Southern IFCA
Inshore Fisheries and Conservation Authority

Solent Bivalve Stock Survey
Spring 2018

This report has been produced by the Southern Inshore Fisheries and Conservation Authority

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1. Introduction

This report details the surveys carried out in Southampton Water, Portsmouth Harbour and Langstone Harbour during March and April 2018 to assess the distribution and abundance of populations of clam and cockle species. These surveys follow on from the survey carried out in Southampton Water in October 2017, using the same methodology of employing a local fishing vessel and dredge equipment to assess the populations of Manila clam (*Ruditapes philippinarum*) and common cockle (*Cerastoderma edule*) across a number of defined shellfish beds.

For 2018, shellfish beds in the areas of Portsmouth Harbour and Langstone Harbour were surveyed in addition to those in Southampton Water. This allows data on the stocks of commercially important shellfish species to be gathered across the three main areas of importance for the local dredge fishery. In addition, the outcomes from the survey will provide data which can be used as a baseline on which to monitor future trends and potential changes to populations which will feed into the development and monitoring of local management measures.

1.1 The Fishery

The dredge fishery for clams and other shellfish species in the Solent operates year-round, subject to seasonal restrictions, mainly within the areas of Southampton Water, Portsmouth Harbour and Langstone Harbour. The main commercial species fished for using this gear type is the Manila clam (*Ruditapes philippinarum*) with other species also taken when in suitable quantities such as the common cockle (*Cerastoderma edule*), the American hard-shelled clam (*Mercenaria mercenaria*) and, occasionally, the Grooved Carpet Shell or native clam (*Ruditapes decussatus*).

The dredge fishery uses a type of mechanical dredge, commonly referred to as a ‘box clam dredge’ (Figure 1.1). The dredge consists of a metal frame with a front opening beneath which is a row of metal teeth. The dredge is towed from the stern of the vessel, supported on the seabed by skis which are fixed to the base of the dredge, with the teeth digging into the sediment as the dredge is towed along. As the dredge is towed through the sediment, the teeth disturb the shellfish and cause them to be caught in the dredge basket. The basket consists of a metal cage construction with spacing between the bars to allow sediment, debris and smaller sized shellfish to be washed through whilst retaining the sizable shellfish. The dredge is towed for varying time intervals but commonly 1-2 minutes. Once the tow is complete the dredge is recovered and held at the surface to allow water to wash through the contents and reduce the amount of sediment which is recovered with the catch. The dredge is brought inboard and emptied onto a sorting table at which point the catch is sorted.

Vessels either use one or two dredges at a time when fishing. The overall construction and set up of the dredge can vary between vessels as there are currently no regulations specifying gear construction for this fishery, however the general gear type remains the same following the design outlined above.

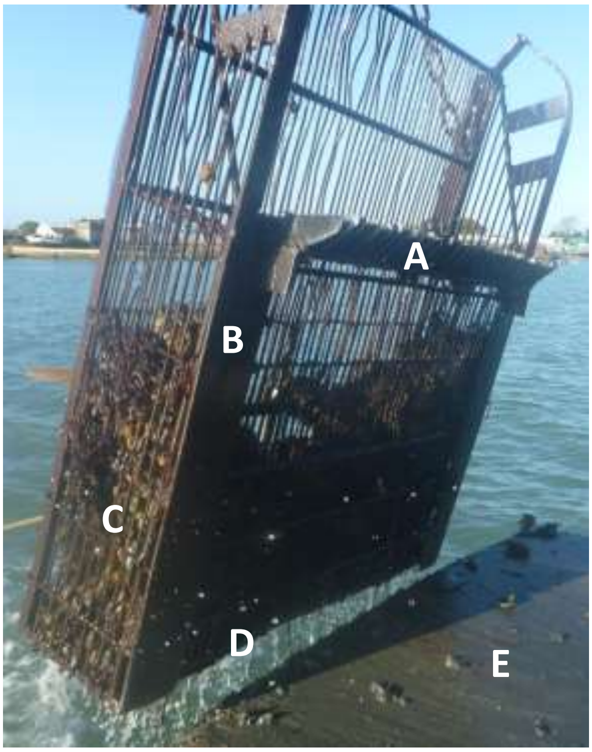


Figure 1.1: a box clam dredge used in Southampton Water; A) metal teeth defining the front opening of the dredge, B) skis to support the dredge on the seabed, C) dredge basket, D) spring-loaded opening to remove contents onto E) sorting table.

Dredging for clams tends to take place over small, distinct areas where shellfish beds are found including both Portsmouth and Langstone Harbours and Southampton Water, the latter having several defined areas where activity tends to concentrate. The fishery operates both intertidally and subtidally, with the appropriate tide the vessels are able to access some very shallow intertidal areas. Levels of fishing activity in the Solent have varied greatly over time. Sightings of fishing vessels compiled by Southern IFCA show that dredging for clams occurred predominantly in Southampton Water between 2005 and 2011 (Gravestock, 2016b) across a number of areas including Hythe, Bird Pile, Ashlett Creek and adjacent to the river Hamble. Data shows that there has been a decline in activity since 2012 which is also reflected in a decrease in the number of vessels operating in the fishery (Gravestock, 2016b). The decline in activity could be attributed to a number of factors however a significant influence has been the prohibition on fishing for clams in the upper reaches of Southampton Water between 2012 and 2015 due to a downgrade in shellfish classification. Despite declining levels of activity, there is still a commercial value to the fishery with the Manila clam being the most commercially valuable species varying between £3.50 and £5.00 per kilo. This high value species and the demand from merchants for clam species keeps vessels engaged in the dredge fishery. Many of the vessels have become multi-use, set up for a combination of fishing methods with seasonal regulations, productivity of the fishery and market demand defining the level of engagement in a particular fishery.

1.2 Commercial Species

The main species harvested by the clam dredge fishery is the Manila clam (*Ruditapes philippinarum*) with other species taken including the Common cockle (*Cerastoderma edule*), the American Hard-Shelled clam (*Mercenaria mercenaria*) and, occasionally, the Grooved Carpet Shell clam (*Ruditapes decussatus*).

1.2.1 Manila Clam

The Manila clam, *Ruditapes philippinarum* (Adams and Reeve, 1850) is a bivalve mollusc from the family Veneridae. It is found in fine sediments within both the intertidal and sub-littoral (Jensen *et al.,* 2005). Adult clams are suspension feeders, living buried within the sediment. The clam has a planktonic larval stage which allows for natural dispersion, followed by metamorphosis with the clams settling on the seabed (Humphreys *et al.,* 2015). Both adult and larval stages are euryhaline and tolerant of salinities as low as 12-15 which allows the development of estuarine populations (Jensen *et al.,* 2005; Humphreys *et al.,* 2015).

The Manila clam is not native to the UK although its distribution has widened significantly from its native region in the Indo-Pacific to include the Pacific coast of America, the Atlantic coast of Europe and the Adriatic and Aegean seas (Jensen *et al.,* 2004; Jensen *et al.,* 2005). The expansion in the distribution of this species is largely as a result of human activity, the species was first introduced to the UK in the 1980s for the purposes of aquaculture by the Ministry of Agriculture, Fisheries and Food (MAFF) (now DEFRA) after which the species was made available to commercial growers and finally naturalised populations developed, the first of which was reported in Poole Harbour in Dorset (Jensen *et al.,* 2004). It is thought that the species was first found in Southampton Water in 2002 with larger individuals up to 45mm long becoming commonplace by 2005 (Humphreys *et al.,* 2015).

1.2.2 Common Cockle

The Common Cockle, *Cerastoderma edule* (Linnaeus, 1758) is a bivalve mollusc from the family Cardiidae. The species is found in muddy and sandy habitats at the mid to lower reaches of the intertidal and occasionally in the subtidal. Adults burrow to no more than approximately 5cm below the surface operating as suspension feeders (Tyler-Walters, 2007). The species is a broadcast spawner with larvae living for 3-6 weeks in the plankton before settling on the substrate after metamorphosis. The Common cockle is tolerant of salinities as low as 10 which allows for the development of extensive estuarine populations (Hayward and Ryland, 1995).

The Common cockle is native to the UK and is found distributed around the coasts of Britain and Ireland. Populations are also found from the wester Barents Sea and northern Norway to the Iberian Peninsula and the coast of West Africa.

1.2.3 American Hard-Shelled Clam

The American Hard-Shelled clam, *Mercenaria mercenaria* (Linnaeus, 1758) is a bivalve mollusc from the family Veneridae. They are found in muddy/sandy sediments on the lower intertidal and shallow sublittoral, commonly found within estuaries and sheltered bays (Carter, 2005). Adult clams are suspension-feeders and broadcast spawners with a planktonic larval stage of 6-10 days before settling onto suitable muddy/sandy substrate as the shell starts to form (Whetstone *et al.,* 2005). The species has a lower tolerance for low salinities than other clam species and can only exist in low salinity environments for a short period of time (Whetstone *et al.,* 2005).

American Hard-Shelled clams are native to North America although introduced populations occur in Europe and California. The species was purposefully introduced into British waters (Humphreys *et al.,* 2015) and is found in isolated populations on the south coast of England, Pembrokeshire and in Scotland (Carter, 2005).

1.2.4 Grooved Carpet Shell or Native Clam

Image by Joop Trausel and Frans Slieker via www.marinespecies.org

The Grooved Carpet Shell Clam, *Ruditapes decussatus* (Linnaeus, 1758) is a bivalve mollusc from the family Veneridae. It is very similar in appearance to the Manila clam; however, the two species can be identified by their siphon anatomy with the Carpet Shell having distinctly separate inhalant and exhalent siphons compared to the Manila clam where the siphons are fused for most of their length (Humphreys *et al.,* 2015). In addition, the Carpet Shell has distinctive radiating lines on the shell.

The Carpet Shell is a suspension feeder and is found on the lower intertidal and shallow sublittoral in sandy, muddy gravel or clay sediments (Haywood and Ryland, 1995). The species is a broadcast spawner with a 10-15 day planktonic larval stage before the larvae settle as spat on suitably sandy and silt substrates (Figueras, 2005). The species is native to the British Isles and is mainly found off the southern and western coasts of Britain and Ireland as well as in the Mediterranean and west Africa (Carter, 2003).

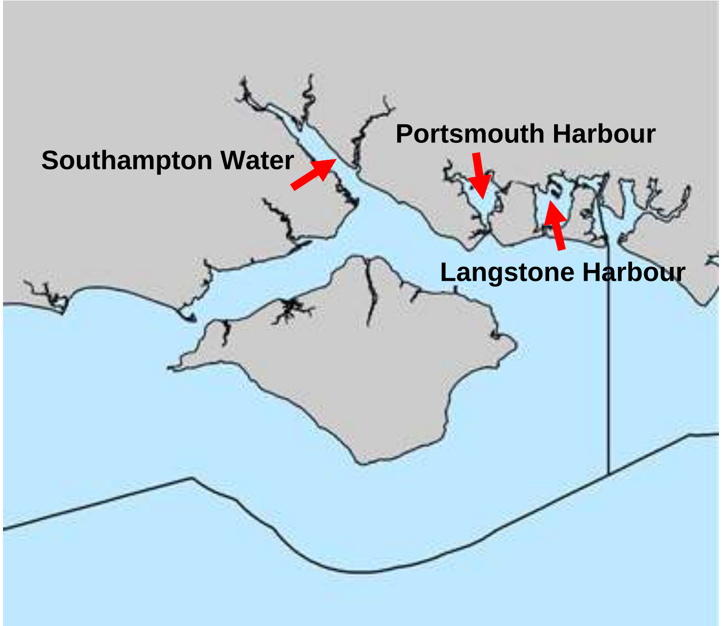


Figure 1.2: Solent and adjacent estuaries showing the three locations for the survey. The solid black lines indicate the boundaries of the Southern IFCA District.

1.3 The Solent

The Solent is a strait of water with adjacent estuaries which separates the mainland of England from the Isle of Wight (Figure 1.2). It is a highly protected area with the wider Solent containing two European Marine Sites (EMS), the Solent EMS and the Solent and Isle of Wight Lagoons Special Area of Conservation (SAC). The Solent EMS is a complex site encompassing both Special Areas of Conservation (SACs) designated under the EC Habitats Directive and Special Protection Areas (SPAs) designated under the EC Birds Directive. The EMS is made up of the Solent Maritime SAC, the Solent and Southampton Water SPA, Chichester and Langstone Harbour SPA and Portsmouth Harbour SPA. The Solent EMS is unique in Europe with regard to the complexity of the marine and terrestrial habitats present including mudflats, saltmarsh, eelgrass (*Zostera* spp.) and natural shoreline transitions to adjacent coastal habitats including grazing marsh, saline lagoons and reedbeds (SEMS, 2017). This variety of habitats supports key species of birds and form rich grazing, breeding and nursery grounds. The mudflat habitat in particular, a key habitat under both the SAC and SPA designations, supports a rich invertebrate fauna which in turn provides a food source for internationally important populations of migratory species and an internationally important assemblage of wildfowl (Gravestock, 2016).

The three areas sampled during this survey are Southampton Water, Portsmouth Harbour and Langstone Harbour. Full details of the designations which cover these sites, the associated habitats and species of importance and the potential interactions between these and the clam dredge fishery can be found in the Habitats Regulations Assessments:

- HRA/06/001 Solent Maritime SAC – Clam Dredging (Gravestock, 2016a)
- HRA/08/001 Solent and Southampton Water SPA – Clam Dredging (Gravestock, 2016b)
- HRA/09/001 Chichester and Langstone Harbours SPA – Clam Dredging (Gravestock, 2016c)
- HRA/10/001 Portsmouth Harbour SPA – Clam Dredging (Gravestock, 2016d)

1.4 Current Management

There are a number of management measures currently in place regulating clam dredge fishing within the Solent.

- Solent Dredge Fishing Byelaw 2016

The Solent Dredge Fishing Byelaw 2016 defines a prohibition on the use of a dredge within Southampton Water, Portsmouth Harbour or Langstone Harbour between 1st March and 31st October each year (both days inclusive). The byelaw also defines a daily fishing period of 07:00 to 17:00 each day during the dredge season. In addition, for both the daily and seasonal closures, a dredge must not be retained on board, stored or transported by means of a vessel within these areas unless all parts of the dredge are inboard and above the sea.

- Bottom Towed Fishing Gear 2016 byelaw

The Bottom Towed Fishing Gear 2016 byelaw prohibits the use of any bottom towed fishing gear within certain defined areas as well as requiring that any vessel carrying bottom towed fishing gear in these areas must have all parts of the gear inboard and above the sea. The prohibited areas are defined to protect sensitive features and habitats.

- Other Byelaws

Other Southern IFCA byelaws also apply to this fishery including the 'Vessels Used in Fishing 2012' byelaw specifying that any commercial fishing vessel must not exceed 12m in overall length and the 'Fishing for Cockles' byelaw which defines certain gear restrictions and a season (1st May to 31st January) for the fishing for and taking of cockles.

- The Solent European Marine Site (Prohibition of Method of Dredging) Order 2004

This Order prohibits any fishing vessel from deploying or carrying (unless inboard, secured and stowed) a dredge which is used in conjunction with any means of injecting water into the dredge or in the vicinity of the dredge.

- Minimum Size Regulations

Shellfish species that would potentially be taken by the dredge fishery are governed by a minimum legal size. The minimum sizes for Manila clam (*Ruditapes philippinarum*) and the Grooved Carpet Shell clam (*Ruditapes decussatus*) are defined in European legislation under Council Regulation (EC) 850/98 at 35mm and 40mm respectively. The minimum sizes for both the common cockle (*Cerastoderma edule*) and the American Hard-Shelled clam (*Mercenaria mercenaria*) are both defined in Southern IFCA byelaws, namely the 'Fishing for Cockles' byelaw (23.8mm) and the 'American Hard-Shelled Clams – Minimum Size byelaw' (63mm).

- Other Regulations

In addition to the above regulations, the fishery is also subject to regulations on the classification of shellfish. EC Regulations 853/2004 and 854/2004 set out regulations relating to the commercial production and sale of live bivalve molluscs (clams, cockles, oysters, mussels etc.) from classified production areas. These regulations are implemented by means of the Food Safety and Hygiene (England) Regulations 2013. Data on shellfish waters in England and Wales is compiled by CEFAS using the results of monthly bacteriological sampling. Production areas are then classified by the Food Standards Agency (FSA) according to the E. coli levels present in the samples. This classification into one of five categories then determines the areas where bivalves can be harvested from and how they have to be treated to ensure they are safe for human consumption. Classifications are defined as follows:

A Class – bivalve molluscs can be harvested for direct human consumption

B Class – bivalve molluscs can be marketed for human consumption after purification in an approved plant or after relaying in an approved class A relaying area or after being subjected to an EC approved heat treatment process

C Class – bivalve molluscs can be marketed for human consumption only after relaying for at least two months in an approved relaying area followed, where necessary, by treatment in a purification centre, or after an EC approved heat treatment process

Prohibited Areas – bivalve molluscs must not be subject to production or be collected

Unclassified Areas – bivalve molluscs must not be subject to production or be collected

Currently, Southampton Water has mixed classifications for the Manila clam and the American Hard-Shelled clam. These include areas where harvesting is prohibited due to high E. Coli levels and there are areas defined as C Class and Long-term B Class.

2. Materials and Methodology

The stock assessment survey was carried out in three parts. For each area, the survey was carried out using a fishing vessel which routinely operates in that area:

- Langstone Harbour on 21st March 2018, using vessel 'Sand Julie'
- Portsmouth Harbour on 22nd and 23rd March 2018, using vessel 'Solent Star'
- Southampton Water on 4th April 2018, using vessel 'Benjamin Guy'

The samples were obtained using a box clam dredge, with the same dredge being used on all three vessels. The dredge was obtained specifically for the purposes of conducting this survey having been originally made to be used on the vessel FV Benjamin Guy. To ensure that the dredge was suitable and would obtain the samples required on a different vessel to that for which it was made the first survey day in Langstone Harbour was conducted using both the survey dredge and the dredge usually used on the vessel FV Sand Julie to see if there were any noticeable differences which would affect the results of the survey. There were no notable differences between the two dredges therefore for the purposes of this survey the results from Langstone Harbour from the survey dredge are used to provide consistency between the three areas sampled.

Shellfish beds were defined for each of the survey locations, the beds for Southampton Water were the same as those sampled during the initial survey in the autumn of 2017. For Langstone and Portsmouth Harbours the beds to be sampled were defined in conjunction with the local fishers, using their knowledge and experience of the areas commonly used by the fishery. The shellfish beds sampled for each area are detailed in tables 2.1-2.3 below and show on the charts in appendices 1-3.

Three dredge tows were completed for each of the shellfish beds. The location of the dredge tows was arbitrarily set within each of the shellfish beds to ensure the bed received sufficient sampling coverage, tows were completed as close to these points as possible according to the following methodology:

- The start time and GPS position, using a Garmin 72H hand-held GPS unit, of the vessel were recorded at the start of the tow
- A waypoint was created at the start of the tow using the hand-held GPS unit and the waypoint number recorded
- The vessel's speed was recorded at the start of the tow and any significant changes in speed during the tow were noted
- The dredge was towed for a period of 1 minute
- The end time and GPS position of the vessel were recorded at the end of the tow
- A waypoint was created at the end of the tow using the hand-held GPS unit and the waypoint number recorded
- At the end of the tow, the dredge was recovered in-board and the contents emptied onto the sorting table at the stern of the vessel
- The contents of the dredge on the sorting table were photographed

- The presence/absence of certain species/habitat types was recorded from the dredge contents, where present the abundance was scored from 0-5. The species/habitats recorded were; Slipper Limpet (*Crepidula fornicata*), mud, weed, shell, stone and sand.
- Any bivalve species present in the dredge were retained and placed in a bucket labelled with the bed and tow numbers

From the bivalves retained from each tow, the length was measured along the widest axis (mm), using Vernier callipers, for all species. For the Manila clam, which is the dominant species for the fishery, individuals were separated into above or below the minimum size of 35mm and the weight of each size class was recorded (kg). After this analysis all bivalves were returned to the area they were caught from ensuring that they were returned to areas of the same classification from which they were taken. Prior to the survey taking place, the dimensions of the dredge were also recorded.

Shellfish Bed ID No.	Shellfish Bed Name	Dredge ID No.	Latitude °N	Longitude °W
1	Chadock Lake	1	50.841	-1.006
		2	50.840	-1.010
		3	50.838	-1.005
2	North Penner	4	50.839	-0.998
		5	50.837	-0.994
		6	50.835	-0.999
3	Bridge	7	50.835	-0.988
		8	50.834	-0.987
		9	50.832	-0.985
4	South Penner	10	50.832	-0.997
		11	50.828	-0.995
		12	50.830	-0.991
5	Stokes Lake	13	50.823	-0.992
		14	50.821	-0.990
		15	50.820	-0.996
6	Langstone Main	16	50.814	-0.999
		17	50.812	-1.000
		18	50.810	-1.004

Table 2.1: Shellfish beds defined for Langstone Harbour with identified dredge points

Shellfish Bed ID No.	Shellfish Bed Name	Dredge ID No.	Latitude °N	Longitude °W
1	Port Solent 1	1	50.845	-1.111
		2	50.845	-1.105
		3	50.845	-1.108
2	Port Solent 2	4	50.842	-1.112
		5	50.841	-1.112
		6	50.839	-1.111
3	Port Solent 3	7	50.842	-1.108
		8	50.840	-1.108
		9	50.839	-1.108
4	Tipner	10	50.834	-1.106
		11	50.832	-1.105
		12	50.831	-1.102
5	Portchester 1	13	50.834	-1.122
		14	50.833	-1.117
		15	50.834	-1.112
6	Portchester 2	16	50.827	-1.121
		17	50.828	-1.112
		18	50.824	-1.108
7	Wicor	19	50.840	-1.150
		20	50.840	-1.152
		21	50.841	-1.155
8	Fareham 1	22	50.839	-1.172
		23	50.839	-1.173
		24	50.840	-1.174
9	Fareham 2	25	50.845	-1.176
		26	50.846	-1.176
		27	50.847	-1.177
10	Adhoc Bed 1 - Whale Island	28	Additional bed added during survey, no prior coordinates defined	
		29		
		30		
11	Adhoc Bed 2 - Portchester Lake	31	Additional bed added during survey, no prior coordinates defined	
		32		
		33		

Table 2.2: Shellfish beds defined for Portsmouth Harbour with identified dredge points

Shellfish Bed ID No.	Shellfish Bed Name	Dredge ID No.	Latitude °N	Longitude °W
1	Calshot	A	50.820	-1.310
		B	50.815	-1.309
		C	50.828	-1.325
		D	50.829	-1.320
		E	50.826	-1.316
		F	50.821	-1.309
2	Fuel Jetty	G	50.833	-1.325
		H	50.837	-1.336
		J	50.837	-1.330
		K	50.829	-1.321
3	Bird Pile	L	50.844	-1.337
		M	50.843	-1.340
		N	50.846	-1.350
		O	50.854	-1.365
		P	50.856	-1.361
4	Deans Lake	Q	50.857	-1.362
		R	50.854	-1.366
		S	50.865	-1.389
		T	50.867	-1.385
5+6	Hythe and The Gymp	U	50.877	-1.398
		V	50.876	-1.400
		W	50.883	-1.411
		X	50.884	-1.405
		Y	50.884	-1.405
		Z	50.883	-1.411
		AA	50.892	-1.421
		AB	50.893	-1.418
		AC	50.890	-1.410
7	Marchwood	AD	50.879	-1.422
		AE	50.895	-1.424
		AF	50.897	-1.426
		AG	50.898	-1.424
8	Millstone Point (River Itchen 1)	AH	50.910	-1.375
		AI	50.913	-1.376
		AJ	50.915	-1.378
9	Ocean Village (River Itchen 2)	AK	50.899	-1.386
		AL	50.895	-1.387
10	Weston Shore	AM	50.889	-1.384
		AN	50.884	-1.385
		AO	50.876	-1.366
		AP	50.878	-1.366
11	Netley	AQ	50.870	-1.352

		AR	50.869	-1.355
		AS	50.862	-1.343
		AT	50.863	-1.341
12	Hamble Spit	AU	50.853	-1.324
		AV	50.850	-1.326
		AW	50.840	-1.314
		AX	50.849	-1.311
13	Hook Sands	AY	50.838	-1.304
		AZ	50.838	-1.308
		BA	50.830	-1.301
		BB	50.824	-1.282
		BC	50.829	-1.273

Table 2.3: Shellfish beds defined for Southampton Water. Shellfish beds for this site were defined during the first survey undertaken in the autumn of 2017, the beds were defined by coordinates for this site with three dredges taken from within the bed aiming to provide as complete coverage of the bed as possible.

2.1 Data Analysis

For the Manila clam, common cockle and American Hard-Shelled clam the total number of individuals per tow was recorded as well as the number of individuals above and below the minimum size (35mm, 23.8mm and 63mm respectively). For all species, the length of the individual along the widest axis (mm) was also recorded and, for the Manila clam only, the total weight (kg) per dredge was recorded as well as the weight above and below the minimum size (kg).

From the tow data, the distance of each tow was calculated based on the GPS co-ordinates taken at the start and end of the tow using a derogation of the haversine formula:

*(ACOS(COS(RADIANS(90-start latitude)) *COS(RADIANS(90-end latitude)) +SIN(RADIANS(90-start latitude)) *SIN(RADIANS(90-end latitude)) *COS(RADIANS(start longitude-end longitude)))*6371)*

This formula gives the great-circle distance between two known points of a sphere. A number of tow lengths were checked to ensure accuracy of the formula using GIS software. Using this data and that of the species recorded, the following calculations were made:

Number of individuals per average tow

From the determined distance of each tow, an average tow distance across all tows was calculated for each of the areas sampled (Langstone Harbour, Portsmouth Harbour and Southampton Water). For each tow, the average tow distance was combined with the actual tow distance as calculated above and the number of individuals of a particular species (total, above minimum size and below minimum size) according to the following formula:

*(Number of individuals in tow A / actual distance tow A (m)) * average tow distance*

This gave a number of individuals per average tow for each shellfish bed, standardising the data and therefore allowing the number of individuals of a particular species to be compared between different shellfish beds within each area.

Weight per meter of dredge per hour

For Manila clam, weight measurements were taken of the total weight of catch per dredge as well as the weight of catch above and below the minimum size.

This gives a measure of the effort level of the fishery through an estimate of catch per unit effort (CPUE) as weight (kg) per hour based on the size of the dredge used. All the tows completed for this survey had a duration of 1 minute. As the width of the dredge was 1m there was no need to multiply by the dredge width therefore the weight per meter of dredge per hour was calculated as the weight obtained for a tow multiplied by 60. This was done for the total weight as well as the weight above and below the minimum size.

2.2 Points to be aware of

There are points relating to the collection of survey data and the way in which the survey was carried out which need to be considered when analysing the data.

Adverse weather conditions were experienced during the Southampton Water survey. This meant that two of the survey sites, sites 9 and 11 could not be surveyed due to the expose to the wind and tidal conditions making the deployment and operation of the dredge unsafe.

The dredge used for all three surveys is designed specifically for the fishery and therefore the spacing between bars in the dredge basket is designed to minimise the retention of large quantities of shellfish under the minimum size, particularly in relation to the Manila clam (minimum size 35mm). Therefore, there will be a degree of bias in the shellfish retained by the dredge with a greater proportion of the larger size classes being retained. Due to the retention of sediment and other habitat matter, a proportion of smaller size classes were obtained however this should not be considered a complete representation of the whole population as a proportion of smaller individuals would have been lost through the dredge basket.

Finally, the data does not factor in dredge efficiency. The efficiency of the box clam dredge is likely to be low, other studies with a range of different fisheries and dredge types have shown that dredge efficiency can vary from 2% to 35%. There are no comparable studies for the type of dredge used in these surveys therefore it is difficult to determine an efficiency coefficient which could be applied to the data. The data here should therefore be treated with a degree of caution, assuming that it represents an underestimation of the population of shellfish on the seabed.

3. Results

The results for this survey will focus on two main commercial species; the Manila clam (*Ruditapes philippinarum*) and the common cockle (*Cerastoderma edule*). Some information can be provided for catches of American Hard-Shelled clam (*Mercenaria mercenaria*) although quantities for this species were very low compared to those of the Manila clam and common cockle so the ability to analyse the data is limited. Tables 3.2 to 3.4 show a summary of the results of the survey, at all three locations, for Manila clam, common cockle and American Hard-Shelled clam respectively, with data combined from all three dredge tows for each bed. The tables show the total number of individuals of each species for each bed as well as the size of the largest and smallest individuals and the average size across all measured individuals. The total number of each species across all the shellfish beds for each area surveyed were as follows (Table 3.1):

Manila Clam	
Langstone Harbour	121
Portsmouth Harbour	417
Southampton Water	1384
Common Cockle	
Langstone Harbour	343
Portsmouth Harbour	2411
Southampton Water	876
American Hard-Shelled Clam	
Langstone Harbour	26
Portsmouth Harbour	43
Southampton Water	34

Table 3.1: Total number of each species caught across all shellfish beds for each of the three areas surveyed.

For the Manila clam, overall the greatest number of individuals were found in Southampton Water, however for both the common cockle and American Hard-Shelled clam the greatest quantities were found in Portsmouth Harbour.

Looking at individual shellfish beds, the greatest number of Manila clams for Southampton Water was found at site 3 'Bird Pile', for Langstone Harbour at site 3 'Bridge' and for Portsmouth Harbour at site 5 'Portchester 1'. For cockles, the greatest abundances were found at site 2 'Fuel Jetty' for Southampton Water, site 1 'Chadock Lake' for Langstone Harbour and site 6 'Portchester 2' for Portsmouth Harbour. Abundances for American Hard-Shelled clam were much lower by comparison with only Langstone Harbour yielding this species for all beds sampled with the highest abundance (17) at site 1 'Chadock Lake'.

Manila Clam				
Langstone Harbour				
Bed ID	Total Number	Largest (mm)	Smallest (mm)	Average (mm)
1	26	42	25	35.27
2	27	49	34	41.33
3	35	52	28	43.03
4	2	49	37	43.00
5	22	53	29	41.68
6	9	49	35	42.33
Portsmouth Harbour				
1	11	47	21	35.73
2	10	56	40	44.10
3	2	46	45	45.50
4	85	56	22	36.53
5	120	57	22	35.30
6	50	48	22	33.02
7	20	54	28	41.40
8	29	56	15	35.48
9	37	49	14	36.19
10	3	53	37	46.67
11	50	50	22	34.68
Southampton Water				
1	188	45	26	33.37
2	212	48	20	33.45
3	409	46	21	32.43
4	392	50	18	32.43
5+6	4	36	31	34.00
7	1	33	33	33.00
8	89	55	26	38.63
9	Not surveyed			
10	30	40	24	32.90
11	Not surveyed			
12	55	48	26	34.96
13	4	38	32	34.00

Table 3.2: Summary data for Manila clam for all three survey locations, showing total number, size of the largest and smallest individuals (mm) and the average size (mm) for each shellfish bed within each area. The data shown is combined across all three dredges for each bed.

Common Cockle				
Langstone Harbour				
Bed ID	**Total Number**	**Largest (mm)**	**Smallest (mm)**	**Average (mm)**
1	197	38	21	27.42
2	27	37	25	29.89
3	45	41	23	31.44
4	1	23	23	23.00
5	66	40	22	31.18
6	7	35	28	32.00
Portsmouth Harbour				
1	49	51	17	28.47
2	30	40	21	30.43
3	15	36	19	28.80
4	162	41	18	28.78
5	150	39	16	26.22
6	1022	44	12	24.55
7	71	38	20	29.46
8	94	38	17	27.87
9	168	40	12	28.88
10	63	49	17	27.97
11	587	36	14	23.63
Southampton Water				
1	237	37	20	26.55
2	259	36	18	25.48
3	0	n/a	n/a	n/a
4	2	22	22	22.00
5+6	0	n/a	n/a	n/a
7	0	n/a	n/a	n/a
8	164	37	20	27.02
9	Not surveyed			
10	24	30	21	25.58
11	Not surveyed			
12	167	38	20	27.60
13	23	36	23	28.78

Table 3.3: Summary data for Common cockle for all three survey locations, showing total number, size of the largest and smallest individuals (mm) and the average size (mm) for each shellfish bed within each area. The data shown is combined across all three dredges for each bed.

American Hard-Shelled Clam				
Langstone Harbour				
Bed ID	**Total Number**	**Largest (mm)**	**Smallest (mm)**	**Average (mm)**
1	17	60	26	43.59
2	3	97	39	63.67
3	9	83	31	45.44
4	11	111	37	70.36
5	5	63	49	55.80
6	1	50	50	50.00
Portsmouth Harbour				
1	9	58	23	39.67
2	0			
3	0			
4	2	54	50	52.00
5	1	36	36	36.00
6	0			
7	4	48	29	39.30
8	16	67	23	38.31
9	11	82	16	44.45
10	0			
11	0			
Southampton Water				
1	3	46	38	41.00
2	3	39	33	36.67
3	0			
4	0			
5+6	13	62	27	47.92
7	3	59	52	54.67
8	0			
9	Not surveyed			
10	8	58	29	43.63
11	Not surveyed			
12	4	44	30	34.75
13	0			

Table 3.4: Summary data for American Hard-Shelled clam for all three survey locations, showing total number, size of the largest and smallest individuals (mm) and the average size (mm) for each shellfish bed within each area. The data shown is combined across all three dredges for each bed.

Cockles were found at all sites in Langstone and Portsmouth Harbours but were not found in any dredges in Southampton Water at sites 3 ‘Bird Pile’, 5+6 ‘Hythe and the Gymp’ and 7 ‘Marchwood’. Manila clams were found at all beds across all three sites however abundances varied greatly with fewer than five individuals found at some sites such as sites 5+6 ‘Hythe and the Gymp’, 7 ‘Marchwood’ and 13 ‘Hook Sands’ in Southampton Water, sites 3 ‘Port Solent 3’ and 10 ‘Whale Island’ and sites 4 ‘South Penner’ for Langstone Harbour.

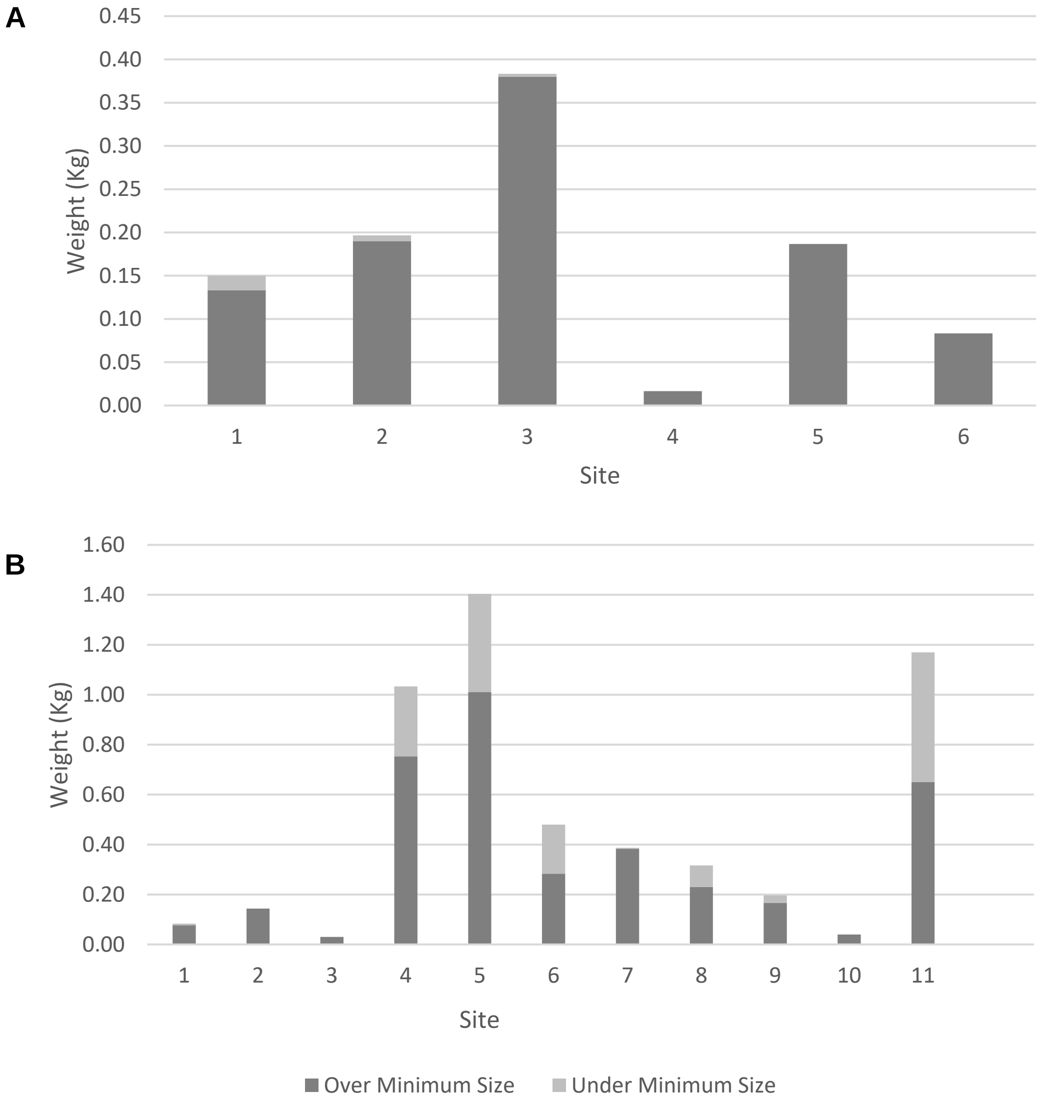


Figure 3.1: Weight (kg) of Manila clam for shellfish beds in A) Langstone Harbour and B) Portsmouth Harbour. Each bar represents total weight and it also split into the weight of catch over minimum size (dark grey) and under minimum size (light grey).

3.1 Manila clam weight

In addition to counts, for the Manila clam weight data was also obtained. For each dredge the weight of Manila clam was recorded (kg) as well as the weight above and below the minimum size. This data is presented here for Langstone Harbour and

Portsmouth Harbour, due to rough conditions experienced when sampling Southampton Water the weigh scale was not able to give accurate readings so weight data for this area is not available.

Figure 3.1A and B shows the total weight, and weights of Manila clam over and under the minimum size for Langstone and Portsmouth Harbours. For Langstone Harbour (Figure 3.1A) the weight of Manila clam at all sites is dominated by individuals which are above the minimum size of 35mm. Undersized individuals are seen at sites 1-3 however the proportion of the total weight is low. The data for Portsmouth Harbour (Figure 3.1B) is more varied however all sites still show a greater proportion of clams above the minimum size. Sites 4, 5, and 11 show the highest proportions of Manila clam under the minimum size. It must be remembered that the sampling method used in this survey is designed to maximise retention of shellfish at or above the minimum size whilst allowing undersized individuals to be returned to the seabed therefore the proportion of sizeable to undersized should be considered in light of the fact that a proportion of the undersized individuals would not have been retained using this sampling method.

3.2 Size Frequency and Average Size

For each area, the average size for the three main species was determined for each shellfish bed surveyed (Figures 3.2-3.4). For the Manila clam, the greatest range in sizes across the different beds surveyed was seen in Southampton Water with 8 out of the 10 sites surveyed showing an average size below the minimum size of 35mm. For Portsmouth Harbour, all but two sites showed an average size at or above the minimum size and for Langstone Harbour all sites surveyed showed an average size on or above the minimum size.

For cockles, the average size appears to be more uniform both across shellfish beds within a survey area and across all three areas. The majority of beds show an average size at or above the minimum size (23.8mm) with only sites 4 in Langstone Harbour, 11 in Portsmouth Harbour and 4 in Southampton Water showing an average size under the minimum size.

For American Hard-Shelled clams, the general pattern seen is that the average size across the majority of shellfish beds for all three areas is below the minimum size (63mm). Only two sites in Langstone Harbour (sites 2 and 4) showed an average size on or above the minimum size. For some sites in both Portsmouth Harbour and Southampton Water the average size is well below the minimum size, the smallest being 34.75mm at site 12 in Southampton Water. However, it is important to note that the average size for this species is based on small sample sizes.

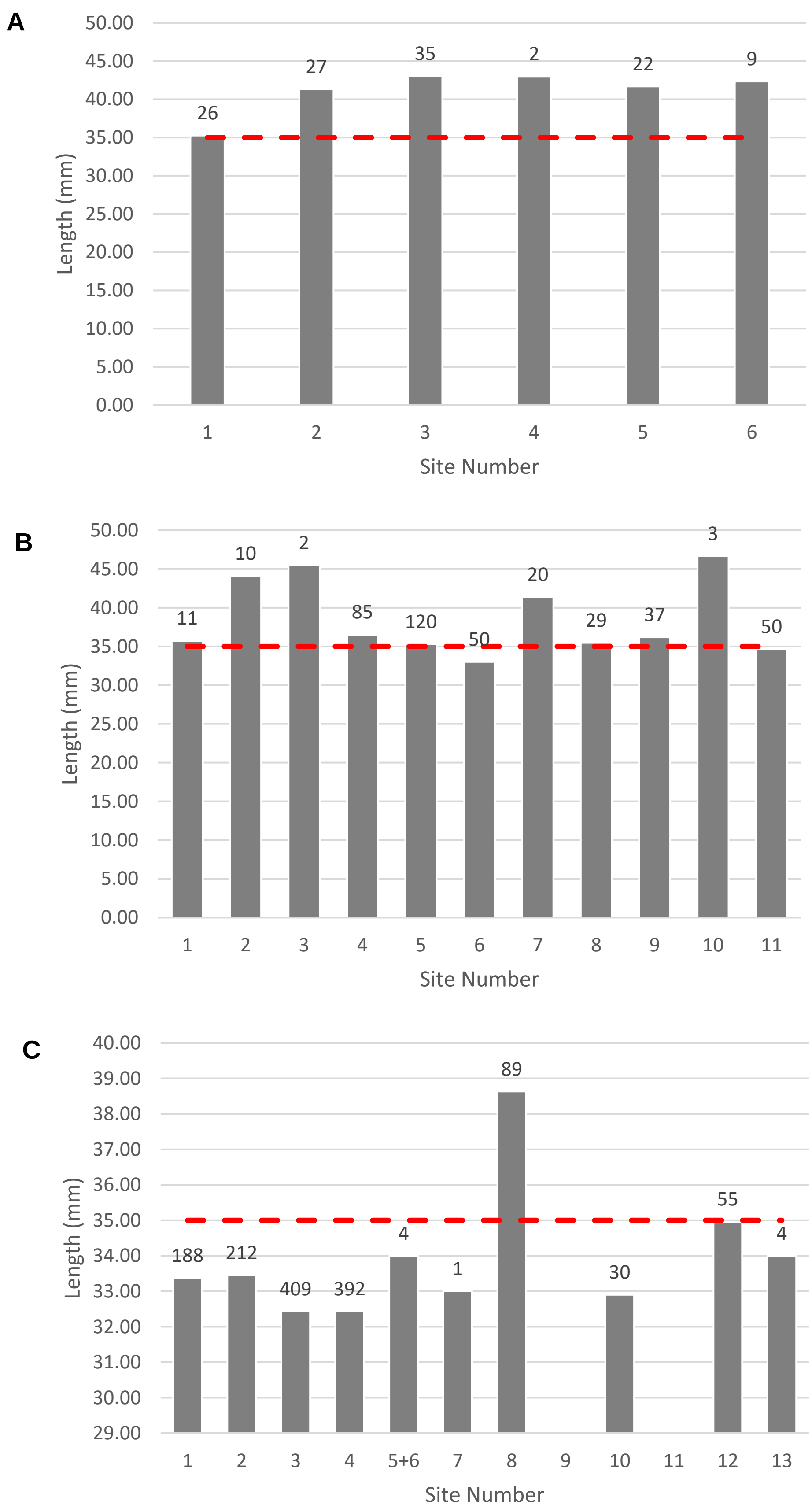


Figure 3.2: Average size (mm) of Manila clam for each shellfish bed in A) Langstone Harbour, B) Portsmouth Harbour and C) Southampton Water. The red dashed line represents the minimum size (35mm). The number above each bar refers to the number of individuals obtained at that shellfish bed on which the average size is calculated.

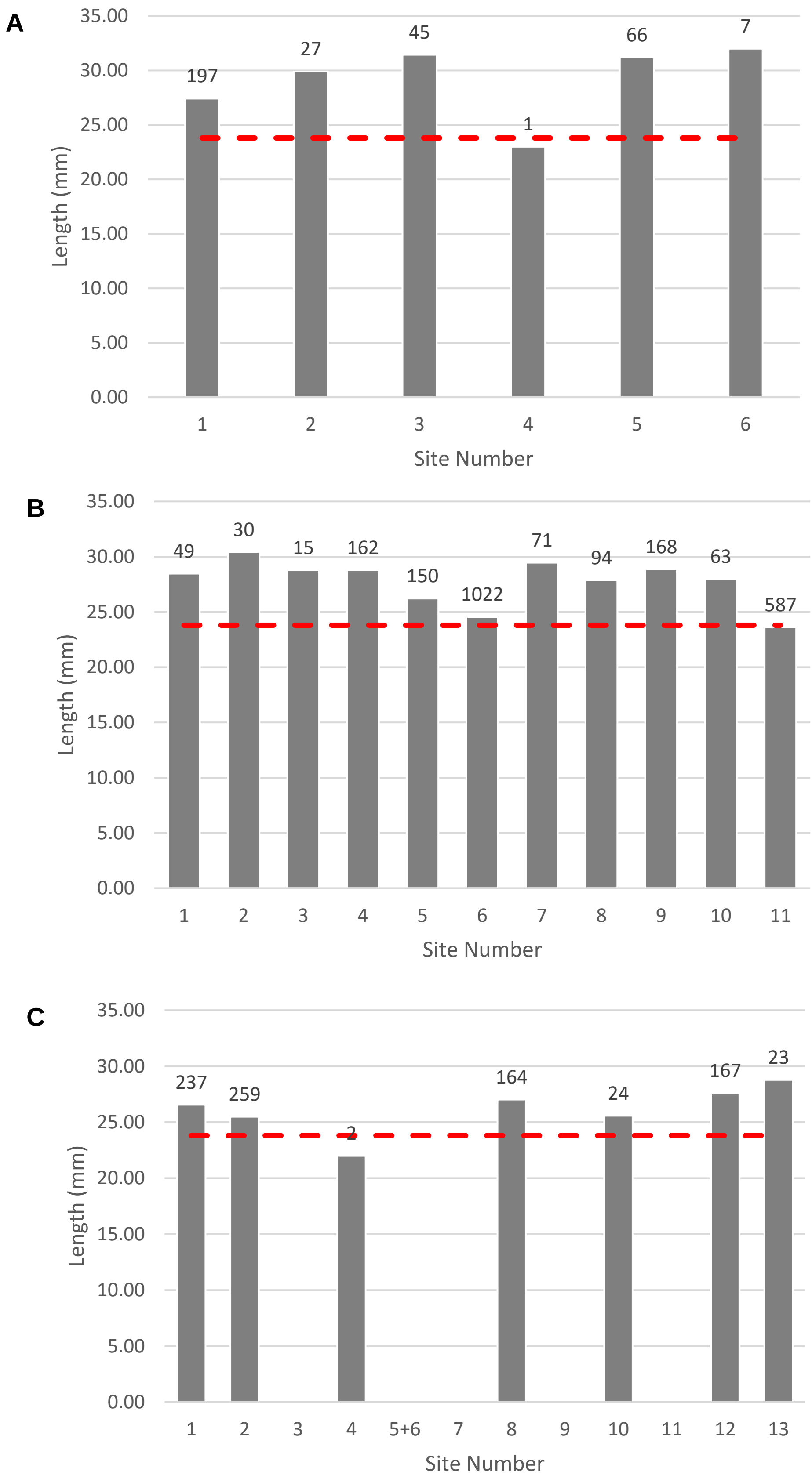


Figure 3.2: Average size (mm) of Common cockle for each shellfish bed in A) Langstone Harbour, B) Portsmouth Harbour and C) Southampton Water. The red dashed line represents the minimum size (23.8mm). The number above each bar refers to the number of individuals obtained at that shellfish bed on which the average size is calculated.

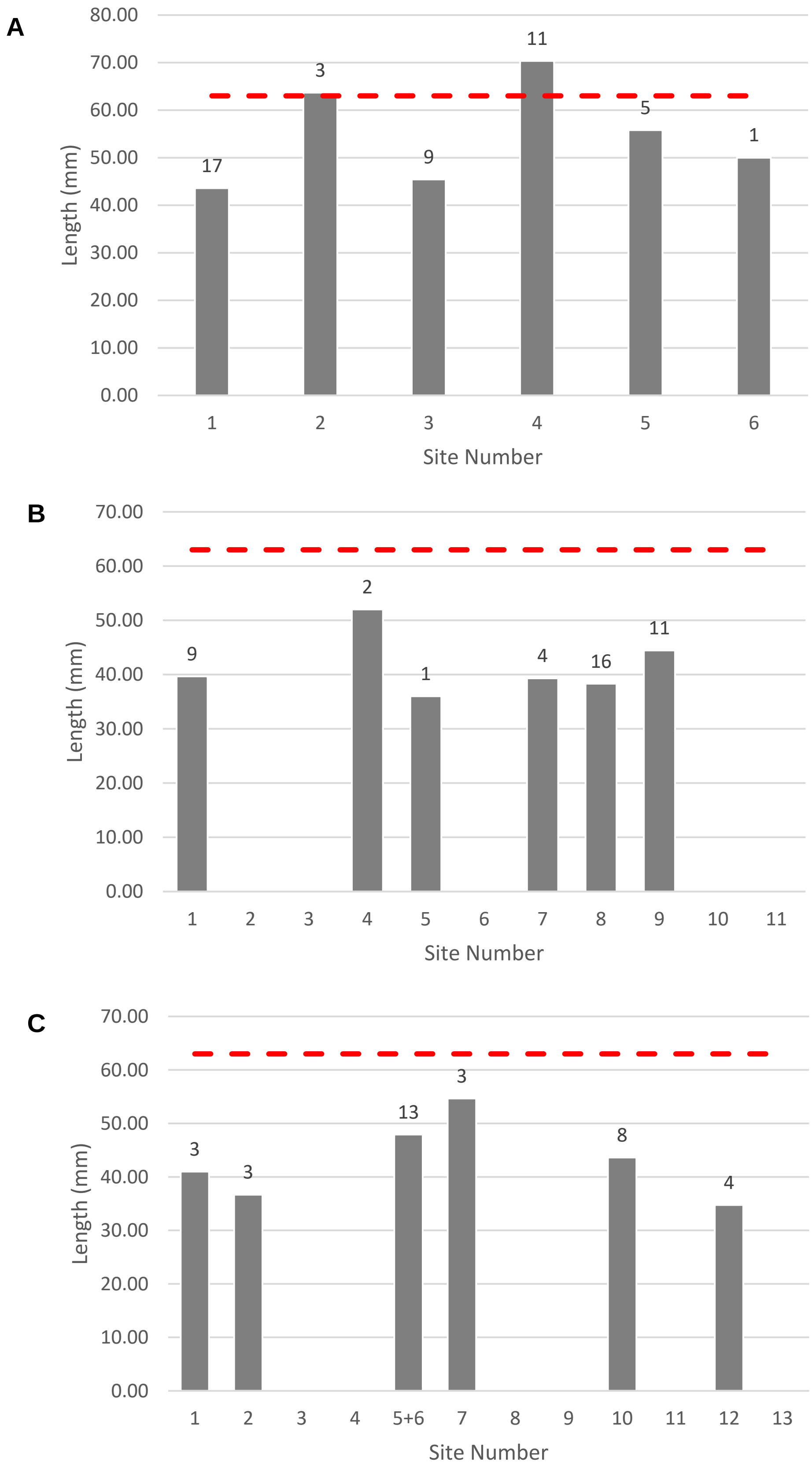


Figure 3.3: Average size (mm) of American Hard-Shelled clam for each shellfish bed in A) Langstone Harbour, B) Portsmouth Harbour and C) Southampton Water. The red dashed line represents the minimum size (63mm). The number above each bar refers to the number of individuals obtained at that shellfish bed on which the average size is calculated.

Data on the size of individuals was further analysed to look at the size frequency distribution across the different shellfish beds for all three areas. Histograms for Manila clam and cockle for all beds across all three areas are given in full in appendices 4 (Manila clam) and 5 (common cockle).

For the Manila clam, size frequency distributions varied between beds and areas. For sites where the quantity of Manila clam was higher it was easier to see a distribution pattern however the pattern is still skewed by the bias towards the larger size classes as a result of the gear type. For example, sites 4, 5 and 6 (Figure 3.4) in Portsmouth Harbour yielded higher quantities of clams therefore a distribution pattern can be more clearly seen. The data shows that there are quantities of clams at size classes beyond the minimum size of 35mm up toward 60mm however the number of clams deceases as the size class increases.

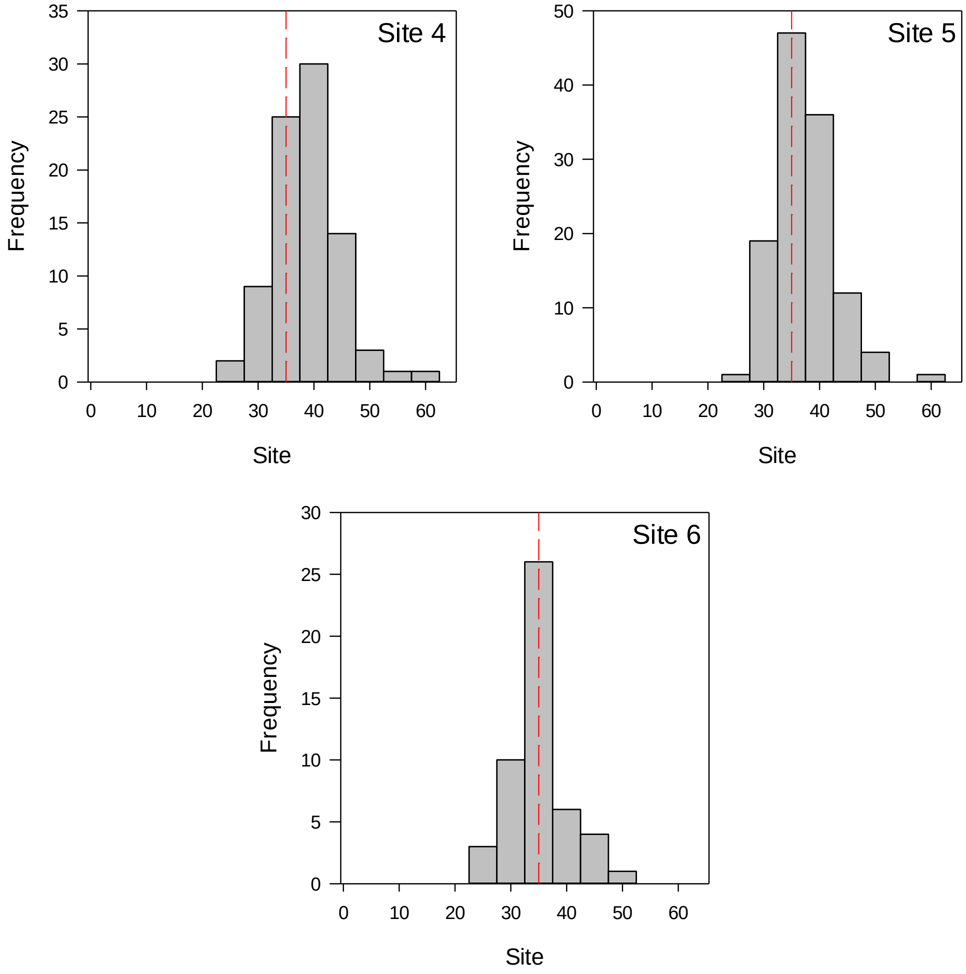


Figure 3.4: Histograms showing the size frequency distribution for Manila clams for shellfish beds 4, 5 and 6 in Portmsouth Harbour. The red dashed line shows the minimum size.

In Southampton Water, at the sites where a larger quantity of clams was obtained, the size frequency distribution is narrower than that see in Portsmouth. For sites 1, 2, 3 and 4 (Figure 3.5) where the greatest quantities were seen, the distribution is centred

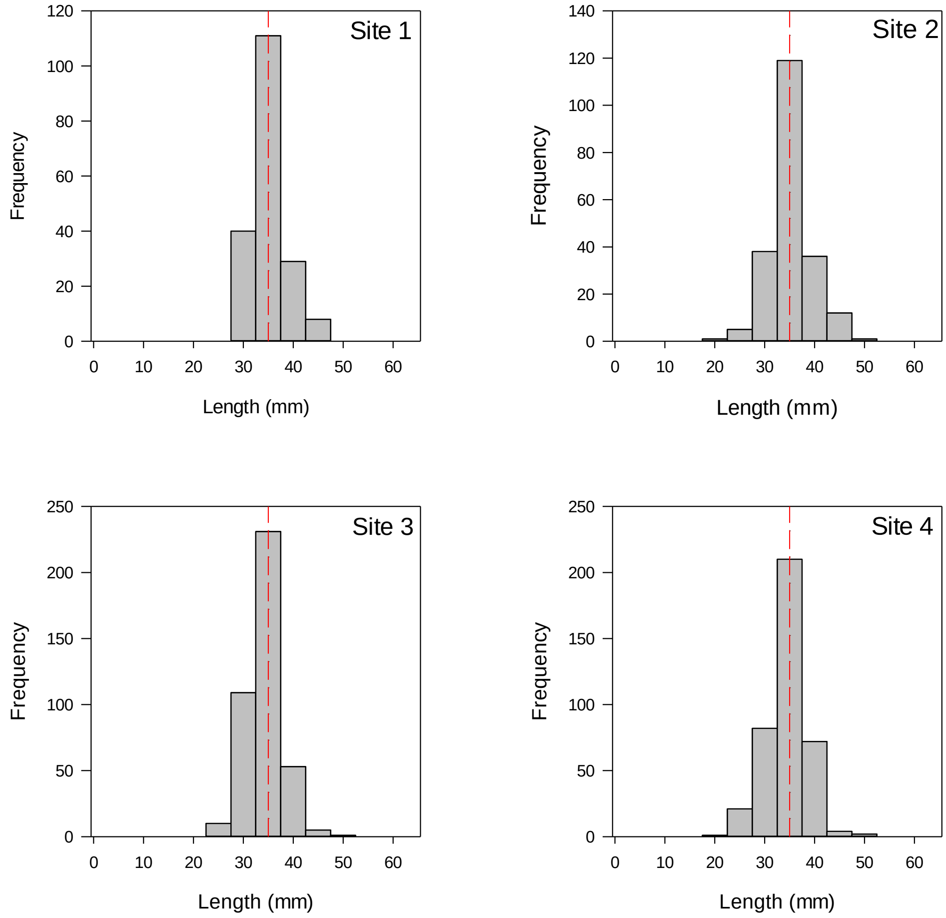


Figure 3.5: Histograms showing the size frequency distribution for Manila clams for shellfish beds 1, 2, 3 and 4 in Southampton Water. The red dashed line shows the minimum size.

just under the minimum size (30-34mm). There is generally a lower frequency of clams in the larger size classes compared to Portsmouth Harbour, only site 8 showed clams in the larger size classes, similar in size to what is seen in Portsmouth, but the quantity of clams at these sizes found at this site overall is lower.

Langstone Harbour showed smaller quantities of Manila clam but the size frequency distribution generally appears skewed more toward the larger size classes (Figure 3.6) with very small frequencies lower than the minimum size. Again, this may be due to the gear used for sampling however the same gear type was used for all three areas so comparisons can be made despite the caveat that not all of the clams under the minimum size will have been captured by the dredge.

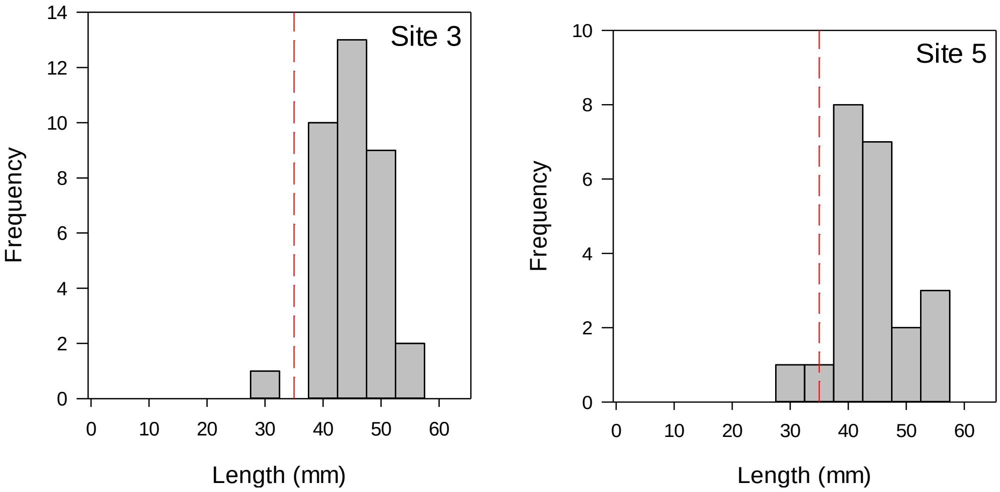


Figure 3.6: Histograms showing the size frequency distribution for Manila clams for shellfish beds 3 and 5 in Langstone Harbour. The red dashed line shows the minimum size.

For cockles, all sites across all three areas surveyed show a skew towards size classes above the minimum size of 23.8mm with the dominant size classes being 30-35mm for most sites (Figure 3.7). For the majority of sites, the largest sizes were around 40mm, where cockles larger than this were found they were in very small quantities usually consisting of only 1 or 2 individuals. Again, the bias toward the larger sizes will be due in part to the gear sampling method however, as with the clams, the use of the same gear type for all three areas does allow comparisons to be made. Generally, the pattern seen is similar across all three areas.

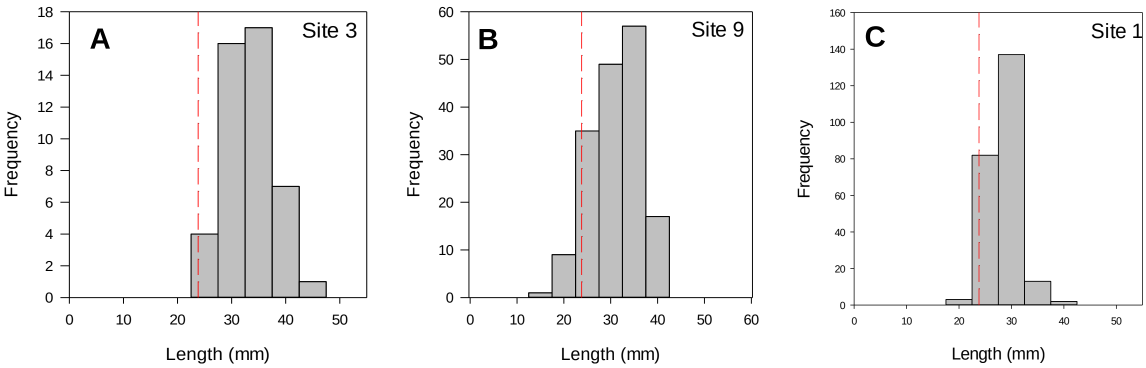


Figure 3.7: Histograms showing the size frequency distribution for common cockle for shellfish beds at A) site 3 in Langstone Harbour, B) site 9 in Portsmouth Harbour and C) site 1 in Southampton Water. The red dashed line shows the minimum size.

3.3 Number of Individuals per Average Tow

As outlined in section 2.1, an average tow length was determined and the number of individuals per average tow was calculated for each tow and then further averaged across the three tows to give a number of individuals per average tow length for each shellfish bed in each of the three areas sampled.

Figure 3.8 shows the data for Manila clam for each of the three areas surveyed with data split into individuals above and below the minimum size of 35mm. The data shows that the lowest number of individuals per average dredge tow was seen in Langstone Harbour with the majority of the catch composed of individuals above the minimum size. For Portsmouth Harbour the largest number of individuals per average tow is seen in sites 4 and 5 which show a markedly higher value than all the other sites. Again, for all sites, individuals above the minimum size are dominant. For Southampton Water, a different pattern is seen with sites 1-4 being dominated by undersized individuals. Sites 3 and 4 show the largest number of individuals per average tow and site 4 shows the largest number of individuals for any bed across all three areas.

For cockles (Figure 3.9), across all shellfish beds in all three areas the number of individuals is dominated by cockles over the minimum size. For Langstone Harbour, the largest number of individuals per average tow is seen at site 1 with all other beds showing a much lower number of individuals. For Portsmouth Harbour there isn’t a clear pattern, sites 6 and 11 show the largest number of individuals per average tow with sites 1-3 showing the lowest number of individuals. For Southampton Water, where cockles were present, the largest number of individuals per average tow was seen at site 2. Again, as with Portsmouth Harbour there is no clear patterns emerging from the data.

3.4 Weight of Catch per Meter of Dredge per Hour

The weight of Manila clam was also used to look at the weight of catch per meter of dredge per hour to give a measure of the effort level of the fishery through an estimation of catch per unit effort (CPUE) as weight per hour based on the size of the dredge used. The data is only able to be analysed for Langstone Harbour (Figure 3.10A) and Portsmouth Harbour (Figure 3.10B) as the adverse weather conditions experienced during the Southampton Water survey meant that weight data could not be taken.

In Langstone Harbour, the weight of catch was greatest at site 3 at 23kg per meter of dredge per hour. Site 4 showed the lowest weight. For all sites the weight of catch is dominated by oversized individuals with a maximum of only 1kg of undersized clams seen at site 1.

For Portsmouth Harbour the weight of catch was greatest at sites 5 and 11 at 84.2kg and 70.2kg respectively. Generally, the weight of clams under the minimum size is greater than for Portsmouth Harbour with sites 4, 5 and 11 showing 27%, 28% and 44% of the total weight respectively as being comprised of undersized individuals.

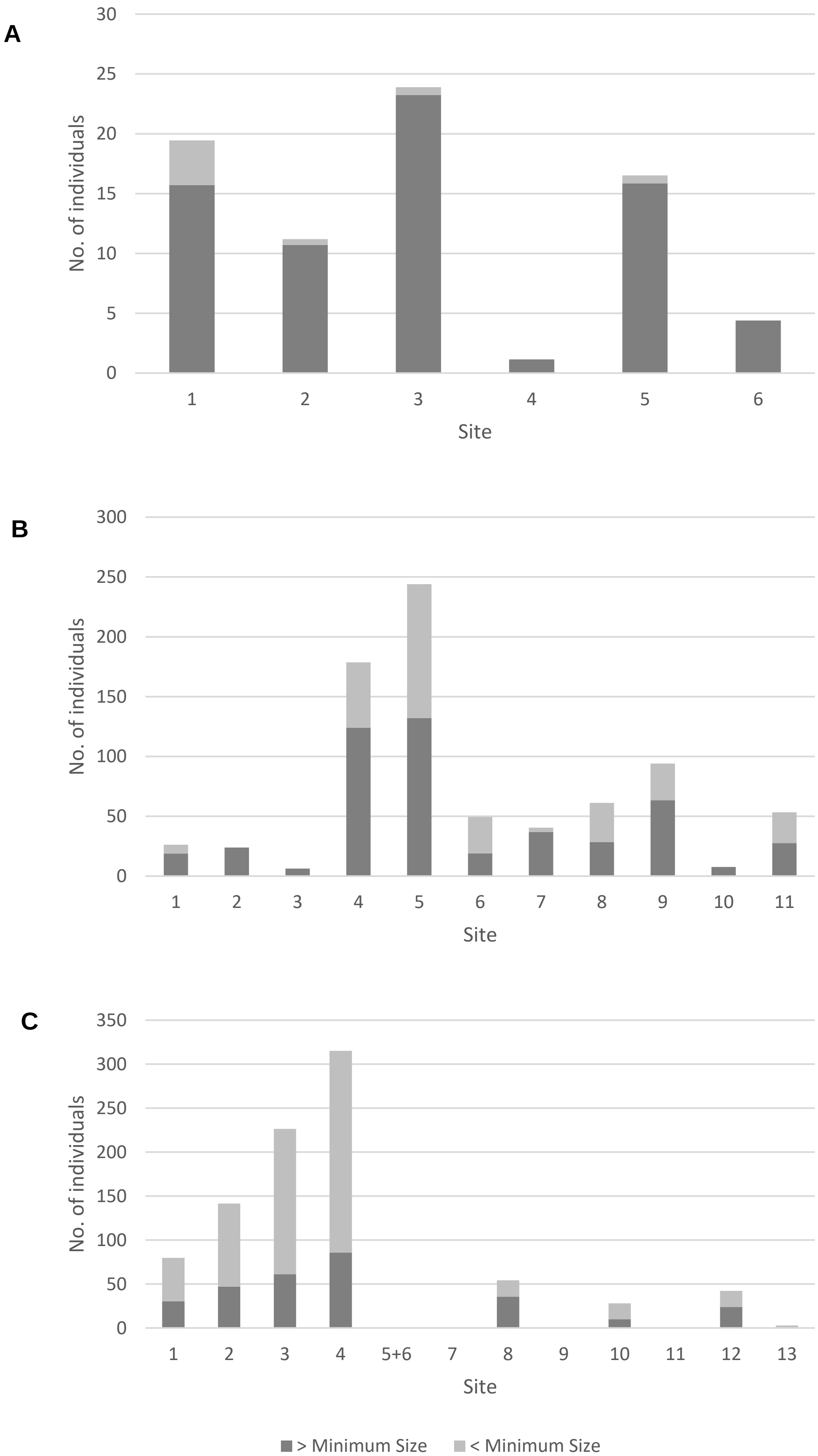


Figure 3.8: Number of individuals per average tow length for Manila clam for A) Langstone Harbour, B) Portsmouth Harbour and C) Southampton Water (note sites 9 and 11 were not sampled). Data is split to show individuals over (dark grey) and under (light grey) the minimum size of 35mm.

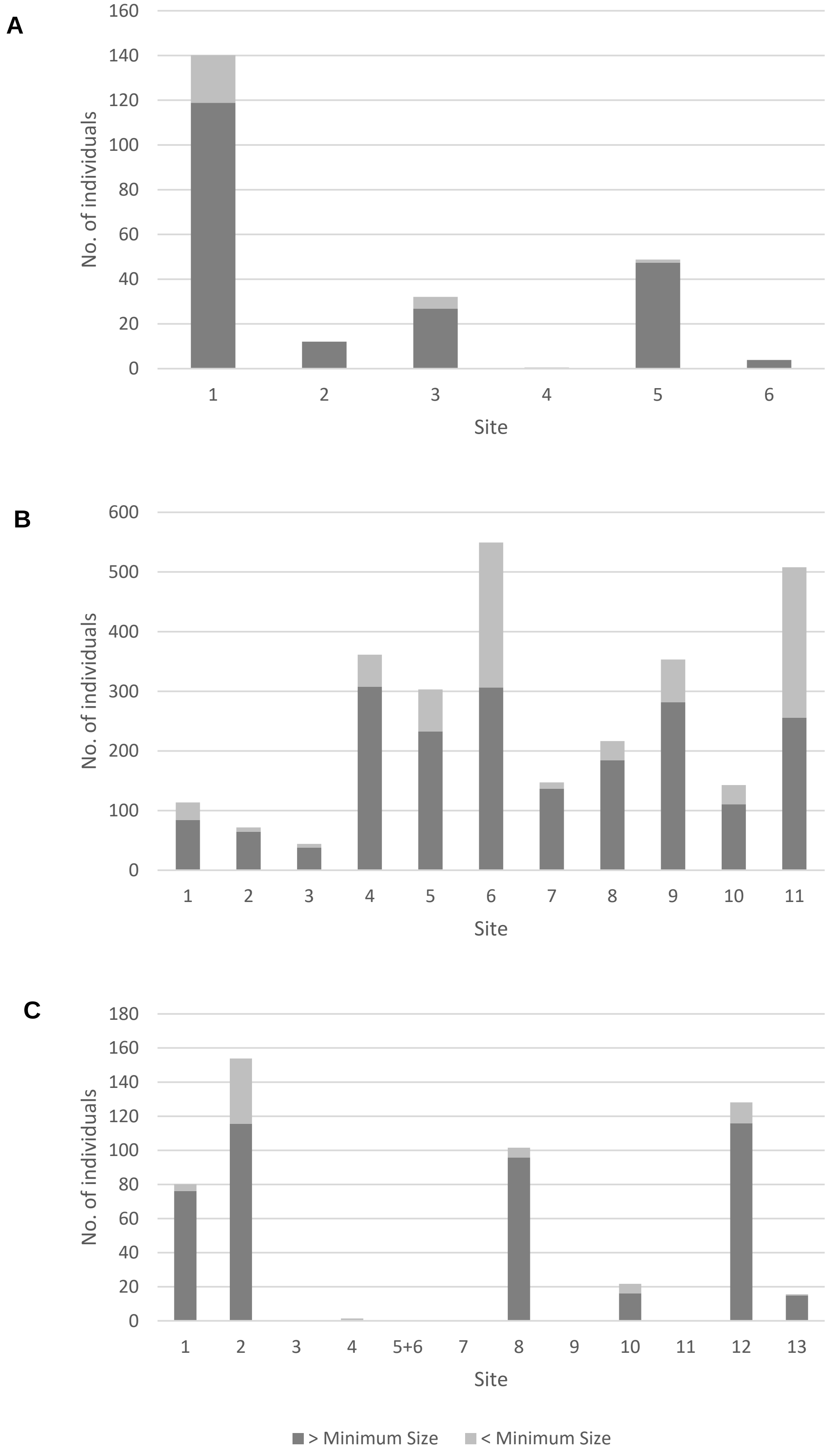
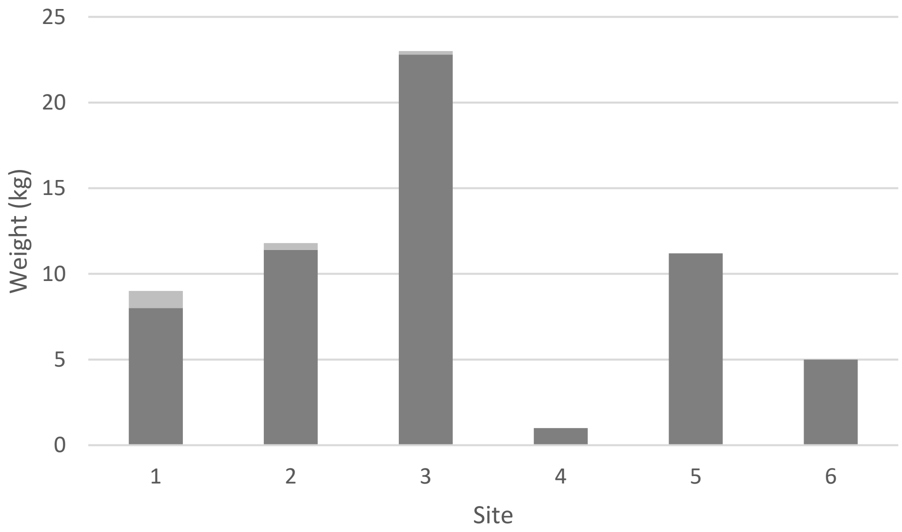


Figure 3.9: Number of individuals per average tow length for common cockle for A) Langstone Harbour, B) Portsmouth Harbour and C) Southampton Water (note sites 9 and 11 were not sampled). Data is split to show individuals over (dark grey) and under (light grey) the minimum size of 23.8mm.



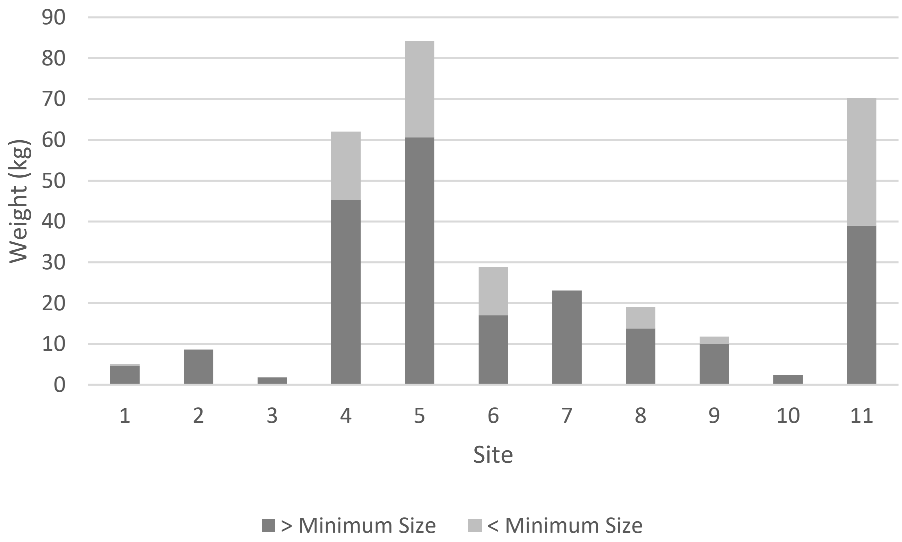


Figure 3.10: Weight of catch per meter of dredge per hour (kg) for A) Langstone Harbour and B) Portsmouth Harbour Data is split to show weight of catch over (dark grey) and under (light grey) the minimum size of 35mm.

4. Time-Series Data

Comparisons of data between years is only possible for Southampton Water as this survey was only carried out for the first time in 2017 using Southampton Water as a pilot. In the future the aim is to conduct these surveys twice a year, in the spring and autumn, for all three areas to allow comparisons to be made and patterns and trends to be identified which can be used to monitor the impact of and inform future changes to management measures.

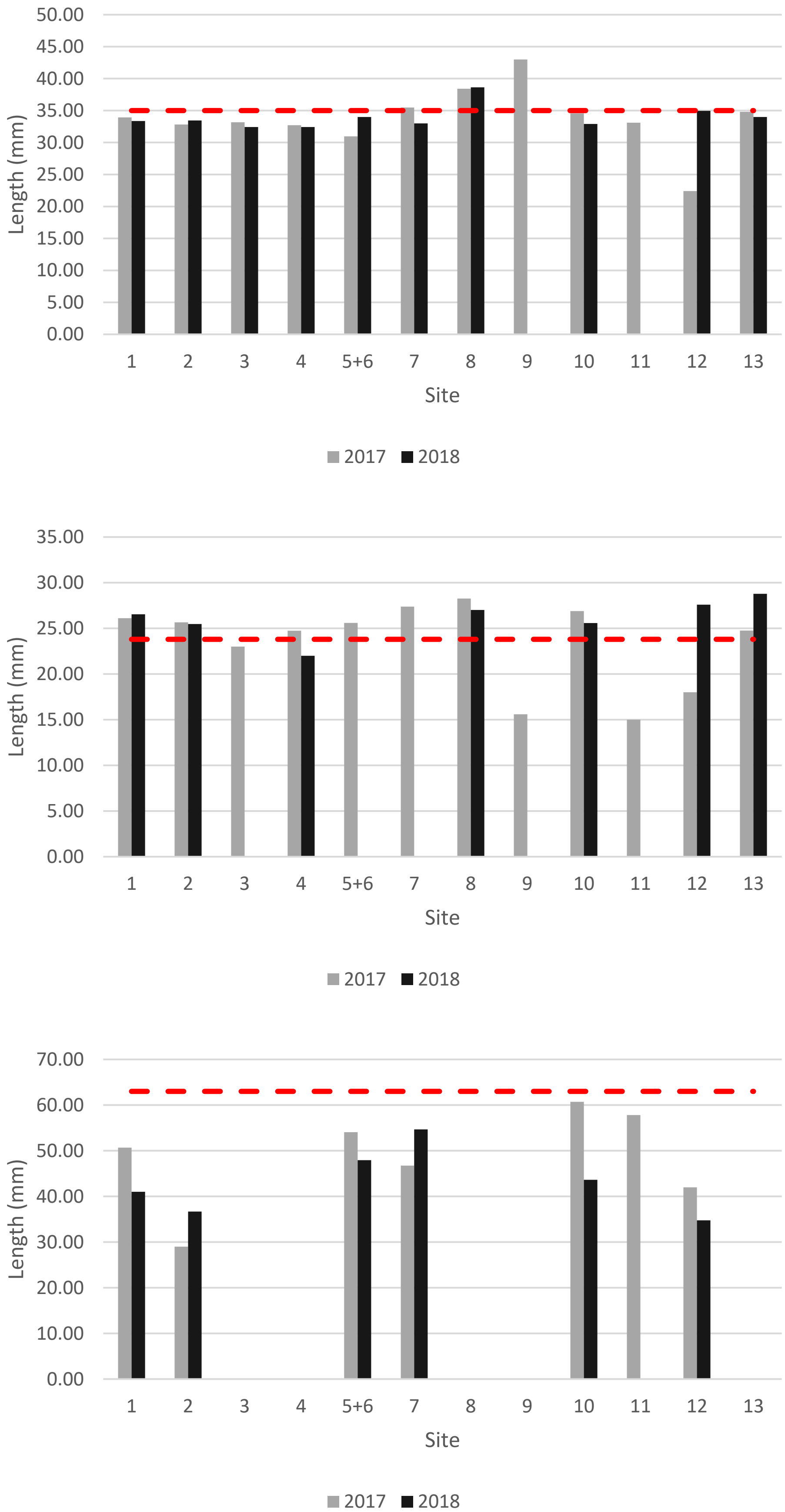


Figure 4.1: Average size (mm) for A) Manila clam, B) common cockle and C) American Hard-Shelled clam for Southampton Water comparing data between 2017 and 2018.

Comparing average size for the Southampton Water shellfish beds between 2017 and 2018 for Manila clam, common cockle and American Hard-Shelled clam (Figure 4.1) shows that for Manila clam there isn't generally a significant difference in the sizes between years. The biggest difference is seen at site 12 where the average size has increased from 22.4mm to 35.0mm, this is the only site where a change in average size has resulted in the average size in 2018 being at the minimum size rather than under it. The pattern for American Hard-Shelled clams shows a mix of increases and decreases in size for shellfish beds between sites although the average size for all sites is below the minimum size of 63mm for both years. For cockles, it is noticeable that for three of the sites (3, 5+6 and 7) no cockles were found in 2018 where they were found in 2017. This is more significant for sites 5+6 and 7 which yielded 42 and 39 cockles respectively in 2017 (site 3 only yielded 4 cockles in 2017), however these catches are still low in comparison to other sites so the decrease to 0 for these sites in 2018 should be considered in light of this. In two of the sites (12 and 13) the average size has increased in 2018 to above the minimum size with site 4 being the only site where the average size had decreased to below the minimum size, however this site only yielded 4 cockles in 2017 and 2 in 2018 so data should be treated with caution.

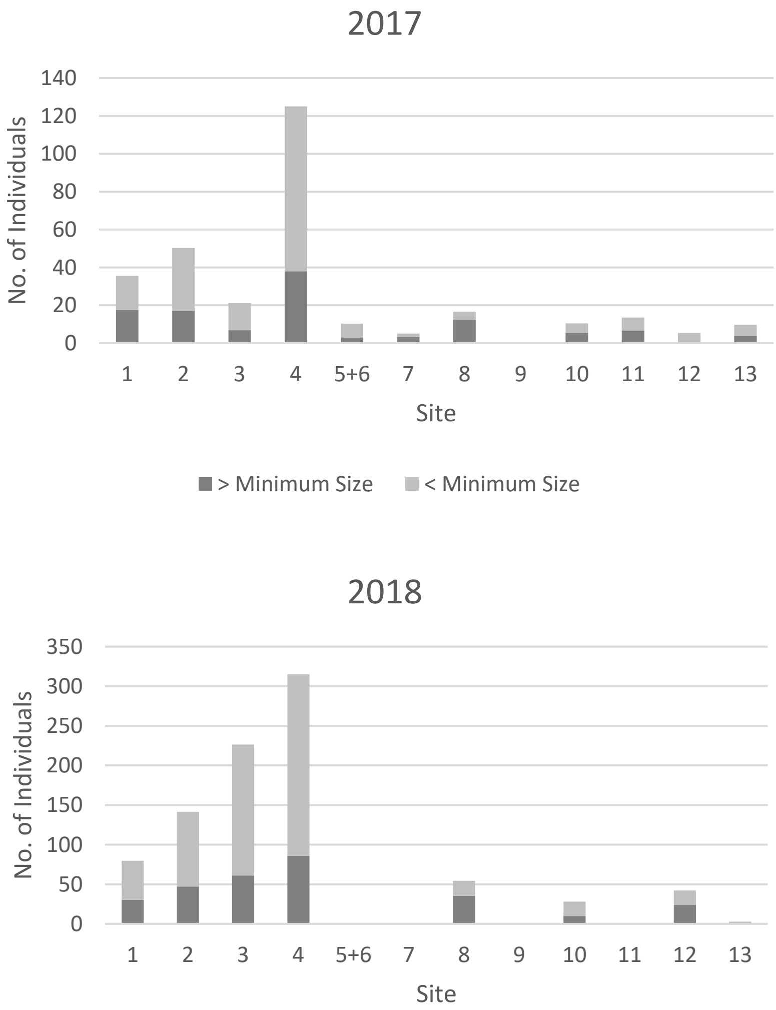


Figure 4.2: No. of individuals per average tow for Manila clam for 2017 and 2018. Data is split to show weight of catch over (dark grey) and under (light grey) the minimum size of 35mm.

Comparisons cannot be made on CPUE data as weight data is not available for 2018. Looking at number of individuals per average tow between both years there has been a significant increase in the number of Manila clam under the minimum size for an average tow at site 4 from 87 in 2017 to 229 in 2018. Number of clams above the minimum size have increased for this site too although by a smaller margin from 38 in 2017 to 86 in 2018. Site 3 has also seen a significant increase in both size classes with an increase from 14 in 2017 to 165 in 2018 for undersized clams and an increase from 7 in 2017 to 61 in 2018 for oversized clams. Where clams have been found in the 2018 survey the number of individuals per average dredge is higher for all shellfish beds except sites 5+6, 7 and 13 where the number is greatly reduced for both over and undersized individuals although it is important to note that numbers for these sites were low in 2017. Site 5+6 has declined from a total of 10 individuals in 2017 to 0.1 in 2018, site 7 from 5 in 2017 to 0.2 in 2018 and site 13 from 10 in 2017 to 2.7 in 2018.

As this survey has only been carried out, so far, in the autumn of 2017 and the spring of 2018 it is difficult to see if the data is showing any trends. As further surveys are carried out, comparisons will be able to be made between years and seasons and data can be analysed in relation to management measures.

5. Discussion

This survey involved a second survey of the bivalve populations in Southampton Water, the first having been carried out in the autumn of 2017, and the first survey for bivalve populations in Langstone Harbour and Portsmouth Harbour. Following the pilot survey looking at Southampton Water it was determined that the survey should be expanded to include Langstone Harbour and Portsmouth Harbour to allow data on the stocks of commercially important shellfish species to be gathered across the three main areas of importance for the local dredge fishery. The aim is to continue to conduct the survey twice a year (autumn and spring) to provide data which can be used to monitor trends and potential changes to populations which can feed into the development and monitoring of local management measures.

When analysing the survey results it is important to remember that the data is likely to be an underrepresentation of the abundance of bivalve species in the Solent. This is due to two main factors; firstly, that the dredge used is designed for use in the commercial fishery and is therefore constructed so as to optimise retention of individuals at or above the minimum size whilst allowing a proportion of the individuals under the minimum size to be returned to the fishery. Secondly, the efficiency of the dredge is unknown, the data presented here assumes the dredge to be operating at 100% efficiency however the actual efficiency is likely to be much lower. There is no data available on which to base an assumption of dredge efficiency, data from other studies using other gear types such as oyster and scallop dredges puts efficiency at anywhere from 2 to 35%. To develop this data in the future to provide a more accurate picture of what is on the ground, work would need to be carried out to determine an estimate of efficiency for a box clam dredge. However, as the same dredge is used for all sites, and is planned to be used for future surveys, comparisons can be made as data will be obtained using the same gear type therefore general trends and patterns can still be identified as a time series dataset is built up.

Since the survey was first carried out in Southampton Water in 2017 new management measures for the dredge fishery have been introduced. The most significant is the introduction of the Solent Dredge Fishing Byelaw 2016 which introduces seasonal and temporal restrictions to the dredge fishery in Southampton Water, Langstone Harbour and Portsmouth Harbour including a closure of the fishery between the1st March to 31st October (both days inclusive). The fishery was closed for the first time in March 2018 shortly before the first spring survey was carried out therefore it is difficult to link the results from the 2018 survey directly to any impacts from the management measures. However, going forward, conducting these surveys in the spring and autumn will give data on the bivalve populations directly after the fishing season and directly following a period of closure thereby providing data to support monitoring of the management measures.

For Southampton Water, the data shows that the dominant bivalve in 2017 was cockle however for the 2018 survey this has changed with the dominant bivalve now being the Manila clam. For this area, the greatest number of individuals in 2018 were found in areas on the western side of Southampton Water which correspond to the preferred fishing areas including Calshot, the Fuel Jetty, Deans Lake and Bird Pile. The latter two sites also showed the highest number of individuals per average tow and the areas at Calshot and the Fuel Jetty also show a higher abundance of cockles than other sites in Southampton Water and a higher number per average tow. This is similar in pattern to the data found in the 2017 survey however the overall numbers of shellfish obtained have increased. For the 2018 survey, the majority of Manila clams caught, particularly in the areas where abundance is highest, were under the minimum size of 35mm with the average size across all but two of the sites sampled showing an average size under the minimum size. The high abundance coupled with the smaller average size may indicate that the areas on the western side of Southampton Water in Calshot, the Fuel Jetty, Deans Lake and Bird Pile provide suitable ground for spat settlement for the Manila clam resulting in an increased population however further work would be needed to confirm this including a detailed look at the juvenile section of the population which is missed by, and is outside the scope of, this survey. Fishing pressure too may be having an impact with oversized individuals being removed from the population creating a skew in size distribution resulting in the majority of individuals left on the ground being under the minimum size (between 30-34mm). However, if fishing pressure was the dominant factor in size distribution we would expect to see a greater proportion of larger individuals at the sites where fishing does not take place such as the northern most end of Southampton Water. The data from the survey is showing that the average size remains under 35mm even for low impact sites, therefore the pattern in size distribution cannot be attributed to fishing activity alone.

For Langstone Harbour, a site sampled for the first time in this survey, the were relatively fewer Manila clams found than in Southampton Water or Portsmouth Harbour. The average size of the Manila clam was shown to be at or above the minimum size across all the sites sampled with size frequency data showing the occurrence of larger individuals up to 53mm. By comparison, Portsmouth Harbour varied more in patterns of abundance between sites but showed more sites with an average Manila clam size of above the minimum size than in Southampton Water. As with Langstone Harbour the size frequency data showed more clams reaching larger sizes up to 57mm at site 5 which also showed the greatest overall abundance and greatest number per average tow. The CPUE data showed differences between sites for both Langstone and Portsmouth Harbour but no fixed pattern could be seen other than a dominance by Manila clam over the minimum size. Being that this is the first time that either of these sites have been sampled it is difficult to explain why these results are being seen. As with Southampton Water, it is likely that fishing activity will be having some impact on the populations but the degree to which this is happening and its relative importance against other factors such as environmental parameters, hydrographic parameters and the occurrence of other activities cannot be determined at this stage.

Across all three areas sampled, the average size and size frequency data for the common cockle shows populations dominated by individuals at or above the minimum size. Although this needs to be considered alongside the fact that the dredge will not retain all individuals under the minimum size it is still worth noting that a similar pattern is seen across the majority of sites in all three areas. The common cockle is occasionally fished as the dominant species but is more often retained as a secondary species with the Manila clam being the target, therefore fishing activity is more likely to target areas favourable for the Manila clam than the common cockle. This may, therefore, result in a lower overall fishing pressure on the common cockle allowing a greater size range to be maintained within the population as fewer larger individuals are being removed.

It is difficult to determine a pattern of data for the American Hard-Shelled clam as the quantity of individuals obtained is low. Across all sites sampled in all three areas, the average size for this species is below the minimum size (63mm). This species is also occasionally targeted as a main species by the fishing fleet, particularly when prices are higher, however it is still not targeted at the same effort level as the Manila clam therefore impacts from the fishing fleet may be lower. The small average size across all areas sampled however indicates that some factor may be having an impact on the population but there is not enough data to determine whether fishing activity is contributing to the pattern seen.

The lack of consistent pattern seen across all species for all sites indicates that while, in some cases, fishing pressure may be having an impact, there is insufficient data to isolate fishing as the main impacting factor. Further work on quantifying the effort level of the fishery through determination of days spent fishing and catch rates of different species within these three areas would be beneficial in determining the potential impact of fishing activity on the bivalve populations. In addition, the data needs to be considered in conjunction with other data sources such as habitat type, hydrology and the prevalence of other activities to determine what additional factors may be impacting the populations and resulting in the patterns seen.

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