The effects of fishing effort on Manila clam populations in the Thames Estuary 2026 trial fishery

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Figure 1. Manila clam trial fishery participating vessel, Audacity, showing the water injection batch dredge lowered from the back of the vessel in the Thames Estuary, 2024. Photo credit: Colm O'Laoi.

1 Summary

Kent and Essex IFCA (KEIFCA) conducted a study to assess the effects of fishing effort on Manila clam (*Ruditapes philippinarum*) populations during the 2026 Thames Estuary trial fishery. The primary aim was to determine whether current fishing levels were causing measurable declines in Manila clam abundance and density.

A Before-After-Control-Impact (BACI) design was used to compare Manila clam and cockle populations before fishing in March 2026 and after fishing in May 2026. Surveys were undertaken within High-effort, Low-effort and unfished Control zones across two fishing areas:, Foulness Sand and Buxey Sand. Fishing effort was quantified using fishing footprint, defined as the area of seabed contacted by fishing gear. Fishing footprint was first used to compare population responses between fishing-effort zones. A second analysis used Swept Area Ratio (SAR), a measure of local fishing intensity derived from fishing footprint data, to assess whether changes in clam and cockle abundance were related to fishing pressure at individual survey stations.

Fishing activity was concentrated within relatively small areas of the available fishing grounds. Although fishing effort differed between the High-effort and Low-effort zones, only around 2% of the total fishing area was directly contacted by fishing gear, leaving approximately 98% of the grounds undisturbed. As a result, most of the Manila clam population remained outside areas directly affected by fishing activity. Consistent with this, statistical analyses found no significant differences in Manila clam or cockle densities between fished and unfished areas. Similarly, no relationship was detected between increasing SAR and changes in Manila clam or cockle abundance at survey stations.

At the level of fishing effort applied during the 2026 trial fishery, no measurable population-level declines were detected in Manila clam or cockle populations. This is likely because fishing activity was too limited in both scale and spatial extent to generate detectable effects across the wider fishing grounds.

These findings indicate that the current management approach is precautionary and operating within sustainable limits. However, the absence of a detectable population-level response should not be interpreted as evidence that fishing has no effect. Instead, the results suggest that any impacts are likely to be localised and confined to areas directly affected by dredging. KEIFCA therefore recommends repeating the study at higher levels of fishing effort and undertaking targeted surveys within and outside dredge tracks to better quantify direct fishing mortality and identify sustainable exploitation thresholds. This information will support the future management and development of a sustainable commercial Manila clam fishery in the Thames Estuary.

2 Introduction

Increasing densities of Manila clams (*Ruditapes philippinarum*) have been recorded by Kent and Essex IFCA (KEIFCA) on intertidal sandbanks along the Essex coast of the Thames Estuary since 2018. As the population has expanded, fishers have expressed interest in developing a fishery for the species. In response, KEIFCA opened a trial Manila clam fishery in late 2024 to support assessments of stock size, population viability and the appropriate scale of any future fishery, while also improving understanding of how commercial harvesting affects the population.

Previous studies have shown that Manila clam populations can be vulnerable to overexploitation if harvest levels are not carefully managed, and declines have been reported in some wild-capture fisheries. As a result, the species is more commonly farmed through aquaculture than exploited through wild fisheries. At present, the relative importance of natural mortality and fishing mortality in the Essex population remains poorly understood.

Data collected from the trial fishery also suggest that Manila clams may be susceptible to damage from bottom-towed fishing gear. This raises the possibility that fishing-related mortality may extend beyond the retained catch, affecting clams that are damaged but not landed. Equally, little is known about how quickly the population recovers following fishing disturbance. Understanding these effects is therefore a key focus of KEIFCA's ongoing survey programme.

During KEIFCA's spring 2025 survey, Manila clam abundance was substantially lower in areas that had been fished during 2024. Although declines were also observed in unfished areas, they appeared to be less pronounced. This raised an important question: were Manila clams particularly sensitive to fishing pressure, leading to population declines greater than the direct catch removed by the fishery, or was the observed decline part of a natural fluctuation following a period of strong recruitment leading up to 2024?

Given the limited information currently available on stock size and population dynamics, KEIFCA has adopted a precautionary approach to managing the trial fishery. While this reduces the risk of overfishing, a better understanding of how Manila clam populations respond to fishing pressure is needed to support the development of a sustainable commercial fishery and better estimates of sustainable exploitation rates.

Understanding the proportion of the population removed by fishing is central to this process. Estimates of fishing mortality help distinguish losses caused by fishing from those resulting from natural mortality, both of which are fundamental to sustainable fisheries management. This study therefore examined the extent to which Manila clam populations are affected by the current level of fishing pressure exerted by the 2026 Manila clam trial fishery.

A further consideration is the potential impact of the Manila clam fishery on cockle populations. Manila clams and cockles often occur on the same intertidal beds, and cockles are regularly encountered as bycatch during clam fishing operations (though most is not retained by the fishing gear owing to their smaller dimensions). Mechanical batch dredging can also affect seabed habitats, benthic communities and cockle populations through direct and indirect disturbance of sediments and associated fauna (Hiddink et al., 2017; Kaiser et al., 1996; O'Neill and Ivanović, 2016; Piersma et al., 2001).

Although not the primary focus of this study, initial findings relating to cockles are also reported.

The aim of this study was to assess the effects of fishing effort on Manila clam and cockle populations in the Thames Estuary.

Research Question 1 (RQ1)

What effect does fishing effort have on Manila clam populations?

To address this question, the trial fishing grounds were divided into zones with different levels of fishing effort. Fishing effort was quantified using the fishing footprint, defined as the area of seabed contacted by fishing gear.

Hypothesis 1 (H1): Manila clam densities will decline more in areas exposed to high fishing effort than in areas exposed to low fishing effort or no fishing.

In addition to comparing predefined effort zones, we also examined whether changes in Manila clam abundance were related to the intensity of fishing activity. Throughout this study, fishing footprint is used as a proxy for fishing effort, or more specifically, fishing pressure.

Research Question 2 (RQ2)

What is the relationship between fishing effort and changes in Manila clam and cockle abundance at survey stations?

To investigate this, we used the Swept Area Ratio (SAR), calculated from fishing footprint data around individual survey stations. SAR is a widely used measure of bottom-fishing intensity in fisheries science and management. It is calculated by dividing the area contacted by fishing gear by the area of a defined survey cell surrounding each sampling station.

SAR values range from 0 to 1. A value of 1 indicates that an area equivalent to the entire survey cell has been swept once by fishing gear, while values between 0 and 1 indicate partial coverage. SAR is widely used to quantify seabed disturbance and assess the spatial extent of fishing impacts (Eigaard et al., 2016; Hiddink et al., 2026, 2017). Its widespread use makes it a robust and appropriate metric for investigating links between fishing disturbance and changes in population abundance.

Hypothesis 2 (H2): As SAR increases around survey stations, Manila clam densities will decline.

Together, these analyses test two related predictions. First, fewer clams and cockles should remain in an area after fishing than before fishing. Second, areas exposed to greater fishing disturbance should experience larger declines than areas subjected to lower levels of fishing effort.

If a clear relationship can be identified, the ultimate goal is to determine the level of fishing effort at which measurable declines in Manila clam and cockle populations begin to occur. Defining this threshold is important for setting precautionary management measures and ensuring fishing effort remains within sustainable limits.

2.1 Assumptions and limitations

This study assumes that repeated sampling within fixed areas before and after fishing can detect population-level changes caused by fishing activity. If fishing removes sufficient numbers of Manila clams from an area, a corresponding reduction in density should be detectable through survey data.

However, the level of fishing effort required to produce a detectable change is currently unknown. As this is a new fishery, natural year-to-year variation in Manila clam abundance is also poorly understood. For this reason, fishing effort during the trial was intentionally kept low to minimise the risk of overfishing while improving our understanding of population responses.

The trial should therefore be viewed as the first stage of a longer-term programme of work in which fishing effort is increased incrementally and population responses are monitored.

Manila clams are patchily distributed, which can increase uncertainty in density estimates. To reduce this source of error, survey effort was doubled compared with standard survey designs.

We also recognise the ecological relationship between Manila clams and cockles. Although this report focuses primarily on Manila clams, we include a limited assessment of cockle responses and intend to expand this work in future studies.

2.2 Definition of fishing effort

In this study, fishing effort was measured using fishing footprint: the area of seabed contacted by fishing gear. This provides a more direct measure of disturbance to the seabed, and therefore potential impacts on Manila clam populations, than fishing time alone.

Fishing footprint was calculated using data collected through Remote Electronic Monitoring (REM) systems equipped with gear-in/gear-out technology. These systems provide a more accurate record of fishing activity than traditional measures based solely on time spent fishing.

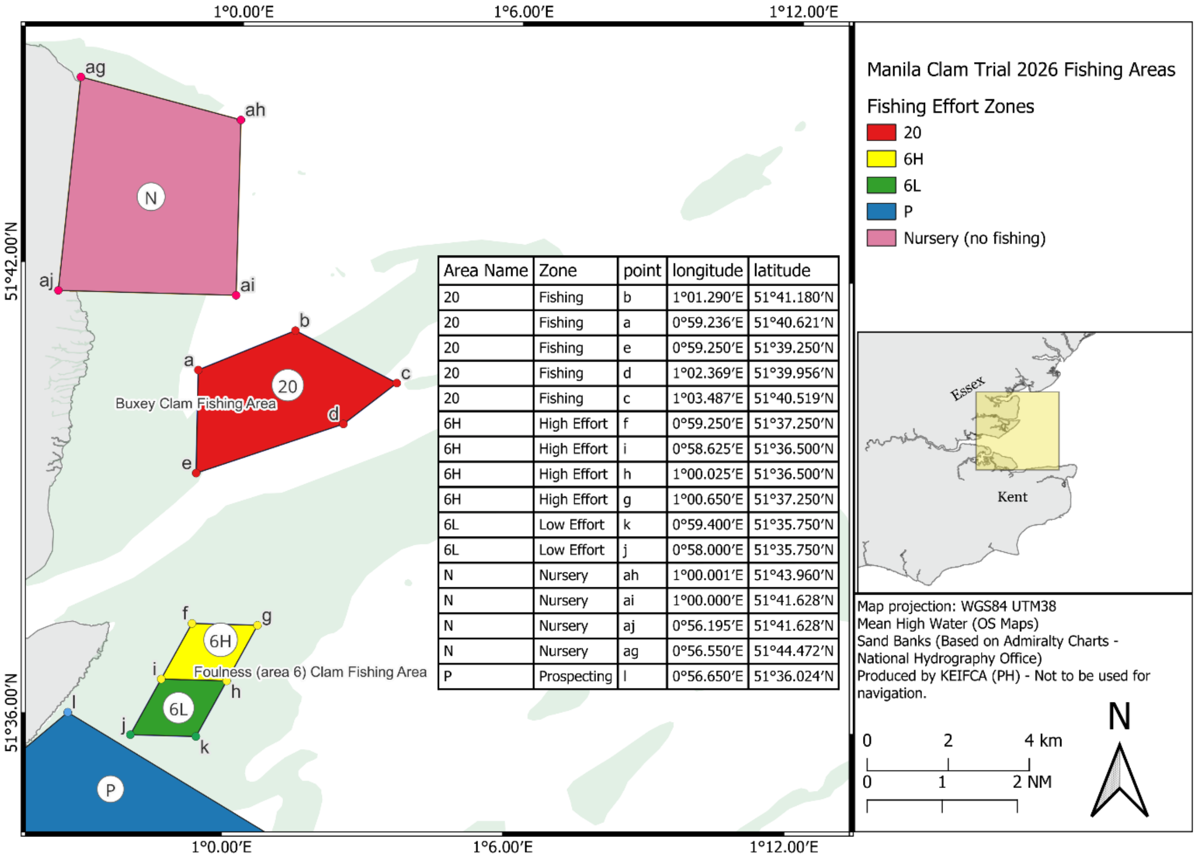
As a result, fishing effort in this study is defined by the extent of seabed disturbance rather than the duration of fishing activity. This approach reflects KEIFCA's commitment to incorporating the best available evidence and monitoring technology into fisheries management.

3 Methods

3.1 Study site & effort zones

The Manila clam fishing area were used as the study site (Figure 2). To assess the effects of different levels of fishing pressure, Foulness (Fishing Area 6) was divided into a High-effort zone (6H) and a Low-effort zone (6L). An unfished Control zone was set aside immediately north of the fishing area.

The Buxey (Area 20) was designated as a Low-effort zone only, with an adjacent unfished Control zone located immediately to the west.



Area Name	Zone	point	longitude	latitude
20	Fishing	b	1°01.290′E	51°41.180′N
20	Fishing	a	0°59.236′E	51°40.621′N
20	Fishing	e	0°59.250′E	51°39.250′N
20	Fishing	d	1°02.369′E	51°39.956′N
20	Fishing	c	1°03.487′E	51°40.519′N
6H	High Effort	f	0°59.250′E	51°37.250′N
6H	High Effort	i	0°58.625′E	51°36.500′N
6H	High Effort	h	1°00.025′E	51°36.500′N
6H	High Effort	g	1°00.650′E	51°37.250′N
6L	Low Effort	k	0°59.400′E	51°35.750′N
6L	Low Effort	j	0°58.000′E	51°35.750′N
N	Nursery	ah	1°00.001′E	51°43.960′N
N	Nursery	ai	1°00.000′E	51°41.628′N
N	Nursery	aj	0°56.195′E	51°41.628′N
N	Nursery	ag	0°56.550′E	51°44.472′N
P	Prospecting	l	0°56.650′E	51°36.024′N

Figure 2. Map showing the study area and Manila clam fishing grounds (2025 – 2027), including Area 6 (Foulness), divided into High-effort (6H) and Low-effort (6L) zones, Area 20 (Buxey), Prospecting Areas (P) and Nursery Areas (N).

3.2 Sampling design

A Before-After-Control-Impact (BACI) design was used to assess the effects of fishing on Manila clam populations (the target species) and cockle populations (a bycatch species).

A BACI design compares conditions before and after a defined disturbance while also incorporating both fished (impact) and unfished (control) areas. This allows changes caused by fishing to be distinguished from natural environmental and biological variation.

The Before survey was completed in March 2026. Fishing took place during April 2026, followed by an After survey in May 2026. Population size and biomass were recorded during both survey periods.

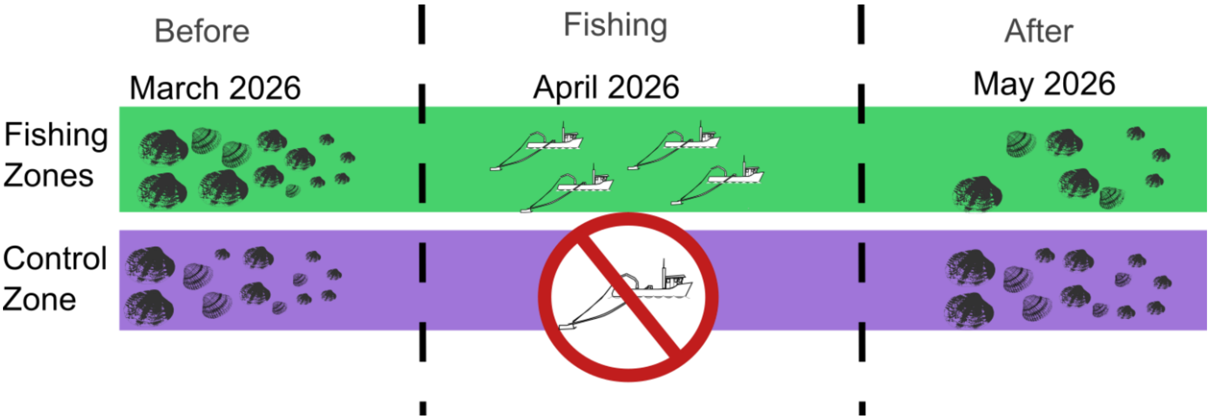


Figure 3. Schematic showing the BACI study design. Manila clam populations were surveyed before and after fishing within both impact (fished) and control (unfished) zones.

3.2.1 Sampling grid

Surveys were conducted using a sampling grid with twice the density normally used during KEIFCA cockle surveys. The grid covered the fishing zones at Foulness and the Buxey, together with their adjacent control areas.

Sampling stations were spaced at 1/8-minute latitude and 1/4-minute longitude intervals. The increased survey density was intended to account for the patchy distribution of Manila clams and improve the likelihood of detecting localised effects of fishing.

Samples collected along the boundaries between zones were assigned to separate boundary categories. This allowed potential boundary effects to be excluded or accounted for during analysis, reducing the risk of artificial gradients influencing the results.

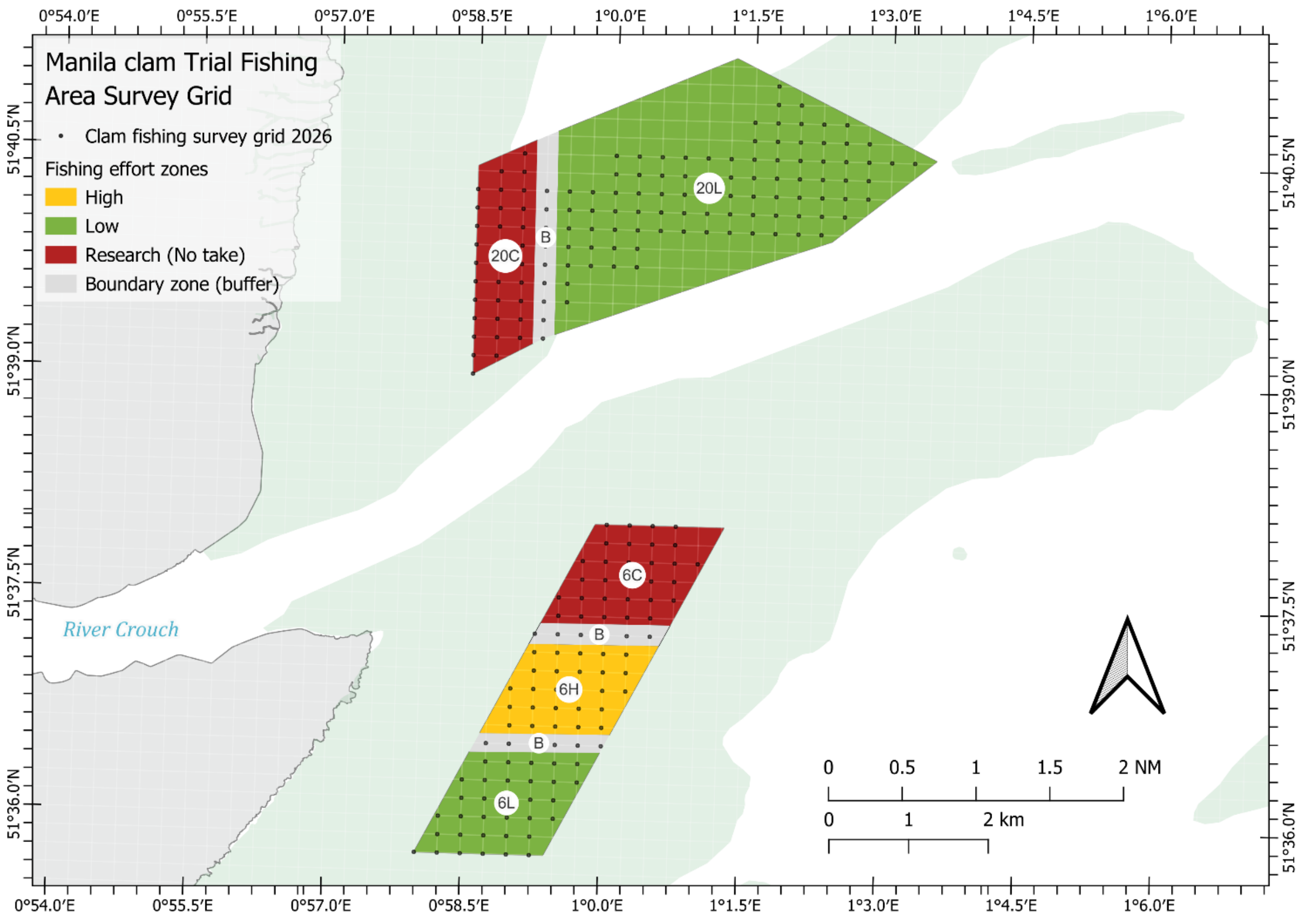


Figure 4. Survey grid showing sampling stations within High-effort, Low-effort and Control zones, together with buffer areas separating zone boundaries.

3.3 Samples and data collection

Sampling methods were based on those routinely used during KEIFCA cockle surveys.

Foulness was surveyed using quad bikes during spring low tides because the shallow intertidal habitat is inaccessible to the Fisheries Patrol Vessel (FPV) *Tamesis*. The Buxey was surveyed from FPV *Tamesis* during high tide because the beds are inaccessible by land.

At each sampling station, a 0.1 m² quadrat was excavated to a depth of approximately 6 cm using a short-handled rake. Material was passed through a 5 mm sieve to retain Manila clams and cockles. At the Buxey, equivalent 0.1 m² samples were collected using a Day Grab deployed from FPV *Tamesis*. Samples were then processed using the same methods as those used at Foulness.

Manila clams were assigned to three size classes:

- 0-23 mm
- 23-35 mm
- ≥35 mm (above Minimum Conservation Reference Size)

Individuals within each size class were counted and assigned to their respective survey station.

Cockles were initially counted at station level and later separated into three size classes:

- <14 mm
- 14-16 mm
- 16 mm

Counts and weights were recorded for both species and used to estimate density, population size and biomass.

3.3.1 Fishing effort and footprint

Fishing effort was quantified using fishing footprint, defined as the area of seabed contacted by fishing gear. Fishing footprint was used instead of fishing time because it provides a more direct measure of physical disturbance to the seabed and potential impacts on Manila clam populations.

Fishing activity was quantified using Remote Electronic Monitoring (REM) systems equipped with gear-in/gear-out technology. These data allowed fishing footprints to be mapped and used as a measure of fishing pressure.

Further details of REM data collection are provided in the 2026 Manila Clam Trial Fishery Public Summary Report.

3.3.2 Metrics for Assessing Fishing Impacts

Several population metrics were assessed, including:

- Total abundance
- Density
- Biomass
- Estimated stock size

Mean density and total abundance were considered the most informative measures of fishing impact. Biomass was considered less suitable because both Manila clams and cockles grow rapidly between March and May. Biomass can therefore increase even when fishing mortality occurs, making it difficult to separate growth effects from fishing effects.

Estimated stock size and total abundance can also be influenced by differences in survey area and sample numbers between zones. Mean density is less affected by these factors because it standardises counts by area and sampling effort.

For the zone-based analysis, mean density was therefore considered the most appropriate response variable. For the station-level analysis, raw counts were used because they allowed direct comparison with local measures of fishing pressure.

3.4 Data analysis

The data were analysed in two complementary ways. First, we examined whether changes in clam and cockle density differed between High-effort, Low-effort and Control zones.

Second, we investigated whether changes in abundance were related to a continuous gradient of fishing pressure measured using Swept Area Ratio (SAR).

Using both approaches allowed us to assess fishing effects at both the zone level and the individual survey-station level.

3.4.1 Fishing-effort zone BACI analysis

This analysis examined whether Manila clam and cockle densities changed differently among predefined fishing-effort categories.

Mean densities were compared among:

- High-effort zones
- Low-effort zones
- Control zones

Boundary samples were excluded from this analysis to avoid potential overlap between treatments.
At Foulness (Area 6), High-effort, Low-effort and Control zones were included.
At the Buxey (Area 20), only Low-effort and Control zones were included because Manila clam densities were insufficient to justify a High-effort treatment. Fishing activity was managed throughout

the season to ensure clear separation between effort categories. Although density, biomass and abundance were examined, mean density was considered the most reliable measure of population response and is therefore the primary metric reported.

3.4.2 Fishing-pressure gradient analysis

This analysis examined the relationship between fishing pressure and changes in abundance between the Before and After surveys. Fishing pressure was quantified using Swept Area Ratio (SAR), calculated around each survey station. By linking local SAR values to changes in clam and cockle counts, we assessed whether increasing fishing pressure resulted in greater declines in abundance. Unlike the zone-based analysis, boundary stations were retained because fishing pressure was analysed as a continuous variable rather than as discrete treatment categories.

3.4.3 Calculating Swept Area Ratio (SAR)

Swept Area Ratio (SAR) was used as a measure of local fishing intensity around each survey station. Fishing vessel tracks were converted into swept-area polygons using vessel-specific gear widths. Circular sampling cells with a diameter of 33 m were then created around each survey station using GIS software.

The overlap between fishing footprints and sampling cells was calculated and expressed as:

SAR = swept area ÷ cell area

A SAR value of:

- 0 indicates no fishing activity
- 1 indicates fishing activity equivalent to sweeping the entire cell once

Each survey station was therefore assigned both biological data (clam and cockle counts) and a corresponding measure of local fishing pressure.

To identify an appropriate spatial scale (size of circular cell), SAR was initially calculated using cell diameters ranging from 11.5 m to 115 m. Smaller cells captured highly localised fishing activity but produced many zero values, while larger cells included increasing amounts of unfished seabed. Breakpoint analysis identified approximately 33 m as the scale at which additional increases in cell size yielded diminishing returns (with respect to accumulating additional fished grounds relative to unfished grounds). This distance was subsequently used for all SAR calculations and modelling.

3.5 Statistical Analysis

Density data were highly skewed and contained many zero values, which is typical of ecological count data. We therefore fitted Generalised Linear Mixed Models (GLMMs) to account for non-normality and repeated sampling at the same survey stations. Survey station was included as a random effect to account for variation among sampling locations. The interaction between Area and Zone was tested but did not improve model performance and was removed from the final models.

Fishing-effort zone model

```
density ~ BACI_period * Zone + (1 | sample_id)
```

Where:

- Density = Manila clam density
- BACI_period = Before or After
- Zone = High, Low or Control
- sample_id = Survey station

Before-After model
A second model tested for overall changes between the Before and After surveys across all sites.

```
density ~ BACI_period + (1 | sample_id)
```

Where:
- BACI_period = Before or After
- sample_id = Survey station

BACI impact-control model

A third model tested whether changes between Before and After surveys differed between Impact and Control areas.

```
density ~ BACI_period * CI + (1 | sample_id)
```

Where:
- BACI_period = Before or After
- CI = Control or Impact
- sample_id = Survey station

4 Results

4.1 Fishing Effort - Footprint

Fishing activity from the four participating vessels is shown in Figure 5. The mapped fishing tracks show the spatial distribution of gear contact with the seabed across the two fishing areas and three fishing-effort zones.

Overall, 62% of the fishing footprint occurred within the High-effort zone (6H), 20% within the Low-effort zone (6L), and 17% within Area 20 (Low). Combined, the Low-effort zones accounted for 37% of the total fishing footprint, providing clear separation between the High- and Low-effort treatments (Figure 6).

A single tow was recorded within the inshore boundary of the Foulness Control zone. The tow was 777 m long and generated a footprint of 0.0013 km².

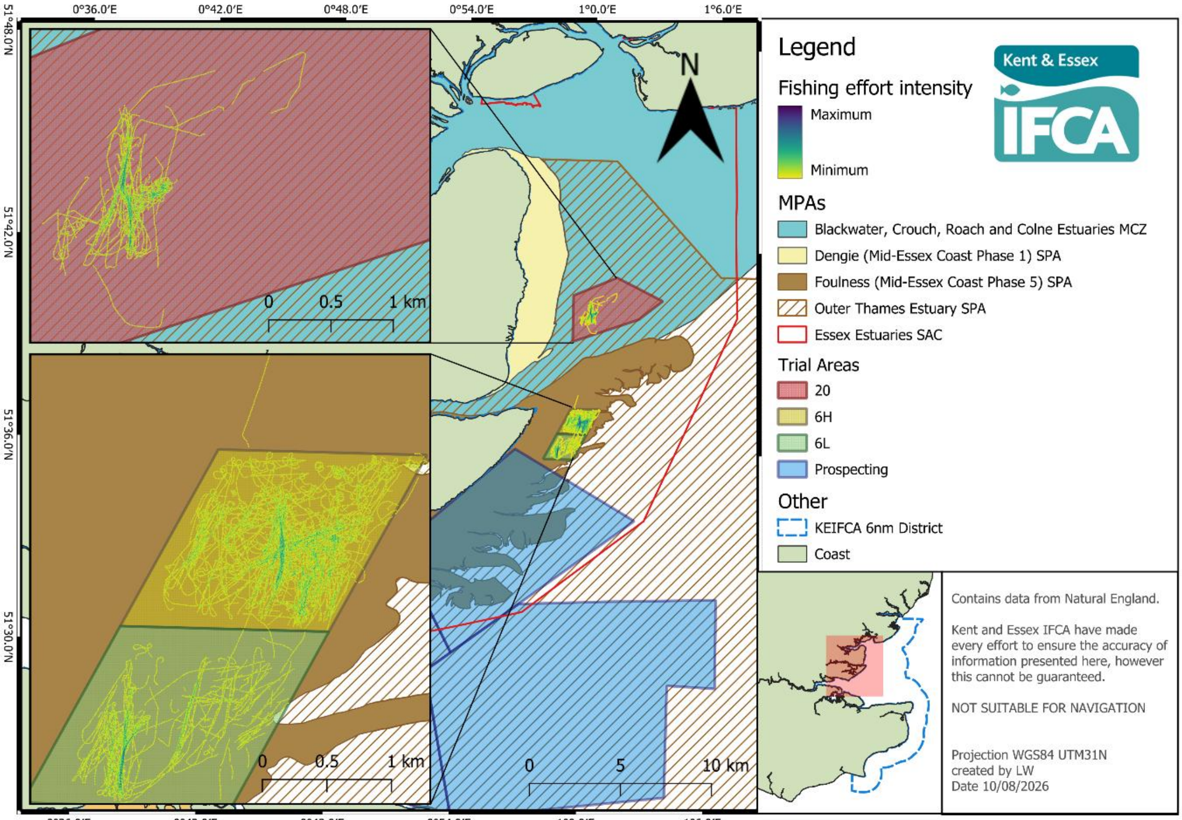


Figure 5. Heatmap of fishing tracks in Manila clam fishing zones in the 2026 trial fishery.

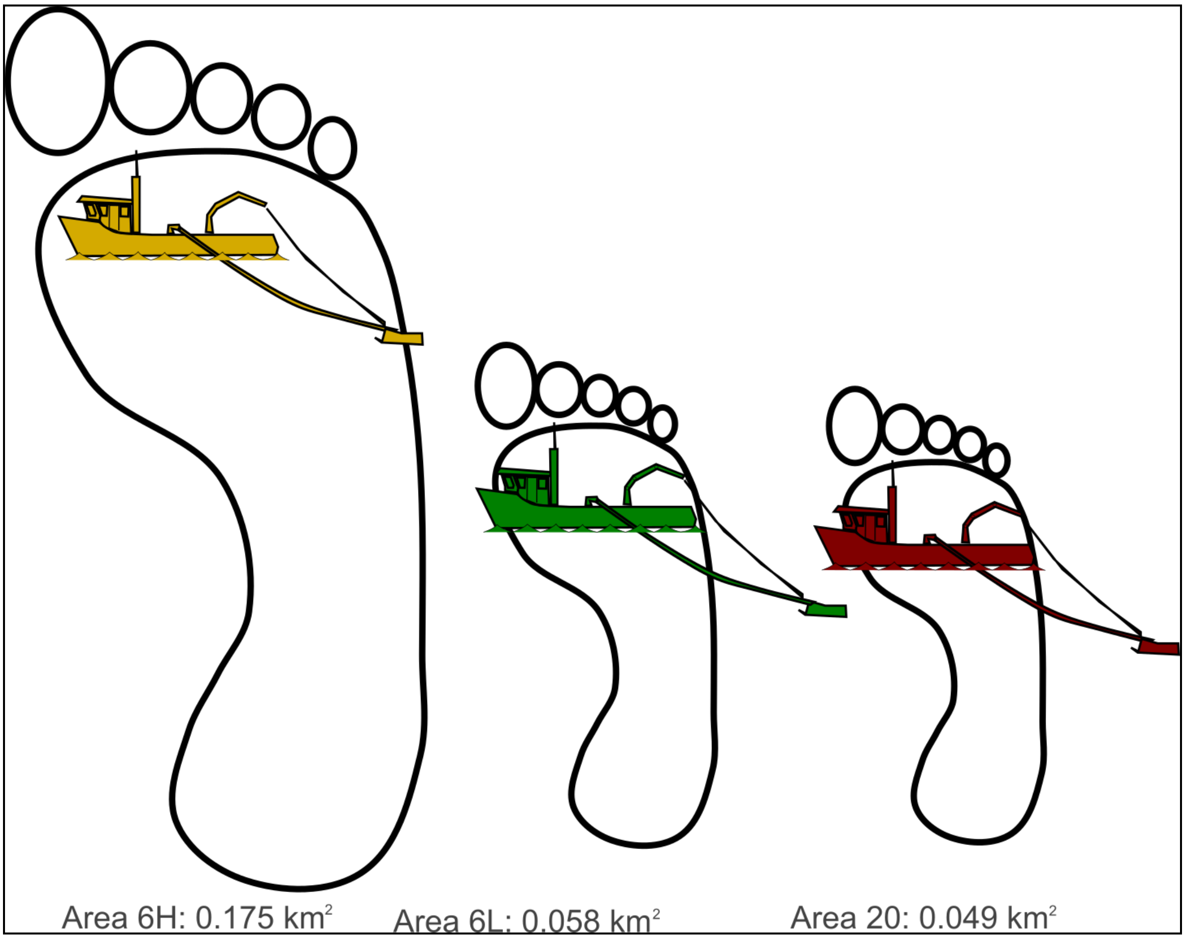


Figure 6. Area-scaled schematic showing relative fishing footprint sizes in the fishing zones from the two areas (Foulness (6) and Buxey (20), namely, 6H (yellow), 6L (green), Area 20 (red)) – expressed surface area in kilometre squared.

4.2 Swept Area Ratio from fishing footprint

Swept Area Ratio (SAR) values ranged from 0 to 0.47. A SAR value of 0.47 indicates that 47% of the seabed within 33 m of a survey station had been contacted by fishing gear. No survey stations reached a SAR value of 1, which would have indicated that the entire area surrounding a survey station had been swept once.

Fishing disturbance was unevenly distributed across the study area. A small number of survey stations experienced relatively high levels of fishing activity, while many stations experienced little or no disturbance. Consequently, many survey stations within fishing zones remained effectively unfished (Figure 4 and Figure 7).

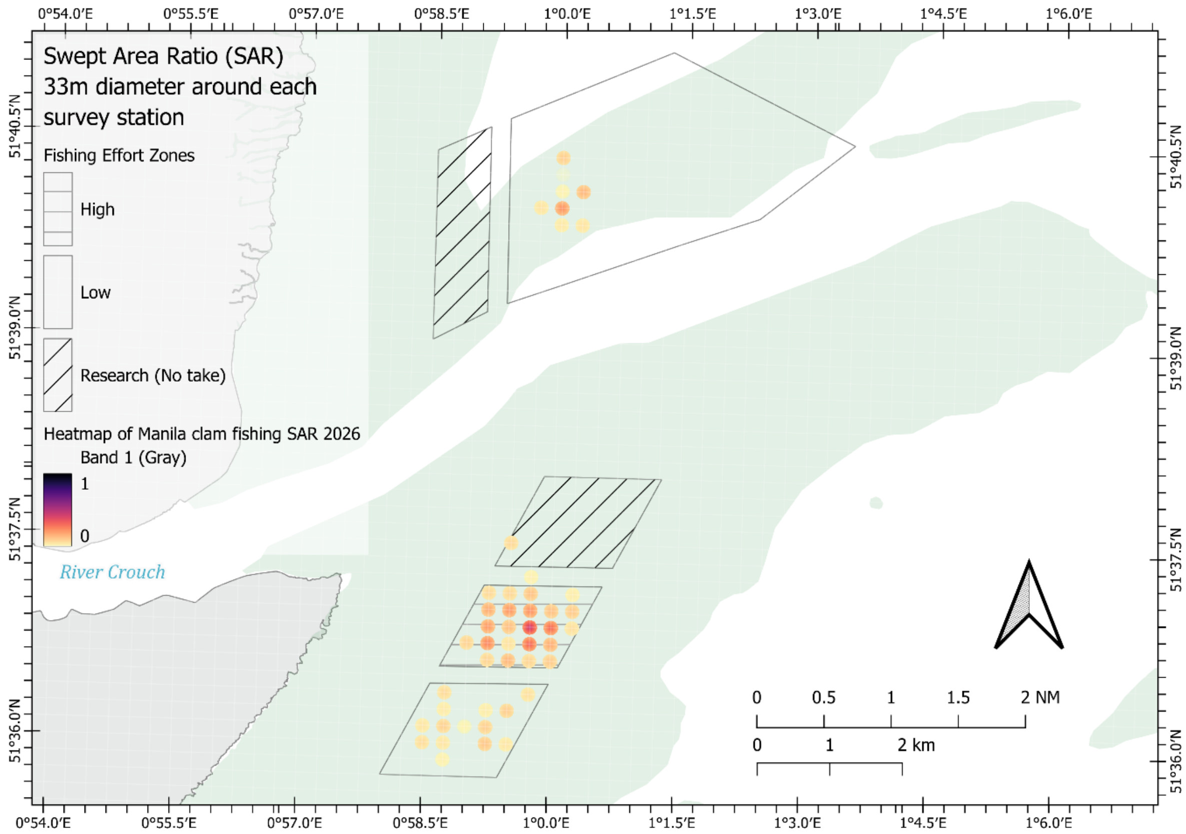


Figure 7. Swept Area Ratio (SAR) values at Manila clam survey stations, which represents the proportion of surface area that had been in contact with the fishing gear in circular-cells (33m diameter) around each survey station. (Maximum SAR value 0.47)

4.3 Fishing effort among Areas

Fishing effort was unevenly distributed between fishing areas. There were clear differences in fishing effort distribution across the two areas, with the majority fishing pressure being expended in the Foulness area. Fishing effort was spread out across Foulness (Area 6 fishing zones) with 42 out of 59 survey stations experiencing some level of fishing pressure, with SAR values ranging between 0.05 – 0.47 (5% to 47% of the areas in cells around survey stations were in contact with the fishing gear). At the Buxey, only 8 survey stations had any fishing recorded, ranging between 0.01 and 0.24 in SAR values.

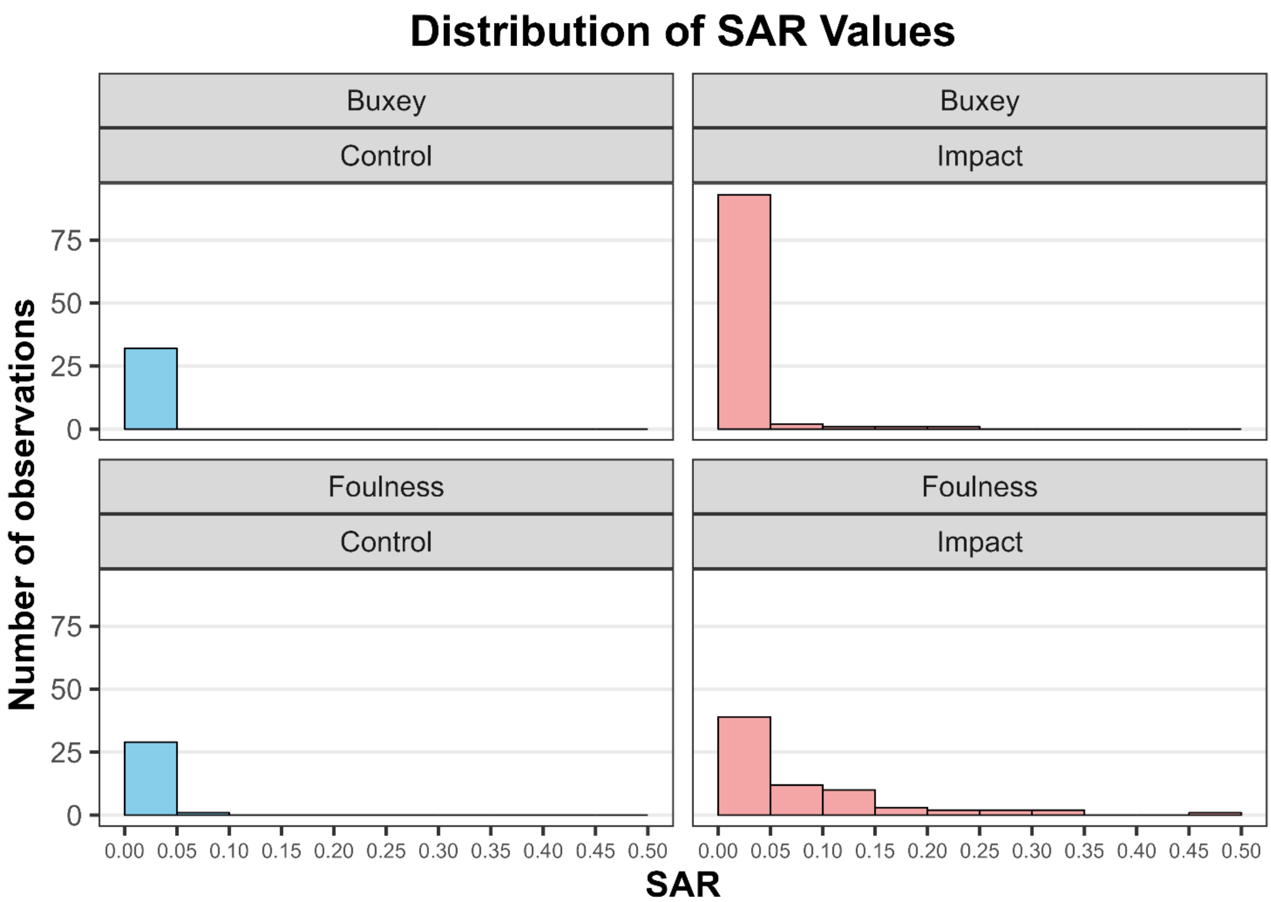


Figure 8. Histogram showing a count of the number of sampling stations displayed as tally of survey sites per 5% increments in SAR values.

4.3.1 Fishing Pressure among Zones

Fishing effort was therefore clearly unevenly distributed between the fishing zones. Only three survey stations in the High fishing effort zone (6H) had no fishing near survey sites and 23 stations which SAR ranged between 0.096 to 0.47. The Swept Area Ratio was significantly lower in the Low fishing effort zone (6L) at Foulness than 6H, with values ranging between 0.02 and 0.12, and fishing recorded at 14 out of 33 sites. At the Low fishing effort zone on the Buxey, 81 out of 89 survey stations had no fishing pressure (0 SAR values). At the eight sites where fishing was recorded SAR ranged between 0.01 and 0.24.

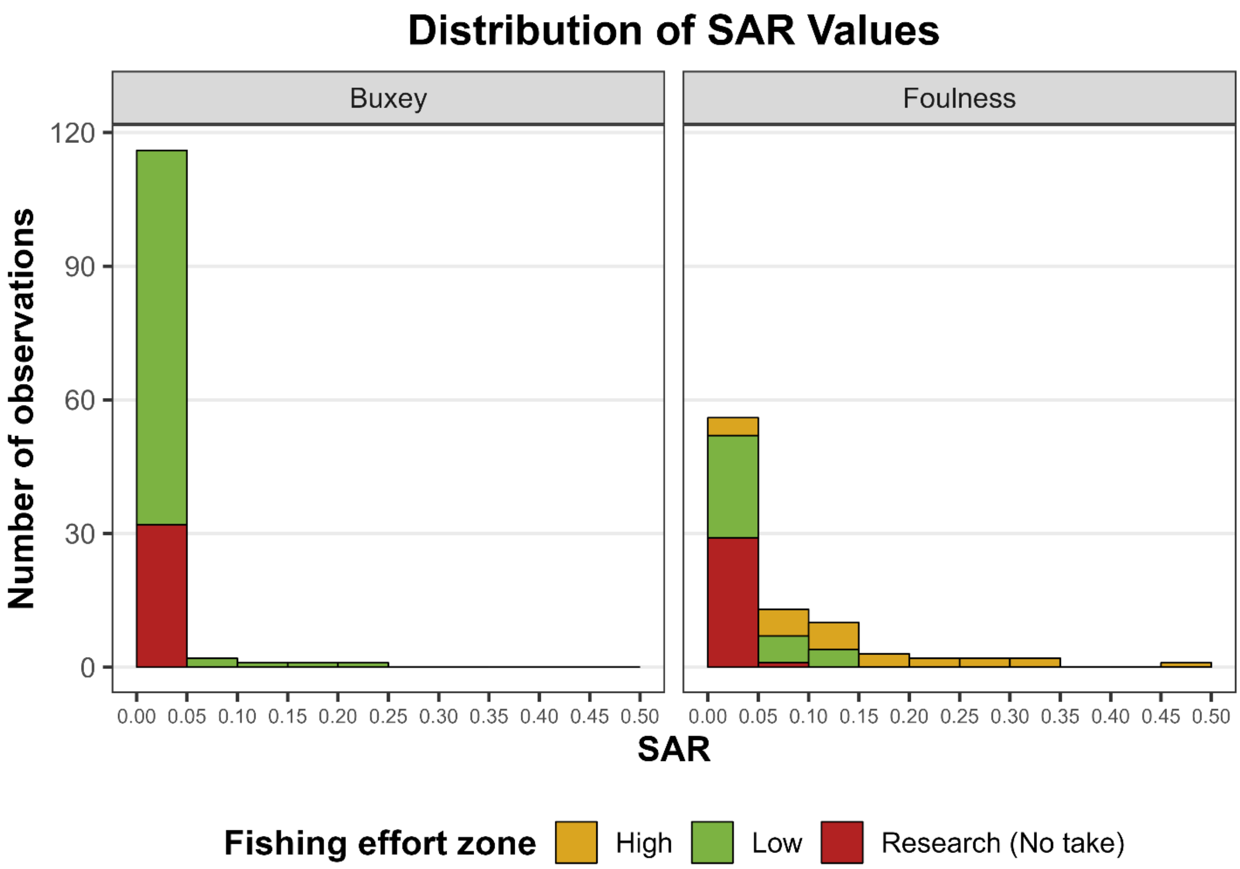


Figure 9. Number of survey stations at a given level of fishing effort represented by Swept Area Ratio (SAR) values going up in 5% increments.

4.4 Densities of Clams and Cockles Before and After Fishing

Cockle densities were generally higher than Manila clam densities in all zones before and after fishing, except in 6L and the Buxey Low-effort zone, where densities were more similar (**Table 1**).

4.4.1 Clam densities

Manila clam densities increased between the Before and After surveys in both the High- and Low-effort zones at Foulness (**Table 1**). Densities declined slightly in the Foulness Control zone. A different pattern was observed at the Buxey, where Manila clam densities declined in the fished area and remained stable in the Control zone.

4.4.2 Cockle densities

We recorded an increase in the density of cockles on Foulness in fished (High and Low effort zones) and Control zones from before to after fishing, and a decrease on the Buxey in all zones. However, all increases were relatively small compared to the mean densities (see **Table 1** for values).

Table 1. *Mean density of Manila clams and cockles (1 m²) before and after fishing in three fishing effort zones (High, Low, Control [Research-No take]). Impact here means fished, and control means not fished. Standard error values follow ± symbol as a measure of variation adjusted for n samples.*

AREA	CONTROL/ IMPACT	FISHING EFFORT ZONE	CLAMS BEFORE ± SE	CLAMS AFTER ± SE	COCKLES BEFORE ± SE	COCKLES AFTER ± SE	SAMPLES PER SURVEY
6	Control	No take	22 ± 4	19 ± 4	182 ± 20	195 ± 16	30
6	Impact	Low	69 ± 8	81 ± 11	85 ± 11	97 ± 13	33
6	Impact	High	69 ± 10	76 ± 12	129 ± 22	136 ± 35	26
20	Control	No take	10 ± 5	11 ± 04	63 ± 11	53 ± 14	33
20	Impact	Fishing/Low	36 ± 11	20 ± 4	28 ± 9	21 ± 07	89

There was no statistically significant effect of the fishing effort zone on the densities of Manila clams or cockles, in either area. The pattern in the change in densities from before to after was inconsistent between zones across the two areas (Figure 10 & Figure 11). The only decline in Manila clams observed from before to after fishing, was at the Buxey, where fishing effort was comparatively low and highly localised. We observed stability at both Control Zones and increased densities at both high and Low Effort Zones at Foulness. This inconsistency makes it unlikely that differences in fishing effort alone explain the change densities. From the change observed in this study, we cannot conclude that fishing pressure acted to increase or decrease the densities of either species at the current levels of fishing.

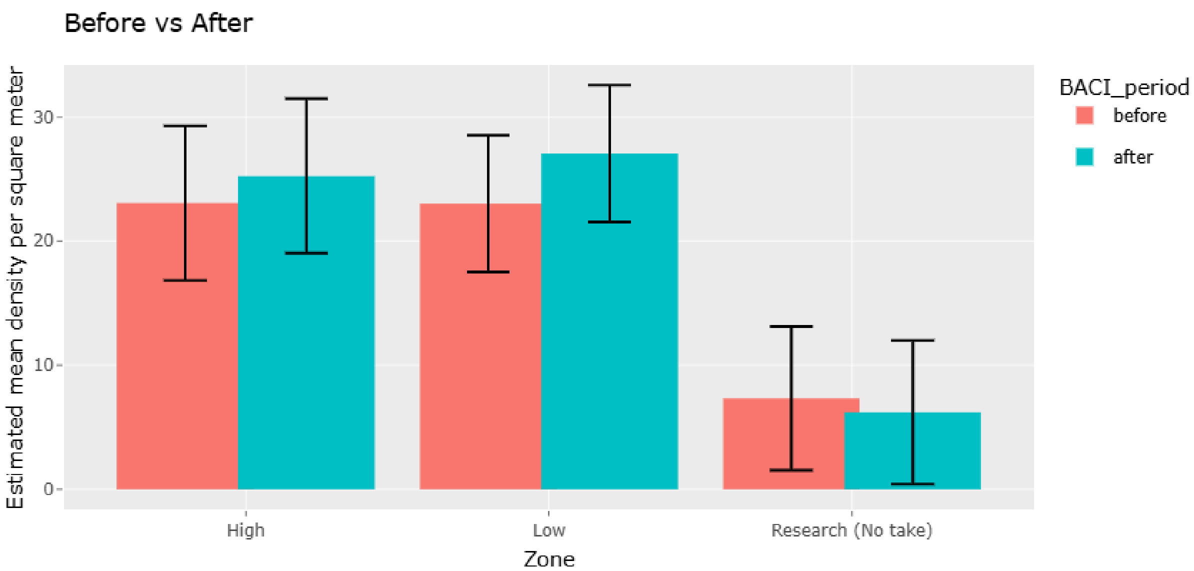


Figure 10. Densities of Manila clams before and after fishing in the three fishing effort zones on The Foulness Sand.

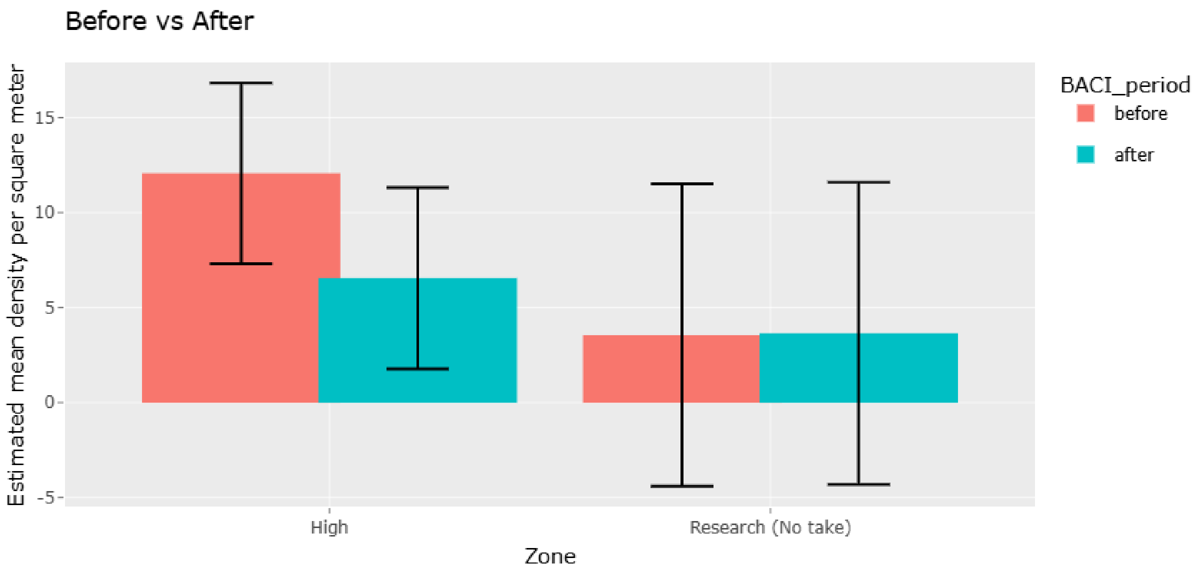


Figure 11. Densities of Manila clams before and after fishing in the three fishing effort zones on The Buxey Sand.

We tested the effects by fitting a linear mixed model to the data, for each area, which showed that there was no significant difference of density change from before to after in any of the fishing zones. The mixed-model analysis detected differences in baseline densities among zones. However, these differences remained consistent throughout the study and there was no significant Before × After effect in any fishing-effort zone.

These differences were however maintained throughout the experiment – such that the difference did not change from before to after fishing - and consequently no evidence could be found that the current levels of fishing pressure impacted the densities of either species in the experimental fishing zones.

Pairwise comparisons between the respective combinations of zones, were carried but are not reported on because there were no significant effects found between areas when comparing the before to the after densities for clams or cockles.

4.4.3 Before – After (BA)

After discounting the effects of fishing effort zones, the analysis still indicated that there was no clear overall effect of fishing on densities of either species from before to after fishing at current levels (Estimated effect size = -4.33 (Confidence Interval: -14.34 to 5.68)).

4.4.4 Before and After in Control and Impacted (BACI)

No take zones tended to have higher numbers of cockles than clams in fished areas (before and after). Conversely, fished areas tended to have higher numbers of clams than cockles, before and after. This was because fished areas were originally designed to take place in most favourable fishing areas, where calm densities were highest. However, we found that the change in densities of either species did not change significantly from before to after fishing. (This test was carried out after discounting the effects of specific effort-zones, such that the statistical test only tested for fished-versus-control sites, but still found no significant effect on the densities of either species at current fishing effort levels).

4.5 Survey station-level change from before to after fishing

The map below shows the spatial distribution of Manila clam densities (per meter square) before fishing, in March 2026 (Figure 12) and After fishing (Figure 13). The maps show that Manila clams have a patchy distribution throughout the study area. On Buxey, we can see patches of high densities and large areas with much lower densities or even absent. On Foulness the distribution is much more uniformly high throughout the fished area – and in both areas, the fished zones clearly have higher densities than the control zones.

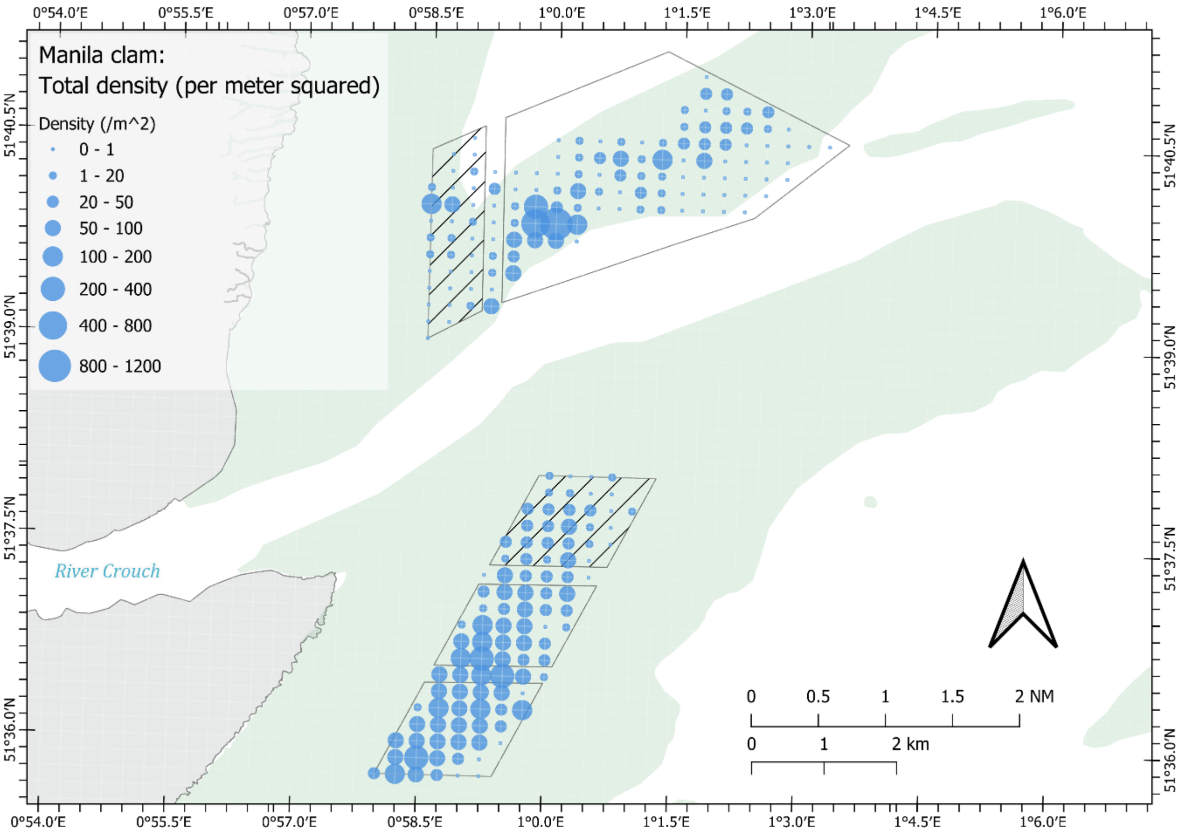


Figure 12. Map showing the density of all Manila clams Before Fishing in March 2026 in the Manila clam trial fishing areas, control sites, and boundary zones in between zones.

The spatial distribution of Manila clams, and indeed the patches of high densities remain in the same locations from Before fishing to After fishing, suggesting that the effects of fishing did not change their geographical distribution substantially. The patches with lower densities remain low, and the patches with higher densities remain high in both areas.

The largest localised decline occurred within a high-density patch in the Buxey Low-effort zone, where densities decreased from approximately 800 clams m^{-2} to between 200 and 400 clams m^{-2}.

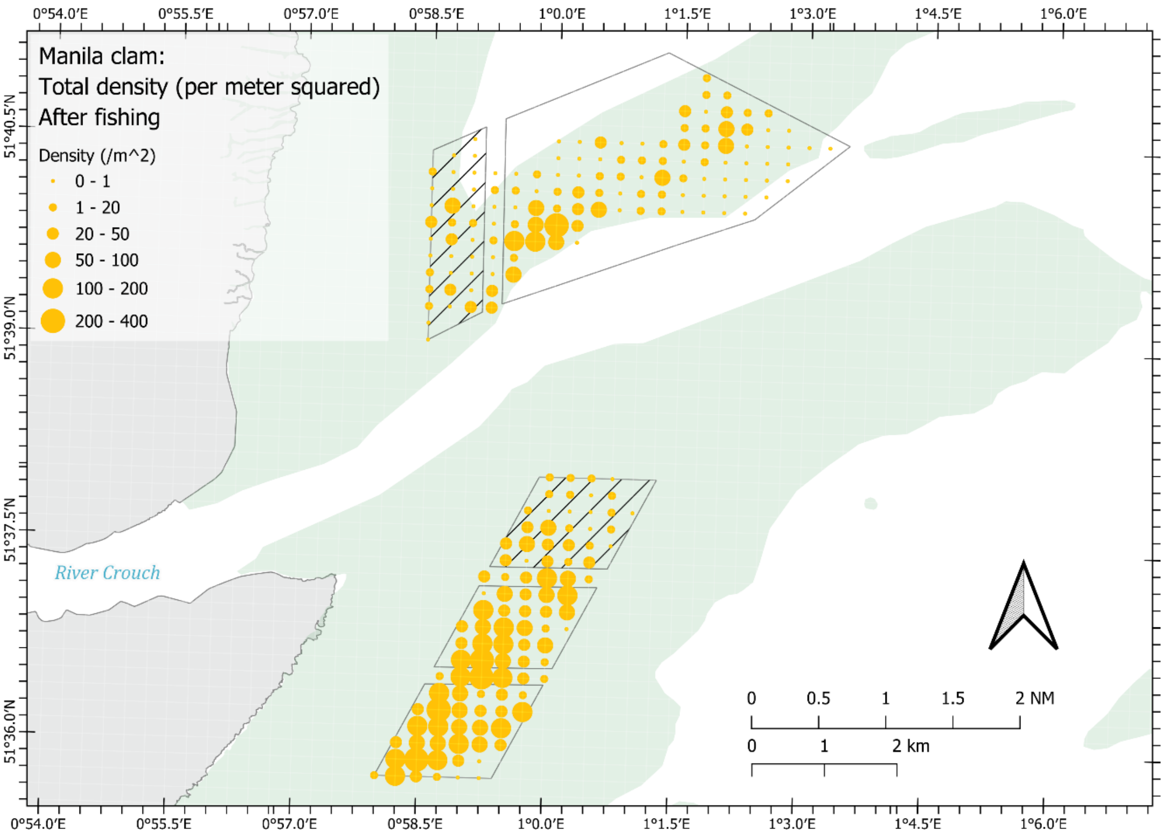


Figure 13. Map showing the density of all Manila clams After Fishing in May 2026 in the Manila clam trial fishing areas, control sites, and boundary zones in between zones.

In the plots below we show the counts of Manila clams (Figure 15) and cockles (Figure 15). Here the axes correspond to counts of individuals Before (x-axis) and After (y-axis) fishing for the same survey station. The dashed line indicates zero change, such that points falling above the dashed line indicate an increase, and below the dashed line indicates a decrease. Figure 15Figure 14 shows that most of the counts of Manila clams stayed similar between the Before and After surveys at the same. Overall, there were slightly more sites where counts increased than decreased for Manila clams. However, there were a couple of survey stations where Manila clam counts were very high before fishing (>40), while the highest was <30 after fishing. There was no clear signal for change in cockle counts at the same survey stations either, with most points falling close to the dashed line, representing low level change from Before to After.

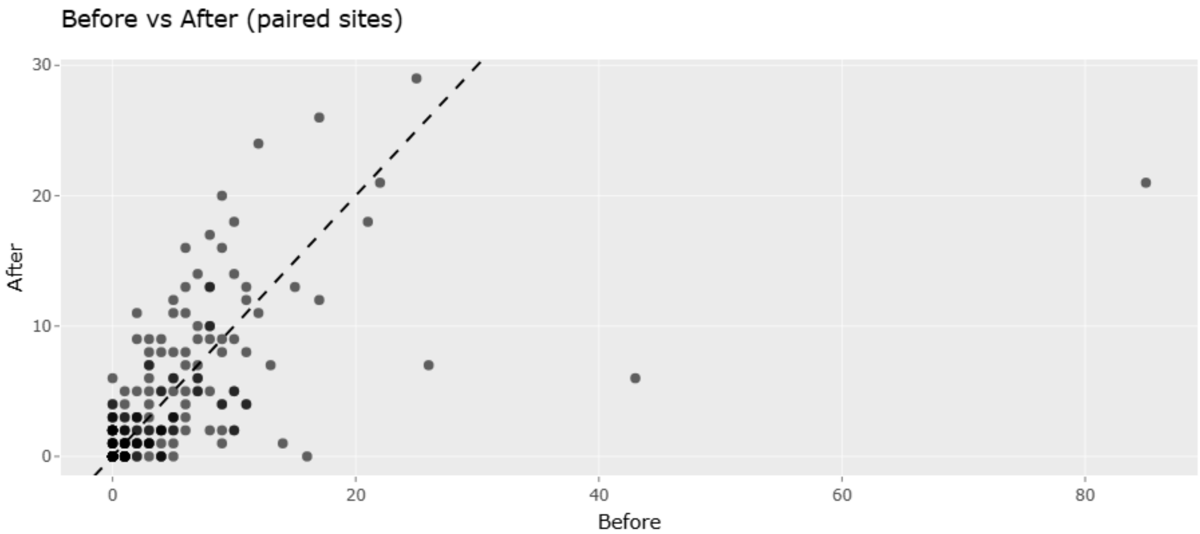


Figure 14. Before and After-fishing counts of Manila clam counts at each survey station.

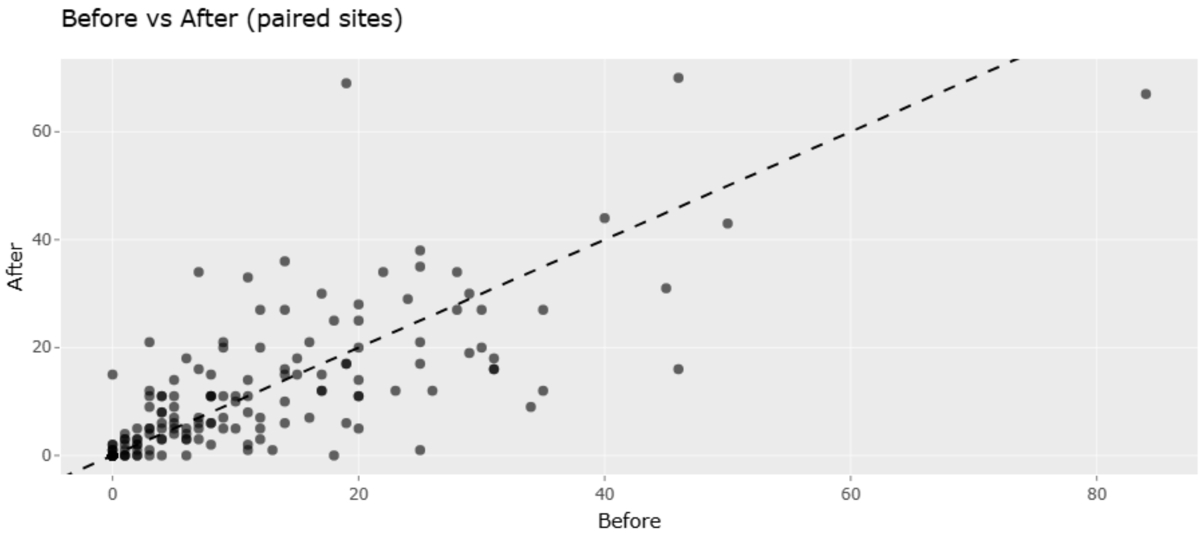


Figure 15. Before and After-fishing counts of cockles counts at each survey station.

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4.6 Fishing effort's relationship with abundance in samples

Changes in abundance were calculated by subtracting After counts from Before counts at each survey station and plotting these changes against local SAR values (corresponding SAR value at given site).

No statistically significant relationship was observed between SAR and changes in Manila clam abundance (Figure 16) or cockle abundance (Figure 17). Regression lines were approximately flat, indicating little change in abundance across the observed range of fishing effort.

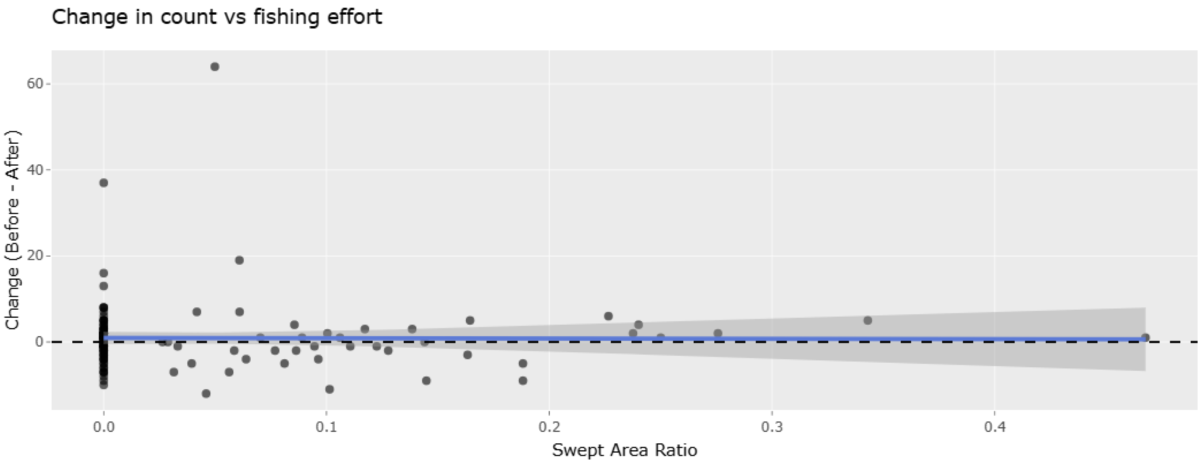

Figure 16. Change in the counts of Manila clams from individual sampling sites before vs after plotted against the fishing pressure, represented by Swept Area Raio (SAR) values.

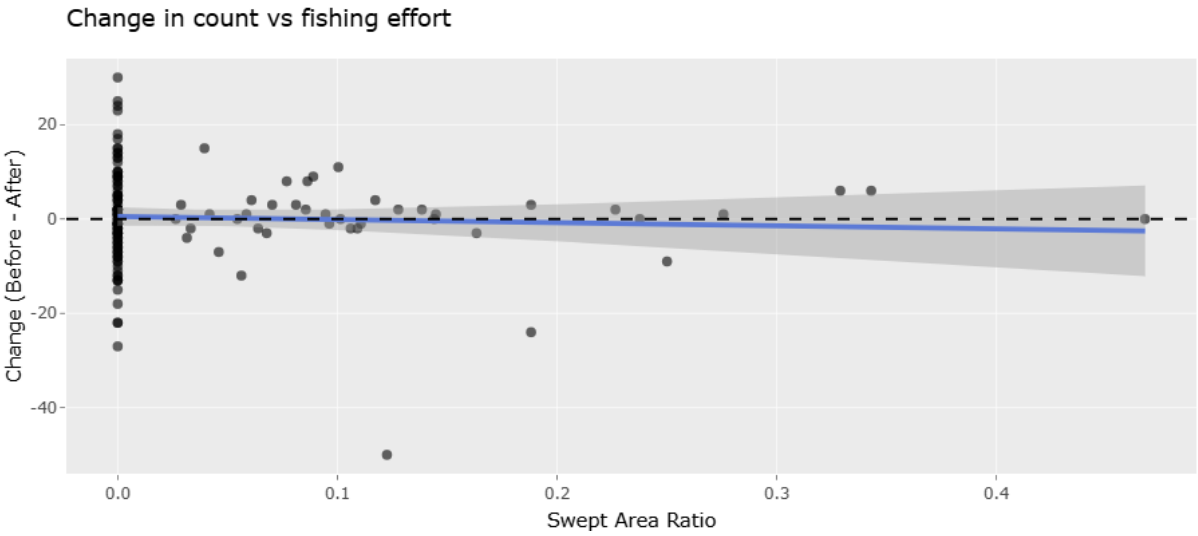

Figure 17. Change in the counts of cockles from individual sampling sites before vs after plotted against the fishing pressure, represented by Swept Area Raio (SAR) values.

5 Discussion

This study aimed to improve understanding of how fishing effort affects Manila clam populations in the Thames Estuary. Fishing effort was assessed using both fishing footprint and Swept Area Ratio (SAR), and population responses were measured by comparing clam and cockle abundance before and after fishing in both fished and unfished areas.

At the level of fishing effort allocated to the 2026 Manila clam trial fishery, we found no detectable effect on the population density of either Manila clams or cockles. We hypothesised that Manila clam densities would decline more in areas exposed to higher levels of fishing effort than in areas exposed to lower levels of fishing effort or no fishing. However, no significant differences were detected among the High-effort, Low-effort or Control zones. We therefore reject Hypothesis 1 for the range of fishing effort applied during this study.

The absence of a detectable population-level effect is likely explained by the relatively small proportion of the available fishing grounds that was directly contacted by fishing gear. The Buxey fishing area covers approximately 10 km^2 and Foulness approximately 4.5 km^2, while the fishing footprints recorded during the trial were only 0.049 km^2 and 0.233 km^2 respectively. Collectively, the fishing gear contacted around 2% of the available fishing grounds, leaving approximately 98% of the habitat undisturbed.

The results from this study indicate that the effects of fishing were highly localised. Although the direct impact within dredge tracks remains uncertain, the scale of fishing activity was too limited to produce detectable changes across the wider fishing areas. If fishing mortality and disturbance are largely confined to the footprint of individual dredge tracks, then most of the population remains unaffected and any localised reductions are unlikely to be detectable through surveys conducted at the scale of entire fishing grounds.

The second component of the study examined whether increasing fishing pressure, measured using Swept Area Ratio (SAR), resulted in greater declines in Manila clam or cockle abundance at individual survey stations. This approach was designed to address a limitation of the zone-based analysis by linking biological observations directly to localised fishing pressure.

Using SAR substantially improved the spatial resolution of the analysis. Rather than comparing large fishing areas in which much of the seabed remained unfished, SAR allowed fishing pressure to be quantified within 33 m of each survey station. This enabled us to investigate whether abundance changed in response to increasing fishing disturbance at a much finer spatial scale.

Despite this more sensitive approach, we still found no clear relationship between fishing pressure and changes in Manila clam or cockle abundance. Counts remained relatively stable across the observed range of SAR values, and no consistent directional trend was detected. We therefore reject Hypothesis 2 within the range of fishing pressures applied during the trial fishery.

It is important to note that failing to detect an effect does not necessarily mean that fishing has no effect. Rather, it suggests that fishing effort during the trial was too limited, or too spatially patchy, for population-level effects to be detected at the scale of the surveys. The results indicate that the current fishing effort falls below the threshold at which measurable declines in Manila clam abundance become apparent.

This conclusion is consistent with the study's underlying assumptions and limitations. A key assumption was that repeated surveys within fixed fishing areas would detect population-level changes caused by fishing. While this approach remains appropriate, the low level of fishing activity and the small proportion of seabed disturbed limited our ability to detect changes at the scale of the fishing grounds. Future studies may therefore benefit from explicitly comparing clam densities inside and outside individual dredge tracks, where the direct effects of fishing are most likely to be observed. If reductions within dredge tracks can be quantified, they could be related directly to fishing footprint and used to estimate the level of fishing effort associated with a given percentage reduction in abundance. This would provide an evidence-based method for determining sustainable levels of fishing effort and would support future management decisions relating to effort allocation within the fishery.

5.1 Cockle populations and bycatch

Cockles were included in this study because they frequently co-occur with Manila clams and are regularly encountered as bycatch during clam fishing operations. Although not the primary focus of this investigation, the results provide useful preliminary information on how cockle populations respond to the current level of fishing activity.

Similar to Manila clams, we detected no significant changes in cockle densities associated with fishing effort. This was not unexpected given the relatively small scale of the Manila clam trial fishery. By comparison, the local cockle fishery operating on adjacent beds removes substantially greater quantities of cockles each year. The cockle fleet may remove approximately 154 tonnes of cockles per trip, often over more than 30 trips annually, whereas the Manila clam trial involved four vessels undertaking 12 trips in total and collectively landing approximately 1.6 tonnes per trip.

Given the large difference in fishing intensity between the two fisheries, any effects of the current Manila clam trial on cockle populations are likely to be minor relative to the fishing pressure experienced during commercial cockle harvesting. Consequently, direct impacts on cockle populations do not currently appear to represent a significant management concern, although further monitoring is recommended as fishing effort increases.

5.2 Interactions between Manila clams and cockles

The relationship between Manila clams and cockles warrants further investigation. Both species occupy similar habitats and are likely to compete for food and space. It is therefore possible that changes in the abundance of one species could influence the other.

While no clear relationship was identified during this study, differences in clam and cockle densities among fishing grounds suggest that ecological interactions may contribute to population dynamics. Understanding these interactions could become increasingly important as the Manila clam population expands and as future management seeks to balance opportunities for both fisheries.

5.3 Management implications

Previous studies have shown that Manila clam populations can be vulnerable to overexploitation when harvest rates are not carefully controlled. Combined with uncertainty regarding stock size and population dynamics, this justified KEIFCA's precautionary approach to managing the trial fishery. The results of this study indicate that current fishing effort levels are operating well within sustainable limits. No evidence was found that the 2026 trial fishery caused measurable population-level declines in Manila clam or cockle abundance. This suggests that there may be scope to increase fishing opportunity while remaining within precautionary management boundaries.

However, any increase in fishing effort should continue to be supported by annual stock assessments and adaptive management. The long-term objective should be to identify the relationship between fishing effort and population response, allowing fishing opportunities to be expanded while maintaining healthy and productive Manila clam stocks.

The future vision for the fishery, developed in partnership with industry, is based on maintaining a low-volume, high-quality product capable of generating economic value at relatively low catch rates. Achieving this balance will require continued monitoring, careful management and a clear understanding of the levels of fishing effort that Manila clam populations can sustain over the long term.

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