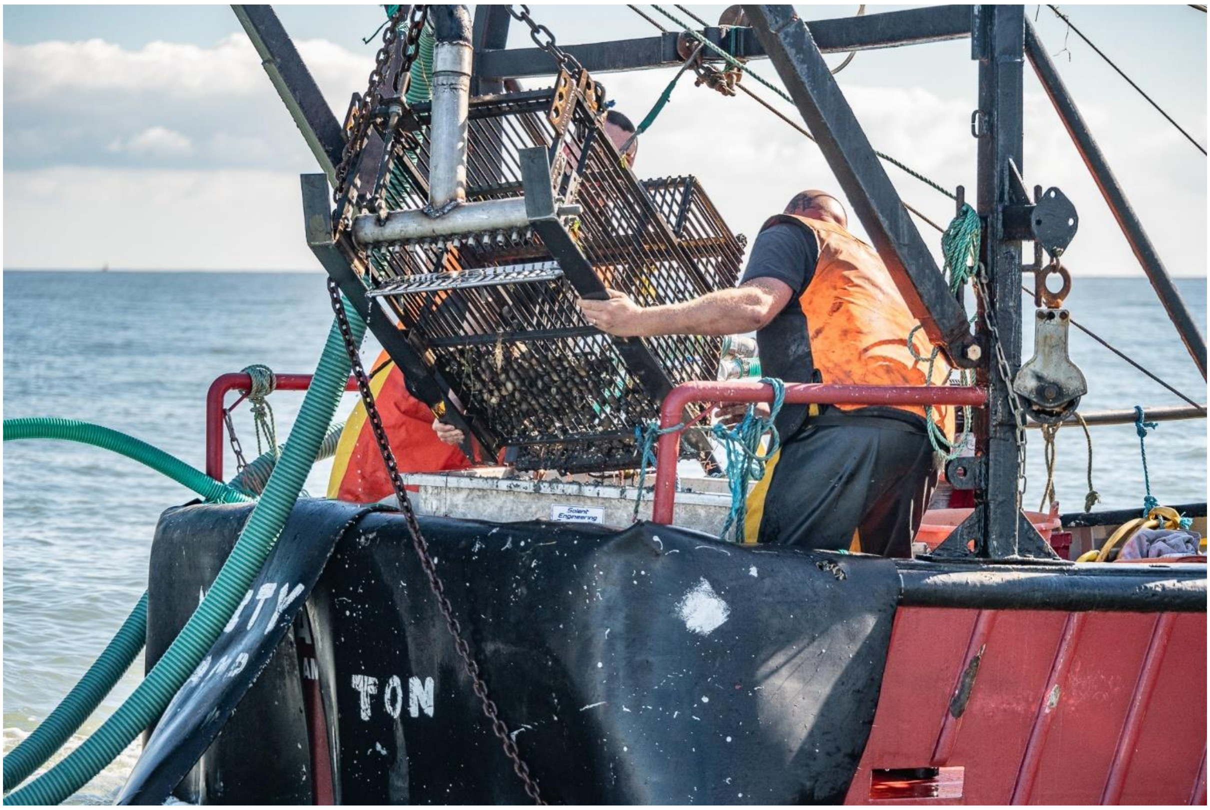
Appendix 1 to Agenda Item B4

Manila Clam Bar Spacing Experiment

May 2025



Introduction

Manila clams (*Ruditapes philippinarum*) are a high-value seafood harvested across the globe, but are susceptible to commercial overexploitation if not carefully managed (e.g. Venice Lagoon (Canu et al., 2011)). KEIFCA are looking into opportunities for a Manila clam fishery in the Thames Estuary. These clams are often found in the same habitats as cockles, meaning any new fishery must also consider potential interactions with the existing cockle fishery. The overarching aim of this study is to develop the understanding around 1) gear specification measures to ensure that the Manila clam trial fishery is managed sustainably and 2) better understand the potential impacts on cockles and the cockle fishery in the Thames Estuary.

Minimum Landing Size (MLS) is a common fisheries management measure that prohibits the selling of fish under a given size (Takar and Gurjar, 2020) to ensure that individuals are able to reproduce at least once before becoming vulnerable to harvest (Lanzat et al., 2014; Suja and Mohamed, 2013; Winstanley, 1992). MLS is species specific and based on the length at which the population is able to reproduce (Lanzat et al., 2014). This protects future fish stocks by ensuring that the next generation of fish [or shellfish] are produced (Lanzat et al., 2014).

Manila clams are harvested by towing a dredge through the sediment, with shellfish funnelled into a dredge body that is hauled onboard. Manila clams have an MLS of 35mm (shell length) (Figure 1). To reduce the number of undersize clams that are brought onboard, the dredge body is composed of metal bars. Small shellfish pass through the bars, whereas large shellfish are retained in the dredge body. The larger the spaces between the bars, the larger the shellfish that are retained. Once catch is onboard, it is placed through a riddle, which are broadly composed of a chute covered by metal bars. All shellfish small enough to pass through the bars and into the chute are discarded back to the sea, and those too large to pass are retained to be landed.

Figure 1: Shell length measurement in bivalve molluscs (including Manila clams). Source: https://eur-lex.europa.eu/eli/reg/2019/1241/oj/eng

Bar spacing of both dredges and riddles are set at a particular size by fishers and managers alike to avoid the harvest of undersize Manila clams. Determining appropriate bar spacing is complex, with many factors at play (Table 1). A balance must be found between the need to discard undersize clams and retain sizeable clams at a financially viable rate. If the bar spacing is too small, there is increased risk of retaining undersize catch. If bar spacing is too large, sizeable catch will be discarded, and fishing time will increase. This results in a less financially viable operation. Additionally, Manila clams are reported to vary in shape, with some described as globular (short and fat) and other as elongate (long and skinny). Therefore, a globular, undersize clam may be retained while an elongate, sizeable clam may be discarded by the same bar spacing. This means that a larger bar spacing is preferable, reducing the risk of retaining globular, undersize clams.

Further, the Manila clam fishery in the Thames is co-located with the Thames Estuary cockle fishery. The cockle fishery is key to the local community and a significant source of income for the KEIFCA district. Similar fishing techniques are used to fish for clams and cockles, and as such there are concerns regarding the impact of a clam fishery on the existing cockle fishery. Selecting a bar spacing that would effectively exclude cockles from the clam catch would help separate these two fisheries and allow both fisheries to be managed sustainably in their own right.

KEIFCA are currently investigating the potential for a Manila clam fishery in the Thames Estuary. It is essential to collect data from local beds so that future management decisions can be based on the best available evidence. KEIFCA ran a trial fishery in 2024, which primarily focussed on damage rates between gear types. Bar spacings between 19mm and 22mm were used by trialists, and there were no significant issues with undersize catch being retained. However, hand sorting was common throughout the fleet. There was also no evidence to suggest that high numbers of cockles were being harvested and retained, indicating that the much smaller cockles were being effectively discarded.

Table 1: Factors influencing the size of bar spacing when harvesting Manila clams in the Thames Estuary.

Factor	Influence
Compliance with MLS	Larger bar spacing
Variability in clam shape	Larger bar spacing
Co-located cockle fishery	Larger bar spacing
Retention of sizeable catch at a financially viable rate	Smaller bar spacing

KEIFCA wish to set a standardised bar spacing for both dredges and riddles across the fleet that is suitable to the clam population in the Thames Estuary. It would aim to ensure that no undersize clams are retained but simultaneously allow legal catch to be retained at a financially viable rate. Although the 2024 trial fishery gave an initial insight into an appropriate bar spacing, further experimentation is required to come to a robust conclusion.

In this study, the specific objectives were to determine the effects of a range of bar spacing distances on 1) the proportions and sizes of retained and discarded Manila clams, and 2) the number of cockles retained as bycatch.

This experiment uses a range of riddles with different size gaps to assesses the effects of changing bar spacing on the number of retained cockles and the number and size of retained Manila clams.

Methods

Both practical experiments and modelling using existing data were undertaken, to gain as much understanding as possible with limited resources.

Practical experiment: Manila clams

Frozen Manila clams from the KEIFCA 2024 Manila clam trial fishery were selected to create an experiment sample of 225. Clams came from Areas 6 (Maplin Sands) and 20 (previously Area 7, Buxey Sand) and were selected to have a normal size distribution to allow robust statistical analysis. Each clam was dried off with a paper towel, then numbered from 001 to 225 using a permanent marker (Figure 2A). The width and heigh of all sample clams were measured using callipers to the nearest 0.1mm (Figure 2).

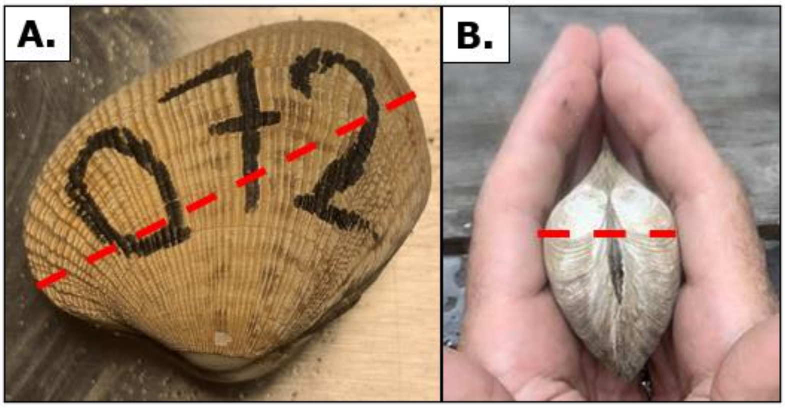


Figure 2A: Manila clam shell labelled with permanent marker. Red dotted line represents shell length measurement. 2B: Red dashed line represents shell width measurement.

A set of laser-cut, stainless steel riddles were used in this experiment, of bar spacing 19mm, 20mm, 21mm, 22mm, 23mm, and 24mm (Figure 4).

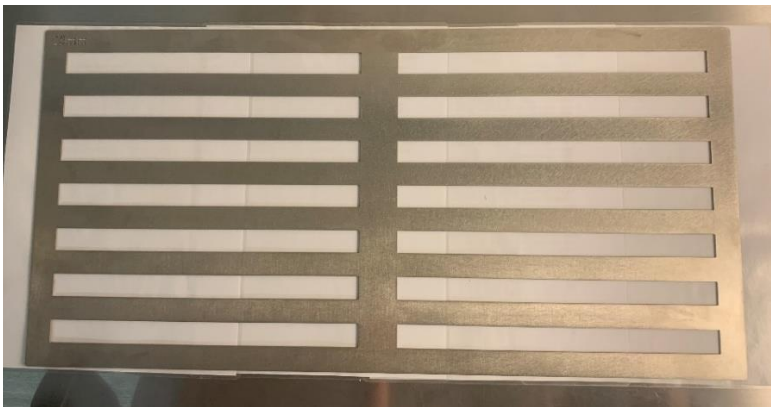


Figure 3: The 19mm stainless steel laser-cut riddle used in this experiment.

Each riddle was placed inside a Styrofoam box on an angle. All numbered clams were taken directly from the freezer and placed on top of the riddle. Clams were then rolled back and forth along the length of the riddle for approximately thirty seconds to allow enough time for undersize clams to fall through the riddle (Figure 5). The unique number of each clam that did not pass through the bars of the riddle (remained on the top) was recorded – allowing reference to its specific dimensions. The unique number of each clam that passed through the bars of the riddle (fell inside the Styrofoam box) was recorded. This was repeated three times with each riddle.

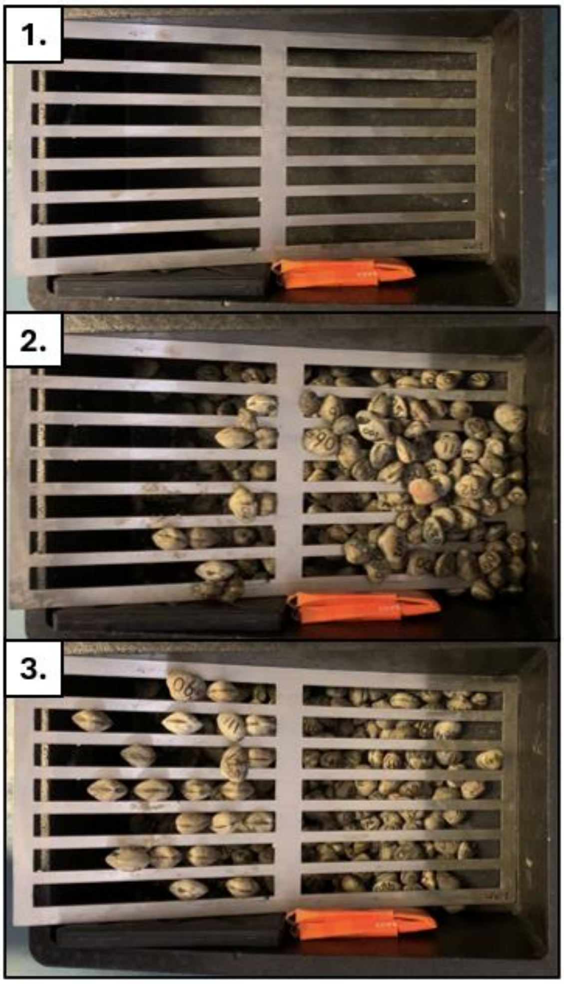


Figure 4: Bar spacing experiment set-up and process. 1: Riddle placed in a Styrofoam box on an angle. 2: All clams placed on top of the riddle and rolled along the length of the riddle for ~ 30 seconds. 3: All clams too large to pass through the riddle remain on top of the riddle, and all clams small enough to pass through remain in the Styrofoam box to be collected.

Practical experiment: cockles

Frozen samples from 2025 cockle and clam surveys in Area 20 (previously Area 7, Buxey and Ray Sands) were used in this experiment. Two samples were used, one from the Buxey and one from the Ray Sands, both containing Manila clams and cockles. The same riddle set up was used as the Manila clam experiment (Figure 5).

The same method was used as the above experiment, with the Ray and Buxey samples put through each riddle three times each. Cockles were not measured or labelled, only the number passing through or retained were recorded.

Modelling

An existing dataset was used to model the effect of changing bar spacing on the size of retained Manila clams. Clams from a range of beds within the Thames Estuary have been measured by KEIFCA as part of a range of projects and compiled into a central dataset. The width and length of each individual clam was measured with callipers to the nearest 0.1 millimetre.

The following rules were applied to the existing dataset:

If the width of a clam is > or = the bar spacing, it would not pass through the bars (retained).

If the width of a clam is < the bar spacing, it would pass through the bars (discarded).

Results

Cockle Retention

Less than 1% of cockles were retained across all bar spacings, samples and replicates (Figure 5).

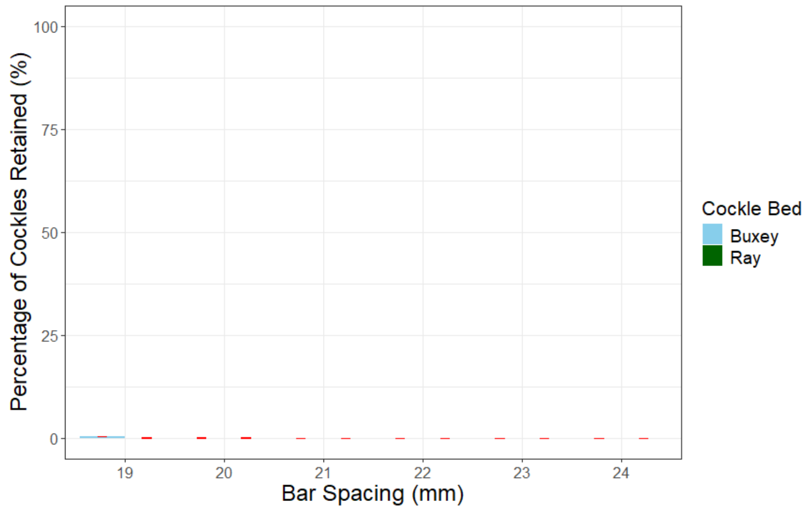


Figure 5: Percentage of cockles retained within samples from the Buxey (blue) and the Ray (green). Red error bars indicate standard deviation from the mean across three replicates.

Figure 6 (below) zooms in on the data presented in Figure 5, only showcasing 0 – 1% on the y-axis. The most cockles were retained from the Buxey Sand sample at 19mm bar spacing, with an average of 0.4% retention across three replicates. Bar spacings above 21mm did not retain any cockles (Figure 6). There was no detectable pattern in the size of cockles that were retained.

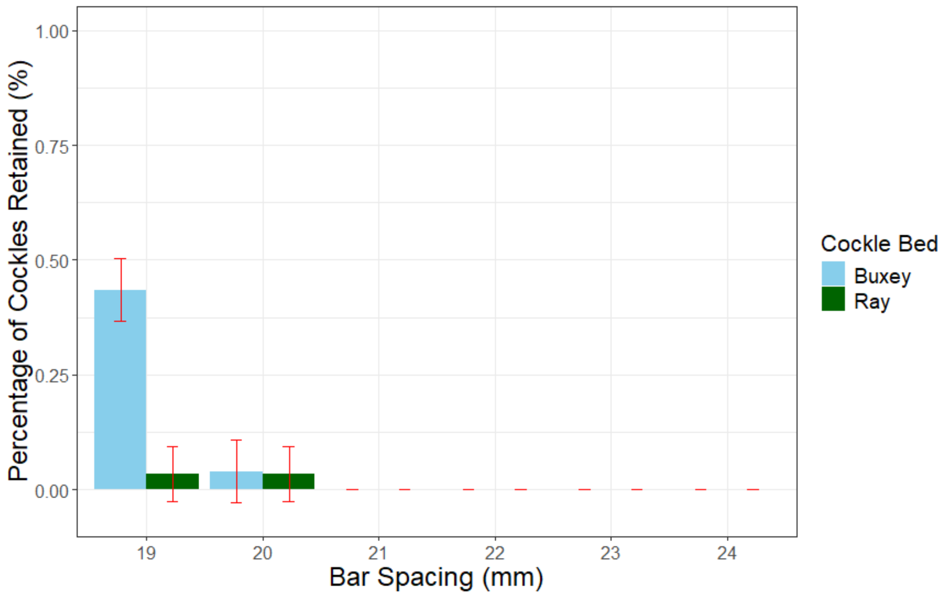


Figure 6: Percentage of cockles retained within samples from the Buxey (blue) and the Ray (green) Sands across several bar spacings. Red error bars indicate standard deviation from the mean across three replicates. It should be noted that the x-axis only extends to 1%, not 100%.

Manila clam length-width relationship

There is variation in the length-width relationship of Manila clams in the Thames Estuary. There is no detectable difference between clams from Areas 6 (Maplin Sands) and 20 (Buxey Sand) (Figure 7).

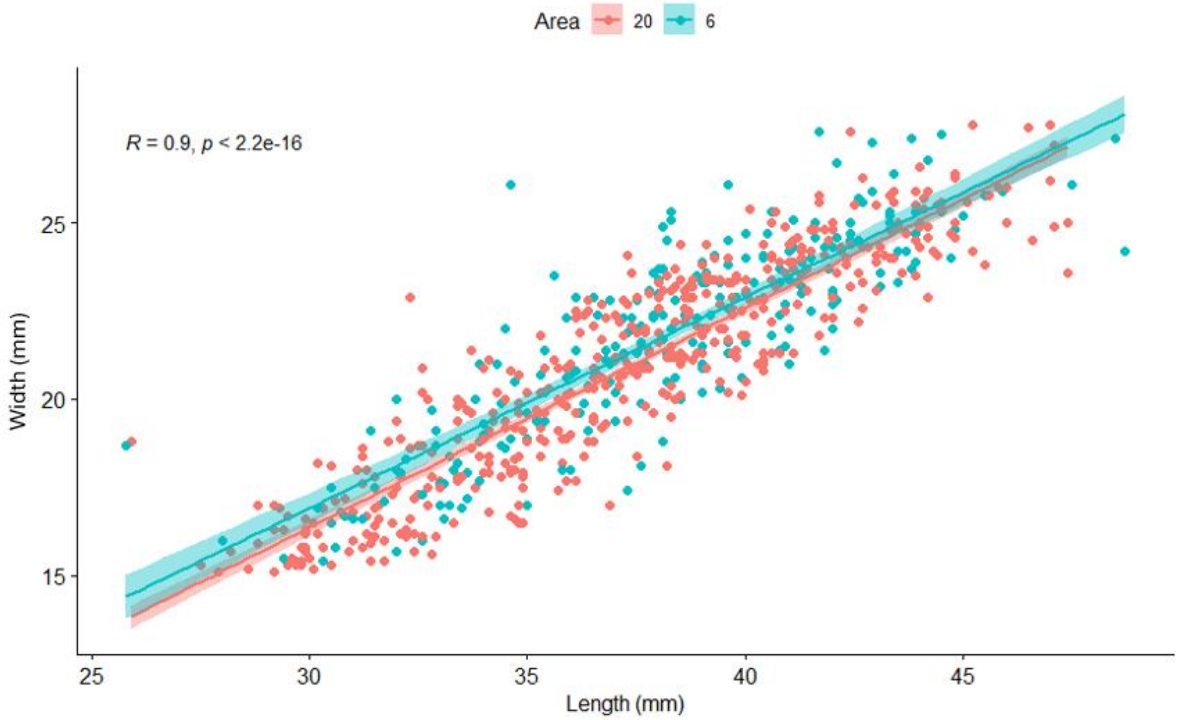


Figure 7: Spearman's correlation between the shell length (mm) and shell width (mm) of Manila clams from the Thames Estuary. Significant correlation ($p < 0.05$) but high levels of variation around the general trend. Clams from Area 6 (Maplin Sands) are coloured red, and clams from Area 20 (Buxey Sand) are coloured blue.

Across the range of bar spacings tested, 19mm bar spacing retained the most undersize Manila clams (Figure 8). On average, 19mm bar spacing retained 22.4% of the total undersize clams in the sample. A limited number of undersize Manila clams were retailed by the 20mm riddle, with an average of 4.3% retained undersize clams. All bar spacings over 20mm did not retain any undersize clams. As bar spacing increased, the percentage of sizeable clams retained decreased (Figure 8).

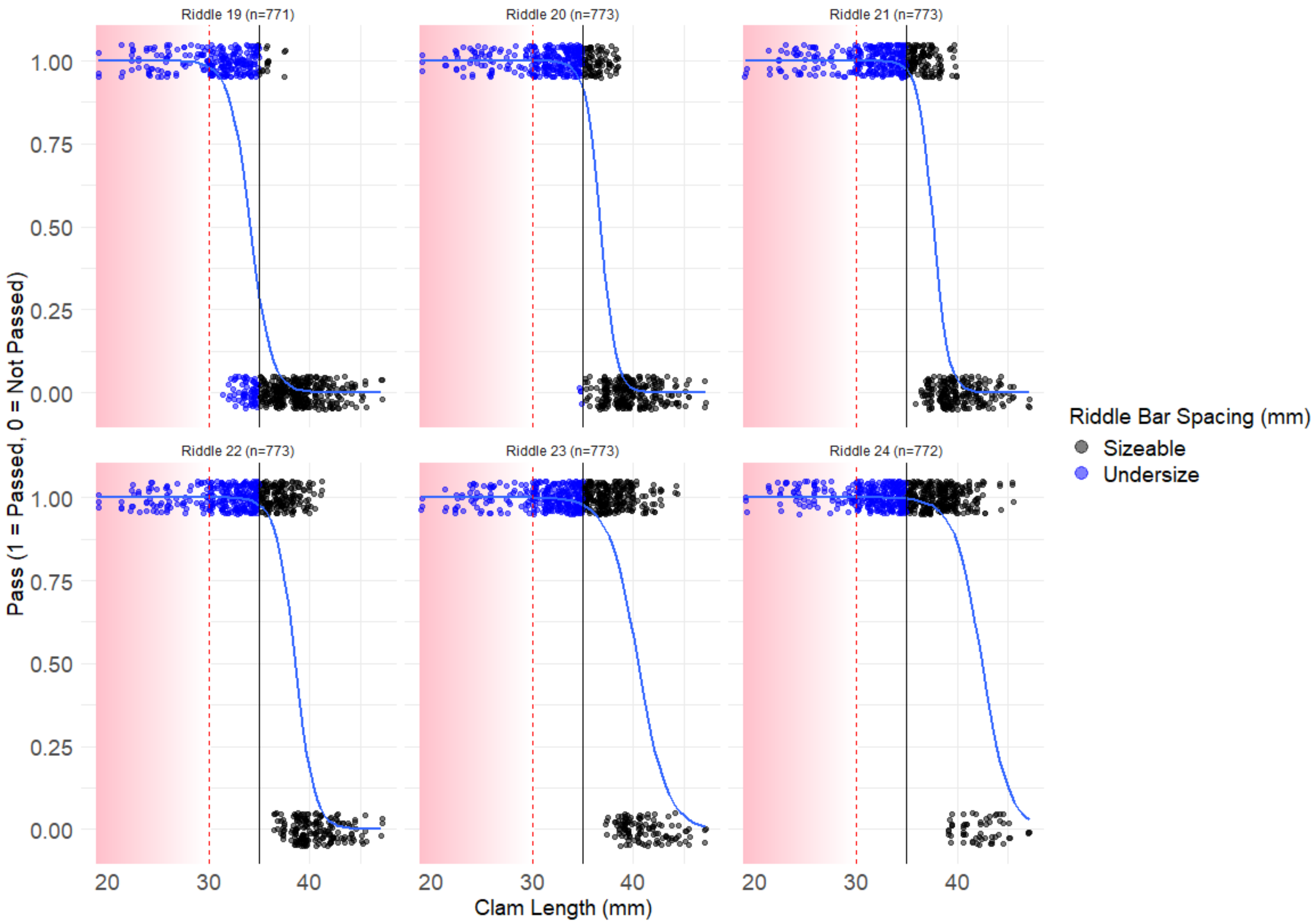


Figure 2: Logistic regression analysis of all replicate trials conducted across riddle bar spacings from 19mm to 24mm. The dashed, vertical, red line at 30mm represents the estimated shell length at which all Manila clams in the population have reached sexual maturity. The background pink gradient represents that the proportion of Manila clams that are sexually mature increases with shell length up to 30mm. The pinker the background, the smaller the proportion of Manila clams in the population that are sexually mature. The solid, vertical, black line at 35mm represents the legal minimum size of Manila clams. Points on the graph represent individual clams across all three trials. Blue points are clams with a shell length less than 35mm. Black points are clams with a shell length greater than or equal to 35mm. The blue curved line is a predicted model of the probability of a clam of a particular shell length passing through the riddle, with 1.00 representing 100% probability of passing through the riddle (being discarded). This line has been fit as a binomial generalised linear model.

Modelled effect of bar spacing

Modelled effects of bar spacing on the size of Manila clams retained echoes the findings of the practical experiment, however the model consistently predicts a higher proportion of retained undersize clams. In the model, both 21mm and 22mm bar spacings theoretically retain a small number of undersize Manila clams (Figure 3).

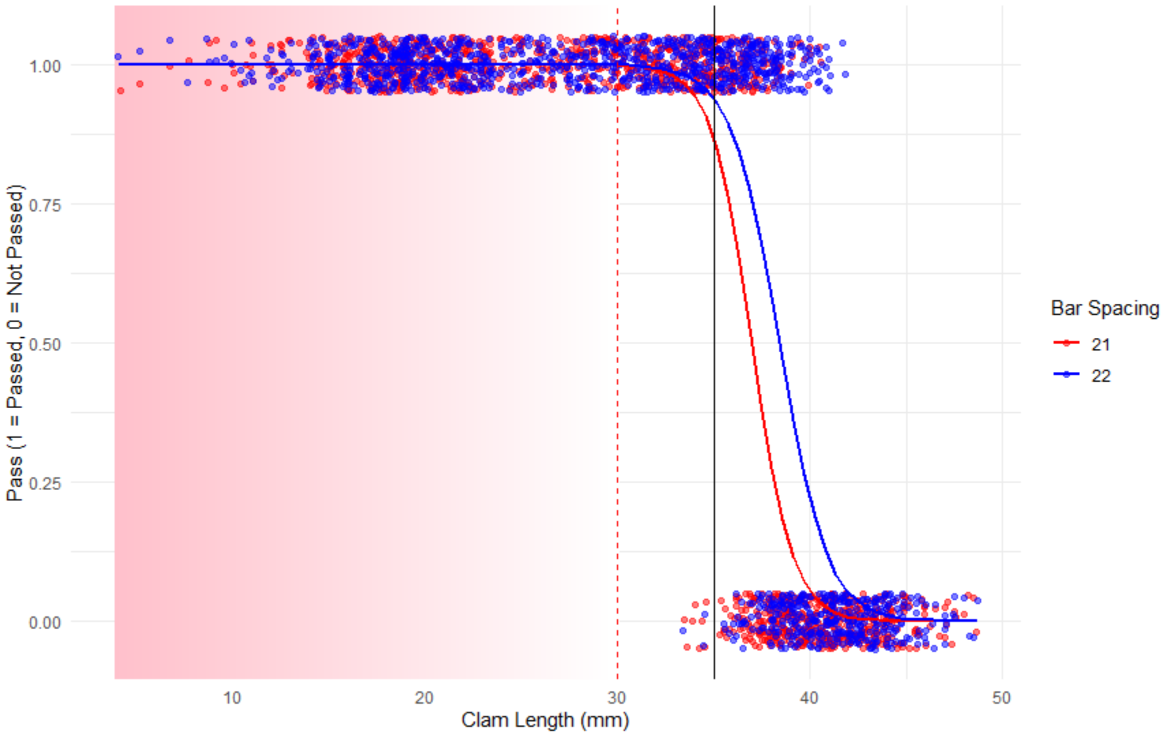


Figure 3: Logistic regression analysis of 21 and 22mm bar spacing from a large, theoretical dataset. The dashed, vertical, red line at 30mm represents the estimated shell length at which all Manila clams in the population have reached sexual maturity. The background pink gradient represents that the proportion of Manila clams that are sexually mature increases with shell length up to 30mm. The pinker the background, the smaller the proportion of Manila clams in the population that are sexually mature. The solid, vertical, black line at 35mm represents the legal minimum size of Manila clams. Points on the graph represent individual clams across all three trials. Blue points are clams with a shell length less than 35mm. Black points are clams with a shell length greater than or equal to 35mm. The blue curved line is a predicted model of the probability of a clam of a particular shell length passing through the riddle, with 1.00 representing 100% probability of passing through the riddle (being discarded). This line has been fit as a binomial generalised linear model.

Discussion

Cockle retention

Across all tested bar spacings there were low levels of cockle retention (<1%). This is consistent with findings from the 2024 Manila clam trial fishery, which found that only very low levels of cockles bycatch were retained. Cockles are much smaller than Manila clams, and this study presents further evidence that Manila clam harvesting gear effectively excludes cockles. The retention of a few cockles under 16mm suggests that they are getting caught up in clams and other debris. The smaller the bars, the more clams and other debris is retained, and therefore the more likely it is that small cockles will get caught and be retained also. Overall, to reduce the impact of clam dredging on cockle bed health, a larger bar spacing on sorting and fishing gear is desirable.

Manila clam length-width relationship

The variability in the length-width relationship of Manila clams from the Thames Estuary suggests that individuals differ in shape, some being long and slender, whilst others are shorter and wider. The lack of a detectable difference between clams in Area 6 (Maplin Sands) and clams in Area 20 (Buxey Sand) suggests that this variability isn't driven by differences between clam beds included in this experiment. Variable clam shape has implications for sorting catch. Shell width is the primary dimension that determines whether a clam will pass through bars of a particular spacing, but MLS is measured as shell length. High variability in the relationship between length and width results in the need to examine the influence of bar spacing across a large population of clams.

Manila Clam Practical Experiment

Experimental data suggests that bar spacings of both 19mm and 20mm will retain undersize clams, with 19mm bar spacing retaining markedly more undersize clams than 20mm bar spacing. Legally, there is no tolerance for landing undersize clams. This means that both 19mm and 20mm riddles are inappropriate for the potential Outer Thames Estuary clam fishery. There is also a need to ensure that bar spacings aren't too large that available sizeable catch is discarded at a high rate. Due to sizeable catch discard increasing with bar spacing, setting bar spacing small as possible is desirable. Therefore, balancing the sustainability, and financial impacts of bar spacings, 21mm or 22mm seems appropriate.

A significant limitation of this study is that the probability of a clam passing or not passing through bars is strongly influenced by factors external to bar spacing that could hinder the effective sorting process. These factors include the volume of catch (as seen with small cockles being retained in 19mm riddles), mud and debris content in catch, and the time spent riddling. These factors are expected to increase the likelihood of undersize catch being retained by a given bar spacing compared to the result of this study. Therefore, 22mm may be more appropriate than 21mm.

Conclusion/Recommendations

A bar spacing of either 21 or 22mm balances the need to comply with the legal minimum length for Manila clams and discard cockles with the need to retain a reasonable proportion of available sizeable catch. Considering real world factors which may cause a greater retention of undersize clams than found in this experiment, 22mm may be an appropriate bar spacing.

However, it is recommended that before a standardised bar spacing is set for trials and the potential fishery, more experiments be undertaken in the 2025 Manila clam trial. These experiments should consider real world factors that could result in a refinement of the findings from this experiment to better inform a final management recommendation on bar-spacing to be used to fish for Manila clams in the Thames Estuary.

References

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