ANNEX C

INVESTIGATING THE PRESENCE AND ABUNDANCE OF NON-COCKLE BIVALVES ON THE NORTH WIRRAL FORESHORE JULY - OCTOBER 2020

To provide evidence to inform management of non-cockle bivalves on the North Wirral Foreshore, it was necessary to develop methodology to assess the large bivalves present, and to collect information on the other bivalve species present. This report firstly outlines the ecology of targeted and opportunistically fished species that were observed during this work, and then describes the iterative process of method development, presents the evidence collected, and discusses the implications of findings.

1.0 Ecology of bivalve species

The large bivalves *Lutraria lutraria* (Common Otter Shell) and *Mya arenaria* (Sand gaper) have been identified as species targeted by recreational gatherers on the North Wirral Foreshore, and a range of other bivalves are reported to be opportunistically fished, although thus far these species have not been identified. The ecology of the targeted species and the other small bivalves, assumed to form part of the opportunistically gathered species, are outlined below.

1.1 Ecology of targeted species

<u>*Lutraria lutraria* (Common Otter Shell)</u>

Lutraria lutraria is a deep burrowing long lived bivalve in the Mactridae (trough shell) family. *L. lutraria* inhabits sand, sandy mud and gravel substrates from the low intertidal to continental shelf (200m), and is distributed throughout the UK (Oliver *et al.* 2016).

Once buried as juveniles the pedal muscle becomes atrophied and the animal remains permanently buried. They are a largely sessile organism that only moves by burrowing deeper with growth and can be found at up to around 30cm depth. Siphons are long and can be 2 to 3 times the length of the animal (Holme 1959, Kerr 1981). Due to the weak pedal muscle, *L. lutraria* have poor ability to rebury following disturbance (Hauton *et al* 2003).

Few UK populations have been studied; a subtidal population in the Clyde Sea was observed to have patchy distribution. The majority of the animals present were suggested to be from one year class that settled in 1967 and were 14 years old at the time of study. Individuals from this cohort measured 11-12cm in length, the occasional individual greater than 13.5cm was suggested to have been from a population that settled in 1963. Spawning occurs during the summer with a peak in May (Kerr 1981), the age at maturity of this species is unknown.

<u>*Mya arenaria* (Sand gaper)</u>

Mya arenaria is a deep burrowing long lived bivalve in the Myidae (softshell clam) family. *M. arenaria* inhabits sand, sandy mud and muddy gravel substrates in estuaries and sheltered shores and is distributed throughout the UK (Oliver *et al* 2016). Although *M. arenaria* are most abundant in the shallow subtidal and low intertidal, they have been observed as deep as 192m (Tyler-Walters 2003). The species is native to North America and in its native range is an important commercial species. *M. arenaria* is thought to be one of the earliest invasive species possibly brought to European waters in the 15th to 17th centuries and is now considered naturalised (Jensen 2010,Tyler-Walters 2003)

Burrowing may not be by muscular mechanism. Jensen (2010) suggests burial is achieved by ejecting water through the small pedal gap in the anterior end of the mantle, and that the pedal foot is small and serves as an anchor during burial. However, Tyler-Walters (2003) discusses the decreased size of the pedal muscle in adults compared to juveniles, suggesting that the inability to raise the shell in position inhibits reburial in specimens larger than 50mm. The siphons are long and leave a characteristic ‘keyhole’ shaped hole in the sediment, and the depth of burial is up to 50cm (Tyler-Walters 2003).

Reproduction has been reported to first occur between the sizes of 20-50mm, relating to an age of 1-4 years. Spawning has been recorded to occur once or twice a year between March and November; in European waters larvae are most often found in May and June. Populations are patchy and recruitment success is sporadic (Tyler-Walters 2003).

1.2 Ecology of opportunistically fished species

White furrow shell (*Abra alba*)

A small thin shelled oval bivalve species which can grow to 25mm in shell length (Budd, 2007). *Abra alba* is widely distributed around the UK and typically inhabits muddy fine sand and mud substrates, and has a depth range from the lower shore to 70m (Budd, 2007). Size of maturity is approximately 7-9mm and the species has a high fecundity of 10,000-100,000 eggs (Budd, 2007). As with most bivalves, fertilisation occurs externally and the species has a planktonic larval stage before settling out. Due to this there is the potential for very high mortality as well as dense settlements.

Striped venus clam (*Chamelea striatula*)

A medium sized bivalve with a thick triangular shape and fine concentric ridges, which can grow to 40mm in shell length (Carter 2008). *Chamelea striatula* is common around the UK other than in the south east of England, and typically inhabits sand and muddy sand substrates, and has a depth range from the lower shore to 55m (Carter, 2008). Literature is limited on the life history of the species.

Baltic tellin (*Limecola balthica*)

A small round bivalve which can grow to 25mm in shell length (Budd & Rayment, 2001). *Limecola balthica* is common in estuaries and on tidal flats around the UK and inhabits sand, mud and muddy sand substrates, and has a depth range from the upper shore to 190m (Budd & Rayment, 2001). Size of maturity is approximately 3-6mm with suggestion that there is a time dependency by which the species matures in its second year (Budd & Rayment, 2001). The species has a high fecundity of 10,000-100,000 eggs (Budd & Rayment, 2001). As with most bivalves fertilisation occurs externally and the species has a planktonic larval stage before settling out. Due to this there is the potential for very high mortality as well as dense settlements.

Thin tellin (*Macomangulus tenuis*)

A small rounded triangular bivalve which can grow to 30mm in shell length (Carter, 2005). *Macomangulus tenuis* is common around the UK and inhabits sandy habitats, and has a depth range from the middle shore to 10m (Oliver et al., 2016). Literature is limited on life history but it is expected that it is similar to *Abra alba* in terms of a high fecundity.

Rayed trough shell, surf clam (*Mactra stultorum*)

A medium size bivalve which can grow to 51mm in shell length (Oliver et al., 2016). *Mactra stultorum* is widely distributed around the UK and typically inhabits sand and muddy sand substrates, and has a depth range from the intertidal to 200m (Oliver et al., 2016). Literature is limited on the life history of the species.

Cut trough shell (*Spisula subtruncata*)

A small thick shelled bivalve which can grow to 26mm in shell length (Oliver et al., 2016). *Spinsula subtruncata* is widely distributed around the UK and typically inhabits silt and muddy sand substrates, and has a depth range from the intertidal to 200m (Oliver et al., 2016). Literature is limited on the life history of the species.

2.0 Development of survey methodology

The area of the North Wirral Foreshore observed to be targeted by recreational gatherers is an approximately 5km stretch of beach from Kings Parade to Leasowe lighthouse (figure 1). Although gathering had been recorded to happen most frequently in discrete areas of the beach, to assess the distribution and abundance of large bivalves it would be necessary to survey a large area. Observations made by IFCOs and Science Officers have recorded the presence of large bivalves from the near shore to the extreme low water mark.

The size of the area to be assessed for this study was determined during a pre-survey assessment of the beach (described in full in section 3.2.1) and is approximately 4.3km^2, dependant on the height of the tide above chart datum. To survey this area robustly and within the capacity of the Science team posed a variety of issues to overcome, and are discussed below.

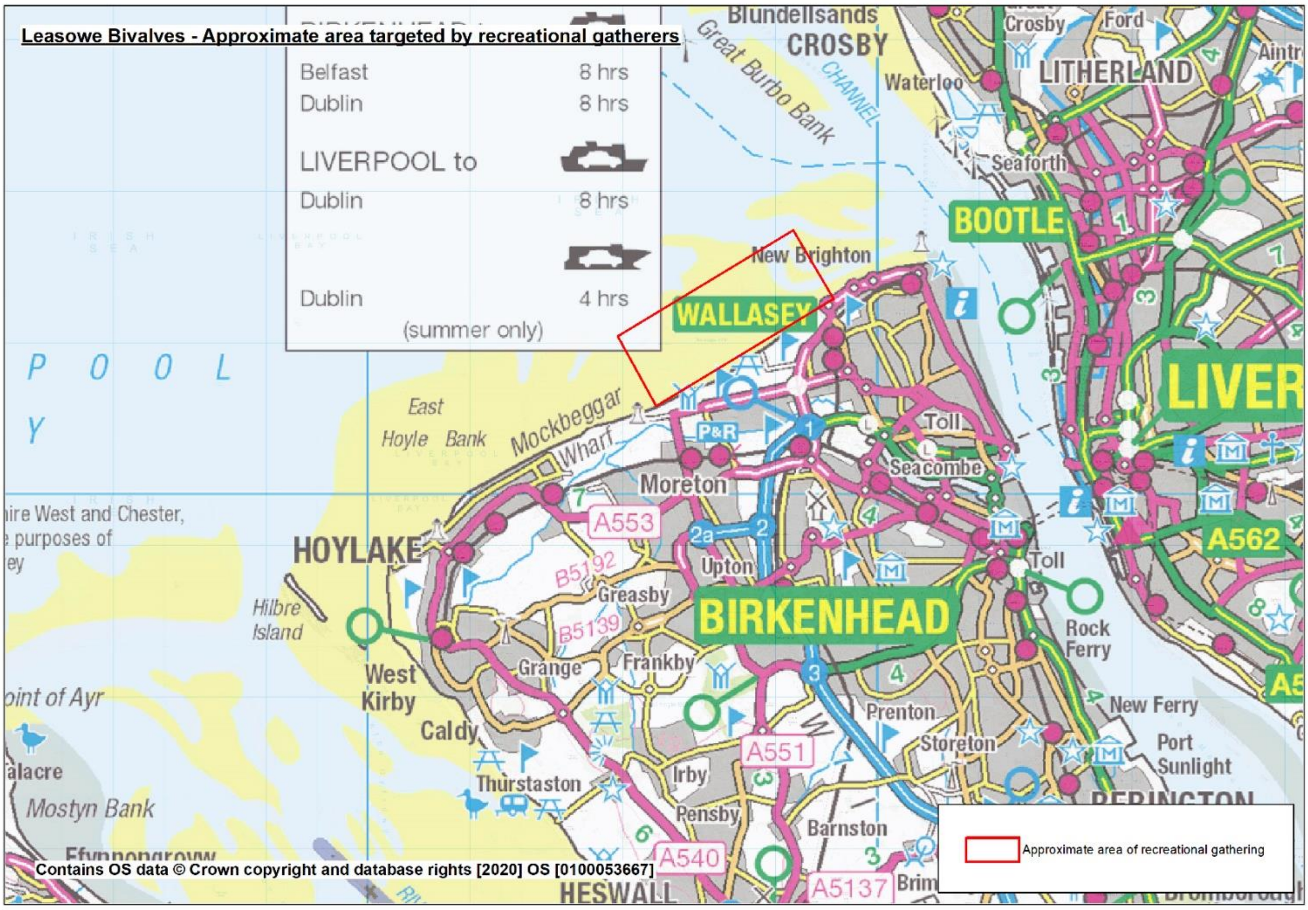

Figure 1. Approximate area of the North Wirral Foreshore that is tageted by recreational gatherers.

2.1 Problems in surveying buried clams over a large intertidal area

The large bivalves described in section 1.1 burrow to a maximum depth of 30-50cm (Oliver *et al.* 2016, Tyler-Walters 2003), and as such it would not be possible to liquefy the sand with a jumbo and survey by the same methodology as a cockle survey. Alternative survey methods include grab sampling from a vessel and digging of quadrats. The issues with these methods are briefly discussed below.

2.1.1. Vessel grab sampling

Grab sampling from a vessel requires a suitable depth of water below the vessel for its safe operation. Grab sampling would be conducted from the North Western Protector; the intertidal areas of Leasowe beach would only be covered in sufficient water for this vessel for a very limited amount of time either side of high water, severely restricting the number of grab samples that could be undertaken. The grabs available for use are the Day grab and Mini Hamon grab. The Day grab has a maximum digging depth of 10cm, and the Mini Hamon a maximum digging depth of 20cm. Neither of these grabs will reach the average burying depth of the target large bivalves.

2.1.2 Digging quadrats

Standard methods for surveying intertidal clams is by digging quadrats (Gillespie and Kronlund 1999, Barber *et al* 2009). The size and number of quadrats required for the survey are determined by species distribution and characteristics. The patchy distribution of large bivalve species suggests a larger 1m² quadrat to be appropriate, dug to an average of 30cm depending on the size of the clam. Excavating this area to this depth would be time consuming and destructive to any beach organisms encountered.

2.1.3 Issues brought by scale of the intertidal area

As there is little data on large bivalves on Leasowe beach, the distribution of bivalves other than cockles is unknown. The density of the target organism in a survey would normally dictate the sampling rate, i.e. the number of quadrats required. Using the minimum sampling rate stated in Gillespie and Kronland (1999) of

10 quadrats per hectare, to assess the 430 hectares identified for the survey of Leasowe beach, the number of samples required would be far beyond the capacity of the science team.

2.2 Overcoming issues with surveying large bivalves on a large intertidal area

Although there were concerns on the sample frequency and survey methodology, to further our understanding of the beach and assess how realistic digging quadrats would be, a pre-survey assessment was conducted on Leasowe beach.

3.2.1. Pre-survey assessment

The aim of this assessment was to roughly delineate sediment types, make observations on the organisms present and gain understanding from the local IFCOs on areas that recreational gathering of large bivalves had been observed most frequently.

The survey was conducted on the 26th July 2020, low water was at 10:42 and the height of the tide at low water was 1.4m (Liverpool tides).

Officers surveyed a 427 ha area of Leasowe beach that includes the main area targeted by recreational clam gatherers. Officers were able to discriminate roughly between sediment types, raised and lower areas of the beach and make observations of organisms indicated by surface shows (figure 2). This resulted in three main groupings of beach type and a large channel that runs through the area. The proportion the surveyed area allocated to each beach type is summarised in table 1. Additionally officers delineated the main areas targeted by recreational clam gatherers. Two areas were identified, the largest was within the surveyed area of beach. Examples of the sandy mud habitat and the shows of large bivalves are shown in figure 3.

Table 1. Summary of beach types identified on Leasowe beach 26-07-20.

Rough beach types	**Label**	**Area (ha)**	**Proportion of surveyed area (%)**
Sandy raised area	S	51	12
Sandy areas occasional sand mason and worm casts	OS	108	25
Sandy mud, sand masons, worm casts, cockles	MS	260	61
Channel	-	9	2
	Total	**427**	

3.2.2 Method development

Officers investigated techniques for quantifying larger bivalves that cannot be enumerated using jumbos to bring them to the surface. Standard methodologies for surveying intertidal clams dig quadrats of a size appropriate to the density of the organism, to a depth dependent on the depth the organism can be found, at a sampling rate appropriate to the area to be surveyed (Gillespie and Kronlund 1999).

Previous observations of the largest clam targeted by recreational gatherers at Leasowe, the Common Otter Shell (*L. lutraria*), have indicated a relatively low density distribution on the beach when compared to cockle. As such officers selected a 1m² quadrat and trialled digging to a 30cm depth. Officers found digging quadrats destructive to all beach organisms, time consuming, and had concerns that due to the relatively low distribution of Otter clams on the beach the number of quadrats that would have to be dug would require more capacity than is available.

Based on methodology developed for surveying Razor clams, officers marked out a 10m by 10m plot (100 m²) and located all shows of organisms present in the plot. Digging every show present in the plot would be possible, but again time consuming and as such officers investigated an alternative approach to determining which show contained a clam. Clams can have distinctive shapes to their shows often described as a keyhole shape.

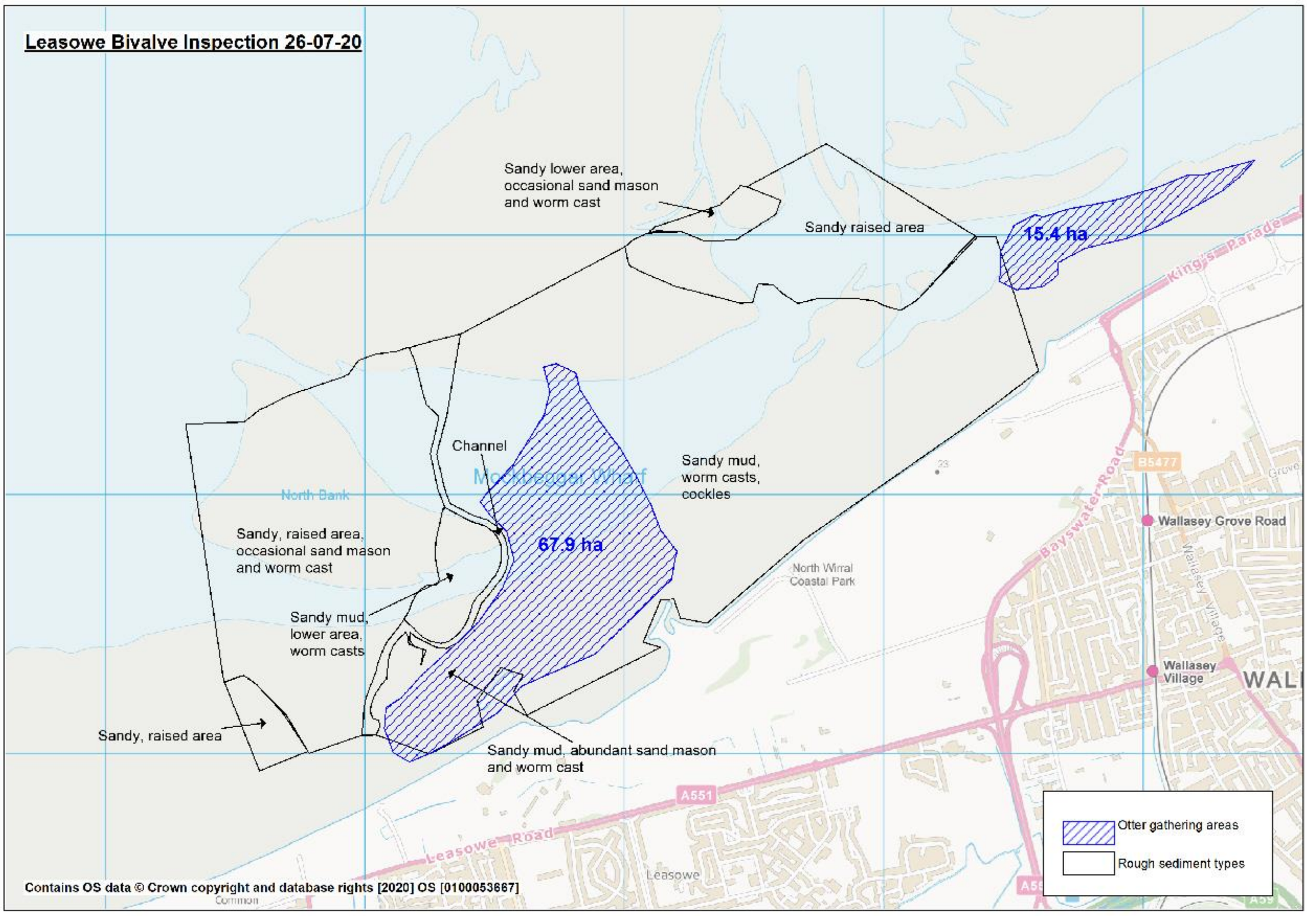

Figure 2. Distribution of rough habitat types on Leasowe beach, July 2020. Areas were delineated by assessing sediment type and presence of organisms. Total area surveyed including the channel was 427.2 ha (4.3 km^2). Areas where gathering of large bivalves had been observed by local IFCOs are outlined in blue.

Figure 3. Muddy sand with sand masons (left) and large bivalve show (right).

Officers had previously investigated the use of this technique in determining the location of Otter clams, but found the similarity of the shows to other beach organisms (e.g. sea potato) required a great deal of practice in identification and generated a lot of uncertainty. However, officers found that by inserting a finger into the show and examining the behaviour of the hole as it got deeper it was possible to differentiate between clams and other organisms with relative certainty. If the hole became larger as it got deeper, then it was very likely to contain a large bivalve. If the hole remained narrow and it took force to continue further, it was not likely to be a large bivalve. Officers validated this by digging by hand around the show to reveal the organism.

Investigating the show in this manner to differentiate between shows likely to be from large bivalves, and digging by hand, greatly reduced the destructive nature of the survey. Officers estimated that with some validation of organisms inhabiting shows, a 10m by 10m plot could be assessed in 15 minutes, depending on how many organisms were excavated. This approach may yield a more rapid and therefore thorough assessment of large bivalves on Leasowe beach.

These investigations found two species present in the 10m by 10m plot, Common Otter Shell (*L. lutraria*) and Sand Gaper (*M. arenaria*). These were identified in the lab and the ranges of lengths and weights are outlined in table 2. It would not be possible to visually differentiate between the shows of the two species of large bivalve; however due to the nature of the indiscriminate and opportunistic fishing undertaken by the recreational gatherers, the rapid assessment of large bivalves would be of more value to informing future management than a more in depth understanding of the distribution of each of the species. As such the rapid visual assessment was taken forward to the next stage of method development.

Table 2. Large bivalves sampled on Leasowe beach 2-07-20

Species	Count	Length (mm)	Weight (g)
Sand Gaper (*Mya arenaria*)	3	59 - 104	26.8 - 117.4
Common Otter Shell (*Lutraria lutraria*)	8	92 - 107	61.3 - 119.5

3.2.3 Opportunistic assessment of the distribution of small bivalves on Leasowe beach

Officers undertook the cockle survey on Leasowe on the 6th of August 2020 (LW 08:27, 1.5m Liverpool tides). To supplement understanding of the distribution of small bivalves on Leasowe beach, cockle survey stations where small bivalves were observed were recorded during the survey and results overlaid on the rough habitat types assigned to the beach (figure 4). Bivalves observed during the survey were Surf clam (*Mactra stultorum*), Thin tellin (*Macomangulus tenuis*) and Baltic tellin (*Limecola balthica*). There is an indication that small bivalves prefer the muddy sand habitat on Leasowe beach although there is not sufficient evidence from these observations to be conclusive.

4.0 Preliminary study of non-cockle bivalves on Leasowe beach.

To assess the presence and distribution of non-cockle bivalves across the identified habitat types on Leasowe beach, a stratified randomised survey was planned. This survey was designed to both identify non-cockle bivalves present on Leasowe beach and the habitat type they were found in, and to validate the rapid assessment methodology. The results of this survey would inform the next iterative stage of the investigation.

4.1 Preliminary survey planning

The habitat types determined from the pre-survey assessment and the proportion of the survey area they represented (table 2), informed selection of 23 randomly located survey plots (figure 5). In brief, the survey area was stratified by habitat type, a 1km grid overlaid and grid squares allocated a label. Grid squares were selected using a random number generator and exact plot location by randomly clicking within that square on MapInfo. To ensure the beach was assessed out to the low water mark, an additional layer of stratification was included to place at least one plot per habitat type near to the low water mark. As we are most interested in the area where large bivalves area collected from, some additional plots were allocated to this area to be surveyed if sufficient time were available to do so.

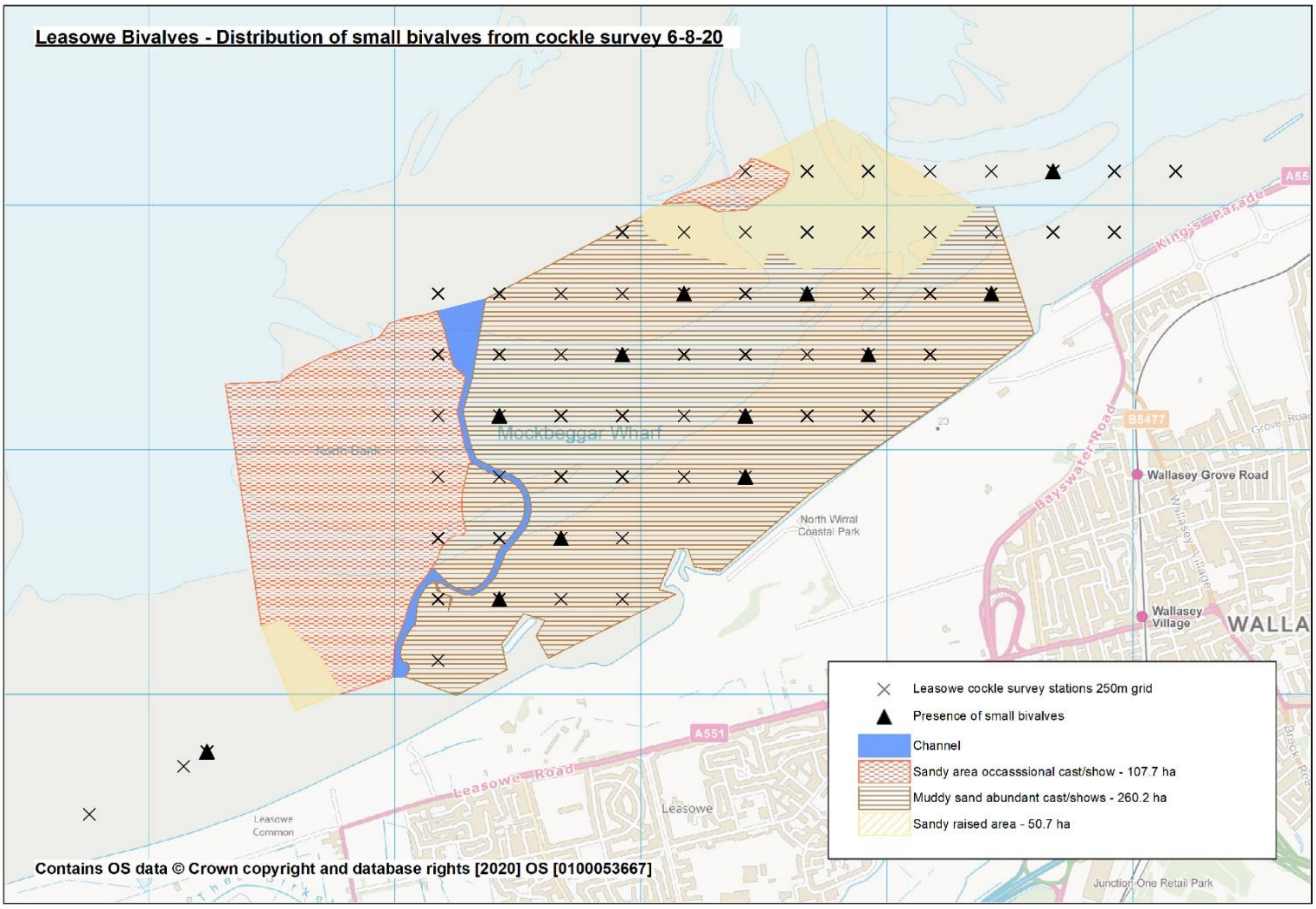

Figure 4. Locations where small bivalves were recorded during Leasowe cockle survey 6th August 2020, overlaid on the rough habitat types assigned to Leasowe beach.

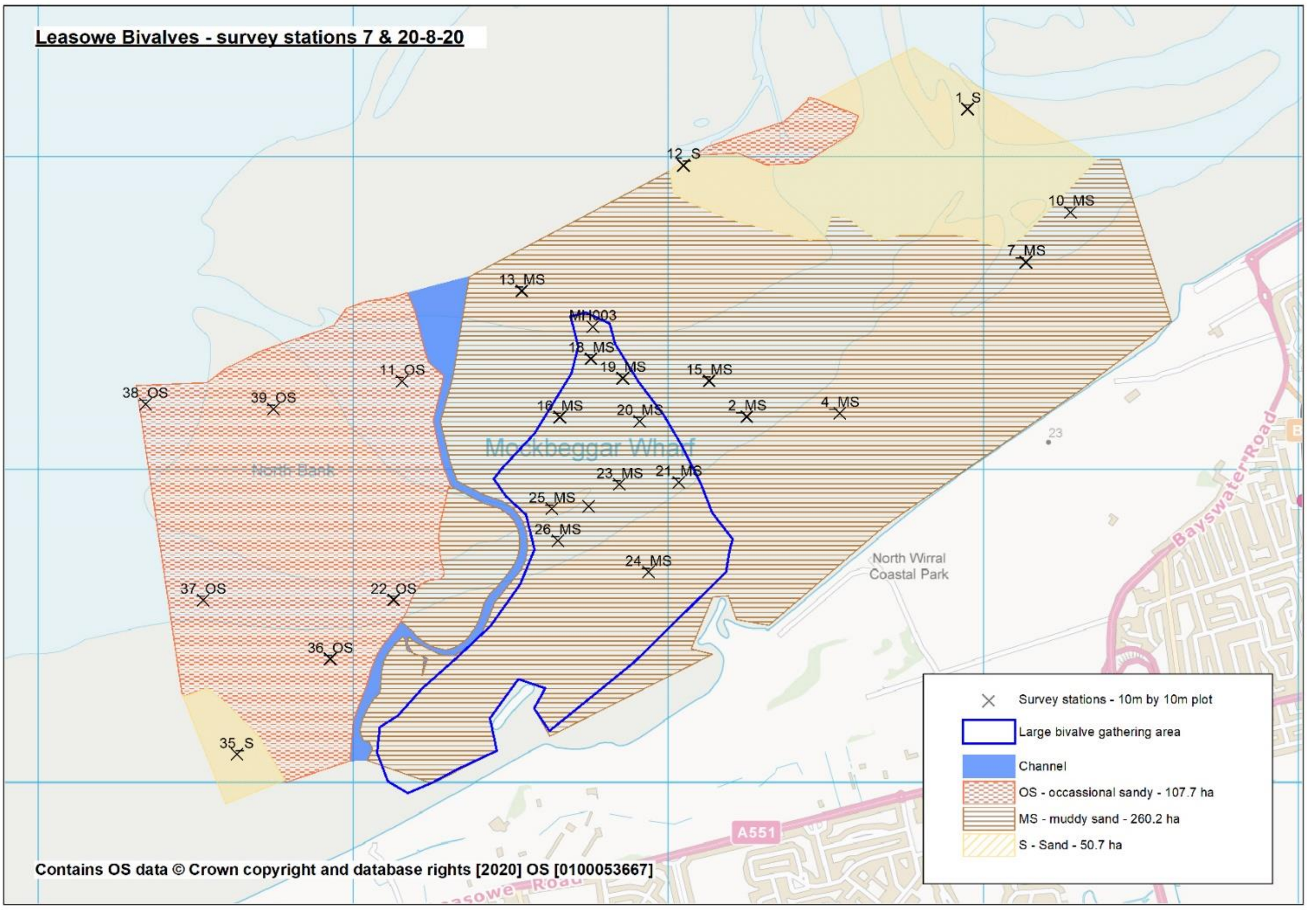

Figure 5. Plot locations for the preliminary assessment of Leasowe beach.

4.2 Methods

The survey was conducted across 2 days, the 7th of August (LW 08:59, 1.6m Liverpool tides) and the 29th of August 2020 (LW 19:42, 1.1m Liverpool tides). A 10m by 10m area was marked out using a pre-measured rope and pegs. A methodical search of the plot was undertaken and organism shows* were marked with either a red or blue flag. A red flag indicated a non-large bivalve show and a blue flag a large bivalve show. Shows thought to be large bivalves were investigated as described in section 3.2.2. To validate that the shows had been correctly identified as large bivalve or non-large bivalve, five shows from each flag colour (where sufficient numbers were present) were excavated to determine the organism present. The total number of each flag colour, and the species present in each excavated show were recorded. Figures 6-8 show examples of plots from each habitat type.

Within each 10m by 10m plot, a jumbo was used to liquefy the sand in three randomly selected locations. A 0.5m² quadrat was placed on the liquefied sand and any small bivalves collected were amalgamated to form a composite sample of small bivalves for each plot where they were present.

*There were large numbers of worm shows and casts present in some areas of the beach, it was decided that as officers were familiar with these shows (i.e. a show with clearly associated cast) they could be disregarded from the survey to reduce the time taken assessing non-large bivalve shows.

Figure 6. Example of muddy sand (MS) plot with flags indicating organism shows.

Figure 7. Example of sandy (S) habitat plot with red flags indicating non-large bivalve holes.

Figure 8. Example of sandy habitat with occasional organisms (OS) habitat with red flags indicating non-large bivalve holes.

4.3 Results

A wide range of species (n=13) were observed during the surveys (figure 9), including bivalves, polychaete worms, snails, and the sea potato (table 3). Across the two days 26 plots were surveyed. Identification of large clam holes was largely successful, only one potentially incorrect identification of a large bivalve show was recorded across the whole survey. However there were shows from both large bivalve and non-large bivalve holes that when excavated no organism was found. The number of shows and the number of empty holes for each habitat type are shown in (table 4). Large bivalve shows were found only in the muddy sand (MS) habitat type (figure 10), shows from other organisms were found across all habitat types, although a greater number of shows were observed in the muddy sand habitat (figure 11). It is important to note that no juveniles of large bivalve species were found when investigating the smaller organism shows.

Figure 9. Example of species recorded during the preliminary survey, Sea potato (left) and Sand gaper (right).

Table 3. Species present from preliminary survey on Leasowe Beach August 2020

Species name	Common name	Category
Abra nitida	Glossy furrow shell	Small bivalve
Acteon tornatilis	Lathe acteon, Beer barrel snail	Non-bivalve organisms
Cerastoderma edule†	Common cockle	Small bivalve
Chamelea striatula	Striped venus clam	Small bivalve
Echinocardium cordatum	Sea potato	Non-bivalve organisms
Ensis sp.†	Razor clam	Small bivalve
Lanis conchilega	Sand mason	Non-bivalve organisms
Limecola balthica	Baltic tellin	Small bivalve
*Lutraria lutraria**	Common otter shell	Large bivalve
*Mya arenaria**	Sand gaper	Large bivalve
Macomangulus tenuis	Thin tellin	Small bivalve
Mactra stultorum	Rayed trough shell, surf clam	Small bivalve
Spisula subtruncata	Cut trough shell	Small bivalve

*indicates species targeted by recreational gatherers
†indicates species targeted by recreational gatherers outside of the remit of this study

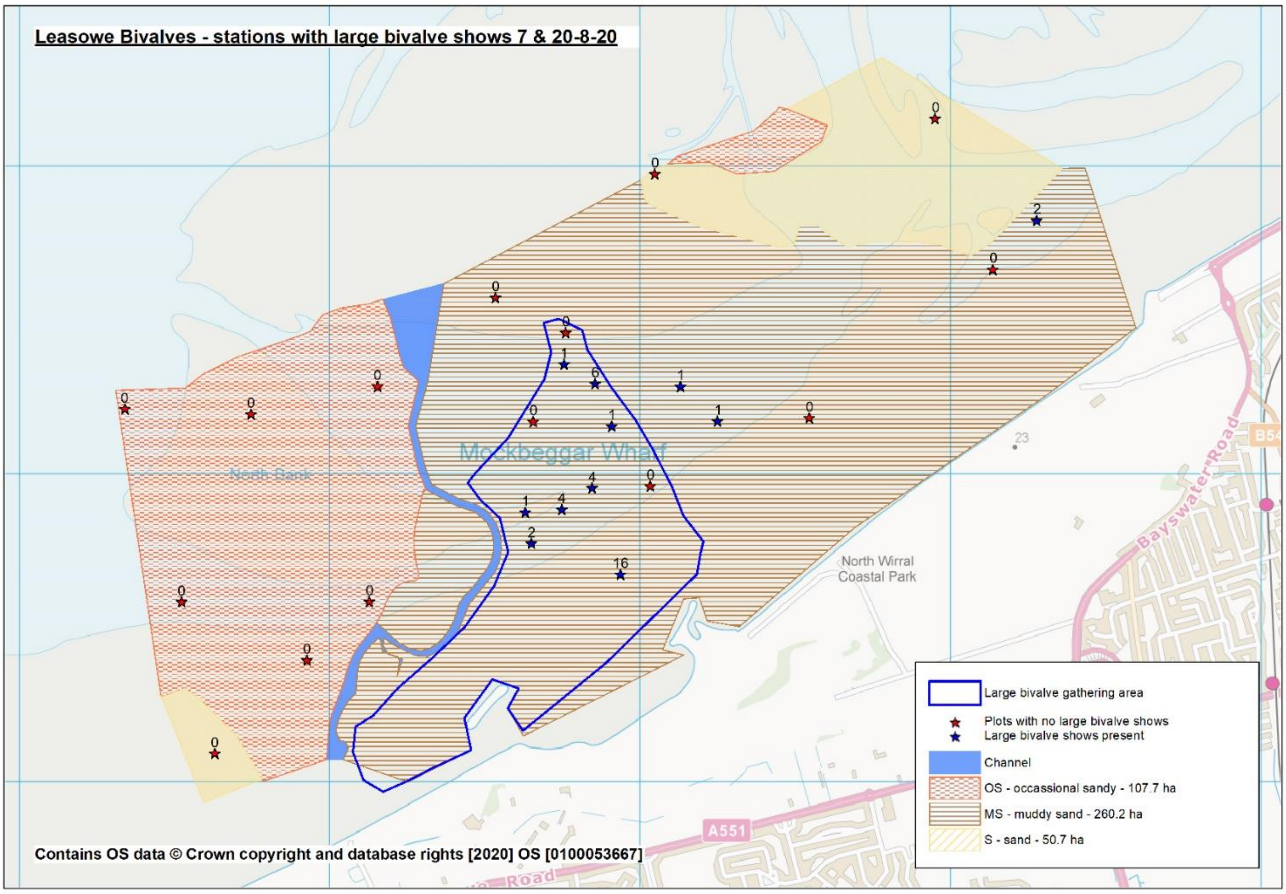

Figure 10. Survey plots indicating the number of large bivalves shows present (blue) and plots where large bivalves were absent (red) on Leasowe beach on the 7th and 20th of August 2020.

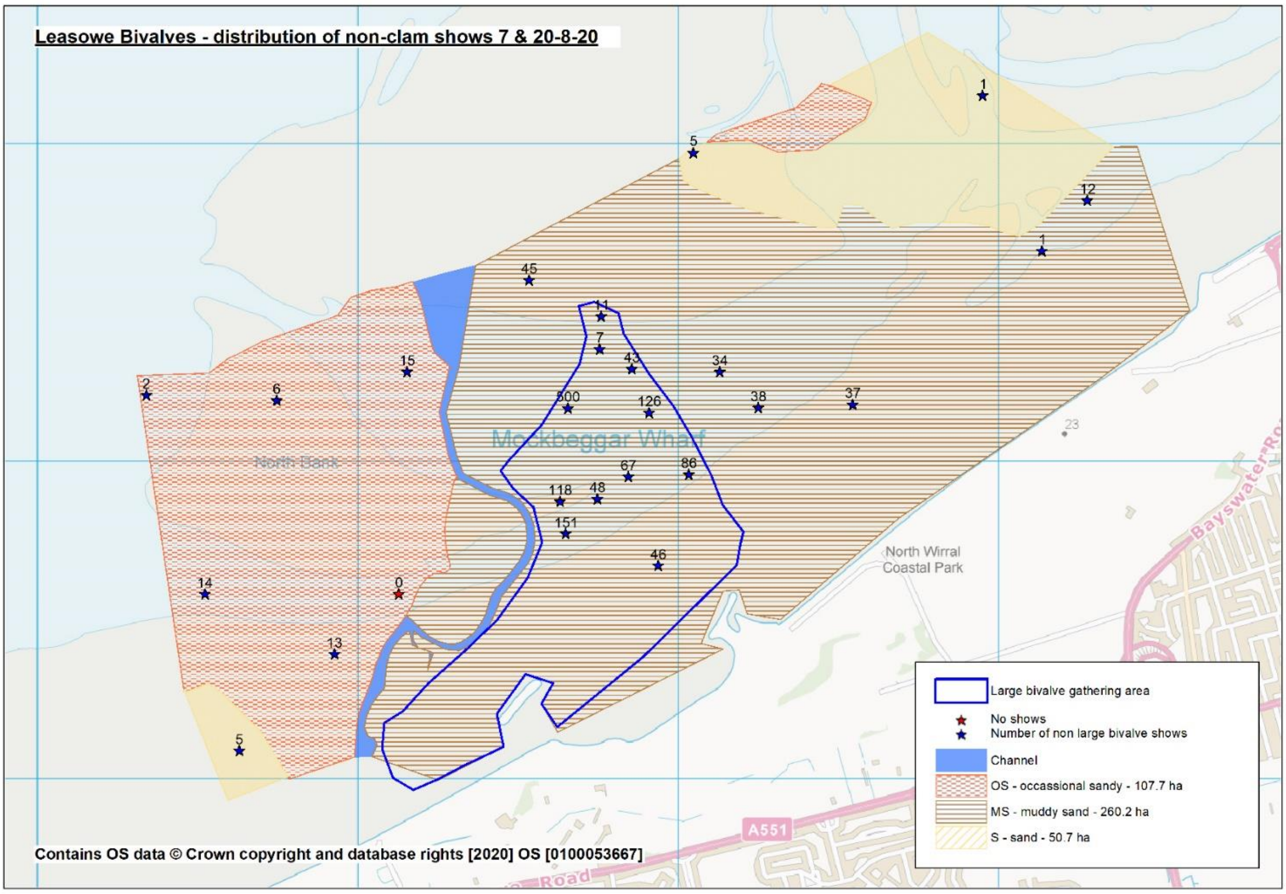

Figure 11. Survey plots indicating the number of shows from non-large bivalves organisms(blue) and plots where organism shows were absent(red) on Leasowe beach on the 7th and 20th of August 2020.

Table 4. Showing the numbers of identified shows and number of shows found to be empty

Habitat type	Count of plots	No. of large bivalve shows	No. of non-large bivalve shows	No. of empty large bivalve shows	No. of empty non-large bivalve shows
MS	17	39	1370	4	7
OS	6	0	50	0	8
S	3	0	11	0	3
Totals	**26**	**39**	**1431**	**4**	**18**

The shows of large bivalves were identified in 11 plots surveyed, the numbers found of each species and the success rate as a percentage of holes excavated is outlined in table 5. Of the surveyed plots, 100% success in locating a large-bivalve in the excavation holes of identified shows was achieved in 6 of the 11 plots, one excavation hole was found to be empty in 4 of the 11 plots, and one excavation hole contained a sea potato. The total number of holes excavated was 27, the number of empty holes was 4 and 1 hole was incorrectly identified. This yields an 81% success rate for identifying clam holes, a 15% rate of not finding an organism and a 4% rate of finding the incorrect organism.

Table 5. Survey plots where large bivalve shows were identified, the species found in each excavated hole and the success rate as a percentage of the holes that were excavated, the maximum number of holes excavated per plot was 5.

Date	Plot	No. large bivalves holes	No. of Otter clam excavated	No. of Sand gaper excavated	Empty holes	Success rate (%)
7.8.20	2_MS	1	1	0	0	100
7.8.20	10_MS	2	0	1	1	50
7.8.20	15_MS	1	1	0	0	100
7.8.20	18_MS	1	0	0	0	0*
7.8.20	19_MS	6	4	0	1	80
20.8.20	20_MS	1	1	0	0	100
7.8.20	23_MS	4	0	3	1	75
7.8.20	24_MS	16	0	5	0	100
20.8.20	25_MS	1	0	1	0	100
20.8.20	26_MS	2	0	2	0	100
7.8.20	28_MS	4	0	3	1	75
	Total	38	6	15	4	-

*This show was associated with a Sea potato in the field notes and as such is not recorded as empty.

The bivalves sampled during the study are summarised in table 6, the two large bivalve species *L. lutraria* and *M. arenaria* identified in the pre-assessment survey were observed this study. *M.arenaria* were found in higher numbers, the distribution of the two large bivalve species observed in this study is shown in figure 12. A range of small bivalves species (n=7) were observed in this study, the distribution of all species were mainly in the muddy sand habitat, there was one exception of a Thin tellin found in the occasional sandy (OS) habitat, the distribution of these species is show in figure 13. The distribution of organisms found in non-large bivalve shows are not a focus of this study, however it may be of interest to note that only the Sea potato (*E.chordatum*) was found only in the muddy sand habitat figure 14.

Table 6. Number of large and small bivalves sampled during the survey

Species name	Count	Range of lengths (mm)	Range of weights (g)
Abra alba	10	8-15	0.1-0.3
Chamelea striatula	1	25	4
Ensis sp.	1	24	0.1
Limecola balthica	4	9-12	0.1-0.2
Lutraria lutraria	7	76-108	33.9-125.6
Macomangulus tenuis	13	6-23	0.1-0.8
Mactra stultorum	8	8-20	0.1-0.9
Mya arenaria	16	84-106	63.6-162.1
Spisula subtruncata	1	14	0.6

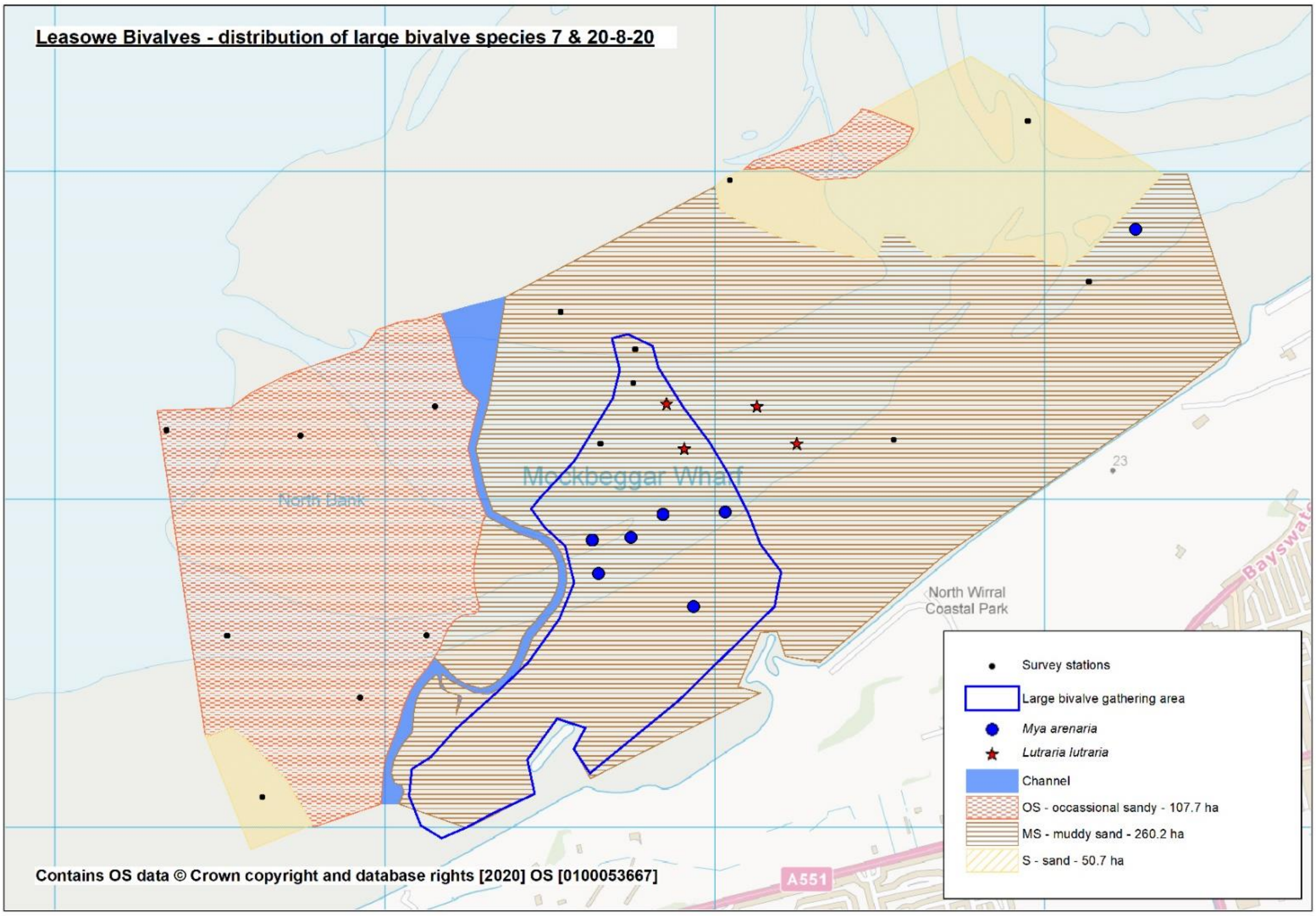

Figure 12. Distribution of the two large bivalve species, *Lutraria lutraria* and *Mya arenaria* identified during the preliminary study on the 7th and 20th of August 2020.

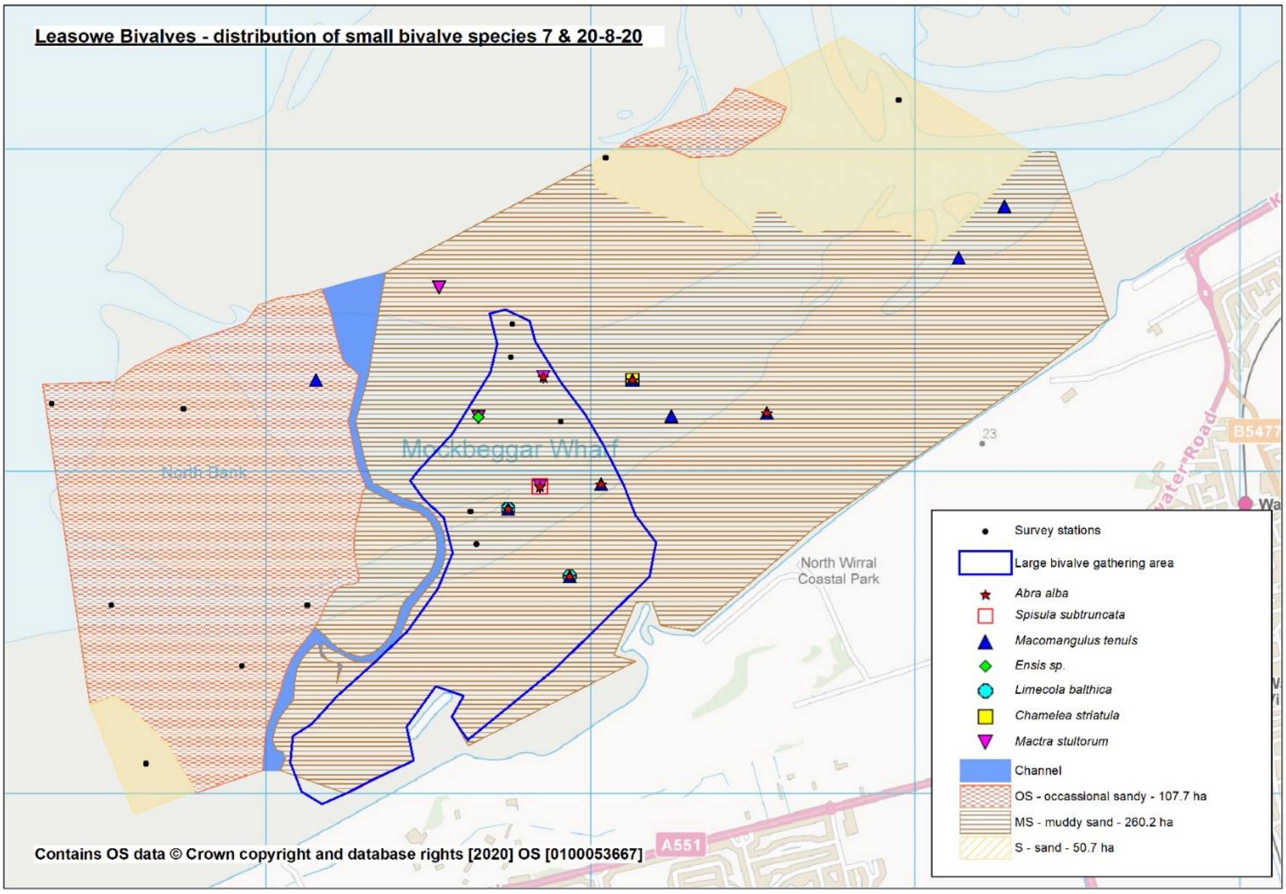

Figure 12. Distribution of small bivalve species identified during the preliminary study on the 7th and 20th of August 2020. The symbol indicating each species and the species name is indicated in the figure legend.

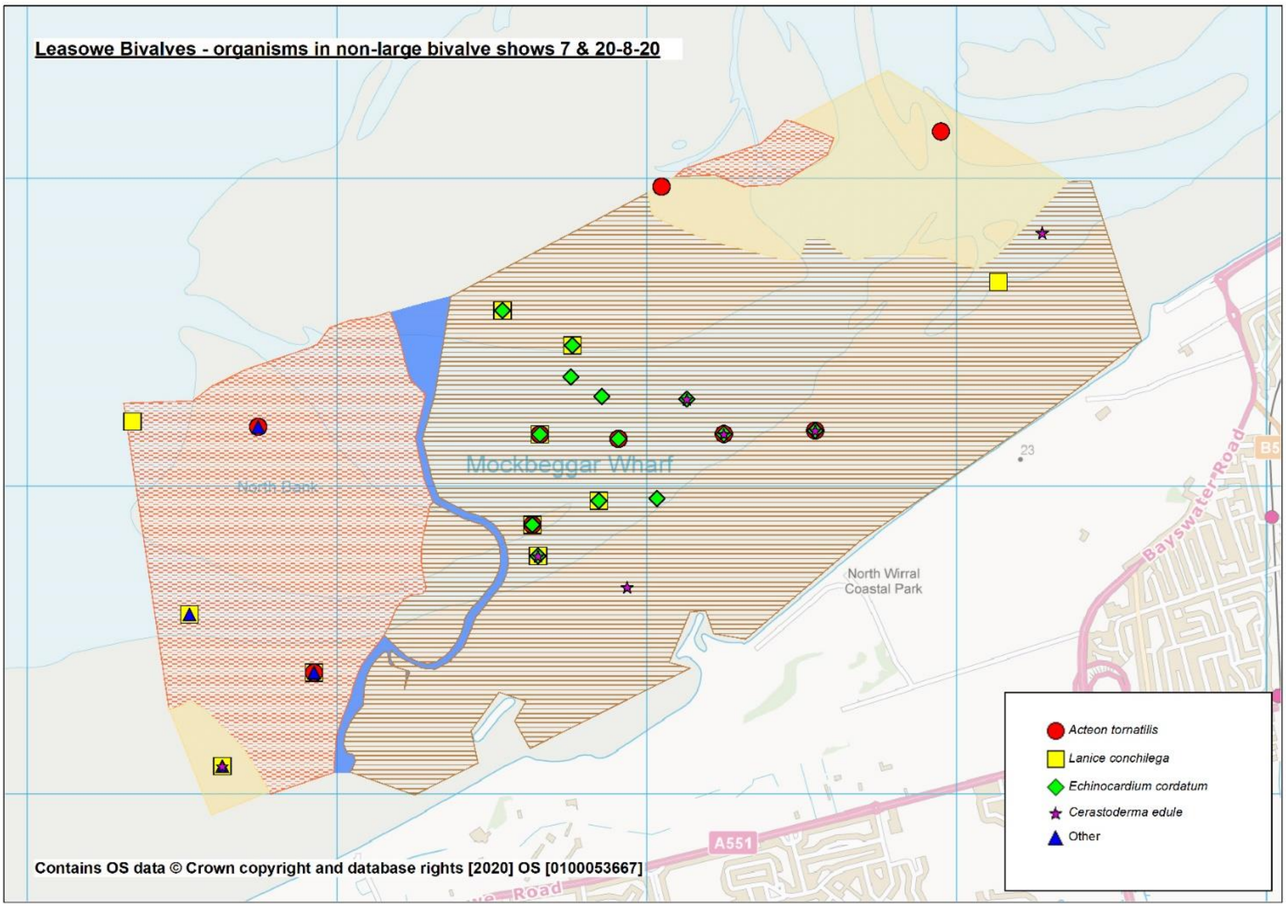

Figure 13. Distribution of organisms in non-large bivalve shows, species and symbol indicated in the figure legend. The organisms indicated by other are 2 species of polychaete worm and one Thin tellin.

4.4 Discussion

The main aims of this preliminary study was to identify the habitat types present on Leasowe beach in which the large bivalves targeted by recreational gathering could be found, and the species of smaller bivalves that are present. This study has successfully identified that it is the muddy habitat areas inhabited by the large bivalve species, this can also be said for the smaller bivalves as supported by data presented in section 4.3. Life history characteristics and ecology of these species are discussed in section 3.2.3.

The secondary aim of this study was to validate the rapid assessment methodology for determining shows of large bivalves. Overall officers are confident that the methodology is robust, that the shows of large bivalves can be correctly identified from amongst a variety of organism shows present on the beach. Four shows identified as large bivalves were recorded as empty, one is noted in the field notes to have felt a siphon when the hole was investigated, giving confidence that there was a large bivalve inhabiting the hole but it was not discovered during excavation.

Both *L. lutraria* and *M. arenaria* are largely sessile organisms: however as they increase in size, the depth that they burrow too increases and *M. arenaria* can be found to a depth of 50cm (Tyler-Walters 2003). Observations made by officers during excavations suggest that burrows are angled rather than straight down, further increasing the area of search required for a larger organism. It seems highly likely as the shows identified were the same as those where the organism was successfully found, that the search area was just too great suggesting the organism was just not found rather than being incorrect identification of a large bivalve hole. Similarly, the excavation of the one show that was identified as a large bivalve although when excavated yielded a Sea potato, could also have been a large bivalve that was just not found, and during the search a Sea potato was found. The number of Sea potatoes found during the survey suggests a high density of these organisms on the beach.

This preliminary study has identified that further investigations into the abundance and distribution of large bivalves on Leasowe beach should focus on the muddy sand habitat, and that confidence in the rapid assessment methodology to identify large bivalve shows is great enough to be used in a more comprehensive survey of large bivalves on Leasowe beach.

5.0 Systematic survey

The aim of this study was to more accurately assess areas of the beach that held large bivalves, to be used to estimate abundance of large bivalves on the beach. The muddy sand habitat identified in the pre-assessment and preliminary surveys is completely encompassed by the 250m survey grid used for the Leasowe cockle survey. To get a complete picture of the distribution and abundance of large bivalves on Leasowe beach the cockle grid was overlaid on the muddy sand habitat area. The 39 stations identified from the cockle grid were surveyed using the 10m by 10m rapid assessment methodology.

5.1 Method

The survey took place on the 21st of September 2020 (LW 09:16, 0.8m Liverpool tides). The rapid assessment methodology is the same as in the preliminary study (described in section 4.2) except refined so that only the shows of large bivalves were identified and enumerated, and validation of shows by excavation was reduced to a maximum of 3 shows being excavated. The 250m cockle survey grid overlaid on the muddy habitat as defined in the pre-survey assessment yielded 39 survey stations. To document sediment characteristics the habitat type "muddy sand" was broken down to include: muddy sand, sandy mud, mud and sand.

5.2 Results

Of the 39 stations identified for the survey officers surveyed 38 as one was too muddy to access. The location of survey stations, sediment types, and number of large bivalves shows observed are presented in figure 14. Only five shows were observed during the survey, and excavations of all five holes proved unsuccessful. As such no large bivalves were sampled during the survey.

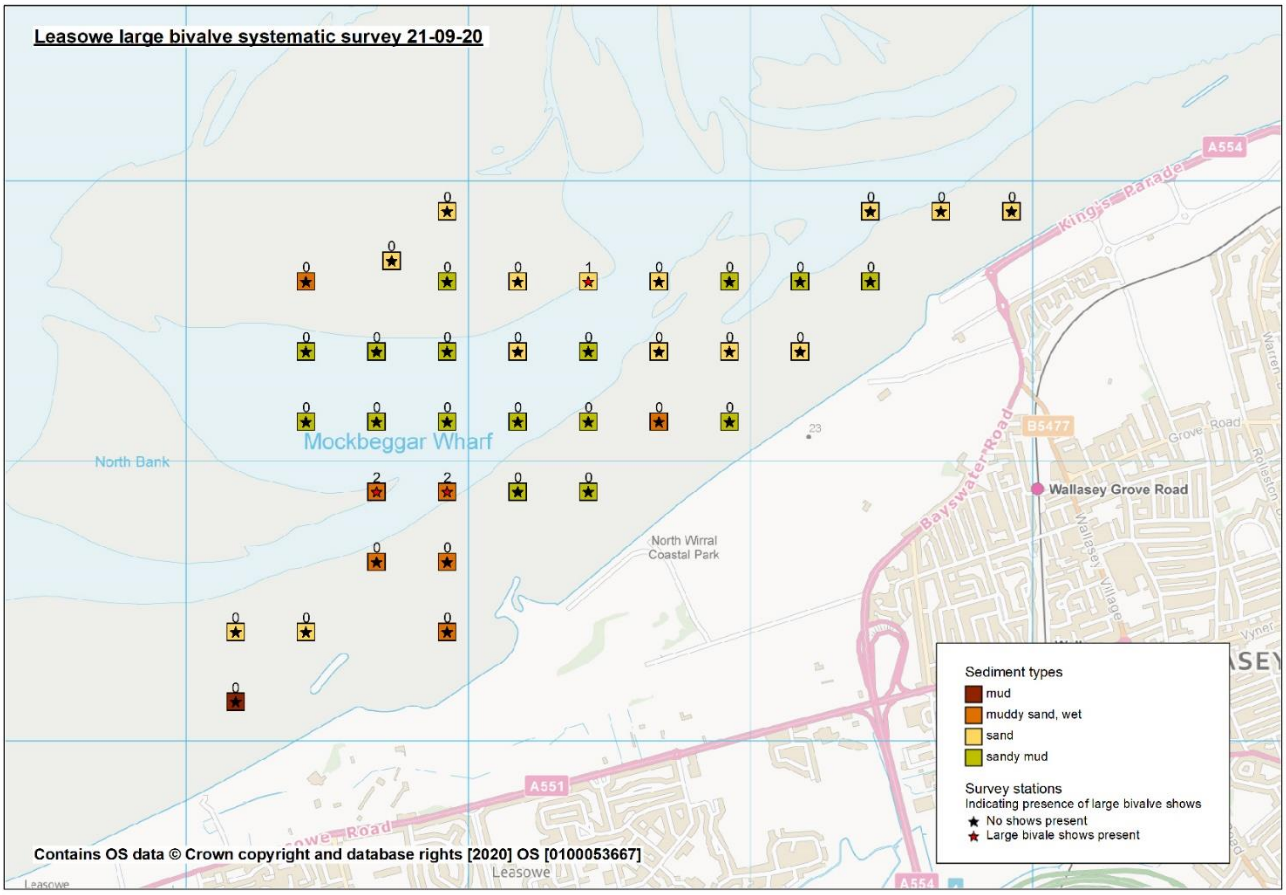

Figure 14. Showing survey stations, observations of large bivalves shows and sediment type from the systemeatic survey of large bivalves on Leasowe beach 21st September 2020. Sediment types observed are indicated in the legend, stations where large bivalve shows were observed are indicated by red stars and the number of shows observed are labelled.

5.3 Discussion

Only five shows of large bivalves were found during this survey. Reasons for this may be that there fewer large bivalves present on the beach, or that the systematic grid overlaid on the beach was not of a high enough resolution to detect the patchy distribution of these organisms. Given that some areas of the beach did hold reasonably high numbers earlier in the year, as observed by officers during the pre-survey assessment where 11 large bivalves were sampled during a relatively short time (under an hour) and 38 shows being identified in the preliminary study, it seems surprising that the grid would be so unsuccessful; however this cannot be ruled out with the current evidence. As such, it would be necessary for officers to return to the beach to determine if it was the survey design or number of large bivalves present that caused the lack of success in this survey.

All five shows observed in this survey were excavated but no large bivalves were found. It is possible that officers incorrectly identified shows; however given the 81% success rate in excavating large bivalves in the preliminary survey officers are confident that this is unlikely. It could have been that these large-bivalves were buried too deep for officers to excavate. Given that the numbers found were so few, it may be plausible that the remaining large bivalves on Leasowe beach were those that were buried too deep for successful gathering by hand. However it would take further investigation by officers to continue to hypothesise on the outcome of this study.

6.0 Large bivalve inspection 21-10-20

This inspection was conducted on the 21st of October 2020 (LW 09:31, 1.6m). The aim of the inspection was to determine if large bivalve shows could be found on Leasowe beach, to corroborate hypotheses put forward from the systematic survey. Officers visited every area of the beach large bivalves had been found in previous surveys and conducted a thorough search. Officers also walked areas previously known to hold large bivalves along the channel edge, an area further towards New Brighton identified as a large bivalve gathering area in the pre-survey assessment, and the low water line. However no shows of large bivalves were observed across the entire survey area. The outcome of this inspection and implications from the work conducted by Science Officers will be discussed below.

7.0 Discussion of scientific investigations into non-cockle bivalves on Leasowe beach

The main aims of this iterative series of surveys in the first instance was to establish a rapid assessment protocol for large bivalves on Leasowe beach, and understand the range of bivalve species found there. This aim was achieved. Officers are confident that the shows of large bivalves can be differentiated from other organisms on the beach and that the majority of small bivalves present on the beach at the time of survey have been documented.

Once the protocol had been established, systematic surveying was intended to define areas inhabited by large bivalves, allowing for estimations of abundance of large bivalves on Leasowe beach. As discussed in section 5.3 there was little success in observing large bivalves during the systematic survey, and the subsequent inspection (section 6.0) corroborated that the abundance of large bivalve shows had dramatically decreased. This is reflected in the observations of IFCOs that have seen very few large bivalves present in their inspections of recreational gatherers. This precludes further survey development and any assessment of abundance of large bivalves on Leasowe beach in 2020.

Unfortunately the lack of large bivalves present to further test survey techniques leaves much of the discussion in earlier sections around the resolution of a systematic survey grid, and the reasons why clearly defined shows of large bivalves did not yield an organism, as plausible hypotheses. However officers are confident that the work they have completed is scientifically robust and the lack of success in finding large bivalve shows during the final two visits to Leasowe beach is due to the population being severely depleted. Similar populations of *M. arenaria* in North America have been shown to recover after five years of fishing pressure being removed (Tyler-Walters 2003); however there is some suggestion that *L. lutraria* require a mass settlement to develop a population (Kerr 1981).

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