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Marine Scotland

Update: Electrofishing for razor clams trial (1 February 2019 – 31 January 2020)

Purpose

The purpose of this supplementary report on the electrofishing for razor clams trial is to build on the information presented in the publication *'Update: Electrofishing for razor clams trial 1 February 2018 – 31 January 2019'*[1], outlining developments and data gathered under the trial between 1 February 2019 and 31 January 2020.

Introduction

The Scottish trial of electrofishing for razor clams commenced its second year of operation on 1 February 2019 with the main aims of:

i. Further developing the biological and fisheries related data gathered under the first year of the trial, thus building the evidence base for the species and developing an improved basis for the future management of the fishery; and,
ii. Maintaining the regulatory standards and improved access to the sector achieved in the first year of the trial, as reported by the key regulators of inshore shellfish harvesting.

The principal operational elements of the trial – the vessels eligible to participate, the fishing gear, the trial areas, the Remote Electronic Monitoring ("REM") devices installed on all vessels participating, the catch and effort limits - were unchanged from the control details set out in the previous publication (see (1) in Reference Section).

Whilst this is a Scottish Government trial – with significant input from Marine Scotland ("MS") Sea Fisheries Division, MS Compliance and MS Science – it continues to receive vital support from other key public sector partners, in particular the Health and Safety Executive ("HSE") and Food Standards Scotland ("FSS").

During the second year of the trial, officials from MS, FSS and HSE maintained regular contact with trial participants and held two face-to-face meetings with representatives of the Scottish Razor Clam Association (established by trial participants) to discuss the management of the trial, progress and scientific requirements. These exchanges have proved invaluable in ensuring a flow of information and feedback between parties to improve standards, and help to ensure that scientists are provided with unique information about the fishing practices and grounds. HSE has continued with a programme of ad hoc vessel inspections (on land and at sea), with approximately 90% of the trial vessels inspected and found to be compliant with health and safety legislation. HSE continue to carry out regular checks of participants' diving qualifications and diving medicals, including additional divers joining the trial.

Electrofishing for razor clams trial: Year 2

Vessel activity: landings, value and employment

25 of the 28 eligible participants were active during the second year of the electrofishing trial, running from 1 February 2019 to 31 January 2020.

The greatest fishing activity under the trial in terms of landings was between May and July 2019 (see Fig. 1).

While prices fluctuate somewhat between vessels, buyers and months, the average price per kilogram (kg) achieved by the trial vessels was estimated to be around £8.1 per kg. The highest prices (per kg) were generally seen between January and March, perhaps due to the lower amount of landings in these months. While the lowest prices were seen during the summer months, when landings are generally higher. In total, the active vessels were estimated to have landed around 820 tonnes of razor clams worth around £6.6 million.

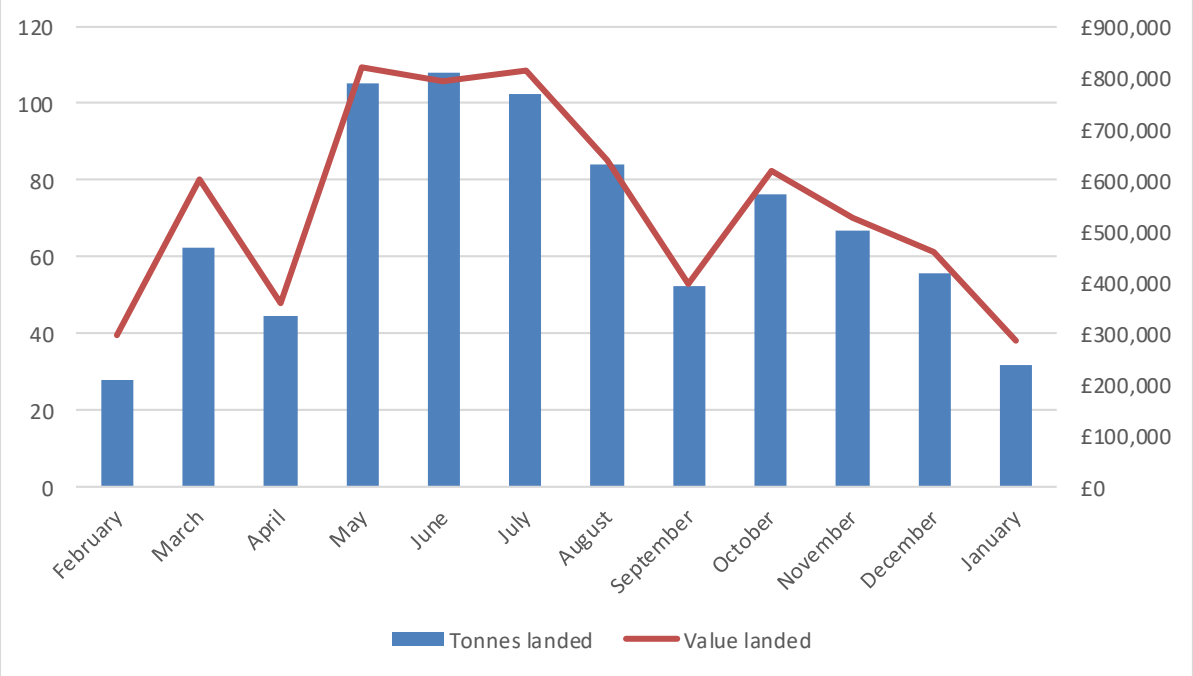

Figure 1: Monthly tonnages and value of razor clams landed by trial vessels, February 2019 to January 2020.

The trial also supports further economic activity and employment for people in the wider supply chain supporting these vessels in Scotland, and in the transportation of the product to market. The vessels active during the reference period provide employment for around 120 people, of which around 90 were regularly employed.

MS Compliance : Inspections and Monitoring

MS Compliance continues to employ a risk based approach to the inspection of vessels participating in the trial and deploys land and sea based resources to monitor these vessels. During 2019-20, 124 inspections were carried out both by inspectors on land and at sea where compliance has been good in relation to daily landed catch limits, with a total of twenty-one weight checks undertaken.

The owner of each vessel participating in the trial is entirely responsible for the purchase, installation and maintenance costs of all fishing apparatus, generating gear, and monitoring equipment specified by Marine Scotland as necessary to participate in the trial. This includes a bespoke REM device which is proving a highly valuable tool for both scientific data collection purposes and compliance management.

From a compliance perspective, the REM data is received at MS's Fully Documented Fishery Unit, where it is analysed and verified for compliance. During 2019-20 there were >2100 voyages analysed. Compliance with the requirements of the trial's Terms and Conditions was found to be high. All MS coastal offices and the Marine Protection Vessel fleet have access to live positional data of the vessels to aid inspections (subject to the 3G coverage in a vessel's area of operation).

The tracking equipment has shown to be extremely reliable. The inbuilt system tools ensure that time spent on analysis is efficient. The analysis software can incorporate layers which identify the delineated razor clam trial areas and also FSS classified waters, generating automatic alerts to compliance officers should fishing activity occur out with these areas. During the second year of the trial reporting processes between FSS and MS Compliance continued to evolve and there is now a robust reporting procedure to deal with any suspected incidences of fishing outwith classified areas.

During the reference period, there were several cases of suspected fishing outwith classified waters. These were referred to FSS for further investigation and were generally for minor discrepancies. However, it became increasingly apparent that the mapping reference system used by FSS was not directly electronically transferable to the systems used by MS and the fishermen at sea. This caused some relatively small discrepancies and uncertainties in the projection of the boundaries ("shapefiles") of the FSS classified waters.

A technical realignment of FSS shapefiles was created to take account of the mismatch. Through discussions between FSS, MS, the REM providers and representatives of the Scottish Razor Clam Association a process has been established whereby these realigned shapefiles are now automatically uploaded onto the chosen REM platform of the fishermen, rather than requiring to be entered manually on the vessels' standalone fishing plotters. This has led to an increase in compliance of remaining within classified waters and a significant proportionate decrease in referrals to FSS.

MS Science

There are several strands to the science programme. Live samples, provided by trial participants, are being used to derive length/weight relationships and information on size at maturity and spawning period of razor clams in the different trial areas. Participants are also providing measurements of the razor clams landed from different trial areas. Coordinating this sampling has required MS Science to communicate regularly with trial participants, providing instruction and sampling equipment and taking part in meetings.

In addition, MS Science is analysing remote electronic monitoring data to study where catches are taken and combining fishing effort and landings data to monitor landings per unit effort. MS Science have also been involved in the design and commissioning of surveys. Progress and findings over the reporting period are summarised below.

1) Biological data

From August 2018, samples of live razor clams have been sent to MS Science on an approximately monthly basis (Table 1). Sample numbers were low in 2018 as vessels gradually entered the fishery and improved in 2019 after engagement with the fishers to remind them of the importance and protocols for submitting live samples. The number of samples is highest from the West Coast SW trial zone area and this is perhaps reflective of the higher number of vessels fishing in that area. As of January 2020, 47 samples had been received and 45 fully processed and over 5,000 razor clams weighed, measured and dissected. Two samples were not processed because of the poor condition of the razors due to a delay in the delivery chain. Samples have been obtained from all four zones and eight of the trial areas. The samples comprised, almost exclusively, the pod razor *Ensis siliqua*. A few specimens of the bendie razor, *E. magnus*, (previously known as *E. arcuatus*) were identified in samples from sites in the West coast SW zone. These were excluded from analyses.

	Zone Area											
	Firth of Forth			Outer Hebrides			West coast NW			West coast SW		
	2018	2019	2020	2018	2019	2020	2018	2019	2020	2018	2019	2020
January		1	1								2	1
February												
March		1			1						2	
April								1			1	
May		1									2	
June					1							
July		1			1							
August	1	1						1			3	
September	1				1		2	1		3	1	
October		1									4	
November	1			1						2	1	
December	1							1		3		
Grand Total	4	6	1	1	4	0	2	4	0	8	16	1

Table 1. Number of razor clam live samples by year, month and trial zone area.

Length / weight relationships

Data have been analysed to derive length / weight relationships (Figure 2). Length / weight relationships are required to convert survey estimates (sizes of razor clams and numeric density) into biomass density (weights) in the surveyed areas. They are also used as a check on the data when raising sampled length frequency distributions to landed weights.

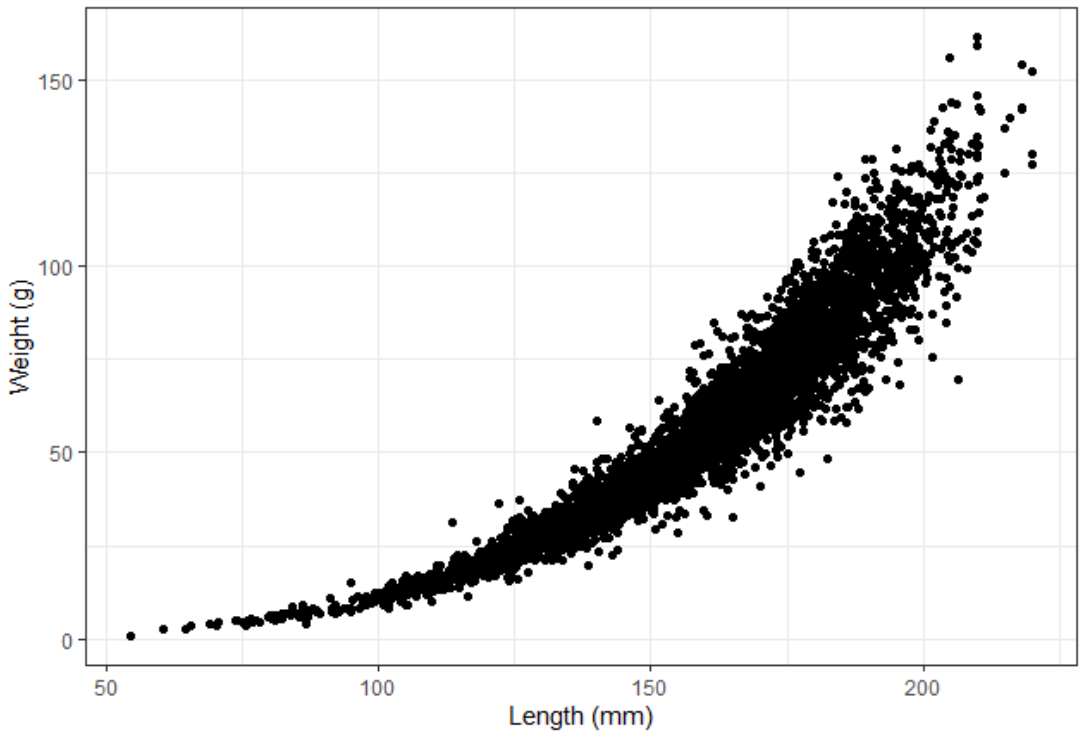

Figure 2. Combined length/weight relationship for razor clam (both sexes and all areas) up to 31 January 2020.

Initial analyses have indicated there are significant differences in the length/weight relationships between the four trial zones and some of the trial areas. There is also evidence of differences between month and year but these are more difficult to interpret because of the paucity of samples from some of the trial areas. At the end of 2018, a monthly time table was introduced and agreed with the industry to improve the coordination of samples. The live sampling schedule assisted the increase in number of samples for certain trial areas but there continued to be months where no samples were received. Using area specific length weight relationships will improve stock assessments based on survey data.

Some of the razor shells from samples have been retained for age determination. This is being done with a view to deriving estimates of area specific growth parameters for use in length based stock assessments.

Sex determination, reproductive development and size at maturity

It has proved difficult to determine the sex of the razor clams dissected on the basis of the macroscopic appearance of the gonad tissue. Although initially it was thought possible to do this on the basis of the colour of the gonad, particularly of animals in the late stages of development, relatively few of the samples contained razors which could be sexed. Overall 80% of the specimens examined were classified macroscopically as sex 'undetermined'. It was also difficult to distinguish animals in the very early stages of maturation from those that were immature. Only 1% of the razor clams examined were classified as immature. However, few of the samples provided to MS Science included smaller razors i.e. those under 150 mm in length, those most likely to be immature.

To address these issues, histological examination was conducted on 320 samples, a subset of the larger samples collected at different times of year. Sections of tissue were examined microscopically to determine the stage of gonadal development and to test the reliability of sex as determined on the basis of macroscopic examination. It was found that 'sex' was determined correctly in less than 25% of cases (although this included those initially classified as sex 'undetermined'). On the basis of this it was decided that length/weight relationships should be determined for the sexes combined.

Gonad development was staged according to the six stages of the gametogenic cycle of *E. siliqua* published by Darriba *et al.*, 2005[2]. The numbers and the sex of animals at each stage are summarised in Table 2 and the seasonality of stages, for the sexes combined in Figure 3.

Stage	Definition	Undetermined	F	M	H
0	Sexual rest	7	39	42	
I	Start of gametogenesis		43	44	
II	Advanced gametogenesis		61	48	1
IIIA	Ripe				
IIIB	Start of spawning		11	6	
IV	Exhaustion		6	11	

Table 2. Number and sex of razor clams sampled at each stage of gonad development (after Darriba et al. 2005[2]).

In the histological samples taken we were unable to identify all of the stages of the reproductive cycle and appear to have missed animals at the critical stage IIIA, the condition when the gonads are ripe. This is thought likely to reflect the reduced sampling in March and April when fewer vessels are at sea and the laboratory has reduced capacity to receive samples because staff are at sea.

Samples collected in May 2019 were at stage (IIIB) or in the stage of exhaustion (IV). In July, the majority of samples were exhausted (IV) or at rest (Stage 0). The early stage of gametogenesis, stages I and II, were evident in samples taken in August and October 2019 respectively, with more animals in stage II from October through to January.

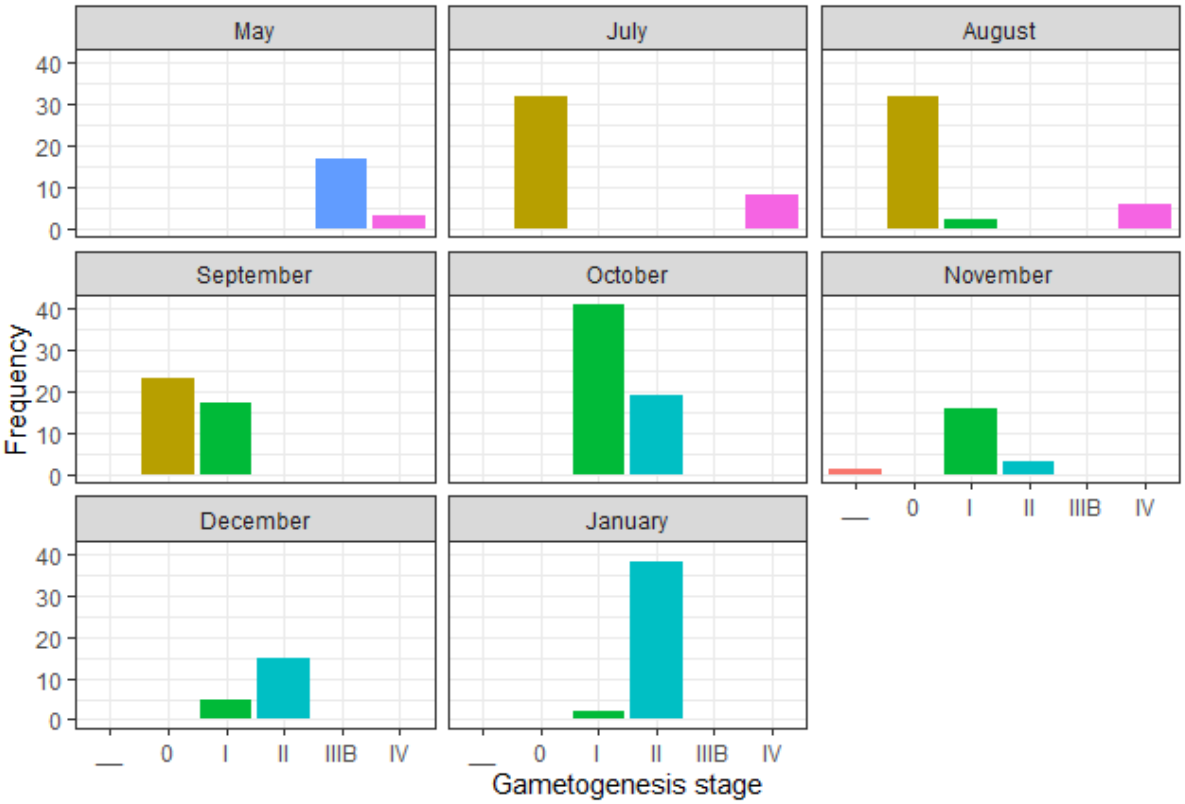

Figure 3. Numbers of razor clams at developmental stage May 2019 to Jan 2020. Data for males and females combined.

On the basis of the work done to date, it seems likely that spawning takes places in March and or April. However, further sampling will be required to confirm this. This would also be the best time of year to obtain samples which include better representation of smaller size classes to derive good estimates of size at maturity.

Razor clam landings length measurements

Trial participants and associated processors have provided measurements of the lengths of razor clams landed from each of the four trial zones. In the short term, any marked changes in the length frequency distribution (the representation of different sizes classes) of clams landed from particular grounds could be indicative of changes in the health of the stocks. In the longer term, this type of data combined with information on quantities landed and growth parameters can

be used in stock assessments which indicate whether fishing mortality F is above or below an estimate of F_{MSY}.

As of the end January 2020, a total of 72 length samples were submitted to MS Science. These were measurements of landings made by 21 different vessels which collectively provided coverage of all four trial zones. Sample numbers are low in 2018 as vessels gradually entered the fishery and improved in 2019 after engagement with the fishers to remind them of the importance and protocols for submitting measurement samples of landings.

Fishermen measuring razor clams. Photograph courtesy of T. Shields.

Landings from the West coast NW and West coast SW trial zones had been sampled on a regular basis i.e. in most months of the year (Table 3). The number of samples is highest from the West Coast SW trial zone area and this is perhaps reflective of the higher number of vessels fishing in that area. Coverage of other zones, where there are fewer vessels authorised to participate in the trial, was sporadic and less satisfactory.

	Zone											
	Firth of Forth			Outer Hebrides			West coast NW			West coast SW		
	2018	2019	2020	2018	2019	2020	2018	2019	2020	2018	2019	2020
January								1			3	3
February					2			1			4	
March					2			1			4	
April								2			2	
May								1			3	
June								1			1	
July		1						1			6	
August								1			3	
September		1			1			1		1	3	
October		1						1			5	
November	1									4	6	
December										1	3	
Total	1	3	0	0	5	0	0	11	0	6	43	3

Table 3. Number of razor clam length frequency distribution samples by year, month and trial zone area.

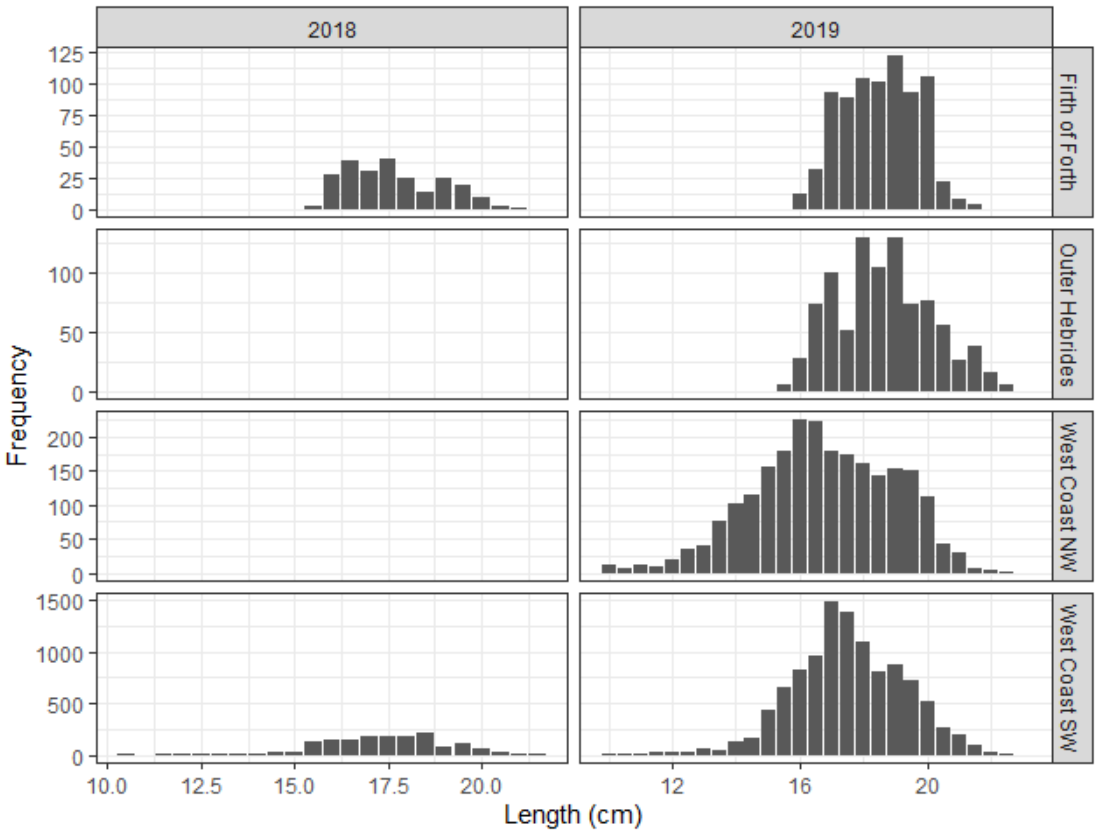

Figure 4. Length frequency plots of samples of razor clam landings from the four trial zones, in 2018 and 2019.

The majority of razor clams in the landings sampled were above 150 mm length (Figure 4), above the minimum landing size of 100 mm, which is understood to reflect the size preference of the market. An initial examination of the length data suggests some variation in the sizes of razor clams landed from the different trial zones which may reflect differences in the size structure of stocks. Over the second year of the trial, there was some indication that representation of the largest size, those greater than 200 mm, had declined on some grounds which had been regularly sampled but there was no obvious shift to smaller size categories for other areas.

Data for some trial areas are, however, limited and the analyses which involve raising measurements to landed weights, to determine the proportions of different size classes harvested are ongoing. Marine Scotland have taken steps to increase sample coverage and frequency. Sampling throughout the year and a time series of four to five years of data is generally required for length based stocks assessments so this type of approach will not produce results in the short term.

2) Remote Electronic Monitoring

MS Science is analysing the data from REM devices to build up a precise footprint of the fishery and to study fishing behaviour. Some vessels move between areas within their allocated zone

and fish in a number of production areas (areas classified for the FSS for shellfish harvesting) whereas others tend to fish more locally in only one or two production areas. Most fishing takes place at depths of less than 10 metres and over limited extents of the various production areas. The data are being analysed to map electrical fishing effort.

Fishermen are recording landings on a tow by tow (as opposed to a daily) basis to enable MS Science to refine spatial mapping of landings per unit effort ("LPUE") and monitor trends during the trial. MS Science has developed data checking procedures which identify instances of apparent mismatches between landings and sensor data. These are not uncommon in REM studies but can take time to resolve. However, for the majority of fishing trips the total electro fishing duration and reported landings have been matched on a daily basis to allow investigations LPUE (kg/hour) on each fishing day.

LPUE is typically variable, among vessels and over time, which makes it difficult to reliably discern trends which might be related to stock abundance. Although, there is some suggestion of declines in catch rates in some production areas over the reporting period relatively high catch rates have been maintained in others. LPUE can also be influenced by individual vessel fishing patterns, vessels moving between grounds. MS Science continues to monitor LPUE in trial and production areas and is considering whether LPUE data in combination with changes in the length distributions of landings could be used as indicators of changes in stocks.

3) Other work streams

Surveys of razor clam grounds in the Firth of Forth and the Clyde Sea, scheduled for 2019, had to be deferred for operational reasons. Survey work in the Firth of Forth was rescheduled for March 2020.

A paper on the survey methodology developed by The Scottish Association for Marine Science ("SAMS") and MS Science was accepted for publication in the Journal Fisheries Research [3].

SAMS, with support from MS Science, have been successful in securing NERC (Natural Environment Research Council) funding for a PhD studentship to study the organism and ecological impacts of electrofishing in Scottish shallow coastal habitats.

MS Science have also been providing razor clam tissue samples for genomic analysis in a study of population connectivity. This is part of a PhD project which aims to elucidate relationships between razor clam stocks and determine source, sink and self-recruiting populations.

4) Plans for future work

Considerable progress has been made towards addressing the scientific goals of the of the trial and a significant amount of biological, sampling and fisheries data has been collected. The

collation and analysis of this data continues. Efforts are being made to address the identified data gaps, through more targeted sampling and/or increasing sample coverage. Work on age determination and deriving area specific growth parameters for razor clams and investigating length based stock assessment methods is planned as part of the PhD study. Monitoring of the volume and size distribution of landings, fishing effort and the footprint of the fishery continues. Collectively, this work will improve the evidence base and enable MS Science to evaluate possible approaches to stock assessment and appropriate management of any future fishery.

References

[1.] 00548864.pdf (nrscotland.gov.uk)

[2.] Darriba, S., Fuencisla, S.J. and Guerra, A. 2005. Gametogenic cycle of *Ensis siliqua* in the Ria de Corcubion Northwestern Spain. *Journal of Molluscan Studies* 71:47-51

[3.] Fox, C.J., McLay, A and Dickens, S. 2019. Development and application of electrofishing with towed video as a new survey method for razor clams (Ensis spp.). *Journal of Fisheries Research* 214: 76-84.