Poole Harbour Bivalve Stock Assessment 2018

Survey Report on Samples Obtained using Pump-Scoop Dredge Methodology

Contents

Executive summary

This report summarises the 2018 Poole Harbour Bivalve Stock Assessment. The survey is undertaken annually, during March-April before the dredge season opens in May. The methodology used is consistent with that used in the 2016 and 2017 surveys. Samples of bivalves were taken at specific sites throughout Harbour and analysed, with a focus on the two main target species for the dredge fishery, the Manila clam (*Ruditapes philippinarum*) and the common cockle (*Cerastoderma edule*). The survey provides an indication of the stock of commercially important species in Poole Harbour and allows for spatial and temporal comparisons to be made.

1.0 Introduction

1.1 Poole Harbour

Poole Harbour, located on the south coast of England, is enclosed by a bar at the mouth and consists of five islands and two embayments (Humphreys, 2005; Hubner, 2009). The Harbour is influenced by several freshwater river inputs. Along with the shallow depth of 0.5m, double high water and small tidal range, the Harbour exhibits a complex environment including extensive intertidal mudflats (Humphreys, 2005). These unique characteristics result in a range of habitat types supporting diverse benthic communities, including suspension and deposit feeding species, which further provide a food source for the internationally important bird species protected under the Special Protection Area (SPA) designation for the Harbour (Bennett, 2011; Dyrynda, 2005). The Harbour is subject to significant levels of anthropogenic activity including dredging, recreational and commercial fishing of shellfish and bait, and angling.

1.2 The Species

The clam and cockle fishery in Poole Harbour targets two main species: the common cockle (*Cerastoderma edule*) and the Manila clam (*Ruditapes philippinarum*). The American Hard Shelled clam (*Mercenaria mercenaria*) and the native clam (*Ruditapes decussatus*) are also fished, but in smaller quantities than the two main species.

1.2.1 Manila Clam

The Manila Clam, *Ruditapes philippinarum* (Adam and Reeve,1850) was first introduced to the UK in the 1980s by the Ministry of Agriculture, Fisheries and Food (MAFF) for the purposes of aquaculture. It was believed that conditions would be unsuitable for the species to breed and create wild populations (Humphreys, 2010). However, the species did reproduce and the first wild settlement was reported in Poole Harbour, where it has since become commercially exploited. The fishery was first licenced in 1994 (Humphreys et al, 2007; Jensen et al, 2004).

The Manila clam lives in fine sediment within intertidal and sub-littoral areas of the Harbour, settling onto the seabed following metamorphosis as a suspension feeder (Jensen et al, 2004). The most common method of fishing is the pump-scoop dredge, uniquely modified to reduce the impact to the seabed (Humphreys and May, 2005).

1.2.2 Common Cockle

The common cockle, *Cerastoderma edule* (Linnaeus, 1758) is native to Britain, found within sandy and muddy sediments at the mid to lower intertidal range. The species tolerates low salinities allowing the colonisation of estuarine habitats (Hayward and Ryland, 1995) and are also suspension feeding organisms. The common cockle is often secondary to Manila clam in catch weight and associated fishing effort in the Poole Harbour dredge fishery.

1.3 Management

1.3.1 Southern Inshore Fisheries and Conservation Authority

The Southern Inshore Fisheries and Conservation Authority (IFCA) manages and regulates inshore fishing activity on the south coast of England, covering Hampshire, Dorset and the Isle of Wight, out to 6 nautical miles from territorial baselines. Management measures under the Southern Inshore Fisheries and Conservation Authority, and its predecessor before 2011, the Southern Sea Fisheries Committee, have evolved and developed over time. Under the Poole Harbour Fishery Order 1985, alongside a number of other byelaws, the wild fishery was regulated through the issue of an annual clam licence, a restricted fishery season and regulations on gear type. In 2015 the management was reviewed and two new measures were introduced; the Poole Harbour Dredge Permit byelaw to regulate the wild shellfish fishery and the Poole Harbour Fishery Order 2015 to manage aquaculture. The byelaw introduced a restricted entry permit system with permit conditions covering requirements for catch reporting, gear type and construction and spatial and temporal restrictions.

1.3.2 Conservation Areas

An important role of the Southern IFCA is to manage the Marine Protected Areas (MPAs) in the district and ensure fishing activity is sustainable. Poole Harbour is designated as a Special Protection Area (SPA), which classifies it as a European Marine Site (EMS), a RAMSAR Site and a Site of Special Scientific Interest (SSSI). The conservation status given to Poole Harbour is largely based on the internationally important bird populations supported, including waterfowl, wildfowl and waders. The Southern IFCA is a competent authority under the Conservation of Habitats and Species Regulations (2010) therefore is required to give consideration to the potential adverse impacts of fishing activity to protected species and habitats.

1.3.3 Historical Surveying

Since 2003, the Southern IFCA has carried out an annual stock assessment. The results are to inform the annual appropriate assessment of the fishery (Bannister, 2006). The survey design was modified in 2016 which involved the inclusion of the sediment drag for juvenile samples to be collected and the implementation of a more consistent methodology and coverage across all sites (Jones, Addison and Blyth-Skyrme, 2018). The modifications allow for more robust data on stock densities and species distribution across the Harbour, providing data on the whole population rather than previously limited to only the commercially available population.

1.4 Aims

The overall aim of the Poole Harbour Bivalve stock assessment is to assess the population distribution and stock density. The continuing temporal dataset will determine any future changes in the population. Once a suitable timeseries of data has been developed, the data could be combined with landings data to determine the sustainability of the fishery based on the relative proportions of bivalves above and below the Minimum Landing Size (MLS). Jensen, Carrier and Richardson (2005) outlined establishing the density and size-frequency distributions within commercially fished areas of Poole Harbour would allow for improvements to management through a better understanding of the sustainability of the fishery. The ability to assess the sustainability of the fishery is particularly important in light of the fishery's certification in 2018 under the Marine Stewardship Council (MSC) Standard (Jones, Addison and Blyth-Skyrme, 2018). Although the ability for the data to determine the sustainability of the fishery is reliant on a suitable timeseries of data, the annual survey is used to inform the management of the fishery and is considered in the annual Habitats Regulations Assessment for the Permit byelaw.

2. Methodology

The study conducted uses the standardised methodology, consistent with the 2016 and 2017 assessment, consisting of the two independent sampling methods across 27 defined shellfish beds. The allocated sites were used to represent the majority of shellfish beds within Poole Harbour, including areas which are seasonally and permanently closed to the dredge fishery.

At each site, three replicate samples were taken for both methodologies. The survey is carried out at the same time each year, prior to the start of the fishing season in May, with specific sampling dates and times chosen to coincide with periods of high spring tides allowing maximum access to fishery grounds. For 2018, the first part of the survey using the pump-scoop methodology was carried out on the 16th and 17th April 2018, using the trailed pump-scoop dredge, as used by commercial fishers, to gather samples of bivalves. The second part of the survey was undertaken on the 18th and 19th April 2018 using a modified sediment hand-operated dredge, which allows collecting of bivalve samples at a fine scale, including those below the minimum legal size.

2.1 Pump-scoop methodology

Using a permitted commercial fishing vessel with a pump-scoop dredge, three samples were taken at each of the 27 sampling sites (Figure 1) according to the following methodology:

- A stake is placed at the centre of the shellfish bed at known coordinate (Table 1)
- The dredge is deployed for a period of 2 minutes with the start and end positions of the dredge recording on a hand-held GPS
- The dredge is recovered and the contents emptied on to the sorting table. Any bivalves are retained and sorted into species.
- The length along the widest axis is recorded for all species using Vernier Callipers.
- Any Manila clam or common cockle are separated into above and below the respective minimum legal sizes and weighed.

2.2 Sediment drag methodology

A hand-operated, modified sediment dredge is used to take sediment samples. The dredge has a fixed frame opening and a mesh collecting bag into which the sediment is collected. Three samples were taken at each of the 27 sampling sites (Figure 1) according to the following methodology:

- Two canes are positioned 1 meter apart in the sediment around the central coordinate for each sampling site
- The dredge is deployed by hand and dragged through the defined 1 meter of sediment with the dredge penetrating to approx. 10-20cm
- All sediment within the drag is retained and sieved through a 1mm sieve
- Any material remaining on the sieve is preserved in 4% formalin solution
- In the laboratory, samples are analysed and any bivalves are removed
- All bivalves are photographed at a high resolution and the computer program ImageJ is used to measure the length of any individuals of the species Manila clam and common cockle along the widest axis

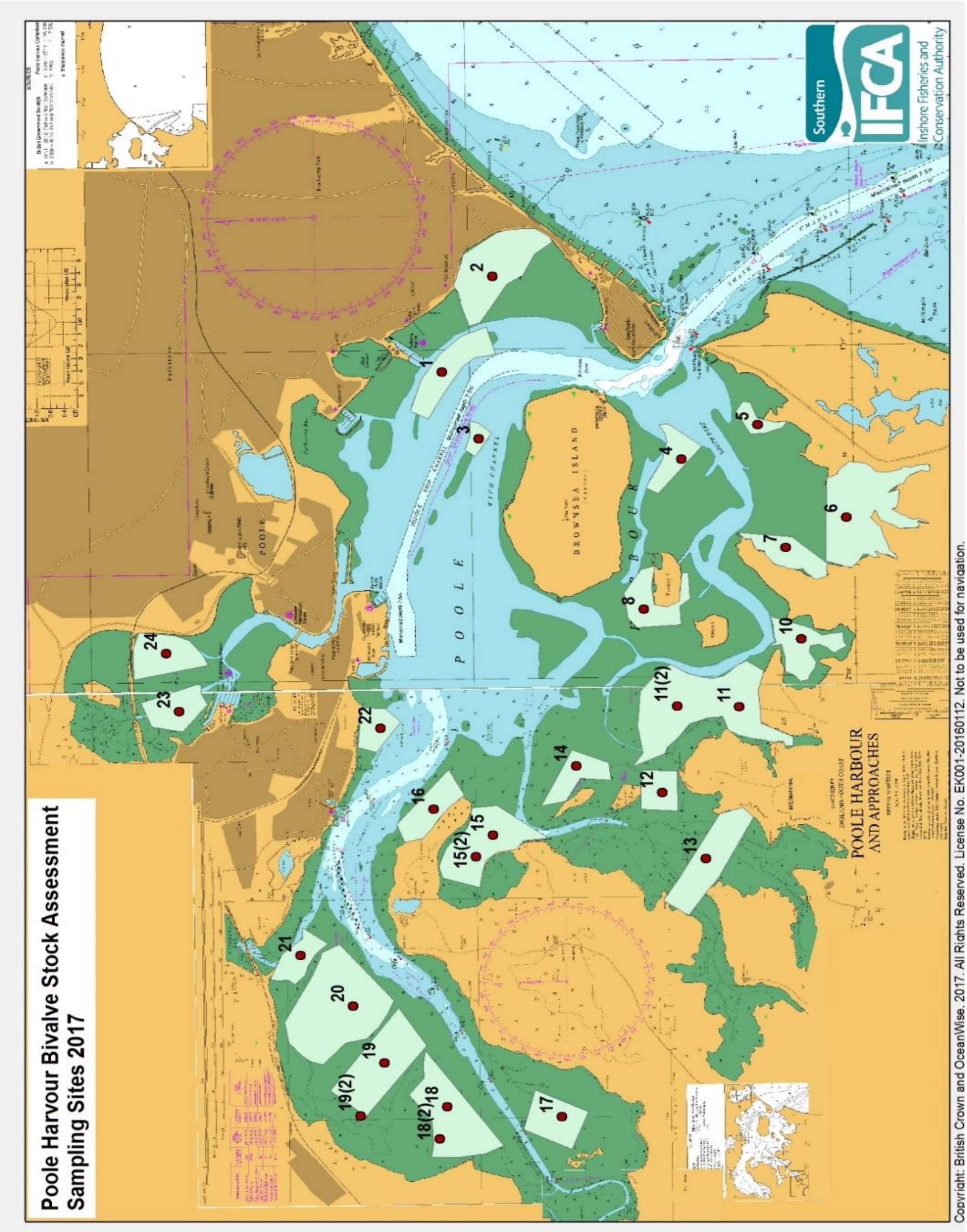


Figure 1: 27 sampling sites which are sampled during the Poole Harbour Bivalve Stock Assessment. Numbers correspond to site names and coordinates listed in Table 1.

2.3 Site names and codes

Site No.	Site Name	Location of central mark			
		Latitude		Longitude	
1	Middle Ground	50	42.147	1	57.205
2	Whitley Lake	50	41.875	1	56.337
3	Aunt Betty	50	41.959	1	57.813
4	Blood Alley	50	40.900	1	58.023
5	Jerrys Point	50	40.498	1	57.717
6	Brands Bay South	50	40.040	1	58.569
7	Brands Bay West	50	40.362	1	58.837
8	Furzey Island	50	41.110	1	59.384
10	Newton Bay	50	40.286	1	59.671
11	Wards*	50	40.617	2	00.282
11(2)	Ower Bay*	50	40.943	2	00.272
12	Round Island*	50	41.027	2	01.053
13	Wych and Middlebere Lake	50	40.804	2	01.659
14	Long Island	50	41.475	2	00.803
15	Arne	50	41.914	2	01.425
15(2)	Inner Arne	50	42.006	2	01.621
16	Patchins Point	50	42.224	2	01.180
17	Giggers	50	41.575	2	03.996
18	Keysworth	50	42.175	2	03.894
18(2)	Inner Keysworth	50	42.215	2	04.181
19	Holton Mere	50	42.499	2	03.488
19(2)	Inner Holton Mere	50	42.629	2	03.965
20	Seagull	50	42.660	2	02.964
21	Rockley Spit	50	42.931	2	02.501
22	Hamworthy	50	42.494	2	00.437
23	Upton Lake	50	43.546	2	00.267
24	Creekmoor Lake	50	43.610	1	59.738

Table 1: Site number, as seen in Figure 1, and site name of each shellfish bed surveyed, with the given pre-determined latitude and longitude coordinates for the location of the central mark used in the sampling

3. Results and Discussion

The results presented here are from the samples collected using the pump-scoop dredge methodology. The samples collected from the second methodology, using the hand-operated sediment dredge, are in the process of being analysed.

3.1 Weights of Shellfish

3.1.1 Manila Clams

The highest biomass was collected at site 18(2) with 7.83kg, followed by site 19(2) with 5.99kg as seen in Figure 2. This is predominately as a result of the high weight of Manila Clams under MLS (6.75kg and 5.30kg for sites 18(2) and 19(2) respectively) (Figure 2). These two sites are regularly fished (Southern IFCA, per comm.), the lower weights of individuals above the minimum size may therefore be as a result of increased fishing pressure in these areas, whereby the commercial harvestable individuals are removed. Also, these sites (18(2) and 19(2)) are close inshore and subject to less tide and wave action than those of the nearby sites 18 and 19, consequently the inner areas could provide good settlement areas for juveniles, resulting in the greater population of under MLS individuals. In addition, site 18(2) at Inner Keysworth is seasonally closed, from 1st November until the end of the season in 23rd December, resulting in a greater period of recovery for the clam population following the 2017 fishing season. This may explain the higher overall weight seen at this site. Similar characteristics of a close inshore, more sheltered area are seen at site 11(2), with this area also subject to the same seasonal closure as area 18(2). This may explain the higher weight of Manila clam below the minimum size (0.93kg) than in the nearby site 11 (0.45kg) which is more exposed and not subject to seasonal closure. The greater biomass of undersized Manila clams in these heavily fished sites is encouraging as it suggests that the current management scheme is proving successful in preventing illegal removal of undersized individuals.

The lowest weights of Manila clam were found at sites 1-8 and sites 21-22, with <0.02kg of under MLS clams being found at the majority of these sites. However, it is important to consider the methodology as the use of the size-selective pump-scoop dredge, which selects for sizeable Manila clams, greater than MLS, is likely to be an influential factor in the quantity of undersized Manila clams collected at all sites. Sites 1-5 and 22 also comprise of coarser, sandier sediment types which would be less suitable for clam settlement. At site 3, no Manila clams were found at all.

For the sites 23 and 24, within the area of Holes Bay, which is permanently closed to the dredge fishery, there is a higher weight of above MLS Manila clams, particularly for site 23 (2.42kg at site 23, 1.37kg at site 24). This would be expected as the management regulations prohibit harvesting of clams in this area allowing for populations to be maintained at a higher overall size. The weight of undersized Manila clams is however similar to that of sites 11-19(2), indicating the permanent closure of Holes Bay does may not significantly improve the abundance of juvenile clam populations. However this cannot be fully concluded due to the size selectivity of the methodology, results from the second phase of the survey, looking at the juvenile population, would provide more evidence to indicate if this was the case.

3.1.2 Cockles

The average weight of the common cockles across all sites varies greatly (Figure 3), however the scale is significantly lower than that of the Manila clam weight. The largest average weight of cockles is 2.47kg at site 4; however the majority of sites have less than 1kg. The variation of average weight across the sites is predominately due to the variation in weight of cockle over MLS. The biomass at site 4 is predominately due to over MLS cockles, likely as a result of the low fishing intensity at this site (Southern IFCA, per comm.) allowing the population to grow. Similarly, site 24 within the closed

Holes Bay region, where dredge fishing is prohibited, shows a higher weight (1.18kg), particularly due to the occurrence of oversized individuals. This again may be attributed to there being no dredge fishing activity in this area, however site 23, also within this prohibited region has a much lower volume (0.16kg).

Sites 11, 11(2) and 18-20 have low cockle biomass (<0.55kg) likely due to the heavy fishing that occurs in these areas, including sites 18(2) and 19(2) which have a particularly low average cockle weight with 0.06kg and 0.04kg respectively. At all sites there is less than 0.05kg of under MLS biomass, however as mentioned earlier it is important to consider the implications of the size-selective pump-scoop dredge which selects for bivalves at or greater than MLS, influencing the quantity of undersized Manila clams collected. This emphasises the importance of the joint methodologies for a more representative sampling of the population.

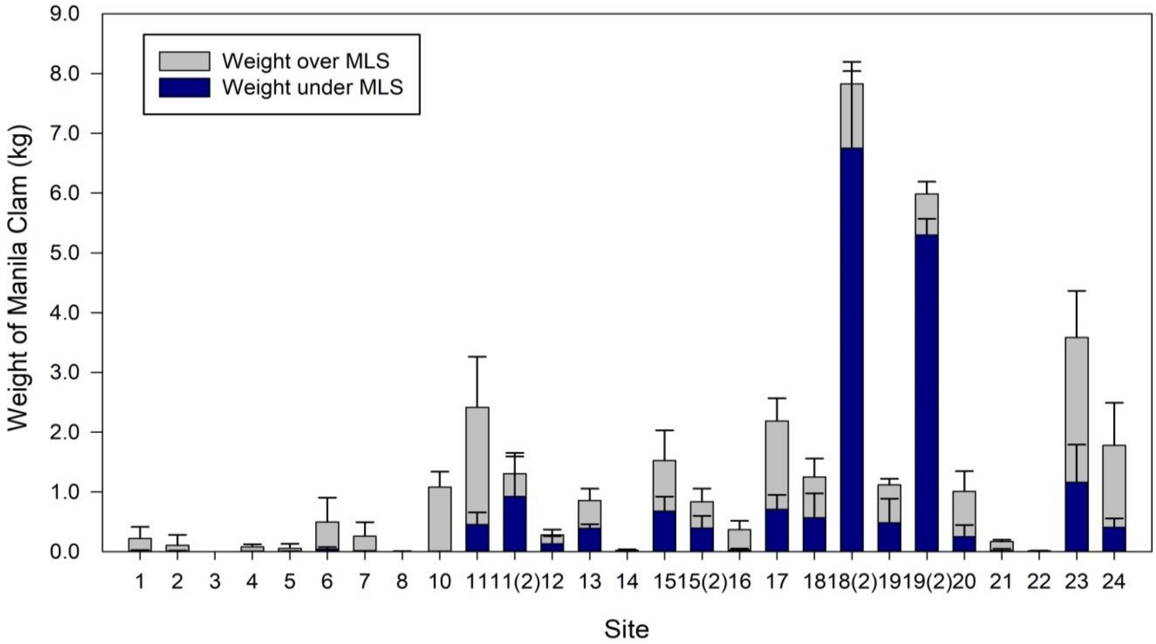


Figure 2. Average Weight (kg) of Manila Clam at each site above and below MLS, with standard deviation error bars.

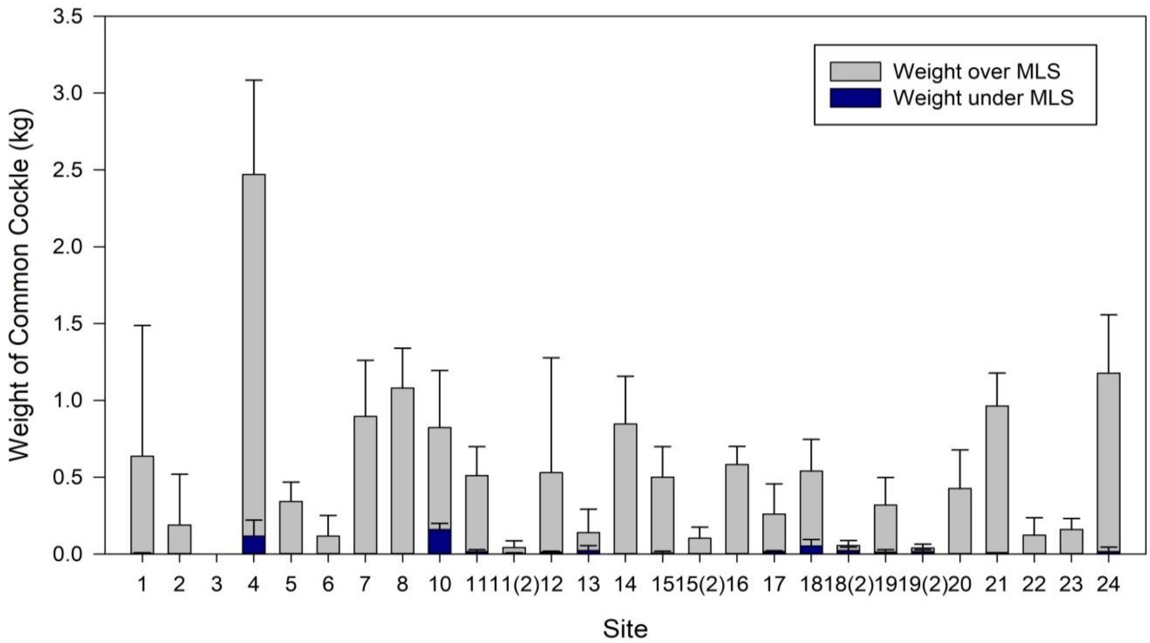


Figure 3. Average Weight (kg) of Common Cockle at each site above and below MLS, with standard deviation error bars.

3.2 Sizes of Cockles

3.2.1 Average and Maximum

Across all sites, except site 3 where no cockles were found, the average size ranges from 23.5-39.6mm, seen in Figure 4a. At only two sites, site 18(2) and 19(2) the average size was less than 23.8mm, the minimum legal size. This is likely due to the regular, heavy fishing that occurs within these areas resulting in harvesting of the majority of above MLS cockles. However, this could also indicate a high quantity of undersized cockles at these sites; which provides a positive indication for the 2018 fishing season recruitment potential. For the remaining sites, the average cockle size is above MLS (Figure 4a); this is an encouraging finding suggesting that the management measures are proving successful in reducing illegal harvesting of undersized shellfish.

The size of the standard deviation across all sites is fairly consistent, ranging from 2-6.1mm variation. The heaviest fished sites, 18-20 has a consistent low variation of 2.01-2.48mm, indicating high precision of the findings at these sites in particular. Site 21 has a particularly high average cockle size of 39.6mm (Figure 4a), however this is likely due to limited number of individuals found at this site (15), reducing the confidence in the findings. Figure 4b indicates the maximum cockle size found at each site varies greatly. It is important to note the accuracy of the maximum size largely relates to the number of individuals collected, the sample size, at each site. As expected in general the more heavily fished sites, 15, 15(2) and 18-20, have a lower maximum cockle size than the rest of the sites (Figure

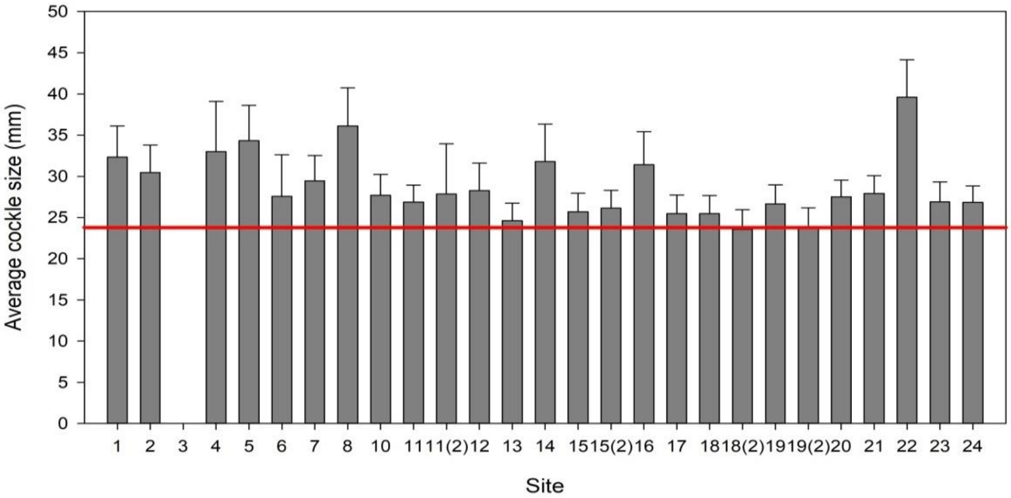


Figure 4a. Average size of cockle at each site, with standard deviation error bars. The red line represent the Minimum Landing Size, 23.8mm.

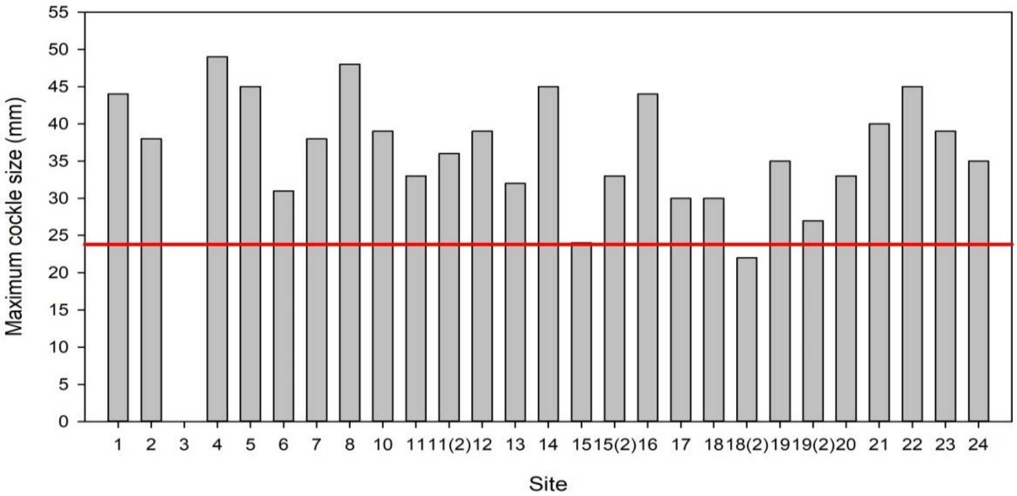


Figure 4b. Maxmium size of cockle at each site. The red line represent the Minimum Landing Size, 23.8mm.

4b). The largest recorded maximum cockle sizes were at the sites 4 and 8, likely due to the less frequent pressure (Southern IFCA, per comm.).

3.2.2 Histograms of each site

The size-frequency distribution for each site indicates the frequency of cockles within each size-class collected during the pump-scoop dredge sampling survey, seen in Figure 5. For site 3, no cockles were found within the survey sampling therefore there is no histogram. The red dotted line in Figure 5 represents the minimum legal size, 23.8mm, which provides a reference to the frequency of individuals below and above the MLS. The distribution indicates the future recruitment potential, and level of exploitation in the previous fishing season. However it is important to note the active selection from the pump-scoop sampling, selecting for individuals greater than 23.8mm, which likely misrepresents the below MLS frequency.

For the sites 6, 7 and 10 the frequency appears to be predominately within main size class 25-30mm (Figure 5a, 5b). The cockles in this class were likely below MLS during the previous fishing season and the seasonal closure experienced at these sites likely allowed the growth of the below MLS individuals to a harvestable size. This likely explains the frequency seen in Figure 5a and 5b, and indicates a successful harvestable population for the 2018 fishing season.

For sites 18(2) and 19(2) the frequency is predominately in the one main size class, 20-25mm (Figure 5d). Due to the high levels of fishing experienced at these sites (Southern IFCA, per comm.) fewer individuals occur at larger size classes. For sites 11, 18 and 19, the highest frequency of the cockles are predominately within the size classes 20-30mm, likely due to growth of individuals following the previous fishing period. Although the frequencies at these sites are greater than at 18(2) and 19(2), the similar narrow size-frequency distribution likely reflects the high intensity fishing pressure (Figure 5b, 5c, 5d). Although site 11(2) indicates a left-skewed size-frequency distribution, the total frequency of samples representative of each size-class is low which reduces the confidence that can be put in the data (Figure 5b).

The sites 14, 15 and 15(2) appear to display slightly right-skewed size-frequency distributions (Figure 5c), with the highest frequencies around the MLS. These sites experience moderate fishing intensity (Southern IFCA, per comm.) which could explain the higher frequencies than those of the heavily fished sites in above MLS size-classes. However the fewer below MLS individuals leading to the right-skewed distribution could be a result of the size selective pump-scoop dredging sampling methodology, as few individuals below 20mm would be collected.

Due to the area being closed to fishing activity, as expected, the highest frequencies of sites 23 and 24 are above MLS (Figure 5e). The total frequency of site 24 is much larger than site 23 as seen in Figure 5e, although under the same management regulations which may require further investigation.

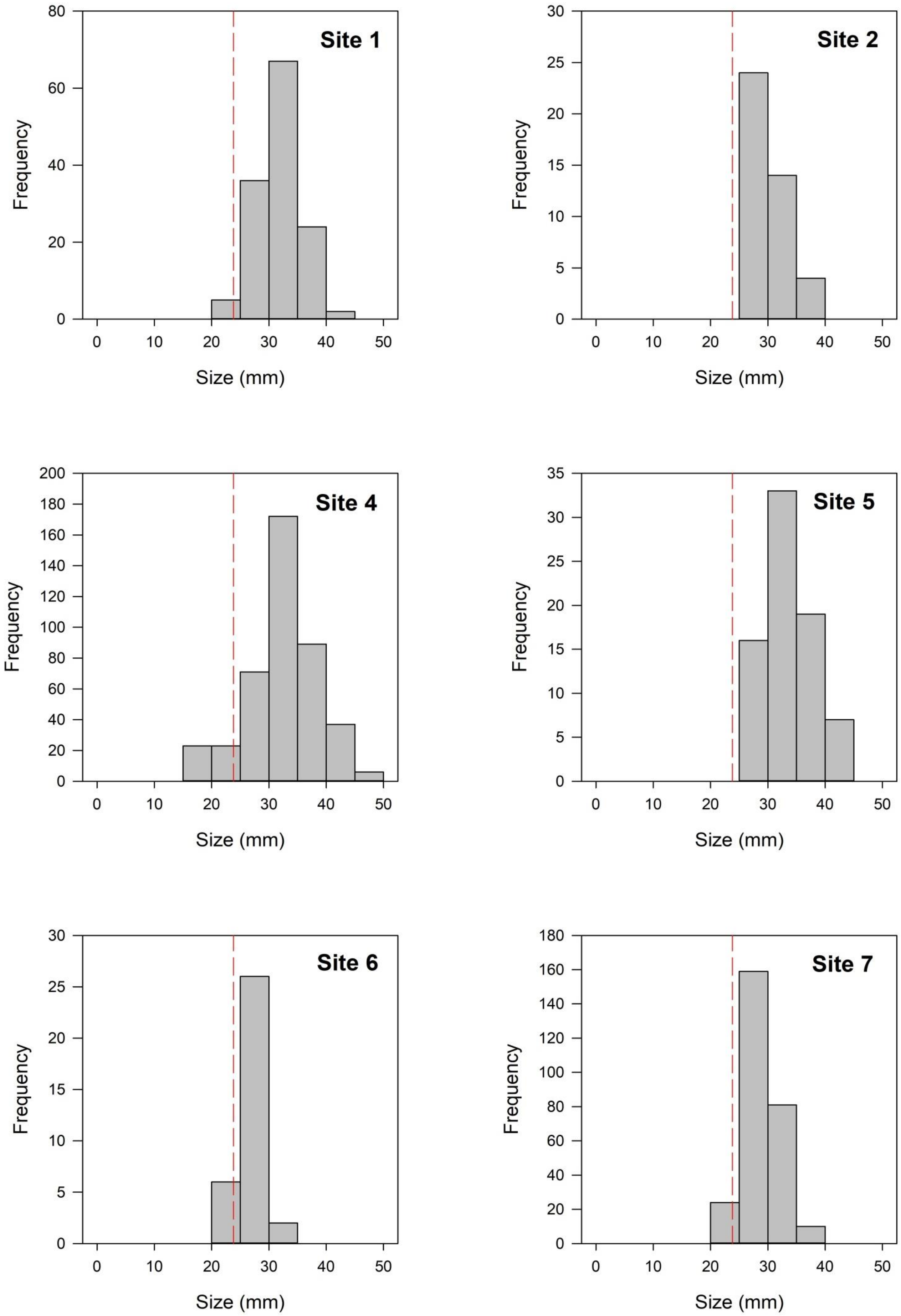


Figure 5a. Size-frequency distribution histograms for sites 1-7 for the cockle data collected. There were no cockles found at site 3. Size-class every 5mm, from 5-50mm. The red dotted line represents the Minimum Landing size of 23.8mm.

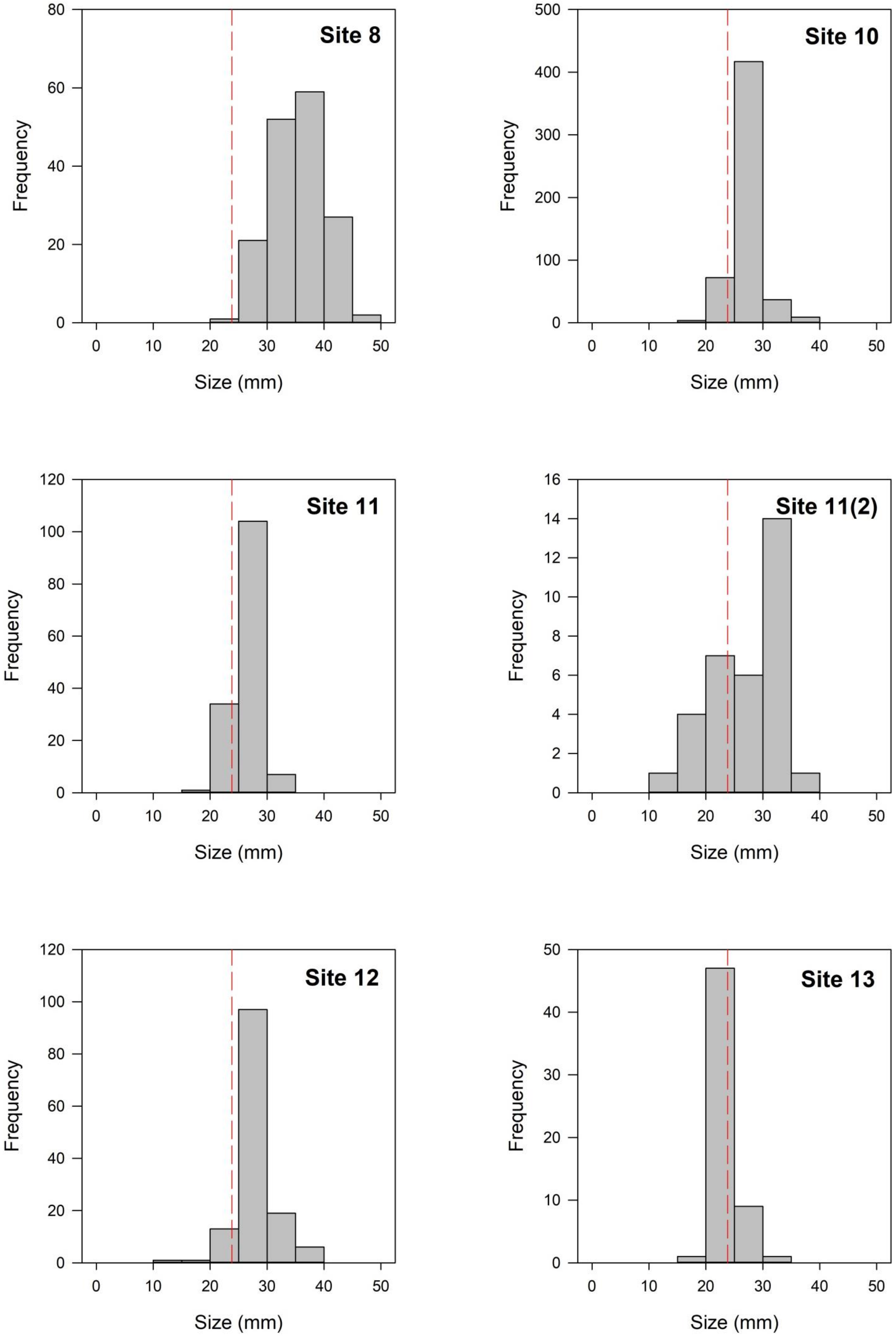


Figure 5b. Size-frequency distribution histograms for sites 8-13 for the cockle data collected. There is no site 9. Size-class every 5mm, from 5-50mm. The red dotted line represents the Minimum Landing size of 23.8mm.

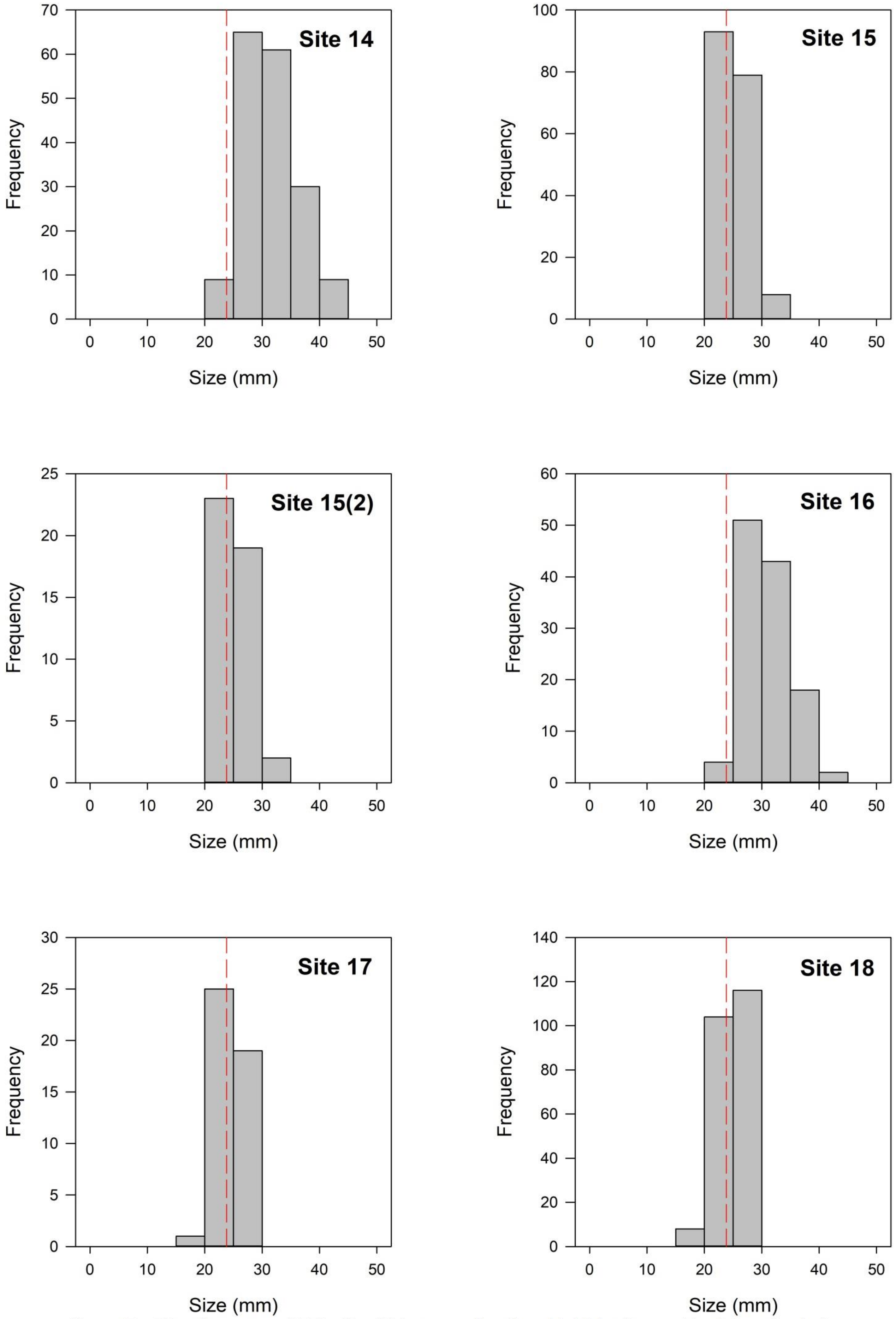


Figure 5c. Size-frequency distribution histograms for sites 14-18 for the cockle data collected.
Size-class every 5mm, from 5-50mm. The red dotted line represents the Minimum Landing size of 23.8mm.

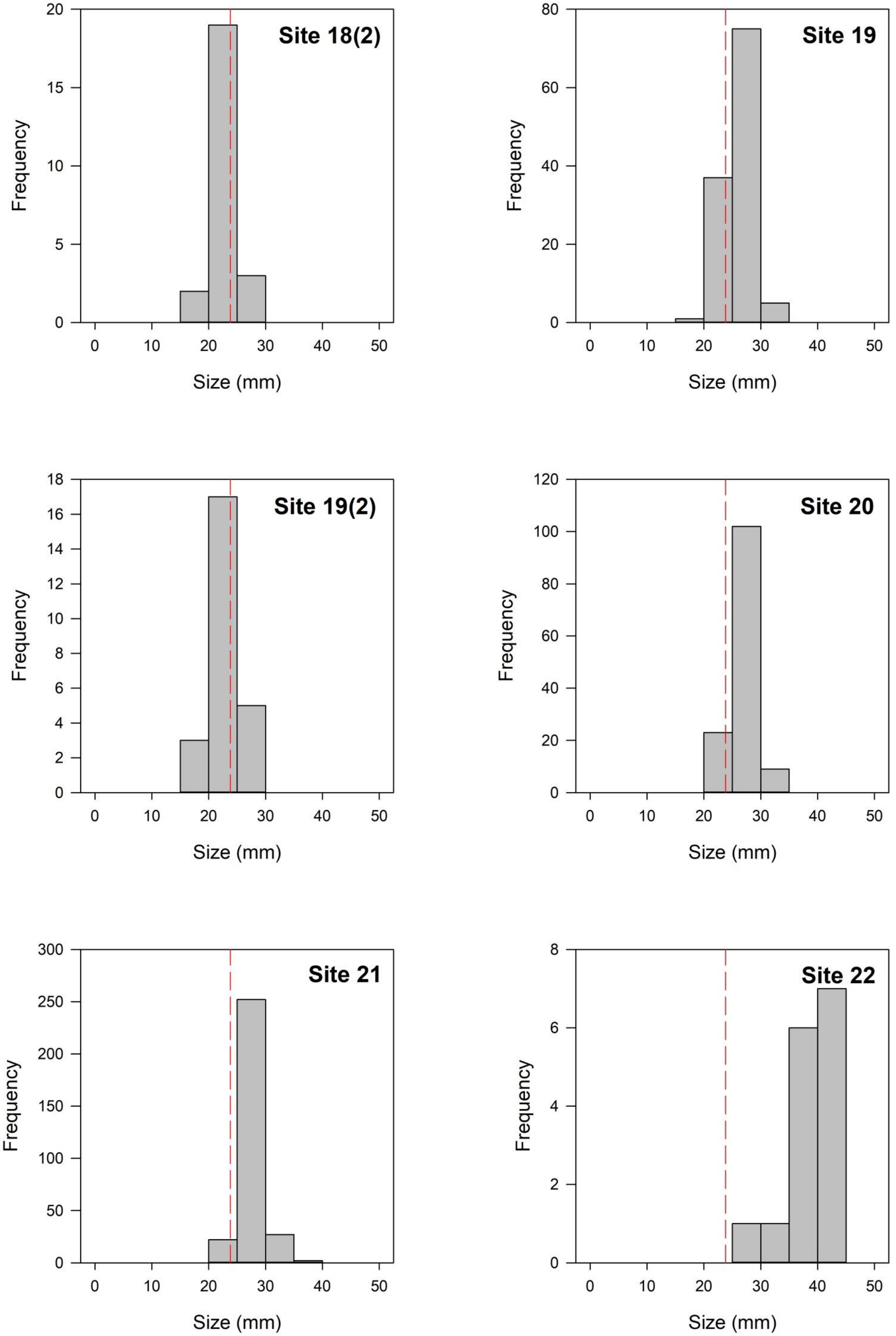


Figure 5d. Size-frequency distribution histograms for sites 18(2)-22 for the cockle data collected.
Size-class every 5mm, from 5-50mm. The red dotted line represents the Minimum Landing size of 23.8mm.

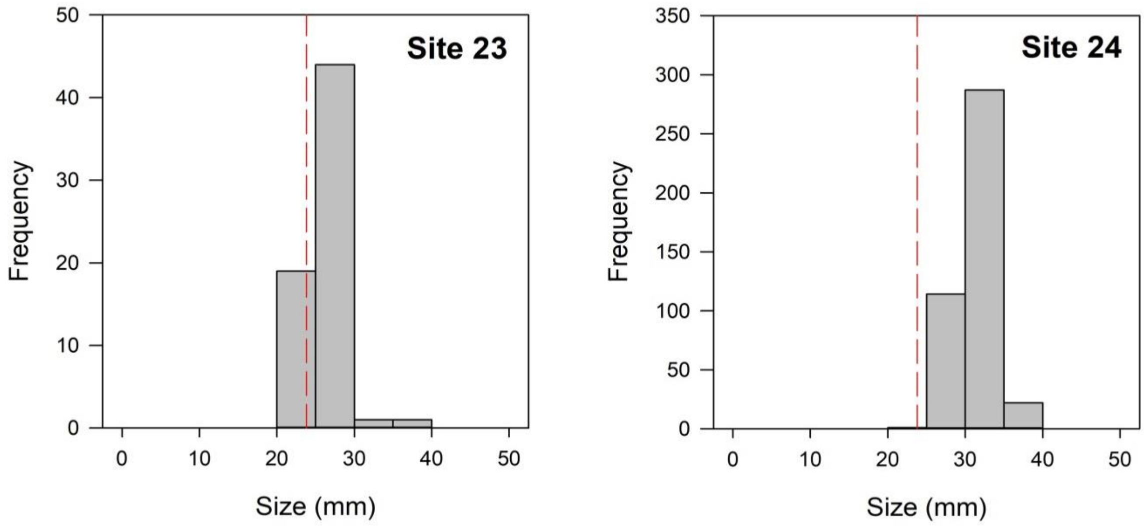


Figure 5e. Size-frequency distribution histograms for sites 23 and 24 for the cockle data collected. Size-class every 5mm, from 5-50mm. The red dotted line represents the Minimum Landing size of 23.8mm.

3.3 Size of Manila Clams

3.3.1 Average and Maximum

The average size of the Manila clam across all the sites ranges from 31.1mm - 54mm (Figure 6a). However, only site 8 has an average size greater than 47mm, however this was only based on two individuals. The high average size at site 22 of 45mm is also only based on the small sample size of 3. At site 3, no Manila clams were collected whilst sampling therefore no average size is given.

At the sites 11(2), 18(2) and 19(2), the average size was less than the minimum legal size (35mm), with 33.17mm, 31.82mm and 31.1mm respectively (Figure 6a). This is likely as a result of the heavy fishing pressure from the previous fishing season at these sites harvesting the above MLS individuals. The average clam size found at sites 12-15(2) and 18, 19, 20, were also <1mm lower than the MLS (Figure 6a); again this is likely due to the moderate to high fishing intensity at the majority of these sites. Furthermore, this could indicate that there are large quantities of undersized individuals at these sites, providing a positive indication for the 2018 recruitment potential. The weight data seen in Figure 2 supports this, particularly for sites 18(2) and 19(2) where weight of under MLS cockles is greater than that of above MLS cockles. The standard deviation of the majority of these sites is between 2-3mm which suggests good precision within the findings, particularly in the sites with greater sample size.

The average clam sizes for the areas closed to fishing, represented by sites 23 and 24, are both greater than the MLS (Figure 6a). This is encouraging as it suggests that the management measures are proving effective by preventing the illegal removal of shellfish from these areas.

The maximum Manila clam size found at each site is indicated in Figure 6b. It is important to note the accuracy of the maximum size largely varies relative to the number of individuals collected, the sample size, at each site. The sites 11(2), 18(2) and 19(2), where the lowest average clam sizes occur, predictably have the lowest maximum sizes (Figure 6b). The largest recorded maximum Manila clam sizes were at sites 4, 5 and 8, likely due to the less frequent fishing pressure (Southern IFCA, per comm.).

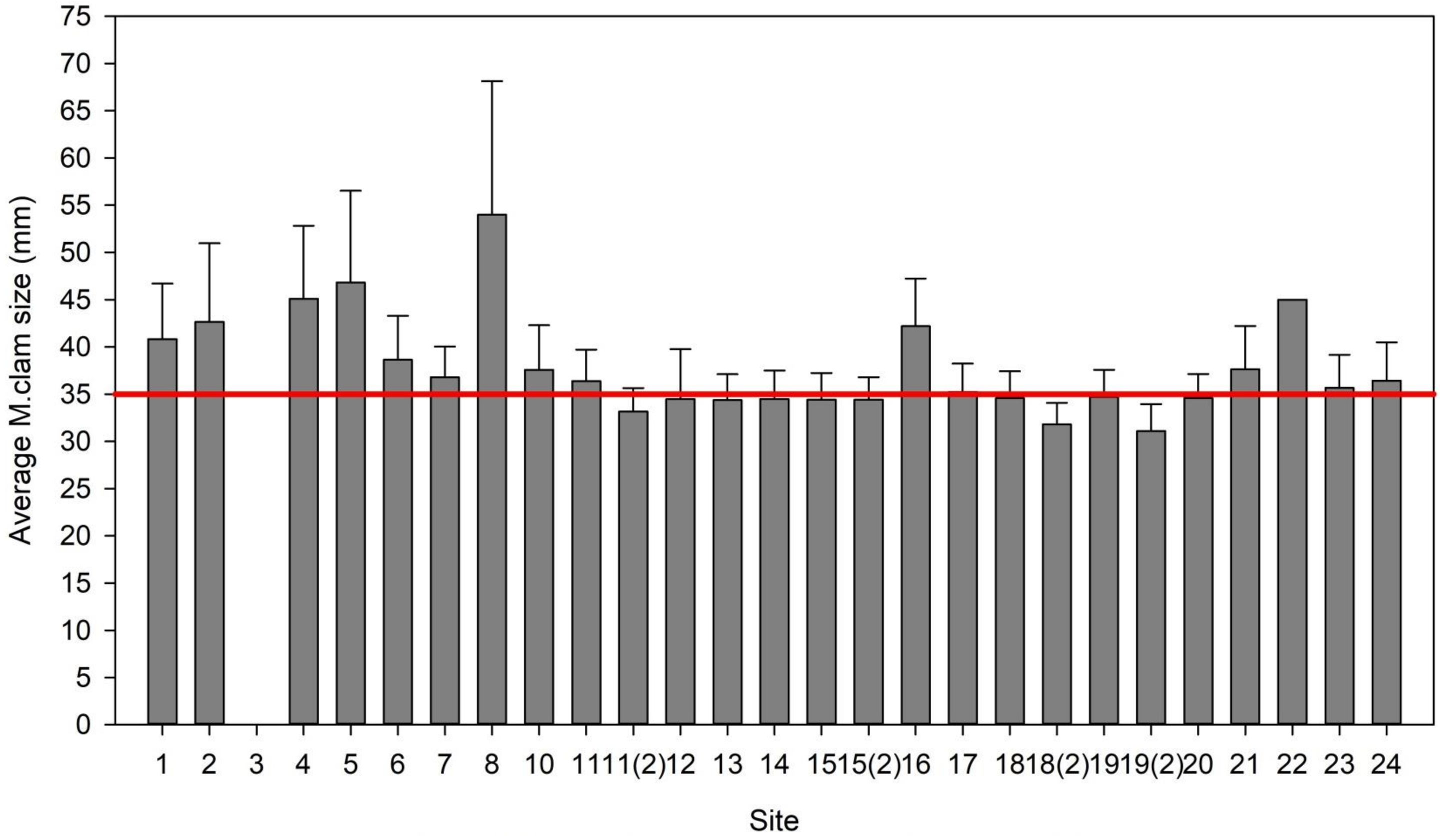


Figure 6a. Average size of Manila clam at each site, with standard deviation error bars. The red line represents the Minimum Landing size, 35mm.

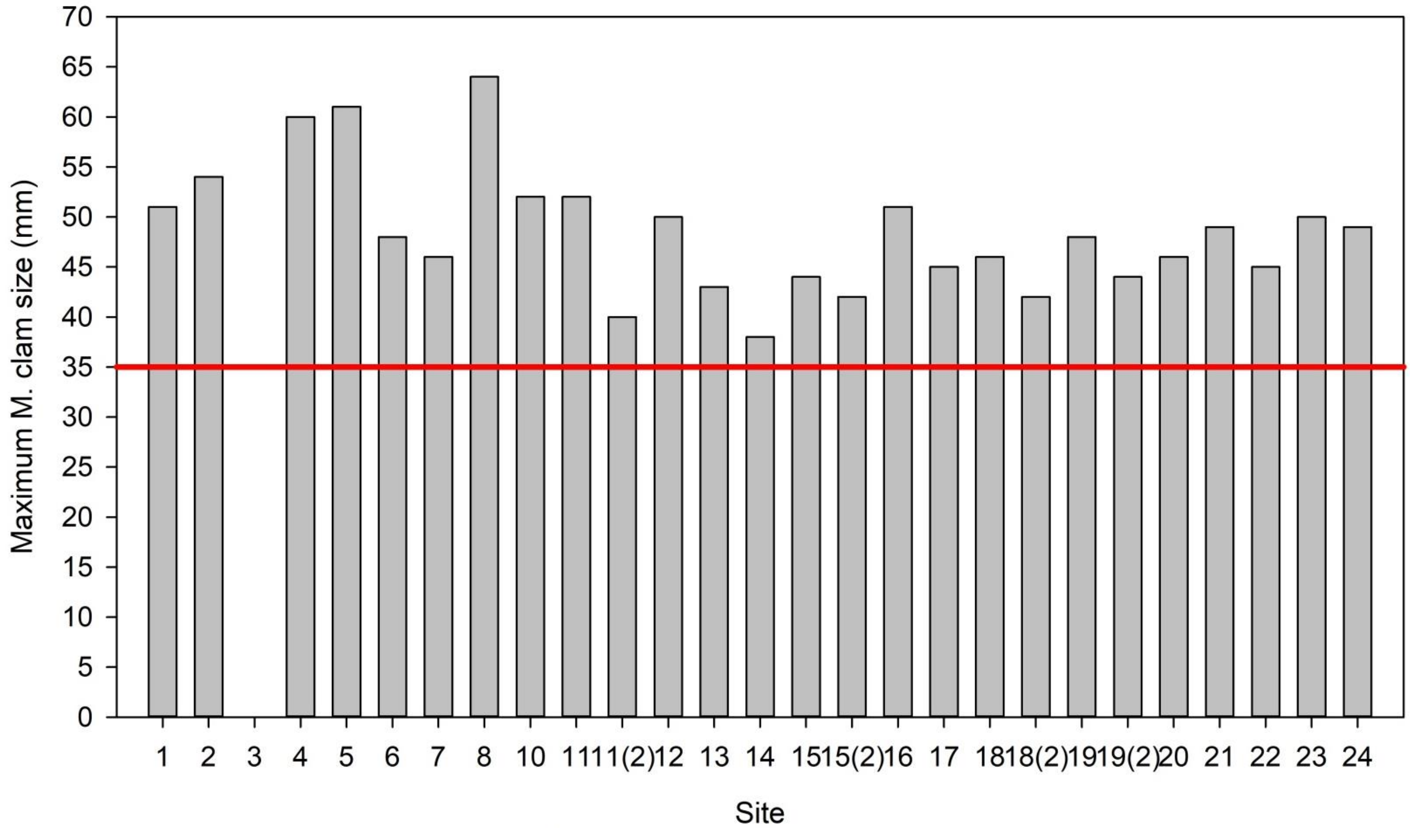


Figure 6b. Maximum size of Manila clam at each site. The red line represents the Minimum Landing size, 35mm.

3.3.2 Histograms of each site

The size-frequency distributions in Figure 7 show the frequency of Manila clams within each size-class, sampled using the pump-scoop dredge. This indicates the future recruitment potential, the success of the previous year's recruitment and intensity of exploitation. The red dotted line in Figure 7 indicates the minimum legal size of 35mm. No Manila clams were found at site 3 therefore no frequency distribution is given for this site. It is important to note, in general, few individuals are found below MLS likely as a result of the size selective characteristics of the pump-scoop dredge which select for sizeable individuals.

The sites 1-5 have low total frequencies as few clams were sampled at these locations as well as no clear pattern observed among the size-frequency distributions. This would be expected as the low quantity of clams in these locations is reflective in the low fishing intensity experienced.

For the sites 11(2), 15, 15(2), 17, 18, 19 and 20, the frequency of Manila clams is predominately consistent within the size-class interval 30-40mm, indicating a narrow size-frequency distribution, with the greatest frequencies within the 30-35mm class (Figure 7c, 7d). The lower frequency in the 35-40mm class is likely due to the exploitation of sizeable clams in the previous fishing season due to the high fishing pressure (Southern IFCA, per comm.). The greatest frequency is seen in the 30-35mm class indicating significant recruitment potential for the 2018 fishing season and suggests that the management is proving effecting in preventing illegal harvesting both outside the dredge season and during the dredge season with no removal of undersized shellfish. The greatest frequency is again seen in the size class 30-35mm for the sites 18(2) and 19(2) however the scale of the frequency for these two sites is much larger, particularly for 18(2), indicating the importance of these areas for clam recruitment (Figure 7d). These two sites also indicate significant levels of 25-30mm individuals which is encouraging for future recruitment levels.

The seasonal closures at sites 6, 7, and 10, could explain the greater above MLS frequencies, in the class 35-40mm (Figure 7b, 7c). The seasonal closure would have allowed for additional time to allow recovery of the population and reduced harvesting intensity of sizeable individuals. This could have led to some growth of individuals throughout winter period.

The closed fishing areas for sites 23 and 24 display a right skewed size-frequency distribution. The greatest frequency for these sites is in the 30-35mm size-class with significant frequency is also in the class 35-40mm, particularly for site 23 (Figure 7e). The greater frequencies above MLS that occur than seen within sites 15, 15(2) and 17-20, complements the fact that these areas have no harvesting due to the prohibition of fishing.

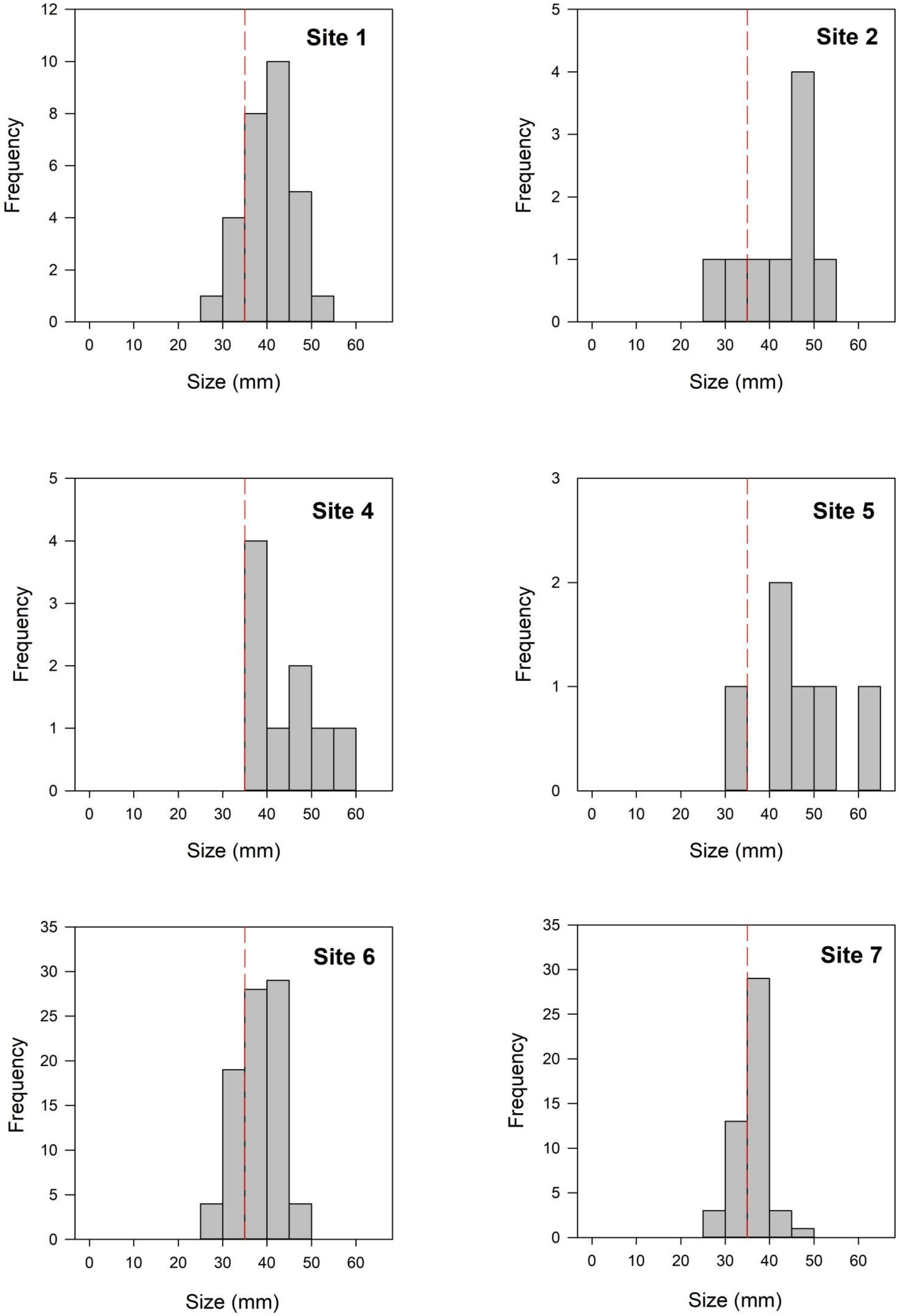


Figure 7a. Size-frequency distribution histograms for sites 1-7 for the Manila clam data collected. There were no Manila clams found at site 3. Size-class every 5mm, from 5-65mm. The red dotted line represents the Minimum Landing size of 35mm.

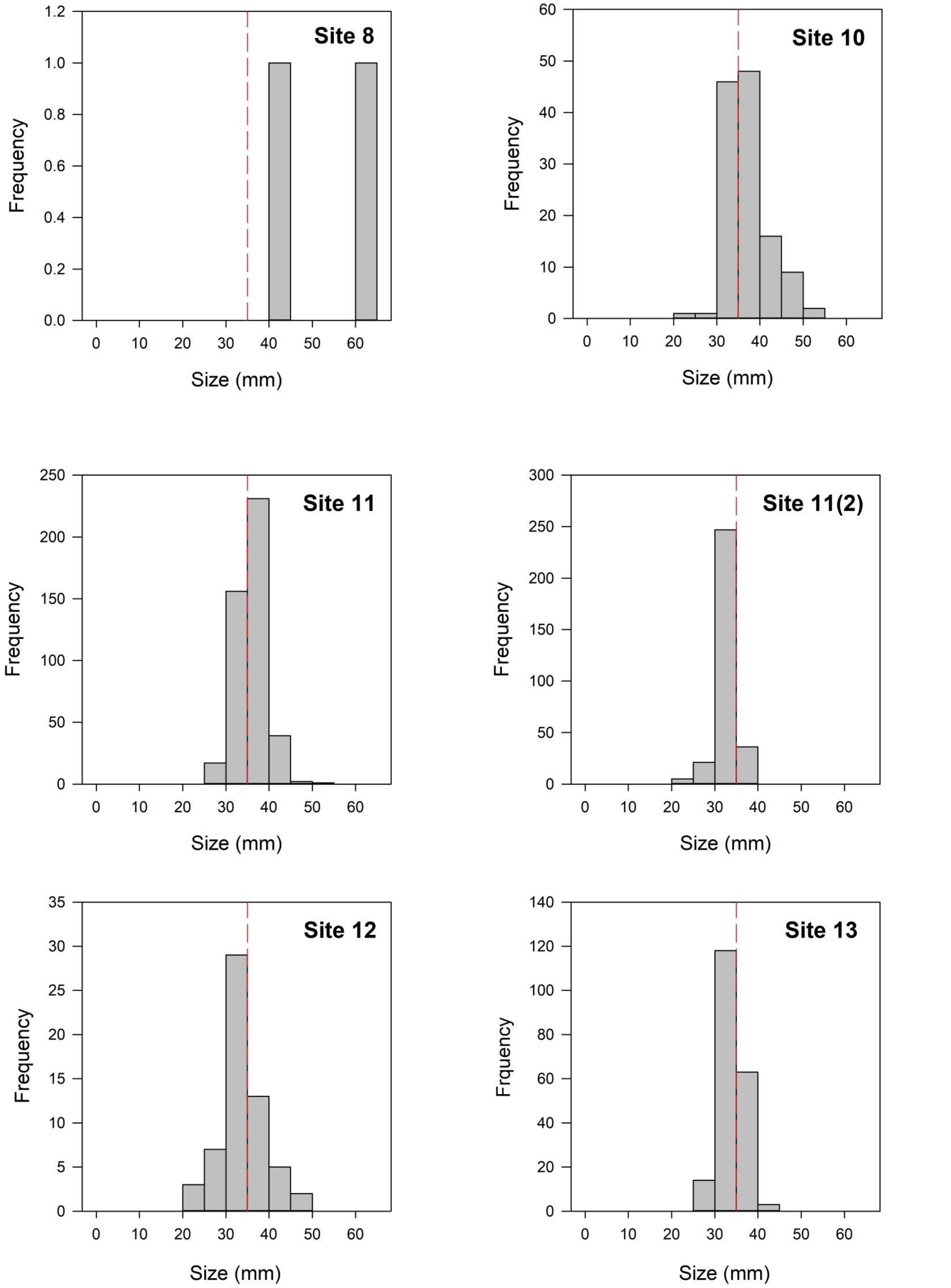


Figure 7b. Size-frequency distribution histograms for sites 8-13 for the Manila clam data collected. Size-class every 5mm, from 5-65mm. The red dotted line represents the Minimum Landing size of 35mm.

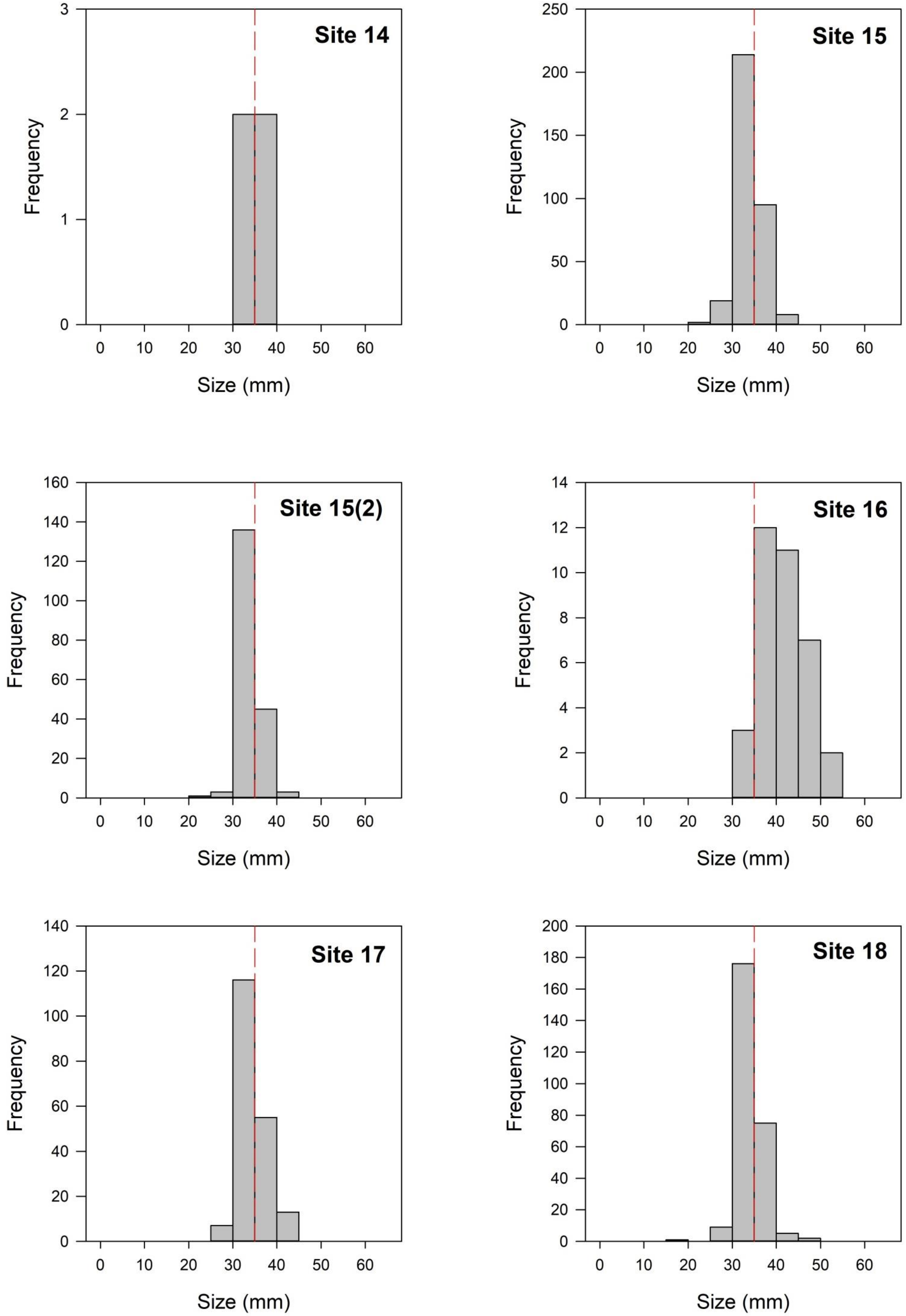


Figure 7c. Size-frequency distribution histograms for sites 14-18 for the Manila clam data collected. Size-class every 5mm, from 5-65mm. The red dotted line represents the Minimum Landing size of 35mm.

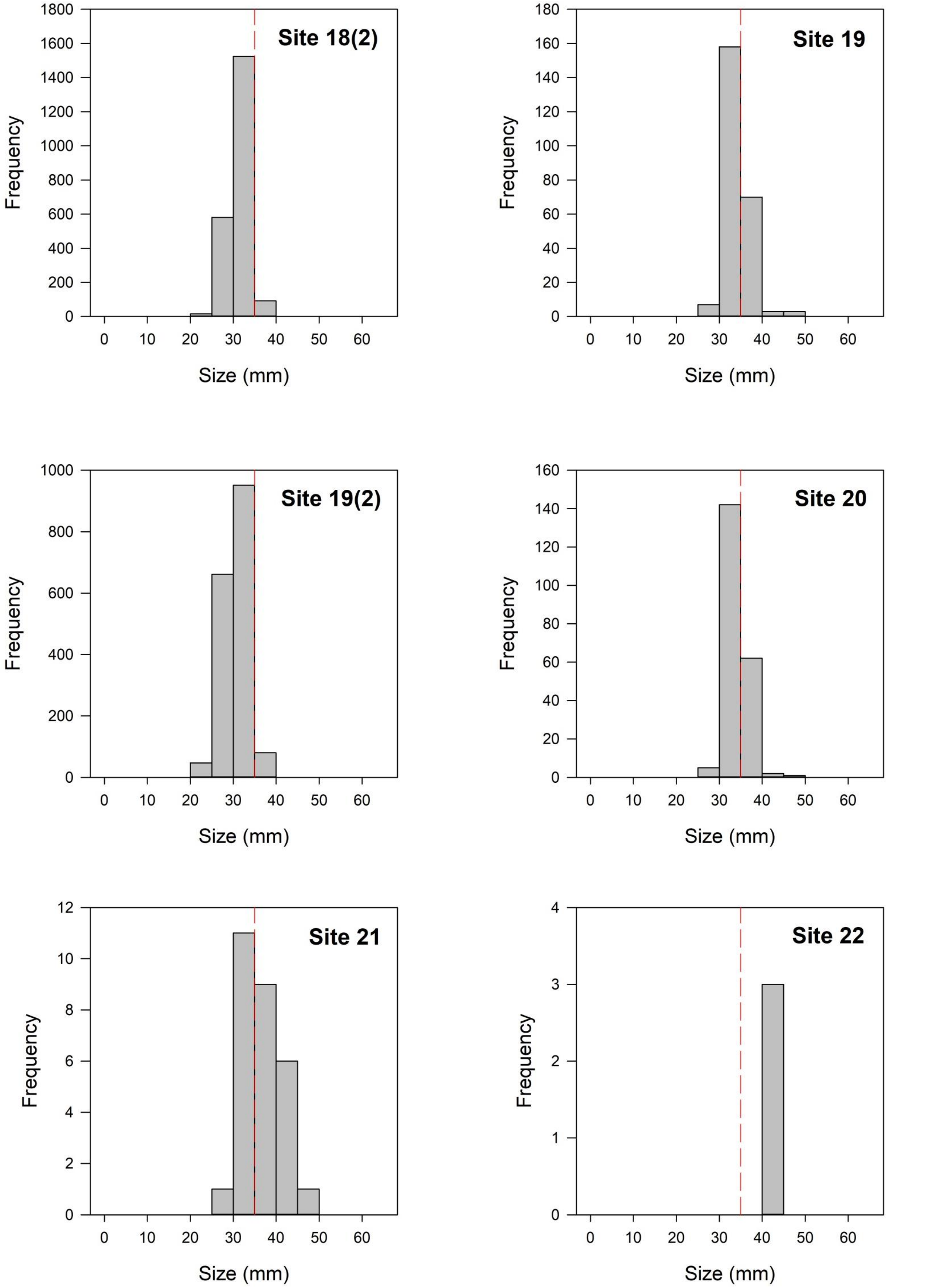
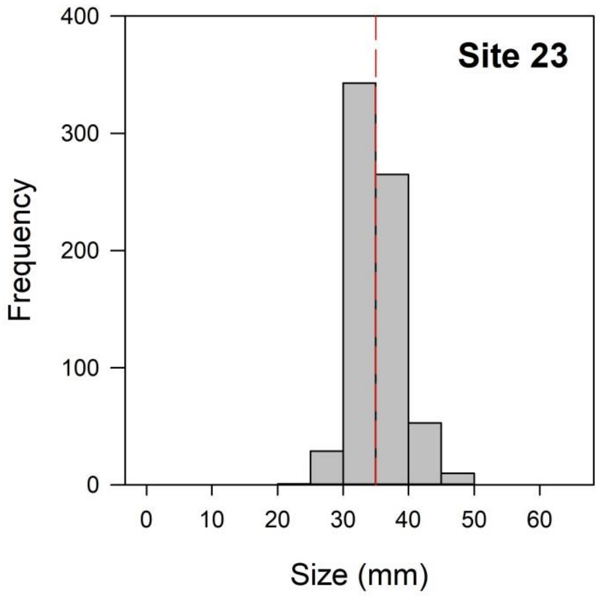


Figure 7d. Size-frequency distribution histograms for sites 18(2)-22 for the Manila clam data collected. Size-class every 5mm, from 5-65mm. The red dotted line represents the Minimum Landing size of 35mm.



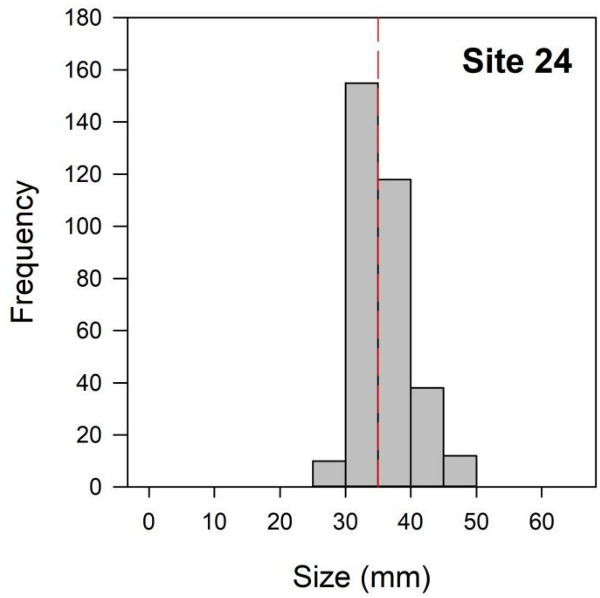


Figure 7e. Size-frequency distribution histograms for sites 23 and 24 for the Manila clam data collected. Size-class every 5mm, from 5-65mm. The red dotted line represents the Minimum Landing size of 35mm.

3.4 Comparison of 2016, 2017 and 2018 survey data

3.4.1 Average size

The average size can be useful to represent the collection of sizes found at the site and therefore determine the changes from one year to the next. However due to the size-selective methodology used through the use of the pump-scoop, the sampling is bias as does not select for individuals below MLS, so the average size has to be interpreted with caution.

3.4.1.1 Manila Clams

The average clam size fluctuates considerably from site to site. In general, the average size of the Manila clam found across all sites seems to have remained fairly consistent from 2016 to 2018. Although there is no substantial increases in average size seen at any of the sites in 2018, the consistency of average size across the temporal scale seen at many of the sites, with majority equal to or above MLS (red line on Figure 8a), suggests stable population frequencies. A decline of >1mm in 2018, below the 2016 and 2017 average sizes is seen at sites 1, 2, 4, 10, 12, 14, 15, 18, 23 and 24 (Figure 8a). The reasons for this are not clear however, the average size may be susceptible to the feeding pressure by birds within this conservation area, for example a survey indicated clams are utilised as food by oystercatchers (Bannister, 2006).

3.4.1.2 Cockles

Likewise, with the Manila clam population, the average cockle size fluctuates from site to site in the Harbour. In general across the three years the variation in average size is +/- 5mm except at site 13 (Figure 8b). At site 13 the average cockle size increases to a high 49.2mm in 2017, however in 2016 and 2018 the average size was 24.9mm and 24.6mm respectively, which perhaps suggests the 2017 was not reliable (Figure 8b).

In particular for the heavily fished sites including 11, 11(2), 18-20, the average cockle size is consistent among the three years. For site 19(2) the average cockle size ranged only from 23.6mm-23.72mm, just below the MLS. The consistency is encouraging to suggest the size-frequency of the population at the sites is stable over time and therefore is not being dramatically changed by fishing activity.

At sites 23 and 24, the 2018 average size is lower than the 2016 average size (Figure 8b). Although this could be concerning, there are other pressures on the population than fishing, particularly in an area where fishing is prohibited and there have been no instances of illegal fishing. Factors such as feeding pressure by birds within the conservation areas may impact the population. Again similarly with Manila clams, the average cockle size also decrease by >1mm from 2016 to 2018 for the sites 2, 4, 12, 14, 15, and 18, as well as at site 3.

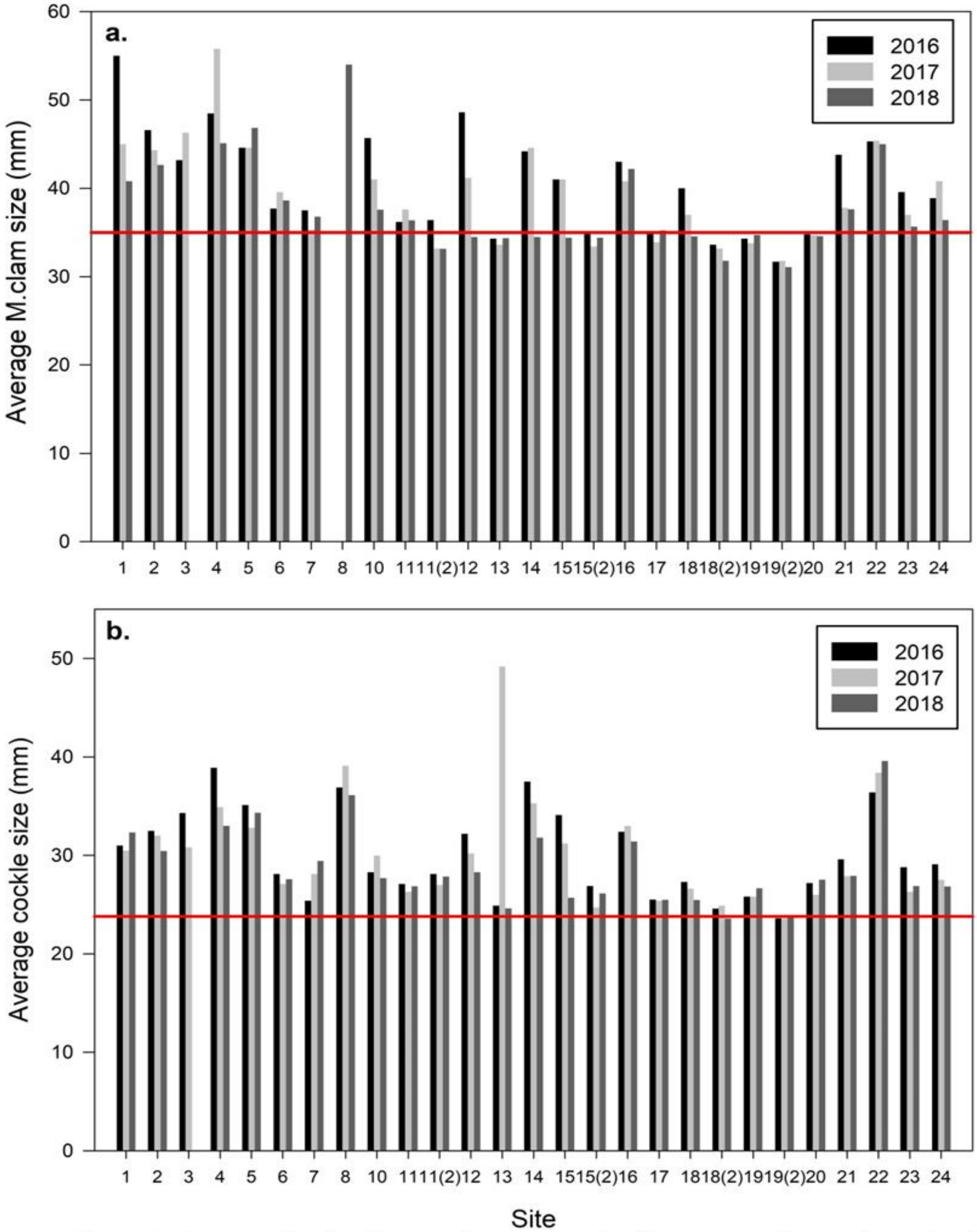


Figure 8. Average size (mm) comparison across the three years of surveying using the pump-scoop dredge methodology; 2016, 2017 and 2018. For a) Manila clam dataset, and b) Common cockle. The red line represents the Minimum Landing size, 35mm for a) and 23.8mm for b).

3.4.2 Average weight

The comparison across the years of 2016, 2017 and 2018 for the average weights of the bivalves (obtained as an average of the three replicates from the pump-scoop dredge samples) are seen in Figures 9 and 10. This can indicate if there are any trends are present over time for each site.

3.4.2.1 Cockles

Comparing the average weight of cockles across the three years, the weight significantly varies from site to site with no clear trend observed across all sites (Figure 9). Although in general there is a greater biomass found in 2017 than 2016, with marked increases at sites 8, 21 and 24. This increase also continued in 2018 at the sites 1, 4, 14, 15, and 17.

However sites 5, 11(2) and 23 show the most substantial decreases between the three years. This could be concerning for site 23 as it is within the closed fishing area, where average weight would be expected to be maintained or increase. However, for site 24, also in the closed fishing area, the average weight for 2017 and 2018 is above that of the 2016 level, therefore there is unlikely a cause for concern (Figure 9a).

For site 2, 8, 14, and 22, the total change is reflective of the change in oversized cockles, as no undersized cockles are found here for any of the years (Figure 9b, 9c). Similarly, only a few small quantities of undersized cockle were found at the sites 1, 3, 5, 6, 15 and 16 in some years (Figure 9c). Therefore, the changes in the average weight of cockles are predominately due to changes in the volume of oversized cockles. Although this is likely bias due to the use of the pump-scoop dredge methodology which is size-selective for oversized cockles.

The decline seen in sites 15(2), 19-20 from 2017 to 2018, following the increase from 2016 to 2017 could be a concern. This decline is seen in both the weights of under and oversized cockles (Figure 9). These sites are among those subject to heavy fishing, therefore if this trend continues in future years it could negatively impact the fishers catch. The decline from 2017 to 2018 in the sites 23 and 24, within the closed fishing areas, is also seen in both under and oversized weights. However, site 4, 10, 18 and 18(2) indicate an increased weight in undersized cockles from 2017 to 2018 (Figure 9c), and in oversized cockle weight for the site 4 and 10 (Figure 9b). This is encouraging particularly for the heavily fished sites 18 and 18(2) suggesting good recruitment potential for the 2018 fishing season.

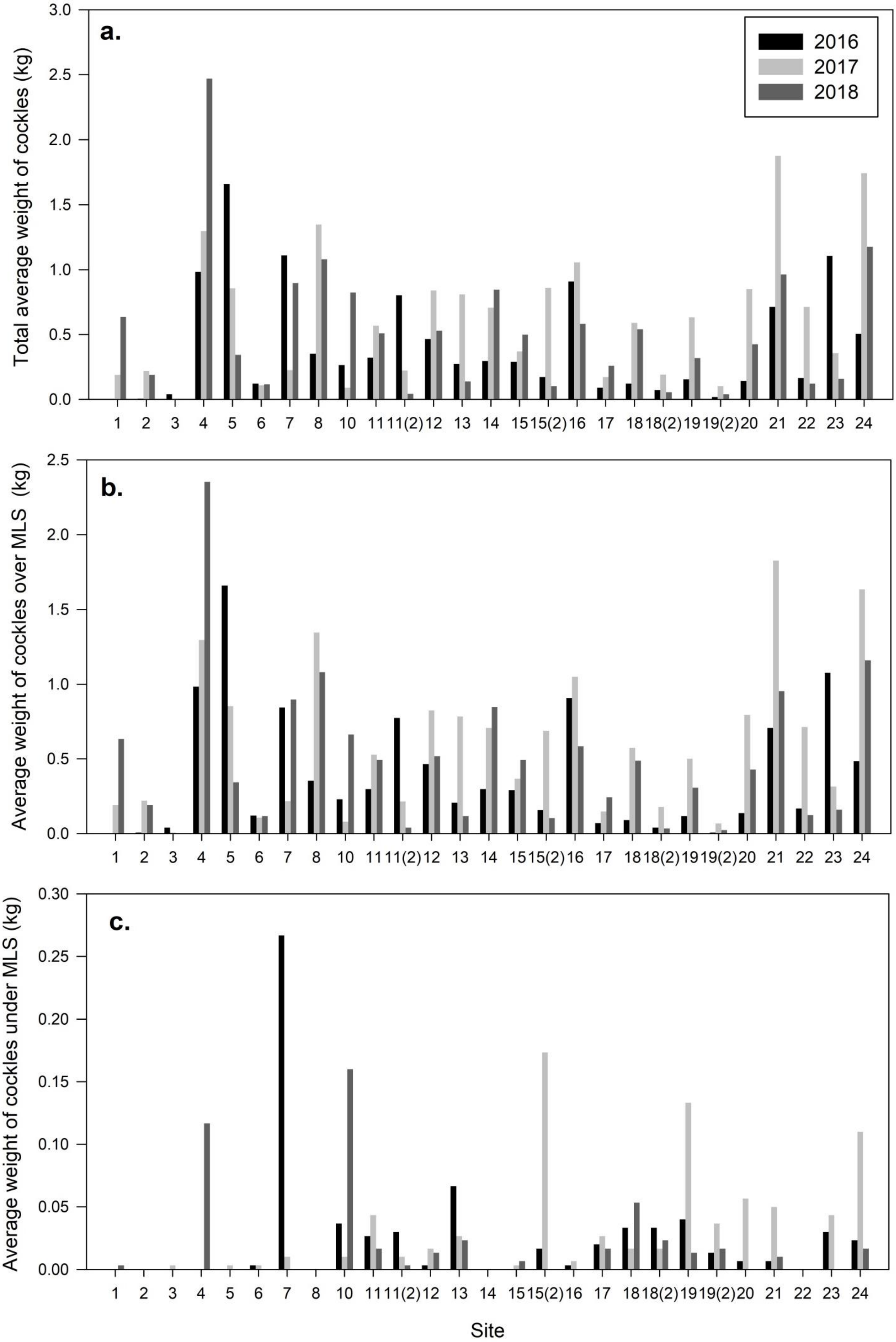


Figure 9. Comparison of the weight of Common cockles across 2016 (black bars), 2017 (light grey) and 2018 (dark grey) collected at each site (1-24). The graphs plot the average weight across the three replicates for each site, for each year. a) displays the average wieght (kg) of cockles collected, b) displays the average weight (kg) of cockles over MLS (23.8mm) and c) the average weight (kg) of cockles under MLS (23.8mm).

3.4.2.2 Manila Clams

For the majority of sites from 11(2) onwards, the average weight appears to have increased from 2016 to 2017, at some sites such as site 18(2) this increase is substantial (Figure 10a). However at many sites average weight of M. clams appears to decrease in 2018. Onwards from site 11, at 7 sites the biomass decreased below the biomass collected in both 2016 and 2017. A decline in particular is also seen at site 3, where in 2018 no clams were found, although in previous years the number of individuals found at this site were low. Only sites 17 and 18(2) indicate a continual increase from 2016 to 2018, and sites 11, 19(2) and 24 indicate an increase from 2017 to 2018 (Figure 10a). It is encouraging that the heavily fished sites 11, 18(2) and 19(2) display increases in weight, suggesting increasing recruitment each year. It is important to note that for the sites within the closed fishing areas, there was a large decline in biomass at site 24 between 2016 and 2017, yet in 2018 the biomass increases again, whereas for site 23 the trend is reversed with a large increase in biomass from 2016 to 2017, followed by a decrease in 2018 (Figure 10a).

When looking at the weight split into above and below MLS the difference at site 24 is reflected in both the over and under sized clams across all three years (Figure 10b and 10c respectively). This is also seen at sites 15, 15(2), 18, 19, 20 and 21 (Figure 10). At site 23 however the decrease from 2017 to 2018, is predominately due to the decrease in oversized clams, whereas there is actually a slight increase in undersized clams (Figure 10b, 10c).

The large increase at site 18(2) from 2016 to 2017 also seems to be as a result of an increase in both under and oversized clams; however from 2017 to 2018 the increase is due to the undersized clams, with a decrease in oversized individuals. Similarly with site 19(2), the majority of the increase in biomass from 2017 to 2018 is seen in the undersized clams, and only a small biomass increase in the oversized clams. Due to the inshore and sheltered nature of these sites 18(2) and 19(2), this would likely provide improved settlement for juvenile clams which could explain the increased population of undersized clams. Equally with site 11(2) from 2016 to 2017, the increase in weight is more substantial in the undersized clams, supporting the good settlement characteristics of the sheltered inshore site. It is important to note the results collected for the average weight of Manila clams under MLS (kg) are likely influenced due to size-selective pump-scoop dredge which selects for individuals at a harvestable size, above MLS. Therefore, the average weight of under MLS clams is likely unrepresentative of the true sample.

In order to objectively determine if there are differences in the total average weights of Manila clams, as the main commercially important bivalve, across the three years, each site's three replicates for each year were compared and tested for statistically significant differences using a one-way ANOVA in Sigmaplot. For some sites, an analysis of variances on ranks was undertaken due to the failed normality or equal variance tests.

The majority of the sites indicate no significant differences across all three years, including the sites 23 and 24 within the closed fishery area, contrary to subjective observations from Figure 10. For site 3, a statistically significance difference with $P<0.05$ was found, using analysis of variance on ranks, between the years 2016 and 2018 due to a decrease in the median value. This suggests that over time, a significant change at the site has occurred. A significant difference with $P<0.05$ was also seen at site 10, between 2018 and 2016, and between 2018 and 2017, where the mean value for 2018 was greater. A significantly greater median was also observed for site 15 from 2017 to 2018. Statistically significant differences are in seen between the years 2016 with 2017, and 2016 with 2018, for site 17. The mean values seems to significantly increase across the three years, as seen in Figure 10, indicating the seasonally closure at this site provides an increasingly greater recruitment potential for the M. clams. For site 18(2), again a significant difference is seen across all years with increasing mean vales each sequential year. However, for site 19 a significant decline is indicated between the years 2017 and 2018.

For site 15(2) although a significant difference occurred between all years, this was due to a greater mean value in 2017, observed in Figure 10. This trend also occurred in sites 20 and 21, where 2017 was significantly greater than both the 2016 and 2018 values. For these sites in particular although some significant changes were observed at the sites, due to only three years' worth of data it is difficult to determine if the trend that will continue on a larger temporal scale.

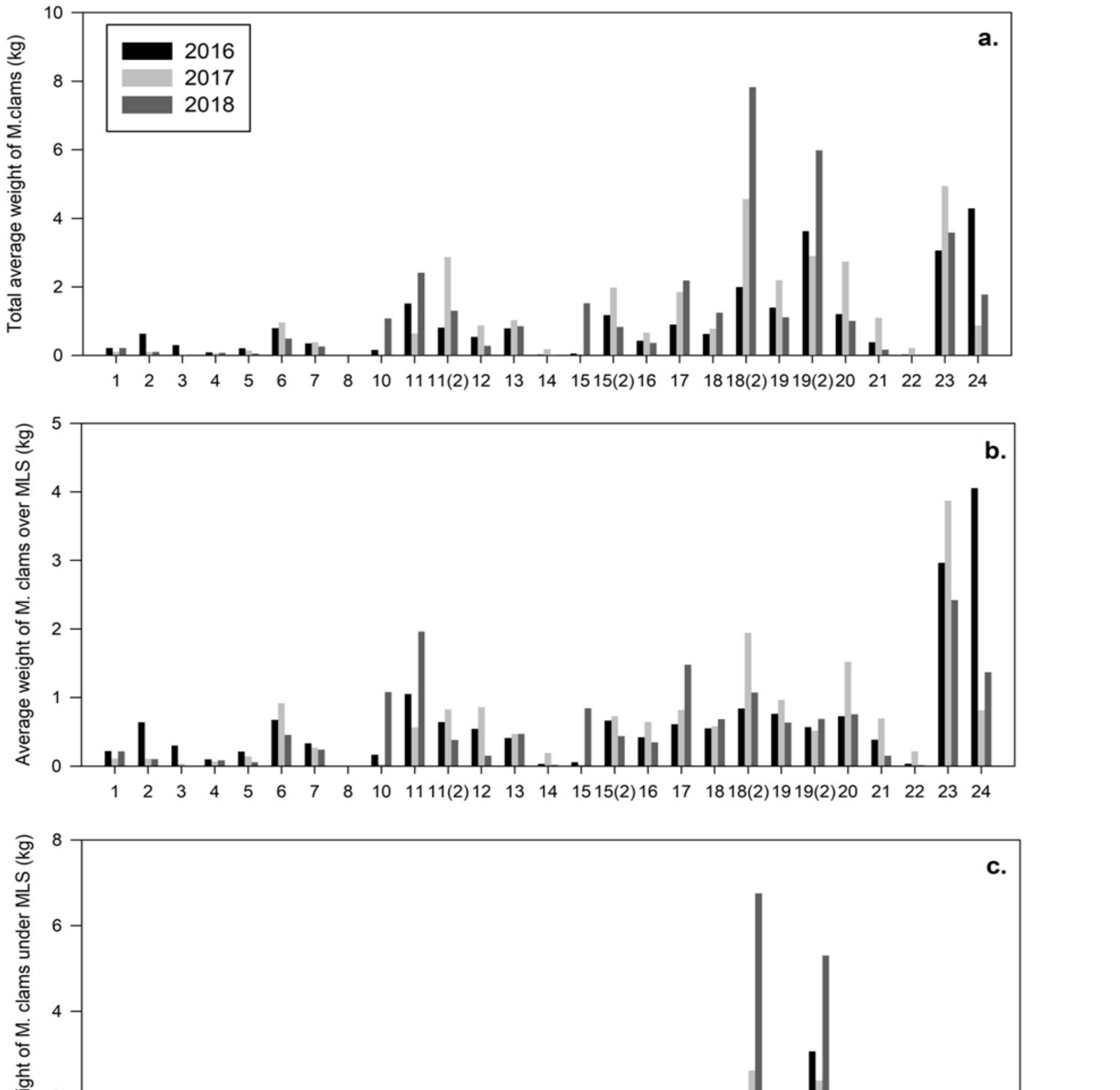


Figure 10. Comparison of the weight of Manila clams across 2016 (black), 2017 (light grey) and 2018 (dark grey) collected at each site (1-24). The graphs plot the average weight across the three replicates for each site, for each year. a) displays the total average weight (kg) of Manila clams collected, b) displays the average weight (kg) of M. clams over MLS (35mm) and c) the average weight (kg) of M. clams under MLS (35mm).

4.0 Conclusions

The outcome and interpretation of the stock assessment is not clear cut. Although the annual stock assessment increasingly provides an understanding of the population and size-frequency distributions of the Poole Harbour Manila clam and common cockle populations, several influential factors result in variation within the dataset. The natural and anthropogenic variation within the harbour influences no clear trend being observed across all sites. Furthermore, currently only a short temporal dataset exists, over a longer time scale it will be easier to identify and outline changes from previous observed inter-annual patterns. This emphasises the importance for this survey to continue annually. A significant limitation to the findings in this report is the selective methodology which results in a substantial bias towards to the sampling of the undersized population, underrepresenting the below MLS bivalve individuals. Further study will involve analysing of the samples collected using the modified sediment drag to obtain a complete picture of the bivalve populations.

5.0 References

Bannister, C. 2006. ‘Towards a National Development Strategy for Shellfish in England: Executive Report’, *Executive Summary Report to Sea Fish Industry Authority.*

Bennett, L. 2011. ‘Poole Harbour Aquatic Management Plan’, *Borough of Poole*.

Dyrynda, P. 2005. ‘Sub-tidal ecology of Poole Harbour – an overview’, *in:* Humphreys, J. and May, V. (eds.), *Proceedings in Marine Science 7: The Ecology of Poole Harbour*, Elsevier, Amsterdam, pp. 109-130;

Haywood, P.J. and Ryland, J.S. 1995. *Handbook of the marine fauna of north-west Europe*, Oxford University Press, Oxford.

Hübner, R. 2009. ‘Sediment geochemistry – a case study approach’, *PhD Thesis*, School of Conservation Sciences, Bournemouth University, pp. 274.

Humphreys, J. 2005. ‘Salinity and tides in Poole Harbour: estuary or lagoon?’, *in:* Humphreys, J. and May, V. (eds.), *Proceedings in Marine Science 7: The Ecology of Poole Harbour*, Elsevier, Amsterdam, pp. 35-48

Humphreys, J. 2010. ‘The Introduction of the Manila clam to British coastal waters’, *Biologist,* **57,** pp.134–138.

Humphreys, J., Caldow, R.W.G., McGrorty, S., West, A.D. and Jensen, A.C. 2007. ‘Population dynamics of naturalised Manila clams *Ruditapes philippinarum* in British coastal waters’, *Marine Biology.* **151**, pp.2255-2270.

Humphreys, J. and May, V. 2005. ‘Introduction: Poole Harbour in context’. *In:* Humphreys, J. and May, V. (eds) *Processings in Marine Science 7: The ecology of Poole Harbour*, Elsevier, Amsterdam, pp 1–8.

Jensen, A., Carrier, I. and Richardson, N. 2005. ‘Marine fisheries of Poole Harbour’, *in:* Humphreys, J. and May, V. (eds.), *Proceedings in Marine Science 7: The Ecology of Poole Harbour*, Elsevier, Amsterdam, pp. 195-204.

Jensen, A.C., Humphreys, J., Caldow, R.W.G., Grisley, C. and Dyrynda, P.E.J. 2004. ‘Naturalisation of the Manila clam (*Tapes philippinarum*), an alien species, and establishment of a clam fishery within Poole Harbour, Dorset, *Journal of the Marine Biological Association of the United Kingdom*, **84**, pp. 1069-1073

Jones, H., Addison, J. and Blyth-Skyrme, R. 2018. .'Marine Stewardship Council (MSC) Public Certification Report: The Poole Harbour Clam and Cockle Fishery', *Lymington: ME Certification Ltd.*