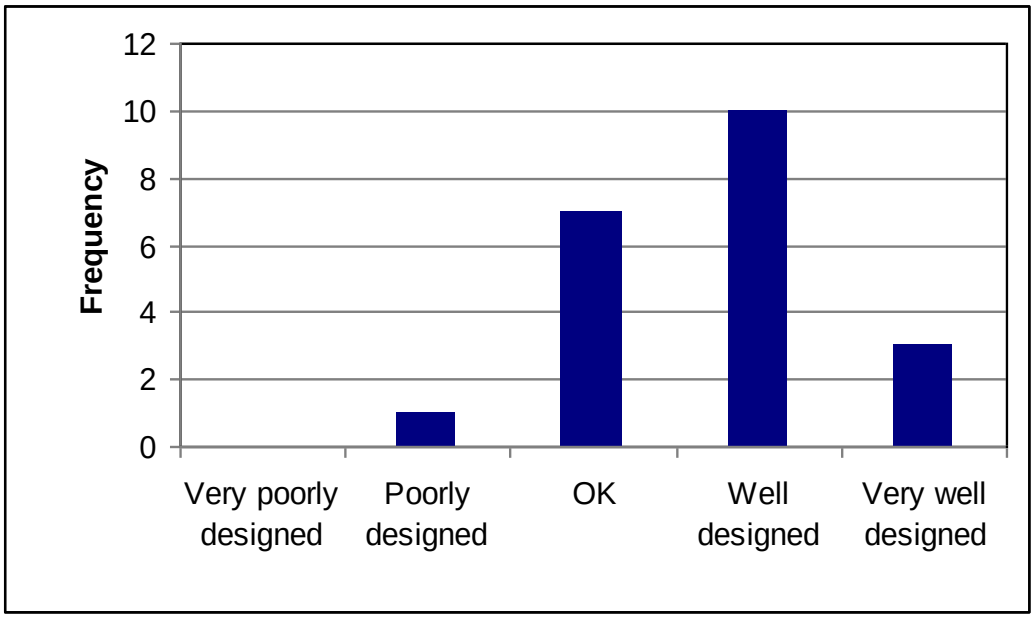
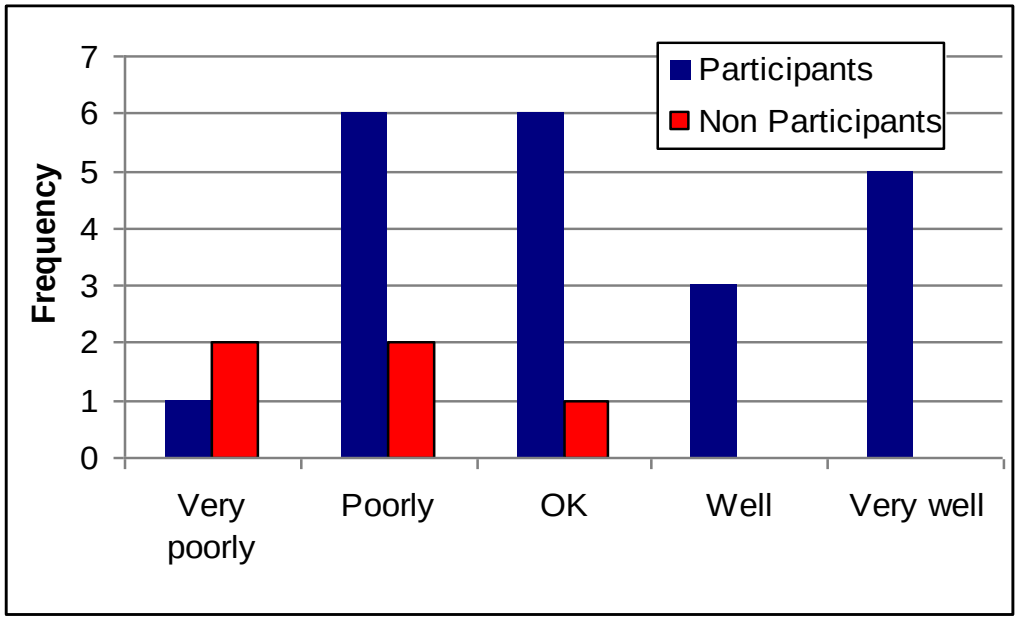


Figure 11: How well do you think the trial is designed?



However, there was a stronger message with regards to the importance of communication of the details of the trial with more skippers suggesting that there remains room for improvement in this area.

Figure 12: How well do you think the government has communicated the details of the trial to vessel owners involved?



Potential to extend the trial to other species

Participating skippers were asked about the scope to extend the trial to other species and whether that would be a valuable exercise. As can be seen in Figure 13, the majority thought that this should be done to some extent, although Table 4 also highlights that there are a number of corresponding caveats. These caveats predominantly relate to the amount of available quota for any included species.

Figure 13: Do you think the trial should be extended to other species?

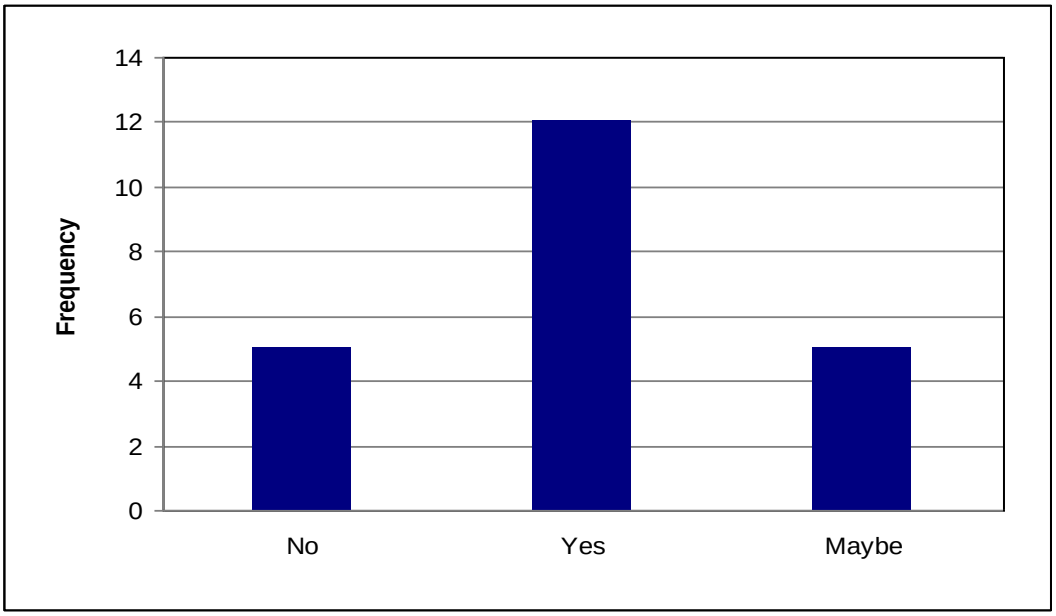
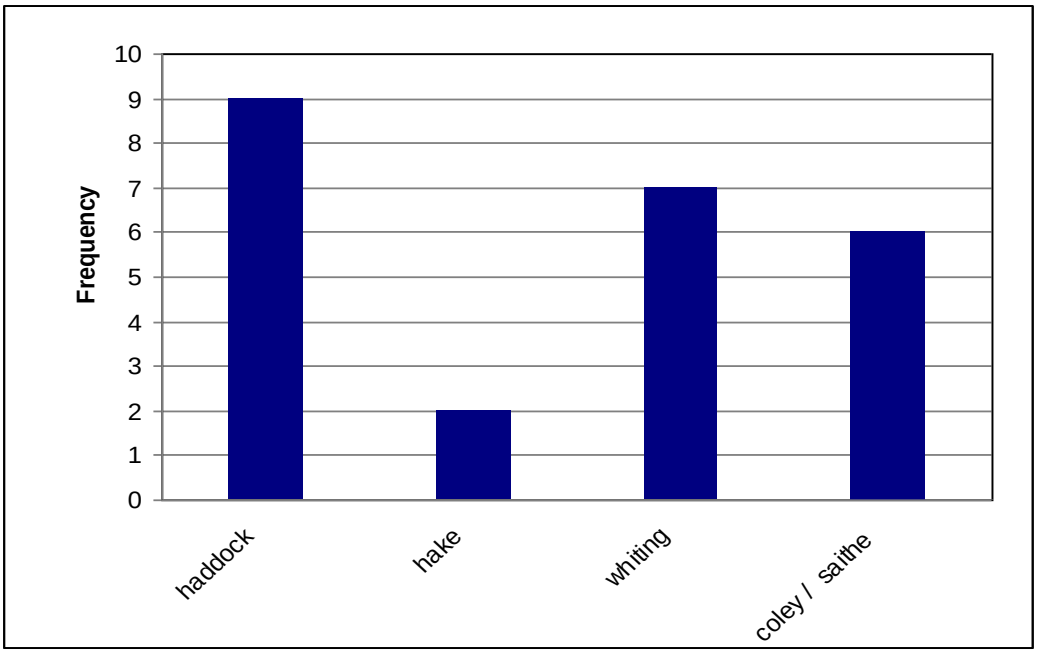


Table 4: Do you think the trial should be extended to other species?

No – Don't extend the trial	Yes – Extend to other species	Maybe – It all depends
Other species not caught very much	Likely to be compulsory so need more understanding from trials first	Depends which species
Don't have enough quota for other species	Only if there is enough quota for other species	Coley and hake would be difficult due to lack of quota
Don't want to drift into compulsory scheme	Depends which species	Possibly, if there are increases in TAC
Not a useful management tool	Will increase quota	

Skippers were also asked if they agreed the trial should be extended and what other species would be appropriate. The results of this are shown in Figure 14 and show a mixture of responses. However, haddock and whiting emerged as the most popular choices overall for such a scheme enhancement.

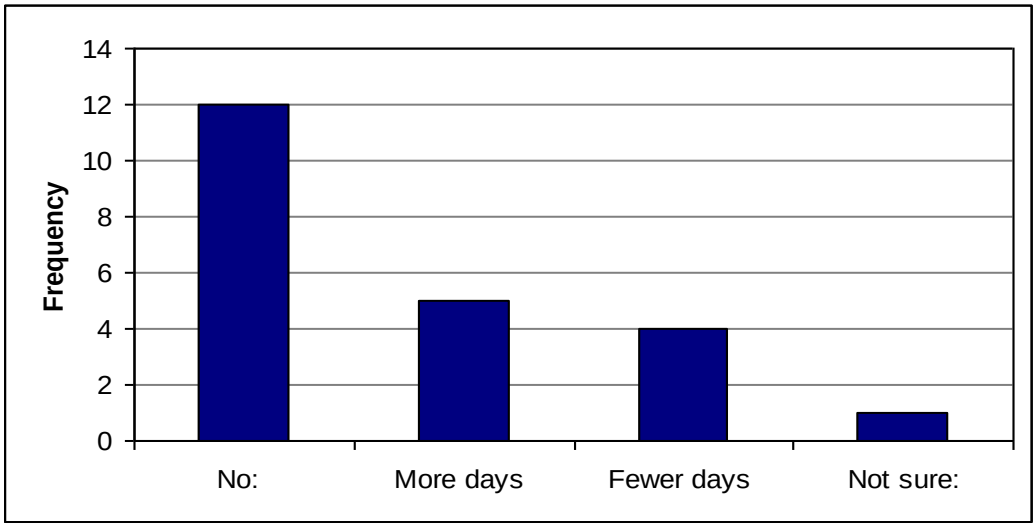
Figure 14: If yes, which other species?



Behavioural change induced by the CQ scheme, including increased gear selectivity or more spatial/temporal fishing measures

One key element of the CQ principle is it increases the incentives for fishers to fish in a manner that improves both stock sustainability and profitability simultaneously. The intention is that fishers will respond to the design of the scheme by altering their business patterns to maximise benefit for all. In order to understand how skippers may have changed such business operations, they were asked whether they had changed effort and/or fishing patterns, with early indications being that this has happened to some extent.
Figure 15 shows there does not seem to have been a significant perceived change in the effort levels of fishers participating in the trial. There would seem to be some minor conflict between this and the statement in paragraph 15 that participation in the trial has caused a small increase in effort.

Figure 15: Has being on the trial affected how many days at sea you are fishing, compared to before you started the trial?



Most skippers stated that they had changed fishing patterns as a result of being in the trial, including fishing in certain areas, fishing at certain times or through gear selectivity. Details of the measures taken to do this are shown in Table 5.

Table 5: Changes to fishing pattern. Do you try to avoid catching cod by…

	Yes	No	Details
…fishing in certain areas?	21	0	Went to Rockall Fish in areas of mixed species to make quota last all year Stay away from SW of Shetland
…fishing at certain times?	18	3	Certain times of year in certain places you know to avoid because there's lots of cod Fish at night to catch coley rather than cod Only fish in day when not many cod around Higher numbers of cod generally caught during the daylight in shallower water, so keep daylight tows to deeper water
…by altering your gear or the way you use your gear?	16	5	Orkney trawl (v. popular) Use bigger hoppers on foot rope and space them out – but lose out on megrims and lemons Bigger mesh in body (300mm) and codend (130mm) Put in Faroe bags, tunnels 135mm. Megrims get more damaged with larger mesh size so lose value Lifting the foot rope of the net and bigger mesh in the mouth of the net

There are two VMS maps attached at Annex 1 to demonstrate the location of fishing trips for CQ vessels between the periods 14 June to 31 December for both 2009 and 2010[10]. Whilst it is difficult to draw any strong conclusions from these, they potentially lend some provisional support to the statement that fishers are focussing more effort around the Rockall area. There appears to be less evidence that they are avoiding the South West of Shetland, although there will inevitably be variations between the behaviours of individual skippers and the fleet overall.

Observed impact upon fishing operating costs

It has been implied above that fishers participating in the trial saw an increase in their fishing revenues as a result. However, there remained a suggestion that some of these increased revenues required initial investments, in the form of operating expenditure and leasing quota, in order to be realised. As a result, skippers were asked whether they felt that participating in the trial had had any impact on their operating costs.

With regards to fuel costs, the surveyed skippers were almost exactly split as to whether they felt that participating in the trial had had an impact. Of the 11 that thought it had, the key explanations are shown in Table 6.

Table 6: Has being on the trial affected fuel costs compared to before the trial?

Increased (8)	Decreased (2)	No (11)
Steaming costs up due to movements to avoid areas of cod also landing in Fraserburgh rather then Scrabster	Helped with fuel spend – catch more cod rather than steaming to other grounds	With unlimited days now have time to steam slowly to save fuel
Increased, have to do more steaming away	Fewer days at sea	
Steaming to Rockall		

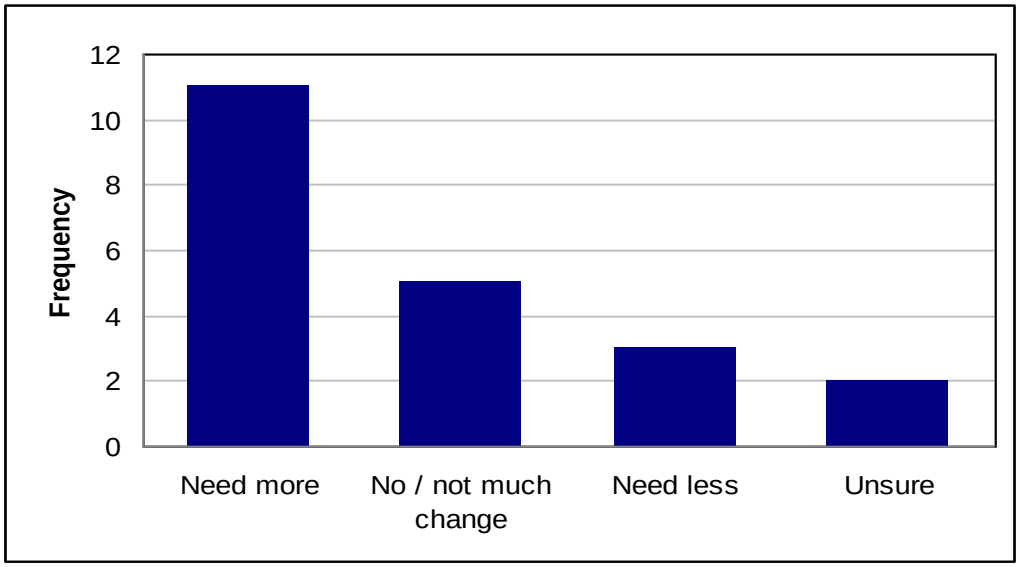
These results were echoed in the fact that 13 skippers thought that the trial had had no impact on the typical trip length, whilst only nine thought it had. Of the nine who thought that it had, there was a mix between those who thought trip lengths had increased, extra days spent steaming to avoid cod and target other species, and those who thought they had decreased, because they had caught large amounts of cod and had to cease fishing to save quota for future trips.

In addition to these operating costs, five participating vessels felt that they had incurred other one off or ongoing costs to be in the trial. These included purchasing or altering gear and the cost of leasing quota.

[10] We use the same time period in different years, as opposed to the preceding six months as in much of the analysis, to prevent seasonal patterns influencing the interpretation.

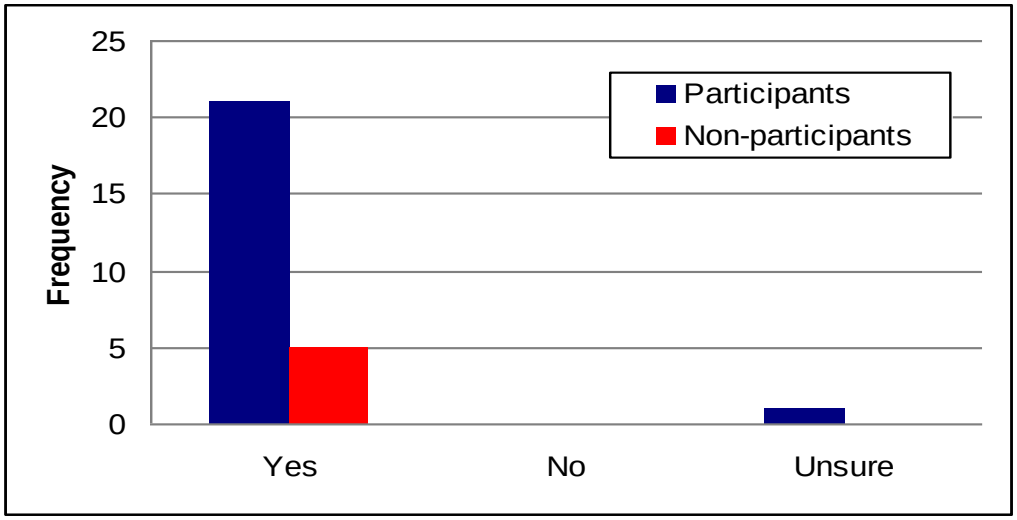
One strong theme to emerge from the skippers' survey was the suggestion that the CQ trial had increased the need to lease in cod quota and the cost of doing so. Approximately half of participating skippers (11) felt that the trial had required them to lease in more quota, in comparison to only three who felt that they needed less (see Figure 16 below). This strongly suggests that, on balance, skippers found the lack of sufficient quota to be a constraint on fishing activities in the absence of being allowed to discard.

Figure 16: Has the trial affected your need to lease in cod quota?



Regarding the cost of leasing quota, of the 22 skippers surveyed who were participating in the trial, 21 suggested that the cost had been affected by the scheme with the one remaining being unsure. All of the non-participants stated that the cost of leasing quota had been affected by the trial.

Figure 17: Has the cost of leasing cod been affected by the trial?



Typical statements to support these views were as follows:

"Cod quota is the most expensive it has ever been. Cost outstrips the landings price."

"Gone up, quite a few agents seeing boats getting free days and extra cod quota, so they are paying high prices to get extra cod."

"Definitely a massive rise in leasing costs"

Why might this be? It remains possible that it is purely due to exogenous factors such as an increase in cod prices or a perceived scarcity of quota but, in theory, the CQ trial should have had opposing effects on the supply of cod quota. Across the industry as a whole, and especially for those vessels within the trial, it has increased the amount of cod that can be landed. However, for those vessels participating in the trial, it implicitly decreases the amount of cod that can be caught due to the banning of discards.

On the demand side, there is potentially a more compelling argument as to why the trial may lead to increases in leasing costs. There seems to be two key drivers of this:

- The lack of restrictions on days at sea means that the marginal cost of fishing decreases for those vessels within the scheme, i.e. they only have to ensure that they have available quota. This is likely to increase demand for such quota.
- Related to the above, the fact that fishers must cease fishing when/if they have no cod quota remaining, means that they may still have a significant amount of remaining opportunity in the form of quota of other species. As a result, the demand for cod quota increases amongst this group as it: a) allows them to catch more cod; and, b) allows them greater effort with which they can catch more of other species.

Of course, there is no reason why increased leasing costs should be a negative thing. To understand the impacts of this change, we can consider three different cohorts within the industry:

Participating fishers - those participating fishers that require to lease in quota will obviously be negatively affected by an increase in the leasing price. However, taking a broader view, one might surmise that, if there is a net benefit overall to this group participating in the scheme, then this should be viewed as more important than changes to specific elements of the costs and benefits calculation. As such, increased leasing costs are a necessary evil in order to facilitate an overall benefit.

Non-participating fishers who are net leasers in of quota - these fishers are likely to be those that are most substantially affected negatively by the change in leasing costs. They compete in the same pool as all other fishers wishing to lease in quota but do not receive the same

benefits from the purchase of such quota, as do those participating in the CQ scheme (i.e. the access to increased effort). As a result, they face upward pressure on their costs without any associated benefits.

Non-participating fishers who are net leasers out of quota - this group of fishers, which may include so-called 'slipper skippers', stand to benefit from any increase in the cost of leasing that the CQ scheme prompts.

It is relatively straightforward to see that the increased cost of leasing quota is essentially a voluntary revenue transfer from one fisher, or set of fishers, to another. There does not appear to be any deadweight loss in such a transaction and, therefore, any immediate impacts on the efficiency of quota allocation. However, it remains possible that there are other distributive impacts of the phenomena, including greater emphasis upon fleet consolidation.

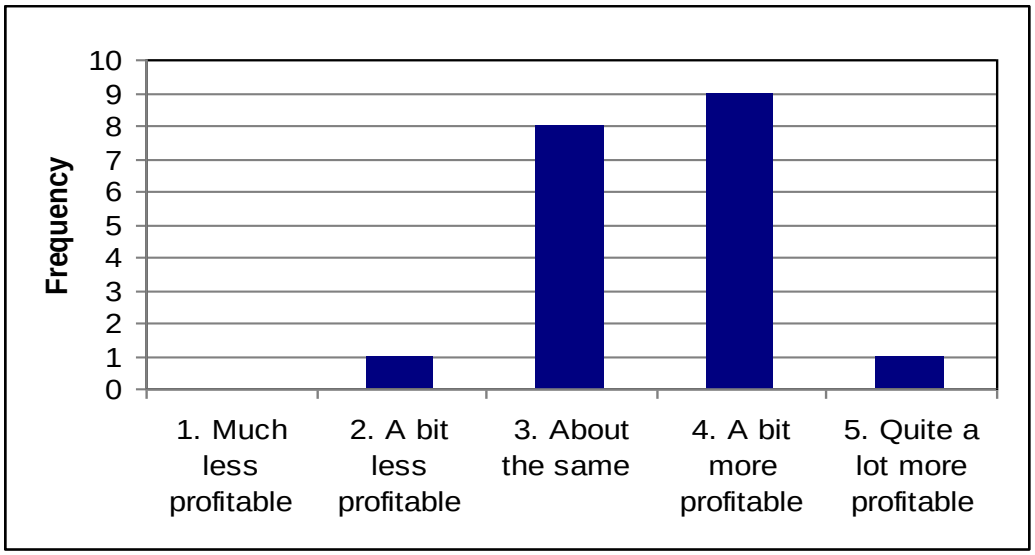
There is also some evidence that participation in the trial has had some impact on catches, including the size of fish caught and the catch composition. Details of this are presented in Table 7 below:

Table 7: What impact has the trial had on catches?

On catch quantity?	Not much change
On discards (volumes, species)	Obviously no cod discarded
On size of fish caught, all species	Average size caught will increase as make efforts to avoid catching smaller cod (e.g. with bigger mesh)
	Get different size distribution because of fishing in different areas
	Cod differs, other species remained the same
On catch composition?	Lemon sole gone, lost out on mix of fish, catfish, monks with higher foot rope
	More mixed
	Less cod and monk due to avoiding areas of high cod catches on the shelf edges
	No change for many

In terms of the overall impact of the trial on business performance, there is, again, a split of opinion between those participating and those not. Participating skippers are broadly positive about the expected impact, as shown in Figure 18.

Figure 18: What impact will the scheme have on business performance?



In contrast, four of the five non-participants suggested that the existence of the trial had impacted upon their businesses, with supporting statements such as:

"Smaller boats cannot afford to lease quota so more discarding."

"Can't afford to keep cod on board therefore having to discard due to the leasing cost."

Economic Conclusion

This initial analysis provides a good indication of the impacts of the CQ trials to date. It covers the financial impact on participating skippers and the views of both participating and non-participating skippers on the implementation and success of the trial. It offers conditional support for the principles of CQs in a number of areas but also highlights areas where it would be appropriate to exercise caution.

In terms of the key findings, the analysis suggests that participating vessels earned an estimated increase in net fishing revenues of approximately £114,000 each on average. However, this increase in fishing revenues should be set against an increase in operating costs, including both the potential leasing in of cod quota and greater effort. There are signs of provisional support for the scheme from skippers who are participating in the trial but, in contrast, those skippers not participating felt generally negative about its impacts. There is some strong, initial evidence that fishers have adapted their fishing techniques in order to maximise the benefit they receive from participating in the trial. This accords neatly with the principle of the scheme of providing the industry with the necessary incentives to fish in a manner that is deemed as more socially beneficial. However, there was also

a strong suggestion that the operation of the trial has led to an increase in leasing costs for cod quota. Whilst not necessarily a bad thing in itself, this could have potential implications in terms of the distribution of wealth across the fleet and, potentially, lead to greater fleet consolidation.

Finally, it should be re-emphasised that these results reflect a partial evaluation of the trial to date. Specifically, they are not necessarily reflective of the likely impacts of future changes to the scheme, including the extension to other species or the inclusion of a greater proportion of the fleet. The likely impacts of any future revision to the scheme should be explicitly considered in advance to ensure that changes are properly designed in order to meet objectives.

CHAPTER 3 – REM AS A COMPLIANCE TOOL

Confidence in REM technology

Marine Scotland's aspiration is to have at least a 95% degree of confidence in the operation of the REM system – very high confidence that North Sea cod is not being discarded. Our analysis of the camera images and two initial comparisons of the weight and size distribution of cod seen in the images against that landed were encouraging, as they did not indicate any significant or systematic discarding of North Sea cod.

Between 1 February 2011 and 25 April 2011, we analysed the images from 216 of 2,128 hauls (10.2%) made across 123 voyages, by 23 of the 25 vessels participating in the scheme (2 vessels had their REM equipment installation completed in May). In total, we believe the video images analysed, (10% of all of the hauls), show that 243 cod have been discarded on these voyages. In one voyage, the first conducted within the scheme by the vessel, 67 of these 243 cod were seen and recorded. The images show the Master of the vessel speaking to the crew, after which no further cod discards were seen in the images analysed. We believe that this demonstrates that the skipper needed to educate the crew to change their working practices. In another instance, 119 cod were discarded during a voyage where the fishing activity was conducted east and west of the 4° line. In this instance, the cod discards were legitimate within the scheme rules and existing EU logbook rules. The exclusion of these two instances leads to our conclusion, from the REM images analysed from 214 hauls in 2011 to date, that 57 cod were discarded.

These encouraging results, especially given the introduction of several new vessels to the scheme this year whose crew have needed to change their sorting practice, led us to believe that, through continued communication with the Masters and our identification of system and process improvements, we should be able to steadily increase our confidence levels over 2011, so that we have 95% assurance that North Sea cod is not being discarded.

Potential discard strategies

Anecdotal evidence from some industry sources and the intuitive views of experienced Fishery Officers, suggests that depending on the specific layout of each vessel, there are several potential strategies which crews could adopt to discard cod out of view of cameras.

In order to adequately address these concerns, we are now exploring modifications to the scheme which should ensure that we can identify the quantity of cod caught in each haul and compare it either with the quantity of cod reported in a haul by haul log and/or at the point of landing. Any significant discrepancy between the two sets of data would indicate discarding.

Marine Scotland Compliance is urgently exploring the following initiatives in order to improve our confidence in the operation of the REM system:

- Better risk assessment process to better target which vessels and which hauls to image review:
  - new FO cod landing's feedback mechanism to REM unit;

- Sole focus on cod taken aboard, compared with cod landed:
  - haul by haul logbook data;
  - new vessel specific camera positions, potentially with five rather than four cameras (one and two above deck, three and four below); and,
  - potential requirement to pass all cod over a measuring 'device' (such as a board or coloured tape/areas on the belt);

- Trip by trip exchange of drives;

- Data integrity software update; and,

- Alter 'port box' trigger.

Resourcing

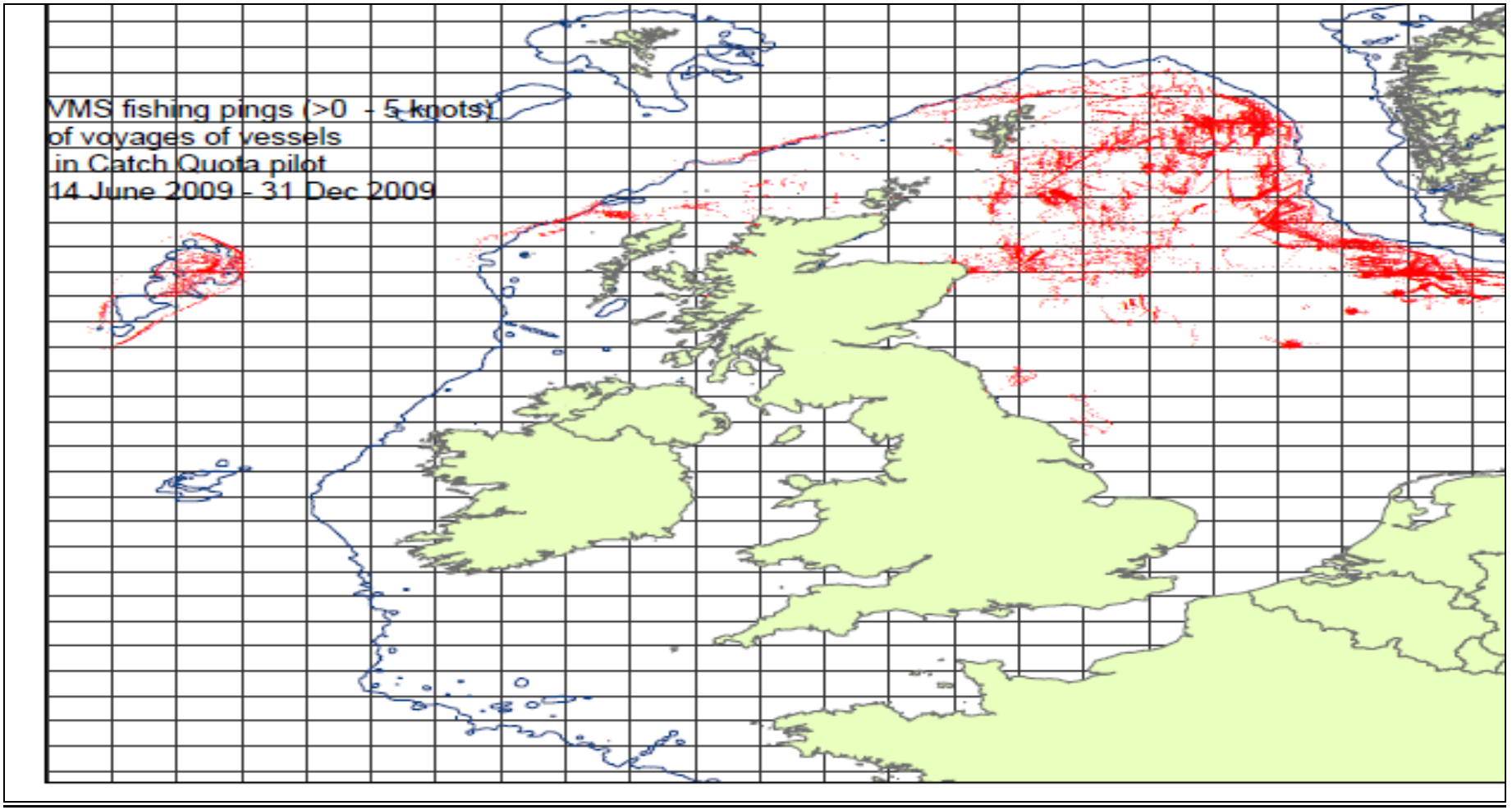
Marine Scotland Compliance has averaged 1 hour and 20 minutes to analyse each of the 216 hauls viewed since 1 February 2011. Currently, 40% of this assessment time involves Senior Fishery Officer (SFO) or Fishery Officer (FO) work, and 60% viewing by Fisheries Administrators, at a **combined cost of circa £28 per haul or approximately £6,000 from 1 February 2011 to end May 2011 (circa £18,000 per annum).** It is important to note that current practice does not include identification of the size distribution of the cod caught, which will increase the analysis time required. It also excludes the two complete voyage assessments which were conducted to compare the weight of cod seen in the images compared with that landed.

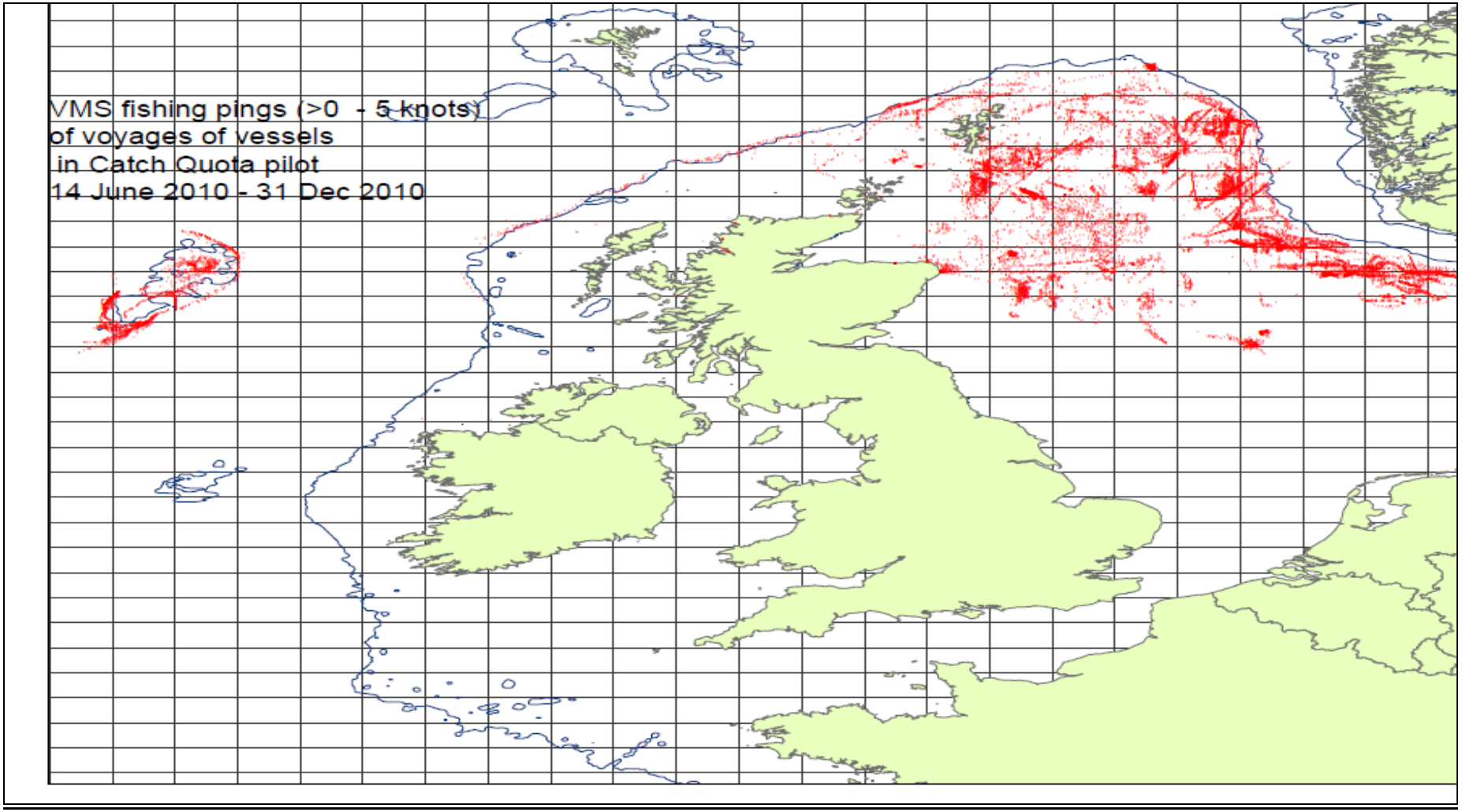
Marine Scotland Compliance will, over the next three months, explore the current and potential future opportunities to minimise costs by utilising any spare or released capacity across both Senior Fishery Officers, Fisheries Officers and/or Fisheries Administrators. We will also explore, as outlined above, the impact and cost benefit of an enhanced risked based approach which could reduce the number of hauls which need to be analysed.

As Marine Scotland, the Scottish industry and the EU develop their strategy regarding CQs, which we expect will be largely dependent on the level of confidence in REM, we will be able to determine the merit of exploring, in detail and with extensive consultation, how REM technology might enhance current enforcement activities, deliver opportunities to release some of our spending on and/or to alter the tasking of our compliance assets, including MPVs and aircraft. This is clearly a very sensitive area of debate which will need careful handling across all parties.

Our current priority is to achieve a cost effective and sustainable solution which delivers at least 95% confidence that the participating vessels are compliant with all of the CQ scheme rules.

Annex 1: VMS fishing pings for CQ vessels – 14th June – 31st December (2009 & 2010)




VMS fishing pings (>0 - 5 knots)
of voyages of vessels
in Catch Quota pilot
14 June 2010 - 31 Dec 2010

Annex 2: Catch Quota Trials – Skippers Interview Questions

Date:	
Name of interviewer:	
Name of skipper:	
Name of vessel:	
PLN of vessel:	
Home port:	
PO membership:	
Any ring-fenced quota within PO?	
Confirm project explained?	
Skipper gives consent to participate?	

Nb. aim for comparison of being in / running the trial to how it would be now if they were not in the trial or if there was no trial, rather than comparison of before being in the trial and since being in the trial.

Categorisation question

1. What type of gear are you currently using?

Attitudes towards and opinions of the CQ scheme and its current format

2. Could you tell me your thoughts about the trial in general?

3. What was your main reason for joining the catch quota trial?

4. Do you think CQ's are a useful management tool Yes / No
    a. Can you give me some details?

5. Has the trial worked out as you expected? Yes / No
    a. Can you give me some details?

6. How easy or difficult were the rules of the trial to understand?

On a scale of 1-5

1. very difficult	2. difficult	3. ok	4. easy	5. very easy

7. How well do you think the trial is designed? On a scale of 1-5

1. very poorly designed	2.poorly designed	3.ok	4.well designed	5.very well designed

8. How well do you think the Government has communicated the details of the trial to vessel owners involved? On a scale of 1-5

1. very poorly	2. poorly	3. ok	4. well	5. very well

9. How well do you think your communication with your producer organisation on the management of your quota works? On a scale of 1-5

1.very poorly	2.poorly	3.ok	4.well	5.very well

10. Do you think the **trial** should be extended to other species? Yes / No / Maybe
    a. Why do you think that?

    b. If yes, what other species should be next?

Behavioural change induced by the CQ scheme, including increased gear selectivity or more spatial/temporal fishing measures.

11. Has being on the trial affected how many days at sea you are fishing, compared to before you started the trial? Yes / No
    a. In what way?

12. Before starting the trial did you have ideas about how to avoid unwanted catches of cod? Yes / No
    a. Can you give me some details?

13. Have you altered your fishing pattern as a result of being in the trial? Yes / No
    a. Can you give me some details about that?

14. Did / do you try to avoid catching cod by fishing in certain areas? Yes / No
    a. Could you give me some details about what you did?

15. Did / do you try to avoid catching cod by fishing at certain times? Yes / No
    a. Could you give me some details about what you did?

16. Have you altered your gear or the way you use your gear in any way as a result of being in the trial? Yes / No
    a. Can you give me some details about that?

Observed impact upon fishing operating costs

17. How did you find the operation of the CCTV? Did you have any issues with it?

18. How did your crew find the CCTV? Were they supportive of it?

19. Did having the CCTV cause any changes to practices onboard? Yes / No
    a. Can you give me some details about that?

20. Would you have participated in the trial if you had to fund the purchase of the equipment, installation and ongoing maintenance costs? Yes / No / Don't know
    a. Why is that?

21. Has being on the trial affected fuel costs compared to before the trial? Yes / No
    a. In what way?
22. Have you incurred any **one-off** or **ongoing** extra costs to be in the trial? Yes / No
    a. Can you give me some details about that? What costs, and how much?

23. Has being on the trial had any impact on your typical trip length? Yes / No
    a. Can you give me some details about that?

<u>Volume of catch, disposal method and average price received for undersized fish</u>

24. What impact has the trial had on catches?

    A – volumes caught (all species)

    B - Discards (volume, species mix)

    C - Size distribution of fish caught (all species)

    D – Catch composition

<u>Perceived changes in the market for leasing cod quota</u>

25. What effect, if any, has being in the trial had on your need to lease in quota?

26. Do you think the cost of leasing cod has been affected by the scheme? Yes / No

27. Overall, do you believe the scheme *has changed* / *will change* how profitable your vessel is compared to how the business would have performed if not on the trial? Yes / No

    a. on a scale of 1-5, compared to how it would have been if not on the trial, has being on the trial made overall financial performance…?

1. Much less profitable	2. A bit less profitable	3. About the same	4. A bit more profitable	5. Quite a lot more profitable

Annex 3: Catch Quota Trials – Non-participant Interview Questions

Date:	
Name of interviewer:	
Name of skipper:	
Name of vessel:	
PLN of vessel:	
Home port:	
PO membership:	
Any ring-fenced quota within PO?	
Confirm project explained?	
Skipper gives consent to participate?	

Nb. aim for comparison of being in / running the trial to how it would be now if they were not in the trial or if there was no trial, rather than comparison of before being in the trial and since being in the trial.

Categorisation question

1. What type of gear are you currently using?

Attitudes towards and opinions of the CQ scheme and its current format

2. Could you tell me your thoughts about the trial in general?

3. What was your main reason for not joining the catch quota trial?

4. Would you join the trial if other incentives where available Yes / No
    a. Can you give me some details?

5. Do you think CQ's are a useful management tool Yes / No
    a. Can you give me some details?

6. From what you know, is the trial working out as you expected? Yes / No
    a. Can you give me some details?

7. If the trial continued would you be interested in taking part in the future? Yes / No
    a. Tell me more, tell me more? Like does he have a car?

8. How well do you think the Government has communicated the details of the trial to vessel owners in general? On a scale of 1-5

6. very poorly	7. poorly	8. ok	9. well	10. very well

<u>Perceived changes in the market for leasing cod quota</u>

9. Do you think the cost of leasing cod has been affected by the scheme? Yes / No
    a. Can you give me some details?

10. Are there any other ways in which the existence of the trial has impacted on your business or other vessels in general? Yes / No
    a. Can you give me some details?

Annex 4: Catch Quota (CQ) Trial 2010 – Multiple Regression Analysis

The general purpose of multiple regression analysis is to identify the relationship between several independent variables and one dependent variable. In this instance, the analysis attempts to estimate the average price for large fish received by the CQ group (the dependent variable), taking account of a number of other explanatory variables such as freshness of the fish and time of landing. It then multiplies this price by the additional quota awarded through participation in the scheme to estimate a theoretical maximum level of value that could accrue to participating fishers.

The individual steps taken within the analysis show a number of findings[11], including:

i. The 15 vessels analysed received a total of 445 tonnes of additional cod quota;
ii. 12 tonnes of undersized cod were recorded as being landed into Peterhead by the end of December 2010. We assume that fishers received no value for these undersized cod;
iii. CQ vessels landed 42% of small cod in comparison to 35% for the control group;
iv. CQ vessels landed 33% of small hake in comparison to 32% for the control group[12];
v. The average price received by CQ vessels for large cod was £2,082/tonne and the average price for small cod was £1,624/tonne;
vi. The potential value of the CQ cod quota allocation is, therefore, 433 tonnes (445 in total minus 12 undersized) multiplied by £2,082/tonne = £902,000;
vii. Had CQ vessels landed all their cod caught in the same size distribution as the control group, they would have landed 108 additional tonnes of large rather than small cod;
viii. Multiplying these 108 tonnes by £458/tonne (the price differential between large and small cod in bullet point v above) gives an 'opportunity cost' of £49,200;
ix. The average price received by CQ vessels for small hake were £543 per tonne lower than the average price for large hake;
x. Had CQ vessels landed all their hake caught in the same size distribution as the control group, they would have landed an additional 3 tonnes of large rather than small hake;
xi. Multiplying the 3 tonnes by the £543/tonne (the price differential between large and small hake identified in bullet ix) implies an estimated 'opportunity cost' to vessels in the pilot scheme of £1,400;
xii. Combining the estimated 'opportunity cost' for the two species leads to an overall estimated amount of £51,000.; and,
xiii. Netted against the £902,000 of potential benefit from the additional quota gives an estimated net return of £851,000 overall to the vessels participating in the CQ pilot.

[11] Some of these figures do not precisely reconcile due to rounding.
[12] There were only statistically significant differences in the landing size distribution between CQ vessels and the control group for cod and hake.

Annex 5 – Terms and Conditions of 2011 Catch Quota Scheme

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CATCH QUOTA MANAGEMENT SYSTEM WITH REMOTE ELECTRONIC MONITORING (REM)

TERMS & CONDITIONS

Overview

1. This is a voluntary system. It is based on catch quota management, not on traditional landing quotas. The catch quota management system (CQMS) will operate in the 2011 quota management year and be applicable to CQMS species in the North Sea only.

2. The purpose of this management system is to reduce discards, reduce stock mortality, provide better scientific data and encourage fishermen to fish more selectively. At the same time, it is aimed at delivering higher revenue for participating vessels compared to those not participating.

3. The main features for vessels participating in the CQMS are that:

    a) all caught fish are recorded;
    b) all CQMS species caught shall count against quota;
    c) all CQMS species caught shall be retained on board and landed;
    d) fishermen will have the responsibility to document that all fish caught are accounted for; and
    e) all participating vessels are exempted from effort controls.

4. The main objectives of the system are to:

- Reduce discard levels.

- Reduce fishing mortality rates for demersal stocks.

- Build on our current evidence base and experience from the scheme working towards the introduction of better fisheries management arrangements, including in a multi-species context and influencing and pre-empting the review of the CFP.

- Provide further detailed evaluation of using catch quota and related incentive schemes as fishery management and discard reduction tools.

- Seek to ensure improved science and advice on the basis of precise fisheries data. In effect, it is hoped that participants in the scheme will significantly enhance our data collection capability. Science needs better data to assess

fish stocks more precisely, but science also needs reliable real-time data to assess e.g. the effect of management initiatives such as a discard ban.

- Improve the effect and tuning of regulations regarding e.g. real time closures, grading bans and effort restrictions by providing precise data on catch rates and discards from reference vessels having full catch documentation.

Eligibility

5. To allow for effective management, monitoring and communication, eligibility shall be limited to Scottish vessels only. For the purposes of the CQMS a Scottish vessel shall be defined as Scottish registered and administered at a Marine Scotland coastal office.

Conditions of participation

6. The scheme shall be open to all vessels.

7. Once accepted into the system, participating vessels must remain in for the remainder of the calendar year.

8. All participating vessels will require fully functioning vessel monitoring systems and electronic logbook system.

9. Participating vessels will be required to secure a REM system from an approved Marine Scotland supplier. Only engineers authorised by the Marine Scotland supplier will be able to carry out repairs and maintenance.

10. Participants will receive a fishing authorisation for the 2011-12 effort management year that does not limit their days at sea. The authorisation will also note those parts of the Conservation Credits scheme that will continue to apply to CQMS participants.

11. Participating vessels shall not be permitted to lease out the quota obtained from Marine Scotland as part of participation in CQMS.

12. The systems shall remain switched on at all times regardless of the sea area in which the vessel is operating.

13. Once a vessel has caught all of any of the individual CQMS species it will be required to cease all fishing in the North Sea. Vessels are therefore strongly encouraged to consider the use of highly selective gears and continue avoidance behaviours to ensure this scenario does not arise. Whilst additional quota can be leased in during the year, this additional quota will not qualify for the *pro rata* increase in quota given at the start of the management year.

14. Due to the need to cross verify the value of electronic monitoring, observers will be required onboard participating vessels from time to time. Participating vessels **MUST** accept an observer under these circumstances.

15. In relation to the equipment installed there shall be a duty of care placed on the master as laid out in **duty of care code**. It is the responsibility of the Master to ensure that crew are cognisant and compliant with the terms and conditions of the CQMS. Failure to do so will result in removal from the CQMS.

16. A vessel engaged in Pair Trawl activities shall only be eligible for the scheme if both vessels are signed up to the scheme.

17. All North Sea **CQMS species** shall be retained onboard. Undersized fish shall not be mixed with fish above the minimum landing size. For the purposes of recording undersized CQMS species and reducing the need for additional weighing, a standard 70/75 litre fish box containing undersized CQMS species shall be recorded as 50 kilos. A standard 600 kilo bin containing undersized CQMS species shall be recorded as 400 kilos. Similar *pro rata* calculations apply to other size boxes and bins.

18. Participating vessels are exempted from the offence of retaining undersized CQMS species only. Undersized fish cannot be sold or offered for human consumption. It can be disposed of by sending for fishmeal or offering as bait to static gear operators.

19. Discarding of species other than CQMS species shall be allowed as long as it adheres to the requirements of the High Grading Ban.

20. In the event of equipment failure the Master shall notify the call centre immediately he becomes aware of the failure. The trip may be finished before return to port but the vessel will not be allowed to return to sea until equipment is fully functioning again. Early communication of any equipment problems will allow Marine Scotland to take steps to ensure that the problem can be corrected as soon as possible on the vessel's return to port.

21. Footage and data gathered may be used in an anonymised and aggregated form in publications and reports produced by Marine Scotland.

22. Enquiries made under Freedom of Information (FOI) shall be answered following normal FOI guidelines. However, personal data (which includes CCTV footage and data) will not be released.

23. Marine Scotland may place additional cameras onboard participating vessels as required.

24. Marine Scotland will engage with those who participate in the scheme to obtain feedback on the impact of the equipment on a vessel. Any installation costs and maintenance costs shall be borne by the vessel. If any funding

opportunities for REM equipment become available through the EU, Marine Scotland will pursue those avenues with the European Commission and seek to allow retrospective payments.

25. Marine Scotland will take action where necessary against vessels which breach the conditions of the scheme or any other general fishery regulations. Action may range from advisory or administrative sanctions, including expulsion from the scheme, to formal enforcement action.

Removal Penalties

26. Removal from the scheme may be considered where the participant has failed to comply with the terms of the management system, including where:

- there has been a failure to allow observers onboard;
- there has been tampering or interference with the onboard REM equipment;
- there has been a consistent failure to maintain the duty of care requirements;
- there has been deliberate blocking of the view from REM equipment to the vessel's catch handling areas; and/or,
- there have been inconsistencies between observed catches and those subsequently landed.

27. Vessels removed from the scheme will be required to make available to their Producer Organisation (PO) (for them to transfer to Marine Scotland) the quota tonnage awarded to them through their participation in the CQMS. If a vessel is not able, during the relevant management year, to provide to its PO the quota made available to it through the CQMS, the vessel will be invited to make a transfer in the following year. Where the vessel is unable to make the transfer in the following year, Marine Scotland will make a deduction from the days at sea allocation of the vessel, at a level to be determined by Marine Scotland.

28. In addition, where a vessel is removed, the days at sea authorisation granted to it will be rescinded and Marine Scotland will thereafter consider the level and terms of any new allocation of days at sea. Marine Scotland will not be able to guarantee an allocation of days at sea to vessels removed from the scheme, particularly where removal takes place later in the effort management year.

29. Vessels removed will not be permitted to join any CQMS in the following year and will be required to repay any additional CQMS species received.

30. Marine Scotland reserves the right to change any of the rules of the scheme at any time.

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Remote Electronic Monitoring onboard Scottish Fishing Vessels

Duty of Care Code 2011

1. Marine Scotland shall fit cameras and sensors to the vessel. The Master and crew will not interfere with the positioning of sensors or cameras.

2. The onus will be on the Master to ensure that the cameras are not obscured in any manner.

3. Any attempts to interfere with, damage or disrupt the camera or footage may result in removal from the scheme and suspension of the associated incentives.

4. The Master will be expected to maintain clean lenses on the cameras at all times. We expect that cameras should be washed and dried on a regular basis and at least daily.

5. The Master will report any damage, disruption or technical failure to the UK Call Centre immediately :-

Telephone: +44 (0)131 271 9700

Fax : +44 (0)131 244 6471

Email : UKFCC@scotland.gsi.gov.uk

6. The Master will be responsible for its maintenance and repair. Only engineers authorised by Marine Scotland will be able to carry out repairs.

7. Marine Scotland will endeavour to resolve any technical problems promptly on the vessel's return to port. Early notification of technical failures will expedite that process.

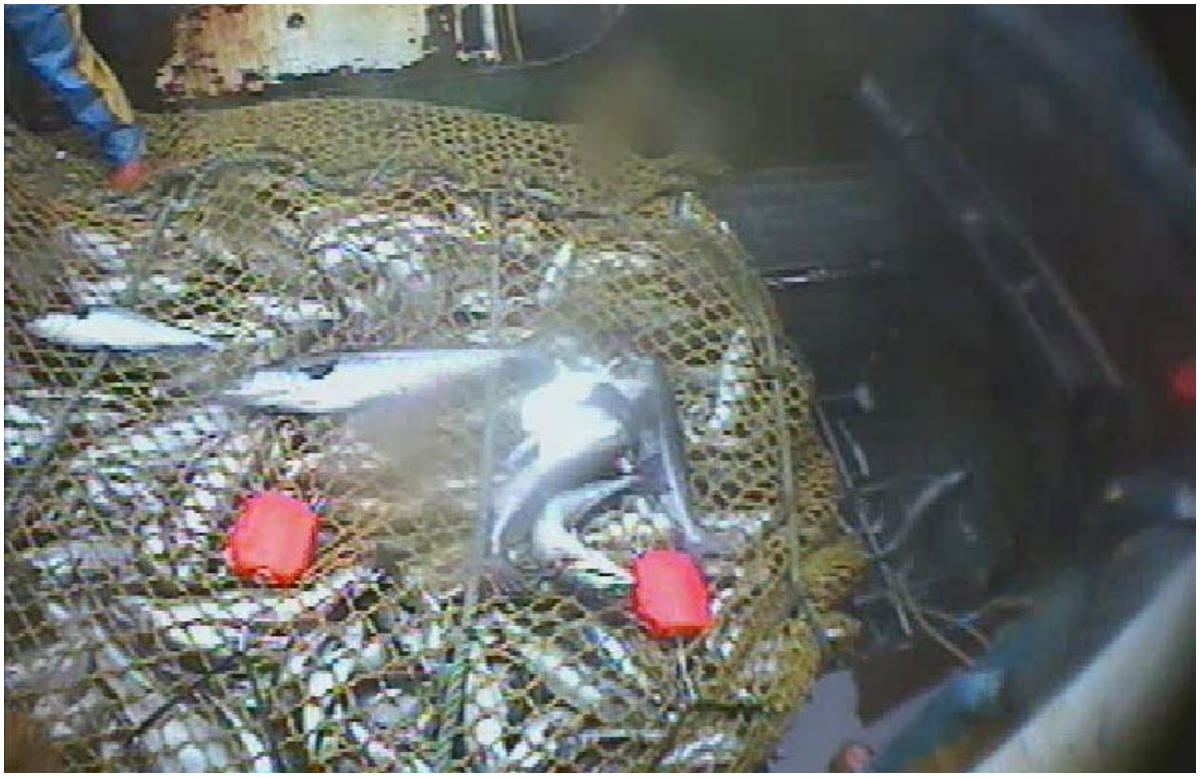
MARINE SCOTLAND
SEA FISHERIES POLICY
December 2010

Annex 6 - Examples of REM footage

View from deck camera of hopper

View from the deck camera of net alongside the vessel

This image from the deck camera shows the fish being discharged into the hopper.



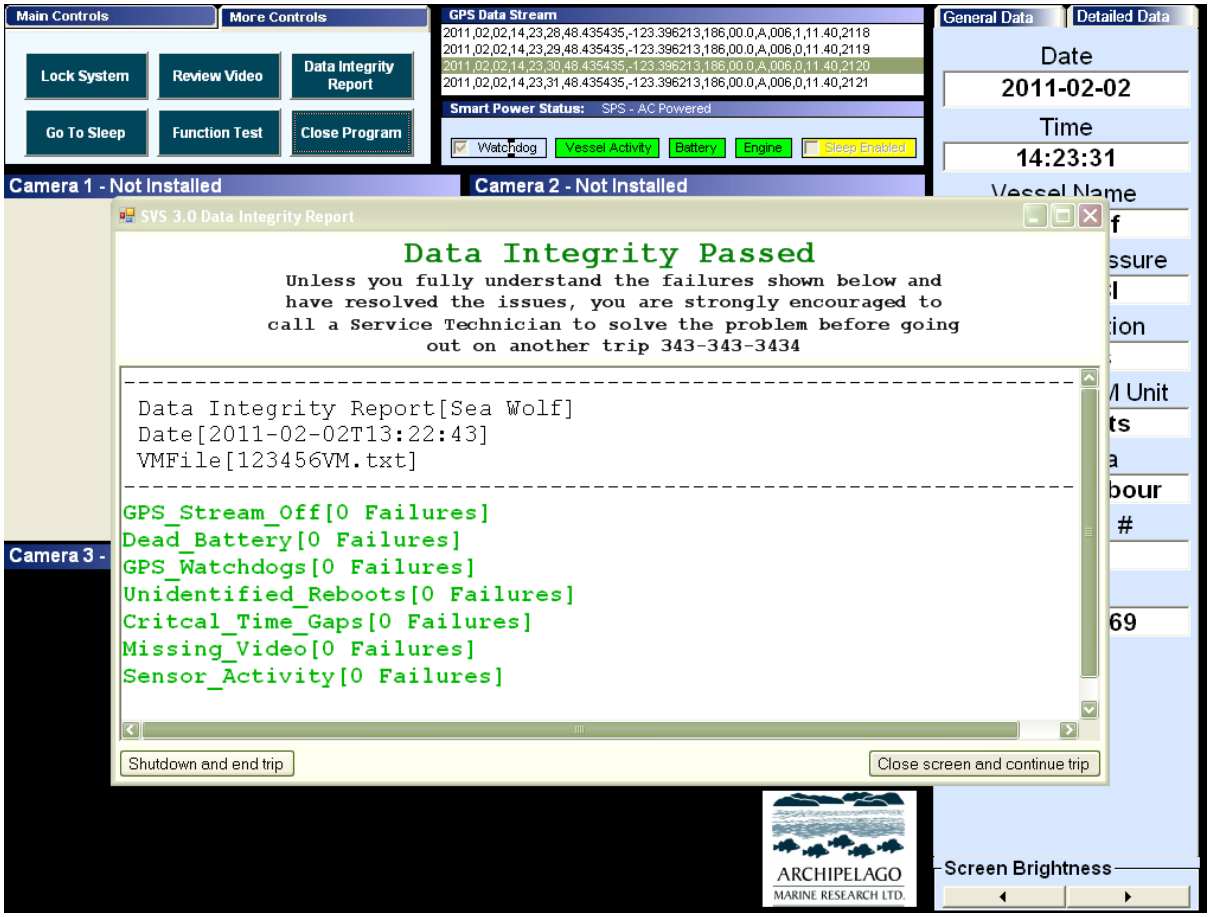
Another image shows the fish coming onboard and the Cod end discharge into the hopper.

Images of the crew at the sorting belt

Cod measurement tool using REM

The picture above shows the callipers being superimposed on REM footage to indicate the size of a cod. This is a new piece of software that Marine Scotland is trialling to help improve our confidence in the scheme. This process is also aided by the installation of measurement boards, placed on the sorting belt. We are working with several vessels to identify how we can better quantify how much cod is bought on board from each haul. One of the challenges when monitoring the camera images is accurately determining the size of each cod, so that we can approximate its weight and establish the total weight of cod caught in each haul. The latter value can then be compared with the relevant logbook entry, which the skipper completes haul by haul, so that we can assess with more confidence whether or not cod is being discarded out of camera view. In some instances, this new process may require a change in how the crew handles cod on the sorting belt. However, early indications are that it will deliver a suitable level of evidence that all cod caught is being landed. It should be noted, however, that using the same process to establish like evidence across other species may not be practical or cost effective.

REM Error Message



It is set out in the CQMS rules that skippers must report problems or technical failures with the REM system to the UK Fisheries Call Centre. The "Data Integrity Report", example above, allows the master to easily identify any problems with the equipment, such as a failure of one of the sensors which will be shown in red. Equipment operating as normal is shown in green. This report allows Marine Scotland to identify the problem quicker which can speed up the process of resolving the problem once the vessel has returned to port.