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PFA
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Summary of the project on the feasibility of electronic monitoring on pelagic freezer-trawlers

Introduction

With the new Common Fisheries Policy (CFP) in the European Union (EU), the EU pelagic fishery has been faced with a landing obligation effective since January 1, 2015. At-sea monitoring is one of the potential methods to confirm compliance with the new regulations. The Redersvereniging voor de Zeevisserij (RVZ) and Archipelago Marine Research Ltd. (Archipelago) have undertaken an exploratory project to assess the feasibility of electronic monitoring (EM) to achieve the monitoring objectives. The project was carried out in the autumn of 2014, as if the regulations were in full effect (i.e., using full retention). Results were further discussed and analysed during 2015.

Results

As part of the trial, RVZ nominated the vessel F/V Jan Maria to participate in this project. This vessel was selected based on its intended fishing profile, support for EM by its owning company, and vessel infrastructure. During the trialling trips, all catch was brought aboard and retained unless this was prohibited by law. Imagery recording occurred for the entire trip, (i.e., port-to-port and 24 hours a day, seven days a week); and cameras were deployed both on the wet deck and in the factory. The EM system was installed in the port of IJmuiden, Netherlands, in July, 2014. Data collection began in August and continued until the end of 2014. EM data were collected from four trips, containing 2262.7 hours of data and 146 tows. The number of fishing events ranged from 28 to 51 in a trip, and trips lasted between 16 and 30 days. EM Data collection rates all exceeded 98.5% of the trip length and two trips had greater than 99.5% data collection.

This trial provided a general methodology for EM equipment set-up and catch-handling requirements, data review protocols for estimating discards, and a reporting system to demonstrate compliance with the landing obligation. EM was an effective means to monitor

large amounts of fishing activity in a cost-effective way. Fishing trips averaging 23.5 days and 36.5 tows could be fully reviewed and reported in about 24 hours of labour. The trial focused on monitoring the catch-sorting operation and reviewers watched the imagery data until all catch was observed to be stowed and all sorting and discarding appeared to be complete. Collecting additional data (likely sensor rather than video data) at intervals along the catch-handling process could further contribute to electronic monitoring on pelagic trawlers.

Conclusions

The trial provided a general methodology for EM equipment set-up and catch-handling requirements, data review protocols for estimating discards, and a reporting system to demonstrate compliance with the landing obligation.

In order for EM technologies to be applicable to EU fisheries, there needs to be a level playing field for fisheries operators from different countries and fisheries. Unfortunately, a harmonized control strategy within the EU regarding the (pelagic) landing obligation has not yet been developed by the relevant member states groupings which is why a level playing field in the control of the (pelagic) landing obligation has yet to occur.

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Annex: excerpts from the Archipelago final report

A final report has been produced by Archipelago Marine Research. Because the report contains detailed information on individual trips of an individual vessel, the report is cannot be made publicly available. Below a series of excerpts from the Archipelago report are reproduced as far as they do not refer to the individual vessel results.

1.0 Introduction

With the new Common Fisheries Policy (CFP) in the European Union (EU), the EU pelagic fishery is now faced with a discard ban (effective January 1, 2015). As fisheries must now confirm compliance with these regulations, stakeholders in the pelagic trawl industry are exploring electronic monitoring (EM) as a means to achieve these monitoring objectives.

The Redersvereniging voor de Zeevisserij (RVZ) undertook this project in collaboration with Archipelago Marine Research Ltd. (Archipelago) to develop a methodology for using CCTV-based data collection to confirm full retention of catch onboard a freezer trawl vessel. This was in continuation of a 2013/2014 project to demonstrate the feasibility of collecting EM data on pelagic freezer trawler vessels with the intention of expanding the effort upon producing deliverables for fisheries-enforcement consumption.

Electronic monitoring (EM) is being trialled or is operational in many fisheries around the world. It is implemented as an alternative and/or a complement to onboard human observers (McElderry, 2008). The EM systems, developed by Archipelago Marine Research Ltd., incorporate technology that has proven successful in monitoring fishing activity and collecting fisheries-related data across a range of applications for more than a decade (McElderry, 2008). Each EM system consists of a centralized computer control centre that records data on an array of sensors and cameras, and provides information on key aspects of the fishing operations such as vessel location, vessel speed, equipment activity, catch sorting and stowing.

1.1 Goal and Objectives

The overall goal of the project was to demonstrate the feasibility of using video-based electronic monitoring on a freezer trawler fishing vessel to document compliance with the regulations banning discards at sea. Specific project objectives were as follows:

- Use EM on a pelagic freezer trawler to document compliance with the discard ban, and document any discarding events that do occur;

- Provide overall project advice on the use of EM technology for fisheries monitoring;
- Supply EM equipment to enable continuous electronic monitoring of a commercial fishing vessel for nine (9) months;
- Provide licenses for EM software products (EM Record™, EM Interpret Lite™ and EM Interpret™ Health Statement Viewer) used by field technicians during the trial period;
- Provide training on the use of EM software products to customer field technicians (EM Record™, EM Interpret Lite™ and EM Interpret™ Health Statement Viewer);
- Develop a methodology for monitoring catch and fishing effort on freezer trawler vessels;
- Develop data analysis and reporting protocols to generate documentation of compliance for the appropriate regulating bodies for each trip;
- Provide analysis of data collected;
- Work with the RVZ to prepare a project report documenting the methodologies developed to document full retention aboard the volunteer vessel.

2.0 Materials and Methods

As part of the trial, RVZ nominated the vessel F/V Jan Maria (BX791) to participate in this project. This vessel was selected based on its intended fishing profile, support for EM by its owning company, and infrastructure.

Before the landing obligation for pelagic fisheries came into effect, the RVZ held internal meetings and decided to trial EM on test vessels operating as if the regulations were in full effect (i.e., using full retention). During these meetings, a general trial methodology was developed:

- All catch was to be brought aboard for sorting;
- All retained catch was to be handled in the traditional manner; and
- Alll catch that may have historically been discarded would be retained separately (this may include separate projects to examine different ways to handle and store such catch).

Based on dialog with Archipelago, it was further specified that:

- Imagery recording was to occur for the entire trip, (i.e., port-to-port and 24 hours a day, seven days a week);
- Cameras were to be deployed both on the wet deck and in the factory;
- Fish were not to be discarded from either the factory or the wet deck unless they were legally mandated discards. All discards from the wet deck were to be performed within the unobstructed view of the camera; and
- The purpose of imagery recording was to capture all catch sorting and discarding events.

2.1 Project Partners and Roles

The project sponsor (RVZ) was responsible for overall programme direction, and served as the main contact with vessel owners. This work included securing vessels to participate in the programme, ensuring that vessels were able to carry EM equipment, and leading outreach within the industry group.

Archipelago was responsible for the day-to-day coordination of the project; providing advice on the programme design; and supplying trained field and data technicians, overall data analysis, and reporting.

2.2 Field Operations

Archipelago staff and the local field technicians installed the EM systems in July, 2014. Technicians met with the vessel's representative to discuss the installation and use of the EM system. Installation was done in the port of IJmuiden, in the Netherlands.

Data collection began August 2014, and continued until the end of 2014.

The EM technician stayed aboard the vessel for its first week of fishing to 'burn in' the EM system and ensure any problems were resolved immediately. Vessel engineers were trained to perform simple troubleshooting and maintenance tasks, and were tasked with changing hard drives at sea and removing all hard drives with data after each fishing trip. Additional services were provided as needed to address any issues or concerns about the monitoring equipment.

2.2.1 Vessel Monitoring Plan

Meeting the data requirements relied on understanding the combination of catch-handling protocols and EM system configurations. The primary data requirement that drove the standards for catch handling and equipment installation was the need to verify that discarding either was not occurring, or had occurred within the designated control points.

Catch-handling and equipment installation standards were documented in the vessel monitoring plan (VMP). The VMP is a communications tool designed to help vessel representatives/skippers, EM field technicians, EM data reviewers, and project coordination staff to understand their roles for a successful implementation.

The VMP used a combination of narrative and images to document the key points related to vessel-specific EM installation and operation:

- General vessel information;
- Skipper responsibilities;
- EM system configuration:
    - General description of the type of data being recorded, and
    - Location and objective of each EM system component (including camera views);
- Catch-handling protocols:
    - Catch sorting, and
    - Discard control points;
- Diagram of the vessel; and
- Software configuration specifications (for EM technician reference).

2.2.2 Electronic Monitoring System

The EM systems were designed and manufactured by Archipelago Marine Research Ltd. in Victoria, BC, Canada, specifically for the purpose of monitoring and collecting fishing-activity data at sea.

The EM system consisted of an EM Observe™ v4.5 control centre with an array of digital closed-circuit television cameras (CCTV), a GPS receiver, a satellite modem, a hydraulic

pressure sensor, and a rotational sensor (Figure 1). The EM Record™ operating software, installed on the control centre, collected high-frequency sensor data every ten seconds throughout the entire trip, and recorded imagery data.

The crew of the vessel was asked to power on the EM system at departure from port, and only power the system off upon return to port. The EM system operated independently and was set to record imagery when the vessel was out of port using a geo-fencing feature in the EM Record data-logging software.

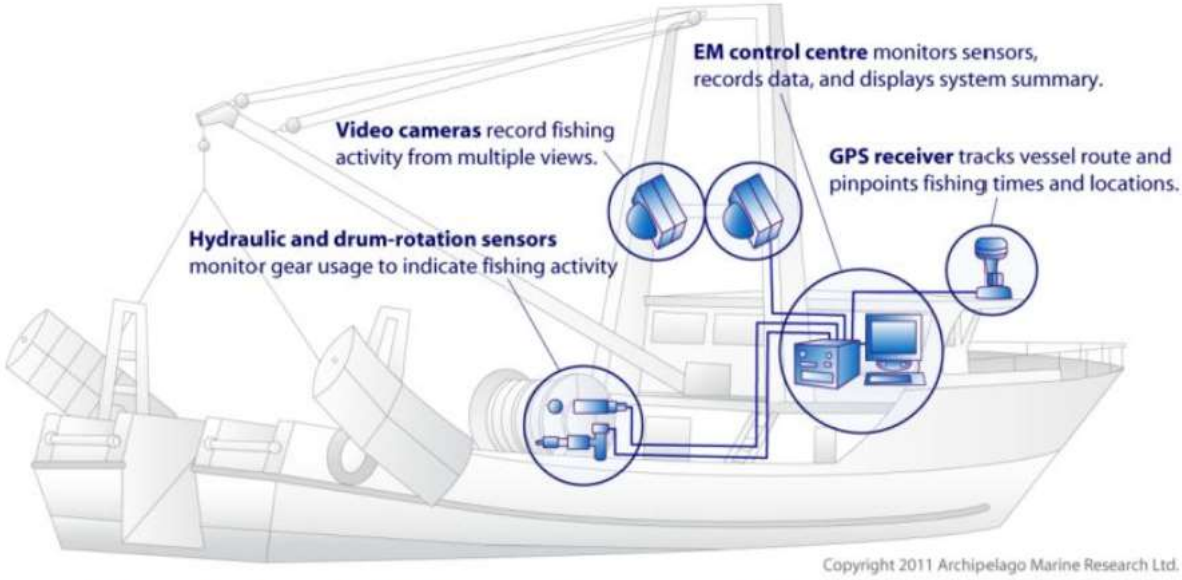

Figure 1: Schematic of a standard EM Observe v4.5 system used during this study.

2.2.3 Onboard Methodologies and Camera Views

Catch Handling

The vessel typically tows three or four times a day for short periods of time using midwater trawl gear, setting on shoals of pelagic fish located by sophisticated sonar equipment. The net is then winched up to the vessel and a pump is attached to the outlet of the codend. The fish and seawater are pumped onboard, passed through water separators, and the fish flow into chilled re-circulated seawater (RSW) tanks located below the trawl deck on both sides of the vessel. From each RSW tank, the fish are pumped to a sizing machine; this machine sorts the fish into one of several alleys on a single conveyor. Damaged and non-marketable fish (retained as part of the CFP landing obligation) are then sorted out at this point. Both groups of fish then move on to the freezing machines and are frozen into standardized blocks of fish each weighing around 20kg.

Camera Views

Camera placement was guided by the experiences in the previous year's pilot project on a similar vessel in the fleet. Eight cameras were used, with six on the wet deck showing the catch handling and stowage, pumping over the water separators, and net to pump operations with close up of the agreed legal discarding zone. The remaining two cameras were located in the factory. Initially it was only one camera, showing the sizing and sorting area but as the project evolved a second camera was added to show additional detail. The factory is a large and complicated operation to monitor so no effort was made to supply enough cameras to cover all areas at that stage of the catch handling.

All cameras were mounted to existing superstructure on the fishing vessels. Vessel representatives provided guidance as to where the cameras could be mounted, and where the cameras were least likely to be damaged or have views obscured during regular vessel operation.

2.3 EM Data Review and Analysis

2.3.1 Sensor and Image Data Interpretation

After the EM data were retrieved from the vessel, they were copied to a hard drive and mailed to Archipelago's offices in Canada for subsequent data review and analysis.

The process for review was established at the start of the project, but was modified over time based on feedback from project partners and results.

The EM data sets were reviewed using the Archipelago EM Interpret Pro™ software, a specialized software package designed to help the reviewer quickly process, evaluate, and report on fishing activity. The EM Interpret Pro™ software integrates thousands of imagery, sensor, and GPS records into a single synchronized profile, and presents it along a common timeline. This allows reviewers to quickly follow cruise tracks, review fishing event' times and locations, and verify catch handling procedures. Key events, comments and observations can be saved as annotations, created by the reviewer and saved along with the data set for future reference. All information is then stored in a standard database format for easy reference, analysis, or secondary processing.

Reviewers were able to adjust the imagery playback speed from frame-by-frame to up to 16 times real-time speed. They could also stop playback at any time and return to a specific frames as necessary depending on the activity on deck. Typically, imagery of the net being towed was viewed at six to eight times real time, while pumping and stowing catch was generally reviewed at three to four times real-time speed, but slowed down and reviewed frame-by- frame at specific times to confirm discards.

2.3.2 Data Collection Success

For the purposes of defining data collection success, we define total trip hours as the time from leaving one port to the time of entering the next (and ending the trip by removing the hard drive). Total time gap is the total sum of all breaks in the sensor data recorded by the EM system. These breaks can occur for various reasons (e.g. hard drive swaps, technician shutdown, power failure, etc.).

Data collection success is the percentage of the total trip hours for which there was sensor and video data recorded (i.e. all time other than time gaps). This indicator reflects the overall success of the data-collection effort.

2.3.3 Imagery Data Review

Reviewers viewed all fishing events, both on the wet deck and in the factory, in an effort to detect discarding events; however, based on the original intent of this project, most of the review was focused on wet deck activity-no attempt was made to gather information on retained catch.

Reviewers documented discarding events and identified each as one of four categories:

- Multiple Discards: Used when more than a single fish/item was discarded. Reviewers visually estimated multiple discard events based on their experience on other fisheries worldwide or estimated the fullness for each bin to the nearest 25% increment.
- Individual Discards: Used when individual or single items were discarded. These were identified to the lowest taxonomical level possible through the video. No weight was estimated.

- Net Flush: Used when the codend was opened up and the contents were dumped directly into the water without being brought onboard (also known as slipping).
- Deck Discards: Used when catch that had been emptied onto the deck from the net and was subsequently shovelled or hosed back off the deck of the vessel into the sea.

Due to a planned evolution in the reporting process, for the first two trips only the number of discard events and total weight of discards (kg) for the trip was reported, whereas for the Trips 3 and 4, an estimate of discard weight by event was included and the total discarded weight by trip was left to the reviewer to calculate.

Reviewers noted when incidents of discarding occurred outside the control points documented in the VMP or where fish were removed from camera view contrary to the expected handling of fish in the VMP.

The data processing methods were designed such that when all fish were seen to be stowed below deck and the crew finished net cleaning and clearing off the deck, data technicians stopped viewing. Occasionally this decision was obvious as the crew would also leave the deck and the deck lights would go out.

2.3.4 Other Events

As this project involved exploring events that can be observed using EM and different ways to report this in support of the CFP's landing obligation, reviewers documented activities that would be considered 'interesting' from a monitoring point of view. As with the other review methods, the approach was adjusted after Trip 2, and an estimation of total weight of discarding was included when appropriate. In the trip reports, the nomenclature associated with these activities also changed from "Point of Interest" to "Other Events"; this was done to more accurately and impartially reflect what was being observed by the EM system.

Reviewers used the following categories to report Other Events

- Catch Processing Occurring Out of View (Trip 1 and 2): Describes the events where catch was initially handled within view of the camera, but was later moved out of view, such as when:
    - Fish fell out of the net onto the deck while the net was being reeled in. Fish were then collected into orange baskets and those baskets were slid forward out of camera view.
    - Hauls ended and the net was unreeled and fish were picked from the net. Those fish were again collected into orange baskets and moved forward out of camera view.
    - It was difficult to visually confirm where fish were flowing from the water separator.
- Suspect Fish May be Discarded: Used for events when the deck was hosed off at the end of net cleaning and it appeared that fish and debris left on deck was hosed forward out of camera view to a discard chute but could not be confirmed.
- Catch Removed from View - Sampling: Used when fish above deck were seen collected into an orange basket, often from the chutes directing the pumped fish into the tank hatches, and then the basket would be carried forward up the ladder and out of camera view and did not return to view during the haul.
- Catch Removed from View - Net Cleaning: Used when fish that fell from or were cleaned from the net, before, during and after pumping out the codend, were collected into orange baskets and moved forward out of camera view. In instances where fish were shovelled or hosed forward out of camera view this annotation was applied too.

- Catch Removed from View: Used when fish were pumped out of the codend but were not seen entering the holding tanks by the normal methods (water separator to chutes to holding tank hatches). The fish were removed from camera view and it could not be determined if they were retained or discarded.
- Other Activity: Describes other potentially noteworthy events that did not involve catch directly (e.g. test tow or a marine mammal sighting).

2.4 Reporting

Throughout the pilot project, results for each trip were provided to the RVZ members and vessel via an evolving trip report within two weeks after the trip's end. These trip reports were a main deliverable in this project and included an update on system performance, trips and tows, reviewed data collection and completeness, observed discards with estimated weight and as individuals, observations that did not align with the VMP, and recommendations to increase data quality or the trip report itself.

3.0 Results

3.1 Trips and Fishing Events

During this trial, EM data were collected from four trips, containing 2262.7 hours of data and 146 tows. Video and sensors data collection rates all exceeded 98.5% of the trip length and two trips had greater than 99.5% data collection. The number of fishing events ranged from 28 to 51 per trip. Trip 1 had the lowest data collection success with 98.5%.

3.2 Discard Accounting

3.2.1 Multiple Discard Events

In the first two trips, only the number of discard events was reported, and for Trips 3 and 4, discard events included an estimate of discard weight. In Trips 3 and 4 there were fewer discard events per trip (range 2-18), and all but one discard event was in the 1-49kg bin, with one discard event being classified to the 100-499kg range.

3.2.2 Individual Discards

As defined above, the individual items that were discarded were identified to the lowest taxonomical level possible through the video. This was to enable alignment with these discard events and the established list of mandatory discards for this fishery.

3.2.3 Other Events

The categories used for Other Events changed during the project to accommodate a more detailed description of the event. Overall the number of Other Events declined during the four trips (Trip 1-4 totals were 98, 61, 59 and 34, respectively).

4.0 Discussion

This trial was successful at providing a general methodology for EM equipment set-up and catch-handling requirements, developing data review protocols for estimating discards, and developing a reporting system to demonstrate compliance with the landing obligation. Importantly, EM was shown to be an effective way to monitor large amounts of fishing activity in a cost-effective way; fishing trips averaging 23.5 days with 36.5 tows could be fully reviewed and reported in about 24 hours of labour.

In general, the skipper and crew conformed to the operational practices required to facilitate the success of EM for data collection and reporting. As documented from other EM applications, such as the BC groundfish hook and line (HL) fishery in Canada and the mid-water trawl Pacific whiting fishery in the USA, it is expected that conformance would improve over time as modifications in fishing practice necessary to support this monitoring method (e.g., catch handling) become mainstream (McElderry et al., 2014; Stanley et al, 2011, 2014). Just as it occurred in those fisheries, EM can play a role in building awareness around discarding practices in the fishery and improvements in conformance are expected as appropriate incentives, regulations and feedback mechanisms are put in place.

One of the goals of implementing an EM program in the pelagic fishery would be to provide reliable, independent information on discarding. Below we explore the efficacy of EM from a technical and methodology perspective. We identify the key assumptions of the trial and assess how sensitive the results are to those assumptions. We also suggest next steps to build on the success of this trial EM deployment.

4.1 Data Collection Performance

During the trial, the EM system captured four trips and 146 tows and EM data collection of sensor and imagery data was very high, at over 98% of all trips. Overall, the main categories that affected data collection success were implementation, technical and behavioural (not powering the EM system).

Data loss is more prevalent at the start of an EM programme due to a variety of start up or implementation challenges. These include trial and error testing of system configuration and component placement as well as testing of on- board methodologies. This is seen in the time gaps from Trip 1 being larger than the other three fishing trips, due to the technician adjusting the system during the 'burn in' period. It is often difficult to fully anticipate the monitoring setting when the vessel is dockside, hence the importance of a burn-in trip to identify and correct initial installation problems. These vessel specific problems usually are usually resolved after a few service events and become streamlined for longer term

deployments. Having technicians sail with the vessel isn't standard practice, but with short project timelines and high vessel operating costs it can be valuable, as seen here.

In the 2013/2014 EM project, data loss resulted from technical issues that would be expected to be resolved in a longer term deployment. This is consistent with experience from other EM programs, in which data collection success increased between the trial and operational deployments. For example, the BC groundfish hook and line fishery collected usable data for about two-thirds of fishing trips during its pilot deployment but collected usable imagery data for 93% of trips in its second year as an operational project and over 99% in fishing year 2012 (McElderry et al., 2003; Archipelago, 2008; Archipelago, 2013). In this project, the system and the vessel interacted smoothly from the outset and the EM system was powered on at all times while at sea, except for hard drive swaps and technician service events.

4.2 EM Onboard Methodologies

The EM equipment set-up and catch handling requirements along with the data processing protocols used to estimate discards tested in this trial appear to have been generally successful at providing an independent estimate of discarding activity at sea. However, the results from this trial show that it is imperative that vessel operators follow the catch handling protocols developed in order to obtain reliable EM discard estimates. Additionally, without multiple, independent indices of catch volumes there is no way of detecting any discard events that aren't occurring in plain view of the camera system. It is important to note that a reliable independent estimate of discards using EM data relies in the overarching assumptions that all discards were observed by EM in some way and that all discards were estimated without significant bias.

Observing all discards

While the emphasis during the trial was on observing discarding from deck (i.e., once catch was brought onboard), the methodology also included reviewing the trawl net haul back to verify that catch was brought onboard instead of discarded directly from the codend.

Furthermore, reviewers were confident that they observed all deck discards when vessel operators followed the catch handling protocols to handle catch on deck within camera view and discard at the control points during catch sorting. However, discarding outside of control points affected the ability of the reviewer to identify species or estimate discard amounts. Discarding outside of control points mainly occurred when catch was brought onboard and not subject to standard catch-sorting practice as defined in the VMP. In those situations, crew would discard off the deck or remove fish from the deck camera view in a manner that did not suggest the fish were being put into the RSW tanks. This issue could be addressed in several ways, including eliminating the practice of changing catch-sorting locations, or installing additional cameras. When assessing the option of adding cameras, the volume of

data capture would need to be taken into account, as this project already accumulated significant volume of data. Over time, as EM monitoring bedded in on vessels, the issue of discarding outside control points would be addressed on a case-by-case basis with vessel operators and would likely cease to be an issue.

The trial focused on monitoring the catch sorting operations and reviewers watched the imagery data until all catch was observed to be stowed and all sorting and discarding appeared to be complete. However, it is possible that crew could carry out secondary sorting at a later time after the catch was initially stowed. While the trial did not address this, it did collect imagery for the entire fishing trip and the methodology could easily accommodate reviewing imagery data for the entire trip after the first tow to look for secondary sorting. The trial validated that EM was able to provide independent estimates of discards with two important caveats: the wet deck is considerably simpler operation to monitor than the factory and that activities beyond these two areas are not monitored at all. Based on the risk analysis in the first pilot project (Bryan et al., 2014) there is the logical possibility of discards elsewhere and therefore a need for additional information on the catch volumes at several points along the processing route.

In the future, collecting data at intervals along the catch handling process (pump times/volumes, RSW tank volumes used, freezer capacities per 24h and boxes leaving the boxing room are logical examples) would allow an examination of 'leakage' in any vessel's control of their fish. To maintain the cost effectiveness of the monitoring (an average trip ran 23.5 days and 36.5 tows but was reviewed and reported in approximately 24 hours of labour) it is suggested that the above data is collected using sensors preferentially, as that kind of data is the fastest to process).

4.3 Discard Observing and Reporting

When discards (or catch handling behaviour that left the disposition of fish unclear) occurred within camera views it was straightforward to identify and report on. The details of eporting changed over the four trips though, and are worth elaborating on.

There was a nomenclature change from 'mass' to 'multiple' discards. This was due to sensitivity on behalf of the RVZ to the connotations around the word 'mass' and by looking at the amounts of fish involved in the vast majority of discards (of 34 mass/multiple discard events that were assigned to weight interval ranges, 33 were estimated to 1-49kg and 1 to 100-499kg ranges). Changing the reporting of discard events to be associated with weight intervals was another change in the reporting to differentiate between small and large discard events. It also allows the reader to mentally calculate total discards for any single trip.

This project operated on the assumption that 100% of all non prescribed discards must be retained but that isn't necessarily true. Assuming the vessel would catch 500 tonnes every

fishing day (her freezer capacity) and that there was a 'de minimus' discard exemption of 7% allowed as an operating rule for this fishery, a legal discard amount of 35 tonnes per day could be possible. This would be orders of magnitude more than the amounts observed being discarded in this project. Should the fishery transition to maximized retention from full retention a thorough reconsidering of the monitoring approach would have to be conducted to allow the differentiation between legal and illegal discards during fishing operations.

Individual discards (prescribed by law) were also reported to the lowest taxonomic detail possible.

Another change in reporting nomenclature was removing the assumption that fish removed from view were discarded and instead reporting that they were simply removed from view. This assumption is a much more defensible position from a monitoring point of view as the fish are seen leaving camera view and no inferences about disposition are made. Should this fishery transition to EM operationally, there would likely need to be regulations around both discarding events and events where fish are removed from camera view (contrary to agreed upon catch handling procedures). Pilot projects like this provide examples of the many catch handling events that will need to be contemplated to create and robust operational program. It also highlights the importance of the RVZ and NVWA working together to pool their knowledge on developing such a program.

4.4 Project Objectives and Deliverables

In the interest of transparency and to guide future projects each of the objectives of this project and their outcome is reported below.

- To use EM on a pelagic freezer-trawler to document compliance with discard ban and to document any discarding events that do occur;
    - The EM system was operational for more than 98% of the time during four fishing trips in 2014. Reporting on the presence and absence of discarding events was done in a trip report for each of those trips.
- Provide overall project advice on the use of EM technology for fisheries monitoring;
    - Project advice was given from multiple experts within Archipelago, including a dedicated project manager throughout the project. This advice was delivered in person and in writing to the RVZ's representative and to the different fishing company owners and representatives in meetings.
- Supply EM equipment and spare parts to enable continuous electronic monitoring of a commercial fishing vessel for nine (9) months;
    - The system was installed in July 2014 and collected EM data until the end of the 2014 fishing year, so only five months and four fishing trips of data were possible to collect. She sailed with a full redundancy of system components, basic training for her staff and remote support from Archipelago.

- Provide licenses for EM software products (EM Record™, EM Interpret Lite™ and EM Interpret™ Health Statement Viewer) used by field technicians during the trial period;
    - The EM Record™ data-logging software was installed on the EM system aboard the participating vessel and EM Interpret Lite™ data review software and EM Interpret™ Health Statement Viewer application was provided to the RVZ to assist in understanding their EM data.
- Provide training on the use of EM software products to customer field technicians (EM Record™, EM Interpret Lite™ and EM Interpret™ Health Statement Viewer);
    - To enhance the understanding of EM data, the project included a day long training session for six employees of RVZ companies on EM Interpret Lite™. Basic training on EM Record™ was provided to vessel staff to aide in system troubleshooting and operation.
- Develop a methodology for monitoring catch and fishing effort on freezer trawler vessels;
    - The monitoring methodology was an ongoing process, one started in the first pilot project. It continues in this final report in the form of documentation and suggestions for future work.
- Develop data analysis and reporting protocols to generate documentation of compliance for the appropriate regulating bodies for each trip;
    - Trip reports were generated for each fishing trip and improvements made to their data and format. A deficiency noted in this final report was the lack of a thorough review of each trip report by both the NVWA and the RVZ.
- Provide analysis of data collected;
    - All data collected was analysed using EM standards and methods approved in dialog with the RVZ and built on years of EM experience by Archipelago.
- Work with the RVZ to prepare a project report documenting the methodologies developed to document full retention aboard the volunteer vessel.
    - The final report was edited by Archipelago staff and by the RVZ Chief Science Officer, all with extensive fisheries monitoring experience.

4.5 Cost Consideration

A natural first question when assessing any new monitoring program is the cost associated with the program being considered. This has proven to be a challenging question for many EM projects in their early stages, as the costs of a trial project and an operational program are very different due to the inherent differences in their design and components. Questions about scale, roles and responsibilities, timelines, deadlines and the nature of the data collected, analysed and reported all can greatly influence the final cost of an operational program. Projects typically are a limited version of the final program, if they bear any resemblance at all, which compounds the difficulty of such cost estimates. As well, program

efficiencies tend to increase over time with operational programs, and pilot projects tend to have higher management and operational costs.

Cost can be described in two meaningful ways: as cost per sea day or as a percentage of the value of the catch. In this instance, costs per sea day are more relevant as they allow direct comparisons to alternative monitoring solutions. In very different fisheries with very different monitoring and reporting designs, this has manifested itself the following ways:

- The British Columbia fixed gear program costs ~125 EUR/sea day;
- The New England midwater trawl herring fishery was estimated to cost ~306 EUR/sea day;
- The British Columbia mid-water trawl hake program costs ~45 EUR/sea day; and
- The British Columbia pot trap crab program costs ~ 55 EUR/ sea day.

All of the above are interesting reference points, but the gear, fishery and monitoring program design are all quite different from what would reasonably be expected from a program that monitors the freezer trawler fleet. Bearing in mind the following rough assumptions derived from the last two RVZ projects, and a general knowledge of the fishery, an estimate for that fleet can be calculated though:

- System price per vessel is 13000 EUR plus installation and would be amortized over a five year span;
- All program staff are based in the Netherlands (likely near IJmuiden);
- Data and field services are billed at 40 EUR/h while professional services are billed at 60 EUR/h; and
- Vessels fish 5 trips of 20 days each in a year.

The total monitoring cost per trip would be -3060 EUR or -153 EUR/ sea day. It is important to note that this calculation is not an exact cost for the program, but should be taken as an indicator of the scale of the program cost and be used to seed discussion rather than provide a solid program cost. Its main purpose is to indicate how some of the factors listed above influence relative cost.

These numbers are different from the North American examples above, but are not out of line with those fisheries. A clearer understanding of the potential costs would require a thorough program design effort to be conducted (a reasonable next step in the EM adoption process) to define the program components and assign their relative costs. In the case of the pelagic freezer trawler fleet, both the nature of the fishing (long trips with low amounts of catch handling activity) and the nature of the data analysis and reporting undertaken in this project and assumed in this example (streamlined to focus on discards and not enumerate or identify retained catch) contribute to making this a cost effective program. Possibly the best frame of reference though is the alternative option- human observers. In the Netherlands this has been estimated to be -800 EUR/ sea day, or about 5 times the estimated cost of EM.

4.6 Other Considerations

The most important next step following this trial is to increase the experience of stakeholders with the programme and the technology, while allowing the interactions between the RVZ and the NVWA to evolve. One of the biggest gaps of this project (but one beyond its direct control) was the amount of interaction between these two groups during the project's operation. While trip reports (a main deliverable) were generated for each trip, due to time and capacity constraints, there was no opportunity to have a shared review of each of them and refine that data collections and reporting process.

The EM programme described in this report was a pilot study, designed to test specific objectives relating to the pelagic freezer trawler fishery in the North Sea. Moving towards an operational programme for this fishery will require a programme design process that could include modification (and expansion of the breadth) of the objectives addressed here, given the findings of this pilot study. The design process links the fishery characteristics and

monitoring needs with technology capabilities, monitoring options, regulatory framework, incentive systems, and programme operational requirements (i.e., field service infrastructure, data analysis specifications, and other programme components) to ensure the programme is efficient, effective, and integrated with management needs. The return on investment of EM programmes, in terms of cost efficiencies and the volume and quality of monitoring data collected, has been shown to increase as trials develop into broader-scale deployment programmes (Stanley et al., 2014).

4.7 Next Steps

This trial successfully provided important information about discarding in the pelagic freezer trawler fleet, and offered insight on how that data can be collected and reported. It continues to build on the first pilot project from 2013/2014 that demonstrated the capability of EM to collect data on these very large and unique vessels. Over time, the return on investment in EM systems tends to increase, as systems are bedded in on vessels, technical issues are resolved, cost efficiencies are realised, and monitoring data accumulate (McElderry et al., 2014). Having demonstrated, at a pilot scale, the efficacy of EM in monitoring discards in the pelagic fishery, the next step is to resolve the data collection 'must haves' through a shared negotiation between the RVZ and the NVWA. This would harness the momentum and acceptance already generated during the initial trial, and would allow the programme to evolve in a positive manner while recognizing the strengths and value that each group can bring to the process.

Additional suggested next steps include the following:

- Expand the programme so a greater proportion of the fleet become familiar with the technology and its application;

- Continue to resolve issues relating to data collection on a vessel-by-vessel basis, to increase data quality;
- Ensure data analysis is timely to provide feedback on improvements needed at the vessel level;
- Continue to build local capacity through increased and repeated contact with the technology; and
- Build efficiencies into the programme to reduce costs while not compromising the quality of data collected-this might include developing local data and field services to be more efficient and extending more responsibility to vessels, especially where there is demonstrated capacity.

5.0 References

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