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North Sea Cod Catch Quota Trials: Final Report 2015



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North Sea Cod Catch Quota Trials: Final Report 2015 September 2016

Report prepared by: Lillian Sandeman, Ashley Royston and Julian Roberts on behalf of the Marine Management Organisation

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1. Executive summary

This report provides the results of the North Sea cod fully documented fishery scheme for 2015. This is the fifth annual scheme run by the UK Marine Management Organisation in which the discarding of North Sea cod is prohibited and all catches count against quota. Eighteen participant vessels in the scheme (seventeen trawlers and one gill-netter) were awarded additional quota (based on UK discard data) and days at sea.

Remote electronic monitoring with CCTV (REM) was used wto assess levels of discards of cod and to test the efficacy of generating cod length data from CCTV footage. In total, 6.6% of hauls were audited to check for compliance with the discard prohibition. The results show high levels of compliance with cod discards well below 1% of total cod catch. This is consistent with results in previous schemes.

Overall, cod length data generated from CCTV footage correlated closely with the landed size distribution calculated from market grading data. Aside from visual auditing for discarding, the length data vs. grading data provides additional confidence that all cod catches are landed.

Landed grade-size distributions of cod were compared between participant and non-participant vessels using the same gear segment in the northern North Sea from 2012 to 2015. Participant vessel landings typically consisted of twice the amount of small size grades compared to non-participant vessels. It is notable that the percentage of the overall catch by participant vessels that composed of smaller grades steadily increased year on year.

This is considered potentially indicative of high-grading amongst non-participant fleet which do not carry monitoring equipment. However, drawing firm conclusions from such a comparison would be to assume the catch profiles are consistent between the two groups. The true catch profile of the non-participant fleet is unknown where no monitoring is in place.

The report considers the extent to which REM monitored vessels can be considered as representative of the wider fleet (i.e. to act as a 'reference fleet'). The results show a significant variation spatially and temporally in the size distribution of cod catch by participant vessels and more recent analysis suggests significant spatial variance between participant and non-participant vessels. Such variance is likely to impact the level of confidence that can be drawn from monitoring a subset of vessels and therefore further analysis in this area is recommended.

Some of the trial participants have reported specific adaptations to avoid juvenile cod. These have included adding square mesh panels, increasing mesh size above legislative minimum requirements and behavioural adaptations. The main behavioural adaptation reported has been avoidance of areas with known high levels of undersize fish. Work is ongoing in 2016 to study spatial variance between participant and non-participant fleets. This work has the potential to provide evidence of the reported spatial avoidance by the FDF fleet.

It is considered that there is the potential for REM to provide a means of retrospective auditing of real-time, industry-reported data such as juvenile fish abundance. This could allow juvenile real time closures to be triggered accurately and in genuinely real time. In addition, REM can be used to generate spatial and temporal trends in length frequency data with potential for scientific use.

2. Introduction

Eighteen English-administered fishing vessels took part in catch quota trials for cod in the North Sea during 2015.

Vessels which participate in fully documented fisheries can be allocated additional quota for that species as long as all catches are retained, landed and counted against quota. Therefore, those participating in the 2015 scheme were allocated extra cod quota on the basis of the 2013 discard rates determined by the European Commission's Scientific, Technical and Economic Committee for Fisheries (STECF). All vessels were also equipped with remote electronic monitoring (REM) equipment including CCTV cameras as a condition of the scheme. This was to both to evaluate the use of REM as a tool but also to monitor compliance with the landing obligation.

The main objectives for 2015 were to:

- Provide evidence and experience from the scheme in advance of the demersal landing obligation being phased in from 2016;
- Investigate the potential of using market grading data for reference fleet monitoring;
- Better understand the impact of the Catch Quota scheme and the landing obligation on the fishing industry

3. Quota Management

Each vessel was allocated additional quota in accordance with the requirements set out for Fully Documented Fisheries (FDF) in Articles 14 and 15 of Council Regulation (EU) No 104/2015. Table 1 shows individual allocations and the total catch of cod in 2015 for participating vessels.

Vessel	Gear Segment	Total catch in 2015 whilst on the scheme (tons)	Additional allocation (tons)
1	TR1	87.2	18.2
2	TR1	24.3	16.4
3	TR1	211.5	27.2
4	TR1	227.2	33.1
5	TR1	200.9	31.1
6	TR1	85.2	11.2
7	TR1	152.6	16.1
8	TR1	101.7	32.0
9	TR1	100.6	19.6
10	TR1	456.5	50.6
11	GN1	41.5	2.2
12	TR1	287.0	49.1
13	TR1	236.8	27.8
14	TR1	33.7	12.4
15	TR1	206.9	27.1
16	TR1	450.7	71.1
17	TR1	136.3	1.2
18	TR1	144.5	23.7
Total	All	3185.1	470.1

Table 1: Individual quota allocations and total cod catch in 2015. Numbers are used instead of names in order to anonymise individual vessels

A discard rate of 41% for vessels using trawls with a codend mesh size of over 100mm (TR1) was used. This was the discard rate in 2013 for UK vessels evaluated by STECF. A discard rate of 6% was used for gill net (GN1) vessels. The allocation is capped at 30% of the vessel's individual quota in the year prior to trial participation under Article 15 of Council Regulation (EU) 2015/104. The full allowable allocation of FDF cod quota was not available, despite some unused FDF quota being

transferred from Marine Scotland. Therefore, additional quota had to be leased in by the vessels if required.

The additional allocation across the English FDF fleet amounted to 14.76% of the total catch whilst participating in the scheme.

4. Fishing activity

As in previous years participant trawlers have engaged in targeted cod, saithe and haddock fisheries in the North Sea with codend mesh sizes of $\geq 120\text{mm}$ and mixed demersal fisheries with codend mesh sizes of $< 120\text{mm}$. Figure 1 shows the distribution of fishing undertaken by the TR1 and GN1 vessels during the 2015 scheme.

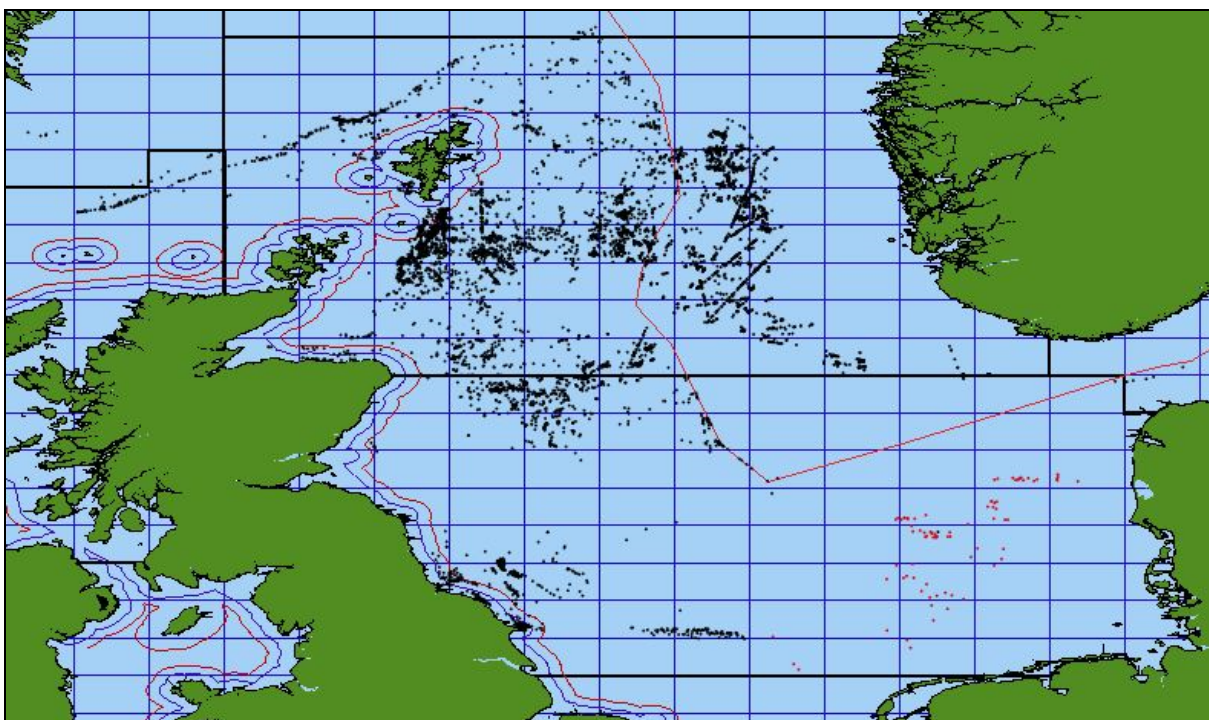


Figure 1: The haul positions of vessels while on the trial, TR1 is shown in black, and GN is shown in red.

5. Methodology

5.1. Methodology vessel video review

All participating vessels were fitted with REM systems supplied by Archipelago Marine Research Ltd (AMR). Two new vessels joined the scheme in 2015 the remaining were involved in the 2014 scheme and as such already had REM systems installed. The REM system fulfils the requirements of Article 15 of Council Regulation (EU) No 104/2015 in providing adequate means of monitoring the landing obligation. The REM system includes a GPS, sensors (drum rotation and pressure)

and CCTV cameras. The data from these are stored on a removable hard drive for later analysis by onshore observers.

6.6 percent of the hauls were reviewed for each hard drive selected. The hauls to be reviewed were chosen at random using an online random sequence generator (<https://www.random.org/sequences/>). Hauls were reviewed for any cod that were discarded i.e. cod that were seen to go over the end of the discard belt or be tipped overboard. The number of cod seen to be discarded were recorded along with any for which their fate is unknown. For example, fate 'unknown' would be used where a basket containing cod is taken out of view but is not seen again.

The weight of cod that were returned to sea contrary to the terms of the scheme was estimated. It was assumed that discarded cod were just below the legal minimum landing size of 35cm and a standard weight conversion was used ($\text{weight} = aL^b$, where $a=0.00952$, $L=34\text{cm}$ and $b=3$) (CEFAS, pers. Comm.) Cod seen to be discarded were uniformly relatively small. This, in conjunction with the quota uplift on the scheme and relatively high value of landings of this species, means that the assumption that discards were mostly below the Minimum Conservation Reference Size (MCRS) is considered to be a reasonable one. In fact, given that a proportion of the cod are likely to be less than 34cm in length, this method is likely to give an overestimate of discarded weight. Discarded cod were not measured for this audit as the overestimate provides for a more time-efficient audit tool. The same methodology was also used to estimate the weight of retained cod under the MCRS.

Camera performance was recorded for every haul reviewed. Firstly, whether or not the camera was 'working' fully, intermittently or not at all was recorded. Then, every camera was 'marked' using drop-down lists of categories which were:

- View
- Cleanliness
- Focus
- Lighting

The definitions used by reviewers for each option are shown in Annex I. The video quality review enabled the team to define the usability of the video data and also to provide more accurate feedback to industry when quality issues were due to lack of cleaning or similar issues.

In addition, overall data confidence was used for all analysis. This further measure was built into a custom Archipelago software configuration. Data confidence could be defined as either: High, Medium, Low or Unusable. The potential reasons for the data confidence selection are as follows: Crew catch handling, camera performance, view is obstructed, other, no selection. 'No selection' was used if data confidence was high as for high data confidence there were determined to be no significant issues with data. Data files containing analyst information were extracted into a Microsoft Access database for analysis.

The estimated weights of discarded cod were raised to an estimate of total discards by multiplying by a raising factor. The raising factor was calculated as: total number of hauls fished divided by total number of hauls sampled. The total estimated

discards were then calculated as a percentage of total catch, where “total catch” was taken from market sales notes. The amount of unmarketable cod (i.e. that below MCRS that was retained and landed) was then calculated using the same methodology. There was not a standard format used to record retained unmarketable cod on sales notes which made determining the weights landed difficult.

5.3. Methodology for 2015 grading data analysis

For the 2015 analysis, cod length measurements were taken from a sample of vessels. There were two main aims. Firstly, to verify lengths from REM footage against grading data from market sales notes; i.e. if these matched, it is a good tool to indicate compliance with the landing obligation. Secondly, to explore the potential for this type of data to be gathered as a representation of the size distribution of catch by the wider fleet and therefore act as a reference base to assess overall compliance levels.

Length measurements were taken for all measurable retained marketable and retained undersize cod in 46 hauls between April and September 2015 for seven vessels. These were taken using an inbuilt electronic calliper tool in the EMI analysis program. It was not possible to measure all fish as some were obscured from camera view by other fish or were curled up. All measurements for which data confidence was “low” (refer Annex I for definitions) were excluded from the final analysis as it was felt that these were unlikely to be accurate. In total, 19,978 cod were measured. However, 737 (3.7%) of these were not used for analysis as the data confidence was low.

The cod length measurements were then converted to weight using standardised seasonal equations from the Centre for the Environment, Fisheries and Aquaculture Sciences (CEFAS, pers. comm.). The seasonal equations take into account the fact that weight-at-length varies in cod due to seasonal factors such as spawning. The standard equation is $Weight = aL^b$ where:

- Quarter two equation for cod in Area IV: $a = 0.01029756$, $b = 3$, $L =$ length of cod
- Quarter three equation for cod in Area IV: $a = 0.010182945$, $b = 3$, $L =$ length of cod

These weights were then converted into Grades using the European standards. These standards are used at Peterhead fish market for grading where the majority of our landings took place. The equivalent weight of fish to market grades is given in Table 2 below.

Grade	Minimum weight (kg)	Maximum weight (kg)
1	7	N/A
2	4	7
3	2	4
4	1	2
5	0.3	1

Table 2: Weight range versus cod grade used in this report

Market grades calculated from the length measurements were then compared to sales note data for each of the vessel landings. That is, a comparison between estimated grade from length measurements and the grades of cod landed to the market. For the purpose of this analysis, any landings which were not graded 1-5 were excluded as it could not be certain what grade distribution these fish fell within and it may have falsely skewed the data.

Finally, the percentage of cod measured which were under the Minimum Conservation Reference Size (MCRS) was plotted by ICES Area. The plot was made using ArcGIS software and the ICES Sub Rectangle Dataset (available from: <http://www.ices.dk/marine-data/Pages/default.aspx>).

5.4 Industry questionnaire

In order to better the impact upon the industry of the scheme in 2015, an online questionnaire was designed and issued with the help of the MMO Communications Team. The questionnaire was made available on the online website “Survey Monkey” (<https://www.surveymonkey.net/>). A copy of the questionnaire issued is in Annex II of this report.

The questionnaire was sent to all of the vessel skippers and owners participating in the North Sea 2015 trial. The questionnaire covered the experience of the scheme from the industry perspective. It also aimed to understand what, if any, changes to fishing behaviour, gear use and target species had resulted from their participation in the trial. Finally, the questionnaire briefly touched on the introduction of the landing obligation and what impacts the industry felt this had had upon them.

6. Results

6.1. Sampling

Overall, there were 638 trips by participant vessels in 2015 where fishing took place and a logbook was submitted. Trips for non-fishing purposes such as guard duty were excluded from the analysis. 100% of trips were reviewed for levels of REM data integrity. Of the 638 trips the REM/CCTV data for 74 trips (11%) was considered unusable through data corruption or control box failures. A full audit of the scheme rules was carried out on 564 trips (89%).

In addition, as previously discussed, data confidence levels were developed to give a fuller picture of the quality of the data for trips subject to a full audit. Data confidence definitions are given in Annex I of this report. In total, data confidence was rated for 475 hauls within trips as 'useable'. The data confidence results are set out in Table 3 below. The 15 'unusable' hauls where no analysis took place were down to lack of cleaning leading to dirt obscuring camera the views and power fails within the control box resulting in either no or limited video for that haul. For occurrences where a haul was found as unusable a replacement haul was selected from the same trip.

Confidence level	No. of hauls	Percentage of hauls
High	289	59%
Medium	134	27%
Low	52	11%
Unusable	15	3%

Table 3: Data confidence

If data confidence was high, the quality of the data was not investigated further as this provided ideal conditions for the analyst. When medium or lower confidence was scored, the analyst was requested to provide the main reason for this. The results of this scoring are given in Table 4. The main issue in the vast majority of cases was 'camera performance'. This was mainly due to lack of maintenance or cleaning by the crew, but technical problems such as cameras becoming loose was a factor. Crew handling made up almost a third of performance issues and was mostly caused by the collection of fish outside of the available camera views.

Main reason for data quality issue	Number of hauls	Percentage
Crew catch handling	62	31%
Camera performance	96	48%
View is obstructed	24	12%
Other	19	9%

Table 4: Reasons given by analyst for less than high data confidence

6.2. Observed cod discards

Observers randomly selected hauls for analysis. The observed and raised discard weights are shown in Table 5.

Gear Type	No. hauls fished	No. hauls sampled	Discard quantity – observed (kg)	Raising factor*	Raised weight observed (kg)
TR1	7455	490	224.9	15.21	3420.7

Table 5: Weight of discarded cod observed. Raising factor (*) calculated as Hauls fished/Hauls sampled

Raised discards were also calculated as a proportion of the total catch, this is shown in Table 6 below. GN1 figures are based on skipper records and include cod that was damaged by predators or parasites.

Gear Type	Raised weight discards (kg)	Total catch (kg)	Proportion of total catch discarded at sea
TR1	3420.7	3058795	0.11%
GN1	249	41500.3	0.59%

Table 6: Proportion of discards as a proportion of total catch

The quantities of cod observed to be discarded were low and the vast majority of them were small fish. In most cases observers noted single or low numbers of small cod going over the discard chute during the processing of large catches where such fish had the potential to be easily missed by the crew.

The unmarketable proportion of Cod, which was identified as either below MCRS or too damaged to be sold, was recorded and compared with zero and low value sales notes as shown in Table 7 below. There was a close match between estimated unmarketable cod from our analysis from the TR1 vessels and from the sales notes, with only a two percent difference. However, there was a much greater difference for the GN vessel (29%). This difference is likely to be due to the fact that only a single GN vessel was sampled compared to seventeen TR1 vessels. In addition, the overall catch of below MCRS cod was a very low quantity meaning that a relatively small quantitative difference led to a larger percentage difference.

Gear Type	Total unmarketable cod from sales note (kg)	Unmarketable cod from REM analyst	Raising factor	Raised unmarketable cod (kg)	% difference between raised analyst and sales note
TR1	63532.8	4280.4	15.21	65104.8	2%
GN	294	25	15.21	380.25	29%

Table 7: Comparison of quantities of under Minimum Conservation Reference Size (MCRS) cod between MMO analyst estimates and market sales notes for TR1 and GN vessels

The estimated percentage of cod under the MCRS was then calculated as a percentage of total catch for 2015. This was 2.1% for the TR1 vessels and 0.71% for the GN vessel. These figures are far below the 2014 Science, Technical and Economic Committee for Fisheries (STECF) discard rates of 22.4% for TR1 vessels and 2.2% for GN vessels.

The process of determining which cod on sales notes were the retained below MCRS fish (or “unmarketable” cod) was difficult as there were inconsistencies in how these were recorded. Sometimes separate sales notes were produced, and other times these were shown on a single sale note with the total catch and often as low-value Grade 5 cod. This was despite the fact that these fish would not have been assigned Grades as they were not of a marketable size. During 2015 there was no facility in the Electronic Reporting System (ERS) hub for buyers to directly record landed undersize fish.

6.4. Grading data review

Grading data for FDF and non-FDF vessels has been compared. FDF vessels have consistently landed a higher percentage of Grade 4 and 5 cod. There has also been a notable increase in Grade 5 cod landed as a percentage of total catch. The data is shown in Figure 2 below.

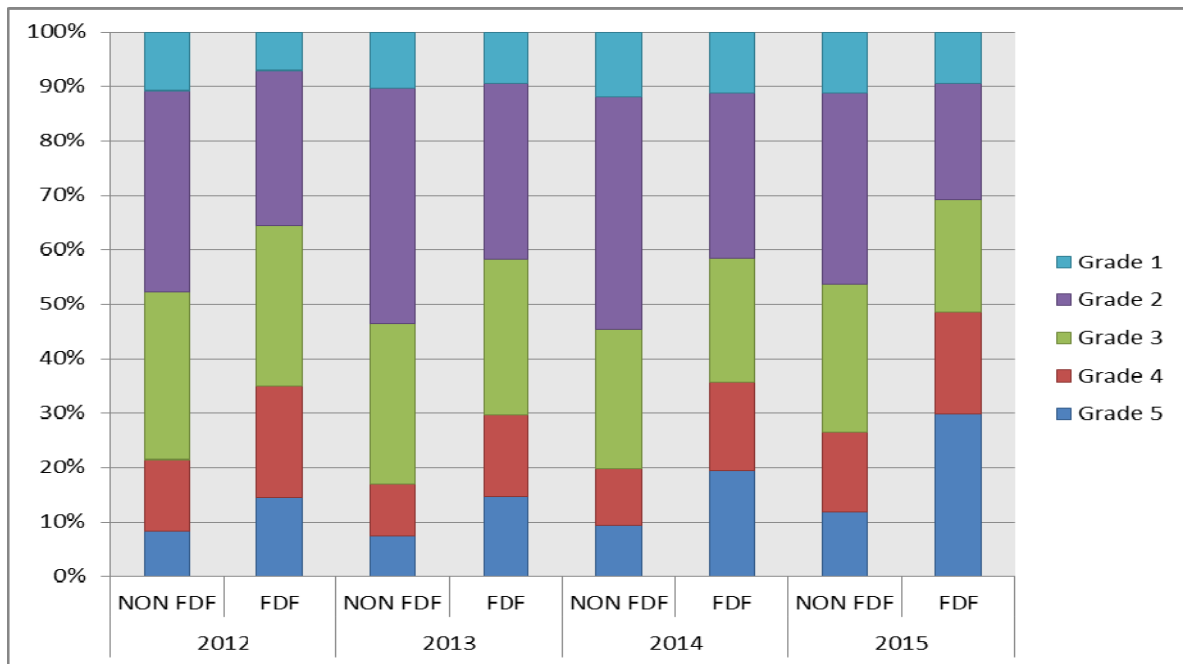


Figure 2: Sales note grading data comparison for FDF and non FDF vessels for 2012 to 2015.

All cod length measurements were plotted against the market grading data for those landings. As can be seen in Figure 3 below, the shape of the curve is very similar for both. The close correlation provides additional confidence that all cod caught and retained were landed and recorded for quota uptake purposes. There are small cod in the length measurements which are shorter than the minimum market grading length as all cod viewed were measured for chosen hauls. This meant that cod below the Minimum Conservation Reference Size (MCRS) would fall outwith the market grading scale, causing the tail on the left-hand side of the length-frequency graph.

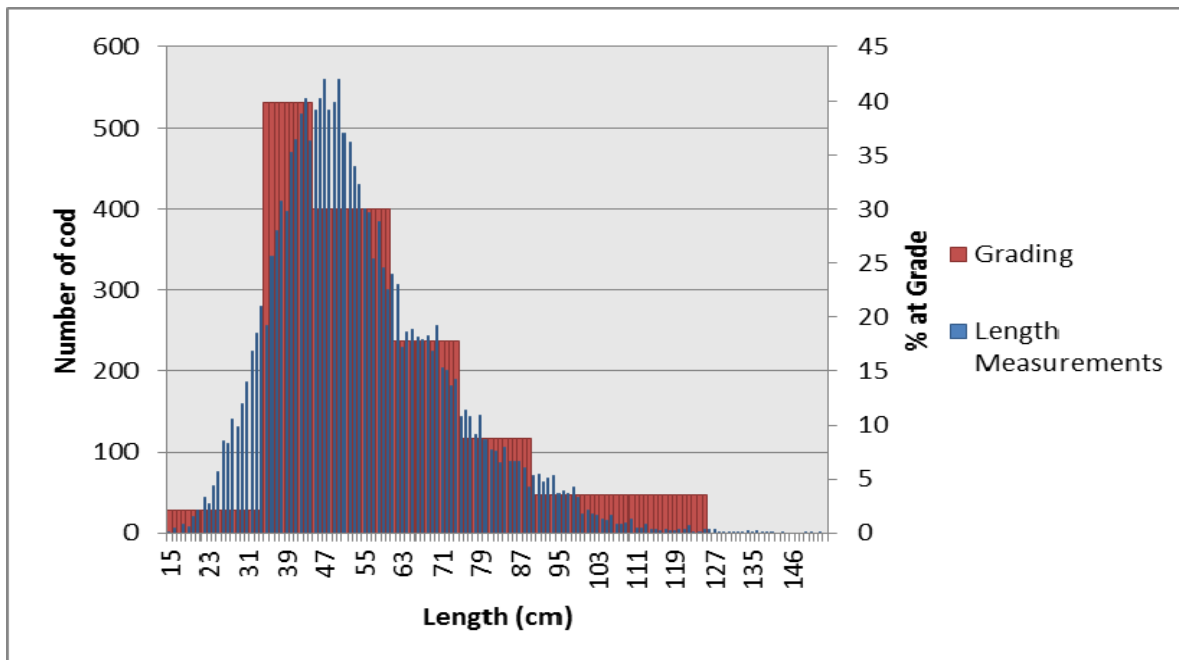


Figure 3: Comparison of cod length measurements taken from REM footage and data from landings (market grading data). The first red grading bar on the left represents the percentage of fish too small to be graded (2.1%), then (left to right) grades 1 to 5.

The data was then broken down to look at whether length measurements taken for individual trips remained comparable with grading data. Figures 3 and 4 show two example trips from vessels where different numbers of cod were measured. In Figure 4, 2740 fish were measured and the shape of the length-frequency curve is a good match for the market grading data. In Figure 5, 246 fish were measured and the shape of the length-frequency curve is a poor match for the market grading data. Further work would be required to identify the proportion of catch which would need to be measured in order to provide a true representation of the size distribution and sufficient confidence in compliance with the landing obligation.

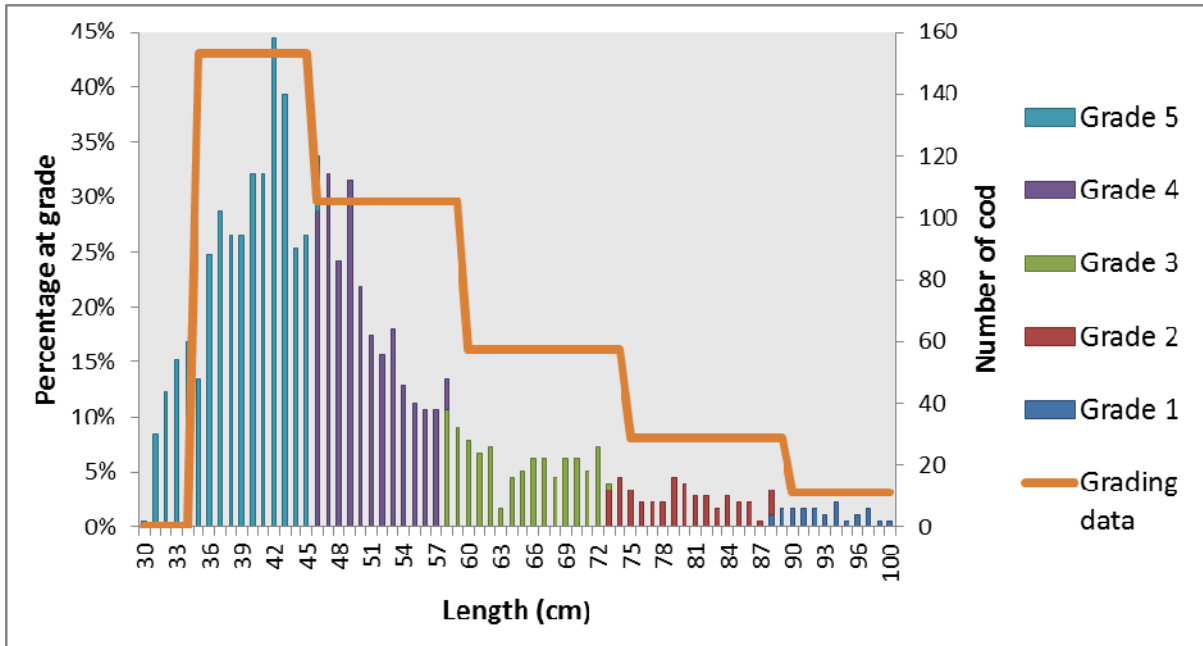


Figure 4: Individual trip comparison of length measurements versus grading data from market sales note. A total of 2740 fish were measured for this trip

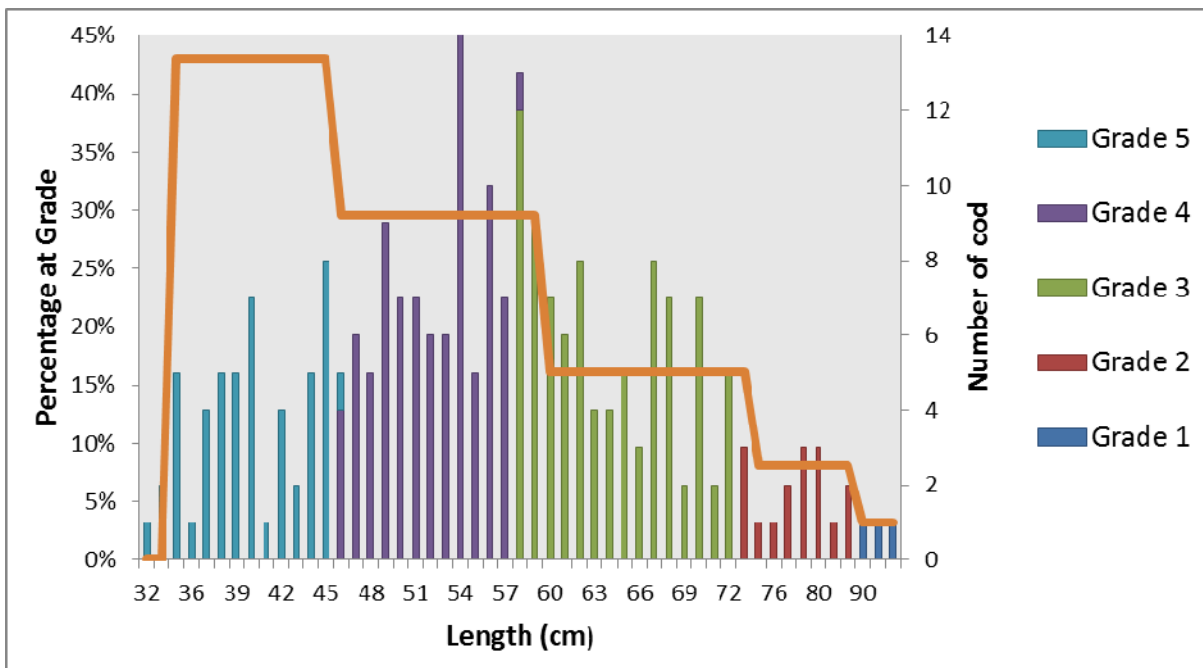


Figure 5: Individual trip comparison of length measurements versus grading data from market sales note. A total of 246 fish were measured for this trip

The percentages of cod at each grade from market sales notes and those calculated from length estimates were compared for each vessel for individual trips. There was not a consistent match between estimated and actual market grades at this fine scale. However, there was a consistent pattern of a higher percentage of grade 4 and 5 cod in the market sales notes compared to the REM measurements. The analysts undertaking this work reported that smaller cod were more difficult to

measure due to handling practices. Smaller cod were generally sorted out of the catch quickly into baskets or containers whereas there was a second viewing of larger cod as it went onto the fishroom belt.

Finally, the percentages of cod under the MCRS (35cm) were plotted by ICES Area. The results are shown in Figure 6 below. As Figure 6 demonstrates, the percentage of fish measured which were under the MCRS increased in inshore areas. The percentage decreased for areas further to the North and West. The area with the highest percentage of cod under MCRS was 43E9. Of the vessels sampled two fished this area and a total of four hauls were analysed. Although the amount of small cod increased in this area, the haddock catch was strong for both vessels and made up the majority of the money earned on these trips.

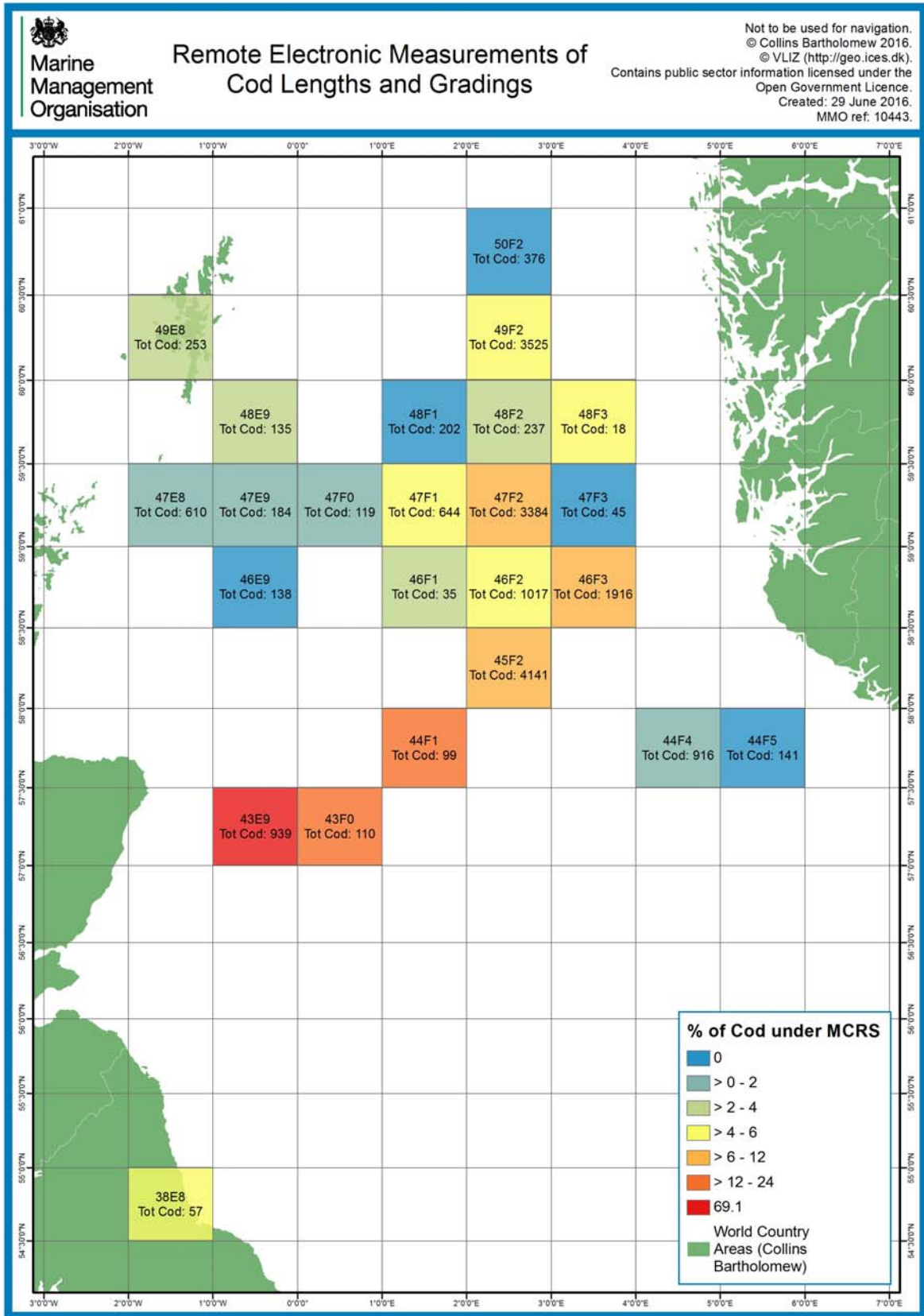


Figure 6: Percentage of cod under the Minimum Conservation Reference Size (MCRS) of 35cm in each ICES Sub-rectangle. ICES Sub-rectangle and number of fish measured for each shown on plot.

6.5. Industry Questionnaire

An online questionnaire was sent out to all fishing vessel owners and skippers who participated in the 2015 scheme. In total, there were seven responses: three skippers, two owners and two joint owner/skippers. A summary of the results from the questionnaire are given below. It should be noted that those responding were able to select more than one answer for each question and therefore the number of responses may exceed seven for some questions.

6.5.1. Target species

The respondents were asked to identify their main target species, the results of this are given in Figure 7 below. All identified cod as one of their main target species with saithe, haddock, plaice and anglerfish also important. Two respondents also identified lemon sole and hake as “other” key target species. All on the trial were also asked if being on the trial in 2015 had changed their target species. All respondents said that it had not.

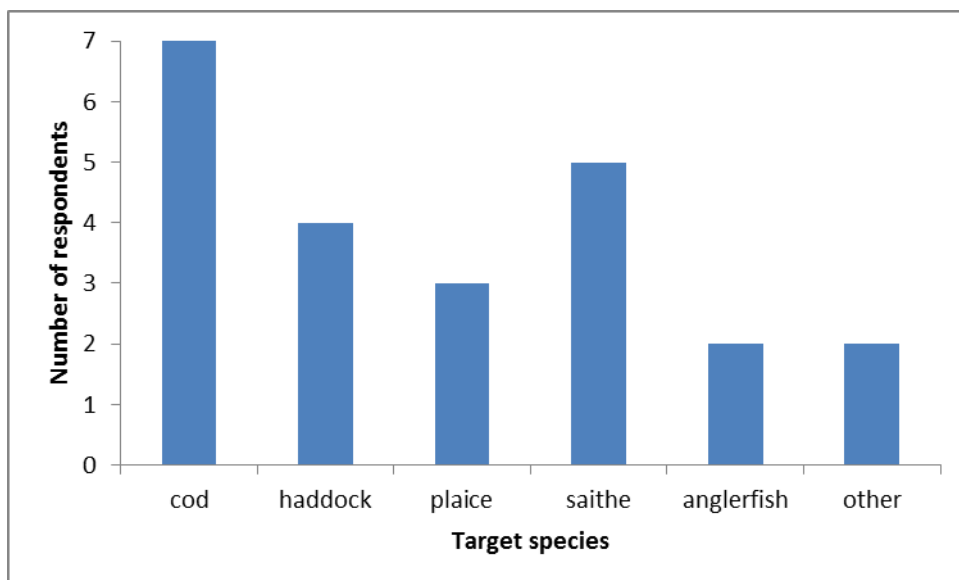


Figure 7: Main target species identified by respondents. All respondents identified cod

6.5.2. Impact of trial on catch and fishing behaviours

The respondents were asked about how the trial had impacted their overall catch. This had mixed responses with no clear preference. Three recorded diversification into other species. Two each replied that: there was an increase in their quantity caught, a decrease in discards, or no impact. One recorded an increase in discards although did not supply a reason for this. It is likely that this respondent was referring to higher discards of other species caused by avoiding cod. Finally, one respondent chose ‘other’ and said that the trial had led to them renting more quota.

Respondents were then asked what, if any, gear modifications they had made in order to avoid catching undersize fish. The majority identified that they had switched to using a larger mesh size. Three respondents also reported using a square mesh panel in the net. The respondents were also asked whether their participation in the trial had changed their fishing behaviour. The results are summarised in Figure 8 below. The main change in behaviour was an alteration in fishing area. The two respondents who had identified “other” behaviours specifically commented that they had changed areas specifically to avoid an abundant catch of smaller cod.

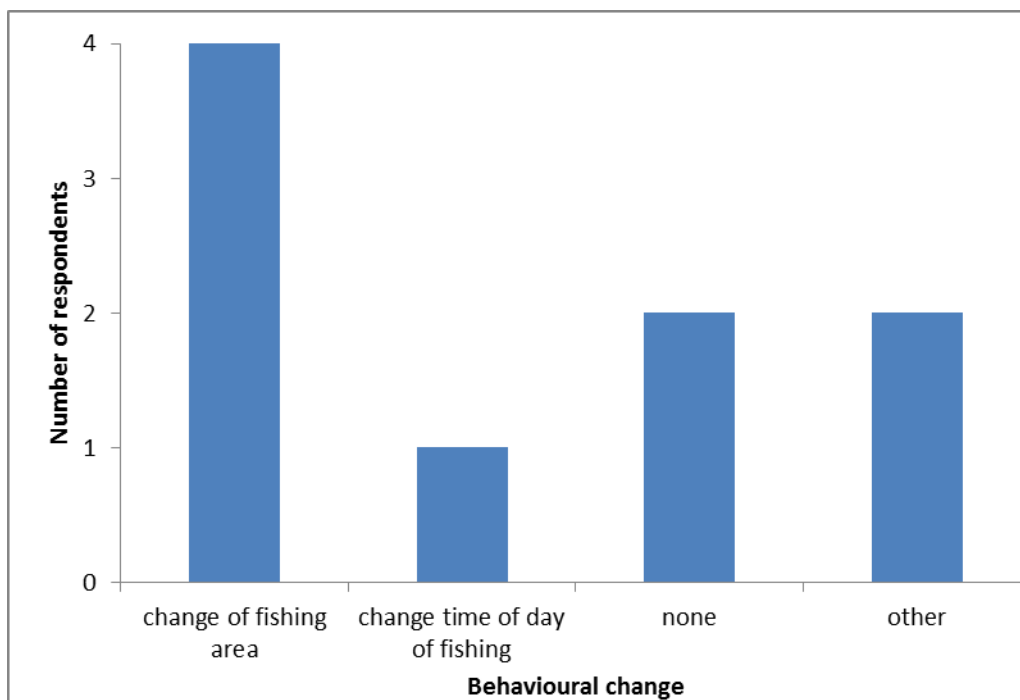


Figure 8: Changes in fishing behaviour due to participation in the trial

As part of the trial, all participants had to land all cod including those under the minimum conservation size. These would therefore count against their quota. The questionnaire therefore asked what arrangements they had in place for these fish which could not be sold for human consumption. Figure 9 below summarises the responses. Of the two that selected “other”, one commented that they put them on the fish market, the other highlighted that the majority went for creel bait.

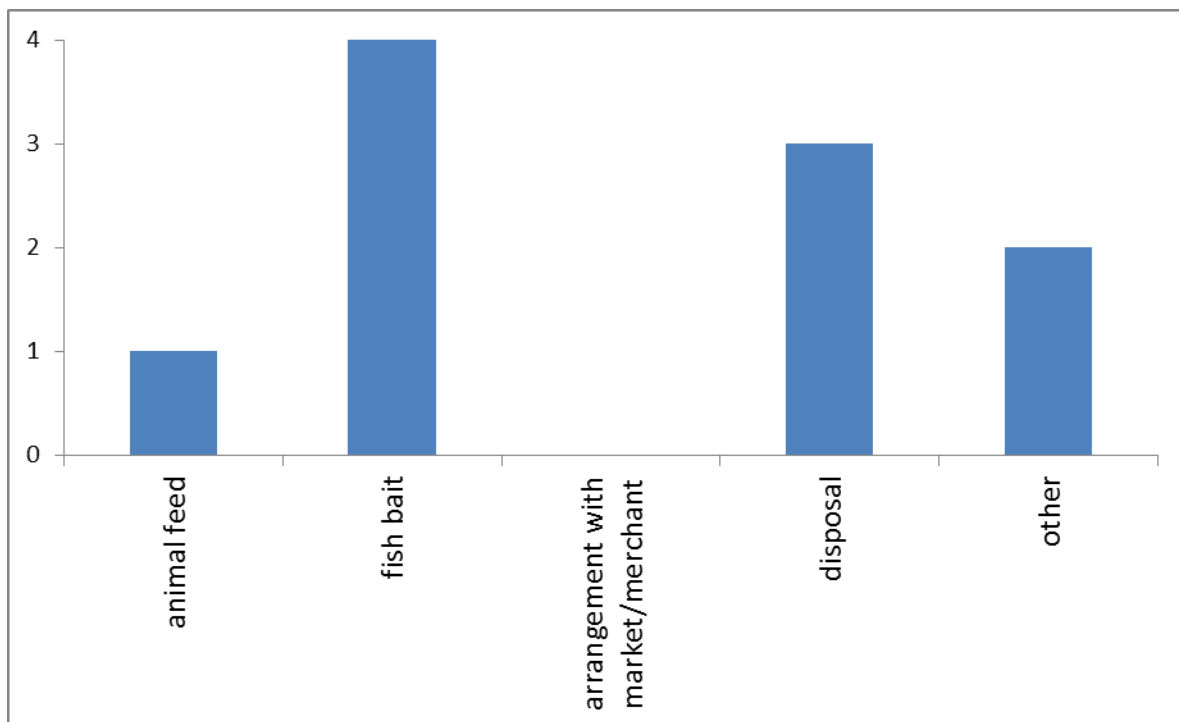


Figure 9: Arrangements for cod under the Minimum Conservation Reference Size (MCRS)

6.5.3. Costs and benefits of inclusion on the trial

Respondents were then asked several questions about the impact of the trial on their business. In terms of costs, there were mixed responses. The majority felt that there was no impact on fuel costs, but two respondents identified an impact. One had commented further saying that an increase in fuel consumption was due to changing area to avoid cod. Respondents were also asked about potential impacts on the overall profitability of their vessels. Four said it had had an impact and three said it had not. It is difficult to interpret this as only one provided an explanation. This was a positive comment saying that it had improved their profitability as it allowed them to fish more selective offshore grounds for larger fish and less discards.

Five out of seven respondents also felt that they had needed to lease more cod quota and one respondent reported higher costs for that quota. Comments provided were that cod quota leasing becomes an issue when fishing in areas with smaller cod and that one felt it had forced the price of cod quota to increase. Only one respondent identified no impact on their quota leasing. This was because they felt that they had improved their management of the quota that they already had.

Respondents were asked if there were any additional one-off or extra costs as a result of the trial. There was a mixed response with three saying yes, two saying no, and two who did not know. Of those that responded positively, extra fuel and the purchase of larger mesh nets to avoid smaller cod were identified as having led to extra cost.

The questionnaire also asked what the main benefit of participation in the trial was perceived to be. The responses are summarised in Figure 10 below. The majority of respondents felt that there was some benefit to them, with only two out of seven identifying no benefit. The main perceived benefits were in terms of ecological improvements and also to their reputation. One commented that it was also a benefit in trying to get North Sea cod up to MSC (Marine Stewardship Council) standards.

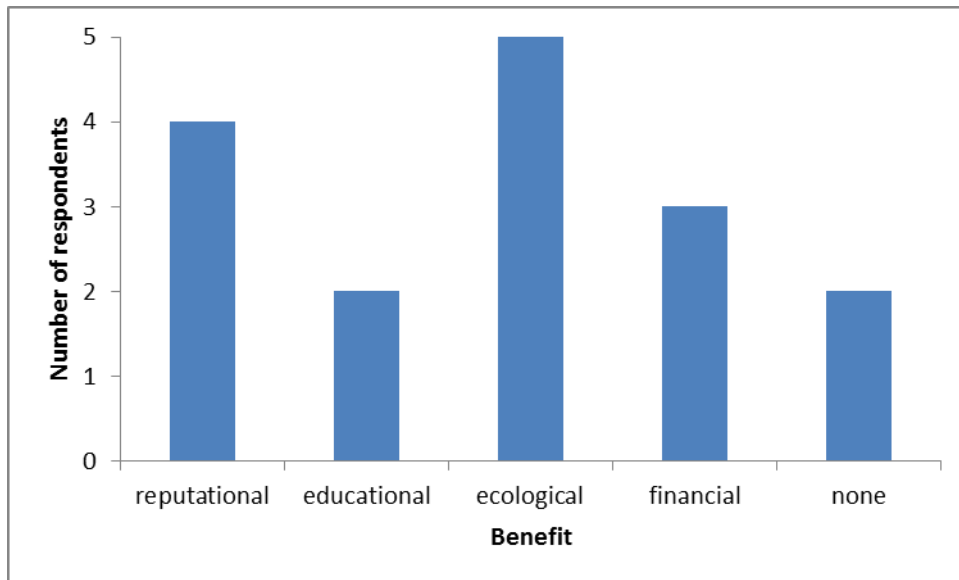


Figure 10: The main benefits of being on the trial

6.5.4. Equipment and trial management

The respondents were asked what equipment issues they had experienced during 2015. Six out of seven identified that cameras had broken. Two had suffered hard drive issues, one had wiring issues and one other had control box issues. Three selected 'other' – these were power failures, joint control box and camera, and did not know. It was expected that in 2015 the old systems (all of which are out of warranty) would suffer breakages and this confirms that.

All respondents were also asked if they had any suggestions for improvement or better management of the trial. The majority (6 out of 7) did not, one commented that he felt it was “proving its worth”. The one suggestion received was not relevant to the trial management but addressed concern over the method of distribution of Fully Documented Fishery (FDF) quota between the Scottish and English administrations.

6.5.5. Forward look

At the end of the questionnaire, respondents were asked about the introduction of the Landing Obligation and its perceived impacts upon them. Initially, they were asked how the Landing Obligation had affected them in 2016. Six respondents provided an answer to this. Three identified safety/working issues around the storage of undersize haddock. Two said that it had had little impact upon them so

far. The final respondent used this answer to express displeasure at the fisheries authorities generally but did not address the question.

Finally, respondents were asked about what impact they predicted the 2017 landing obligation would have on them. One did not provide an answer and another did but did not address the question. Of the other five, two said that they were unsure of what would happen. The other three raised various concerns around the storage of discards and vessel stability, an increasing difficulty as more species are included, and having to pay a high price for quota which only goes for fishmeal.

7. Discussion and conclusions

The review of REM data indicates that discards of cod from participant vessels during 2015 remained at very low levels (below one percent for both gear types). In addition, discards tended to be single or low numbers in hauls with large quantities of fish overall. This evidence suggests that observed cod discards were likely to be unintentional.

A review of the comparison of market grading data from landings with length measurements of cod taken using electronic callipers from REM footage found a good relationship. This provides further confirmation that the vessels on the scheme are not high-grading cod. This measure was however less accurate when individual trips were considered. Clearly, sufficient length measurements need to be taken to ensure a representative length-frequency distribution is achieved. Further work would be required to pinpoint what percentage of the catch would need to be measured in order to be considered an accurate representation of landings.

The findings give an indication of whether gathering data from a subset of a fleet can be assumed to be representative of the non-monitored segment and therefore provide an indication of levels of compliance across the entire fleet (generally referred to as reference fleet monitoring). A comparison of length measurement and market grading data demonstrated that a good picture of monitored vessels can be achieved using this method provided sufficient data is collected.

A consistently lower percentage of lower cod size-grades in landings by non-monitored vessels appear to be indicative of high-grading. However, further work should be undertaken to look into the reason behind these differences. Furthermore the length data clearly shows considerable spatial variance and this would need to be taken into account when assessing whether 'reference' data is representative of other vessel catch profiles. This in turn may require reference data to be considered representative within a defined geographical and temporal space.

In general, length data showed less of the catch consisted of juvenile cod when vessels fished further North and East. This demonstrates that spatial avoidance has the potential to decrease catches of below MCRS cod. The questionnaire responses indicated that this was one of the key methods used to avoid catches of smaller cod. In addition, the majority reported using larger mesh sizes or square mesh panels. The use of square mesh panels is mandatory for bottom trawling vessels in the northern North Sea using less than 110mm mesh (Commission Regulation (EC)

2056/2001). However, the majority of vessels on this scheme report 120mm or 130mm on their logbooks. Therefore, they are exceeding mandatory requirements.

Participants of the 2016 trial have reported concerns about fishing activity in the Turbot Bank area approximately 30nm west of Peterhead where they report an abundance of juvenile haddock and cod. This is consistent with length data reported here for 2015 where in the same area participant vessels' cod catch comprised of 70% undersized fish. For the area with the highest percentage of undersize cod, there were four separate trips from two vessels sampled in the area in 2015. Both vessels appeared not to avoid the high catches of undersize cod, with one returning to the area for a second trip. This may be due to the fact that the vessels appeared to be targeting abundant haddock which made the majority of income from the trips. This is however a very small sample and may not be indicative of overall trends.

Whilst the English scheme allows participant vessels to operate in areas closed because of high mature cod abundance they are required to respect any juvenile abundance closed areas. Juvenile closed areas can only be triggered through data collected by inspection services however. The ability to gather length data using REM suggests that the tool could also be used to corroborate reports of high cod abundance by fishermen. This suggests that vessels monitored using REM could be used as an effective trigger for generating real time closures which would then displace the wider fleet. This provides a novel method of information-sharing, in or close to real-time. Scientific research has recognised the requirement for real-time data in relation to RTCs and the Landing Obligation. There is currently significant research effort being devoted to obtaining closer to real-time data, for example Eliassen and Bichel (2016).

When considering the use of reference vessels in place of 100% monitoring a number of issues are raised. Criteria would need to be determined for the vessel selection process. Consideration would need to be given to the resource implications of a regular turnover of the fleet or indeed whether a more permanent arrangement is put in place where participation could be voluntary and with access to some level of incentive. Such a scheme would need to provide confidence of a level playing field and to ensure that unfair commercial advantage does not arise.

The disposal of undersize cod was reported by the majority of questionnaire respondents to be for animal feed or fish bait. These are traditional methods of disposal of unwanted or small fish by the industry. As more species are bought under the landing obligation in 2016 and beyond, it may be necessary for the industry to seek novel uses for such fish if quantities continue to increase. However, some was also being disposed of directly, although respondents to our questionnaire did not clarify the disposal method. Sending of undersize fish to landfill should be seen as a last resort and it is to be hoped that as greater quantities are landed, processors and others will develop new uses for this.

Our analysis did find that the undersize cod was being included on sales notes by vessels but tracking this was time-consuming and difficult as recording of undersize fish has not been consistent. Under MCRS cod is often recorded as Grade 5 (a marketable grade) with a lower price and separate line rather than being clearly marked as "bait" or "not for human consumption". Part of the issue is that the online

electronic sales note system currently does not have capacity to record under MCRS fish. Once this has been added, consistency may be improved as tracking improves.

The questionnaire highlighted that the majority of those responding (5 out of 7) had seen some benefit to them from participating in the scheme. Benefits to the environment and to their reputation were seen as the main positives. In addition, one further commented that this is helping them towards seeking MSc certification for North Sea cod. This shows that the industry are aware of their potential environmental impact and their public profile. The public are increasingly demanding sustainably sourced fish and produce from these fisheries may also demand higher prices.

There were however issues for some scheme participants around cod quota. The majority of respondents to our questionnaire reported that participation in the trial had led them to leasing in more cod quota. This need may have been exacerbated by the fact that participants did not receive the full FDF quota uplift for 2015. It is likely that this increased quota purchasing by the FDF vessels may also have impacted on non-FDF vessels as this would potentially lead to an increase in the demand for the available North Sea cod quota.

8. Forward Look

The trial continued in 2016. The first demersal North Sea species became subject to the landing obligation in 2016. For all vessels on the scheme, plaice and haddock were subject to the landing obligation. For one vessel only, saithe was also subject to the landing obligation. Compliance with the Landing Obligation is being monitored during the 2016 trial. The trial in 2016 is therefore moving more closely towards a truly “Fully Documented Fishery”.

8. References

Commission Regulation (EC) No. 2056/2001 establishing additional technical measures for the recovery of the stocks of cod in the North Sea and to the west of Scotland. Website:

<http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32001R2056>

(accessed 01/08/16).

Council Regulation (EU) No. 2015/104 fixing for 2015 the fishing opportunities for certain fish stocks and groups of fish stocks, applicable in Union waters and, for Union vessels, in certain non-Union waters, amending Regulation (EU) No 43/2014 and repealing Regulation (EU) No 779/2014. Website: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2015.022.01.0001.01.ENG (accessed 01/08/16).

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<http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=18902> (accessed 11/08/16)

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Stanley, R.D.; McElderry, H.; Mawani, T.; Koolman, J. 2011. The advantages of an audit over a census approach to the review of video imagery in fishery monitoring. *ICES Journal of Marine Science*. 68(8): 1621-1627.

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Annex I – Camera Working and Performance Definitions

	Complete	Incomplete	No video data
Camera Working	Video is recorded for entire event	Video present intermittently for fishing event	No video data for entire fishing event

Camera Performance	View	Clean	Focused	Lighting
High	Camera view shows area necessary for all species identification and or catch handling.	No water spots, moisture, scratches or debris on the camera dome that interfere with species identification or view of catch handling.	Focus is sharp and in the right area.	Light levels are ideal for species identification and view of catch handling
Medium	Camera View is a bit off but shows enough area for adequate species identification and following catch handling.	Water spots, moisture, scratches or debris on the camera dome make it challenging to identify all species and watch all catch handling but view is adequate.	Focus is adequate but identifying fish species is occasionally challenging as is following catch handling.	Lighting is adequate. Glare or shadow occasionally make it challenging to identify species and follow catch handling during the majority of the event.

Camera Performance	View	Clean	Focused	Lighting
Low	Camera View shows a lot of "useless" area, making catch handling difficult to follow or unable to identify all species. View should be readjusted.	Water spots, moisture, scratches or debris on the camera dome obscure several areas of camera view making species identification and catch handling challenging throughout most of the event.	Focus could be greatly improved. Identifying most fish species is challenging. Difficult to follow catch handling.	Glare or shadow makes it difficult to positively identify species and follow catch handling for the majority of the event.
Unusable	Camera view does not show enough or any of the area necessary to identify species and follow catch handling.	Water spots, moisture, scratches or debris on the camera dome block large areas of camera view, making species identification and following catch handling impossible.	Focus is so poor that species cannot be identified.	Camera image appears over exposed 'washed out' by light glare or pitch black from no light, unable to assess anything in picture.
Unknown*	?	?	?	?

* 'Unknown' refers to the fact that this cannot be assessed because the status is unknown. It is mostly used for when a particular camera is broken and showing a blank screen.

Annex II – Questionnaire sent out to industry