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Sentinel survey report

Scallop Dredge Scoping Study – King Scallop Stock Assessment in English Waters

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Cefas report

Executive summary

A project with the aim of determining stock status of the king scallop *Pecten maximus* in English waters relies on two new data streams. One of these is an industry facilitated scallop sampling scheme to provide the size and age structure of the catch. The other relies on abundance and biomass estimates from dredge and underwater TV surveys. Both these require some scoping to determine and solve technicalities and issues concerning data reliability and to enable a robust stock assessment. This report describes the scallop dredge scoping survey carried out in November 2016 in preparation for the pilot dredge surveys planned for the English Channel in 2017.

The primary aims of this scoping were to determine appropriate tow duration, examine the fine scale distribution of scallops in the Eastern English Channel, investigate the repeatability of the catches and trial a method for determining the efficiency of the gear. Secondary aims included trialling experimental dredges for sampling pre-recruits, testing radio transmitting calipers and collecting biological information for the Eastern English Channel.

Tow duration was varied in one study and the catches of scallops quantified from each tow. A fifteen-minute tow would be appropriate for this vessel as it provided an adequate and representative catch but did not appear to fill the dredges to the point where they stopped fishing consistently.

A grid of tows provided density estimates which were subjected to a geospatial analysis (kriging). A semivariogram from this analysis suggested a minimum sampling intensity of, on average, one tow every 15-20km would avoid under sampling. Sampling more intensely than every 15km would further improve the robustness of the results but on a law of diminishing returns (e.g. progressively smaller improvements with increased sample density).

Repeat parallel tows (paired tows) were carried throughout the survey grid, catch repeatability was shown to be good between most paired tows, but somewhat variable for several others. This was consistent with our expectations and typical of many fisheries surveys.

Two studies looking for depletion rates in areas of high and low scallop density were carried out by repeatedly passing over tow tracks. Unlike in other historic trials of this approach, no depletion was detected over the course of seven replicate tows. There are several hypotheses as to why no depletion was observed, but the overall implication is that this approach is not well suited to determining gear efficiency and a modified approach will be required for the future.

Four modified dredges with small belly rings (55mm ID), thirteen-teeth tooth bars and fine mesh backs captured a small quantity of smaller year class scallops but did not fish well and filled with dead queenie shells even over short tow durations. Further modifications suggested by the vessel skipper will be used on subsequent surveys.

Length distributions were collected from eighty-nine of the tows and size stratified samples retained for age determination.

1. Introduction

The project “King Scallop stock assessment in English waters” is a collaboration between the fishing industry, Defra and Cefas scientists and aims to determine the status of scallop stocks, first in the English Channel and subsequently in other fisheries in English waters. It is hoped that it will be the start of a long-term assessment programme that will provide information for fishery managers and the fishing industry. Both the industry and fishery managers require a scientifically robust assessment to inform the potential for management plans. The results need to be transparent and have credibility both in the scientific community as well as in the fishing industry.

The project relies on two new data sources; distribution and abundance estimates from dredge and underwater TV surveys and an industry facilitated biological sampling programme to provide the length and age structure of removals from the fishery. The dredge surveys will describe distribution and abundance of scallops in areas that are accessible to commercial fishing gear whilst the underwater TV surveys will provide information on scallop populations in areas that are not, but may still support populations of scallop.

Design of the dredge surveys requires additional information to overcome technicalities of operation and delivery, and before the information can be used for stock assessment purposes. To provide this some scoping work was required before execution of the first full survey in 2017. This report describes the results of a dredge scoping survey carried out in the Eastern English Channel on a commercial scallop dredger in November 2016.

Objectives

Primary objectives:

1. To determine the optimum tow duration for the dredges
2. To determine the fine scale spatial distribution of scallop in an area of the Eastern English Channel.
3. To determine the repeatability of the catches.
4. To trial a method designed to determine the efficiency of the scallop dredges on different ground types in the Eastern English Channel.

Secondary objectives:

5. To take length samples of scallops to determine the size structure throughout the survey area.
6. To take samples for subsequent age determination.
7. To trial Bluetooth® callipers in the below deck environment.
8. To test the suitability of modified queenie dredges (experimental gear) for sampling pre-recruit king scallops.

2. Methods

Vessel selection

A request for quotation for the charter work was advertised on the government procurement site Contracts-finder in September 2016 and in line with public service procurement rules (see Appendix 1). The owners of the FV "Sylvia Bowers" have a keen interest in the sustainability of the scallop stocks in English waters and offered a price for her hire. No other vessel owner provided a tender and the Sylvia Bowers was awarded the contract after it was clear she was a capable vessel and fulfilled all the vessel selection criteria. The vessel is a 413t 36m scallop dredger with a highly-experienced skipper and crew and a track record of fishing for scallop in the English Channel.

Fishing Operations

Dredging operations were carried out across the tide (the standard procedure for this fishing vessel) but other factors like wind strength and direction, and sea bed topography, occasionally necessitated a tow direction at an alternative angle. Tow speed was approximately 3 knots but dependent on prevailing conditions. Warp out was set to 2 times the water depth plus an additional 18m. The standard compliment of gear for this vessel was thirty-four 0.75m Newhaven dredges fitted with eight-teeth tooth bars and 85mm internal diameter rings in each dredge belly. These were deployed seventeen dredges per side. Gear was maintained periodically to a suitable schedule and tooth bar spring tension was checked frequently and maintained at approximately 100Nm. At the end of each tow the dredges were emptied using a hydraulic lifting gate onto a conveyor system. The double conveyor moved the dredge contents below deck to facilitate manual removal of the catch from the debris which was discarded automatically overboard. Quantification of the catch of commercial and undersized scallops was by means of the vessels’ motion compensated balance. The scoping survey plan is attached at appendix 2 and the trip report appendix 3.

Determination of optimum tow duration

At each of two sites twelve stations were fished within an area approximately 5km wide. The two sites were located around a midpoint of 50 26’N and 00 02’W and 50 26’N and 00 20’W respectively and were approximately 20 km apart (fig. 3.4.1). At each site three tows were carried out at 10, 15, 20 and 30 minutes’ duration. For tow numbers three to twenty-eight, six of the standard commercial dredges on the starboard beam were substituted with four experimental dredges allowing for a space between the experimental and standard gear. This enabled easy differentiation of the catch from experimental dredges and the standard gear. Catches were standardised to provide catches by dredge numbers and by dredge numbers and tow duration.

Analyses were carried out using R statistical package (R Core Team, 2016).

Spatial distributions

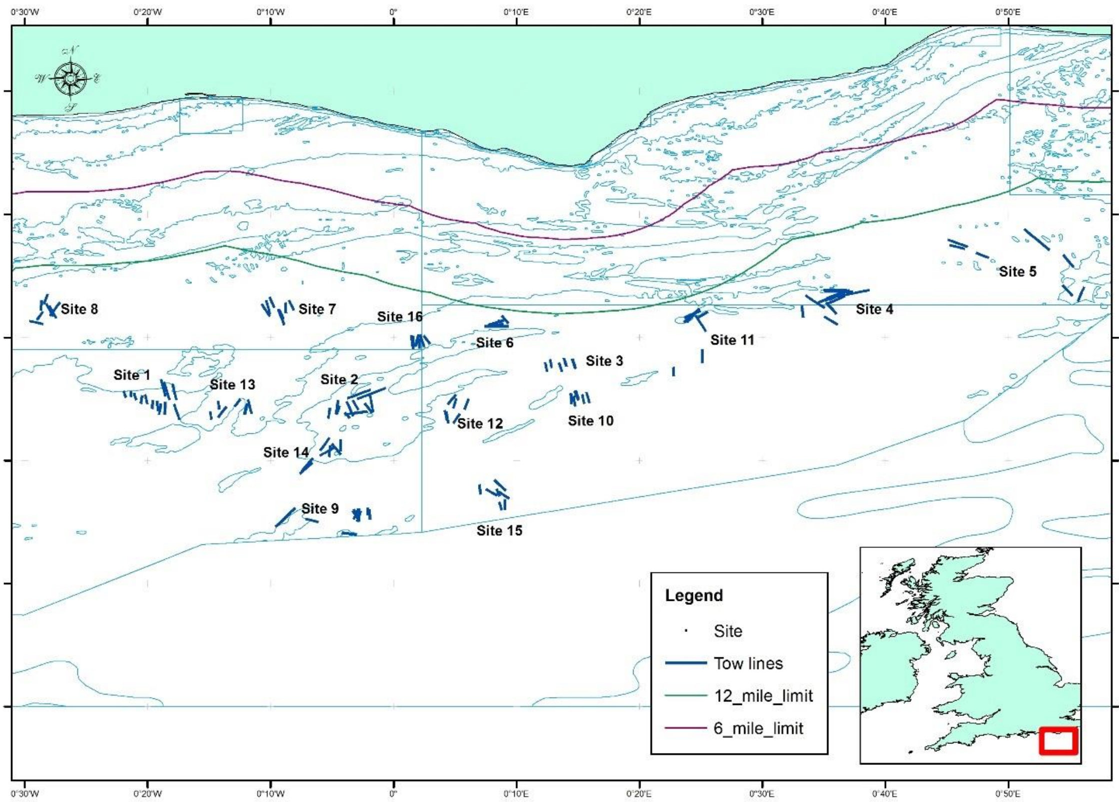

Figure 3.4.1 Tow start and end positions with assumed track

The skipper of the vessel was asked to select a grid of sites approximately 20km apart and at each site carry out seven twenty minute tows within a box approximately 5km wide. The survey was restricted to English waters to the north of the mid-line and outside the 12nm limit from the English coast. Aggregate dredge sites and other navigational issues were also avoided providing a grid of sites and clusters of tows which gave good spatial coverage but which was not symmetrical. Early completion of the original grid of tows enabled carrying out tows at additional sites and in between the original sites. Seven tows were carried out in each of fourteen sites (n=98).

Catches were converted to densities by dividing by the area swept computed from the product of distance run and dredge spread in metres (number of dredges x 0.75m) and where distance run was estimated from the start and end positions after assuming a straight-line tow.

Densities were subjected to geostatistical analysis using a kriging method to predict values between the tow positions. A semivariogram showing semivariance against distance between tows was produced to describe the spatial continuity of the data and using initial variables defined as:

Partial Sill = $gamma_{max}$ (maximum sample variogram distance), Model type = Exponential, Range = $(distance_{max})/2$, Nugget = mean(gamma)/4.

The analyses were carried out using the packages gstat and spatstat (R Core Team, 2016).

A map of the scallop density (kg/m^2) was then produced using Kriging on a 500m square grid.

Repeatability of catches

In each of the fourteen sites defined above and of the seven twenty minute tows carried out within, some were deliberately near and parallel to each other. At three sites two of the tows in each were near and parallel to each other and no more than a few hundred metres apart (paired tows). At Nine sites two paired tows were carried out. Direct comparison of catch rates between these paired tows was made. In addition, seven tows were carried out on the same track at each of two sites as part of the trial depletion studies giving an alternative indication of catch repeatability.

Gear efficiency

Two depletion studies were carried out (site 4 and 9) after initial tows identified these areas as giving reasonable catch rates of scallops. The vessel carried out 7 twenty-minute tows on the same track at each of the two sites to deplete the scallop density over the course of the track. Catch rates from each tow were plotted against cumulative catch for each of the two experiments so that the slope of the fitted straight line is equal to the catchability (q) of the gear (Leslie method). Catchability can be described as the relationship between Catch per unit effort (in our case kg per 20-minute tow) and the population size. Gear efficiency can be described as the probability of a scallop in the path of the gear being captured. Gear efficiency (e) is related to q by the formula $e=q*A/a$, where A is the total area of the population under investigation and a is the area swept by the gear. In this study where we were towing over the same tow track A and a are equal so efficiency and catchability are the same.

Length sampling

Sub samples of scallops were taken from the retained and discarded components of the catch for measuring. The shell height was measured as opposed to the length measurement used for Minimum Landing Size MLS because this parameter is usually less susceptible to bias caused by shell damage. Samples were weighed using the vessels' digital scales along with the total catch to enable raising by weight to the total catch per tow.

Age sampling

Size stratified samples of 5 individuals in each 5mm size grouping were taken at 13 sites for subsequent shore based age determination. The age structure of the catch from this survey and their spatial distributions do not form part of this report and will be presented elsewhere.

Bluetooth® calipers

Bluetooth® LE digital Vernier calipers (Sylvac, 200mm) paired with a Google Nexus 7 2013 android tablets were used to measure samples of scallops to capture size information directly into electronic format. The electronic files produced were copied onto an Asus notebook computer.

Experimental gear for pre-recruit scallops

Four modified dredges were fished alongside 28 standard dredges for 25 tows at the first two sites. The specification included bellies with 55mm internal diameter rings fitted to standard Newhaven dredge frames and 45mm mesh backs. The dredges had thirteen-teeth tooth bars for the first 5 tows but these were substituted for standard eight-teeth tooth bars for the subsequent 20 tows. A qualitative assessment of the quantity of bulk in the dredges was made before tipping. Quantification of the scallop catch from both the experimental and commercial gear was carried out and a few size distributions of scallops taken in the experimental gear were plotted.

3. Results

Determination of optimum tow duration

The distribution of catch rates observed during the tow duration study are presented by site as the first site (site 1) appeared to be a "low-density" area and the second site (site 2) exhibited higher catch rates (assumed high-density, figs. 4.1.1. and 4.1.2).

Mean standardised catch rates for the low-density site were 11.1, 9.0, 10.0 and 11.8kg per 10 minutes per 10 dredges for 10, 15, 20 and 30 minute tows respectively (fig. 4.1.1). Minimum standardised catch rates were 7.7, 6.1, 7.3 and 10.4kg/10min/10dredge and maximums were 16.9, 10.5, 13.4 and 13.7kg/10min/10dredge.

Mean standardised catch rates for the high-density site were 38.9, 38.6, 35.8, 24.1kg/10min/10dredges for 10, 15, 20 and 30 minute tows respectively (fig. 4.1.2). Minimum standardised catch rates were 34.1, 31.0, 22.2 and 22.6kg/10min/10dredge and maximums were 45.6, 47.6, 45.1 and 26.3kg/10min/10dredge.

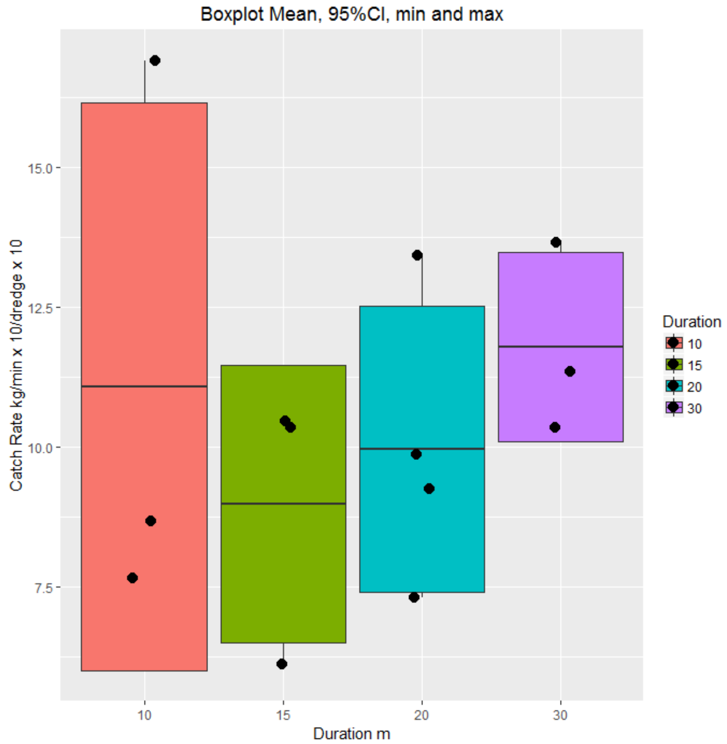

Figure 4.1.1 Catch rate of scallops in a low-density area standardised to 10 dredges per 10-minute tow for each tow duration

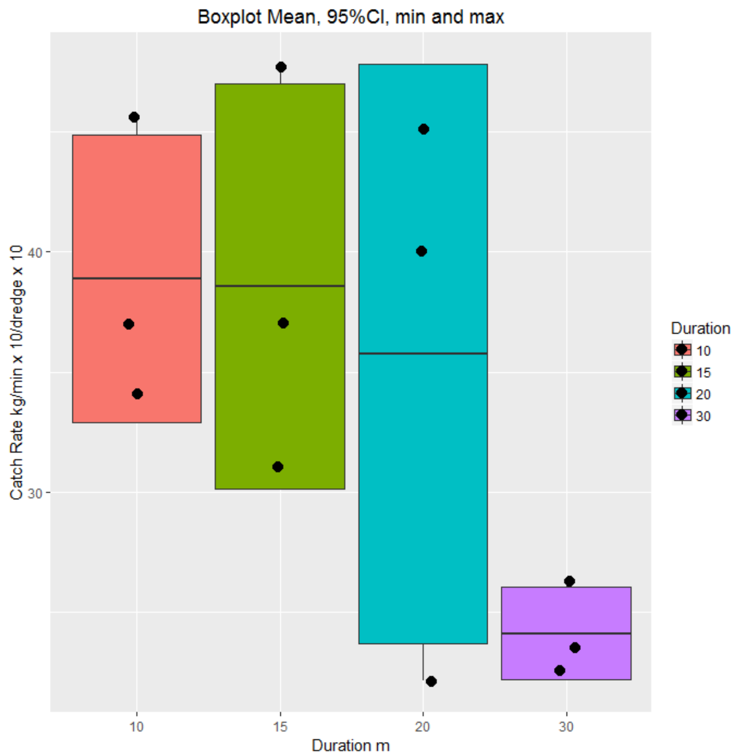

Figure 4.1.2 Catch rate of scallops in a high-density area standardised to 10 dredges per 10-minute tow for each tow duration

Spatial distributions

The distribution of tow tracks shows a good spread of positions within the Eastern English Channel area outside 12 nautical miles from the English coast and inside the Channel midline (Restricted to English territorial waters, fig. 3.4.1). Catch rates were generally lowest at site 5 and highest at sites 2 and 9 and ranging from 2.8kg per 10 dredges per 10-minute tow to 53.6kg (fig. 4.2.1).

Scallop densities at each tow position are presented with the spatial boundary used for the spatial analysis (fig. 4.2.2). The density plot produced by the kriging technique shows the tow positions and highlights the high and low density areas and visualises the interpolated values between sampling positions (fig 4.2.3). A summary of tow details and catches is attached as appendix 5.

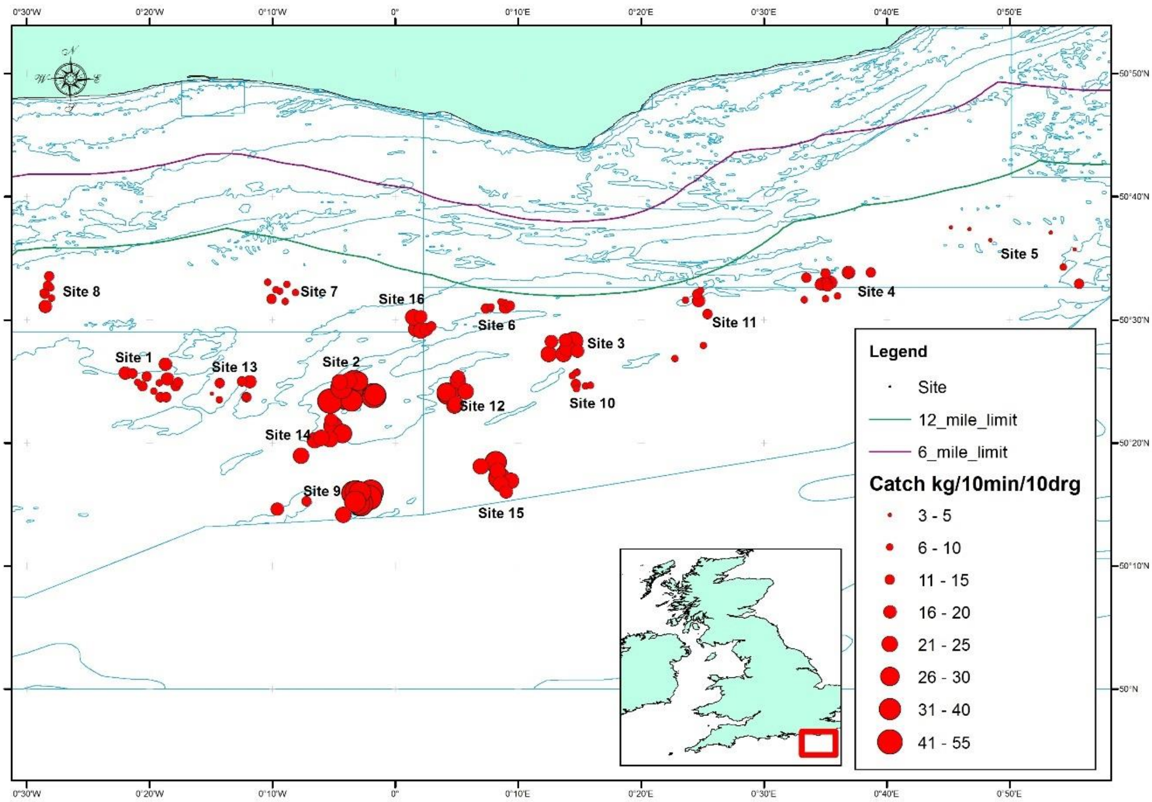

Figure 4.2.1 Distribution of scallop catch rates over the survey area

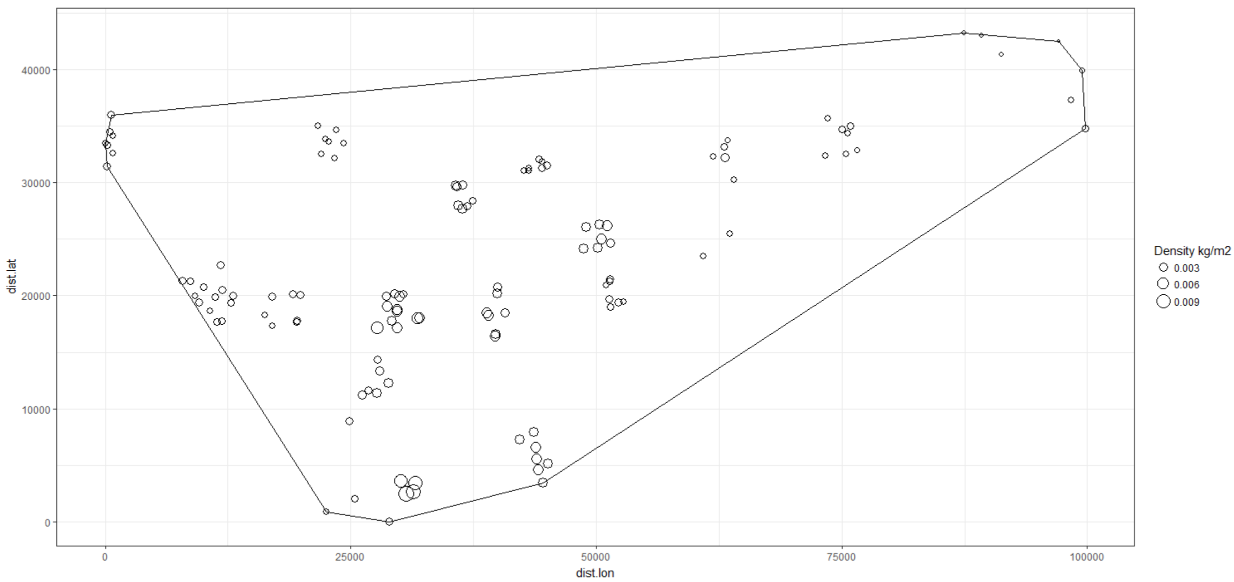

Figure 4.2.2 Distribution of scallop densities and the boundary drawn around the survey area for kriging purposes

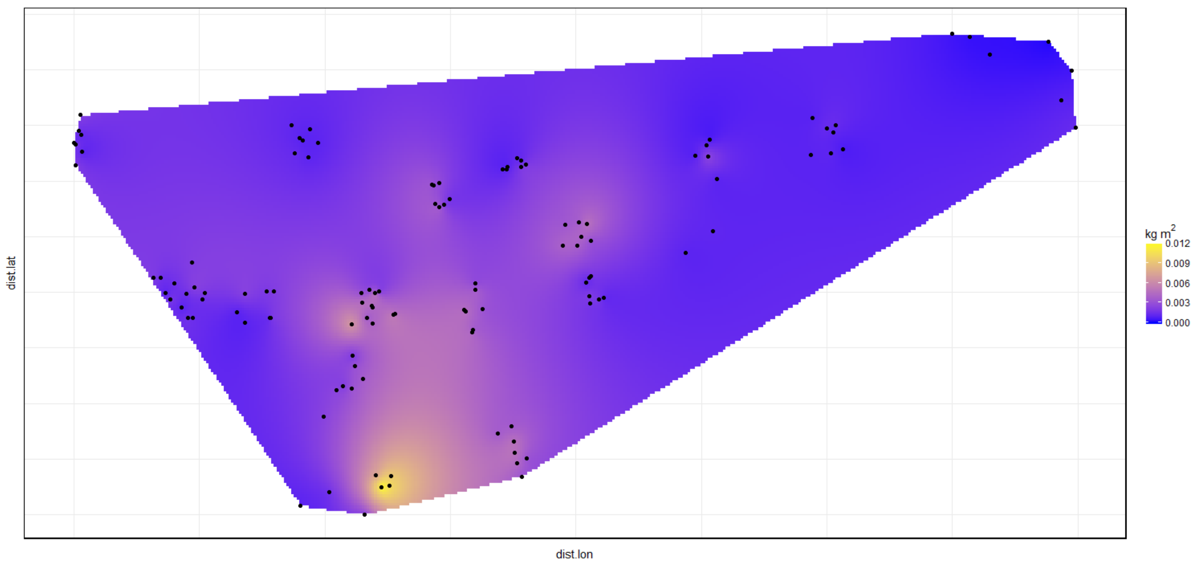

Figure 4.2.3 Tow positions and visualisation of predicted scallop densities after interpolation

The semivariogram produced by the kriging technique (fig. 4.2.4) shows that semivariance is variable at higher tow distances but the fitted curve starts to tend towards a plateau at tow distances more than 20km but is not well defined.

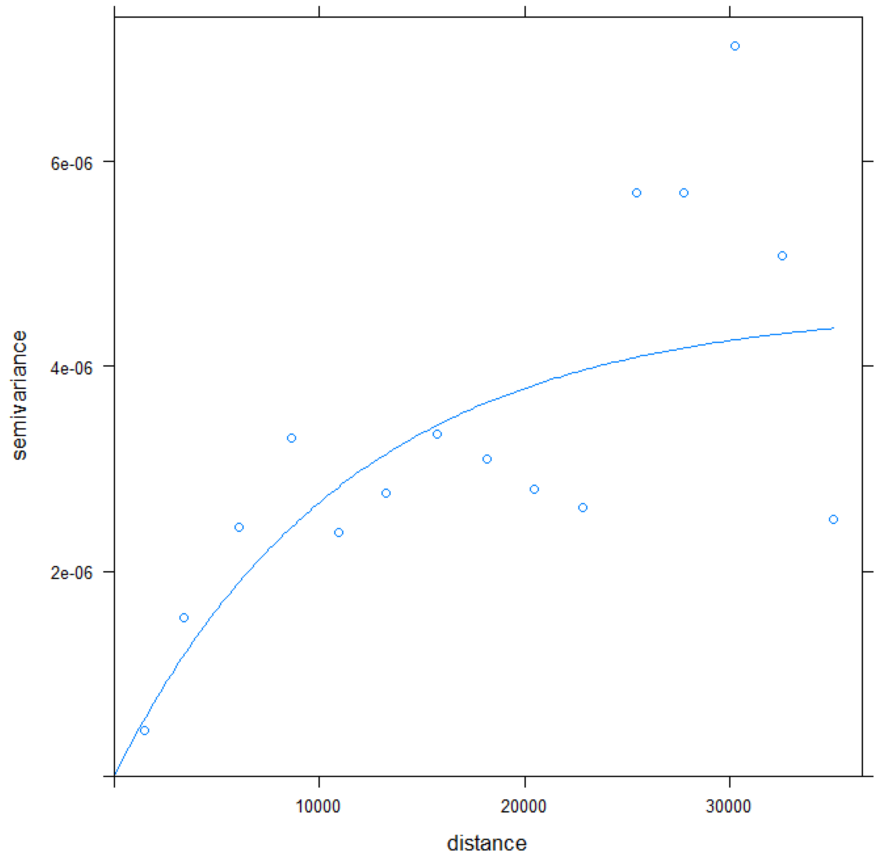

Figure 4.2.4 Semivariogram output from geostatistical analysis.

Gear efficiency

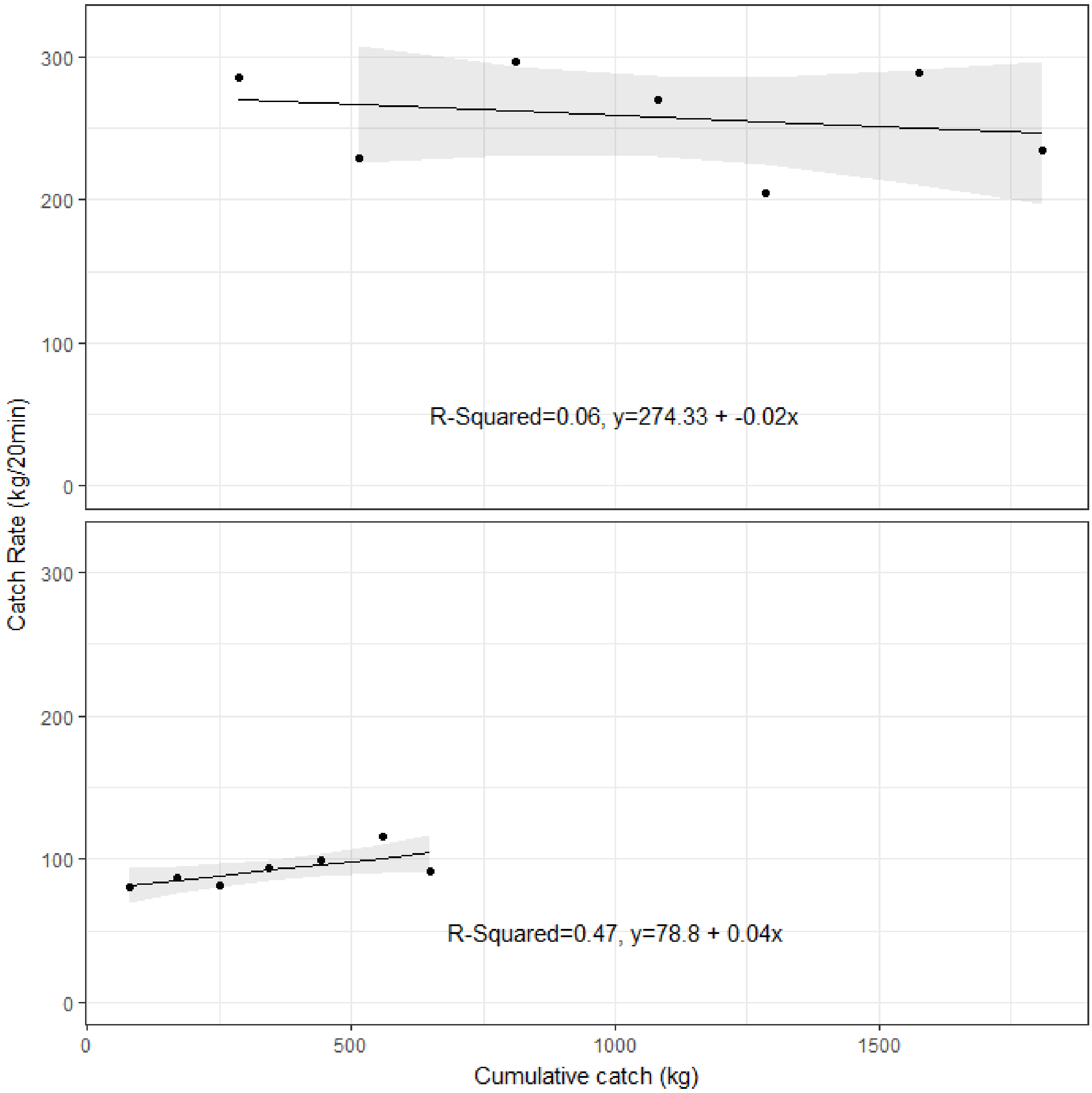

Figure 4.4.1 Results from two depletion experiments. The first experiment carried out at site 9 (top panel) and the second experiment carried out at site 4 (lower panel). Catch rate against cumulative catch.

During the first experiment catch rates ranged between 205 and 296kg per twenty-minute tow. The fitted line was not significantly different from zero showing no depletion occurred over the 7 tows. The second depletion experiment provided catch rates ranging from 80.9 to 115.4kg per twenty-minute tow. Although giving a higher correlation (0.47) than the first experiment, the fitted line provided a positive slope of 0.04 indicating that the catch rates increased as repeat tows were carried out.

Length sampling

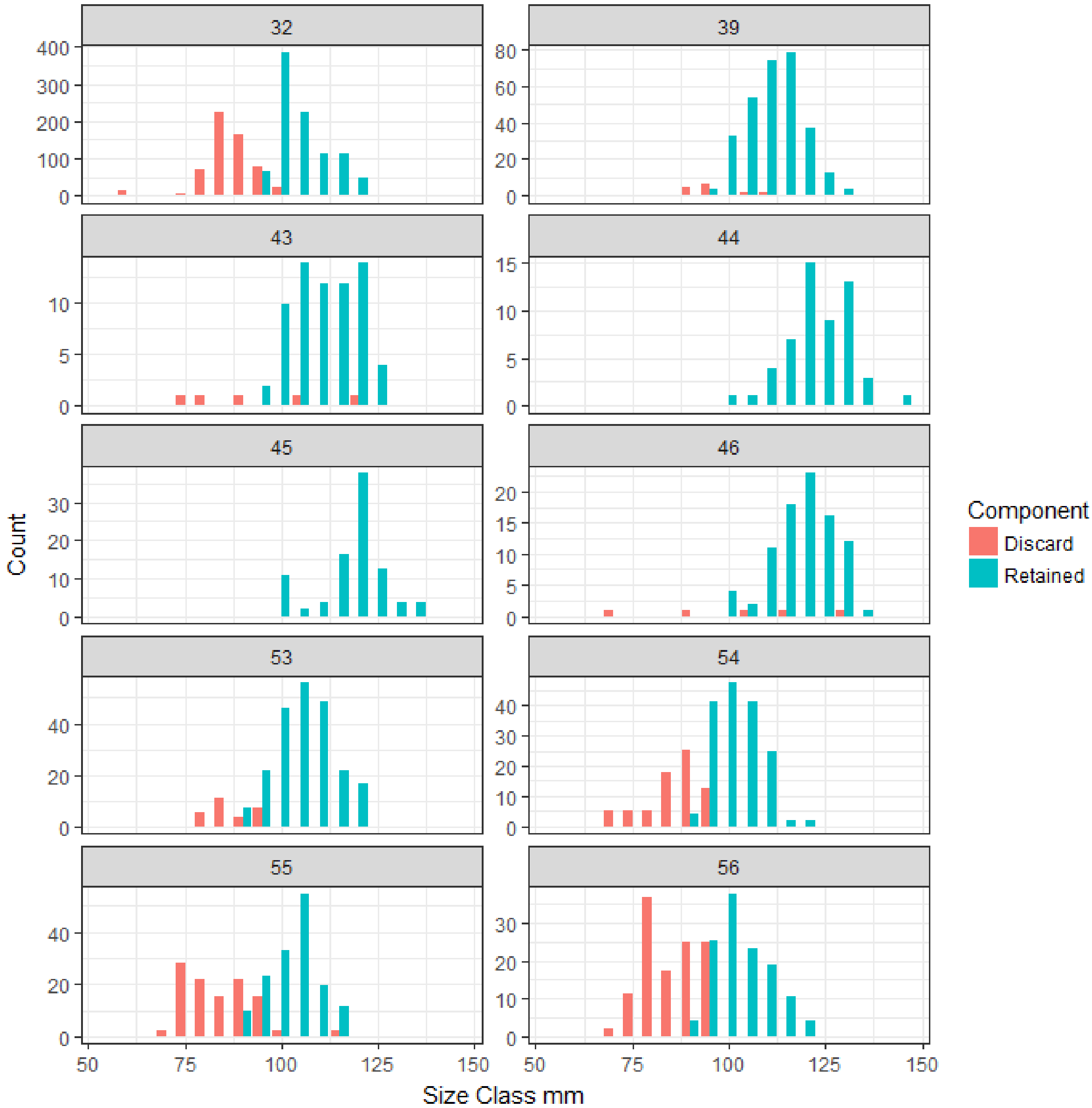

Figure 4.5.1 Example of scallop size distributions. N.B. The length distributions presented in the report are shell height.

Length samples of both commercial and undersized components of the catch are presented for eighty-nine tows (ten above and remainder appendix 4).

The minimum scallop height measured from the commercial gear was 57mm and the maximum was 145mm. The largest scallop measured from the discarded component was 131mm (rejected as damaged) and the smallest scallop measured from the retained component was 75mm. Mean scallop sizes were 89, 108 and 97mm for discarded, retained and combined catch respectively. The modal size class was typically but not restricted to between 100 and 110mm. In some areas, younger year classes were present in significant quantities and in tows from these areas modal size was typically around 90mm.

Age sampling

Thirteen size stratified samples were collected during the survey and ages of scallops at size will be determined at the laboratory by experienced staff using traditional annual ring counting techniques. The relationship between age and size for this region can be presented as region specific age/length keys. Age determination is necessarily a labour-intensive process and results for this aspect will be reported later.

Bluetooth® calipers

The Bluetooth® calipers used on this trip have been successfully deployed on a fishing vessel prior to this study. In addition, this equipment was tested in the office prior to commencement of this survey. During this survey, we found the signal between caliper and receiving tablet was unreliable requiring numerous button presses before successful transmission. These problems necessitated us reverting to older technology and subsequent length measurements were recorded using paper and pencil.

Experimental gear for pre-recruit scallops

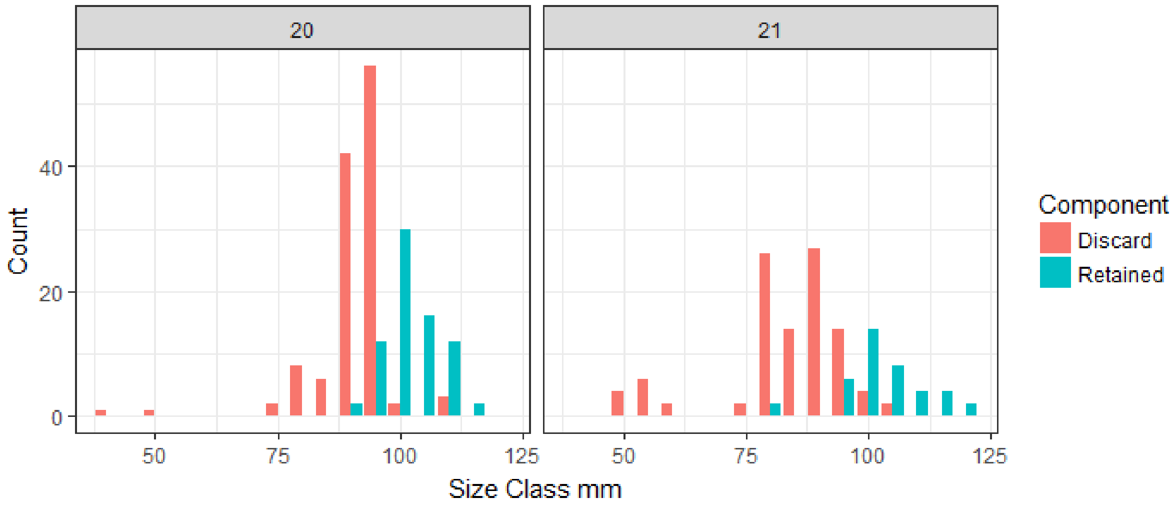

Figure 4.8.1 Size distribution of scallops from the experimental gear for tows 20 and 21.

The size distribution of the scallops taken in the experimental gear were similar to those taken in the commercial gear but there were a few smaller scallops representing a younger year class around 50mm shell height. These scallops were present but very rare in the commercial gear. The smallest scallop of 44 mm shell height was taken in the experimental gear.

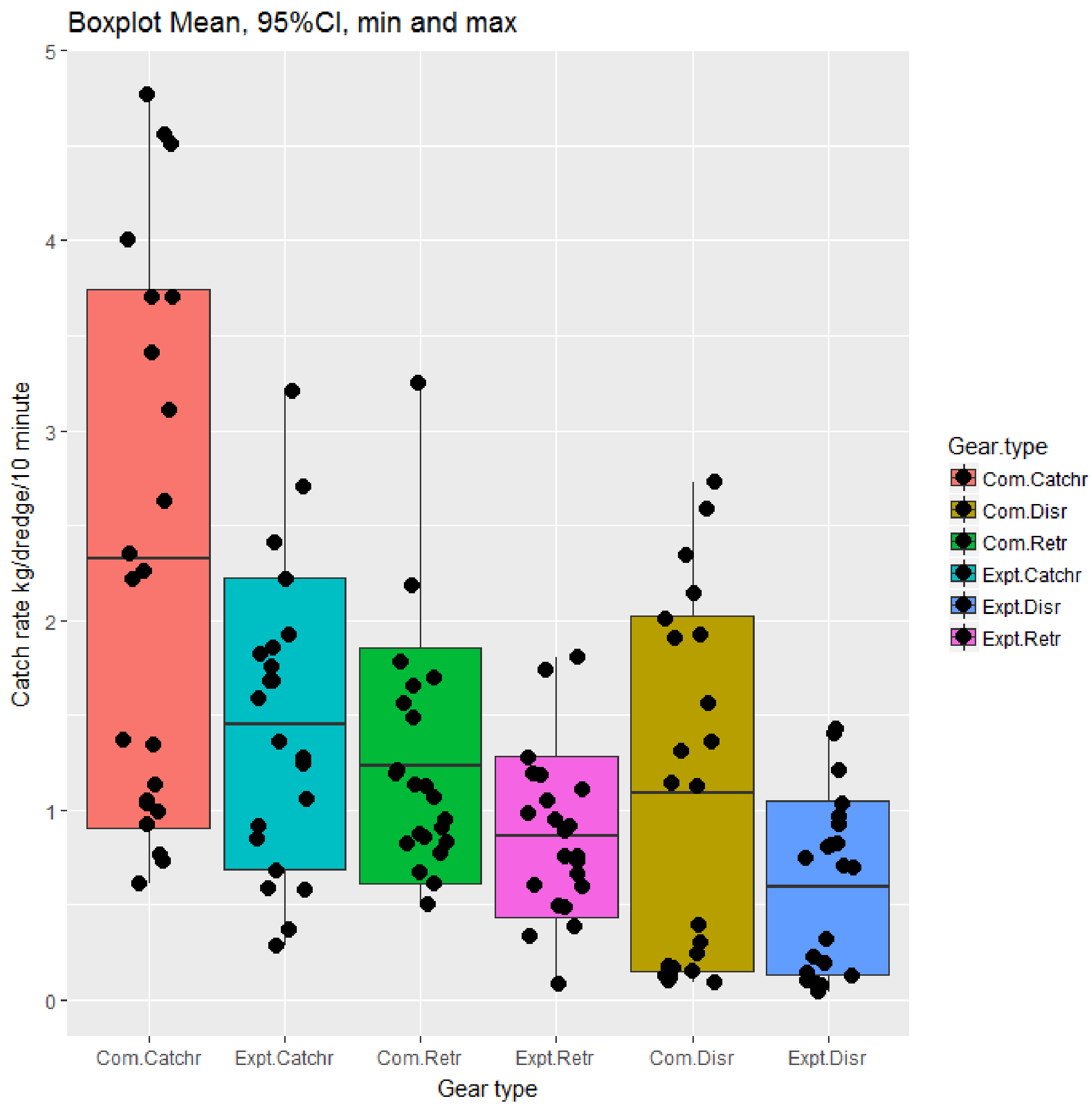

Figure 4.8.2 Total catch and discarded and retained components standardised to dredge number and ten-minute tow for commercial and experimental gear.

Catches for the experimental gear were generally lower than those from the commercial gear. Mean standardised catch in the commercial gear was 2.32kg compared to 1.46kg in the experimental gear. The mean catch of the discarded component were also higher in the commercial gear (1.09kg c.f. 0.59kg) and for the retained component (1.23kg c.f. 0.86kg).

Table x.

Gear.type	min	max	mean
Com.Catchr	0.611905	4.764286	2.324857
Com.Disr	0.091786	2.72625	1.091034
Com.Retr	0.507381	3.250714	1.233823

Expt.Catchr	0.283333	3.203333	1.456117
Expt.Disr	0.04	1.424167	0.593542
Expt.Retr	0.088333	1.801667	0.862576

A qualitative assessment of the fullness of each dredge suggested that for tows where the experimental gear was fitted with thirteen-teeth tooth bars the dredges were always full, usually with queenie shells (*Aequipecten opercularis*). On the same stations the commercial gear were typically only ¼ to ½ full. When the swords were substituted for eight-teeth tooth bars the experimental gear was typically only 2/3 to ¾ full.

4. Discussion

Determination of optimum tow duration

Tow duration is an important aspect for any survey design to consider. Clearly the gear needs to be deployed on the seabed long enough to provide a representative sample that integrates over small scale variability and provides a robust estimate of density at a local scale. Like most animals, scallops are thought to be aggregated on the sea bed in areas that exhibit the right combination of physical and biological characteristics. Aggregated distributions require that the gear needs to be fishing long enough to give a significant probability that any high and low density patches of scallops are encountered by the gear and so that the average catch is representative of the area or stratum being sampled.

Surveys are usually limited by financial and logistic restraints and spending unnecessary time at each site will reduce the possibility of carrying out additional tows at sites elsewhere. Furthermore, long tow durations could lead to the dredges filling with either scallop, stones or by catch, creating a problem where the efficiency of the gear is subsequently reduced. Theory suggests that as the dredge fills a “bow wave” is created in its path and some scallop are swept to the side or over the top of the dredge. At some point, probably before the dredge is completely full, the dredge will stop fishing.

The optimum tow duration is a compromise and will be dependent on gear efficiency and scallop density at each site as well as the nature of the substrate and abundance of by catch species.

The tow duration study at the start of the scoping work was carried out in a part of the scallop fishery which may be considered typical in terms of scallop density and substrate type.

Results show that standardised catch rates at the “low-density” site did not show evidence of dredges filling up and catch rates reducing for all tow durations. However, in the “high-density” site there was obvious indication that the catch rate had declined during the 30-minute tow and during one of the tows during the 20-minute tows. This latter situation must be avoided to prevent underestimation of scallop density during subsequent surveys. These results do not give a definitive answer to the optimum tow duration but provide a useful indication of appropriate tow time. We propose further investigations and refinement as part of the longer-term program but suggest 15 minutes appears to be a good compromise based on these results.

Spatial distributions

Before undertaking a fishing survey, it is desirable to understand the distribution of catches and their variability. Indeed, survey design could theoretically evolve in response to previous survey results to optimise the accuracy or certainty of the assessment. The French annual survey in the Baie de Seine follows this approach where sampling intensity in each stratum is related to variance in the catches in the previous year's results.

Analysis of the distribution of scallop in this survey area was therefore one of the priorities for this scoping work. It compliments work carried out previously by Cefas in the Western English Channel.

A geostatistical technique called kriging was used to predict or interpolate values between those points sampled. As well as providing a visual representation of these predictions, a semivariogram was produced to provide useful information on the continuity of data over distance. In geostatistical terms the distance on the horizontal axis of the semivariogram is called the range whilst the equivalent point on the vertical axis defines the sill. Within the range the data are said to exhibit some degree of autocorrelation which is a phenomenon where tows are close enough together that the value from one is related to the other. Sampling at a mean tow separation significantly below the plateau on the semivariogram plot provides diminishing returns in terms of increased robustness of the survey. Sampling at mean tow separations beyond the plateau on the plot will reduce the robustness of the survey.

Kriging can be used to estimate the total biomass of scallop within the sampling area and this method may well be used to determine scallop biomass from the forthcoming pilot dredge survey and subsequent surveys.

Repeatability of catches

Paired tows were carried out to give an indication of the repeatability of the results. In other words, to indicate how representative the catch from one tow is for that immediate vicinity. Excessively variable catches from paired stations would indicate that the gear is not sampling consistently or there is considerable variability in the abundance on a fine spatial scale. The former would invalidate the results from any subsequent survey and the latter may necessitate such intensive sampling that such a survey would be financially unviable.

The results from the catch repeatability study show most tows had a high degree of comparability between the paired tows. This agrees with the geostatistcs which indicates that intermediate scale variability is higher than local scale variability and that stratifying surveys such that high density or high variability areas received higher station densities would seem appropriate.

The depletion studies also provided another indication of repeatability. Catch rates for the seven replicate tows for each study site were generally consistent (fig. 4.4.1). At the first site the catch rates ranged between 205 and 296 with a mean of 258kg/tow but the fitted line was flat suggesting a level of consistency from the start to end of the study. At the second site catch rates ranged from 81 to 115 with a mean of 93kg/tow.

Gear efficiency

Understanding the relationship between survey catches and population abundance or biomass is a prerequisite for our stock assessment. Without this link our survey catches would only provide an index of abundance rather than the absolute abundance.

The results from the two depletion exercises failed to demonstrate a significant decline in catch rates and therefore makes this approach unsuitable for the determination of gear efficiency. We estimated that 34 dredges would provide sufficient fishing power to deplete the population of scallops in the path of the gear if towed over the same track repeatedly, and that after a few tows the catch rates would reduce. Plots of catch rate against cumulative catch should, in theory, provide a fitted line with a negative slope and per the Leslie model the slope would be equal to the catchability. The intercept on the horizontal axis should equal the initial biomass (as we were using units of weight rather than numbers).

A slightly different depletion design was used in a Cefas study in the Western English Channel in 2002. Here a vessel with fewer dredges was used and the vessel carried out several passes in a spatially defined box (1854x100m). Results indicated that catchability and efficiency was low and dependant on substrate type. Values of catchability (q) ranged from as low as 0.07 to 0.36 and were higher on clean ground and lower on ground with significant numbers of stones or rocks (equivalent to 11 and 58% efficiency).

It was thought that given the increased fishing power of the vessel used for this trial over that used for the earlier trial that a repeated track method would provide noticeable depletion. We suggest 4 hypotheses that could account for the lack of observed depletion:

1) Tracks were not covering the same ground
2) Changes to the benthos with successive tows increased the catchability of the scallops which compensated for the decline in abundance
3) Scallops were actively redistributing on the ground to fill the space left by the removals, or were attracted to the disturbed ground, although there is no known mechanism for this.
4) The efficiency of the gear was improving over the course of the trial

This study did show that determining catchability using depletion methods is not straightforward and we need to pursue an improved methodology or alternative technique to determine this critical parameter. This will be done later and could potentially be done retrospective of the first survey.

Length sampling

The size structure of the catch is a function of gear selectivity and the size distribution of scallop on the ground. Gear selectivity is dependent on many factors which will include, perhaps in order of importance, belly ring internal diameter (ID), number of teeth on the tooth bar, mesh or ring size in the back of the dredge and other, less obvious gear characteristics. The Minimum Landings Size in the Eastern English Channel (Area VIId) is 110mm shell width and the internal ring diameter on the belly of the commercial gear was 85mm.

Measurements of either shell size metric (height and length) can be easily converted to the other using the relationship between shell height and length, but to ensure current and regionally relevant parameters are used for conversion the relationship between shell metrics will be examined during the dredge surveys.

The size structure of the scallops acquired from this study and their spatial distribution are informative, but they will achieve their full potential once converted to age using the relationship between size and age. Although the relationship between the two scallop size metrics shell height and length is available from earlier studies, it is known to vary regionally and it is proposed that size stratified samples of scallops will be measured for both metrics on subsequent surveys to ensure a precise conversion for all areas.

Age sampling

Age samples taken from this survey are stored at the Cefas Lowestoft Laboratory awaiting age determination and to construct age/length keys. These will be applied to the length samples already acquired to provide an estimate of the age structure of the catch. To be reported elsewhere.

Blue tooth callipers

The data transmission problems encountered with our radio transmitting digital Vernier calipers forced us to use a less efficient method of capturing the data (pencil and paper). This can also lead to transcription errors and attempts will be made to find a solution for future trips. A hard-wired system may be the answer for this application but other radio transmitting options could be tried.

Experimental gear for per-recruit scallops

The aim of using the experimental gear is to facilitate sampling of pre-recruit scallops otherwise not retained by standard commercial gear. This could provide an indication of future recruitment to the fishery.

The size distributions from the few samples taken from the experimental gear show that a few individuals of a younger year class were present. Catch rates from the experimental gear were however consistently lower than those from the commercial gear (for all components of the catch, retained and discarded) and this is likely due to the gear not fishing well. With the thirteen-teeth tooth bars the bag of the dredge was always full of shell (mainly queenie) even in the ten and fifteen minute tows. After fitting the eight-teeth tooth bar the bags were not completely full but consistently contained more bulk than the commercial gear which fished much cleaner as was expected.

The difficulty is to use a design which fishes synchronously with the commercial gear without filling completely as this gear is designed not to fish cleanly. It is assumed that the experimental gear filled early in the tows, and stopped fishing effectively. The skipper suggested that the experimental gear was digging in too deep because of the length of the frames compared to the commercial gear being fished on the same beam.

The performance of the experimental gear was discussed at length with the skipper who made the following suggestions for future surveys: The backs should be made from larger meshes, tooth bars should have less than thirteen teeth but more than the eight of the commercial gear (nine was suggested), the frames should be the same length as those of the commercial gear.

5. Conclusions

1. A fifteen-minute tow should provide adequate coverage of the seabed and allow the gear to fish consistently during the tow in most situations.

2. A semivariogram produced by the geostatistical technique (kriging) suggests that the mean density of sampling in this area should be consistent with tows approximately 15-20km apart.

3. Catches from paired tows suggest that results are generally consistent and replicate tows are not required (diminishing returns).

4. Two depletion studies where the same tracks were towed repeatable did not show an obvious reduction in catch rates at each site, highlighting the need for a modified or alternative methodology to determine gear efficiency.

5. Length sampling facilitated construction of size distributions of the catch throughout the survey area.

6. The Bluetooth® calipers tested were found to be unreliable for measuring and capturing scallop size data and alternative technology will need to be considered for subsequent surveys.

7. The experimental gear retained a younger year class of scallops than the commercial gear but did not fish well alongside the commercial gear and further modifications as recommended by the skipper are planned for subsequent surveys.

6. References

R Core Team, 2006. A Language and Environment for Statistical Computing. R Core Team. Vienna, Austria, 2016

7. Acknowledgements

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Centre for Environment Fisheries & Aquaculture Science

Cefas

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