Monitoring of cod catches in Dutch otter trawls and seines

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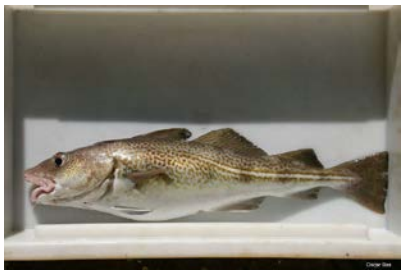

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Summary

This report presents the results of the Dutch Cod Monitoring Project in the bottom trawls and seines (TR), that was carried out in 2011 and 2012. The monitoring project was set up to monitor the cod catches in the different TR gears in order to have better and more detailed information of the catch per unit effort (CpUE) of cod. The Dutch government requested IMARES to set this up in order to arrive at a well-documented conversion factor of the days at sea (DAS) transfer between different fishing gears. This transfer of effort is needed due to the transition of the Dutch fleet from a predominant BT fleet to much more TR vessels. The conversion factor of transfer of DAS from the beam trawl (BT) segment to the TR segment is impacted by the Cod Recovery Plan.

The Dutch government developed the Dutch Cod Avoidance Plan, together with the fishing sector. This report answers two questions related to this Plan. The first is related to this transfer of effort. The second is about the percentage of trips in the TR fleet with less than 5% cod catches (5% rule). The outcome of the latter question is that on average 87% of the TR2 trips in 2012 have small cod catches (less than 5%) and overall more than 94% of the TR1C trips. The mean catch of cod in relation to total catch in 2012 in the TR2 fleet was 2% and 1% for TR1C. For 92% (TR1c and TR2) of the vessels in 2012, cod catches remained below 5%.

Concerning the first question, calculations in the Ex-ante evaluation of Seasonal, Real Time and Move-on Closures related to the Dutch Cod Avoidance Plan (Beare et al., 2011), showed that an exchange rate of 3:1 would fit the Dutch situation (as opposed to the 16:1 exchange rate as set by the European Commission). These calculations needed to be justified by monitoring data. As existing monitoring projects did not cover the TR gears adequately, a separate monitoring project was set up.

Due to high variations in cod catches more than fifty trips needed to be monitored. It was decided to do this via a self-reporting project. Fishers would themselves report their cod catches in kg per haul (<35cm>) on a weekly basis for at least a full year. The data derived from this self-reporting project would be analysed in relation to data from other sources, being the Dutch discard monitoring project carried out under the Data Collection Framework (DCF), the CCTV (camera) monitoring project and an extra set of observer trips.

This set-up, whereby different data-sources were used, did result in variation in the outcomes. Interpreting this variation however proved to be difficult as many sources of variation could be attributable to either natural, environmental variation and/or consistent sampling/reporting errors. Therefore, the data was analysed in such a way that this variation in CpUE estimates was minimized. For this a method was developed whereby an estimate of the quarterly cod discard:landings ratio ([kg discards, <MLS / kg landings, >MLS]) for each metier and monitoring project was calculated. These estimates were then applied to fleet-level Landings Per Unit of Effort (LPUE, in kg/kWday) based on the total landings (available from EU logbooks) and fishing effort per metier. This method, of calculating a discard estimate from the projects and setting that off against the LpUE's, could only be used if a lineair relationship could be established between cod landings and discards. This proved to be the case. In the end this method delivered CpUE estimates per respective metier, allowing for the calculation of an DAS ratio between BT and TR gears. By repeating this calculation a thousand times, taking the variation around cod discards:landings ratios into account, a standard deviation for the ratio estimate was estimated.

The results of the project indicate that the CpUE ratios between TR1C and TR2 on the one hand and BT2 on the other hand, were lower than 3. In general it has become clear that cod discards make up small proportion of the (relatively) small amount of cod catches.

This report ends with a discussion of the results, an evaluation of the project and some recommendations.

1. Introduction

In 2000, the International Council for the Exploration of the Seas (ICES) indicated that the stock of Atlantic cod in the North Sea was outside safe biological limits and in risk of collapse (ICES 2001). A recovery plan for cod in the North Sea was established by the European Council[1] with the aim to avoid the non-target capture of cod ('by-catch'). In this plan the transition of kW-days between gear groups, including TR (bottom trawls and seines) and BT (beam trawl)[2] was regulated, depending on the Catch per Unit of Effort (CpUE) ratio of cod between the respective gear groups. Exchanging BT days for TR days could not be a one on one transition but would need a conversion factor based on the premises that TR gears catch more cod than BT gears.

This transfer of kW-days is important for the Dutch fleet as it has gone through a major transition due to innovation of gears, resulting in the need for more days in the TR gear group than available. Therefore, the Dutch government proposed to shift fishing effort from the beam-trawl segment to the otter/pair/seine trawl segments (Table 1). Although cod is mainly a limited by-catch in the Dutch demersal North Sea fishery, the Cod Recovery Plan has considerable implications for this transition, as the European Commission set a conversion factor at 16:1 (16 kWdays BT2-effort can be exchanged for 1 kWday TR1-effort) and 5:1 (5 kWdays BT2-effort for 1 kWday TR2-effort).

In 2011, the Dutch government, together with the fishing sector, developed a cod avoidance plan. IMARES was asked to provide information on CpUE's of BT and TR gear groups which could be used to calculate a conversion factor between these gear groups. The research showed average cod-CpUE's of 0.06 kg/kWday in the BT2 group and 0.18 kg/kWday in the TR2 group (Beare et al. 2011). This would result in a conversion factor of 3, meaning that 3 kWdays BT2-effort can be exchanged for 1 kWday TR2-Effort. In the Dutch cod avoidance plan, the Dutch government distinguishes between otter/pair trawlers that are directed to cod (TR1AB[3]) and those for which cod is by-catch (i.e. TR1C and TR2). The sea-day transition would than only apply to fisheries with cod as by-catch (Table 1).

The European Commission asked the Dutch government to justify the 3:1 conversion of days-at-sea between BT2 and TR1C/TR2. To justify and confirm the calculations by Beare et al. (2011), extra monitoring data were needed. The Ministry of Economic Affairs[4] and fishing industry requested IMARES to carry out a monitoring project in which CpUE data on cod by metier would become available from a larger number of trips within the respective metiers. Existing monitoring projects at IMARES provided not enough observations of some gear groups to reliably estimate cod CpUEs. This report presents the results of the so-called cod monitoring projects of TR gears ('TRMON') which was established in 2011 in response to this request.

Gear category	Gear	Mesh size (range)	Comments
Otter/pair trawls and seines (OTB,OTT,PTB,SDN,SSC,SPR)	TR1AB	≥ 120 mm	Cod as target species
	TR1C	≥100mm - < 120mm	Cod as by-catch
	TR2	≥ 79 mm - < 100 mm	Cod as by-catch
Beam trawls (TBB)	BT2	≥ 79 - 120 mm	Cod as by-catch

Table 1. *Overview of metiers; gear categories, gears and mesh sizes of relevant Dutch demersal fisheries.*

[1] Council Regulation (EC) No 1342/2008 of 18 December 2008 establishing a long-term plan for cod stocks and the fisheries exploiting those stocks and repealing Regulation (EC) No 423/2004.
[2] And other gears (gillnets, trammel nets and long lines) which are not relevant for this report.
[3] Some fishermen fishing with a TR gear, 120+ mesh size are targeting plaice with cod as a minor by-catch.
[4] Formerly named 'Ministry of Economic Affairs, Agriculture and Innovation'.

2. Assignment

The Ministry of Economic Affairs asked IMARES in 2011 to set up a project to monitor cod catches (both landings and discards) in the Dutch TR fleet with the aim to:

i) estimate the CpUE (expressed in kilos of cod caught per days at sea (DAS) per TR metier; and

ii) compare those with the CpUE in the BT fleet (based on monitoring of this fishery under the European DCF); and

iii) calculate the percentage of trips in the TR fleet (TR2, TR1C), with less than 5% cod catches in relation to the total catch (this is referred to as 'cod avoiding fishing trips' in the Dutch cod avoidance plan).

3. Material and methods

Catch per unit of effort of cod was estimated based on the following information: reported amounts of cod landings available from registered logbook records, the ratio between kg discarded to landed cod were available from three different monitoring projects: 'TRMON', 'DCF' and 'CCTV' monitoring projects (Table 2); which are briefly introduced in the following sections below. Fishing effort expressed as kW DAS was available from registered logbooks.

The number of cod-avoiding fishing trips (with <5% cod caught out of the total catch per fishing trip) was estimated as follows. First, using EU-logbook data, it was calculated per metier what the cod- and total landings are per fishing trip. Then the cod-discards per metier are estimated by using the discard percentages of cod (this report). The discards of the other species in the landings are calculated using discard percentages based on estimates from DCF (Data Collection Framework) data per metier. In the next step total catches are calculated (discards + landings) and finally it was determined per metier what the fraction of cod-avoiding fishing trips is with cod-catches less than 5% of the total catch.

MONITORING PROJECT	**METIERS**					
	TR1AB	**TR1C**	**TR2**	**BT2**	**Data collector**	**Source**
TRMON_Self (self-reporting)	X	X	X		Crew-member[1]	Logbook
Data compared with						
TRMON_obs (Observers on 8 trips)		X			Research[1] staff	Samples
DCF	XX	XX	X	X	Crew-member[2]/ research staff	Samples
CCTV	X	XX	XX		Crew-member/ CCTV & research staff[3]	Logbook/CCTV images[3]

Table 2. *List of monitoring projects and metiers for which either sampled or self-reported logbook data of cod catches were available. X indicates the availability of data at the start of the TRMON project in 2011. XX indicates that data became available later on, after the TRMON project was set up.*
1 As part of the TRMON cod monitoring project, on the majority of trips, crew members quantify and self-report in logbooks the amount of kg cod discards and landings, and total catch of cod per haul.
2 As part of the DCF monitoring, skippers/crew-members collect and retain samples of discards for subsequent sorting and analysis at the laboratory by research staff.
3 CCTV images are collected to validate self-reported logbook quantities of cod catches by the skipper.

3.1 Cod monitoring project (TRMON)

The 'cod monitoring project' (TRMON) was set up in 2011 by IMARES after a request by the Ministry of Economic Affairs to set up a project to monitor cod catches (both landings and discards) in the Dutch TR fleet. While reported landings and effort are relatively accurate and precise, estimates of discards may be inaccurate, biased and imprecise, especially if they are based on a limited sampling project and very low numbers of cod in the catch. This is the case for TR trips. Discard sampling by observers is expensive. Therefore the number of sampling trips is restricted and mainly focused to beam-trawl fisheries which constitute the major demersal fishery by the Netherlands.

To improve the precision of discard estimates of the TR fleet, and also to expand the monitoring to previously not so well covered TR metiers at IMARES, the TRMON project was set up. As a first step, it was necessary to determine the minimum number of trips that were needed to be monitored to obtain sufficiently reliable estimates of cod discards. This depends on variation in cod catches, in particular of discarded fractions (presence/absence of undersized cod) between trips. If discarded amounts differ greatly between trips, more trips need to be sampled to improve precision of discard estimates.

Historically, a limited number of TR trips had been carried out resulting in limited information on cod discards in TR gears. Six trips were monitored between 2007 and 2008 on board otter trawlers targeting *Nephrops*. Extrapolating from the variation that was recorded in the amount of cod discards (weight) in these trips, at least 50 trips per year per TR segment must be monitored to reduce the coefficient of variation of the discard estimate to <20% (Figure 1).

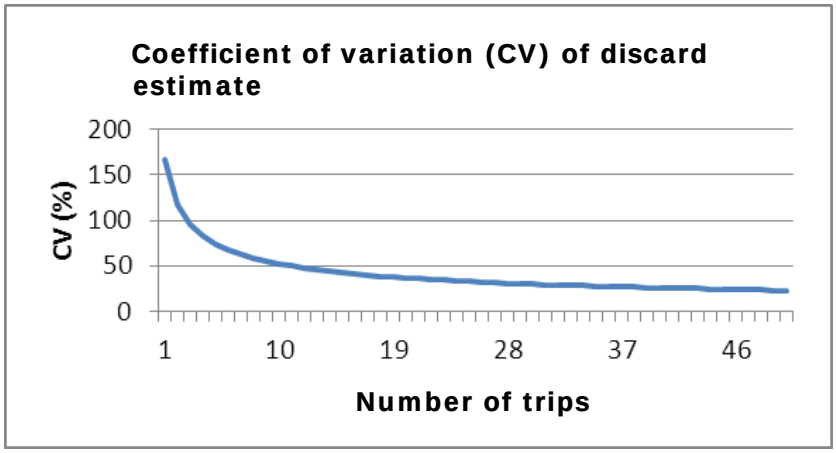

Figure 1. *Coefficient of variation (CV; CV=SE/mean*100%; where SE=SD/√n) of estimated kg discard weights of cod in relation to the number of sampled trips. Extrapolated from data of a monitoring project in the Dutch otter-trawl fishery for Nephrops (2007-08).*

To monitor at least 50 trips with TR gears, it was suggested to set up a self-reporting 'cod monitoring project' (TRMON), where fishers with TR gears monitor their catches (of both quantities of cod landings and discards) in each haul they make. The Ministry and fishing sector agreed to this idea, under the condition that all vessels using the TR1 or TR2 gear[5] participate in this project.

The project started in July 2011 (week 28). All fishers active in the TR-segments were provided with data forms for cod catch registration and via the Dutch fishermen's organisations ("VisNed" and "de Nederlandse Vissersbond") they were instructed how to sample and register the data. Ideally, after every trip these forms were sent to IMARES where their data were processed further.

After a few weeks, it turned out that the initial catch registration form demanded too much time for the fishers to fill out whilst being busy sorting the catch. Therefore, the data form was adjusted and used from week 46 of 2011 for a whole year until week 46 in 2012.

The revised and simplified data form allowed for registering cod catches in kg per haul; split up by marketable (>35cm) landing- and undersized (<35cm) discard categories. In addition, kg weights of cod landings per trip are registered per market category length classes (1-5). Also 'further info' such as the engine power and mesh size must be registered. Figure 2 shows the data forms as provided to the fishers.

[5] Vessels participating in fully-documented fishery trials (i.e. 'Close-circuit-TV/CCTV electronic monitoring') were exempted.

Figure 2A)

CATCH IN KILO'S PER HAUL

haul	date	position setting net lat	long	duration haul	total cod catch (kg)	marketable cod (kg) (>35cm)	undersized cod (kg) (<35cm)
1							
2							
3							

Figure 2B)

COD LANDINGS PER TRIP

cod landings per market category (per trip) in kg					
1	2	3	4	5	
				sub I	sub II
(>88cm)	(72-88cm)	(55-72cm)	(46-55cm)	(40-46cm)	(35-40cm)

FURTHER INFO

Vessel nr.	
Vessel (code)	
Engine capacity (HP)	
Type of gear	
Mesh size	
Main retained species	

Figure 2. *Revised and final data form used by the fishers from week 46 2011-week 46 2012 (translated from Dutch into English for this report). Part A): weights of total cod catches per haul (in kg), and the marketable (>MLS) and unmarketable fractions (<MLS). Part B): additional information of cod landings by market category per trip (in kg) and general information about the vessel and gear.*

3.2 DCF monitoring project (DCF)

In the European Union, the collection of discard data at-sea is enforced through the Data Collection Framework (DCF). In 2009, the DCF introduced the metier (fisheries) concept. The metiers which rank highest in annual quantity of landings, effort or value of the catch should be selected by the Member State for sampling. The introduction of the metier concept required to increase sampling effort for discard significantly in order to comply with the DCF. This lead to the introduction of a self-sampling project carried out by the fishing sector coordinated by IMARES. The self-sampling is carried out by reference fleets representative for the metier. Samples are taken from the discard fraction for the catch by fishermen (according to a sampling protocol) and brought to port. There, the samples are collected and further processed by IMARES. In addition a limited observer discard sampling trips was maintained in order to be able to detect bias in the self-sampling results. The self-sampling project led as a consequence of a considerable increase in sampling effort of some metiers, to an increase in the temporal and spatial spread of sampling compared to the 'traditional' observer-based sampling. Between 2011 and 2012, DCF sampling covered BT2, TR2, TR1C and TR1AB gears (in order of decreasing sampling effort; Table 3).

3.3 CCTV - monitoring project (CCTV)

The utility of CCTV cameras to fully document catches of cod was tested on board of five vessels representing TR1AB, TR1C, and TR2 gear groups in a pilot study (Helmond et al. 2012). Skippers were asked to register and self-report kg catch weights of cod below and above MLS (similar to the self-reported data sheet in the TRMON project, see Figure 2 above). Cod catches were aggregated over fishing days and weeks, because this was the lowest, achievable level of aggregation. All participating vessels were equipped with an electronic monitoring system of hardware (CCTV cameras and sensors) and software components which logged all fishing operations during a trip. The data were downloaded from portable hard drives and processed at the research laboratory. An IMARES staff member screened the CCTV camera footage and noted the number of cod below and above marketable size. Based on length-weight relationships, numbers-at-length were converted into kg weights. These estimates were used to validate the self-reported cod catches. After screening all footage was destroyed. To make

comparisons with discard/landings weights from the cod monitoring project, we used validated logbooks of cod landings and discards of vessels participating within the CCTV monitoring project.

3.4 Comparing data from the 'cod monitoring' with DCF and CCTV monitoring projects

Introducing a new sampling technique (i.e. on board separation of cod into discarded and retained weights and their self-reporting – TRMON) requires its direct comparison against other, established sampling techniques. Such an approach requires, that beyond the two different sampling techniques, any other source which potentially introduces variation in the outcome needs to be controlled in a way that it affects the results to the same extent. For example in the CCTV project, camera-recorded counts of discarded and retained cod were compared against self-reported counts/estimates from the same day/operation. Although the design of the 'cod monitoring project' did not allow for such direct comparisons of results between new and established sampling techniques, we, nevertheless, compared results from cod monitoring trips with those from other trips of the DCF and CCTV monitoring projects of the same metiers; to give some indication on the level of deviation between self-reported and observer-monitored data. Because there were no comparable data for the TR1C segment at the beginning of the TRMON project, additional observer trips were done to produce data which were used for comparisons. Ten observer trips were planned of which 8 were carried out in the second and third quarter of 2012. The season in which fishermen use TR1C is not long, and in many weeks towards the end of the season fishers use 120+ mesh (TR1AB) as well as 100-119mm mesh (TR1C) in a trip. Observers followed the same sampling protocol as fishers used for their self-reporting of the kg weights of undersized or sized cod per haul, and additionally measured the length of all cod. Representative sub-samples were taken, if there were too many cod among discarded and/or retained fractions.

When comparisons are being made of cod discard/landings ratios derived from different methods, it should be considered however, that any deviations may be attributable to either natural, environmental variation and/or consistent sampling/reporting errors. Furthermore, setting a level of 'acceptable' deviation is also difficult. Table 2 summarises the list of monitoring projects and where some overlap in monitoring the same metier existed. For example, trips in the TR1AB, TR1C and TR2 segments were monitored in all cod, DCF and CCTV projects, whereas BT2 was only monitored in the DCF project (Table 2).

3.5 Data analysis

To minimize the variation in CpUE estimates between the different projects, we applied the estimates of the quarterly cod discard:landings ratio obtained by the monitoring projects to the LPUE calculated from EU logbooks. We did this separately for each metier and also separately for each discard information source. Logbook reported landings per quarter were multiplied with the discard percentages taking the variation (based on their mean and standard error) into account, resulting in estimates of discards and -summed with landings- catches per quarter. These catches per quarter were summed, resulting in aggregated catches over the whole period. This was divided by the total effort, resulting in CpUE estimates. These CpUE estimates per respective metier allowed for the calculation of an effort ratio between BT2 and TR gears. By repeating this calculation a 1000 times a standard deviation for the ratio estimate was generated.

In line with ICES working group procedures, fishing effort was expressed as the days spent at sea times the kw power capacity of the vessel. Landings weights were available from logbook-reported records (IMARES VISSTAT database, provided by the Ministry). Catches of cod (in kg: total, <MLS, and >MLS) were summed over all hauls per sampled trip. For all trips, where cod landings were made, a ratio was calculated between the total trip weight of cod discards and landings. From these trip-level ratios, an average (±SE) was calculated per quarter, metier and monitoring project for the period week 46, 2011 until week 46, 2012.
This approach, of applying a cod discard percentage, derived from the monitoring projects, to LpUEs to estimate CpUEs, gives greater importance to the bulk of the data (the landings) which also is the most accurate information available. Via this approach variability in catch per unit effort estimates is relatively

small, even if there is some variability in the estimated discard:landings ratios. However, to justify this approach, we needed to investigate whether there is a linear relationship between cod landings and discards. This would demonstrate that with increasing amounts of landings, the amount of discards also proportionally increases.

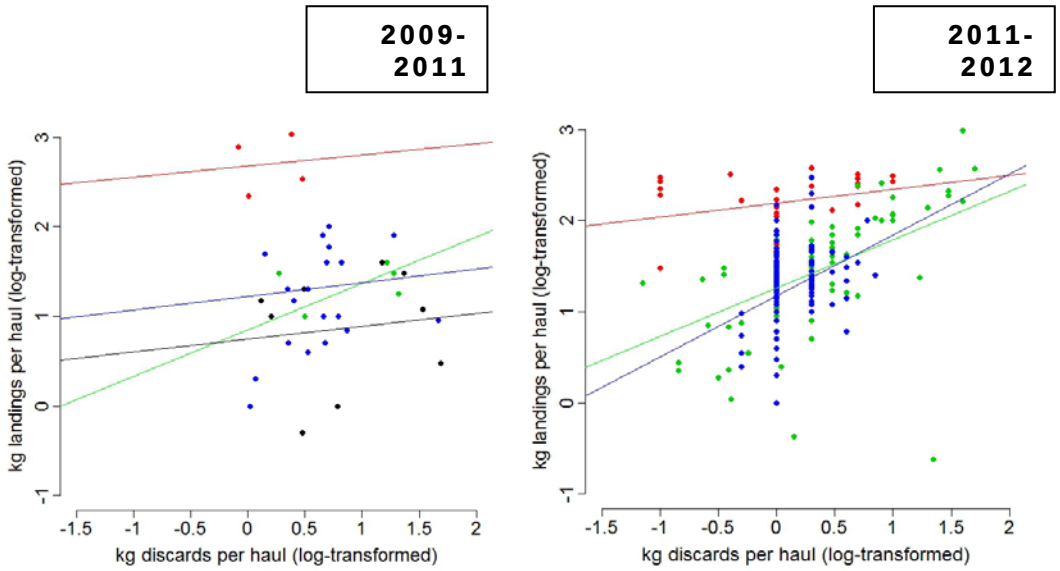

Figure 3. *Relationships (linear regression) between log-transformed kg weights of cod landings versus discards for sampled hauls during either self-reported, observer- or self-sampled trips of the cod and DCF monitoring projects over the periods 2011-2012 (right) and 2009-2011 (left), respectively. Red, TR1AB; green, TR1C; blue, TR2; and black, BT2.*

4. Results

Over the sampling period (week 46, 2011-week 46, 2012) approximately 300, 425, 1400 and 4500 fishing trips in the TR1AB, TR1C, TR2 and BT2 segments, respectively, were officially registered in the national database. However, for about 16% of the trips with TR gears information on cod catches was available and submitted/self-reported by the fishers. If we calculate the coverage excluding the CCTV vessels (which weren't obliged to participate), the coverage is 21%. The sampling coverage was thus well below the 100% as agreed upon at the beginning of the cod monitoring project.

From 345 TR trips, records of cod catches were self-reported by 40 vessels. Nevertheless, for the TR1AB and TR2 segments >50 trips were reported which was above the target to achieve, but despite this coverage, desired coefficients of variation of <20% were rarely achieved (Table 3); because between-trip variation was greater than was expected from the observed trips in 2007-08 (Figure 1). For all, but the BT segment, comparable data are available from at least two different sampling projects (Table 3).

Fleet	Project	Source	Vessels	Trips	Hauls	Cod hauls
TR1AB	TRMON	Logbook	7	64	570	562
	DCF	Self sampled	1	3	6	6
	CCTV	Logbook	7	92	n/a[6]	n/a
TR1C	TRMON	Logbook	10	37	855	195
	TRMON	Observer	8	8	162	75
	DCF	Self sampled	5	17	31	18
	CCTV	Logbook	3	29	n/a	n/a
TR2	TRMON	Logbook	23	244	4061	1628
	DCF	Self sampled	6	21	66	51
	CCTV	Logbook	4	40	n/a	n/a
BT2	DCF	Self sampled/ Observer	34	138	494	82

Table 3. *Number of sampled vessels, trips and hauls in each metier and monitoring project. The source of reporting refers to whether data were either self-reported or sample-based for the period 2011/2012 (database query November 2012). The number of sampled hauls were further divided into the number of sampled hauls with cod catches (excluding those with zero catches).*

4.1 Proportion of discarded cod per metier

Among the sampled trips, the amounts of discarded cod are typically fractions of the amounts of cod landings, on average 15%, but ranging between 0 and up to 260% in some quarters and sampling projects (Table 4). In quarter 3, there were two TR2 trips monitored in the DCF programme, with an unusually large amount of discarded cod (up to 600 kg) compared to their landings (between 60 and 130 kg) which contribute to the relatively large average discard:landings ratio of 260% in this stratum. In the cod-directed fishery (TR1AB), discard quantities were lowest, in the TR2 segment during DCF monitoring the highest in relation to landed quantities (Table 4).

[6] In the CCTV project data were aggregated at day / trip as opposed to haul level.

Metier	Year	Quarter	Project	Trips	Mean discard percentages	SE
TR1AB	2012	1	CCTV	15	0.57	0.4
		1	TRMON.SELF	36	0.14	0.1
		2	CCTV	15	5.34	1.2
		2	TRMON.SELF	5	0.00	0.0
		3	DCF	4	0.14	0.14
		3	CCTV	22	9.80	4.8
		3	TRMON.SELF	n/a	0.19	0.1
	2011	4	CCTV	16	7.72	5.3
		4	TRMON.SELF	22	0.42	0.3
TR1C	2012	1	CCTV	n/a	10.19	9.2
		1	DCF	n/a	4.03	3.0
		1	TRMON.OBS	n/a	18.19	10.0
		1	TRMON.SELF	n/a	2.80	0.8
		2	CCTV	1	0.00	0.0
		2	DCF	5	31.66	23.42
		2	TRMON.OBS	4	17.78	10.3
		2	TRMON.SELF	11	2.88	1.2
		3	CCTV	10	20.38	18.4
		3	DCF	2	0.00	0.0
		3	TRMON.OBS	4	18.60	9.8
		3	TRMON.SELF	9	5.51	1.2
	2011	4	CCTV	n/a	10.19	9.2
		4	DCF	1	0.00	0.0
		4	TRMON.OBS	n/a	18.19	10.0
		4	TRMON.SELF	3	0.00	0.0
TR2	2012	1	CCTV	12	0.58	0.3
		1	DCF	5	10.69	6.49
		1	TRMON.SELF	69	1.17	0.4
		2	CCTV	9	11.74	11.0
		2	DCF	10	66.31	27.05
		2	TRMON.SELF	57	0.65	0.2
		3	CCTV	n/a	6.16	5.7
		3	DCF	5	259.71	185.48
		3	TRMON.SELF	49	0.94	0.3
	2011	4	CCTV	n/a	6.16	5.7
		4	DCF	2	14.12	13.00
		4	TRMON.SELF	18	0.28	0.2

Table 4. *Mean discard percentages (±SE = standard error) by metier, monitoring project and quarter (quarter 4, 2011 until quarter 3, 2012). Sampling projects included CCTV: electronic video monitoring, DCF: observer or self-sampled trips of the DCF, TRMON: TR monitoring with either observers (OBS) or self-reporting (SELF). Rowsin grey: n/a, no samples were available for this quarter. In that case, an average over the available quarters was used.*

4.2 Cod landings and effort

In total, 1893 tonnes of cod were landed by the Dutch fleet categories TR1AB, TR1C, TR2 and BT2 in the period 2011-Q4, 2012-Q3 (Table 5). As expected, the cod-targeting fishery TR1AB landed much more cod than TR2. Landings seemed to increase in quarter 1 (BT2) and quarter 3 (TR1A).

Fishing effort and LpUE by metier are shown in Table 5. Effort by TR1 is generally concentrated during quarters 2 and 3. LpUE of cod in TR1AB was highest and lowest in BT2. Comparing the total LpUE of BT2 with those of TR2 and TR1C shows that cod LpUE in TR gears is twice as high. Taking the seasons into account, it is clear that there is seasonal variation (varying between almost similar cod catches in Q1 2012 to 12 times as high in Q2 2012).

	Landings (t)					Total effort				LpUE			
Q	TR1 AB	TR1 C	TR 2	BT 2	Total	TR1 AB	TR 1C	TR 2	BT 2	TR1 AB	TR 1C	TR 2	BT 2
4	51	16	29	256	351	25	58	501	5981	2.05	0.27	0.06	0.04
1	104	7	51	540	702	42	65	519	6130	2.47	0.10	0.10	0.09
2	185	34	63	57	339	185	428	518	4982	1.00	0.08	0.12	0.01
3	346	46	47	62	501	135	628	556	4969	2.55	0.07	0.09	0.01
Total	685	102	190	916	1 893	388	1179	2093	22061	1.77	0.09	0.09	0.04

Table 5. *Total cod landings (t), effort (1000 KW days) and landings per unit of effort (LpUE) by metier (TR1AB, TR1C, TR2, and BT2) in the Dutch fleet. Based on the period from quarter 4, 2011 - quarter 3, 2012. Source: EU logbooks.*

4.3 Catch per Unit of Effort by metier

Estimates of cod CPUE were derived by adding a fraction of discards to the known amount of landings. This approach can be justified as a a linear relationship between the amount of discards and landings has been established (figure 3). Cod landings and fishing effort for the respective fleet categories and quarters were selected from the EU-logbook database (table 5). Based on the estimated quarterly discards:landings ratios (table 4), corresponding cod catches and CpUE could be estimated (table 6).

The estimation of CpUE's was done using the results of estimated discards:landings ratio per monitoring project separately. The range of estimated values, between monitoring projects, was too large to use one overall average discards:landings ratio per metier. Therefore an iterative procedure (n=1000) was used whereby quarterly catches were calculated from quarterly landings and quarterly mean discards:landing ratio's with their standard errors.

The discards:landing ratio in a single iteration was drawn randomly from a normal distribution using the observed mean and standard error as input. By summing the quarterly catches an overall CpUE of the fleet and BT2 were derived by dividing with the summed effort. Finally an estimation of the CpUE ratio (table 6) could be calculated including its variation (due to the different monitoring projects) whereby also the seasonal variation has been taken into account. For each of the TR metier, an average annual CpUE of cod was estimated based on, at the most, four different sources of data. This resulted in an estimate by metier and project (Table 6).

Our results (ratio column of table 6) confirm that the CpUE ratios between TR1C and TR2 on the one hand and BT2 on the other hand, were smaller than 3 (Table 6). The CpUE ratio between TR1AB and BT2 was considerably higher (Table 6). In general it has become clear, from the various monitoring projects, that cod discards make up a small proportion of the (relatively) small amount of cod catch.

Gear	Monitoring project	Catch (t)	Effort (kW DAS)	CPUE (kg/kW DAS)	Ratio to BT2	StDEV Ratio
TR1AB	TRMON_SELF	686442	387721	1.77	25.43	3.15
	CCTV	733737	387721	1.89	25.41	3.20
TR1C	TRMON_OBS	120559	1178639	0.10	1.34	0.12
	TRMON_SELF	105652	1178639	0.09	1.34	0.12
	CCTV	113610	1178639	0.10	1.34	0.12
	DCF	116146	1178639	0.10	1.34	0.12
TR2	TRMON_SELF	191945	2093113	0.09	1.42	0.12
	CCTV	202826	2093113	0.10	1.42	0.12
	DCF	364398	2093113	0.17	1.42	0.12
BT2	DCF	1411904	22061000	0.064		

Table 6. *Estimated catch (t), effort, CPUE, and average ratios between CPUE of TR gears and beam-trawl (±standard deviation of the ratio: StDEV).*

4.4 5% rule

Tables 7 and 8 show the fraction of trips in which the share of cod in the landings *vis a vis* the total landings was less than 5%. On average 80% of the TR2 landings and 90% of the TR1C landings contain less than 5% cod. During quarter 2 in 2012 the fraction with less than 5% cod catches is lower (93%). The species composition of landings is presented in table 9. Dominant species in the landings are plaice [TR1C] and plaice and nephrops in TR2. On average 1.7% (TR1C) or 3% (TR2) of the landings is cod. A discard/landing fraction of a number of species per quarter is presented in table 10. These estimates are based on data from the DCF sampling program.

Discard percentages of cod used to estimate catches are the averages per quarter for the various metiers. Discard percentages of other species in the landings are selected from table 10. In case no estimation of discard fraction for a particular species is available, a discard percentage of 100% was used, being the weighted average of landings with known discards fractions The fraction of catches that meet the 5% rule, and caught less than 5% cod during the trip, are presented in table 11 for the TR2 fleet and table 12 for the TR1C fleet.

If one would want to know what the annual mean cod catch is in relation to the total catch, figures are slightly different. The mean catch of cod in relation to total catch in 2012 in the TR2 fleet was 2% and 1% for TR1C. For 92% (TR1c and TR2) of the vessels in 2012, cod catches remained below 5%.

Year	Quarter	Metier	N	Fraction less than 5 percent cod in the landings
2011	4	TR2	577	0.82
2012	1	TR2	430	0.63
2012	2	TR2	682	0.72
2012	3	TR2	923	0.91
2012	4	TR2	193	0.88
			2805	0.80

Table 7. *Fraction of TR2 trips with less than 5% cod in the landing*

Year	Quarter	Metier	N	Fraction less than 5 percent cod in the landings
2011	4	TR1C	20	0.7
2012	1	TR1C	194	0.9
2012	2	TR1C	410	0.9
2012	3	TR1C	293	0.9
2012	4	TR1C	72	0.9
	Total:		989	0.90

Table 8. *Fraction of TR1C trips with less than 5% cod in the landing*

SPECIES	TR1C	TR2
PLE	80.9	46
NEP	0.5	31.8
COD	1.7	3
TUR	2	3
DAB	3.8	2.9
MAC	0	2.1
WHG	0.2	1.8
JAX	0.1	1.3
GUG	2.3	0.8
BLL	0.3	0.8
GUU	0.2	0.7
SOL	0	0.7
LEM	5.5	0.6
CRE	0.2	0.5
BIB	0	0.4
FLE	0.1	0.4
HAD	0.6	0.1
Rest	1.7	3

Table 9. *Species composition (% of total) of TR1C and TR2 landings*

SPECIES	1	2	3	4
	Quarter			
DAB	3.67	6.53	31.42	1.71
LEM	0.29	0.20	0.74	0.69
MAC		0.02	0.41	
NEP	0.39	0.66	0.79	2.02
PLE	0.30	0.69	1.23	0.11
SOL	1.63	0.00	0.85	
TUR		0.01	0.00	
WHG	1.20	0.74	4.31	7.63

Table 10. *Discards:Landings Fraction of TR1C/TR2 metiers per species*

Year	Quarter	Metier	N	Fraction less than 5 percent cod in the catches
2011	4	TR2	577	0.88
2012	1	TR2	430	0.78
2012	2	TR2	682	0.8
2012	3	TR2	923	0.94
2012	4	TR2	193	0.89
			2805	0.87

Table 11. *Fraction of TR2 trips with less than 5% cod in the catch*

On average 87% of the TR2 catches have small cod catches. During quarter 1 and 2 in 2012 the fraction with less than 5% cod catches is lower (80%).

Year	Quarter	Metier	N	Fraction less than 5 percent cod in the catches
2011	4	TR1C	20	0.7
2012	1	TR1C	194	0.94
2012	2	TR1C	410	0.94
2012	3	TR1C	293	0.98
2012	4	TR1C	72	0.88
	Total:		989	0.94

Table 12. *Fraction of TR1C trips with less than 5% cod in the catch*

Overall more than 94% of the TR1C catches have small cod catches. During quarter 1 in 2012 the fraction with less than 5% cod catches is considerably lower (70%), but in in quarter 4 the effort is low.

5. Discussion

5.1 Results

The cod monitoring project was set up to monitor cod catches in the TR fleet, by making use of self-reporting by fishermen. The purpose was to 1) arrive at precise and more detailed information of the cod CpUE in the Dutch TR fleet, 2) compare the TR CpUE with the BT CpUE and 3) calculate the percentage of cod-avoiding fishing trips.

As self-reporting was a relatively new method, the initial idea in the proposal was to compare these data with observations from other monitoring programmes, (i.e. as part of the Data Collection Framework - DCF; and the closed-circuit TV - CCTV camera monitoring project and an extra set of observer trips.

This set-up, whereby different data-sources would be used, did result in variation in the outcomes. Interpreting this variation however proved to be difficult as many sources of variation could be attributable to either natural, environmental variation and/or consistent sampling/reporting errors. Therefore, data were analysed in such a way that this variation in CpUE estimates was minimized.

The approach taken in the analysis resulted in comparable CpUE estimates even though they were derived from different projects, with different project goals and methods. In comparing self-reported with data from other monitoring programmes, we noted that the self-reported catches in the TRMON resulted in consistently lower discards:landings ratios (Table 4) compared to matching metiers monitored over at least several trips by the other projects. Why, is not clear. Firstly, The DCF monitoring programme is set up to monitor discards over a wider range of species and metiers and is less suitable to monitor discards of rare or less abundant species like cod in the North Sea. During a DCF self-sampling trip, typically two hauls are sampled for discards, which in the case of cod, is not sufficient to capture the “true” amount of discards that may have been caught over the whole trip. Secondly, the vessels participating in the CCTV project received extra cod quota and participated in a catch-quota regime, which potentially affected their fishing behaviour, although it was not demonstrated that they fished more selectively (Helmond et al. 2013). Thirdly, the observer trips in the TRMON have the problem of most observer trips: they are small infrequent and patchy in their distribution. Finally, in the TRMON project, the data were obtained from 16% of the total number of trips, without knowing reasons for non-participation (see also below). By applying an average cod discards percentage to the landings meant that less weight would be given to the uncertain and relatively small part (discards) and more weight to the larger and more certain part (landings). By doing so, the estimated CpUE’s are less variable.

The downside of the approach is, however, that the variation in CpUE within and between trips is not considered and further discussed. Even though, from a management perspective, a grasp of the variation in cod CpUE would be desirable. At the same time such variation -expressed in a range instead of a single number- would compromise the desired management goal of a fixed effort conversion.

5.1.1 Calculation of CpUE in the BT fleet

The monitoring project was set up to estimate and compare the CpUE of cod in the Dutch trawl gears with the beam trawls in order to estimate a realistic conversion factor for effort between these gear groups. For non-cod directed otter trawl fisheries the ratio between the CpUE of beam trawl and trawl gears is estimated to be less than 2. This compares to the conversion factor of 3, which is presently used to transfer effort from beam trawls to trawl gears. However, using the DCF to calculate a CpUE for cod in the Dutch BT fleet is a less optimal choice. The monitoring in the DCF is aimed at species which are caught regularly (such as plaice, sole, dab), and typically only two hauls out of all hauls during a trip are sampled for discards. If undersized cod were not present in these two sampled hauls, but in other unsampled hauls during a trip, it is possible to underestimate the ‘true’ amount of cod discards.

5.1.2 Calculation of the 5% rule

IMARES was also asked to calculate the percentage of trips in the TR fleet (TR2, TR1C), with less than 5% cod catches in relation to the total catch. This was done by making use of the cod discard percentages from this report, and of the DCF data. Looking at the landings it becomes clear that most trips have a small percentage of cod (80% of the TR2 landings and 90% of the TR1C landings); by looking at the catch composition the relative part of cod becomes even smaller, resulting in most catches containing less than 5% cod (87% of the TR2 landings and 94% of the TR1C landings). Discard estimates of the non-cod species have been based on most landed species in the respective metiers and their known average discard rates. When discard rates were unknown an average was used. This approach gives an idea of the amount of trips with low cod catches. It is however not a very precise method.

5.2 Evaluation of the project

5.2.1 Coverage of the fleet (TRMON)

IMARES had calculated that at least 50 trips per metier needed to be monitored to gather precise data of cod catches. To achieve this high level of coverage, self-reporting was one of the most cost-effective methods. On initiative of the Ministry and the fishing sector it was decided that all vessels using TR1 or TR2 gear[7] are obliged to participate in this project.

But the aim of 100% coverage, was, however not reached. This can be attributed to the set-up of the monitoring project. The role division was such that (i) IMARES was responsible for receiving and analysing the data and for the scientific value of the project as a whole, whereas (ii) the fisheries organisations were responsible for the participation of the fleet and (iii) the Ministry had to monitor participation (and sanction non-compliance). This role division resulted in the situation that all involved parties had access to only a part of the relevant information to ensure complete coverage. Fishers sent in the forms to IMARES after completing a trip. IMARES made overviews of the received forms (by vessel and fishing week) approximately every two months which was then forwarded to the Ministry. The Ministry had to wait for regular, but lagged updates of their database to check whether the coverage was complete, but it took time before this information was readily available. The fisher representative organisations regularly urged the fleet to participate, but had no first-hand, real-time information on who did and did not comply.

This lack of an overview has been discussed on several occasions but proved to be difficult to resolve. In the end IMARES felt responsible for a good coverage in a scientific way (at least 50 trips per metier) but insisted on staying away from the control aspects of coverage; that was an agreement between and responsibility of the sector and the Ministry. IMARES felt strongly about preventing any association between control and research.

The scientific problem with this result of less than 100% coverage, is that the reasons for non-participation are not known as well as the possible implications in terms of introducing bias in the results, if participating vessels exhibited different patterns in cod catches than non-participating vessels. If a complete coverage is not achievable for whatever reason, and alternative approach may be more suited which allows for the stratification in including some vessels over others based on relevant criteria. Any refusals of participation can then be accounted for.

In an evaluation of this problem at the Dutch Research Cooperation Platform in October 2012 the Ministry and fishing sector insisted on full fleet participation (as opposed to sampling of selective participation). It was decided that by a continuation of this monitoring project with self-reporting the fishing sector will play a key role in receiving the forms and monitoring participation. This will likely

[7] Vessels participating in fully-documented fishery trials (i.e. 'Close-circuit-TV/CCTV electronic monitoring') were exempted.

improve the situation by shortening the communication lines as well as by taking away any control associations from IMARES. From January 2013 this is the way the monitoring continues, coverage since then has increased.

5.2.2 Utility of self-reporting as a sampling method

Asking fishermen to cooperate in a monitoring project works best if the project is set up as a cooperative research project (see Kraan *et al.* forthcoming), whereby fishermen have the choice and an incentive to participate, understand the goal, are involved throughout the project and can differentiate between management and research. In this case however they were obliged to participate, and not directly involved in the set-up, goals, methods, analysis of the project. In addition to that the project was largely set up without direct comparison against other established sampling techniques. And finally we generally observed that self-reported occurrences and quantities of discards were consistently and considerably smaller in relation to the landings than from any other monitoring project (Table 4). Although it cannot be reliably stated where these deviations come from, the observation alone, creates room for discussion on the trustworthiness of the data collected by the fishermen. It is however important to differentiate at this point between fishermen; while the majority delivered complete and useable forms, of some others, the quality (based on a visual inspection for completeness) of the forms were poor. It should be realised that data collected by fishermen have trust-associated issues connected to them (Carruthers and Neis, 2011; Faunce, 2011). Therefore any doubts about the data whatsoever quickly lead to issues of mistrust, which is much less the case with data gathered by scientists. Even though all scientists know and acknowledge that issues of bias for instance also play a role in data collected by scientists (see for instance Kraan *et al.* forthcoming). It rather brings to the fore that methods of self-reporting or self-sampling need to be embedded in cooperative research projects and cannot just be used as any other method (Kraan *et al.* forthcoming) and that careful design of cooperative projects is needed. Not in the least because the monitoring of cod catches has, for the majority of participating fishermen meant an enormous amount of extra work, alongside an already demanding job at sea of sorting catch. Careful design of research projects with tasks within the capacity of fishermen is therefore needed.

5.3 Recommendations

The approach taken to analyse the data and to arrive at a CpUE of the TR segment, by applying a cod percentage to fleet level LpUE, questions the usefulness of such an intensive self-reporting project of the Dutch TR fleet. Cod discards make up 15% of the cod landings, the landings part is so dominant that intensive monitoring of the discards part seems to be difficult to justify, especially considering the effort required to warrant participation and difficulty to reliably verify catch records.

However if this monitoring is still considered relevant and if it is decided that self-reporting is the best method to be used, it is recommended to make the project more cooperative, and involve active fishermen much more in the design of the project. Also it should be considered to not make the monitoring compulsory but either work with a reference fleet or stratify participating vessels whereby the project becomes less intensive for the fleet and whereby non-participation should be accounted for. Thirdly cod catches in the BT fleet should preferably also be monitored with more focus than currently possible within the framework of the DCF. And finally comparison of the self-reported catches with data from other projects can only be done meaningfully if the difference between the methods and project designs are better understood.

6. Quality Assurance

IMARES utilises an ISO 9001:2008 certified quality management system (certificate number: 124296-2012-AQ-NLD-RvA). This certificate is valid until 15 December 2015. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V. Furthermore, the chemical laboratory of the Fish Division has NEN-EN-ISO/IEC 17025:2005 accreditation for test laboratories with number L097. This accreditation is valid until 1th of April 2017 and was first issued on 27 March 1997. Accreditation was granted by the Council for Accreditation.

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8. Justification

Report number: C077/13
Project Number: 4308101054

The scientific quality of this report has been peer reviewed by the a colleague scientist and the head of the department of IMARES.

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Appendix A. Abreviations

BT	Beam trawl
BT2	Beam trawl (mesh 80-99)
CCTV	Close-circuit-TV/CCTV electronic monitoring
CPUE	Catch per Unit Effort
DAS	Days at sea
DCF	Data Collection Framework
EU	European Union
ICES	International Council for the Exploitation of the Seas
IMARES	Institute for Marine Resources & Ecosystem Studies
Kg/KWday	Kilogram per kilowatt day
LpUE	Landings per Unit Effort
MLS	Minimum landing sizes
Q	Quarter
SE	Standard Error
StDEV	Standard Deviation
t	tonnes
TR	Bottom trawls, seines (such as twinrig, flyshoot)
TR1AB	Bottom trawls, seines mesh 120+mm
TR1C	Bottom trawls, seines mesh 100-119mm
TR2	Bottom trawls, seines mesh 80-99
TRMON	Monitoring of the TR gears
TRMON_OBS	Monitoring of the TR gears with observers on board
TRMON_Self	Monitoring of the TR gears via self-sampling / reporting of fishers

Appendix B. Sampling locations

In the TRMON observer trips (top), TRMON self-sampling (middle) and DCF (bottom) (2009-2012). Black BT2, Red TR1AB, Green TR1C, Blue TR2.