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Electronic monitoring by the Danish fisheries control, 2021 - 2024

Colophon

Report on

Electronic monitoring by the Danish fisheries control, 2021 – 2024

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Summary

This report constitutes the evaluation of the electronic monitoring (EM) project operated by the Danish Agricultural and Fisheries Agency in 2021 to 2024. The evaluation builds upon the evaluation reports for phase 1 and phase 2 of the EM project in the Kattegat from 2021[1] and 2023[2]. This report expand on these two previous reports by covering the last part of 2023 as well as 2024 of the EM project in the Kattegat. Additionally, this report includes main findings and lessons learned from the trial fisheries and voluntary EM projects that the Danish Agricultural and Fisheries Agency have operated or taken part in from 2022 to 2024.

The report is divided into six sections.

First section describes the background for the reintroduction of EM in the Danish fisheries control in 2020.

Second section analyze EM data and audit of the installation processes, the development in review time, present a general overview of reviewed material which include distribution of discards and landings for target species, and the extent of non-compliance with the landing obligation during the project period. This section also includes an overview of the Danish Agricultural and Fisheries Agency's trial fisheries in the Baltic Sea.

Third section present the fishers' own registration which is compared to the registrations made during review of EM data. The development in BMS (registration of undersized, landing-obligated specimens) before and after installation of EM as well as a comparison between BMS-registrations in the Kattegat and the Skagerrak. The aforementioned analysis shed light upon the development in BMS registrations over time where the subsequent part deals with the spatial aspect as the EM system deactivate video recording outside of the Kattegat. Finally, this section includes an overall comparison of BMS either registered by fishers or estimated based on video review in the Kattegat.

Fourth section describes the cooperation between the Danish Agricultural and Fisheries Agency and vessel owners with vessels subject to mandatory EM. The voluntary trial fisheries in the Baltic Sea are also compared to the Kattegat-projects.

Fifth section present main findings and lessons learned from the trial fisheries and voluntary EM projects that the Danish Agricultural and Fisheries Agency have operated or taken part in from 2022 to 2024.

Sixth section present main lessons learned during the EM projects operated from 2021 to 2024.

Though this report covers the entire period of the EM in the Danish Kattegat (3AS) *Nephrops* fishery it will not include several topics, as they are covered by the two evaluation reports from

[1] Electronic monitoring in the Danish Kattegat (3AS) Nephrops fishery - Evaluation on phase 1 of the Project, Danish Fisheries Agency, October 2021 (Available at https://lfst.dk/erhvervsfiskeri/kontrol/monitering-og-overvaagning/kameradokumenteret-fiskeri/evalueringsrapporter).

[2] Electronic monitoring in the Danish Kattegat (3AS) Nephrops fishery - Full evaluation of the Project, Danish Fisheries Agency, October 2023 (Available at https://lfst.dk/erhvervsfiskeri/kontrol/monitering-og-overvaagning/kameradokumenteret-fiskeri/evalueringsrapporter).

2021 and 2023. Main topics covered in the 2021 report EM in the Danish Kattegat (3AS) *Nephrops* fishery (phase 1) include:

• Installation process in phase 1 of the EM in the Danish Kattegat (3AS) *Nephrops* fishery

• Basic functioning of the EM system

• Effect of guidance when non-compliance is detected

• Overview of sources of error and uncertainty in registrations

• User-friendliness of the EM systems

• Effect of EM on fishers' working conditions

• Vessel Monitoring Plan (VMP) example

• Framework for the EM project in phase 1 (2021-2022), the Common Understanding paper ("Fælles forståelse mellem Danmarks Fiskeriforening og Ministeren for fødevarer, fiskeri og ligestilling").

Main topics covered in the 2023 report on EM in the Danish Kattegat (3AS) *Nephrops* fishery include:

• Installation process in phase 2 of the EM in the Danish Kattegat (3AS) *Nephrops* fishery

• Observer data compared to reviewed video data

• Development and differences from 2021-2023

• Work environment on vessels with EM

• Protection of personal data under EM in fisheries

• Vessel Monitoring Plan (VMP) example

• Framework for the EM project in phase 2 (2022-2024), 10 changes to the monitoring project ("10-punktsplan").

1.0 Introduction

Electronic monitoring with camera documentation (EM) is utilized and tested in several countries, including Australia, Canada, Chile, Cyprus, Estonia, France, Ghana, Ireland, Kenya, Mexico, Micronesia, the Netherlands, New Zealand, Spain, Sweden, the UK and the United States. Among EU member states and former members, particularly Denmark, Scotland and Spain have run long-term and large-scale projects involving camera documentation. For instance, Denmark's trials with catch quota management and camera documentation in the North Sea and the Skagerrak from 2010 to 2016. Furthermore, EM with camera documentation is incorporated into the EU fisheries control regulation, which specifies that, based on a risk assessment, specific vessels of 18 meters and above will be subject to requirements for having camera monitoring systems on board. The risk criteria (fishing/maritime areas) will be further defined in implementing regulations. Additionally, the European Fisheries Control Agency EFCA has initiated a regional EM pilot program, where

Denmark has committed to equip EM on at least two voluntary vessels in the North Western waters, the North Sea and the Baltic Sea.

Following the settling of TACs (Total Allowable Catch) for 2020, it was politically decided that EM and cameras should be implemented in the majority of the Danish trawl-fleet in the Kattegat for vessels with 20 or more days at-sea. The poor condition of cod in the Kattegat was a significant part of the background for the political decision. The condition had been poor for a number of years but with the REM implementation the underlying cause was the lowest populations size since 1997. The very low cod stock means that cod by-catches are relatively small. This is also reflected in the bycatch recorded in the Kattegat-project. In contrast to the situation for the cod stock, in recent years there has been a large growth in the haddock stock in the North Sea and the Skagerrak. The fishermen are also experiencing that part of the growing haddock population is moving into the Kattegat. This is also reflected in the catches of haddock in the Kattegat. Within the camera project, a sharp increase in the catches of haddock has thus been seen, which is clear when looking at the numbers for haddock seen in the Kattegat-project in 2021 compared to 2022, 2023 and 2024 respectively (see section 2.4.3 "Development in number and length of focus species in 2021 to 2024").

This report covers the EM projects which the Danish Agricultural and Fisheries Agency have operated or taken part in from 2021 to 2024. Besides the phase 1 and phase 2 of the EM in the Danish Kattegat (3AS) *Nephrops* fishery (henceforth referred to as the Kattegat-project), this include six trial fisheries with EM and the voluntary EM project that the Danish pelagic sector has launched.

2.0 Vessel overview and video review data

2.1 Vessel overview

An overview of the number and length of vessels fitted with EM in Denmark from 2021-2024 is shown in the table below (table 1). The table is grouped by project type.

Table 1. Number of participating vessels, smallest, largest and average length.

Project	Number of vessels	Minimum length (m)	Largest length (m)	Average length (m)
Kattegat, phase 1 & phase 2	73	11.00	23.96	16.05
Trial fisheries, Kattegat & Baltic Sea	7	14.97	17.37	16.41
Pelagic voluntary	9	39.78	91.80	67.20

The map below (Fig. 1) show the number of vessels for which the Danish Agricultural and Fisheries Agency have had vessel visits in order to install EM since the end of 2020. The map includes trial fisheries with EM, where three vessels have had EM installed, while four vessels already had EM installed as they were part of the Kattegat-project, in addition to participation in trial fisheries. Pelagic vessels are added to the total separately as the Danish Agricultural and Fisheries Agency did not partake in the installation process in the same manner for these vessels instead the Danish

Agricultural and Fisheries Agency approve the Vessel Monitoring Plan (VMP) for pelagic vessels as part of the Agency's participation in the project.

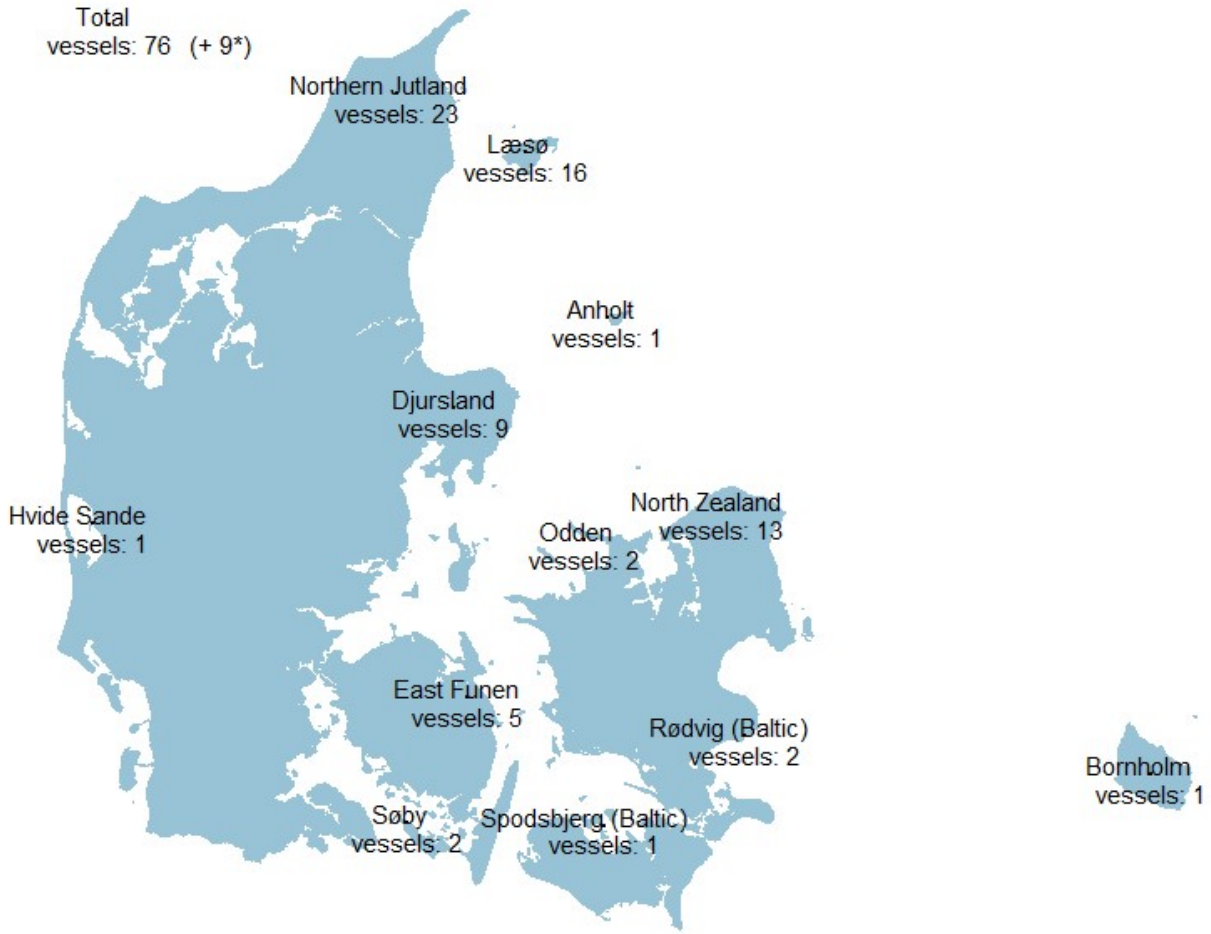

*Figure 1. Map of vessels with primary location for EM in relation to vessel visits, installation, and maintenance of the EM system, total from 2021 to 2024. *Asterisk at +9 is because these vessels are the from the pelagic voluntary EM. The Danish Agricultural and Fisheries Agency do not operate the EM system for these vessels but has access under an agreement between DPPO and the Ministry of Food, Agriculture and Fisheries and has approved the VMP for these nine.*

2.2 Video review information per year

The tables below provides an overview of the Danish Agricultural and Fisheries Agency' registrations (all registrations including all discards and landings).

Table 2. Number of vessels, trips and hauls reviewed pr. yr. in the Kattegat-project.

Year	Reviewed vessels	Reviewed trips	Reviewed hauls	Number of registrations
2021	11	203	380	39,170
2022	18	98	202	49,573
2023	68	193	387	196,184
2024	66	111	265	80,918
Total	**73**	**605**	**1,234**	**365,845**

Table 2 shows that despite a decrease in the reviewed of hauls and fishing trips from 2021 to 2022, there is a consistent increase in registrations, in addition to an increase in the number of vessels. The number of registrations and vessels is higher in 2023 than in 2021 and 2022, which also reflect an increase in the number of video reviewers.

The increasing number of registrations, but lower number of reviewed hauls and fishing trips between 2021 and 2022, is due to several factors which include:

i) the Danish Agricultural and Fisheries Agency has continually expanded the number of species that are registered during video review.

ii) there has been a significant increase in the number of haddock from 2022.

iii) relatively speaking, it takes longer to go through a haul, as experience in the work process on board the individual vessel diminishes when video reviewers have to switch between many different vessels compared to phase 1, where there was a low number of vessels, and

iv) in 2022, in parallel with the Kattegat-project, the Danish Agricultural and Fisheries Agency started trial fisheries, which included EM.

This effect is also seen in 2024 where the number of reviewed trips, hauls and registrations drop compared to 2023. The main reason for this drop in 2024 is however, that until 7th December 2023, phase 2 of the Kattegat-project was expected to stop by 1st January 2024. Phase 2 was then extended into 2024 but due to the uncertainty of the project and funding, it was not possible to extend several video reviewers' positions and the number of video reviewers dropped from 10 in July 2023 to five in July 2024, while the number of vessels subject to mandatory EM in Kattegat only decreased from 72 to 71 in the same period.

It is also apparent from the table that the Danish Agricultural and Fisheries Agency has not made video review for all vessels equipped with EM in the Kattegat each year. The reason for this is that not all vessels conduct fishing operations in the Kattegat every year. Since the requirement for EM only apply in the Kattegat, the vessels' EM system will only record in the Kattegat, meaning that

fishing operations in the Skagerrak or the Baltic are not made, unless the vessel partakes in a trial fishery with EM outside the Kattegat.

The following table is an overview of the registration the Danish Agricultural and Fisheries Agency have made during the review of trial fisheries in the Baltic Sea and the Kattegat.

Table 3. Trial fisheries with EM: Number of vessels, trips and hauls reviewed on average pr. yr.

Year	Reviewed vessels	Reviewed trips	Reviewed hauls	Number of registrations
2021	0	0	0	0
2022	2	55	88	747
2023	4	76	145	6,334
2024	4	33	146	31,767
Total	**6**	**164**	**379**	**38,848**

Table 3 show an increase in vessels taking part of a trial fishery with EM from 2021 to 2023. In 2024 the number of vessels stagnate. The number of registrations go up every year, which has to do with the different trial fisheries. In 2022 a single trial fishery with EM was run in the Baltic. The trial fishery targeted sandeel. In 2023, three trial fisheries with EM was run in the Baltic. One trial targeted sandeel, one trial was for a gillnetter and one trial targeted plaice. In 2024, two trial fisheries with EM was run. One trial was in the Kattegat, targeting greater weever, and one trial was in the Baltic testing a selective gear.

The following table is an overview of the vessels the Danish Agricultural and Fisheries Agency have reviewed from the Danish Pelagic PO (DPPO) voluntary EM program which the Agency accessed data in 2024.

Table 4. DPPO voluntary EM: Number of vessels, trips and hauls reviewed on average pr. yr.

Year	Reviewed vessels	Reviewed trips	Reviewed hauls
2024	1	1	10

This project and the Danish Agricultural and Fisheries Agency' participation is in its infancy. Further experience is expected by to be gained during 2025.

The map (Fig. 2) below presents an overview of the different EM projects and the area where they took place.

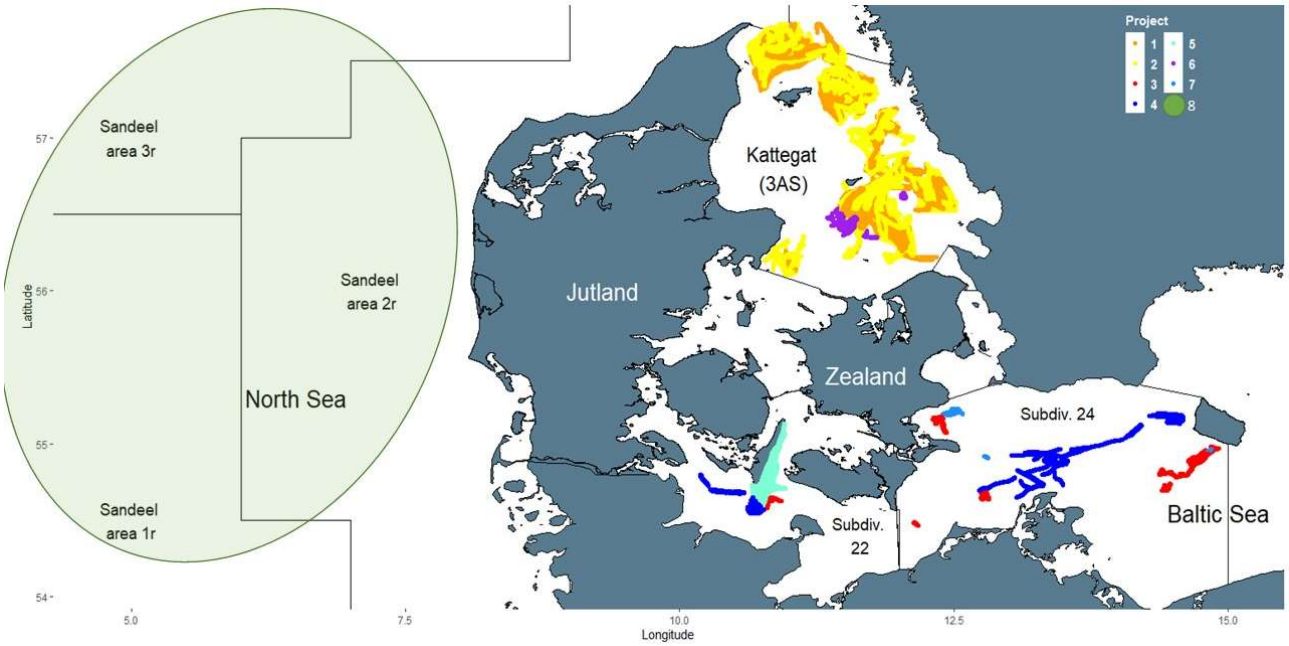

Figure 2. Reviewed fishing activities 2021-2024. 1: Phase 1, Kattegat-project. 2: Phase 2, Kattegat-project. 3: Trial fishery with EM targeting sandeel. 4: Trial fishery with EM, targeting plaice. 5: Trial fishery with EM on a gillnetter. 6: Trial fishery with EM targeting greater weever. 7: Trial fishery with testing selective gear or voluntary EM without trial. 8: Pelagic EM.

2.3 Development in review time

From the first video reviews in January 2021 to 2024, a continuous development in review procedure and registrations have taken place. The approach to video reviews in the 2021 to 2024 EM projects has largely been the same as the approach developed during the Danish AgriFish Agency's Cod Catch Quota Management with EM program (CCQM) in the North Sea and the Skagerrak from 20210 to 2016[3]. However, the level of detail and range of registrations has increased significantly during the Danish Agricultural and Fisheries Agency' EM programs from 2021. Initially, only discards for six species (cod, haddock, hake, saithe, spurdog and whiting) were registered. However, during phase 1 the new experiences lead to a major change compared to the CCQM: Registering both landings and discards. This was done to enable the review of only the catch processing in videos. To ensure compliance with the landing obligation it is necessary to either view all video from the entire trip after the first haul has been conducted or register both landings and discards and then compare the registries from the review with the self-reported catches in the logbooks and landing declarations. This was different than in the CCQM because the CCQM took place before the landing obligation, meaning that discards registered in logbooks were verified by video review in the CCQM.

Additional species have been included in the review from 2021 to 2024. The Kattegat-project has kept six focus species for project reports, where the only change has been the replacement of spurdog with sole as a focus species in phase 2. Regardless of the EM project, video reviewers have made registries if one of the following species was seen after they were introduced in review:

[3] Final Report on Development and usage of Electronic Monitoring Systems as a measure to monitor compliance with the Landing Obligation – 2015 (DOI:10.13140/RG.2.2.13561.67683) and
Final Report on Development and usage of REM systems along with electronic data transfer as a measure to monitor compliance with the Landing Obligation (DOI:10.13140/RG.2.2.23628.00645).

Reviewed species: blue ling, cod, common eider, common murre, common scoter, common sole, cormorant, grey seal, horse mackerel, haddock, hake, harbour porpoise, harbour seal, lesser spotted dogfish, ling, lumpsucker, mackerel, monkfish, northern fulmar, perch, rays and skates, razorbill, saithe, sea trout, squids, turbot, tusk, velvet scoter, whiting and wolffish.

Additionally, if a good image can be taken, flounder is registered in order to build a library for future AI-training and subsampling is done for *Nephrops* and plaice when the video quality is good and workload allow for this extra task during video review. Subsampling involve re-reviewing parts of a video to register *Nephrops* and plaice. The number seen during these samples of the video can then be extrapolated to give an estimate of the total catch of *Nephrops* and plaice in the haul. Subsampling is done because the amount of *Nephrops* and plaice in hauls tend to be too large for review of every specimen, at least by human review.

Figure 3 below shows the analysis setup for catch quantification in the beginning of the Kattegat-project in 2021. Sensor-data show the speed of the vessel (in image blue line called "Knob") and the depth (in example orange line called "Dybde") in addition to rotation sensors (blue or red markings at "Spil 1" in image). Rotations sensors are used together with speed to find the hauls (green bars at "Aktiviteter" in image). Catch processings are made by video reviewers and are marked as red bars at "Annoteringer".

Figure 3. Catch quantification module and sensor data as it would have been shown in BlackBox Analyzer for reviews in 2021. Image permission by courtesy of Anchor Lab K/S.

Figure 4 below shows the analysis setup for catch quantification in the end of 2024. In addition to substantial increase in number of species ("Arter" in Danish) and Catch-categories ("Fangstkategorier" in Danish), the tags ("Markeringer" in Danish) have a new tag for subsampling and State ("Tilstande" in Danish) have been added to allow the reviever to mark rotten or predatory-damaged catches. At the same time, the sensor-data (top part of image) have increased significantly with the addition of motion detection at the drum (in image green line called "Trawl"), where the catch comes in (in image purple line called "Takkelkasse") and where it is sorted and potentially discarded (in image in starboard and port side, yellow line called "Styrbord" and red line called "Bagbord"). Finally, registrations can be shown visually with color codes with the sensor data ("Fangster" below the "Video" and "Annoteringer"). Each color represents a registration and the color can be custom-made to represent different types of species.

Figure 4. Catch quantification module and sensor data as shown in BlackBox Analyzer for reviews in 2024. Image permission by courtesy of Anchor Lab K/S.

Figure 5 below show the date when for each species became part of the review and the time used per review.

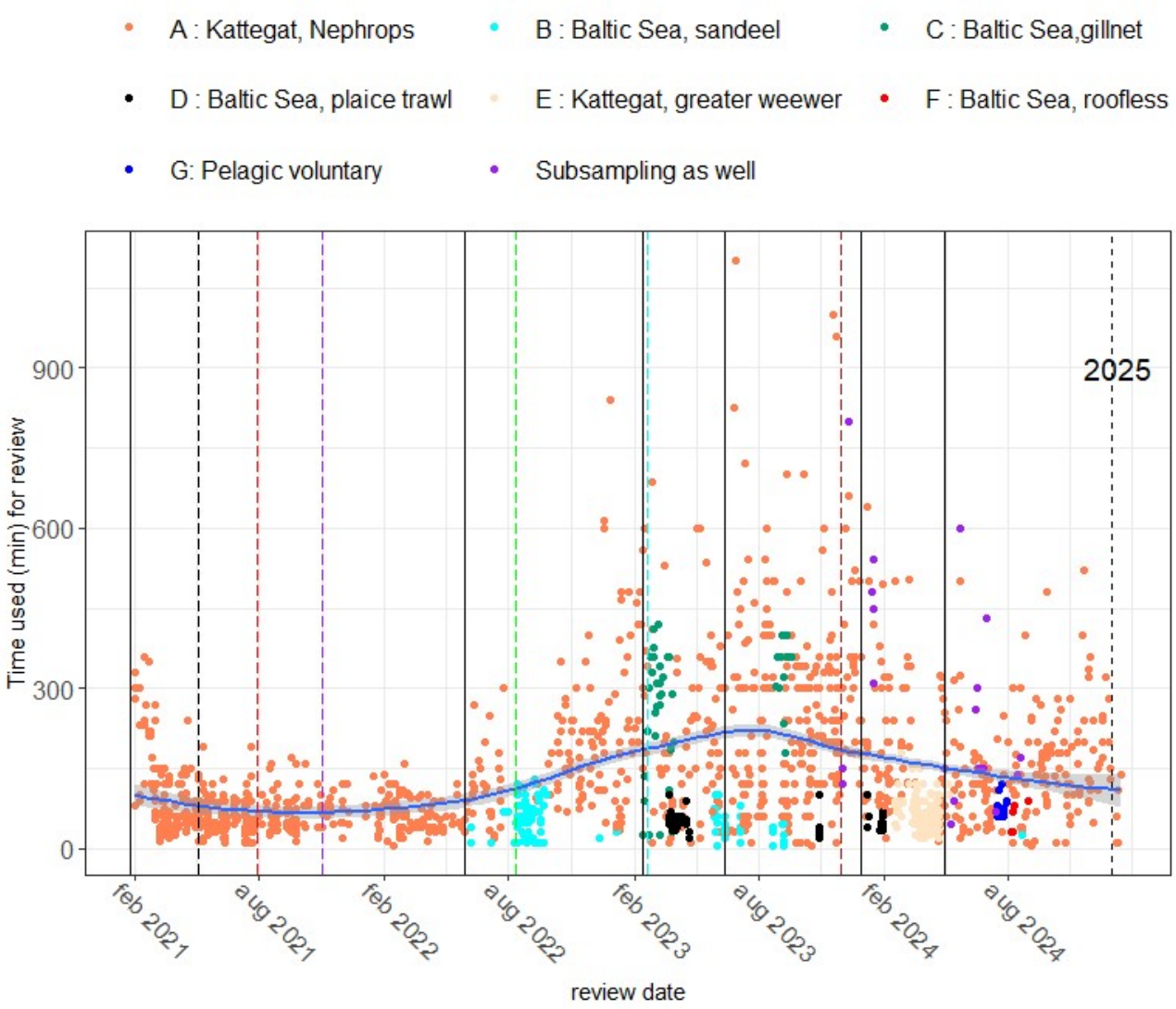

Figure 5. Timeline, development in review time. X-axis display half year intervals since first video review (January 2021). Y-axis display the time used in minutes for the review Each dots represents an review of a catch handling, where coral-colored dots represents reviews of hauls in the Kattegat-project, cyan dots represent the trial fishery with EM targeting sandeel in the Baltic Sea, green dots represent the trial fishery with EM on a gillnetter, black dots represent the trial fishery with EM on a trawler targeting plaice, bisque-color dots represent the trial fishery with EM targeting greater weever in Kattegat, yellow dots represent the trial fishery with EM testing selective gear in the Baltic, blue dots represent the voluntary pelagic EM project and purple dots are for reviews where subsampling for Nephrops and/or plaice has been made (all of which have been in the Kattegat-project). Blue horizontal line shows the average review time. Vertical full black lines show when the number of video reviewers changed (first (January 2021): three video reviewers, second (June 2022): four video reviewers, third (February 2023): eight video reviewers, fourth (June 2023): 10 video reviewers, fifth (January 2024): six video reviewers, sixth (May 2024): five video reviewers. Vertical dashed colored lines denote changes in the registrations to be made during review. Prior to the first line (color: black, month: May 2021) only discards and six species (cod, haddock, hake, saithe, spurdog and whiting) were registered. After the first dashed line (color: black, month: May 2021) only discards for 15 species (cod, haddock, hake, harbour porpoise, harbour seal, lesser spotted dogfish, ling, lumpsucker,

monkfish, rays and skates, saithe, spurdog, turbot whiting and wolffish). After the second dashed line (colour: red, month: August 2021) landings of the 15 species are registered along with discards. After the third dashed line (color: purple, month: November 2021) seven more species (blue ling, common sole, great silver smelt, Greenland halibut, horse mackerel, mackerel, tusk) are added putting the total number of species reviewed at 22. where 30 (blue ling, cod, common eider, common murre, common scoter, common sole, cormorant, grey seal, horse mackerel, haddock, hake, harbour porpoise, harbour seal, lesser spotted dogfish, ling, lumpsucker, mackerel, monkfish, northern fulmar, perch, rays and skates, razorbill, saithe, sea trout, squids, turbot, tusk, velvet scoter, whiting and wolffish) are always registered, two (Nephrops and plaice) is subsampled and one (flounder) were qualitative registries are made to build an AI-library.

Review time of video has an impact on the cost of running EM programs. Overall, over the project's period, the review time has fluctuated with a peak in 2023. The main driver for this peak is the largely increase in haddock which began in the autumn of 2022 (see the report "Electronic Monitoring in the Danish Kattegat (3AS) Nephrops Fishery - Full Evaluation of the Project", October 2023 for figure supporting this).
Except for the trial fishery with EM on a gillnetter (green dots) the review times have been lower for trial fisheries than for the Kattegat-project (coral-colored dots). Subsampling (purple dots) increase the review time, which is logic since subsampling-reviews imply that parts of the video has to been seen twice. As subsampling illustrate well, there is a trade-off between the level of detail wanted from the output of video review and the needed time to conduct the review.

2.4 Data on catches and discards, Kattegat-projects

Consistent focus species in the Kattegat-project from 2021 to 2024 were cod, haddock, hake, saithe and whiting. Sole came in as a focus in phase 2 of the Kattegat-project in 2022. The rest of section 2 and section 3 will focus on the Kattegat-projects. Tables or figures including sole only focus on the years 2022 and 2023, while tables or figures covering the entire span of the Kattegat-projects from 2021 to 2024 only include cod, haddock, hake, saithe and whiting as these five species are the only species which have been registered through the entire span of the two Kattegat-projects.

The following tables until section 2.4.3 "Development in number and length of focus species in 2021 to 2024", focus on catch records in reviewed material in 2022, 2023 and 2024. The report Electronic Monitoring in the Danish Kattegat (3AS) *Nephrops* Fishery - Evaluation on Phase 1 of the Project, shows tables and figures for catch records in 2021.

2.4.1 Compliance with the landing obligation for the focus species

Table 5 below shows the number of hauls where the landing obligation has not been complied with. The table shows that almost all vessels violate the landing obligation for haddock (69 out of 71, where haddock has been seen), cod (67 out of 73, where cod has been seen), hake (66 out 70 where hake has been seen) and sole (55 out of 64, where sole has been seen). Saithe has only been seen for 20 vessels and roughly half of these have complied with the landing obligation for saithe. It should be noted that the Danish Agricultural and Fisheries Agency sends feedback sheets to vessel owners with information on what the Danish Agricultural and Fisheries Agency has observed, including discarding of fish, and that the Danish Agricultural and Fisheries Agency has continuously provided guidance on the landing obligation either directly or after inquiries from vessel owners.

Table 5. Landing obligation (LO) violated on the following hauls for the following species and vessels, 2022 to 2024. Note that the table extends over several years and may therefore have a higher number of vessels and hauls than the table of inspected vessels and hauls per year in the Kattegat. Data from 1. July 2022 to 31. December 2024.

Species	Vessel where seen	Vessels with LO non-compliance observed[4]	Number of hauls where seen	Hauls with LO non-compliance observed	Illegal discarded number of fish
Haddock	71	69	601	525	28,075
Hake	70	66	504	268	1,261
Saithe	20	11	28	13	15
Cod	73	67	672	443	3,337
Sole	64	55	448	200	603

Based on the "10-punktsplan" (see the report "Electronic monitoring in the Danish Kattegat (3AS) *Nephrops* fishery - Full evaluation of the Project" for the "10-punktsplan"), the Danish Agricultural and Fisheries Agency has operated with a *de minimis* approach on assessment for each specific case considering guidance as the principal approach when discarding was seen.

2.4.2 Grouping of vessels in relation to compliance with the landing obligation (haul by haul) based on a ratio between landing and discarding of focus species.

Table 6 below shows the grouping of vessels in relation to the ratio between landing and discarding of fish per haul. The table only include landings and discards of the five focus species subject to the landing obligation.

[4] It should be noted that this includes discards of predatory-damaged fish that can be legally discarded. The Danish Agricultural and Fisheries Agency has been able to enter in the EM system if a discard could be seen on the video material to be damaged since 4. December 2022 By the end of 2024, the Danish Agricultural and Fisheries Agency has in total marked seven haddock, eight cod, one hake, one sole and zero saithe as predatory-damaged.

Table 6. Grouping at 10% interval for the ratio of discards of the focus species cod, hake, haddock, sole and sole. A total of 73 vessels have had video reviewed from 2022 to 2024. Data until 31. December 2024.

Illegal discards, interval	Number of vessels	Number of hauls reviewed	Discards, number	Landings, number	Average percentage, discards compared to landings*
0-10%	11	152	1,925	25,393	6.45
10-20%	8	87	2,125	12,229	14.25
20-30%	12	177	4,551	14,262	25.33
30-40%	8	81	3,476	6,183	36.38
40-50%	14	162	7,452	8,765	45.29
50-60%	6	73	3,521	3,165	54.83
60-70%	2	15	1,129	502	67.00
70-80%	3	25	1,037	338	75.67
80-90%	5	53	6,866	1,057	84.80
>90%	4	28	1,588	117	97.00

** Average percentage, discards compared to landings, is calculated as ('discard number'/('landed number' + 'discard number'))*100*

Discard and landing registrations are totaled for the focus species: cod, hake, haddock, saithe and sole. It should be noted that this table only contains data from 2022 to 2024, as it was only in August 2021 that the Danish Agricultural and Fisheries Agency began to register both landings and discards of fish. Thus, it would only be possible to have data for a little under half of 2021 and in order to give a more direct relationship between the total reviewed landings and discards, it has been chosen to only use data from 2022, 2023 and 2024 for this table.

Table 6 shows that 11 out of 73 vessels land more than 90% of the focus species covered by the landing obligation, while 19 out of 73 vessels land more than 80% of the focus species covered by the landing obligation. There is no trivial limit in the regulations for the landing obligation, meaning there is no room for situations where discarding of fish occurs as a result of random accidents rather than deliberate action. The table cannot be used to determine whether discarding happened accidentally, due to ignorance or as a deliberate act. The table shows that nine out of 73 of the vessels have discarded more than 20% of the focus species that must be landed. For 20 vessels, more than half of the focus species that must be landed are thrown out regardless.

2.4.3 Development in number and length of focus species in 2021 to 2024

The following histograms and barcharts show catch records in both phase 1 and phase 2 of the Kattegat-project. Because sole and spurdog were not focus species throughout phase 1 and phase 2, histograms are only made for cod, haddock, hake, saithe and whiting. Furthermore, it should be noted that landings where first registered from August 2021, which artificially drags the green bar for the year 2021 down the histogram. The figures show the number and estimated weight4 of discards and landings. The overall trend is that the majority of catches and discards primarily consist of fish below the minimum size. Overall, more kg is landed than are thrown out of the focus species that must be landed.

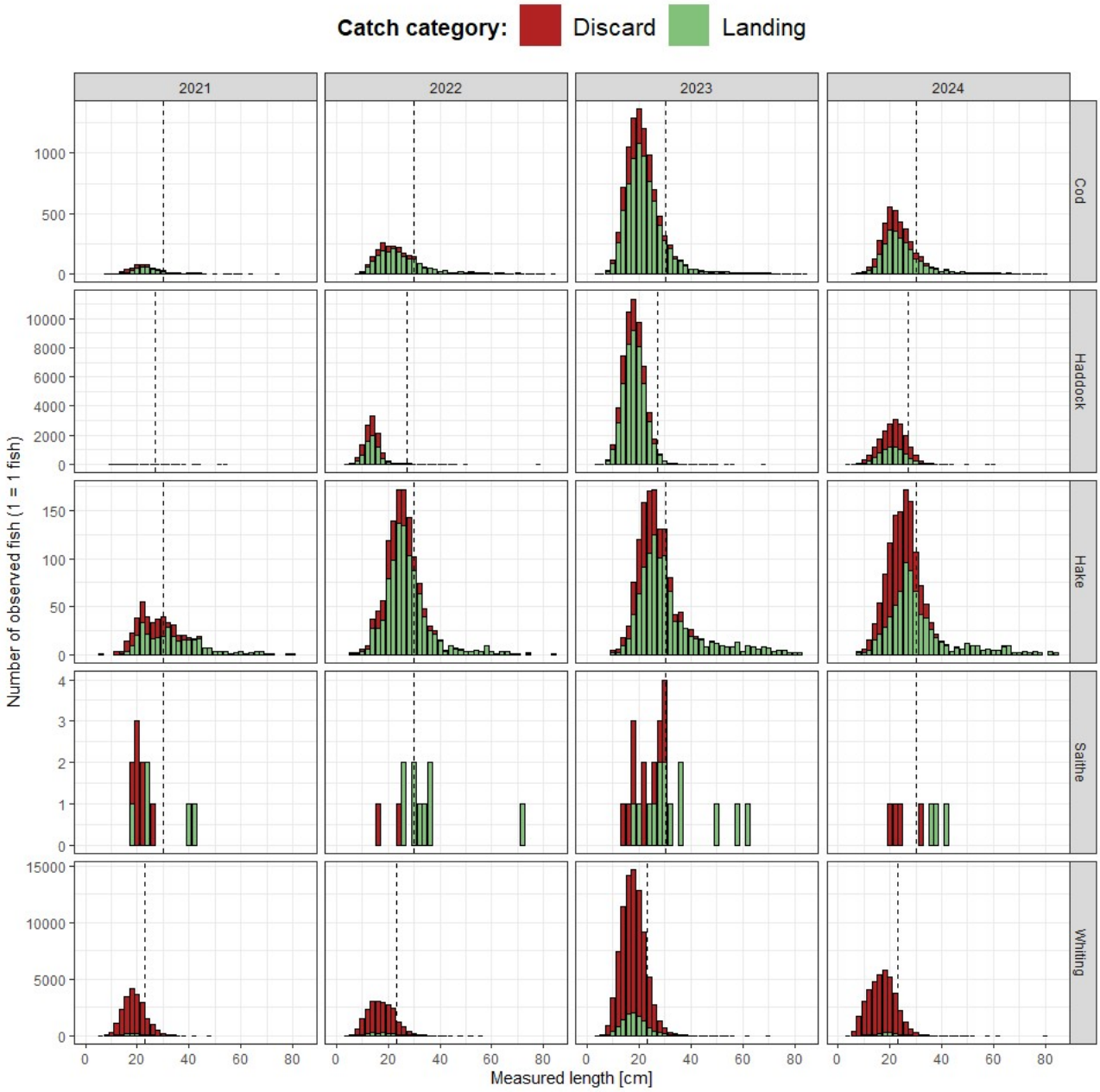

Figure 6. Histogram of observed landings and discards of the focus species cod, hake, saithe and haddock per year in the Kattegat-project. X-axis shows the length of the measured fish in cm. Y-axis shows the number of catches (discards in red, landings in green) for the species in question.

Note that the scale varies between species. Dashed vertical lines show the minimum size for the individual species. It should be noted that there is a level of uncertainty associated with measurements of fish length during video review. Data until 31. December 2024.

Figure 6 shows that the majority of specimens registered of cod, hake, haddock and saithe seen has been landed, while the majority of whiting has discarded. The majority of registrations are below the minimum size (MCRS) regardless of species, reflecting that these species are caught as a bycatch in the fishery for *Nephrops*. The increase in haddock which begin in the autumn of 2022 is easily seen when looking at the number of haddock registered in 2021 compared to 2022, 2023 and 2024. As a note to this, more haddock have been registered during video review in the catch processing of a single hauls catches in 2022 than the total amount of registered haddock for all of 2021 and the first half of 2022 combined.

Figure 7. Barchart of catches per year in the Kattegat-project (landings and discards) converted to kilograms[5] based on length-weight equation for the species. X-axis shows whether the catch has been registered as discard or landing during review. Y-axis shows the estimated weight based on the number and measured length for whiting. Data until 31. December 2024.

Figure 7 shows that, when converted to kilograms, the majority of cod, hake, haddock and saithe seen has been landed, while the majority of whiting seen is discarded.

[5] The estimated weight is calculated using the length-weight ratio for each individual fish. Length-weight ratios are based on information from DTU Aqua for each species.

3.0 BMS-registrations

3.1 Development in BMS before and after camera (2022 to 2023), vessels in phase 2

Table 7 below show the registrations of BMS-fish of species subject to the landing obligation from the vessels' eLog-registrations in 2022 and 2023. The table is for the vessels where EM was installed during phase 2. The registrations are divided into before and after installation of EM equipment. Vessels from phase 1 are not included as they had EM systems installed in the beginning of 2021. Vessels from phase 1 can thereby function as a control group to phase 2 vessels.

Table 7. Registration of BMS per species and amount in the Kattegat. Before and after camera, total and per trip. The number of trips in the Kattegat before camera was 5,587 and trips after camera was 4,496. Data from 1. January 2022 until 31 December 2023.

Species	Before camera, total (kg)	After camera, total (kg)	Difference, total (kg)	Before camera, per trip (kg)	After camera, per trip (kg)	Difference, per trip (kg)	Difference in %^
Hake	412	7.061	6.649	0,074	1,571	1,497	2.030
Haddock	1.563	139.959	138.396	0,280	31,130	30,850	11.027
Saithe	0	37	37	0,000	0,008	0,008	Inf*
Sole	166	687	521	0,030	0,153	0,123	414
Cod	2.247	26.577	24.330	0,402	5,911	5,509	1.370

*^ Difference in percentage is calculated as "Difference per trip (kg)"/"Before camera, per trip (kg)"*100. Kg per trip is used to correct for a different number of trips for the vessels in the Kattegat before and after the camera. "Before camera" is used in the denominator, as the starting point is that there is no camera system on vessels and a change in registrations must be seen in the context of the new element (camera system on board).*
**Percent cannot be calculated because one cannot divide with zero.*

The numbers in table 7 are different than for the 2023 report on EM in the Danish Kattegat (3AS) *Nephrops* fishery because that report did not include data after 21. August 2023, which was less than two months after the full implementation of phase 2 of the Kattegat-project had finished. More vessels and a timespan including all of 2023 leads to much higher numbers in this report compared to the corresponding table in the 2023 report on EM in the Danish Kattegat (3AS) *Nephrops* fishery.

For all species, the BMS registrations increase after an EM system with cameras is. This is particularly the case for hake, haddock and cod, where cod has the lowest increase of the three with an increase of 24,330 kg (1,370% or approximately 5.5 kg of cod per trip). For comparison, the total Danish landings of cod in the Kattegat were 19 tonnes in 2022 and 42 tonnes in 2023. The large increase in total amount and percentage is seen despite the number of trips being lower after EM is installed than before EM is installed. This is also reflected in the large per trip increase of BMS.

For hake there is an increase of 6,649 kg (2,030% or approx. 1.6 kg hake per trip), while haddock has an increase of 138,396 kg (11,027% or approx. 31.1 kg haddock per trip). It should also be noted that the stock development play into this. This is clearly seen for haddock, where a significant

increase in the occurrence of haddock in the Kattegat has been seen from autumn 2022. This is also reflected in figures 4 and 5 in section 2.5.3. The total Danish landings of hake in the Kattegat in 2022 were 16 tonnes and 18 tonnes in 2023. The total Danish landings of haddock in the Kattegat were 7 tonnes in 2022 and 147 tonnes in 2023.

3.2 Development in BMS 2022 and 2023, vessels from phase 1

The development in registration of BMS for the 12 vessels from phase 1 is described in the evaluation report for phase 1.

Table 8 below shows eLog-registration of undersized fish (BMS) in 2022 and 2023 from the 12 vessels that were part of the Kattegat-project from the beginning in phase 1. That is, the 12 vessels that have had an EM system since 2021 and there throughout 2022 and 2023 continued to have EM on board. These vessel function as a control group when comparing to vessels that had EM installed during phase 2 in 2022 and 2023. For comparison with the development in the BMS-registrations for vessels in phase 2, the cut-off is set for 1 January 2023. All of 2022 thereby function as "Before camera" when comparing to phase 2-vessels, while 2023 function as "After camera" when comparing to phase 2-vessels. 1. January 2023 has been chosen, as it allows for registrations from a full year on both sides of the cut-off. It was not possible to have EM installed on all vessels where EM became mandatory by 1. January 2023. However, the majority (36 of 61 vessels[6]) had 1. January 2023 as the latest date for the vessel to be equipped with EM. The Danish Agricultural and Fisheries Agency therefore see the best comparison between the control group and phase 2-vessels to be achieved by assuming 2022 correspond to the "Before camera" for phase 2-vessels and 2023 correspond to the "After camera" fore phase 2-vessels.

Table 8^. Registration of BMS per species and amount in the Kattegat in 2022 and 2023 for vessels which have had EM systems installed from phase 1 2021. The number of trips in the Kattegat in 2022 and 2023 was respectively 1,157 and 977. Data from 1. January 2022 until 31 December 2023.

Species	2022, total (kg)	2023, total (kg)	Difference, total (kg)	2022, per trip (kg)	2023, per trip (kg)	Difference, per trip (kg)	Difference in %^
Hake	1.991	807	-1.184	1,721	0,826	-0,895	-52
Haddock	3.158	24.330	21.172	2,729	24,903	22,173	812
Saithe	3	0	-3	0,003	0,000	-0,003	-100
Sole	113	28	-85	0,098	0,029	-0,069	-71
Cod	3.147	3.570	423	2,720	3,654	0,934	34

^ *Difference in percent is calculated as following: "Difference pr. trip (Kg)"/"2022 , pr. trip (Kg)"*100.*

The numbers in table 8 are different than for the 2023 report on EM in the Danish Kattegat (3AS) *Nephrops* fishery because that report did not include data after 21. August 2023, which was less than two months after the full implementation of phase 2 of the Kattegat-project had finished.

[6]61 vessels because 12 already had EM installed in phase 1

More vessels and a timespan including all of 2023 leads to much higher numbers in this report compared to the corresponding table in the 2023 report on EM in the Danish Kattegat (3AS) *Nephrops* fishery.

For the control group (phase 1-vessels) the BMS-registrations of sole, saithe and hake decrease from 2022 to 2023. Sole decrease by approx. 0.01 kg per trip (-71%) and hake decrease by approx. 0.9 kg pr. trip (- 52 %). The change is notable compared to phase 2-vessels as it is the opposite (increase of BMS for hake and sole in the same period) that is seen for phase 2-vessels. Saithe go from a total of three kg in 2022 to zero kg in 2023. Cod increase by approx. 0.9 kg per trip (34%) while haddock has a notable increase of approx. 22.2 kg (812%). Although lower than for phase 2-vessels, the control group also have a large increase in BMS-registrations of haddock between 2022 and 2023. The control group also has an increase of cod registered as BMS from 2022 to 2023, but it is markedly lower than for phase 2-vessels.

3.3 Comparison of BMS-registrations between the Skagerrak and the Kattegat

The following table show registrations of undersized fish subject to the landing obligation (BMS) in 2023, depending on whether the vessel conducted fishery in the Kattegat (EM in operation) or in the Skagerrak (EM turned off). The EM system automatically stop the video recording, when the vessel exits the Kattegat as the legal requirement for EM only applied in the Kattegat. All vessels, regardless whether they were part of phase 1 or 2 are included in this table.

Table 9. Difference in registered BMS per trip (species and amount), trips in the Kattegat compared to the Skagerrak in 2023. Cameras are on in the Kattegat but switch off in the Skagerrak. The vessels have had 2,117 trips in the Skagerrak and 5,761 trips in the Kattegat. Data from 1. January 2023 until 31. December 2023.

Species	BMS 3AS, total (kg). Camera on.	BMS 3AN, total (kg). Camera off.	Difference, total (kg)	BMS per trip (kg), 3AS. Camera on.	BMS per trip (kg), 3AN. Camera off.	Difference per trip (kg)	Difference in % (- if more in the Skagerrak)^
Hake	5.644	533	5.111	0,980	0,252	0,728	289
Haddock	160.667	14.298	146.369	27,889	6,754	21,135	313
Saithe	37	37	0	0,006	0,017	-0,011	-63
Sole	549	1	548	0,095	0,000	0,095	20.074
Cod	28.216	5.323	22.893	4,898	2,514	2,383	95

*^Difference in %, calculated as ("Difference per trip (Kg)")/("BMS per trip (kg), 3AN. Camera turned off)*100, by default, no camera system is installed on the vessels and a change in registrations should be seen in a context of added elements (camera on in the Kattegat).*

The following table show registrations of undersized fish subject to the landing obligation (BMS) in 2024, depending on whether the vessel had its fishing activity in the Kattegat (EM in operation) or in the Skagerrak (EM turned off). All vessels, regardless whether they were part of phase 1 or 2 are included in this table.

Table 10. Difference in registered BMS per trip (species and amount), trips in the Kattegat compared to the Skagerrak in 2023. Cameras are on in the Kattegat but switch off in the Skagerrak. The vessels have had 2,010 trips in the Skagerrak and 6,171 trips in the Kattegat. Data from 1. January 2024 until 31. December 2024.

Species	BMS 3AS, total (kg). Camera on.	BMS 3AN, total (kg). Camera off.	Difference, total (kg)	BMS per trip (kg), 3AS. Camera on.	BMS per trip (kg), 3AN. Camera off.	Difference per trip (kg)	Difference in % (- if more in the Skagerrak)^
Hake	9.625	1.703	7.922	1,560	0,847	0,712	84
Haddock	95.855	15.345	80.510	15,533	7,634	7,899	103
Saithe	6	33	-27	0,001	0,016	-0,015	-94
Sole	472	1	471	0,076	0,000	0,076	15.274
Cod	16.009	3.461	12.548	2,594	1,722	0,872	51

*^Difference in %, calculated as ("Difference per trip (Kg)")/("BMS per trip (kg), 3AN. Camera turned off)*100, by default, no camera system is installed on the vessels and a change in registrations should be seen in a context of added elements (camera on in the Kattegat).*

The two tables show larger total amount of BMS-fish in the Kattegat compared to the Skagerrak, except for saithe in both 2023 and 2024. A direct comparison isolated solely to the presence of EM with cameras between the two areas is not possible, as other factors also affect the BMS registrations. A direct comparison can only be made if the areas have the:

- Same gear requirements
- Same stock assessment
- Same development in the year classes for the stock
- Same fishing season and period
- Same fishing depth

3.4 The BMS register in relation to landing and discarding of species observed during the review of video material.

Figure 8 below shows total registration of focus species in 2021, 2022, 2023 and 2024 based on the fishers' own registrations in eLog and landing declaration, as well as the estimated weight (both discard and landed) based on review of video material.

Registrations included in the figure for eLog and landing declaration are:

- BMS (undersized fish caught that must be landed)
- DIS (discard)
- DIM (de minimis-exempted landing-obligatory species which can be discarded)
- LSC (landing for consumption)

Only fishing trips with video review are included in the analysis. Sole is not included because it was not reviewed until 5. November 2021, whereby sole cannot be included in the analysis in 2021. It should be noted that the amount of landed weight registered in 2021 seen by video review likely is underestimated, as it was only from 1 August 2021 that landings were recorded during video review. Previously, only discards were recorded.
The figure only shows data from the eLog, landing declarations and video review data for the fishing trips that have been reviewed. There may well be catches of, for instance, whiting or saithe on other fishing trips for the vessels where video material has not been reviewed. On the fishing trips seen, there are no whiting in the landing declarations, which fit with the fact that almost all whiting seen on video material has been registered as discards. This is legal as whiting is a *de minimis*-species in the Kattegat trawl fishery targeting *Nephrops*.

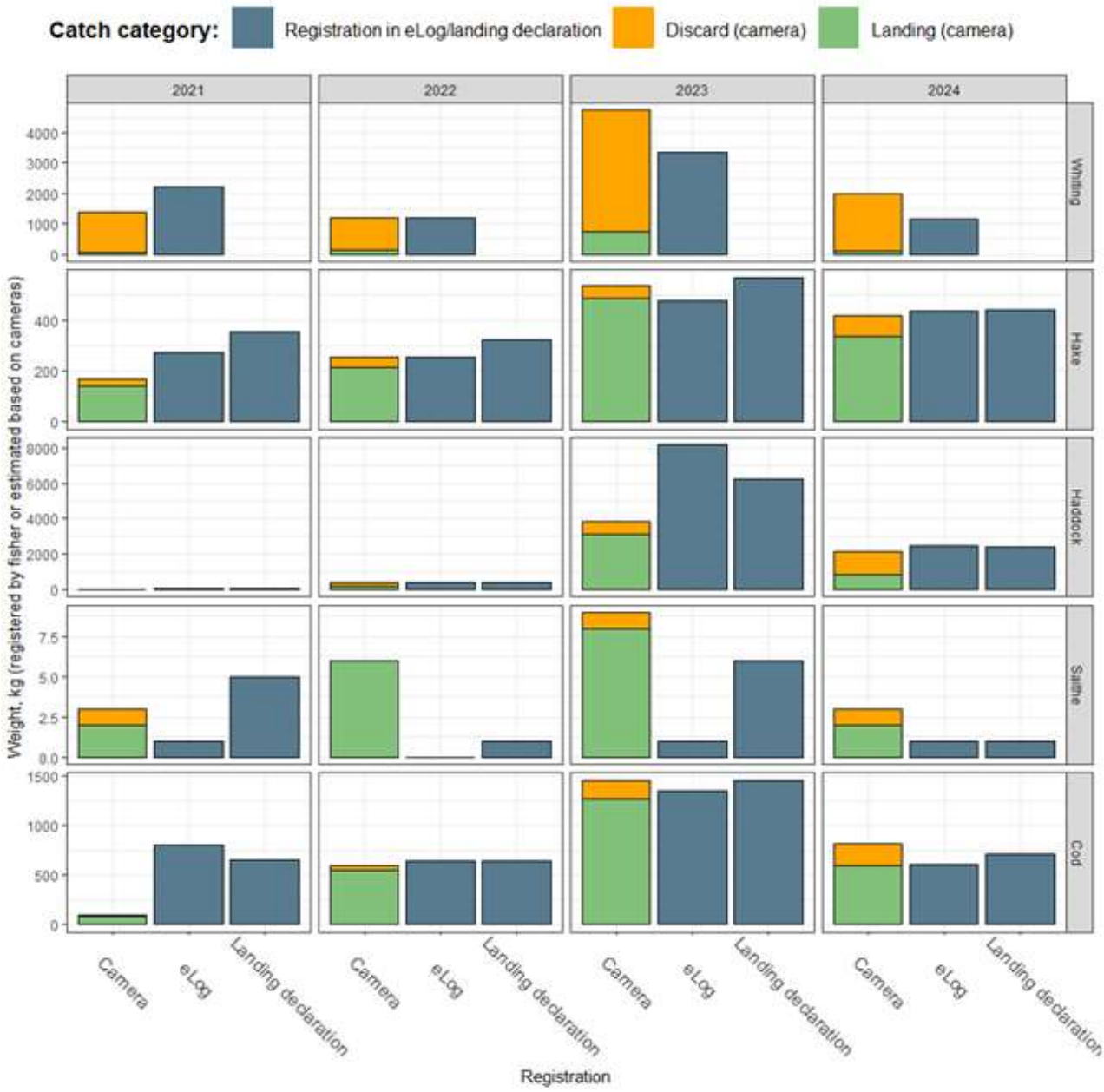

Figure 8. Registration in eLog and landing declaration (BMS, DIS, DIM and LSC) compared to estimated weight of landing and discard of species based on video review.

Overall, figure 8 show a fair agreement between registration in eLog and observations from the EM system converted to an estimated weight, especially considering that eLog is an assessment of weight which can only be written in whole kg, while the data from EM reviews record species and length (with a measurement uncertainty), meaning that estimated weight is calculated from the length-weight ratio for the species.

4.0 Collaboration

A major difference between phase 1 and phase 2 of the Kattegat-project is that phase 1 was voluntary. To a greater extent in phase 2 than in phase 1, the Danish Agricultural and Fisheries Agency had to deal with some issues. These included issues regarding lending agreements, responsibility when breakdowns occurred and covering of camera lenses during fishing events in the Kattegat. These issues were not present in phase 1 of the Kattegat-project and have not been an issue in the trial fisheries with EM.

4.1 Video quality

When reviewing video material, video reviewers score the quality of the video material using a grade system from 0 to 10, where 0 is completely useless, while 10 is optimal. Table 11 shows the average rating for cameras at the sorting area, the maximum rating for cameras at the sorting area and the minimum rating for cameras at the sorting area in phase 1, phase 2 of the Kattegat-project, the five trial fisheries with EM in the Baltic Sea, the trial fishery with EM targeting greater weever in the Kattegat and the pelagic voluntary EM project.

Table 11. Average video quality for sorting cameras, maximum video quality for sorting cameras (average of the highest value for the cameras) and minimum video quality for sorting cameras

(average of the lowest value for the cameras) divided into the five project types with camera documentation. Data until December 2024.

Project	Average video quality (sorting area cameras)	Highest video quality (sorting area cameras)	Lowest video quality (sorting area cameras)
Pelagic voluntary, 2024*	9.3	9.3	9.3
Baltic trial fisheries (voluntary), 2022-2024	7.8	10.0	3.5
Greater weever Kattegat trial fishery (voluntary), 2024	7.5	9.0	1.5
Phase 1 Kattegat (voluntary), 2021-2022	6.9	10.0	0.5
Phase 2 Kattegat (not voluntary), 2022-2024	6.3	10.0	0.0

**For pelagic vessels, cameras at dewatering box and stern view has been used as sorting area cameras*

Table 11 shows that the average video quality was highest in the trial fisheries in the Baltic Sea projects closely followed by the trial fishery for greater weever (it is too early to state conclusions on the pelagic project because only one trip has been made available for review by the Danish Agricultural and Fisheries Agency currently). Additionally, phase 1 has a higher overall average rating for video quality than phase 2. The figure below (Figure 9) show the change in video quality for the two main cameras used during video review over time in the Kattegat-project. The vertical lines denote major changes like the move from phase 1 to phase 2, the extension of phase 2 and the announcement that the Kattegat-project was to be voluntary.

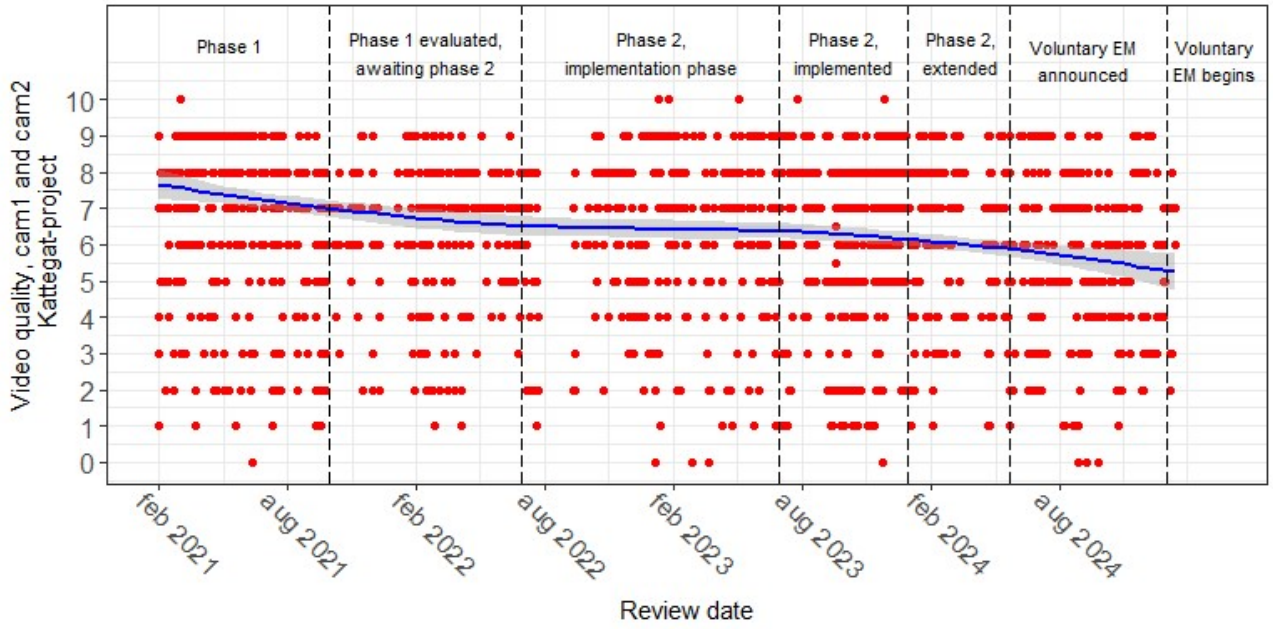

Figure 9. Timeline, development video quality, Only the Kattegat-project (phase 1 and phase 2). Red dots denote the video quality grade given to the two main cameras at the sorting areas. Blue line shows the trend in video quality.

The overall/average video quality decline over time with a stagnant period in phase 2 from roughly August 2022 to roughly August 2023. This is followed by a new decline in the average video quality after phase 2 of the mandatory Kattegat-project is extended beyond 2023 and a continuous decline after the announcement in May 2024 that the Kattegat-project will become voluntary.

4.2 Guidance

In both phase 1 and phase 2 of the Kattegat-project, the Danish Agricultural and Fisheries Agency has been instructed to have a guiding approach. Guidance was done by phone contact to the vessel masters and/or owners in phase 1. The video review was a minimum of 10% in phase 1 which allowed for a swift follow-up and renewed review if an issue (e.g. poor video quality or unwanted behavior) was detected. This too is the principle for the trial fisheries with EM. For phase 1, a feedback sheet was sent once a month or, if no video had been reviewed in the previous month, a message that nothing had been seen. A feedback sheet contain an overview of observed discards of target species subject to the landing obligation, as well as the video quality. The Danish Agricultural and Fisheries Agency, in dialogue with the industry, has continuously updated the content of feedback sheets. Current feedback sheet also includes information on observed landings of landing obligated focus species, as well as eLog and landing declaration data from the reviewed fishing trip.

From phase 2, the Danish Agricultural and Fisheries Agency sent feedback sheet to the vessel owners after review of the fishing trip. These feedback sheets served as the Danish Agricultural and Fisheries Agency's guidance to vessel owners. In the message to vessel owners sent together with the feedback sheet, vessel owners were also invited to contact the Agency if they had questions or if further guidance was wanted. It was not possible to have the same continuous guidance in phase 2 as in phase 1 because the framework for the project set in the "10-punktsplan" stated that the video review should be a 5% sampling with the possibility of an additional 5% risk-based control. This meant that follow-up could not be done as swiftly because the Danish Agricultural and Fisheries

Agency risked going above the maximum threshold for video reviews on a vessel. Even with the 5% risk-based control.

For comparison, the lowest review rate for a vessel in phase 1 was 13.4%, the highest was 35.5% and the average video review was 23.7%. In the trial fisheries with EM, three trial fisheries have had 100% review of trips (trial fishery on a gillnetter 2023, trial fishery for greater weever in the Kattegat 2024 and trial fishery testing selective gear in the Baltic 2024). The trial fishery targeting plaice in the Baltic Sea had the lowest rate at 54.5%. The review rate in the trial fishery for sandeel ranged from a review rate at 61.7% at the lowest and 100% at the highest.

4.3 System Development / improvement of camera systems

The Danish Agricultural and Fisheries Agency and the system provider, Anchor Lab, as well as fishermen and DFPO have continuously developed the EM systems. The following outlines the various changes in the systems from 2021-2024.

4.3.1 Masking and limiting of video recordings

The purpose of the EM in the Kattegat is to document the *Nephrops* fishery, in particular in terms of bycatch of cod and compliance with the landing obligation. It is therefore necessary to film where the catch comes in, where the catch is sorted and where the catch is discarded. The Danish Agricultural and Fisheries Agency puts masking/blocking on the cameras' field of view to limit recording of the fishers as much as possible. However, it cannot be avoided that fishers come within the cameras' field of view, for example if they lean over the sorting area during catch processing. If relevant, and in the case of public access to documents, further blurring is subsequently applied to the videos manually.

In addition, the vessel owner is sent a Vessel Monitoring Plan (VMP), which display areas of the vessel that will be filmed. After completed installation, the VMP is updated with the camera field of view, including masking areas. The vessel owner can at any time contact the Danish Agricultural and Fisheries Agency regarding potential change in the masking, if it turns out that this needs to be adjusted. This information is given to the fisher during the vessel visits and also when the final VMP was sent.

An issue that the masking can lead to is, that it can block the view. Masks are embedded within the camera recording, so if the camera rotate, the masking will also rotate. This can happen due to vibrations or cameras getting knocked by accident, whereby fish handling may not be seen and crew may be seen instead. The masking could be adjusted online in the Live View module, but only for future trips. An example of this can be seen in Fig. 10.

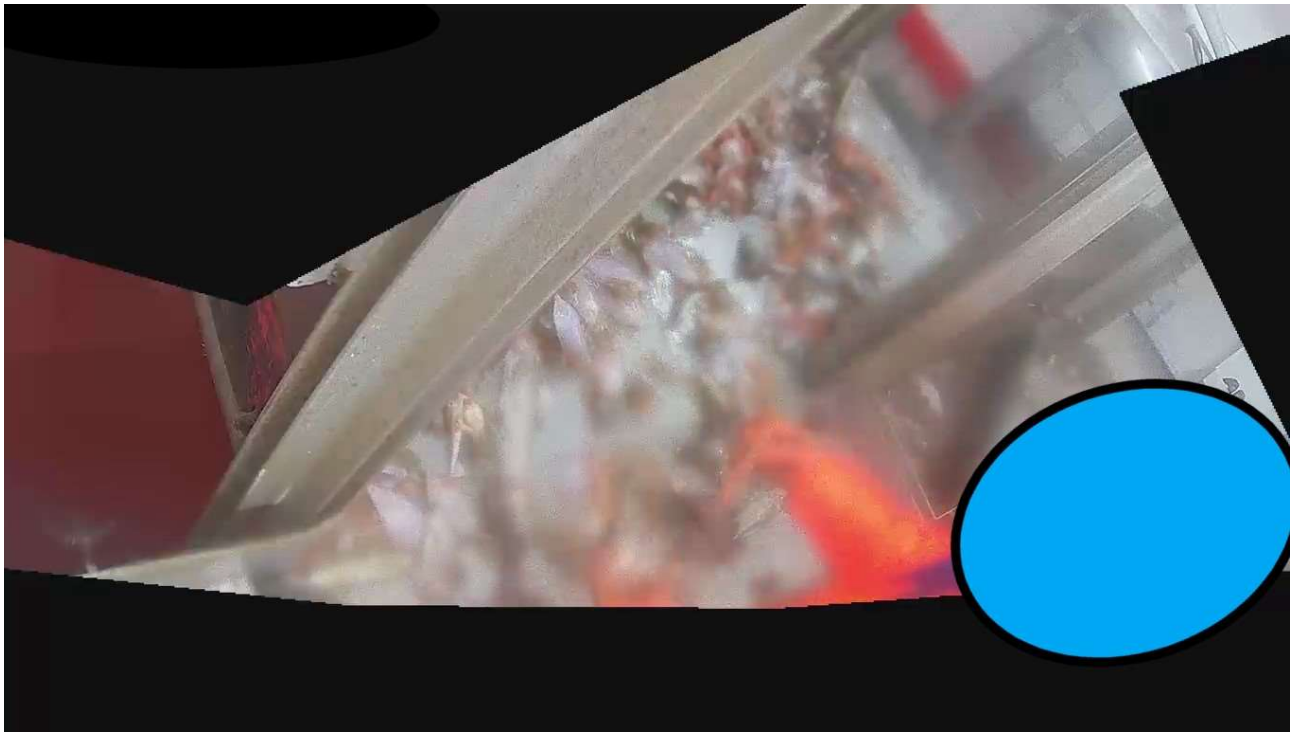

Figure 10. Example image from a camera that has rotated, whereby field of view and masking is skewed. Black areas are the masking while blue area is introduced by the Danish Agricultural and Fisheries Agency to ensure no identification of the person is possible. The black masking should have been along the sorting table and fish identification, including discards, should have been possible to observe in the bottom left area of the image. Image permission by courtesy of vessel owner.

In 2022, the Danish Agricultural and Fisheries Agency implemented motion detection sensors in the cameras themselves. Based on motion sensor graphs, the Danish Agricultural and Fisheries Agency can request less video from the vessels, as the Danish Agricultural and Fisheries Agency can pin point the times when catch sorting during the fishing trip more accurately. This limits the amount of video material that the Danish Fisheries Agency requests and review. The supplier of the EM systems has further developed firmware to stop and start video recording on board vessels to limit recordings to fishing activity and catch processing. The Danish Agricultural and Fisheries Agency has used this on five vessels so far. In general, it works well, but is easier to implement if there are few cameras (two to three) on the vessel and when the threshold for the motion detection is easy to discern. That is, if the motion detection threshold can be set for cameras that do are not interfered by a lot of noise in the field of view (e.g. shadows moving depending on the angle of the sun, loose object rolling within the field of view or seabirds landing within the field of view).

4.3.2 Face blurring camera

In January of 2023, the Danish Agricultural and Fisheries Agency initiated supplementary work, implementing new camera with face-blur capabilities, using artificial intelligence. The Danish Agricultural and Fisheries Agency acquired three camera and found two vessels willing to test the new cameras. Initially challenges regarding lower robustness of the new cameras caused problems. Moreover, the sensitivity of the blurring capabilities of the camera, needs to be constantly adjusted to accurately blur the person's face and hands. If the sensitivity is set too low, the person will not be blurred, and if it is set to high, other objects will be blurred by the artificial intelligence (e.g. fish which needs to be determined by species). Hitting the appropriate level requires constant

adjustments, especially due to changing light conditions on fishing vessels which is affected by factors like time of day and weather conditions. It has therefore turned out to be challenging, and the Danish Agricultural and Fisheries Agency has not reached a level of satisfaction on the two vessels yet. Among the issues are that the sensitivity of the blurring needs to be adjusted depending on conditions like light in order to function at the optimal level. Additionally, the ability to automatic blur seem to affect the video quality at a level where even an increase of the frame rate could not compensate for the degradation. The Danish Agricultural and Fisheries Agency will on these grounds, suggest further development in testing of the cameras, in cooperation with vessels that are willing to have a higher amount of reviews than the "10- punktsplan" allowed for. Figures 11 and 12 present a snapshot from a face blurring and non-face blurring camera to of a catch sorting process.

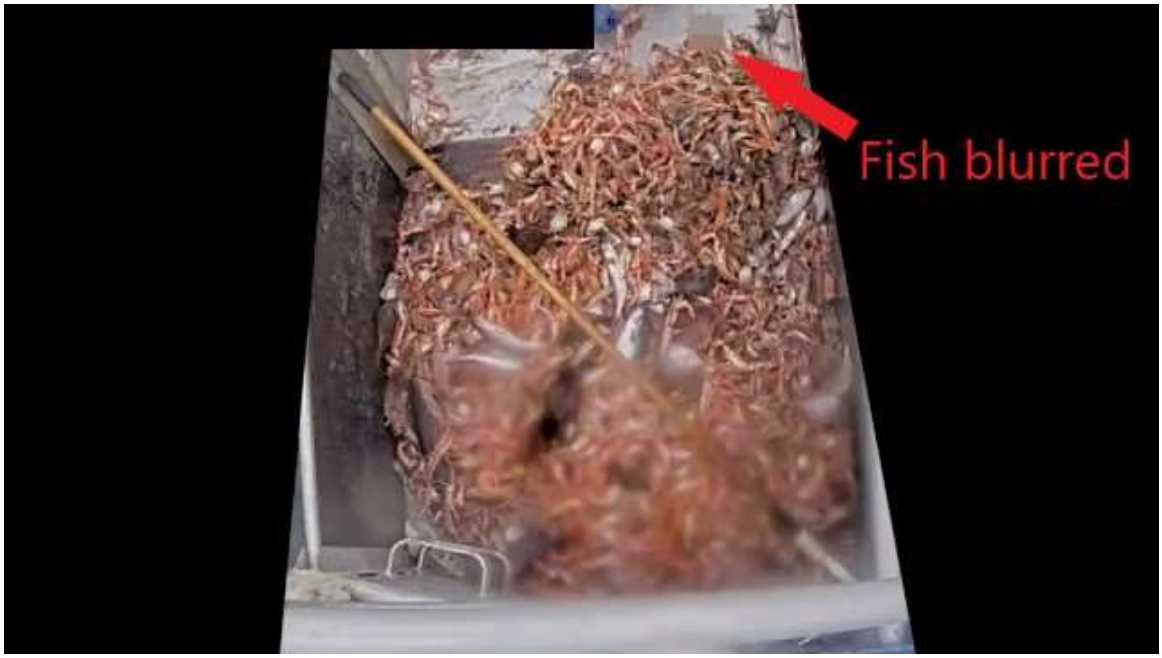

Figure 11. Example image from a camera with blurring capability. Fish blurred. Video quality and resolution set to same as Fig. 12. Black areas are the masking. Image permission by courtesy of vessel owner.

Figure 12. Same time as example image in Fig. 11 but from camera not capable of blurring. Fish not blurred. Video quality and resolution set to same as Fig. 11. Black areas are the masking. Image permission by courtesy of vessel owner.

4.3.3 Receipt module and video request

The "10-punktsplan" between DFPO and former Fisheries Minister Rasmus Prehn states that the Danish Agricultural and Fisheries Agency only retrieves video recordings from the EM vessels' BlackBox hard drives with the fisher's knowledge and consent. Prior to the "10-punktsplan", the EM system did not have a technical solution that locked access to video recordings for the Danish Fisheries Agency. The supplier of the EM system developed a receipt module in order for the Danish Agricultural and Fisheries Agency only to have the option of retrieving video recordings after the request for the transfer of video material has been accepted and acknowledged on the vessel in question. This solution was rolled out to all vessels subject to mandatory EM in the Kattegat from week 50, 2022.

4.3.4 Wrongful recording and handling of breakdowns

There have been cases where the EM system recorded in port in 2021, 2022 and 2023. The reason has typically been an error in setup eg. due to removal of geofencing by mistake during installation or that adjustments needed to be made to the geofencing around a port. In 2024 no wrongful recordings (eg. in port or when fishing was outside the Kattegat) has been reported by any vessels, regardless of the project. The Danish Agricultural and Fisheries Agency believe this to be due to the maturity of running EM projects by the Agency, meaning that most teething troubles have been identified and eliminated.

Since phase 2 in 2022, the Danish Agricultural and Fisheries Agency has been able to minimize the impact on fishing in the event of breakdowns with the text of the "10-punktsplan" stating that "Ved tekniske problemer og nedbrud af kameraudstyret kan Fiskeristyrelsen i førstegangstilfælde og ud fra en konkret vurdering tillade, at fiskeriet fortsætter". In phase 1, there was not as flexible a framework for handling breakdowns. Due to the more flexible approach to breakdowns, breakdowns of EM systems have not resulted in days in port for vessels. It is advised to allow for some flexibility when breakdowns occur. Part of the Vessel Monitoring Plans (VMP's) in the Danish

EM projects is a guide on how to proceed when a system component malfunction. This way, the vessel master or owner can easily see who to contact and what to do, while the authorities also have a guide to how critical a component is.

4.3.5 Live View/remote access

Live view/remote access to the EM system is used during installation and repair/maintenance. The Danish Agricultural and Fisheries Agency has informed all vessels subject to mandatory EM that situations may occur during the installation process where the Danish Fisheries Agency must access the EM system via Live View. The following scenarios may highlight the need for this central access:

- Setting/adjustment of masking (possibly at the instruction of the fisher)
- Check and/or add-ons for geofencing
- Adjustment of sensors
- Rebooting camera
- Capture of cameras field of view and masking for grid setting (used for length measurement when registering fish) and VMP
- Recording at diagnostic check
- Central registration of any breakdown or failure of the EM system

In the implementation of phase 2, the industry expressed concern that the Danish Agricultural and Fisheries Agency had the technical possibility to access EM systems centrally via Live View without fisher's consent, even though the guidelines for employees were that access to Live View must only take place after consent had been obtained. On the basis of this concern, the Danish Agricultural and Fisheries Agency asked the supplier to develop a function that put a black masking on the entire image on all cameras when these are not recording during fishing. That is when vessels are in port, or have not yet deployed their gear. Should the need for access to a vessel's EM system arise, the Danish Fisheries Agency can only access cameras after entering a personal code that the fisher has. This code unlocks and removes the black masks in Live View. The code can be changed on board by the fisher.

5.0 Trial fisheries and pelagic with EM

Since 2022, the Danish Agricultural and Fisheries Agency have had at least one trial fishery with EM each year. In 2024, the Danish Agricultural and Fisheries Agency had the first video review from the pelagic sectors voluntary EM project. The following subsections present a summary of each of the projects.

5.1 Trial fishery with EM for sandeel in the Baltic Sea 2022 and 2023.

The two trial fisheries with EM for sandeel (official titles 'Minimization of cod in the sandeel fishery in the Baltic Sea during the closure period' in 2022 and 'Minimization of cod in a sandeel fishery in the Baltic Sea, including the closure period' in 2023) are in terms of procedures for EM so closely linked, that they can be reported as one project. The projects covered two vessels (same vessels in both years) and both vessel visits and installation took place in 2022. Vessel owners participated actively in the vessel visit and installation went smooth with the owners ensuring that their installment proceeded in time, even though installation took place in Rødvig, Stevns while vessel visits were done in Hanstholm, Northern Jutland. The vessels could not begin the trial fishery until the Danish Agricultural and Fisheries Agency had approved the installation. Both trials were in collaboration with DTU Aqua - National Institute of Aquatic Resources. Four cameras were used on both vessels: one at the stern, one overview filming the fishing deck, one filming the center area

where catches were taken in (example in Fig. 13) and one filming the port side were catches could slide in too.

Figure 13. Example image from trial fishery with EM for sandeel in the Baltic Sea. Video quality of 9 out of 10. Black areas are masking. Image permission by courtesy of vessel owner.

The main purpose with the trials was to avoid cod catches in the sandeel fishery and the EM system was placed to document this. The sandeel fisheries were done with trawl and catches were taken onboard in bulk where they went straight into the cargo hold for landing. In general, it was easier to identify species than first thought, as larger fish such as cod and whiting (bycatch) tended to "float" on top of the sandeel. In addition, the catch sorting process was short as the catch simply slided into the cargo hold. Video reviewers would replay videos at down to 0.25 times the speed to see bycatches but as catch came in during the beginning of the catch coming in and because the review only needed to go through roughly 40 minutes of catch handling on average, this was manageable.
The video quality was generally high (an average of 8.3 for one vessel and 9.5 for the other) and there was very good cooperation with the vessel owners. Fig. 11 is an example with the length measurement of a whiting (bycatch). Between 61.7% and 100% of trips and hauls where reviewed, depending on vessel and year.

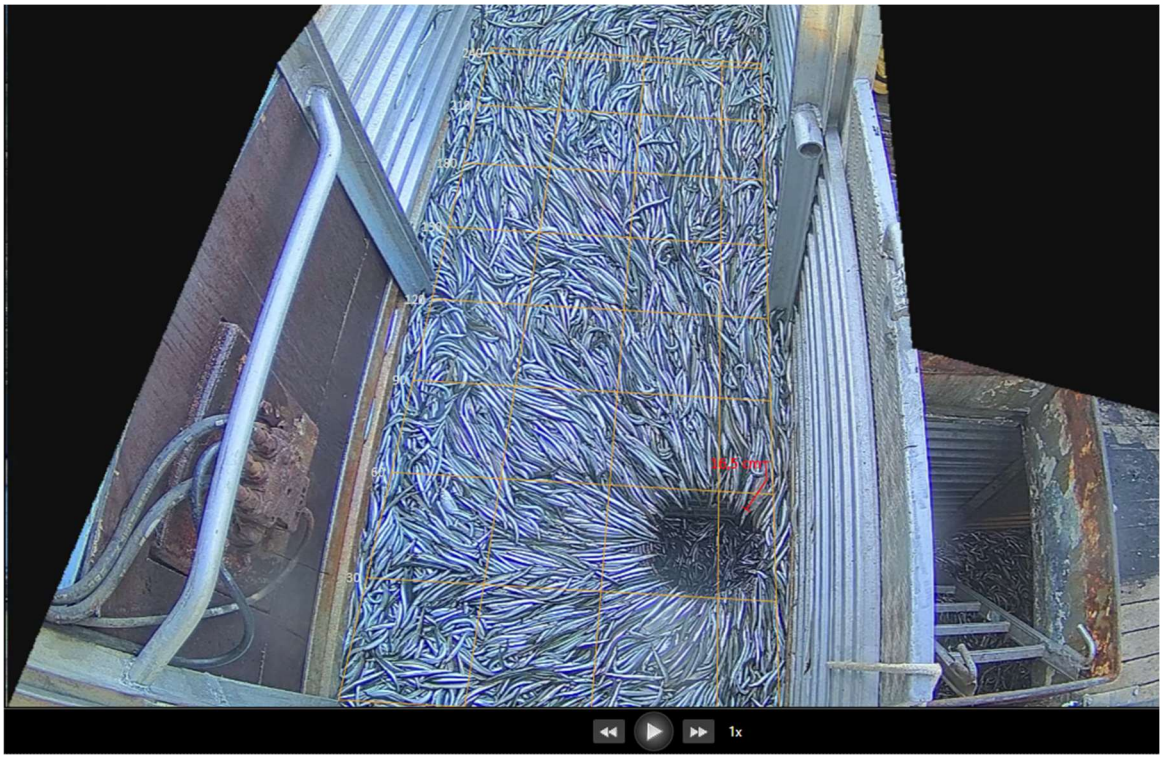

Figure 14. Example image from trial fishery with EM for sandeel in the Baltic Sea. Video quality of 9 out of 10. Grid overlay is shown in orange and red marking is the length measurement of a whiting (16.5 cm in length) caught as bycatch. Black areas are masking. Image permission by courtesy of vessel owner.

Removal of the EM systems at the end of the project was impaired somewhat by unclear agreement regarding the responsibilities between vessel owner, the Danish Agricultural and Fisheries Agency and DTU Aqua. A lesson learned is to get an agreement in writing for the responsibility of each party at the end of projects.

5.2 Trial fishery with EM on a gillnetter

The trial fishery (official title 'Trial fishery during the closure period with nets - vessel over 12 meters on the same terms as vessels under 12 metres, Camera monitoring. Area 22' in 2023) covered the gillnetter SG120 in ICES Subdivision 22. The purpose of the trial was to examine the catches on a vessel over 12 meters in length and compare it with the catches from vessels under 12 meters in length in the same period. The trial was a collaboration between the Danish Agricultural and Fisheries Agency and FSK-PO. Vessel visit and installation was done in 2023 in Spodsbjerg on Langeland. The owner participated actively in the vessel visit and installation was done by a local ships electrician. The owner paid for installation and removal of the system, both of which went smooth. The crew could not begin the trial fishery until the Danish Agricultural and Fisheries Agency had approved the installation.

On average the video quality was good but contact was necessary in the trial to ensure cleaning of cameras. Close collaboration with vessel owner and the fact that no masking were made ensured proper review despite of a few catch processings with a video quality below the grade 7, which is set as the grade for video footage that is acceptable but could be improved. The average video quality for the trial was 7.2 out of 10. 100% of the trips and fishing activities were reviewed. Four cameras were used: One viewing over the starboard side, where the gillnett was taken in, one viewing at the first sorting area were the gillnett entered the vessels, one viewing the center area where gillnett

was emptied of catch and one viewing where landings were put. Because no masking was needed it was easy for reviewers to see the entire catch processing. However, fishers were filmed due to this. It was the vessel owners own request to leave cameras with no masking which was partly because this allowed for fewer cameras to be installed but also because of trust in no misuse of the data would occur This is also evident in that no sensors were installed, only cameras. This meant that cameras would start recording as soon as the vessel left port, even if the vessel did not fish. Rather than relying on rotation sensor data to target review, the Danish Agricultural and Fisheries Agency used motion detection in the cameras to target review at were catch processings occurred. This is a good tool for gillnetters as they do not have hauls as a trawler, meaning that rotation sensors are not well suited for this type of vessel. At the time of the trial, the Danish Agricultural and Fisheries Agency could not start and stop video recordings by use of motion detection. If this trial or a similar was to run again today, the Agency would make use of start and stop of video recordings using motion detection. Not only due to minimization of records of the fishers but also to minimize the video footage recorded and thereby the amount of stored data. Fig. 15 to 17 are examples from the gillnetter.

Figure 15. Example image show handling of net with a flounder in the trial fishery with EM on a gillnetter, Video quality 9 out of 10 for the picture. Black masking in top left corner has been inserted by the Danish Agriculture and Fisheries Agency to blank out date and time. Image permission by courtesy of vessel owner.

Figure 16. Example image show handling of net with a cod in the trial fishery with EM on a gillnetter. Video quality 9 out of 10 for the picture. Black masking in top left corner has been inserted by the Danish Agriculture and Fisheries Agency to blank out date and time. Image permission by courtesy of vessel owner.

Figure 17. Example image show catches of flounder, plaice and turbot in the trial fishery with EM on a gillnetter. Video quality 9 out of 10 for the picture. Black masking in top left corner has been inserted by the Danish Agriculture and Fisheries Agency to blank out date and time. Image permission by courtesy of vessel owner.

5.3 Trial fishery with EM, targeting plaice

The trial fishery (official title 'Trial fishery in ICES subdivisions 22 and 24, during the closure period, intended at testing whether a fishery can be conducted in the western Baltic Sea with minimal bycatch of cod by use of, among other measures, a modified trawl with a Bacoma codend.' in 2023) covered one trawler. The purpose of the trial was to examine whether a minimal bycatch of cod could be ensured while fishing in the area and included a BACOMA codend as a measure to avoid cod bycatches. The trial was a collaboration with DTU Aqua - National Institute of Aquatic Resources. The vessel already had EM installed, as it was subject to the mandatory EM in the Kattegat. No vessel visit and installation was needed. It was necessary to make adjustments in the areas filmed in order to allow for different catch processing's when sorting catches of *Nephrops* compared to catches of mainly plaice. These adjustments could be done online by the Danish Agricultural and Fisheries Agency through the Live View function in the EM system. Four cameras were used: One viewing over the port sorting and potential discard area, one viewing the starboard sorting and potential discard area, one viewing part of the starboard sorting and into where the catch was taken in, and one viewing the trawl.

On average the video quality was good but one camera had continuous issues during part of the project period. Because it was an overview camera, this mainly affected the video quality but not at a level where review was not possible. At 6.3, this trial had the lowest average video quality of any EM project operated by the Danish Agricultural and Fisheries Agency. The main cause for this is the low grade for the overview camera. However, difficulties on adjusting the existing cameras to a new workflow and inadequate focus on clean lenses from crew also played in. Close collaboration with the vessel owner was made, but could not fully mitigate these issues. 54.5% of trips where reviewed. Fig. 18 show an example.

Figure 18. Example image from trial fishery with EM, targeting plaice. Video quality 5 out of 10 for the picture. Black area top has been inserted by the Danish Agricultural and Fisheries Agency to blank out date and time, while the rest of the black areas are the masking. Image permission by courtesy of vessel owner.

5.4 Trial fishery with EM, targeting greater weever in the Kattegat

The EM part of the trial fishery (official title 'Trial fishery for greater weever in the Kattegat for industry and consume.' in 2024) covered three trawlers. The vessels already had EM installed, as they were subject to the mandatory EM in the Kattegat. No vessel visits was needed but adjustments to the cameras field of view and masking had to be made due to a different workflow in the fishing operations between a fishery targeting *Nephrops* compared to greater weever. This was not least due to greater weever being caught as bulk, which was quite similar to the trial fisheries for sandeel, while catches when fishing for *Nephrops* would be sorted. The needed adjustments could be done online by the Danish Agricultural and Fisheries Agency through the Live View function in the EM system. For all three vessels four cameras were used to monitor where the catch came in, where in could go into the cargo hold (in both port and starboard side) and one viewing the trawl gear.

The purpose of the trial was to assess whether a fishery targeting greater weever could be sustainable. Part of the trial fishery was a protocol for sampling of catches as well as self-reporting. The EM was used to verify that these requirements were met and to document bycatches. Catches in the trial fishery would be taken onboard in bulk and video reviewers would register bycatches among the greater weever. The process was very similar to the process for the sandeel trial fisheries. However, bycatches like cod, haddock and whiting were a lot more difficult to detect because the similarity is much greater between those roundfish species and greater weever. Because of the requirement for sampling, video reviewers would also register whether sampling was done correctly. The video quality did fluctuate quite a bit between trips, especially for one vessel. 100% of hauls and trips in the trial fishery for all three vessels were reviewed. Sampling could be documented and the self-reported bycatches covered the same range of species as was seen during video review. However, it was not possible to quantify accurately the amount of bycatches by video review. The self-reported catches were always higher than what had been registered. There is no doubt that this fishery has been the most difficult fishery to monitor with EM that the Danish Agricultural and Fisheries Agency have tried so far. This include the trials in the North Sea, the Skagerrak and Baltic Sea from 2010-2016. Yet, the ability to adapt the review meant, that the EM still added value. Rather than a quantitative approach, as has been the norm for the rest of the EM projects in 2021-2024, the focus shifted to document correct sampling and to estimate the range of species taken as bycatch. That meant that the EM could still be used to verify that the fishers' self-reporting's were correct. Figure 19 show an example of imagery from the greater weever trial fishery.

Figure 19. Example image from the trial fishery with EM, targeting greater weever in the Kattegat. A cod caught as bycatch can be seen above and to the right of the hole to the cargo hold (see red arrow). Video quality 7/8 out of 10 for the picture. Image permission by courtesy of vessel owner.

The Danish Agricultural and Fisheries Agency learned a few new lessons from this trial fishery:

1) EM can just as well be used to verify sampling, rather than the individual fish.

2) Confirmation of the range of species by EM (qualitative estimate of bycatches) might not be as good as range and amount of species (quantitative estimate of bycatches) but does allow for verification of self-reporting as well. Even when target species and bycatches look quite similar on video footage.

3) Because the EM can document what is taken away and what goes into the cargo hold, potential discards can be assessed, regardless of the difficulties of video review in a fishery like the greater weever fishery.

5.5 Trial fishery with EM, roofless selective gear

The trial fishery (official title 'Fishing for flatfish in subdivision 24 with roofless gear.' in 2024) covered two trawlers. One trawler already had EM installed, as it was subject to the mandatory EM in the Kattegat. The other trawler had previously been part of a trial fishery with EM and the previous VMP could be used to re-install EM. No vessel visit was needed. Four cameras were used: One viewing the port side discarding area, one viewing the sorting area, one overview camera and one viewing the trawl.

In terms of fishing, the trial was not successful. Only four trips were made before the trial stopped for the vessels. The catch was simply too poor with as low catches as 50 kg of plaice, one kg sole, four kg turbot and 28 kg flounder for a full trip. In terms of selectivity, no bycatches of any roundfish was observed at all. All four trips and all hauls were reviewed. The video quality from the four trips are among the best ever (all hauls had 9 or 10 out of 10 given as grade). Fig. 20 below is an example of imagery from the roofless trial fishery.

Figure 20. Example image from the trial fishery with EM, testing a selective gear. Flatfish species in image include dab, flounder, plaice and turbot. Video quality 10 out of 10. Image permission by courtesy of vessel owner.

5.6 Pelagic with EM

The Danish Pelagic Producers Organisation (DPPO) introduced EM on the PO's 11 vessels in 2024. The Danish Agricultural and Fisheries Agency participates in project by reviewing data from some of the fishing trips (benchmark of 10%). The project is operated by DPPO on its own, meaning that the Danish Agricultural and Fisheries Agency only participate by and approving Vessel Monitoring Plans (VMP's) and by reviewing data, leaving operational tasks like installation, maintenance and procurement to DPPO. The project has multiple purposes, one of which is the possibility for ease of certain rules in return for access to the EM data for the Danish Agricultural and Fisheries Agency.

As such, the Agency is a project partner/participant and the main focus so far for the Agency is to gain experience on how to operate EM on pelagic vessels as this is the first EM project on pelagic vessels in Denmark. The pelagic sectors voluntary EM project is different from the rest of the EM projects at the Danish Agricultural and Fisheries Agency in several areas. Not only is it the pelagic sectors own project but the EM vendor chosen by DPPO in the procurement process is a different EM vendor than in the EM projects run by the Danish Agricultural and Fisheries Agency. Although similarities exist, there are several differences between Integrated Monitoring and their review software 'Monitor' (pelagic sectors EM vendor) compared to Anchor Lab and their review software 'BlackBox Analyzer' (EM vendor for projects run by the Danish Agricultural and Fisheries Agency).. Finally, it is clear that video review and analysis output is different for pelagic vessels than for demersal trawlers or gillnetters.

The Danish Agricultural and Fisheries Agency have held meetings with the Scottish Marine Directorate with respect to the upcoming Scottish requirements for EM on pelagic vessel and what expectations the Scottish authorities have. Knowledge exchange has also been done with the Swedish Agency for Marine and Water Management (SwAM) as Sweden in 2023 had an EM project on pelagic vessels which the Danish Agricultural and Fisheries Agency have looked to in order to gain knowledge for EM on pelagic vessels[7].

The Danish Agricultural and Fisheries Agency will evaluate the participation in the project when further experience has been gained. Camera documentation allow for easing of certain rules, which means that pelagic vessels with camera documentation approved by the Danish Agricultural and Fisheries Agency may be able to acquire special conditions for the documented fishery. In July 2024, vessels fishing for sandeel in the North Sea were allowed to fish in multiple sandeel management areas on the same fishing trip, if the vessels had an EM system installed, which had been approved by the Danish Agricultural and Fisheries Agency and for which the Danish Agricultural and Fisheries Agency could access and review the EM data. At the time of writing, the Danish Agricultural and Fisheries Agency has approved the VMP for nine out of 11 pelagic vessels with EM in Denmark.

[7] Försök med kamerabevakning av fiskefartyg. English version: Trial involving cameras and sensors on board fishing vessels. https://www.havochvatten.se/om-oss-kontakt-och-karriar/om-havs--och-vattenmyndigheten/regeringsuppdrag/regeringsuppdrag/2021/forsok-med-kamerabevakning-av-fiskefartyg-2021.html

6 Lessons learned and advice

In the following section, some of the main lessons learned in running EM projects are listed with supplementary information.

6.1 Purpose and responsibility

Before starting on EM, the purpose of the EM must be identified. The purpose will influence the level of detail needed during video review and species which are to be covered. The review rate will be influenced by the objective, in general terms for higher accuracy and the more rare the events of interest - the higher the review rate. For example, an EM program targeted at incidental bycatch of protected species will need a higher review rate (typically up to 100%) than an EM scheme with the purpose of verifying self-reporting's in logbooks (typically around 10%). The responsibility for maintenance, system and data ownership must also be made clear as this will also influence the procurement process. In all but one Danish EM trial from 2021-2024, the Danish Agricultural and Fisheries Agency owned the EM systems but borrowed the systems to the vessel owners, meaning that the Agency had to do the procurement and that vessel owners must return the EM systems. In the pelagic trial however, the procurement was done by the industry. Vessel owners own the data in all the EM projects the Danish Agriculture and Fisheries have operated. The Agency get all sensor data but need to request video data and delete it from the Agency's servers after video review. Expenditures to maintenance and installation has been covered by the Agency in all EM trials except the pelagic where the industry cover these costs themselves. However, arranging the installation of EM has been the responsibility of the vessel owners and the Danish Agricultural and Fisheries Agency has made a contract for each vessel installment with local ships electricians. This can be cumbersome in the beginning, but when a local electrician has handled around four to five installations, they know what is needed and how to achieve this. The benefit of subcontracting to local electricians are multiple. For one, it means that a procurement for installation is not necessary since the cost for the individual installations is almost always lower than the threshold where a procurement process had to be made. In addition, having vessel owners choosing their own electricians means, that they usually know the people, which takes the edge of the feeling of being invaded by an authority in the installation process. It also means, that the electricians are close to the place where fishers operate, which lowers the response time for maintenance. Because the local electricians have installed the system, they also know how to fix it.

6.2 Test EM system

The Danish Agricultural and Fisheries Agency have a test EM system at the FMC. This allow for testing of new features, such as motion detection to switch on and off video recordings or new modules for video request, to be tested in a live environment prior to implementation on actual fishing vessels. The test system also functions as a learning platform for new employees and can be used to check whether glitches or bugs seem to be occuring on a single vessel or are more general. The test system is also used to guide vessels into settings at-sea even when the vessel in question is outside of network range, because the Agency can go into the FMC EM system Live View and guide fishers on how to try simple fixes, eg. rebooting their EM system. Finally, the test system allows the Agency to verify whether messages sent via the EM system go through by checking whether the FMC test system has recieved the message.

6.3 Cameras, sensors, placement and type

6.3.1 Cameras

Having robust cameras suited to the rough environment on fishing vessels is a must. Breakdowns and malfunctions will happen nevertheless, but the frequency of such issues can be reduced with proper equipment. It can be a good idea to customize the type of camera depending on location. Codeye-lens cameras are good for locations where an overview is necessary because a broad field of view is needed. Square-lens cameras can be better than codeye-lens cameras at areas where precision in length measurements and species identification is wanted because the video records do not get distorted in the edges of the field of view when using square-lens cameras, allowing for better precision in length measurements. Cameras with optical zoom can be used when it is difficult to find a good location close to the area that needs to be monitored, as these cameras can be placed relatively far away and then be zoomed in to focus on the wanted areas. At other times, out-of-the-box-thinking in placement may work. The Danish Agricultural and Fisheries Agency have a few vessels where cameras have been placed right under the bulwark to view the discards going out at the scupper. This means that the camera is constantly flushed by seawater during fishing and in an extremely exposed location. On the other hand, the placement allows for a close view of the discards and the frequent flush of water cleans the cameras. It is not ideal, but is an example of how at times it is necessary to be creative when placing cameras on fishing vessels. An image from one of these cameras is presented below.

Figure 21. Example image from a camera in the Kattegat-project placed under the bulwark. Black areas are the masking. Image permission by courtesy of vessel owner.

During vessel visits, the Danish Agricultural and Fisheries Agency would use a tablet with a camera connected (see Fig. 22). This made it possible to see how the field of view would be at different placements where the camera could be fitted. Additionally, it gave the vessel master and crew the possibility to see what areas would (and thereby what areas wouldn't) be filmed which also facilitated engagement in camera placement from the crew.

Another factor to remember when placing cameras is, that since the fisher is required to ensure clean lenses, the cameras should be, as much as possible, placed where the fisher can reach the lenses for cleaning.

Figure 22. Tablet with camera connected.

6.3.2 Sensors

Sensors can cover a broad range of components added to the EM system to better target the review to areas and times of interest. Besides the GPS, the main sensor used by the Danish Agricultural and Fisheries Agency has been rotation sensors on the winch. These are set to record when trawl is set or hauled in and the cameras are set to start recording when first rotation sensor input is registered outside port. For trawlers, the start and stop time can be found by use of the rotation sensors.

In addition to rotation sensors (and speed based on GPS), motion detection sensors in the cameras has been used too. This allow the cameras to function as sensors too by showing when motion and thereby activity is high within the field of view. Motion detection makes it possible to better pinpoint what video files the Agency should request for control. This in turn allow for a smaller amount of data transmission because fewer video files needs to be transmitted. Fig. 23 show an example of sensor data.

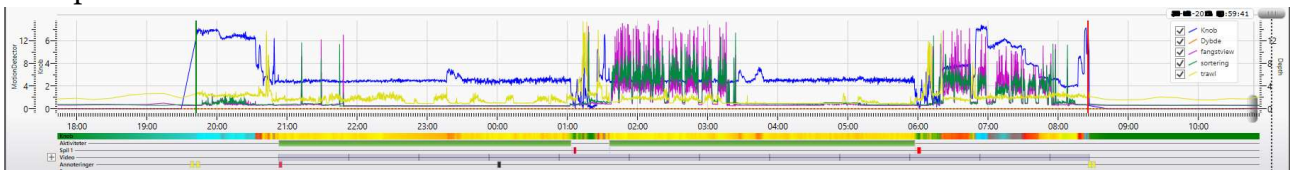

Figure 23. Example of sensor data from a vessel with rotation sensors and video recording based on rotation sensor start. Blue line (Knob) shows the vessel speed, purple line (fangstview) shows the motion detection in the catch hold, green line (sortering) shows the motion detection at the

sortering area, and yellow line (trawl) shows motion detection at the drum. The two green bars in the line “Aktiviteter” shows where the fishing activities started and ended. These have been added automatically by the software. The blue and red smaller bars in the next line “Spil 1” shows where the rotations sensors indicated start and stop of the winch. The line “Video” shows where video have been recorded. The line “Annoteringer” shows where indications occur. The red around 21:00 shows the start of video recording and the black around 00:00 shows that a system status was made.

On some vessels, it has been very difficult to fit rotation sensors onto the winch, either from the start or because the layout in the area around the winch is in a way where rotations sensors continuously have been hit by something (for instance if the winch is a bit loose or if wires bump into the rotation sensors). On some vessels, hydraulic sensors and/or electric on/off switches were able to provide the indication of first fishing activity. However, the Agency’s has also tested the possibility of using the motion detection in the cameras to start and stop the recording. Recording starts when the motion detection is above a certain threshold and stops when the motion detection is under the given threshold for a certain time (eg. 15 minutes). This eliminates the need for rotation or similar sensors on the winch. However, it takes a bit more knowledge of the vessel to get in place because the threshold can vary depending on vessels and location of cameras. This is due to multiple factors, such as but not limited to shadows, loose objects and false positives (e.g. crew or seabirds moving through the field of view). An example of such a setup is shown in Fig. 24.

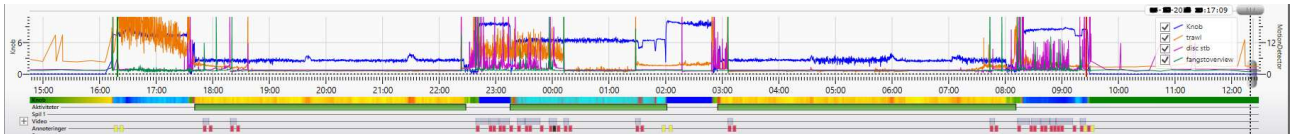

Figure 24. Example of sensor data from a vessel without rotation sensors and video recording based on motion detection. Blue line (Knob) shows the vessel speed, purple line (disc stb) shows the motion detection in the starboard side where sorting occurs, green line (fangstoverview) shows the motion detection in the catch hold, and orange line (trawl) shows motion detection at the drum. The three green bars in the line “Aktiviteter” shows where the fishing activities started and ended based on the motion detection. These have been manually added. The line “Video” shows where video have been recorded and the line “Annoteringer” shows where indications occur. Note that compared to Figure 22, there are several red small bars in “Annoteringer” and several smaller video files available. This is because the video start and stops based on motion detection. Additionally, there are no blue and/or red smaller bars in the line “Spil 1” because there is not input from rotations sensors.

Comparing Fig. 22 and Fig. 23, one might note that the disadvantage in using motion detection to start and stop video recording is that the data gets “muddier”. The experience in the Danish EM trials is that there is a trade-off between repair costs compared to more manageable data when it comes to what sensor best suits the purpose. It is an assessment that in the end must be made for each vessel.

Below is a table of some common issues encountered during the years with EM in Denmark (from 2010 to 2024) and countermeasures for these.

Table 12. Typical issues with cameras encountered during EM projects 2010 to 2024 and countermeasures.

Issue	Countermeasure
Obstruction of camera view, work procedure	Get vessel master and crew engaged in placement; Be (very) creative in placement of cameras; Use tools (e.g. camera-tablets) to help in possible placements
Water droplets on lens	Tilt cameras so that water droplets (mainly) form outside the central field of view; Use cameras with hydrophilic dome or capable of dog shake (not yet tested by the Agency)
Low or no light	Cameras with capability of infrared recording or supportive light
Smudge on lenses	Video quality listed as a risk factor for additional review; Stressing the importance of clean lenses to fishers; Placing cameras where fishers can reach the them for cleaning; Cameras equipped with wiper or self-cleaning spray (not yet tested by the Agency)
Obstruction of camera view due to masking being askew	Treat masking blocking fish handling area the same way as smudge blocking the view. It is part of system check to check camera view, not only for clean lenses, but also for whether masking is askew
Rotation sensors prone to breakdown	Switch to automatic start of REM system when vessel leaves port rather than start based on first rotation sensor input; Switch to motion detection threshold on one or multiple cameras to start and stop recording (cameras film all the time, but only record for a certain time when motion detection is above the specified threshold.
Vessel owner or master doubting the quality of the video review	Have each registry recorded with a picture as well and have the possibility to trace the registration to the camera where the fish in question was seen. This makes it possible to send pictures to vessel owners as documentation and to highlight cases where some of the crew comply with rules while others do not.

Fig. 25 to Fig. 32 show example pictures of the video quality from different EM projects and vessels in Denmark.

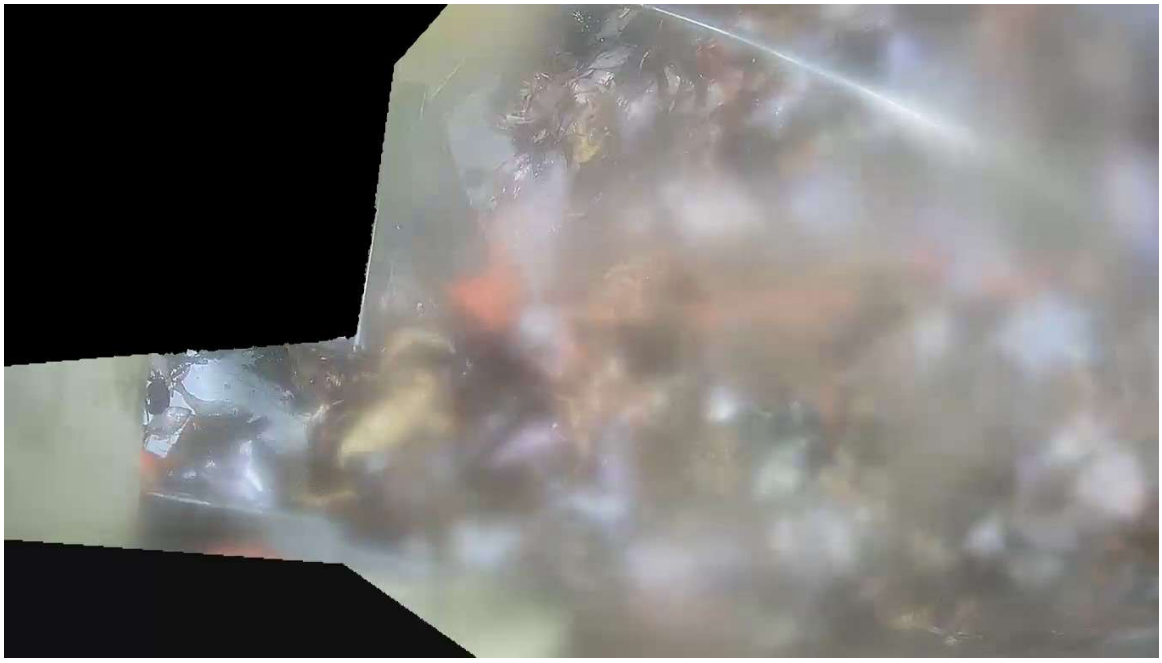

Figure 25. Video quality 1 or 2 out of 10. Smudge on camera. Image permission by courtesy of vessel owner.

Figure 26. Video quality 2 or 3 out of 10. Smudge on camera. Image permission by courtesy of vessel owner.

Figure 27. Video quality 3 or 4 out of 10. Smudge on camera and work process blocking view. Image permission by courtesy of vessel owner.

This example also show how it is impossible to block out areas where crew might handle fish, since at times is on the actual sorting table.

Figure 28. Video quality 5 out of 10. Smudge on camera. Image permission by courtesy of vessel owner.

Figure 29. Video quality 6 out of 10. Issue with camera giving pink coloration. This specific issue has in most cases been fixed by rebooting the camera through the Live View function. Image permission by courtesy of vessel owner.

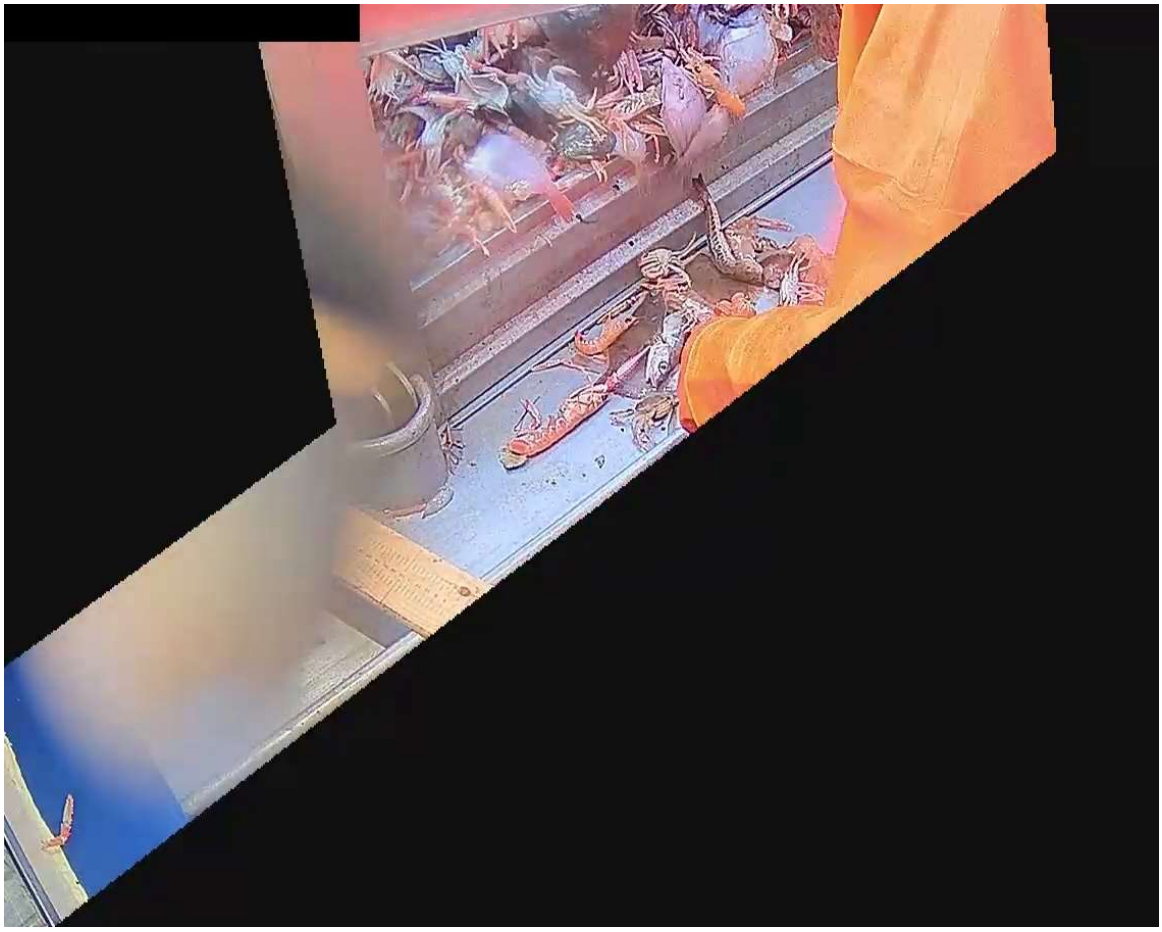

Figure 30. Video quality 7 out of 10. Water droplet in corner of field of view. Image permission by courtesy of vessel owner.

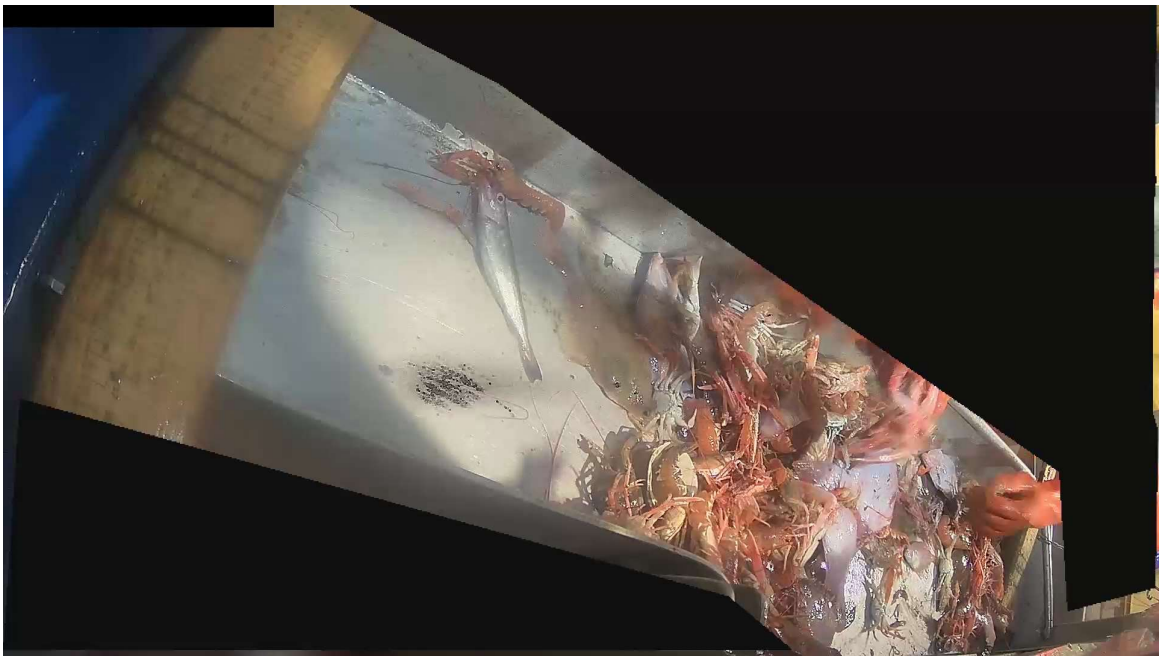

Figure 31. Video quality 8 out of 10. Bit foggy in corner of field of view. Image permission by courtesy of vessel owner.

Figure 32. Video quality 9 out of 10. Image permission by courtesy of vessel owner.

6.4 Frame rate, resolution and video quality

Set frame rate, video quality and resolution at a level that enables the necessary function for the specific camera. This can be compared to the requirements stated in the VMP. There is no need to put 30 frames per second (FPS) if 10 or 15 FPS allow for species identification. On the other hand, if 30 FPS is necessary then adjust the setting or number of other cameras accordingly or upgrade the data storage capacity. The Danish Agricultural and Fisheries Agency tested the effect of overshooting the video quality in the trial fishery with EM targeting sandeel. The two vessels had four cameras and as a test, the frame rate, video quality and resolution were set to the highest possible for the EM system which was 30 FPS, 1920x1080 and Ultrahigh. It took a bit less than three months for the onboard storage of 2TB to be full, that is, not more data could be stored without overwriting previously recorded data. Just by reducing to 15 FPS, 1600x904 and Very high for sorting cameras (two out of four) and 5 FPS, 1600x904 and Medium for the overview and stern cameras, the 2TB storage was more than enough for a full year. At the end of the day, the largest effect on the quality of recorded video tends to be whether camera lenses are cleaned or whether cameras could be placed with a good field of view for their purpose.

6.5 Review rate

The Danish Agricultural and Fisheries Agency operate with a review rate as a percentage of the trips. In the previous trials in the North Sea and the Skagerrak from 2010-2016, the review rate was based on the number of hauls. The haul-based approach means that a larger part of trips can be covered with the same review rate (unless vessels always merely have one haul on a fishing trip). The drawback with basing review rate on haul is, that it is more difficult to calculate. Missed entries can happen (e.g. fisher reporting five hauls on a trip but EM only registering four) which makes it less clear what the review rate is. Reviewing a share of the video footage is even less clear because the review rate will be affected by short or long trips, hauls and catch processing. Calculating review rate based on trip is the easiest option, because the logbook number function as a unique identifier for each trip. At the same time, reviewing all hauls on a trip makes it easy to compare the EM analysis out with the self-reporting in logbooks and landing declarations. A typical benchmark for review rate is 10%. It is adviced to never promise 100% review but allow for the possibility. The

reason for this is, that if a data loss happens (e.g. due to a breakdown) then 100% review is not possible. At the same, a maximum cap on the review rate should be avoided because such a cap means that close follow-up when unwanted behavior is detected becomes difficult if not impossible. The review rate needs to be adjusted to the objectives but will also be influenced by resources.

6.6 Target what to review

Following up on the previous advice, it is advised to target what to review. It is not the actual fishing activity but the handling of the catch that is the main purpose with the review if compliance with a discard ban/landing obligation is the main purpose of the EM. Using motion detection in cameras to present sensor data for activities within the field of view enables reviews to be focused at when catch handling takes place. By recording both landings and discards of the reviewed species, it is not necessary to view for potential discards outside designated discard areas after the catch processing, because landings recorded during review can be compared to the self-reported landings in the logbook and landing declaration.

6.7 Video reviewers

The Danish Agricultural and Fisheries Agency has always used student workers as video reviewers. Most video reviewers have been natural science students from the University of Copenhagen or Roskilde University. Video reviewers are grouped loosely into three categories: 1) New video reviewer, 2) Video reviewer, and 3) Senior video reviewers. There are no financial gains in advancing between these categories. Rather they are an overall concept for the camera coordinator to assess the experience level.

Usually a one month training phase is needed before a new video reviewer is experienced enough to advance to be a video reviewer, who can do reviews on their own. In most cases it takes another four to five months before video reviewers are experienced enough to be considered senior video reviewers, although this can vary a lot and is based on an assessment by the camera coordinator. Senior video reviewers can train new video reviewers. Except for the initial start of the Kattegat-project in 2021, the training period is done by first having new video reviewers following a senior video reviewer, then having the new reviewers doing their own video review with a senior video reviewer double checking all registries and then finally having the new video reviewer going through review with a senior reviewer double checking. When the senior reviewer estimates the new video reviewer to be experienced enough, the new video reviewer is allowed to do reviews on their own. The assessment on experience level is discussed between the senior video reviewer(s) and the camera coordinator prior to this. In case of doubt, video reviewers have always been encouraged to ask. This is regardless of whether the video reviewer has been employed for a week or more than three years. Except for the first half of 2021 and in 2024, roughly half or slightly more of the video reviewers have been senior video reviewers. In the first half of 2021 no video reviewers had become senior yet, while all video reviewers have been senior in all of 2024. As a quality assurance, a minimum of 10% of all hauls reviewed are re-reviewed by another video reviewer as a doublecheck. This is done regardless of whether the first review was done be a video reviewer or a senior video reviewer. Table below show the doublecheck rate for each year.

Table 13. Reviewed and doublechecked hauls for each year.

Year	Reviewed hauls	Hauls doublechecked	Doublecheck percentage
2021	380	41	10.8
2022	290	41	14.1
2023	532	156	29.3
2024	411	50	12.2

6.8 Prior to installation

6.8.1 Vessel visit

A vessel visit is always needed for new vessels. The purpose of the vessel visit is not only to go through the purpose of the EM, place the EM system components and draft the Vessel Monitoring Plan (VMP). It is also an opportunity to engage in a dialogue with fishers on what to expect as part of an EM scheme. This includes the possibility for fishers to ask questions and is thereby also an opportunity to do some mythbusting. Two common myths in the initial part of the Danish Kattegat-project was that the EM system would video monitor the entire ship and that it also recorded sound. Showing where the cameras would actually film and showing that this could be seen on the screen in the wheelhouse removed the first myth and informing on the fact that the EM system could not record sound removed the second myth. If a vessel has had EM before, it may be possible to use the previous VMP for re-installation of EM, whereby the vessel visit can be saved.

6.8.2 Information meetings

Because of the large number of vessels (61) entering the EM scheme in phase 2 of the Kattegat-project, the Danish Fisheries Agency and the Danish Fishermen's Association Producer Organization (DFPO) invited vessel owners whose vessels became subject to mandatory EM in the Kattegat, as well as other interested parties, to participate in information meetings. A total of four information meetings were held in the ports Østerby (Læsø), Gilleleje (Northern Zealand), Grenå (Djursland) and Strandby (Northern Jutland). During the information meetings, terms and conditions, installations process as well as daily maintenance and operations were presented and discussed. Any interested party could ask questions during the meeting to clarify any elements. After the information meetings, vessel owners interested in getting the vessel visits done were invited to make use of the fact that the Danish Agricultural and Fisheries Agency were in their port anyway. The information meetings speeded the installation phase up a lot because most questions vessel owners and masters had concerning the EM tended to be quite similar. The 1½ to 2 hours used for an information meeting could then cover the general questions on the EM scheme and made it possible for fishers' to vent some frustrations as well. The following vessel visits would in most cases take around 20 minutes because focus could be on the practical placement and drafting of the VMP. In phase 1 of the Kattegat-project, no information meetings were held and most vessel visits took between 1 to 2 hours.

When a lot of vessels become part of an EM scheme, it is advised to host information meetings prior to vessels visits.

6.9 Installation and maintenance

The Danish Agricultural and Fisheries Agency have made individual contracts with local ship electricians for installations of EM systems. The vessel owners chose the ship electrician. This means that single contract for the installation cannot be made and therefore cannot be part of the procurement process for the EM vendor. However, the gain is that the vessel owner and master usually know the person or company employed for installation quite well. The Danish Agricultural and Fisheries Agency set a deadline for installation and the logistic details on exactly when and where the installation will be done can be left for the vessel owner or master to agree on with the electrician. The Agency is not physically present at the vessel during installation but installers can call the Agency or the EM vendor if questions arise during. The combination of available support by the Agency and EM vendor together with approach of leaving the logistic details of installation to the fisher and installer to handle within an agreed deadline makes the installment more flexible, making it possible for the installation (which in most cases took three working days) to avoid times where the vessel could have been at-sea to a large extent. For instance, one electrician chose to start installment on six different vessels at the same time but would always stop on each vessel at a stage in the installation where the vessel could go fishing without damaging the unfinished installation. This meant that the three working days needed could be smoothed over four weeks, whereby installation was done when poor fishing weather or similar factors meant that the vessels had to stay in port anyway. Thus, no potential days at-sea were lost due to installation of EM at all.

There have been a few cases where the vessel owner did not want to choose an electrician for installment or where the collaboration between the vessel owner and the electrician chosen for installment was poor. In these few cases the Danish Agricultural and Fisheries Agency had to, in collaboration with DFPO, contact the vessel owner and make it clear that if the deadline was not met, the vessel had to stay in port until EM was installed. However, for the large majority, having local electricians employed to do the installation seems to have lowered the feeling of intrusion for the installation process. Another gain by having local electricians employed is, that when breakdowns happen, the local electrician know how to repair the system because they have become familiar with the EM system during the installation. To ensure swifter repairs, and thereby a lower nuisance due to the EM, several local electricians have made an agreement with Anchor Lab to have an EM spare part reserve (e.g. extra cameras) at their company storage. In the EM projects, vessel owners are responsible for ensuring that the EM system is function when fishing. In the EM projects and scheme in Kattegat, this requirement is stated by law while in the voluntary projects combining trial fishery and EM, the responsibility for a functioning EM system is stated as a condition in the permit for the fishery.

The Danish Agricultural and Fisheries Agency covers the costs of maintenance in the EM scheme In Kattagat where the requirement is mandated by law. Maintenance expenditures have increased over the years, which is to be expected as wear and tear naturally accumulate over time. In 2022, maintenance costs amounted to €5,251. This rose to €14,899 in 2023, and further increased to €20,226 in 2024 (see Appendix 1).

6.10 Feedback and contact

Feedback to fishers on the review is for some of the EM schemes in Denmark not just sound advice but also mandatory as part of the fisheries control. A standard feedback sheet / control report allows for a common feedback format to fishers with a written documentation of the feedback. In the Danish EM projects, the fishers have always had the possibility to contact the EM team at the Danish Agricultural and Fisheries Agency by phone for additional information on their review. In the VMP for each vessel, the phone numbers for the EM team at the Danish Agricultural and Fisheries Agency is written in order to contact of EM team if needed, regardless whether the

contact is due to a breakdown, questions to the feedback sheet or something else. In January 2023, the Blackbox Analysis software at the Agency was upgraded to record the camera identification of registries, whereby all registrations could be traced to the camera where it was seen during review. This was done, as there had been cases where vessel owners or masters could not understand why discarding had happened. On some vessels with multiple designated discard areas, it turned out that some of the crew did not understand the rules well enough while others did. Being able to pinpoint where illegal discards had occurred (e.g. in the port side and none in the starboard side) made it possible for masters and vessels owners to correct the behavior.

6.11 Be flexible

Perhaps the best advice when running EM is to be flexible. The number one consistent feature in the EM schemes run in Denmark since the first test trial in 2008 is, that things always change. It can be due to new technological options, new types of fisheries with EM, new rules coming into force, new frames or purposes for the EM or something else and the best options to handle this is to be able to adapt the EM setup.

7.0 Conclusion

The Kattegat project shows that EM can document catches on fishing vessels and thus functions as an effective control tool for checking the landing obligation. EM has replaced parts of the traditional at-sea control in the Kattegat with the introduction of the "10-punktsplan" in 2022. EM provides the opportunity to target the traditional control against other fisheries, where the challenges to a lesser extent include compliance with the landing obligation or closed areas, or towards foreign vessels, as vessels with EM systems on board can be checked for discards and fishing using video recordings.

The different EM trial fisheries highlight the array of fisheries EM can be used in but also show that new vessels and new fisheries provide their unique challenges calling for new approaches to ensure the necessary monitoring by the EM system, including new approaches to what and how to document and control using the video from the EM system.

The results from video review show that there extensive discarding of landing obligated species in the Kattegat (including cod, haddock and hake) still occur. Species that must be brought ashore. In phase 1 of the project, it was found that the extent of discards is noticeably reduced after vessels have been equipped with EM and have received guidance on the landing obligation (see the evaluation report for phase 1 for details). A corresponding study has not been possible to carry out in phase 2, since the "10-punktsplan" states that the Danish Agricultural and Fisheries Agency takes a maximum of 5% of the fishing trips for sampling and a maximum of a further 5% for risk-based control. This has meant that the Danish Fisheries Agency has not had the opportunity to follow up with review of new fishing trips shortly after guidance. Otherwise, the Danish Agricultural and Fisheries Agency would very likely exceed the permitted review rate.

For the majority of vessels, it can be said that if one or more of the five focus species (haddock, hake, saithe, cod and sole) have been seen in the catch, then discarding of the species has also been seen, which is non-compliance with the landing obligation. The majority of discards and landings seen on video recordings are below the minimum size. This is consistent throughout the project's period from 2021 to 2024.

Self-reporting in the electronic logbook (eLog) of undersized fish subject to the landing obligation (BMS) increases after installation of EM. This could be seen for several vessels in phase 1 and the

trend continues with new vessels in phase 2. Overview in this report of BMS-registration before and after installation of EM does not include the 12 vessels that participated in phase 1. Instead, these are used as a control group, since they have had EM back from 2021. For hake, haddock and cod, a significant increase in the amount of registered BMS occur after installation of EM on vessels in phase 2 during 2022 or 2023. For the control group's BMS-registration, an increase also occurs for haddock and cod but the increase is smaller than for the new vessels in phase 2. For hake, there is a decrease in BMS-registrations from 2022 to 2023 for the control group, which is the opposite compared to what is seen for phase 2 vessels.

In the report conclusion for phase 1, the Danish Agricultural and Fisheries Agency put forward a number of points that could be optimized in phase 2. This included:

• introduction of a risk-based selection of video recordings for control (implemented in phase 2)

• a de minimis threshold for enforcement of violations (implemented in phase 2)

• a smoother installation process (implemented in phase 2)

• more accurate cameras (square lens for instance) on certain vessels (not implemented)

• exemption from part of the traditional controls at-sea for the participating vessels (implemented by the fact that EM vessels are not subject to Last Haul control in the Kattegat).

Overall, the experience after four years of camera documented fisheries in the Kattegat and the Baltic Sea is that camera documentation is an effective form of control, especially for documenting catches and thus compliance with the landing obligation. From the perspective of the authorities, EM with cameras is therefore a very effective control tool. The possibility to use EM as a tool to verify compliance with conditions in trial fisheries add to the usefulness of EM in fisheries control and management.

8.0 Future perspectives

8.1 Voluntary EM scheme in Kattegat from January 2025

From 1 January 2025, the EM project in Kattegat went from a mandatory project to a voluntary scheme. This means that EM no longer is a project in the Danish fisheries control in Kattegat, but a scheme. The scheme is voluntary to participate in. Vessel owners of Danish vessels engaged in commercial trawl fishing for *Nephrops* in the Kattegat can chose between one of three groups:

- Group 1: Vessels with an EM system for control purposes.
- Group 2: Vessels with an EM system, but not for control purposes.
- Group 3: Vessels without an EM system.

Vessels in group 1 are allowed to use certain gears, are exempted from Last Haul control and are not subject to a rule where the vessel must have access to at least 50 kg of cod quota.

Vessel owners who were subject to the mandatory EM requirements in the Kattegat in 2024 and do not wish to continue with EM data to the control (group 1) can choose to take over the EM system (group 2) or have the EM system taken off (group 3). Regulations for fishing are the same for group 2 and group 3, but by taking over the EM system, vessel owners have the option of keeping the system installed in case EM becomes necessary for the vessel in the future (e.g. due to a trial fishery with EM as a condition or by granting access to the vessels EM system to a research institute).

8.2 AI

In total, the Danish Agency for Agriculture and Fisheries has access to 404,693 images from four years of EM. However, not all images are suitable for AI training. This can be because the video quality is too low due to smudge on camera lenses, or multiple registrations may have been made in the same frame because there were more fish that needed to be registered. Nevertheless, the Agency has a large library and as part of the transition in January 2025, the Agency has begun annotation images for AI training.

To start with, the species that have already been registered during the video review will be annotated in the image and the length measurement will also be entered when possible. It is not always possible to add the length measurement, e.g. because a length measurement may not have been made for the species (for instance for *Nephrops*) or there may be too much uncertainty in the image taken for the registry on the length measurement (for instance if the fish is lifted close to the camera whereby the plane for the grid does not fit where the fish was in the image. This lead to distortion in the length measurement).
The aim is for the AI model to recognize species and estimate length at the same time. In addition, if persons, or rather parts of persons, can be seen in the image, this too will be marked so the AI model can learn to blur people automatically.

The AI project runs in parallel with the Danish Agency for Agriculture and Fisheries' other tasks and the amount of resources that can be allocated to the project also depends on how many voluntary vessels the EM scheme in Kattegat get.

	Klasse	Yderligere klasser	Længde (cm)	Redigeret	Redigeret af bruger	Oprettet
	TOR		25,15	21-01-2025 11:20:15	krscoh	21-01-2025 11:08:44
	DVH			-	-	21-01-2025 11:13:24
	Person			-	-	21-01-2025 11:15:26
	DVH			-	-	21-01-2025 11:16:42
	DVH			-	-	21-01-2025 13:04:16
	DVH			-	-	21-01-2025 13:07:51
	DVH			-	-	21-01-2025 13:09:41

Figure 33. Example image from Kattegat phase 2, annotation started. Annotated objects include a cod (orange), five *Nephrops* (purple) and the hands and part of an arm for the fisher (green). The length measurement from the original video review has been added for the cod. No length measurement was taken for the *Nephrops*, so this will not be added.

Appendix 1: Maintenance cost of REM

Table 14: Total maintenance cost for the Kattegat REM project in period 2022-2024

2022-2024			
Maintenance	**Pcs**	**Average price (€)**	**Cost (€)**
Camera	48	508	24.399
Sensor	19	240	4.568
PC/BlackBox system	7	310	2.173
Cable	2	168	336
Screen	3	132	396
GPS antenna	7	244	1.711
Troubleshooting	12	244	3.231
Removal of REM system	1	591	591
Total	**99**	**378**	**37.406**

Table 15: Total maintenance cost for the Kattegat REM project in 2024

2024			
Maintenance	**Pcs**	**Average price (€)**	**Cost (€)**
Camera	21	483	10.623
Sensor	10	334	3.342
PC/BlackBox system	3	457	913
Cable	2	-	336
Screen	-	-	-
GPS antenna	4	298	1.192
Troubleshooting	2	298	1.192
Removal of REM system	1	2.627	2.627
Total	**43**	**562**	**20.226**

Table 16: Total maintenance cost for the Kattegat REM project in 2023

2023			
Maintenance	**Pcs**	**Average price (€)**	**Cost (€)**
Camera	16	673	10.771
Sensor	9	136	1.227
PC/BlackBox system	3	324	973
Cable	-	-	-
Screen	3	132	396
GPS antenna	3	173	519
Troubleshooting	5	173	1.013
Removal of REM system	-	-	-
Total	**39**	**382**	**14.899**

Table 17: Total maintenance cost for the Kattegat REM project in 2022

2022			
Maintenance	**Pcs**	**Average price (€)**	**Cost (€)**
Camera	10	300	3.004
Sensor	-	-	-
PC/BlackBox system	2	144	287
Cable	-	-	-
Screen	-	-	-
GPS unit	-	-	-
Troubleshooting	5	392	1.960
Removal of REM system	-	-	-
Total	**17**	**309**	**5.251**