Marine Management Organisation

Future fisheries – Implementing remote electronic monitoring.

Lessons from established fisheries

(MMO1281)






...ambitious for our seas and coasts

MMO1281: Future fisheries – Implementing remote electronic monitoring. Lessons from established fisheries, March 2023

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Contents

Tables

Executive Summary

Remote Electronic Monitoring (REM) technology is a cost-effective tool that can be used to support sustainable fishing. REM of fishing vessels consists of a number of interlinked monitoring and observing components, including CCTV video cameras to record fishing and processing activity, geographic position systems (GPS) to record vessel location, hydraulic winch pressure sensors, and drum revolution counters to determine when vessels' nets are in the water, and on-board PCs with linked, removable hard drives to record data (Needle *et al* 2014). The Marine Management Organisation (MMO) have conducted pilot studies and confirmed the effectiveness of REM for monitoring and improving accuracy of catch recording by fishers. Evidence gaps remain with respect to implementation of REM at scale and evidence of improved fishery performance and compliance by fishers following deployment of REM.

This project aimed to address these evidence gaps by engaging with experts from the United States of America and New Zealand fisheries administrations who have implemented REM monitoring programmes at scale to understand their experiences.

Key findings include:

- **Benefits** - cost efficiencies compared with observers, providing fisher options for monitoring, supporting better management, increased accountability and increased crew safety.
- **Costs** - Financial: installation, upkeep, data transfer/storage, loss of earnings if not able to sail due to equipment issues, revising systems, Time: fisher extra processes, data analysis, acting on footage, Social: trust of peers,
- **Incentives** - initial reduced financial outlay, increased access, allowing flexibility in gear rules.
- **Challenges** - industry reluctance, regulatory barriers, cost/benefit balancing, additional work for both regulators and fishers, large geographical ranges.
- **Data issues** - legal basis clarity needed, ethics and privacy, needs clarity on what data is collected and how it will be used, data ownership and sharing clarity needed.
- **Machine learning and Artificial intelligence** – potentially useful but the practicalities are not there yet.
- **Further steps needed** – increase involvement, increase clarity around the data trail, technological advances, encourage innovation, improve policy and legal framework and scope expansion.
- **Lessons learned** - engage all stakeholders in an experimental approach, outreach and clarity with stakeholders at the outset, ensure benefits are mutual from the outset, learn from others, avoid implementing new systems into legacy systems, funding is challenging, be patient and think globally.

Despite progress in Electronic Monitoring implementation, barriers remain such as concern over social impact, privacy, cost, and additional work can limit industry uptake. However, the experts interviewed here were able to identify numerous solutions that could be developed to improve REM roll out.

1. Introduction

1.1 Background

The UK Government is committed to achieving a future of fully documented fisheries (FDF's), which can ensure a well evidenced, sustainable future for the fishing industry. The Marine Management Organisation (MMO) have conducted pilot studies in UK waters, confirming the effectiveness of Remote Electronic Monitoring (REM) technology for monitoring FDF's and improving accuracy of catch recording by fishers. (MMO, 2016; 2017).

Evidence gaps remain with respect to implementation of REM at scale and evidence of improved fishery performance and compliance by fishers following deployment of REM. This project aims to address these evidence gaps by engaging with other fisheries administrations who have implemented REM monitoring programmes at scale.

1.2 Project aims and objectives

The overall aim of the work was to collate knowledge and lessons learnt from various fisheries to establish in which fleets full implementation has been possible and successful, and why. The report showed where demonstratable improvements to fisheries have occurred to the fishery and compliance rates post REM roll out.

The report also addressed challenges faced in moving from trialling REM to full REM implementation in fisheries and possible solutions to blockers.

To meet these objectives, the project was split into two components:

- Component 1: Key parameters and foci of US regional fisheries - Surveys
- Component 2: Views, opinions, experiences, and insights - Interviews

1.3 About this report

This report outlines the methods used to perform the research and summarise key findings. The key parameters and foci of US regional fisheries are covered in Section 3 whilst Section 4 summarises the experiences and insights from all participants interviewed. In this we have provided participant's recommendations about how to increase the success of REM roll out.

1.4 Limitations of this report

This research relied upon 'opportunity sampling.' Participants were not randomly selected to participant in the project, instead they were selected by the MMO team from known contacts. Due to time constraints, some participants were unable to participate in the interview. An overview of participants and their involvement is provided in **Error! Reference source not found.** of Section 2.

This report cannot be considered a comprehensive review of REM, instead it represents the views and opinions of experts working on REM roll out in the regions covered.

2. Methods

2.1 Participant recruitment

Pre-identified experts in electronic monitoring implementation from the United States of America (US) and New Zealand (NZ) were targeted to take part in the research. These personnel have trialled and/or implemented REM or Electronic Monitoring (EM) programmes (New Zealand interviewees tended to refer to REM whereas US interviewees tended to refer to EM) to inform fisheries management and meet specific monitoring requirements so are familiar with many aspects of successful roll outs and the challenges. We used this recruitment method because we wished to elicit opinion and knowledge from experts in REM. The MMO team created the shortlist of individuals to invite to take part in the online survey and interviews working with the REM lead for the US, Brett Alger and the REM lead for NZ, Daniel Kerrigan.

MMO selected and made the initial contact with potential participants and formally introduced them to the Dialogue Matters team via email, describing the topic and purpose of the project. At this point, the Dialogue Matters team emailed potential participants to build some trust and invite participants to book an interview slot at a time that suited them.

Participants were sent a consent form to complete prior to their interview. All participants gave fully informed consent to the interview prior to it taking place. This complies with the Food Standards Agency /Natural Environment Research Council Joint Code of Practice for Research. A copy of the consent form can be found in Annex 1.

2.2 Participant demographics

The research team conducted a total of 5 interviews as part of component 2. An overview of the sample of participants interviewed also indicating those that completed the survey is shown in Table 1 below.

Table 1: An overview of the participants

Participant name	Participant organisation	Role within organisation	Completed survey?	Completed interview?
Justin Kavanaugh	West Coast Fisheries	West Coast region Electronic Monitoring (EM) Lead	Yes	Yes
Jennifer Ferdinand	Alaska Fisheries	FMA Division Director	Yes	
Brad McHale	Atlantic Highly Migratory Species (HMS) Fisheries	Information, Reporting, and Monitoring Branch Chief		Yes
Ian Miller	Atlantic HMS Fisheries	Fisheries Management Specialist	Yes	Yes
Nichole Rossi	Northeast Fisheries	Fisheries Scientist		Yes
Claire Fitz-Gerald	Northeast Fisheries	Policy Analyst	Yes	Yes

Brett Alger	National Oceanic and Atmospheric Administration (NOAA) Fisheries United States	US EM Programme Lead		Yes
Daniel Kerrigan	Fisheries New Zealand	Digital Monitoring Lead NZ		Yes

2.3 Ethics and participant anonymity

The default was for all participant views to be attributable to them. Researchers asked participants to say if they wanted to make a point that could not be attributed to them. We explained the level of anonymity to each participant via emails, in the consent form (see Annex 1), and at the start of each interview. Participants had the name and number of the Director of Dialogue Matters so they could approach them independently if they had any concerns.

2.4 Online survey

The Dialogue Matters team designed the online survey with input from the MMO team. The survey consisted of a mixture of open and closed questions (e.g., multiple-choice responses and Likert scale (an approach to scaling responses) questions) and took approximately 30 minutes to complete. The final survey design can be found in Annex 2.

2.5 Interview method

2.5.1 Interview method and structure

The interviews took place using a video conference tool and lasted approximately one hour. Interviewers maintained a friendly, informal, and neutral stance whilst doing the interviews. MMO and Dialogue Matters developed the interview structure collaboratively. The interview was semi-structured, providing a framework whilst allowing flexibility for the interviewer to follow lines of enquiry with neutral prompting questions. The interview design can be found in Annex 3.

2.5.2 Recording responses

The research team recorded participant responses live during the interviews in typed note form. Following the interviews, they reviewed their notes to correct typographical, grammatical, and spelling errors. Once corrected, the record was sent to participants for them to check and confirm they were satisfied it was a fair record of the discussion. Interviewers explained to participants that they were welcome to provide any clarifications or correct any misunderstandings of a comment they made. Interviewers were careful to explain that they wanted participant's spoken words, so this step was to check what was recorded, not to add to it or rewrite it.

2.6 Data processing and reporting

Following the interviews, the researchers extracted the salient points from the interview record and placed them into a 'word for word' template in Microsoft Word. The researchers analysed the data from the online survey and follow-up

conversations using the Dialogue Matters ‘emergent processing’ method to avoid prejudgement or bias. This method takes the essence of what interviewees said and identifies separate points. Researchers then analyse the outputs looking for points at the level of ideas rather than existing concepts. In this way, key topics and ideas emerge from interviewees responses which are then linked, or clustered, together. Further clustering is done where needed to capture links between similar ideas and topics. The clusters were in turn summarised to form the content of this report.

3 Parameters and foci of US regional fisheries

The findings from component 1 (the survey) are covered in this section.

This is focused on four US regional fisheries: West Coast, Alaska, Atlantic Highly Migratory Species and North East. Survey responses are presented in table format to enable comparison between approaches. Surveys comprised both multiple choice and open-ended questions. When multiple choice options were provided, all options have been retained in the tables. Written responses are included word for word where provided. Where no response has been provided, these boxes have been left blank.

3.1 Fishery characteristics

Table 2 details the characteristics of each fishery. The gear they use, the species they target, information on their discards and by-catch as well as information on their vessels and how many are fitted with EM technology.

Table 2: Fishery characteristics

		North East	Atlantic Migratory	Alaskan	West Coast
Gear	Demersal/bottom trawl	Y		Y	Y
	Gillnets	Y			
	Longline	Y	Y	Y	
	Purse seine	Y			
	Pole and line	Y	Y		
	Pots and traps			Y	Y
	Dredges				
	Pelagic or midwater trawls	Y		Y	Y
	Fish aggravating devices				
	Other			Jig gear	
Target Species		Northeast multispecies (i.e., groundfish)	Swordfish	Walleye Pollock	Pacific whiting
		Herring	Bigeye tuna	Pacific cod	Pelagic rockfish (widow)
		Mackerel	Yellowfin tuna	Flatfish (mixed)	Sabelfish
				Rockfish (mixed)	Dover sole
				Sabelfish	

Vessel lengths	0-10m	Y		Y	
	10-12m	Y	Y	Y	
	12-18m	Y	Y	Y	Y
	18-24m	Y	Y	Y	Y
	24-40m	Y	Y	Y	Y
	40+m			Y	
No of Vessels		200 for groundfish, 21 for herring/mackerel	110	1323	140
No with EM		30 for groundfish, 6 for herring/mackerel	80	~240	55
Discards	Quota stocks	Y	Y	Y	Y
	Non-Quota stocks	Y	Y	Y	Y
	Other				
By-catch	Avians	Y	Y	Y	
	Pinnipeds	Y		Y	
	Cetaceans	Y	Y	Y	
	Reptiles	Y	Y		
	Elasmobranchs	Y	Y		
	Protected seabed sp.				
	Protected fishes	Y		Y	Y
	Crustaceans				
	Other				

3.2 REM in your fishery

As exact wording is used, some of the tools listed in Table 3 below are the same but identified with slightly different names (e.g., electronic monitoring, video monitoring, camera-based REM, and camera system). Three out of the four fisheries covered named camera monitoring as the most important EM tool in their fishery. The fourth also identified it in their top three. Vessel monitoring systems and locational data ranked second in importance overall, and electronic logbooks ranked third. Gear sensors were identified as important tools by the West Coast fisheries. These tools are explored further in Table 4.

Table 3: REM in your fishery

	North East	Atlantic Migratory	Alaskan	West Coast

Who owns REM data?		Fishing industries	Government	Vessels	Vessel owner
Most important EM tools in your fishery	1	Electronic monitoring (i.e., camera systems)	Video monitoring	Vessel Monitoring System (VMS)	Camera system
	2	Electronic vessel trip reporting (i.e., logbooks)	Spatial monitoring (VMS)	Electronic logbook	Location (GPS)
	3	Vessel monitoring systems (i.e., locational data)		Camera-based REM	Gear sensor

Table 4 details the four tools identified in the previous table in the order of overall ranked importance as scored by the fisheries representatives. The table outlines which fisheries representatives identified the tool, its cost, what data they collect with the tool, the sampling rate they require and the level of confidence they have in the data produced (score out of 10). Where data is missing a response was not provided.

Table 4: REM tools

Tool	Fishery	Cost	Data collected	Sampling rate	Confidence
Camera monitoring systems	North East	15,000USD	On deck fishing activity	50% of trips	8
	Atlantic HMS		Fishing events	10% of trips	8
	Alaska	1.3million USD	Catch location, catch by species (after review), fishing effort information	30% of trips	8
	West Coast				
Vessel monitoring systems (VMS)	North Eastern	3,100USD for equipment	Locational data	VMS is required for all groundfish and herring trips	9
	Atlantic HMS		Bluefin tuna set reports and spatial information	100% of trips	8
	Alaska	I do not know	Vessel location and speed	100% of trips	10
	West Coast		Locational data		
eLogbook (Vessel Trip Reporting)	North East	Free applications are available; a laptop or smartphone is required	The vessel's self-reported effort and catch information, as well as trip details (e.g., location, date/time sailed/landed)	100% of trips	9

	Alaska	I do not know.	Fishing effort information from the vessel operator's input	100% on vessels that are required to use logbooks	6
Gear sensors	West Coast				

3.3 Cost and Maintenance

All the fisheries surveyed fund their REM programme with government funding/grants, North East, Alaskan, and West Coast fisheries are also self-funded, while the North East fishery also receives private grants. All REM equipment is installed and maintained by service providers and only North East fisheries experienced skills shortages to meet these installation and maintenance requirements. Where there is expertise, vessel crews perform system maintenance daily whilst trained technicians perform maintenance on an as needed basis. The yearly cost of maintenance is unknown. Tables 5 to 8 show further details.

Table 5: Cost and maintenance

		North East	Atlantic Migratory	Alaskan	West Coast
How is REM programme funded?	Government funding/grants	Y	Y	Y	Y
	Private grants	Y			
	Fishing industry self-funded	Y		Y	Y
	Private companies				
	NGO charity and donations				
	Fines/admin charges				
	Research funding				
	Other				
Who installs and maintains REM equipment on the vessels		Certified service providers	Saltwater INC	REM service providers (private companies)	EM service provider
Have you experienced skills shortages to meet REM installation & maintenance requirements?		Yes	No	No	No
How often is system maintenance performed by vessel crew?		Daily	Daily	Daily	I do not know
How often is system maintenance performed by trained technicians?		Varies in response to system performance	As needed	On an as needed basis. Routine checks flag issues	Annually and as needed

Yearly cost of maintenance	Do not know as this is an industry cost		I do not know. This is not broken out in reporting in my region	

3.4 Data collection, analysis, and storage

REM data is owned by both the vessel owners and the authorities in different fisheries. All primary analysis of REM video data is performed by 3rd party contractors (both government and industry). In all fisheries, data is retrieved on hard drives and stored on cloud-based storage. In both North East and Alaskan fisheries data is stored for a year after the end of the fishing season whereas the Atlantic fishery stores their video data for a minimum of 5 years. All utilise human analysts to assess catch. The North East and Alaskan fisheries integrate their REM data into central fisheries database. Throughout the US fisheries, less than 50% of assessment of fish stocks utilise any REM data.

Table 6: Data collection, analysis, and storage

	North East	Atlantic Migratory	Alaskan	West Coast
Who owns the REM data?	Vessel owner	Government/fisheries authority	Vessel owner	
Who performs primary analysis of REM video data?	3rd party industry contractor	3rd party gov/fisheries authority contractor	3rd party gov/fisheries authority contractor	Transition from fisheries authority to 3rd party industry contractor
How is data collected from vessel?	Hard drive retrieval by contractor	Hard Drive mailed to government contractor by vessel	Hard drives mailed to reviewers by vessel operators	Hard drive retrieved by contractor
How is video data stored shoreside?	Cloud storage maintained by 3rd party contractor	Amazon Web Services cloud	on the hard drive and cloud-based storage	Local servers/cloud storage
How long is video data stored after analysis?	12 months following the end of the fishing year	Minimum 5 years	1 year after end of fishing season (Because most of our fisheries extend throughout the year, this equates to between 2 and 2.5 years)	
Method of analysis	Human analyst identifies hauls and assesses catch	Human analyst assesses catch	Human analyst identifies hauls and assesses catch	Human analyst identifies hauls and assesses catch
Is the REM data integrated into central fisheries database	Yes		Yes	No

What extent is REM data used for assessment of fish stocks in your fishery	25%	0%	49%	45%

3.5 Implementation

Three of the four fisheries interviews strongly agree that pilot studies of REM are essential before full implementation and this process will take over 5 years. The Atlantic Migratory fishery disagrees with the statement, stating that implementation takes 1-2 years.

Table 7: Implementation

	North East	Atlantic Migratory	Alaskan	West Coast
'Pilot studies of REM are essential before full implementation in fisheries'	Strongly agree	Disagree	Strongly agree	Strongly agree
How long does it take to implement REM in a fishery?	>5 years	1-2 years	>5 years	>5 years

3.6 Compliance, finance, and admin

Three out of the four fisheries give tolerances to vessels who break rules. Of these, only the West Coast fishery agreed this tolerance prior to REM implementation. All fisheries asked record repeat offences. In half the fisheries (North East and West Coast) the percentage of footage reviewed has been agreed. The North East fishery is the only fishery with confirmed experience of EM equipment being tampered. The Alaskan fishery has experienced suspected tampering and West Coast has experienced loss of data. For the two fisheries where this information is known, 10% of offences detected using EM resulted in enforcement action. Sanctions are being enforced in a variety of ways, the most common being a variable financial penalty with three of the four fisheries identifying it as a common sanction.

Table 8: Compliance, finance, and admin

	North East	Atlantic Migratory	Alaskan	West Coast
Is any tolerance given to vessels that break the rules?	Yes	No	Yes	Yes
Was a tolerance level agreed prior to implementation?	No	No	No	Yes
Are repeat offences or patterns in offences recorded?	Yes	Yes	Yes	Yes
Have there been any agreements on the percentage of footage to be reviewed?	Yes	No	No	Yes
Have you experienced tampering of EM equipment?	Yes		Suspected tampering, but most offences are operators not following their Vessel Monitoring Plan.	No – but experienced data loss (missing hard drives)

What percentage of offences detected using EM result in enforcement action?		10	10	Unknown	
How are sanctions enforced?	Financial penalty – fixed amount fine	Y	Y		
	Financial penalty – variable fine	Y	Y	Y	
	Criminal prosecution – courts decide penalty	Y	Y		
	Administrative charges – fisher pays for additional reviewing of data				
	Administrative charge – fisher penalised via quota penalty			Y	
	Other				

4 Key findings from interviews

Below is a summary of all insights of REM uses, experiences and lessons learnt from all interviews; the four US regional fisheries as well as the US and NZ overview. All responses have been captured and therefore some of them conflict. The words of participants have been used as much as possible. Whilst these points have been complied to give a complete overview of points discussed, it does not mean that experiences can be applied across the board. Some points are specific to individual fisheries, others are more generalised. For more detailed contextual summaries specific to the experience within those regional fisheries and National overviews are covered in Annex 4.

4.1 EM's use and capacity

EM onboard vessels results in illegal activity being a lot more detectable. Video footage enables the ability to verify fish catches and ensure compliance and can be used as evidence to secure convictions. NZ interviewees notes with this increased detectability, offences and penalties had to be reviewed to reflect this as previously large and rarely used penalties had become more frequent.

There is a need to find a balance between enforcement with data collection for science and management. If used correctly, REM roll-out can be a valuable opportunity to build relationships with fishers. US interviewees suggested using REM to invite corrections in behaviour and compliance rather than rushing to prosecution.

There is a need to be very specific within regulations about what cameras will be used for and what they will observe.

REM offers opportunities far beyond regulation and these are still being explored by both NZ and US. Data is used to build understanding about the fisheries discards and bycatch. This and wider environmental data could also be used to strengthen scientific data and strengthen the management of fisheries and the marine environment.

4.2 Prioritisation and drivers for EM deployment

Drivers can include:

- **Cost saving** - This has been driven both by the industry where they are required to fund the monitoring requirements and in prioritising certain fisheries due to increased logistical costs of getting physical observers onboard vessels due to their remote or small nature.
- **Risk posed to protected species** - fisheries that pose the largest risk to the most at-risk species were prioritised.
- **Compliance** - Fisheries or vessels were prioritised to verify fleet interactions with protected species or concern about illegal discarding.

4.3 Benefits of EM

Benefits can include:

- **Cost efficiency** - With reduced observer coverage and their related logistical issues, there is potential to monitor fisheries at 100% at a much cheaper cost.

- **Provide options** - For fisheries that are required to self-fund their monitoring, EM introduces options to accomplish this.
- **Support better management** - Improved and verified information can give the confidence to make adaptive management decisions, allowing for better vessel and fishery management. Depending on data collected REM can allow for environmental and fishery needs to be better balanced, whilst feedback on vessel management can lead to improved sustainability outcomes.
- **Increased accountability** - Linked to the above point, increased accountability can allow for increased flexibility resulting in beneficial behaviour changes. This accountability is likely to have reputational benefits as well as the potential to allow access to overseas markets and otherwise closed areas.
- **Safety** - The ability to monitor crew on deck can enable the development of safer day-to-day practices.

4.4 Costs of EM

The installation and upkeep costs of the cameras themselves are just one part of the cost of an EM system. Additional costs can include:

- **Video review process** (Largest cost) - Time intensive especially in more complex analyses.
- **Social impacts** - In participating in REM fishers may lose the trust of their peers.
- **Additional work** - Extra work for fishers on board in terms of operating the system and the behaviour change required to increase the efficacy of cameras.
- **Loss of earnings** - Risk of being unable to fish because of equipment issues/installation delays.
- **Field services** - Employing technicians required for repairs.
- **Data transfer and storage** – Both the hardware and transfer take time and money.
- **Untangling systems** - The time and resources required to revise systems and ways of working that have been in place for 10-20 years, both in bringing data together and the systems and policies surrounding monitoring.
- **Acting on footage** - Compliance and science/management/data resources required.

Considering the combined cost of the above, in some situations, EM programmes are not always cost effective enough to replace a physical observer.

4.5 Incentives

This is an area where NZ and US appear to have taken different approaches. The US interviewees believe that due to the social impacts, the value of being the first adopters of REM need to be clear. They therefore utilised the following incentives (to varying degrees in each fishery):

- **Financial** - Covered the initial installation/data analysis costs for the first few years.

- **Access** - Allowed monitored vessels more flexible time and area management including access to closed areas.
- **Flexibility** - The increased accountability enabled different fishing behaviours such as allowing mixed species trips or use of alternative fishing gear.

NZ has not utilised incentives within their regulatory programmes, however, recognises that the possibility of reduced observer coverage may have acted as such.

4.6 Challenges to implementing EM

Fisheries vary in scope, location, coverage, jurisdiction etc and so face different challenges. Below are some examples of those faced by NZ and US:

- **Industry reluctance** - Due to concern over social dynamics, privacy and lack of understanding or lack of clarity over programme specifics – lifetime costs, data collection and usage etc. Additionally, in contrast to human observers, EM is a tool that provides full coverage and transparency. Therefore, questions and concerns over privacy and confidentiality with increased EM use.
- **Regulatory barriers** - Some regulations will need to be adapted to enable EM implementation.
- **Cost benefit balancing** - Potential cost savings need to be compared with additional work, delays, and other associated costs. Which party receives the various costs and benefits also needs to be considered in the balancing.
- **Additional work** - Changing systems requires a lot of work to set up. Some EM applications or fishing practices will make this switch more complicated, e.g., monitoring at sea discards of diverse catches. Additionally, sometimes the data obtained through EM differs to that which was received through observation so will require extra work to make them comparable.
- **Fishery's broad geographic scope** – Ensuring appropriate installation, maintenance, and operation across all vessels.

4.7 Key issues around data

Issues can include:

- **Legislation and policy** - There is a need to ensure that existing legislation is suitable for EM implementation and make decisions as to how legal mandates are applied to EM data. US interviewees suggested that as EM is complex in its development and implementation, policy wording needs to be flexible.
- **Ethics and privacy** - As in many cases footage may be of people's living spaces, there is a need to ensure that appropriate permissions are obtained and work is done with industry to develop ethical practices.
- **Data collection and use** - From the outset, decisions must be made on what information needs to be collected and how it will be used and reviewed. As an independent data source, or to verify the information that fishers are required to provide? The more data collected, the higher the cost.
- **Data Sharing** - The following decisions need to be made and agreed prior to implementation. Who owns the data? When, how and under what situations are sharing of data allowed? How long is the video footage/data retained?

It is important to build and maintain trust with industry. Therefore, data uses, permissions and ownership need to be clearly defined and established from the outset.

4.8 Future of REM

Steps needed for further REM implementation:

- **Increase involvement** - EM will continue to expand slowly as vessels adjust to the new coverage, technology develops and proves efficient and barriers to participating are removed as learning continues. Sharp uptake is unlikely unless the funding landscape changes dramatically.
- **Increase clarity around the data trail** - Ensure all parties understand and agree with how data will be used and stored. To enable future international work, it would be useful to develop robust data standards.
- **Technological advances** - advances in the last seven years have made it possible for lower costs. This is likely to continue and will allow for an evolution of the programme - i.e., instantaneous data access, reduced review time and machine learning algorithms.
- **Encourage innovation** - Attempt to be standards driven and take an outcome-based approach to allow providers to have a competitive but equitable environment to help move REM forward in the most effective way. NZ has developed a fund for research into how advancements might be realised in the future.
- **Policy and legal framework** - Develop sufficient regulations and policies to support the development of REM, specifically in terms of software and hardware development.
- **Scope expansion** - Once REM has proved effective and passed trial phases, scope expansion can be explored with all stakeholders (e.g., environmental groups, the agency (regulator) and fisheries).

4.9 Use of Artificial Intelligence (AI)/machine learning in REM analysis

Both NZ and US interviewees acknowledged that AI is an area of interesting emerging technology and are researching into it, but the practicalities of it are not there yet. Testing in the US has shown that:

- Complex AI models cannot be applied outside of the context they were developed due to different lighting conditions, vessel background, catch handling practices, etc.
- Currently costs outweigh the benefits both at fishery and national level.

To overcome these, interviewees suggested trials in simpler AI applications and building larger image data set across EM programmes to support future algorithm development.

4.10 Lessons learnt

Lessons that emerge from the two countries include:

- **Engage all stakeholders in an experimental approach** - Both NZ and US highlight the importance of engaging all stakeholders from the outset and scoping throughout the complete process. They suggest a collaborative experimental approach to allow the programme and its systems to be refined over time to meet objectives and address outstanding concerns. The scope and purpose of the programme should be flexible and reviewed regularly, whilst communication should remain open.
- **Outreach and clarity** - Ensure that everybody knows and understands the problem being addressed and the scope of the programme. Systems should be clearly designed and there should be clarity around all aspects of the programme prior to implementation. North East fisheries in the US suggest a clear offer/transition strategy would have been helpful in recruitment of vessel masters.
- **Ensure benefits are mutual from the outset** - ideally these should be demonstrable.
- **Learn from others** - Whilst the challenges should not be underestimated, others have trialled and implemented REM before, learn from their experiences.
- **Avoid implementing new systems into legacy systems** - Use standard technological systems such as browser-based review systems and network data transfer systems.
- **Funding is challenging** - Costs are scaled with scope. Ensure all costs have been balanced with their benefits. Provide transparent and explicit cost profiles to those who will be funding early to build trust and allow for financing. To ease the impacts of the transition on vessel owners, North East US fisheries met short-term costs.
- **Be patient** - Confidence is built over time.
- **Think globally** - Prepare for international collaborations through standardising procedures and data.

5 Conclusion

There is a significant amount of ongoing work to improve and implement REM programmes across the US and NZ. Whilst some are still in the trial phase, several tools are already widely used with great confidence. For contextual details over where and how specific applications and experiences identified in Sections 3 and 4 have been applied see Annex 4.

Through this research we have developed a clearer understanding of the current work being done in US and NZ. We have identified some of EM's capacity, its potential to build deeper relationships with industry, develop deeper understanding around practices and their impacts, thus supporting better fisheries management and its potential for increasing cost efficiency. We have also identified the characteristics of the US fisheries trialling/implementing EM and recorded specific tools that they have worked on.

Despite progress in EM implementation, barriers such as concern over social impact, privacy, cost, and additional work limit industry uptake. However, the experts we interviewed across the US and NZ were able to identify numerous solutions that could be developed to improve REM roll out. This potential future work may be supplemented by the ongoing work of these organisations.

The primary aim of this report was to collate knowledge and lessons learnt from various REM rollouts. To identify demonstratable improvements because of REM implementation and to identify possible solutions to blockers. We do not provide a discussion of these results or recommendations for MMO here as it falls outside of the scope of this report. Despite the progress made here, some of the organisations invited to participate in this research were unable to participate fully. For this reason, it may be useful to perform additional research in this area to develop a fuller picture of REM implementation across a wider area.

Overall, we feel that the ongoing work and suggestions summarised in this report will provide a useful platform for MMO to prioritise actions to move forwards with implementing REM in the UK.

6 References

Marine Management Organisation (2016). Catch Quota Trials. Available online at https://www.gov.uk/government/collections/catch-quota-trials-reports, accessed on 24 January 2023.

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Needle, C., Dinsdale, R,. Buch, T,. Catarino, R., Drewery, J., Butler, N., Scottish science applications of Remote Electronic Monitoring, *ICES Journal of Marine Science*, Volume 72, Issue 4, May 2015, Pages 1214-1229. Available online at: https://doi.org/10.1093/icesjms/fsu225, last accessed 24 January 2023.

Annex 1 Consent Form

Consent form for MMO Future Fisheries Project

Please read this, sign it, and email it back to me.

Taking Part

I understand this research is to collate knowledge and lessons learnt about implementing remote electronic monitoring (REM) programs at scale.

I agree to take part in the interview.

I agree to what I say being noted in writing.

I agree to an audio recording being made for the sole use of the interviewer to check their notes of my interview.

I understand that the interviewer will send me the notes to check what they have written

I understand taking part is voluntary. I can withdraw at any time and do not have to give any reasons for why I no longer want to take part.

Use of the information I provide for this project only

I understand that unless I tell the interviewer differently, notes of the interview will be passed to MMO with my name attached and MMO will know what I said.

I understand I can tell the interviewer to only report something I say in a way that can't be traced to me or my location, project, or other identifying factors.

I understand my contact information will not be passed to anyone outside the research team.

I agree Dialogue Matters Ltd can archive my interview notes

I agree that Dialogue Matters can include what I said in a summary report to MMO

I agree my notes will be passed to MMO for further analysis.

Name of participant [capitals]	Signature	Date
Researcher [capitals]	Signature	Date

If at any stage in the research, you wish to report an issue of concern about the interview or interviewer or withdraw from participation you can contact our Director (Diana Pound) independently. Email: diana.pound@diloguematters.co.uk

Annex 2 Survey design

About you

Full name

Insert text here…

Email

Insert text here…

Name of your organisation

Insert text here…

Your role within your organisation

Insert text here…

Fishery characteristics

What type of fishery gear is used in your fishery? Please select all the apply.

- *Demersal or bottom trawl*
- *Gillnets*
- *Longlines*
- *Purse seine*
- *Pole and line*
- *Pots and traps*
- *Dredges*
- *Pelagic or midwater trawls*
- *Fish aggregating devices*
- *Other… Insert text here*

What length are the vessels used in your fishery? Please select all the apply.

- *VL 00-10 meters / 0 - 32.8 ft*
- *VL10-12 meters / 32.8 – 39.3ft*
- *VL12-18 meters / 39.3 – 59 ft*
- *VL18-24 meters / 59 – 78.7 ft*
- *VL 24-40 meters / 78.7 – 131.2 ft*
- *VL 40+ meters / 131.2ft+*

What are the main target species in your fishery?

- *Insert species 1*
- *Insert species 2*
- *Insert species 3…*

How many vessels operate in your fishery?

Insert text here…

How many vessels are fitted with EM equipment?

Insert text here…

What fish species caught in your fishery get discarded? Please select all that apply.

- *Quota stocks*
- *Non quota stocks*
- *Other, please specify*

What protected bycatch species are caught in your fishery? Please select all that apply.

- *Seabirds, sea ducks, penguins (avians)*
- *Seals, sealions (pinnipeds)*
- *Dolphins and porpoise, whales (cetaceans)*
- *Turtles (reptiles)*
- *Protected sharks, skates, and rays (elasmobranchs)*
- *Protected seabed species (e.g., corals)*
- *Protected fishes (e.g., sturgeon, salmon, groupers)*
- *Invertebrates (e.g., crustaceans)*
- *Other… Insert text here…*

REM (Remote Electronic Monitoring) in your fishery

In your fishery, who owns the REM equipment?

Insert text here…

REM tools used in your fishery

What are the three most important electronic monitoring tools used in your fishery?

- *Response box 1*
- *Response box 2*
- *Response box 3*

For each of the three tools, please provide the following details:

What is the name of the tool?
Insert text here…
Approximately how much does the tool cost? Please provide a currency.
Insert text here…
What data is collected by this tool?
Insert text here…
What is the sampling rate of this tool?
Insert text here…
How confident are you in the data you receive from this tool?
Insert sliding scale 0 – 10 here…

Costs

How is the REM program in your fishery funded? Please select all the apply.

- *Government funding and grants*
- *Private grants*
- *Fishing industry self-funded*
- *Private companies*
- *NGO charity and donations*
- *Fines/administrative charges for non-compliant vessels*
- *Research funding*
- *Other… Insert text here*

REM installation and maintenance

Who installs and maintains REM equipment on the vessels, have you experienced skill shortages to meet that requirement?
Insert text here…
How is it maintained?
Insert text here…
How often does system maintenance on board the vessels need to happen?
By the vessel crew?

- *Daily*
- *Weekly*
- *Monthly*
- *Once a year*
- *Less often than once a year*
- *I don't know*
- *Other*

By a trained technician?

- *Daily*
- *Weekly*
- *Monthly*
- *Once a year*
- *Less often than once a year*
- *I don't know*
- *Other*

What are the yearly costs of maintenance? Please provide a currency.
Insert text here…
Have you experienced incidence of tampering with EM equipment in your fishery?
Insert text here

REM data collection, analysis, and storage in your fishery

Who owns the REM data?

- *The master of the vessel*
- *The owner of the vessel*
- *The owner of the EM system*
- *The Government / Fisheries authority*
- *Other, please insert text*

In your fishery, who performs primary analysis of the REM video data? Please select all that apply.

- *3rd party contracted to work for industry*
- *3rd party contracted to work for government / fisheries authority*
- *Government / fisheries authority*
- *Other*

How is data collected from the vessel in your fishery?

- *Hard drive retrieval by contractor*

- *Hard drive retrieval by Government / fisheries authority*
- *Remote access download of data using Wi-Fi / mobile network*
- *Other*

How is the video data stored shoreside?

Insert text here…

How long is video data stored after analysis is complete?

Insert text here…

What method is used for analysis of the REM data?

Human analyst identifies hauls and assesses catch
Human analyst assesses catch
AI / Machine Learning identifies hauls
AI / Machine learning identifies hauls and assesses catch
Other

Is the REM data integrated into a central fisheries database?

- *Yes*
- *No*

To what extent do you use REM data for assessment of fish stocks in your fishery?

Insert sliding scale 0 – 10 here…

Implementing REM?

To what extent do you agree with the following statement? *"Pilot studies of REM are essential before full implementation in fisheries"*

Insert sliding scale 0 – 10 here…

In your experience, approximately how long does it take to implement REM in a fishery?

- *Less than six months*
- *6 months – 1 year*
- *1 – 2 years*
- *2 – 3 years*
- *3 – 4 years*
- *4 – 5 years*
- *More than 5 years*

Compliance, fines, and administrative charges

Is any tolerance given to vessels that break the rules?

- *Yes*
- *No*

Was a tolerance level agreed with industry before implementing EM in your fishery?

- *Yes*
- *No*

Are repeat offences or patterns in offences recorded?

- *Yes*
- *No*

Have there been any agreements on the percentage of footage to be reviewed?

- *Yes*
- *No*

What percentage of offences detected using EM result in enforcement action?

Insert number response 0 – 100

In your fishery, how are sanctions enforced upon vessels that do not follow the rules?

- Financial penalty – fixed amount fines
- Financial penalty – variable fines
- Criminal prosecution – courts decide penalty
- Administrative charges – fisher pays for additional reviewing of data
- Administrative charge – fisher penalised via quota penalty.
- Other – please specify

Annex 3 Interview design

National Overview:

Introduction

At this stage, the interviewer will provide some background about the project, explain the interview process, explain the ethics, informed consent, and attribution/confidentiality, and give the participant an opportunity to ask questions.

Question 1: How has REM contributed to Control & Enforcement capability across US fisheries?

- *Type participant response here*
-

Follow up Q: Is data from your REM programmes also collected to assist with wider environmental monitoring?

- *Type participant response here*
-

Question 2: How did you prioritise which fisheries should have REM systems?

- *Type participant response here*
-

Question 3: Beyond installation or upkeep costs of using REM, have any significant costs to industry been identified?

(e.g. extra work on board, duplication of effort, risk of being unable to fish because of equipment issues)

- *Type participant response here*
-

Question 4: Have any significant benefits to industry of using REM been identified?

(Might include things like streamlining reporting or reputational benefits)

- *Type participant response here*
-

Question 5: Were any forms of incentive used to support participation in REM programmes (including voluntary schemes)?

- *Type participant response here*
-

Question 6: How are you future proofing against technological advancements that might pose a risk to REM systems/programmes becoming outdated?

- *Type participant response here*
-

Question 7: Are you using Artificial Intelligence/machine learning capability in your REM analysis?

- *Type participant response here*
-

Follow up 7: How is your experience of this in terms of the broader costs/benefits of utilising such capability?

- *Type participant response here*
-

Question 8: What would you say are the key issues to consider around data?

(e.g., ownership, privacy, legal structure)

- *Type participant response here*
-

Fishery Specific

Introduction

At this stage, the interviewer will provide some background about the project, explain the interview process, explain the ethics, informed consent, and attribution/confidentiality, and give the participant an opportunity to ask questions.

Question 1: What was the main driver for deployment of electronic monitoring in your fishery? Why was REM introduced?

- *Type participant response here*
-

Question 2: What evidence supported your decision that electronic monitoring was the most appropriate technical solution for monitoring your fishery?

- *Type participant response here*
-

Question 3: What were the main blockers, barriers, or challenges to implementing electronic monitoring in your fishery?

- *Type participant response here*
-

Question 4: Which solutions would you recommend in overcoming these barriers to implementation?

- *Type participant response here*
-

Question 5: Has implementing EM in your fishery been beneficial?

Follow up Q: Have there been any changes to catching policy following REM rollout, for example alterations to catch limits?

- *Type participant response here*
-

Question 6: With the value of hindsight, which areas are most important to address when implementing EM in a fishery? What would you do differently if you could start again?

- *Type participant response here*
-

Question 7: What does the future hold for REM?

Additional question - only ask if there is time

- *Type participant response here*
-

Annex 4 Individual interview summaries

Below are the individual interview summaries, detailing participants experiences of EM implementation in their fishery/Nationwide. Responses have been sorted and condensed but original language is used wherever possible.

US experience

US Overview

EM's contribution to control and enforcement capacity

Still learning how to balance enforcement with data collection for science and management:

Learnt that a heavy focus on enforcement limits EM's value by losing a valuable opportunity to build relationships with fishers.

Tried to use REM to invite corrections in behaviour and compliance rather than rushing to prosecution.

Have seen behaviour changes (where and how fishing is undertaken)

- Enables fishers' freedoms to make decisions enabling changes.
- Able to use video footage to; educate fishers, provide feedback on improving compliance and data quality.

EM and environmental monitoring

REM offers opportunities far beyond regulation and we are still exploring these.

Have programmes that are designed to **build understanding** about the fisheries discards, bycatch, and strengthen scientific data.

Secondary use of this (primary to fishers perhaps) includes ability to **demonstrate compliance** with certain criteria directly to the supply chain - may lead to better prices at market.

Prioritising fisheries for EM distribution

This tends to be Industry driven, in the US, catch share/quota fisheries have a requirement to fund their own monitoring. So, EM programmes were partially driven by the industry because of the potential for cost savings.

There are examples where the agency prioritised certain fisheries due to other drivers such as international agreements e.g., Blue Fin Tuna conservation in the Atlantic Pelagic Longline Fishery.

EM costs/Issues

Some programmes funded more by industry, others by NOAA. In the cases of fisher-initiated programmes, video review and data storage are allocated to the industry (in addition to installation and upkeep), analogous to them funding a human observer to collect similar data in the same fishery. Costs can come from:

- **Video review process** (Largest cost) - Time intensive especially in more complex applications of REM, where specific identification and enumeration are necessary for the overall monitoring programme.

- **Field services** - Employing technicians for repairs which may have to travel long distances, and otherwise ensuring REM systems are operating properly.
- **Data transfer of hard drives** - Both the hardware and transfer take time and money. Wireless data transfer is not possible in most cases due to data size and remote geography of many fishing ports.
- **Untangling systems** - When bringing the data together (e.g., logbooks, VMS, REM etc) a lot of the process is untangling what has been in place for 10-20 years. If we started from nothing, we would probably be able to develop a single system that is more cost-effective and user-friendly for fishers.

Fishers are wanting to explore EM as a more cost-effective tool however the costs do add up as above. EM programmes are often **not cost effective enough** to replace a physical observer.

EM benefits

Most REM systems seem to last 3-5 years and are quire robust and durable, system outages and replacements are uncommon.

We are some ways from realising EMs great potential. But there are other significant benefits of EM:

- **Contributing to the scientific data** on the fisheries - These are not easy to quantify as we are still building a picture around what data is collected, who it goes to and how we turn that data into information to inform policy and management decisions.
- **Increased safety** - Benefits reported by fishers include monitoring crew on deck (for safety reasons). There are even some instances of captains installing EM cameras in their engine rooms to improve their management of the vessel.

Incentives

There are social impacts in participating in REM - fishers who take on REM may lose the trust of their peers. So, we need to show there is value in being the first adopters:

- **Financial** - tried to cover initial installation costs, or some of the data analysis costs for the first few years.
- **Access** - allowed monitored fishers to access closed areas. Widespread implementation of REM could allow for more flexible time and area management.
- **Enable different fishing behaviours** - accountability through the presence of the cameras means that mixed species/gear trips can be undertaken. This is not widespread, but it will continue to grow.

Futureproofing

- We are still, in some cases, trying to get the primary purpose of REM right, this is primarily to: **Increase fisher and vessel involvement Increase clarity around the data trail.**
- Ensure the **policy and legal framework** is in place to support REM:
    - Develop regulations and policies for technology in terms of software and hardware development.

    - Be standards driven so technology providers have a competitive but equitable environment to help move REM forward.

- We are also still learning **how the data can be used**.
    - Being mindful about our long-term data storage footprint.
    - Develop robust standards around data so there is the potential to work internationally easily.

Use of AI/machine learning in REM analysis

AI is being widely tested across the US but is yet to be used extensively in the video review process as:

- Complex AI models cannot be applied outside the context they were developed due to different lighting conditions, vessel background, handling practices, etc.
- Currently costs outweigh the benefits both at fishery and national level.

To try to rebalance this the following is being investigated:

- Trialling AI in simpler applications (e.g., is there crew on deck, gear in the water?)
- Building a larger image data set across all our EM programmes to support algorithm development in the future.

Key issues around data

Data issues include:

- **Legislation** - How do you apply legal mandates to EM data?
    - Current policies will speak to human observers on boats rather than EM.
    - How does this tie in other legislation including the Federal Records Act (national archives), Freedom of Information Act (FOIA) and the Magnuson Stevens Act (1976)?
- **Data ownership**
    - In self-funded programmes, data may be owned and stored by the fishers.
    - To build and maintain trust, clearly define, and establish data uses and permissions.
- **Complex development and implementation** - You cannot plan for every eventuality, so it is vital to be prepared for all eventualities in your policy wording and develop a process for addressing issues as they arise.
- **Ethics** – Do we have appropriate permissions to develop AI on fishers?

Concluding US comments

In conclusion:

- **Communications is key** – involve all the stakeholders in the development of the programmes including tech companies, fishers, data managers, AI Machine learning experts, environmental NGO's, policy officers. etc
- **Think globally** - standardisation of technology, data transfer etc will enable REM to be scaled cheaper and more efficiently if we start off thinking in these terms now.

US Northeast fisheries

There are two different fisheries that are in the process of incorporating EM in this area; Northeast Multispecies fishery (the Groundfish Fishery) which includes 17 fish stocks (including cod, pollock, haddock, flounder) and the Herring and Mackerel fishery (very high-volume fishery)

- We implemented EM as an operational programme only on May 1st of 2021 in the groundfish fishery.
- In the Herring and Mackerel fishery EM is still operating experimentally, at a small scale.

Main drivers for EM deployment

Industry funded monitoring requirement:

- EM for the **groundfish fishery** programme was industry driven to a certain extent as they are open to looking for a cost-effective way to undertake the required monitoring.
- For the **herring and mackerel fishery** it is similar, in that electronic monitoring is not being imposed by the regulator. However, the regulator is imposing an industry-funded monitoring requirement, which may be met with either human monitors or cameras.

Industry funded monitoring is above and beyond any government funded monitoring.

Evidencing

When passing costs of monitoring to the fleet it is important to provide cost effective alternatives.

- The Science Centre did a pilot study to examine EM suitability and how the data could be used.
- There were multiple other examples of EM from within the US to draw upon.

Working with the industry we were able to show that EM could meet the goals and aspirations and requirements for the monitoring in these fisheries.

Challenges to implementing EM

Some of these do not apply equally to both fisheries, challenges include:

- **Privacy and confidentiality** - EM is a tool that provides full transparency, and the human coverage (observation) has historically been less than 100% so there were issues and questions in relation to what vessels may be losing if they chose the EM route.
- **Regulatory barriers** - Some regulations had to be adapted to enable EM implementation. E.g., certain EM models require full retention of catch and that currently goes against regulation.
- **Cost** - Short term there is no motivation to switch to EM as costs are being met from outside of the industry.
- **Additional work** - There is a lot of work to switch to EM, e.g., learning to use a new monitoring tool, following specific catch handling procedures.
- **Different data** - The dataset is different to that obtained through observation, but we were able to learn how to work with the data sets to draw out the required information.

Solutions

There are two ways to approach a new programme:

- The experimental model (as chosen here) where we are learning as we go and testing the programme. But please note that many fishers will wait for the programme to be refined before committing.
- To delay implementation until the programme is refined to the point of certainty.

The principles here are:

- **Experimental approach** – Our approach has been very collaborative in its development. Running studies for an extended time has built a firm foundation on which to move forward.
- **Meet short-term costs** - to ease the impacts of the transition on vessel owners.
- **Increase time** - Concerns around privacy take time to address, confidence is built over time.
- **Continuously evolve** - the programme is continually evolving based on our needs, operational experience and to address outstanding concerns and questions. The benefits of this included collaborative exploration and the lessons learned along the way; however, it is not possible to create absolute certainty for participants.

Benefits of EM

Benefits include:

- **Provide options** - for accomplishing monitoring requirements. This is important when the burden of monitoring is being borne by the industry.
- **Reduced cost** - We are moving towards being able to monitor the fishery at 100% at a much cheaper cost.
- **Better decision making** – able to gather all the information required to manage the fishery and industry.
- **Accountability and flexibility** – With higher levels of accountability, fishers were able to negotiate additional benefits. Such as more flexibility around access to fishing areas or altered gear types.

We will get a better sense of the extent of the benefits a couple of years from now as the programmes develop.

Lessons learnt

Lessons include:

- **Flexibility is important but comes with a cost** - Providing industry with options to meet the monitoring requirement provides a level of flexibility and choice for the fishery which is very important. However, this comes at a cost for regulators in terms of managing multiple systems in parallel and all that comes with them.
- **Funding is challenging** - If you do not have a dedicated funding line to support EM it makes it difficult to scale up and it requires hard work to secure further support.

- **A transition strategy would have been helpful** - Doing some work ahead of time to be able to make an offer to the fishery e.g.
    - Here is a tool we have investigated.
    - Here is how it can/might/will work.
    - Would you like to participate?
- **Know all aspects of the programme** - Working on all the parts of the study from installing equipment, working with software in analysing the data, etc. contributed to a good, strong programme.

Future of REM

We will likely see a continued, slow expansion of EM in the fisheries as well as:

- Vessels will adjust to the 100% coverage.
- Technology will develop and prove itself – we will learn from our experiences.
- As barriers to participating are removed, we will see more fisheries showing an interest in EM to meet their monitoring needs.
- Unless the funding landscape changes dramatically, we do not expect to see a sharp uptake.

Concluding US Northeast comments

There are so many different terminologies used around EM, some of which are all inclusive in that they refer to VMS, electronic reporting (and other electronic methods for monitoring), others refer specifically to the installation of cameras on vessels, we used both interpretations.

US Atlantic Highly Migratory Species fisheries

EM was deployed in our pelagic longline fleet in the Atlantic (stretching from the US Canadian Coast all the way down to the Gulf of Mexico, into the Caribbean, and international waters).

Main drivers for EM deployment

Verifying fleet interactions with protected by-catch species - The need to track by-catch rates within the US Pelagic Longline Fishery was the main driver for the deployment of EM.

Before deploying EM, there were incentives to misreport (because of the small number of Blue Fin Tuna these vessels could catch), vessels were also catching the Blue Fin Tuna but throwing them back dead which resulted in no benefits to the fishers or to the fish and which species, the impacts of this was widespread.

The evidence came down to the confidence we had in the pre-existing data streams which were derived from the fishing vessels themselves (logbooks and observation). EM supplemented the existing data to validate and ensure suitable regulation and compliance with obligations, and that impacts on the resource were as intended.

Challenges to implementing EM

Challenges include:

- **Cost** – they are expensive, and the debate is ongoing as to who should incur the cost to monitor these fisheries. Should the costs be met by the regulator or by the regulated?
- **Significant political challenges** - When implementing on all vessels regardless of home port.
- **Fishery's broad geographic scope** - Creates a challenge of ensuring installation, maintenance and operation are undertaken appropriately.
- **Social dynamics** - installing a government agency as a regulatory body/overseer can cause conflict, as fishing is a profession that attracts independent folk.
- **Initial sample design concerns** - E.g., what data would be reviewed (it is not possible to review all the footage returned). The selection of footage for review is random and stratified but informed both temporally and spatially based on the likelihood of encountering Blue Fin Tuna.

These challenges resulted in a difficult negotiation to determine the operating parameters for the system. E.g., cameras are only installed in areas of the vessel where fishing activity takes place and only operate during fishing operations. Five years into this programme, we no longer hear these concerns and there is a high level of confidence that the cameras are not infringing on their privacy.

Solutions

Solutions include:

- **Demonstrate system benefits** - Highlight it is not just top-down control, there can be benefits to fishers because of these systems. Such as enabling access to a particular fishing ground, or the requirement for less paperwork and reporting.

- **Transparent and explicit cost allocation programme** - Some fisheries do not have economies that can sustain these systems - it is important to fully cost both development and operation, and the cost sharing arrangements beyond the initial deployment and first few operating years.
- **Clear system design** - Ensure clarity around system design to manage expectations. Lock in the purpose and be open to negotiation on other applications with due recognition and acknowledgement of the additional costs associated and that these will need to be negotiated separately.
- **Cost scales with scope** - If you are trying to capture a lot of information the cost will go up, so limiting the scope can be valuable in managing costs both for implementation, management, data examination and storage.

Benefits of EM

The benefits of REM include:

- Behavioural change:
    - The by-catch of Blue Fin Tuna reduced significantly.
    - Increased accountability - the data also allows fishers more autonomy and self-determination.
    - Fishers can fish their allocation as they see fit based on the data this system is returning and enables refinement of management measures.
    - Moving away from broad spatial management the onus is on the vessel to choose their location and gear according to their own level of risk acceptance.
- Supported fisheries management:
    - Expected changes to policy include refined spatial management of marine resources. As knowledge grows in relation to migration and fish behaviour, areas may be refined, or exclusions applied only for specific periods of time.
    - Provides an additional tool in the toolbox.
- Balance needs:
    - The more we can verify vessel activities, the more a management balance can be struck. Not just for fishers but others as well (I.e., environmental groups).

Lessons learnt

Lessons include:

- Collaboration and exchange:
    - Ensure the scope and goals are well defined and well communicated from the off.
    - Ensure benefits are mutual from the outset. Simultaneously reveal benefits to the fishers, regulator, and the industry. When benefits are offered later the fishers may still have a bad taste in their mouths from the initial one directional benefit.
    - Enable more collaborative communication and exchange in refining systems to meet the objectives for both parties.
- Early costing profiles:

- Costing profile projections that cover a long period into the future set up early to avoid surprises once the programme is up and running in relation to who is footing the bill.

Future of REM

Things to consider:

- Communities are starting to think about this technology's role differently, this is likely to continue. Technological advances in the last seven years makes it possible for lower costs, particularly with government programmes (traditionally behind the curve in terms of technology).
- After seven years of experience, we have remained within the scope of the programme - is it now time to expand the scope and what would this look like?
- Working with environmental groups, the agency (regulator) and fishery to explore if this is desirable and what the evolution might look like, as well as negotiating cost arrangements.
- An evolution of the programme may drive more information out of the fishery and what would that look like?
- Where will EM be in 2032?
- Currently collect a lot of information on two species do we really need to do that?
- Do we need data to be collected on hard drives which are then submitted?
- Are there ways to access data instantaneously?
- Review time could be reduced.
- Data storage requirements could be reduced.
- Data transfer could be streamlined.
- Machine learning algorithms, while not cheap, would be another benefit of advancing technology, a cost that could be shared across fisheries to reduce the financial impact.
- As costs reduce options become more available or it is easier to fund.

Concluding US Atlantic HMS fisheries comments

Learn from others - If MMO think they want to do it, someone will have done a pilot on it. Do not think you need to do this in your own way - build on the work already accomplished by others, you get to start higher on the learning curve and save yourselves some trouble.

US West Coast Fisheries

Main drivers for EM deployment and evidence

Drivers include:

- Potential cost saving in terms of monitoring.
- Since 2011 all vessels carry observers on every fishing trip in addition to off-load monitoring at the expense of the industry.
- With some very remote ports and challenging logistics for getting observers in place – REM held great potential.
- Note, we are still technically in an exempted fishing permit situation which exempts fishers from some regulatory requirements (including the requirement for a human observer on board).
- We drew on learning from others' experiences - building confidence that our requirements and expectations for monitoring could be met through EM.
- Working with Pacific States Marine Fisheries Commission, who do the video/data analysis and data storage, allowed the process to be iterative.

Challenges to implementing EM and their solutions

Challenges include:

- **Some industry reluctance** - lack of understanding of what it was that we were proposing.
- **Outreach and clarity** - It was important for stakeholders to understand the scope of the EM programme and define that very clearly. For example, if the cameras picked up illegal activity, not related to fishing, would this activity be reported?
- **Diverse catches** – With EM on board monitoring at sea discards of diverse catches is more complicated. In the beginning, fishers were having to verify identifications by bring their (normally discarded) bycatch back to the shore, taking up valuable space in their holds.
- **Sorting bins** - The requirement for this has reduced over time as we have built capacity for species identification at the point of catch. Catch must be sorted into bins for the catch to be observed by the cameras, making the process more labour intensive and require more time.
- **Artificial intelligence and Machine learning** represent the potential for real benefits in terms of reducing human analysis requirements and in streamlining the whole monitoring process. Note, AI and machine learning are not there yet but, it is promise is something of an incentive.
- **Cost benefit analysis** – Need to balance the savings of EM compared with the with the additional work and delays due to having to change practices on board to enable EM to work efficiently. In some cases, (vessels with very diverse catch) it may still be more cost effective to carry an observer on board than to implement EM.
- **Industry cost savings** - because the monitoring requirements were always at the expense of the industry this was sufficient in our fishery. In a different situation where you are starting from nothing in response to new monitoring requirements this may not be the case.

Benefits of EM

EM has not created opportunities for fishers but has created more flexibility in our knowledge of can be done under EM.

Lessons learnt

Lessons include:

- **Engage stakeholders in the scoping** - Industry challenged whether the programme that is in place is the best programme to serve their needs. Specifically in relation to who undertakes the data analysis. After setting up a permitting system to enable a market approach, industry chose to remain with the original provider. This is illustrative of the importance of engaging stakeholders upfront in the scoping of the EM programme.
- **Programme clarity prior to implementation** - Important to specify roles, and who burdens the cost, and to be clear about what the costs are and where they will be borne by the industry. Resolving these things upfront will smooth the roll out of the programme.

Future of REM

Matters to consider:

- **More buy in from other fisherie**s - We have some other fisheries with smaller monitoring components to them, in these cases it is likely that the drive will come more from the regulator than from the industry.
- **Technological evolution** - Things become cheaper so evolution of the tech may well lead to fully integrated systems with the capacity to show more information in real time:
    - AI and machine learning.
    - Data transfer and storage – network-based systems.

Concluding US West Coast Comments:

Overall, it is felt to implement REM successfully you need to:

- **Understand the problem you are addressing** - We have done some other side projects where folks did not really understand what they wanted out of EM as a monitoring tool – seeing it as a solution without understanding what the problem was.
- **Engage all stakeholders at the outset** - They might have questions too and these will support the development of your overall system and implementation.
- **Remain flexible and revisit the purpose and scope of the EM programme regularly** - If an observer was not collecting this data, should we be? What is the negotiation around this? What about as technology evolves? What might we want to capture in the future that cannot yet be imagined? There will be challenges to explaining a shift in monitoring focus.

New Zealand experience

New Zealand overview

EM's contribution to control and enforcement capacity

It makes some illegal activity a lot more detectable e.g., illegal discarding or failure to report a protected species capture.
Video footage can be used as evidence.
Ability to verify protected species captures and compliance with landing and discard requirements.

Implications:

- Had to review offences and penalties. Our offences and penalties regime were developed at a time where the chance of detecting offence was very low, therefore there were significant penalties regardless of the level of offending.
- Being able to view post-fishing activities (e.g., sorting) has required some changes in our primary legislation governing the use of electronic monitoring (Fisheries Act).
- With a regulatory programme it means that there are more laws now that need to be monitored and enforced creating an additional workload for our compliance team.

Suggestions:

- Need to be very specific within regulations about what cameras will be used for and what they will observe.

REMs wider uses

Currently do not gather wider environmental data with our regulatory programmes. (Assuming environmental monitoring includes information unrelated to fishing such as sea surface temperatures etc)

Recognise the value such data could provide towards the management of fisheries and the marine environment.

Discussing the use of EM in NZ at present is complicated as currently seeking permission from Cabinet to amend regulations.

Prioritising fisheries for EM distribution

Factors include:

- **Risk posed to protected species** (the biggest driver) - Those fisheries that have been prioritised are those that pose the largest risk to the most at-risk species.
- **Logistics** - Our camera programmes (voluntary and regulatory) have been directed towards smaller/inshore vessels as the logistics of placing observers on those boats is challenging – making cameras the most feasible and cost-effective mechanism for getting the level of monitoring required on these vessels.
- **Compliance** – focus on inshore fisheries where there might be concern about illegal discarding, particularly in fisheries that have importance to non-commercial fishers.

EM costs

The installation and upkeep costs of the cameras themselves are just one part of the cost of an EM system. Costs include:

- **Operating costs** - There may be some extra work on board in terms of operating the system (cleaning cameras etc.) which we try to minimise.
- **Transmission of the footage** - The current regulatory programme uses hard drives to transfer data - but some of the previous voluntary trials have used network systems. Preference for a network system for data transfer.
- **Storage, review, and acting on footage** - Compliance resources and science/management/data resources to make the best use of the footage gathered.
- **Loss of earnings** - There is a risk of being unable to fish because of equipment issues which is a potential cost to industry along with time lost to fishing during installation etc.
- **Behaviour change** - May be necessary for fishers in some cases to change what they do on board to increase the efficacy of cameras. (e.g., presenting caught sea birds to the camera in specific orientations to allow the species confirmation or showing discards to allow more accurate weight estimates).

EM benefits

Difficult to answer as people in the industry may have different perspectives of what a benefit is, and it is not really for us to speculate on what constitutes a benefit to them, however benefits can include:

- **Cost efficiency** - EM could enable reduced observer coverage resulting in cost efficiencies and reduced logistical issues. But as our observer coverage across the inshore fleet is low these are specific cases.
- **Reputationally** - There are likely to be benefits.
- **Continued access to overseas markets** (maybe)
- **Better managed fisheries** -
    - Improved and verified information can result in better management decisions.
    - Improved data can give the confidence to make adaptive management decisions.
    - Improved sustainability outcomes.

Incentives

Within our regulatory programmes, this is not something we have utilised.

The possibility of reduced observer coverage may have acted as an incentive for previous voluntary schemes.

Futureproofing

Suggestions include:

- Take an **outcomes-based approach** - State the outcomes wanted and allow providers to determine pathways to achieving these.
- Put aside **funding for innovation** - Allowing us to do some research into how advancements might be realised in the future.

- Do not lock yourselves into **legacy systems** - Use standard technological systems such as browser-based review systems and network data transfer systems.

Use of AI/machine learning in REM analysis

Not currently utilised. It is an area that we are interested in and have done some research in. This is very much an area of emerging technology that is just not there yet!

Key issues around data

Issues include:

- **Ownership** - Particularly of footage - Data in the regulatory programme is owned by us, so is subject to the official Information Act and other regulations around the sharing and release of data.
- **Privacy** - In many cases you are capturing footage of people's homes. How is their privacy managed?
- **Sharing** - How the data is shared? Under what circumstances can data be shared? Under what circumstances MUST data be shared?
- **Retention period** - Balance between the cost and the benefits of storing footage for a long period of time.
- **What data do you record?** - The more data recorded, the longer it takes to review a piece of footage so increases the cost.
  Data use - What are you using the review data for? As an independent data source, or to verify the information that fishers are required to provide. It is quite a nuanced difference, but it makes quite a difference when it comes to your operating model for the system and decisions regarding footage review levels and what data is recorded.

Concluding NZ comments

From our experience, setting up a camera programme is complex, and the challenges should not be underestimated.