Exe Estuary
Cockle Stock Assessment 2010 - 2018

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Inshore Fisheries and Conservation Authority

Contents:

Introduction

The Exe Estuary is the most highly designated nature conservation site in Devon; it is a Ramsar Site, a Special Protection Area (SPA), and a Site of Special Scientific Interest (SSSI). It encompasses over 3,000 hectares of diverse aquatic and terrestrial habitats (EEMP, 2014). The Exe Estuary SPA includes both marine areas (i.e. land covered continuously or intermittently by tidal waters) and land which is not subject to tidal influence (Figure 1). Sub-features have been identified which describe the key habitats within the European Marine Site necessary to support the birds that qualify within the SPA. Bird usage of the site varies seasonally, with different areas being favoured over others at certain times of the year. Several thousand oystercatchers overwinter on the Exe Estuary and although mussels are their main food source, some will also feed on cockles, as well as winkles and ragworms (Goss-Custard & Verboven, 1993).

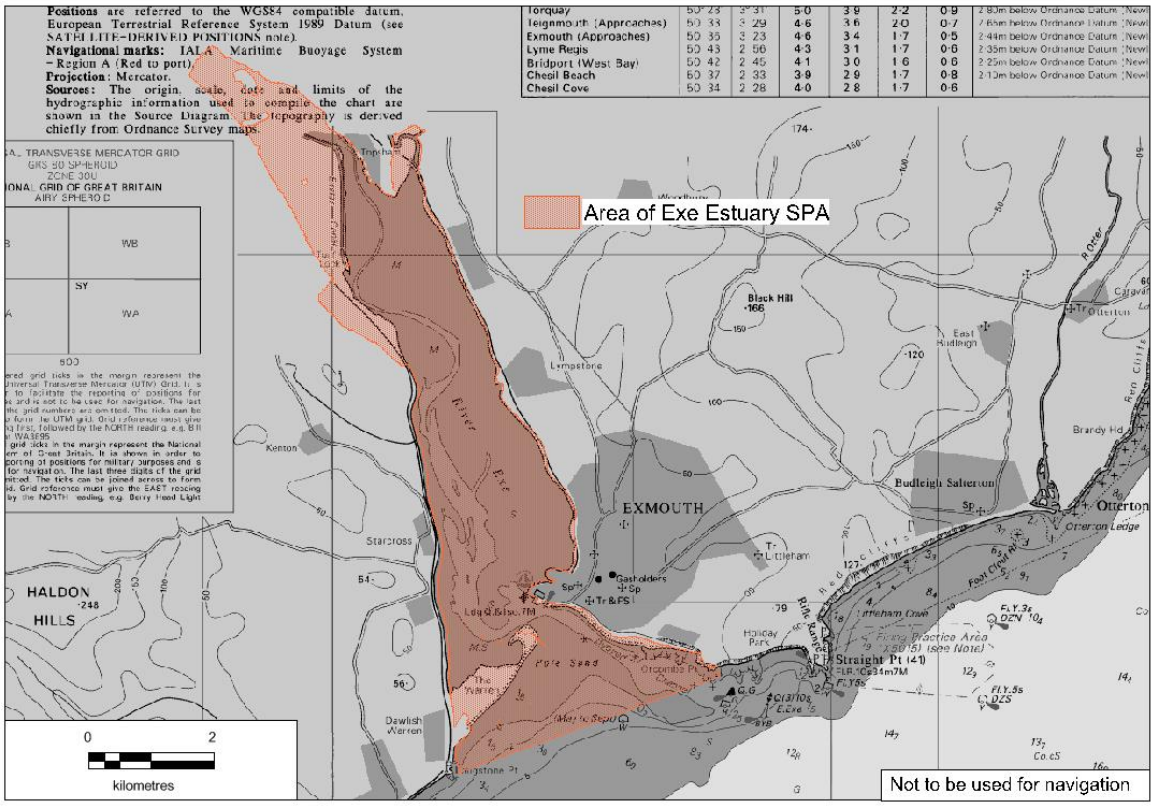

Figure 1 – Area of the Exe Estuary SPA

Cockles, *Cerastoderma edule,* are active suspension feeders. They can grow up to 5cm in length and growth lines are prominent. Cockles are found on clean sand, muddy sand, mud or muddy gravel from the middle to lower intertidal, sometimes subtidally and are often abundant in estuaries. They inhabit the top 5cm of surface of sediments and can tolerate changes in salinity.

Devon and Severn IFCA began carrying out annual cockle stock assessments in 2010 on Cockle Sands, near Exmouth, to determine if there could be a sustainable cockle fishery. Two Masters students looked at the effects of harvesting cockles from the eco-elevator harvester on macrofauna, cockle populations and sediment parameters within the Exe Estuary (Hulme, 2009; Lee, 2010 and Hulme & Lee, 2010). This form of harvesting was found not to have an impact and Natural England were content that the cockle fishery could

take place. However, the fishery could not continue due to a mass mortality event in 2011 depleting the population of cockles on the Cockle Sands. This meant the survey was repeated three times in 2011 and twice in 2012 to monitor the density levels. The mortality of the cockles was investigated by Cefas to screen for notifiable diseases and determine the cause. No notifiable diseases were found but the parasite profile indicate elevated presence of *Minchinia spp* which is a haplosporidian and *Himasthla spp* which is a digenean parasite. Both can cause gaping and death.

Due to the lack of a viable cockle fishery on the Exe the Cockle Sands bed was declassified, and to date there are currently no classified harvesting areas for cockles on the Exe Estuary (Cefas, 2016). There is some small-scale recreational gathering of cockles on the estuary, which is unregulated. During the Devon and Severn IFCA Intertidal Hand Working Survey 2016, between May and June, three individuals, two couples and two families of five were seen raking for cockles on Cockle Sands. The maximum number of cockles seen to be taken was 8kg by one of the families.

This report provides details of the annual autumn cockle surveys carried out by Devon and Severn IFCA between 2010 and 2018. The results of these surveys will help inform future management of the public cockle bed and quantify the availability of cockles as a food source for the bird assemblages within the Exe Estuary SPA.

Method

Surveys have been carried out on one day between September and December annually from 2010 through to 2018 at low water spring tides. The same survey stations are replicated each year and the stations are 115m x 115m apart (Figure 2).
. Some stations have been inaccessible (red on Figure 2) due to being underwater or difficult to reach as the ground is too muddy, but this changes year on year.

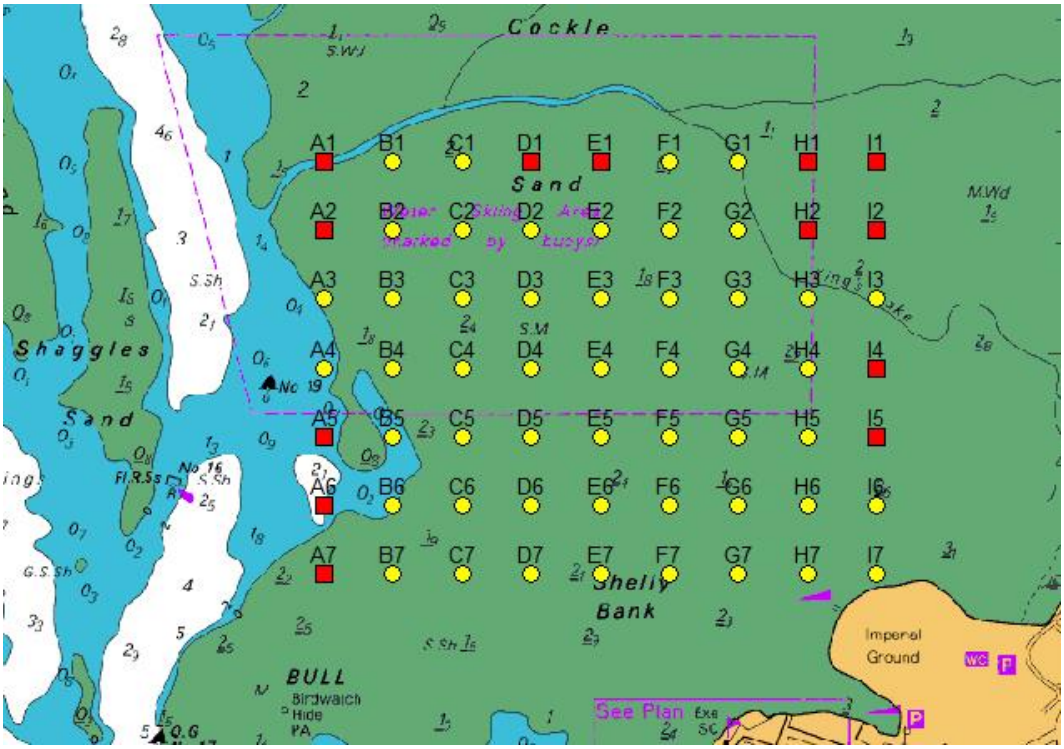

Figure 2 - Exe Estuary cockle survey stations.

A handheld GPS was used to locate the first station e.g. A1 and a quadrat was randomly placed within 10m of the target position for that station. Using a trowel, the sediment was dug out of a 0.1m^2 quadrat (up to approximately depth of the quadrat) into the sieve and then sifted in water nearby (Figure 3). The cockle(s) were put into a sample bag with a label of the station name (one bag per station). If no cockles were found or the station was unable to be surveyed it was noted. This was repeated at all stations.

Figure 3 – Cockle survey photos

For each station sample, cockles were measured by callipers to the nearest millimetre for length and width (Figure 4).

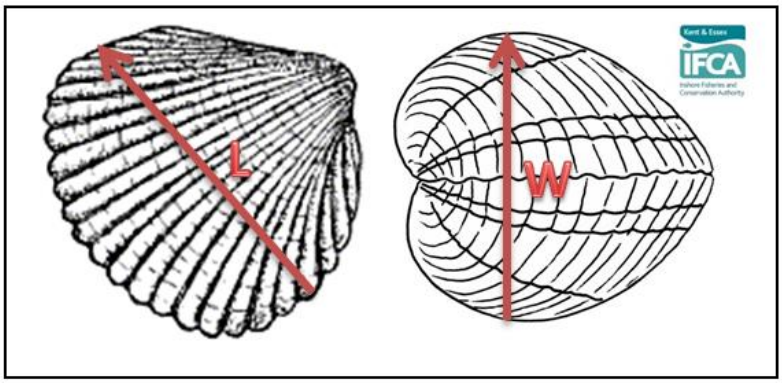

Figure 4 - Cockle length and width measurements.

After measuring, cockles were sorted into age classes by determining how many annual growth rings were present on the shell , which are usually put down each winter e.g. 0 rings = current year, 1 ring = 1st winter /1 year, 2 rings = second winter/ 2 years and so on. Each year group from that station was weighed separately (to the nearest 1g) and recorded. This was repeated for all station samples and once finished all the cockles were returned to the estuary.

Data interpretation

Data from these surveys was entered into Microsoft Excel and size frequency and year class graphs were produced. To determine cockle density, the data was transferred into MapInfo V.16 GIS and QGIS V3.4 software to produce the density maps seen in Figure 16 to Figure 24 which were made using custom ranges. Grid maps for each year were created using interpolator Inverse Distance Weighting (Limits: cell size 0.00344km, exponent 2 and search radius 0.34416km) with custom ranges for Figure 25. The minimum density used to

determine the extent of coverage on the bed was 10 cockles per m². The biomass has been calculated from the mean weight and cockle bed area.

Survey extension

Additional stations were added to the survey in 2017 to cover a wider extent south of Cockle Sands and to capture areas where hand-gathering for cockles occurs (Figure 5).

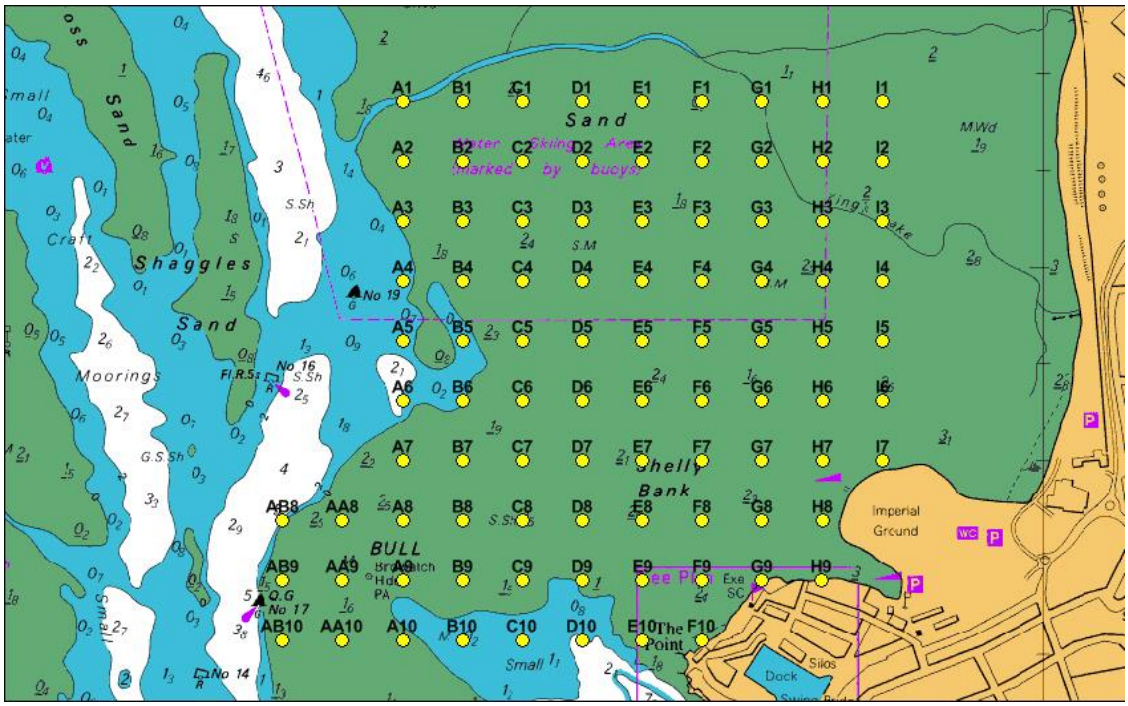

Figure 5 – Additional Exe Estuary cockle survey stations for 2017

Results

Table 1 shows a summary of the number of samples taken across the 63 stations for all years surveyed. The raw data can be seen in Annex 1.

Table 1 – Station counts for all years surveyed of Cockle Sands on the Exe Estuary.

Station counts:	08/10/10	20/10/11	29/10/12	04/12/13	09/10/14	01/09/15	19/10/16	6-7/11/17	11/10/18
Samples taken	42	43	35	45	37	43	46	46	46
Stations with zero count of cockles	0	0	17	5	15	7	10	15	17
Not surveyed	1	2	4	8	8	13	7	2	23
Unknown/ no data	20	18	7	5	3	0	0	0	0

Table 2 shows a summary of the number of cockles taken for all years surveyed across the 63 stations. Although there is no Minimum Conservation Reference Size (MCRS) applied to cockles in the Devon and Severn IFCA District, the results presented in Table 2 divide the stocks into two size groups (cockles that are 16mm width and over, and those that are under 16mm) in accordance with other IFCAs' MCRS (Haywood *et al.* 2017; Jessop, 2015). Figure 6 shows fluctuations in densities of all cockles over the years but it is difficult to determine a

clear trend. There does appear to be an overall decrease when 2010 and 2018 mean densities are compared but the drop in 2012 and the peak in 2013 make this uncertain. There was a large increase in total counts in 2013 but there was not a corresponding highest biomass. This might be as a result of the decline in density of the over 16mm cockles which had decreased by over 44%. The density was very high in 2013 which would might have been the result of a recruitment event and a large number of small under 16mm cockles on the ground. The decline in over 16mm cockle density has continued year on year until 2018where a 10% increase in cockles ≥16mm was observed.

Table 2 – Cockle counts & biomass for all years surveyed of Cockle Sands on the Exe Estuary.

Cockle counts:	2010	2011	2012	2013	2014	2015	2016	2017	2018
Total raw counts	728	694	496	1107	724	583	715	699	796
Biomass (kg/ha)	59.3	61.9	31.7	57.9	32.2	30.8	61.3	33.1	49.5
Mean density (m²)	173	161	95	221	139	117	128	115	87.5
Mean density (m²) for ≥16mm	43	41	27	24	17	17	19	13	19
% of ≥16mm	25%	26%	28%	11%	12%	15%	15%	12%	22%

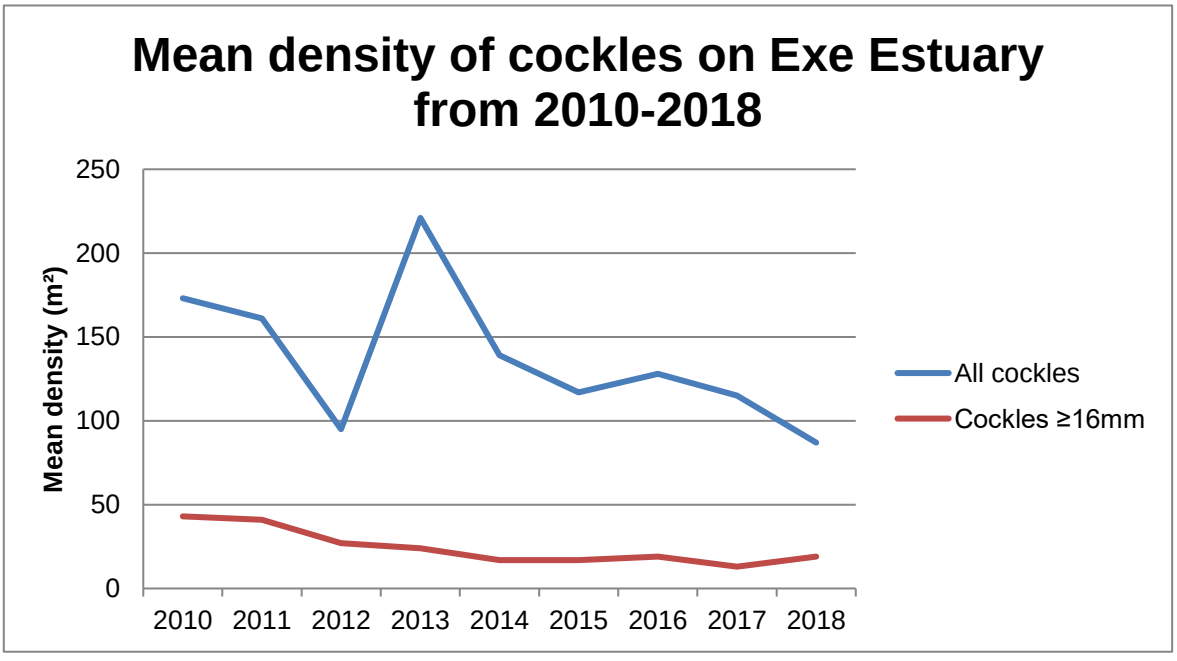

Figure 6 – Mean density of cockles on Exe Estuary from 2010-2018.

Size Frequency and Year Class Distribution:

Figure 7 to 15 show cockle size and age frequencies from 2010 to 2018.

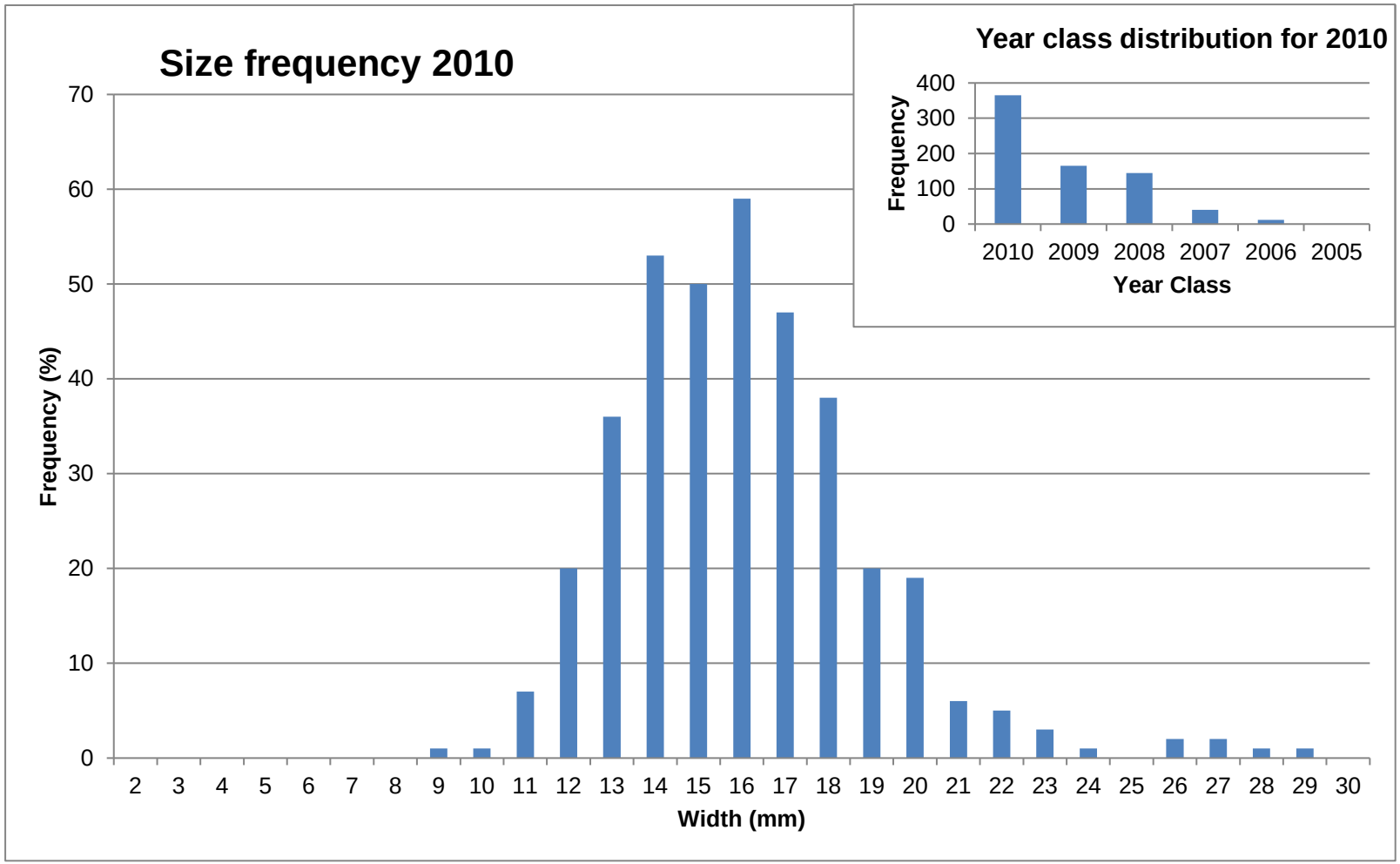

Figure 7 - Cockle size and year class distributions for autumn 2010 of Cockle Sands on the Exe Estuary (356 cockles missing from frequency graph as they were too small to measure).

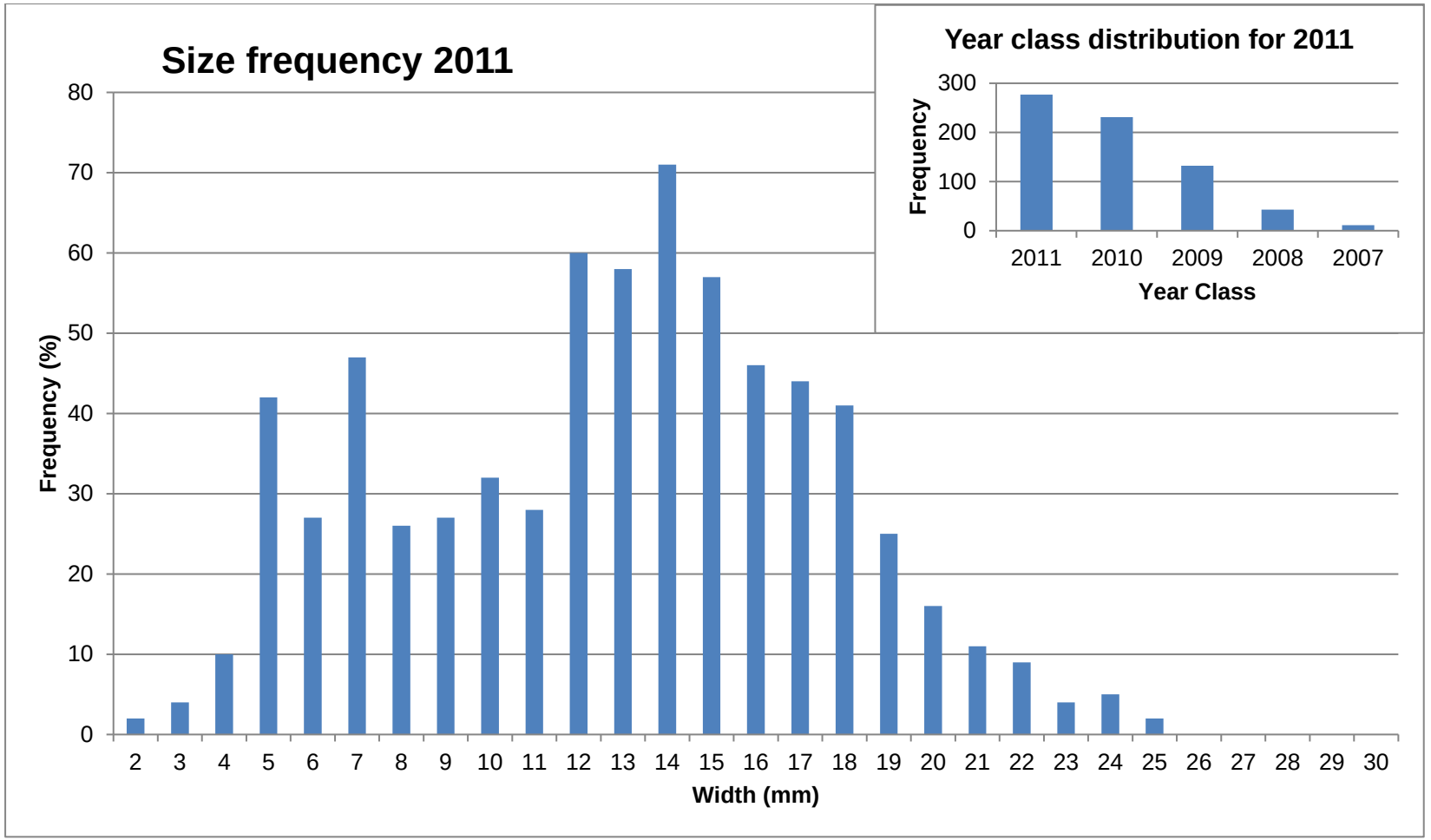

Figure 8 - Cockle size and year class distributions for autumn 2011 of Cockle Sands on the Exe Estuary.

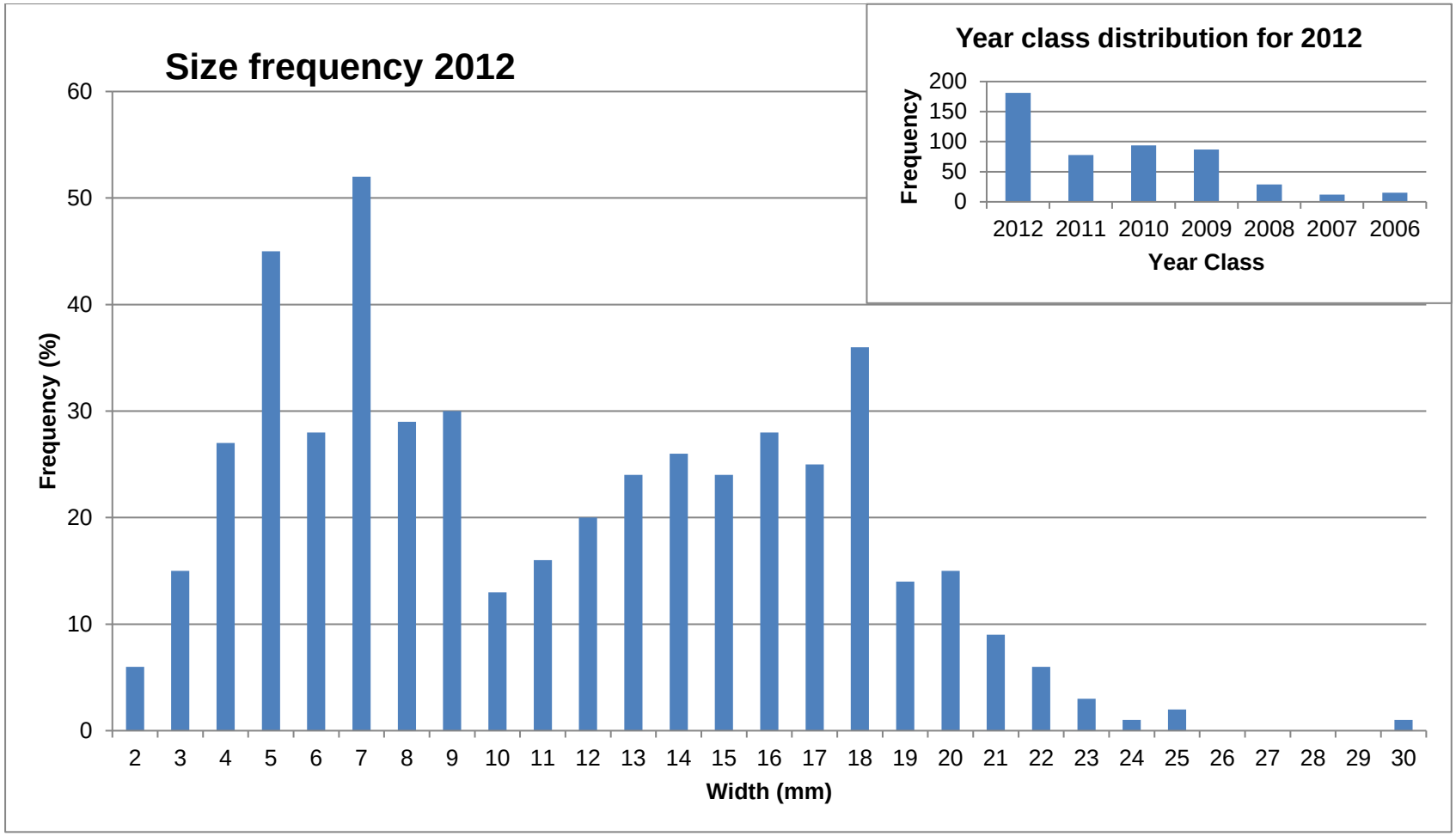

Figure 9 - Cockle size and year class distributions for autumn 2012 of Cockle Sands on the Exe Estuary.

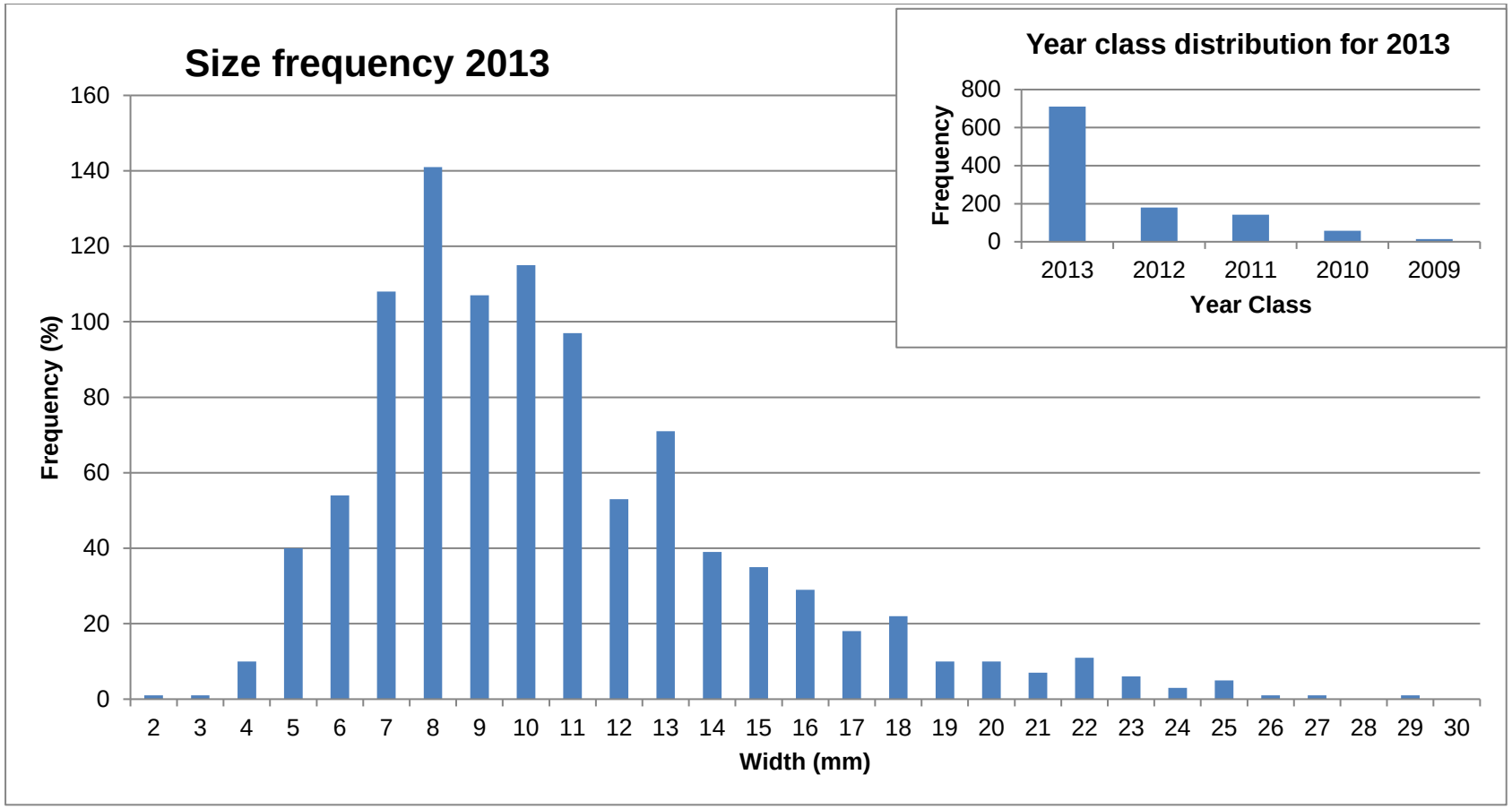

Figure 10 - Cockle size and year class distributions for autumn 2013 of Cockle Sands on the Exe Estuary (108 cockles missing from frequency graph as they were too small to measure).

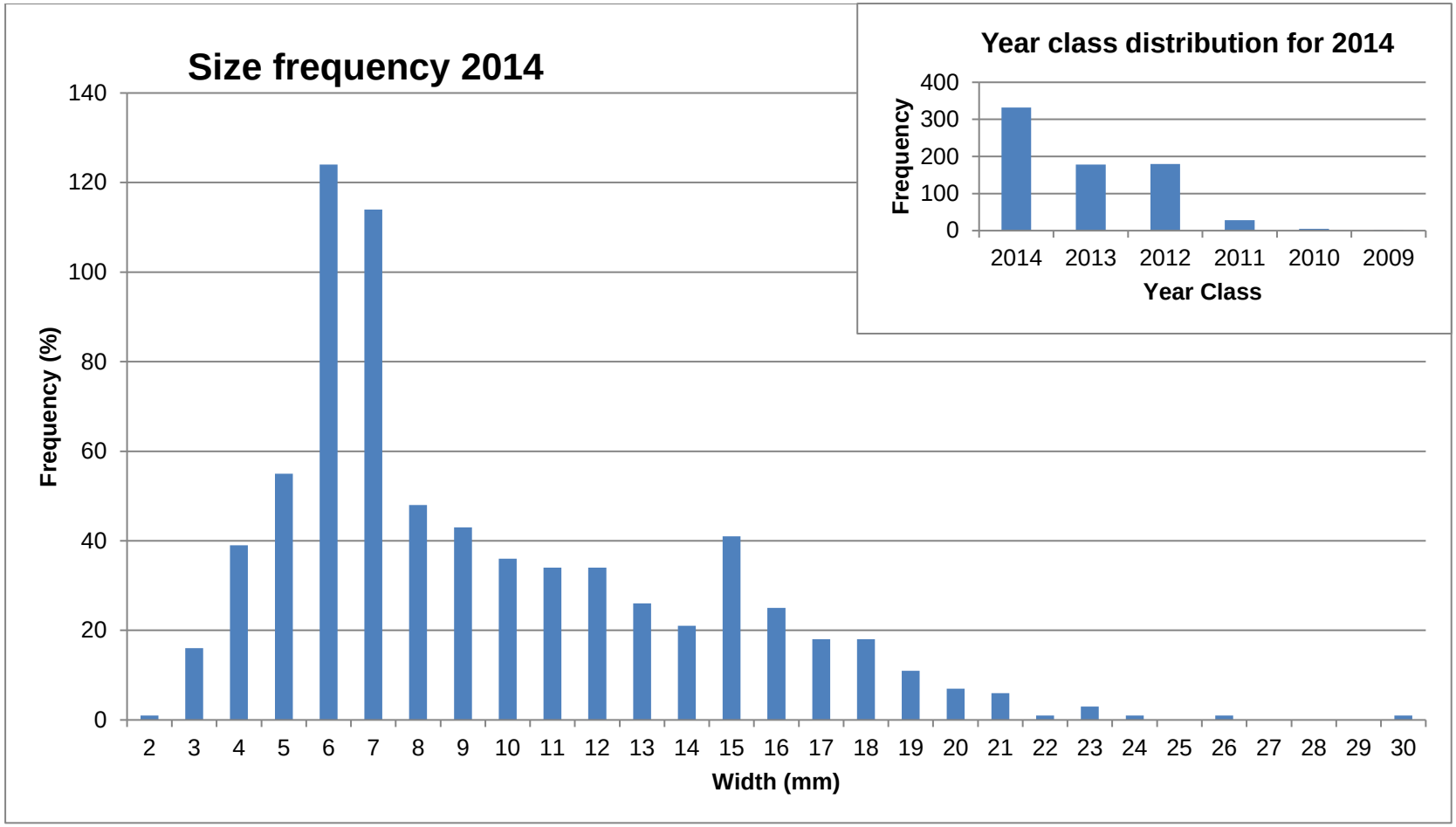

Figure 11 - Cockle size and year class distributions for autumn 2014 of Cockle Sands on the Exe Estuary.

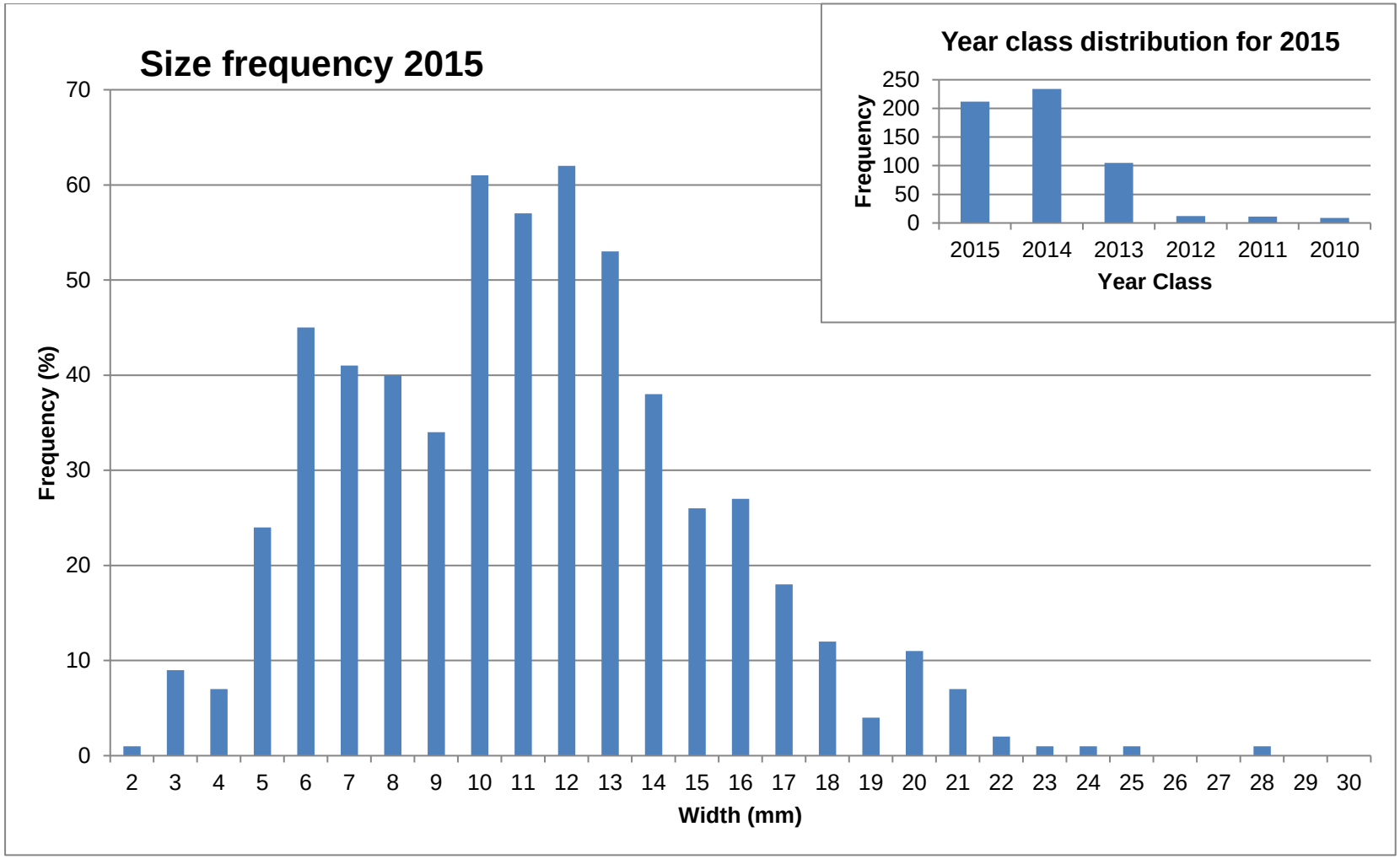

Figure 12 - Cockle size and year class distributions for autumn 2015 of Cockle Sands on the Exe Estuary.

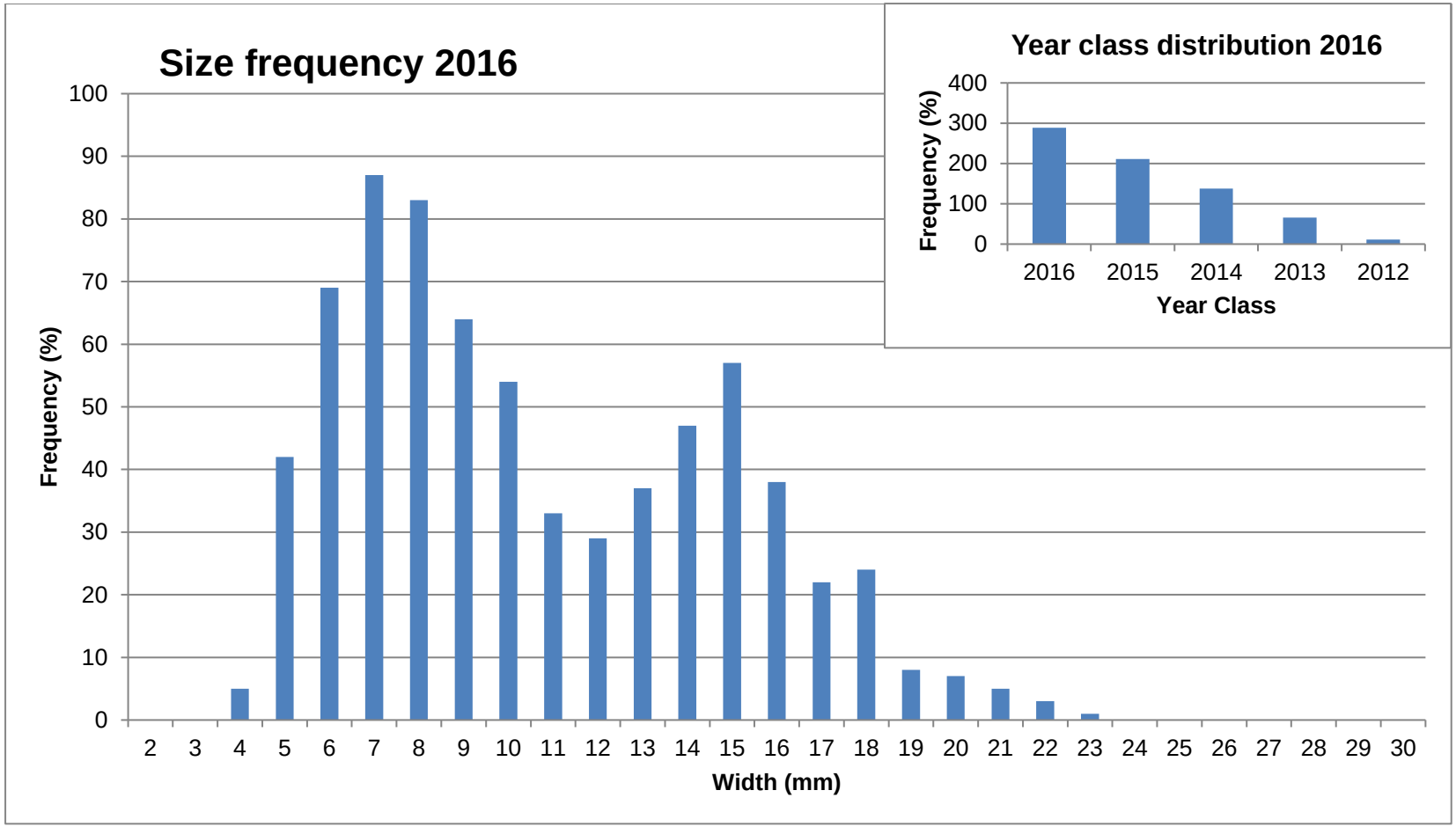

Figure 13 – Cockle size and year class distributions for autumn 2016 of Cockle Sands on the Exe Estuary.

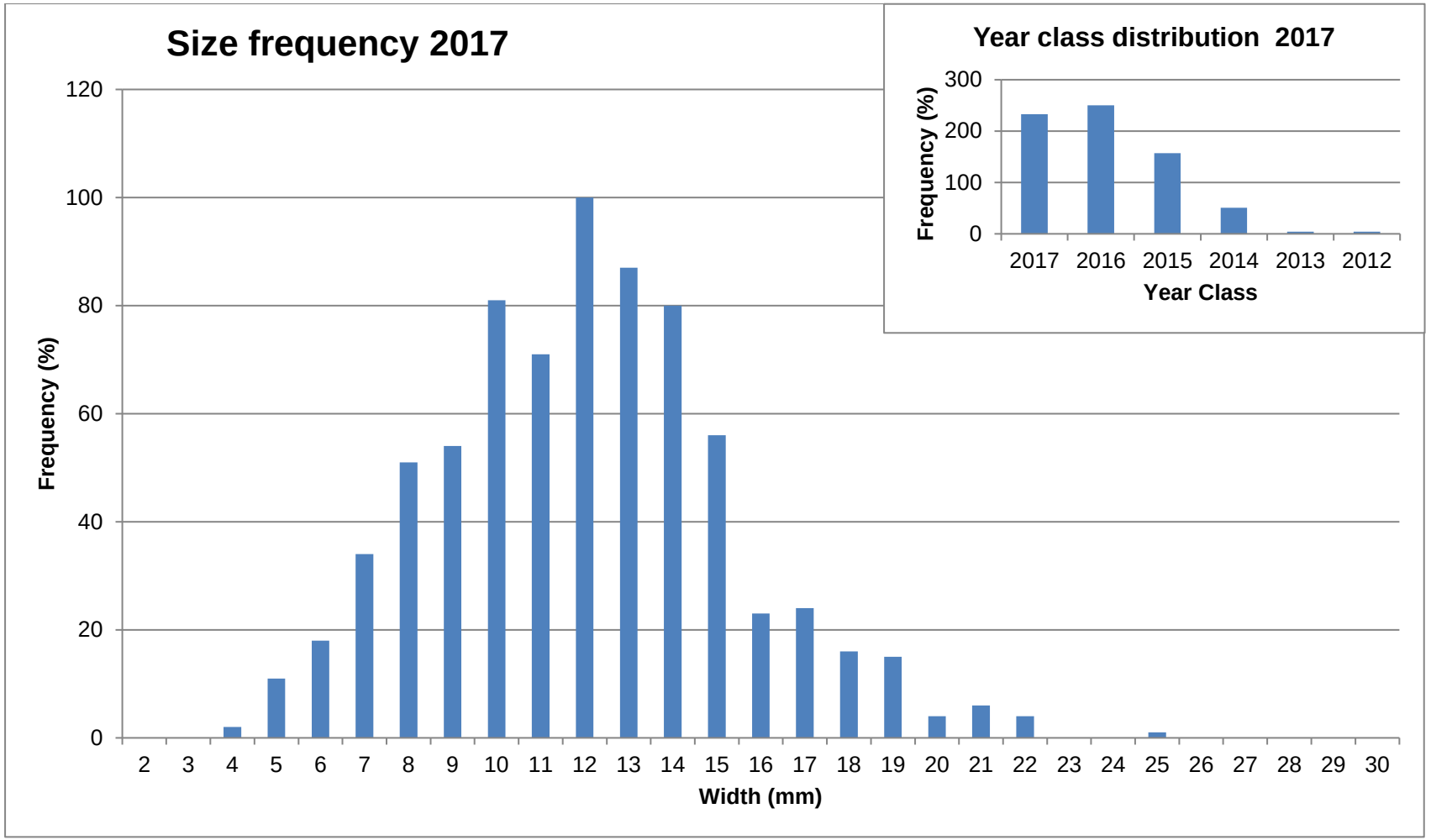

Figure 14 - Cockle size and year class distributions for autumn 2017 of Cockle Sands on the Exe Estuary (includes data from additional stations).

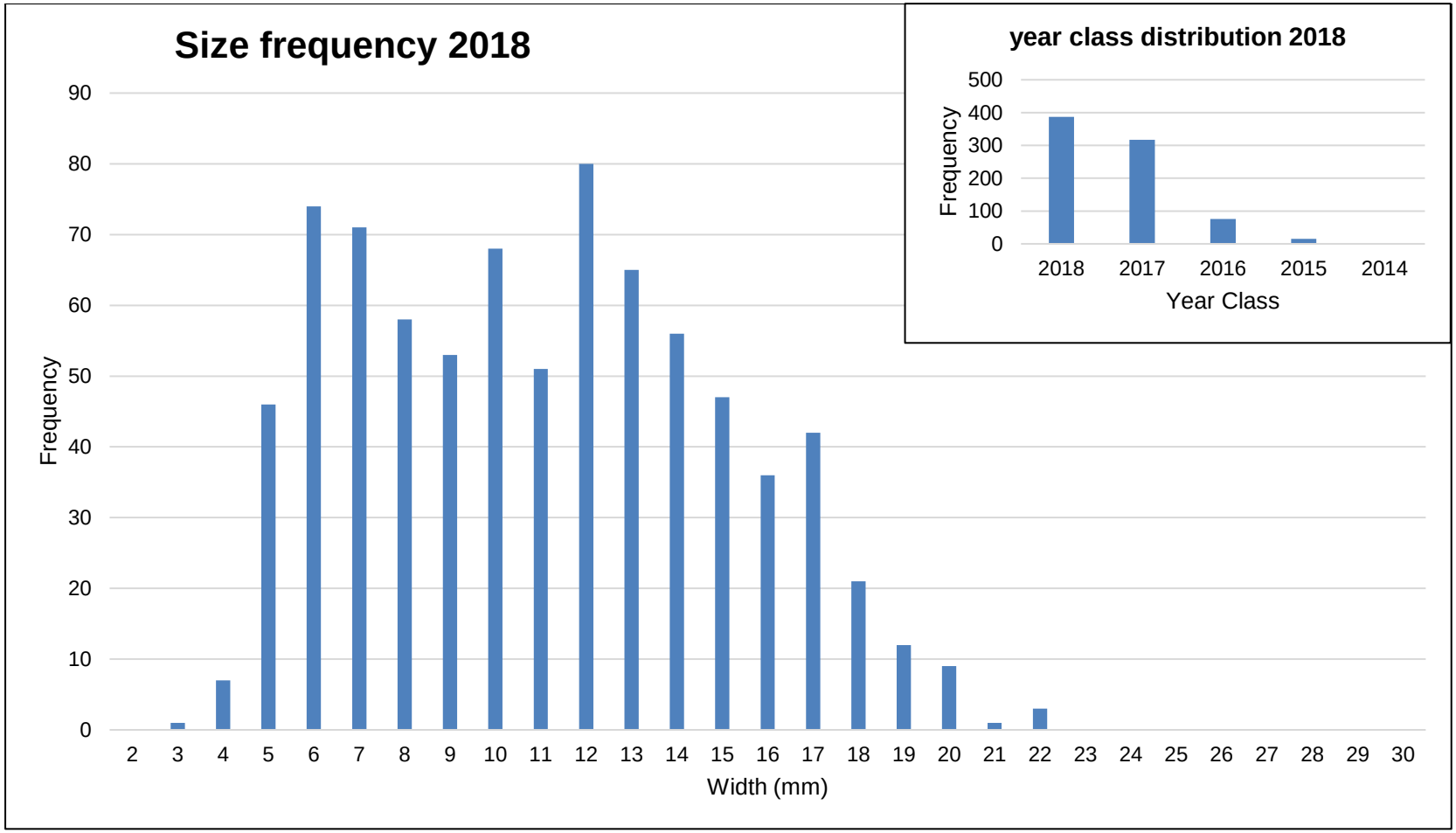

Figure 15 - Cockle size and year class distributions for autumn 2018 of Cockle Sands on the Exe Estuary (includes data from additional stations).

Biomass:

Table 3 shows the mean density and weight of cockles, and the calculated biomass for each year class for all years surveyed across the 63 stations.

Table 3 – Density, weight and biomass of year classes for 2010 to 2018 of Cockle Sands on the Exe Estuary.

2018 Survey			Year class						
			2018	**2017**	**2016**	**2015**	**2014**	**2013**	**2012**
No. samples	46	**Mean density (cockles/m²)**	111	83	33	38	10	-	-
Area (ha)	60.8	**Mean weight (kg/m²)**	0.76	2.32	1.66	2.68	0.07	-	-
		Biomass (kg/ha)	4.62	14.17	10.16	16.27	4.26	-	-
2017 Survey			Year class						
			2017	**2016**	**2015**	**2014**	**2013**	**2012**	**2011**
No. samples	46	**Mean density (cockles/m²)**	75	74	48	24	13	40	-
Area (ha)	60.8	**Mean weight (kg/m²)**	0.06	0.14	0.14	0.12	0.08	0.18	-
		Biomass (kg/ha)	3.71	8.25	8.81	7.24	5.07	10.95	-
2016 Survey			Year class						
			2016	**2015**	**2014**	**2013**	**2012**	**2011**	**2010**
No. samples	46	**Mean density (cockles/m²)**	90	73	43	30	55	-	-
Area (ha)	60.8	**Mean weight (kg/m²)**	0.05	0.12	0.16	0.16	0.52	-	-
		Biomass (kg/ha)	3.06	7.11	9.58	9.9	31.63	-	-
2015 Survey			Year class						
			2015	**2014**	**2013**	**2012**	**2011**	**2010**	**2009**
No. samples	43	**Mean density (cockles/m²)**	82	67	46	17	16	18	-
Area (ha)	56.9	**Mean weight (kg/m²)**	0.05	0.15	0.17	0.08	0.09	0.11	-
		Biomass (kg/ha)	2.71	8.62	9.66	4.75	5.03	6.12	-
2014 Survey			Year class						
			2014	**2013**	**2012**	**2011**	**2010**	**2009**	**2008**
No. samples	37	**Mean density (cockles/m²)**	144	74	75	18	25	10	-
Area (ha)	48.9	**Mean weight (kg/m²)**	0.04	0.07	0.24	0.12	0.18	0.08	-
		Biomass (kg/ha)	2.04	3.65	11.85	6.06	8.56	3.91	-
2013 Survey			Year class						
			2013	**2012**	**2011**	**2010**	**2009**	**2008**	**2007**
No. samples	45	**Mean density (cockles/m²)**	223	55	46	22	16	10	-
Area (ha)	59.5	**Mean weight (kg/m²)**	0.24	0.13	0.21	0.21	0.19	0.08	-
		Biomass (kg/ha)	14.18	7.73	12.34	12.28	11.41	4.76	-
2012 Survey			Year class						
			2012	**2011**	**2010**	**2009**	**2008**	**2007**	**2006**
No. samples	35	**Mean density (cockles/m²)**	95	31	41	36	22	20	150
Area (ha)	46.3	**Mean weight (kg/m²)**	0.05	0.08	0.18	0.22	0.16	0.16	0.07
		Biomass (kg/ha)	2.44	3.65	8.23	10.05	7.3	7.41	3.24
2011 Survey			Year class						
			2011	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**
No. samples	43	**Mean density (cockles/m²)**	82	72	44	48	28	-	-
Area (ha)	56.9	**Mean weight (kg/m²)**	0.11	0.25	0.25	0.29	0.19	-	-
		Biomass (kg/ha)	6.24	14.29	14.05	16.37	10.95	-	-

2010 Survey			Year class						
			2010	2009	2008	2007	2006	2005	2004
No. samples	42	**Mean density (cockles/m²)**	130	66	54	29	15	10	-
Area (ha)	55.5	**Mean weight (kg/m²)**	0.11	0.26	0.3	0.2	0.2	0.2	-
		Biomass (kg/ha)	6.27	14.21	16.79	10.83	11.18	11.11	-

Density:

Figure 16 to Figure 24 show cockle densities per m² from 2010 to 2018 which includes all year classes.

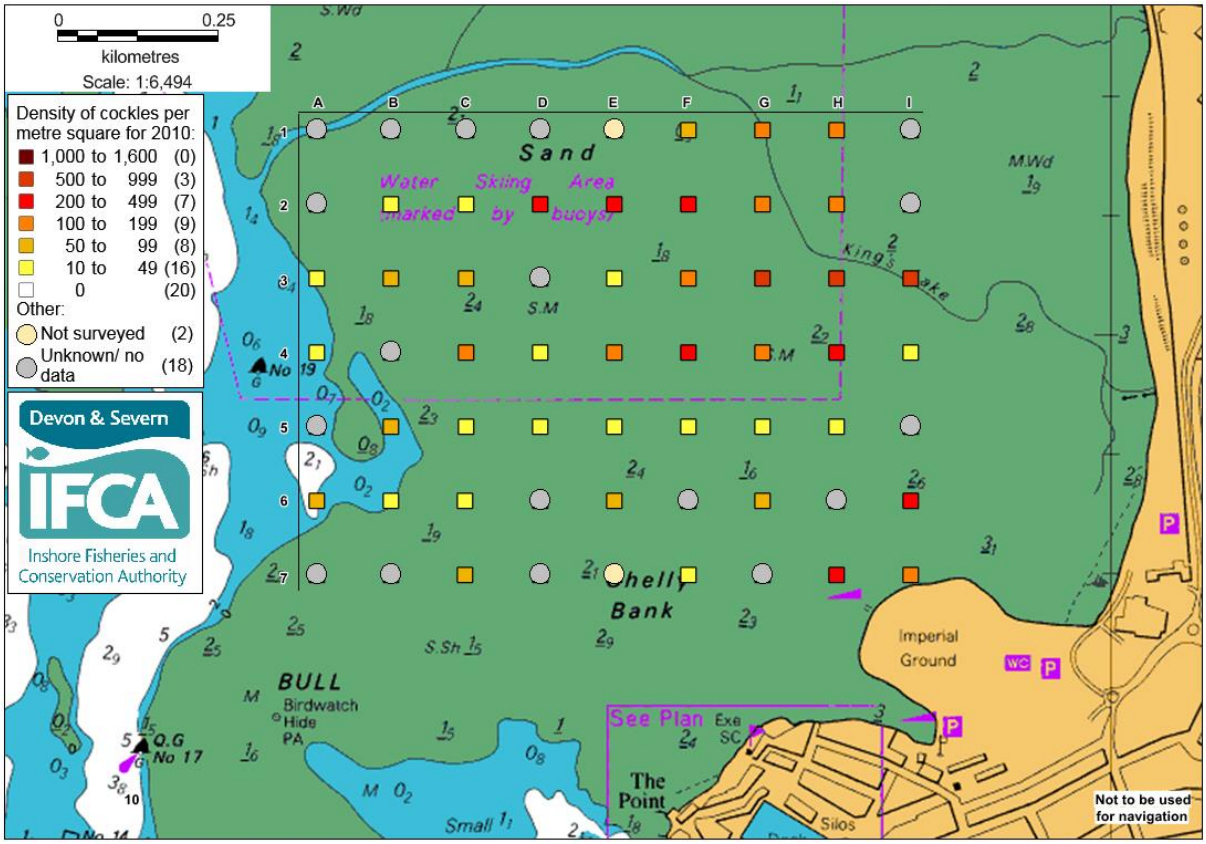

Figure 16 – Cockle density per m² for autumn 2010 of Cockle Sands on the Exe Estuary.

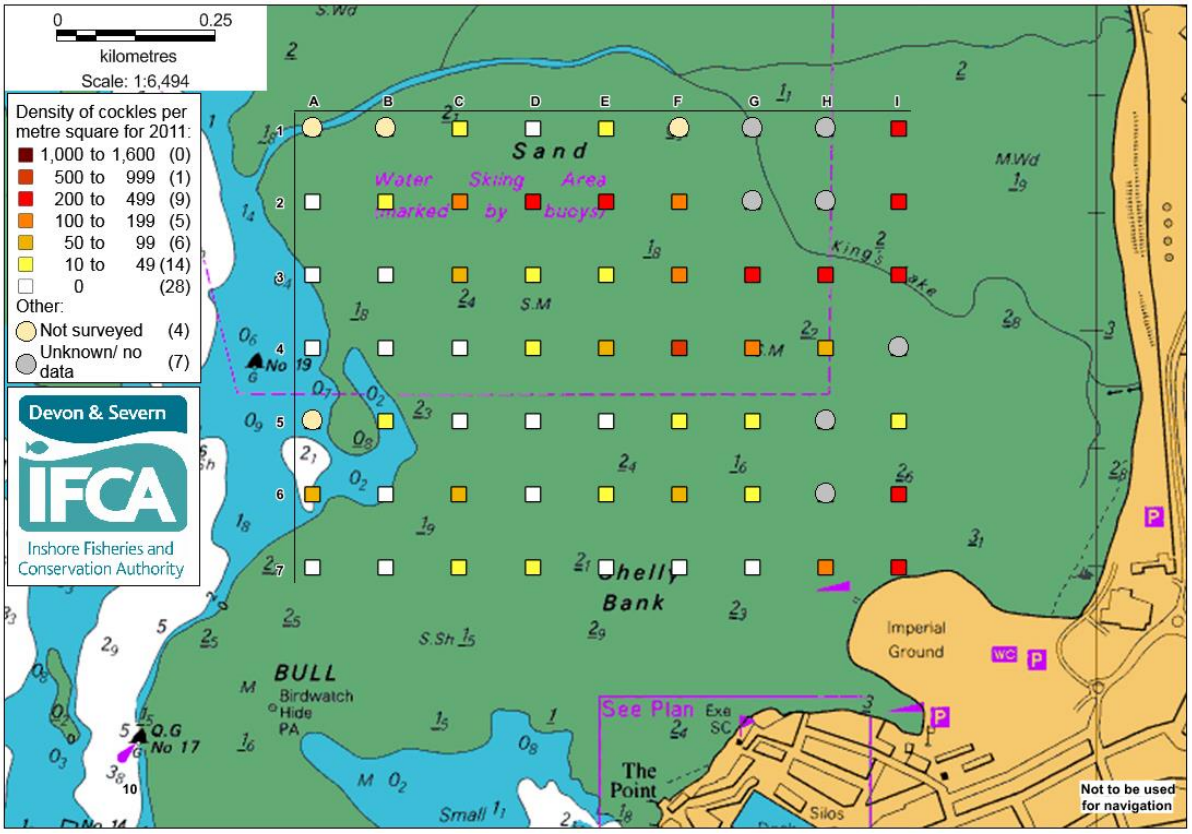

Figure 17 - Cockle density per m² for autumn 2011 of Cockle Sands on the Exe Estuary.

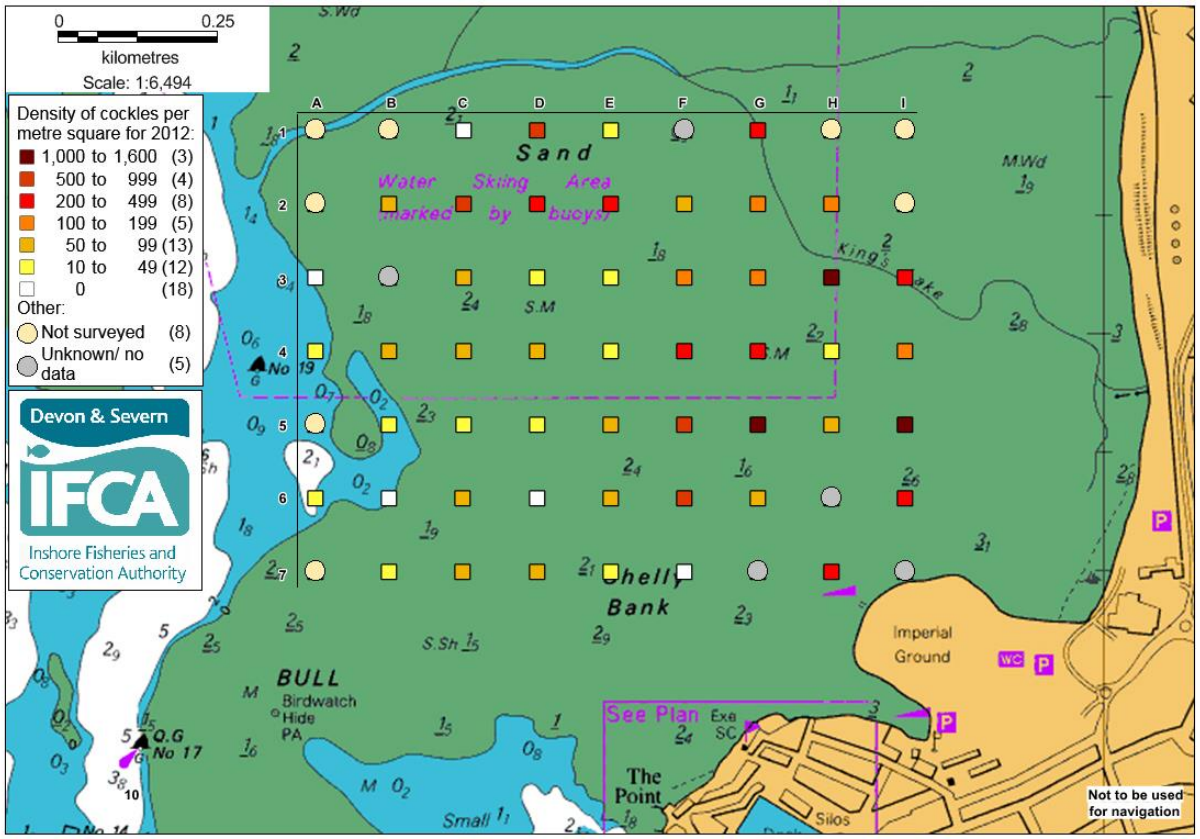

Figure 18 - Cockle density per m² for autumn 2012 of Cockle Sands on the Exe Estuary.

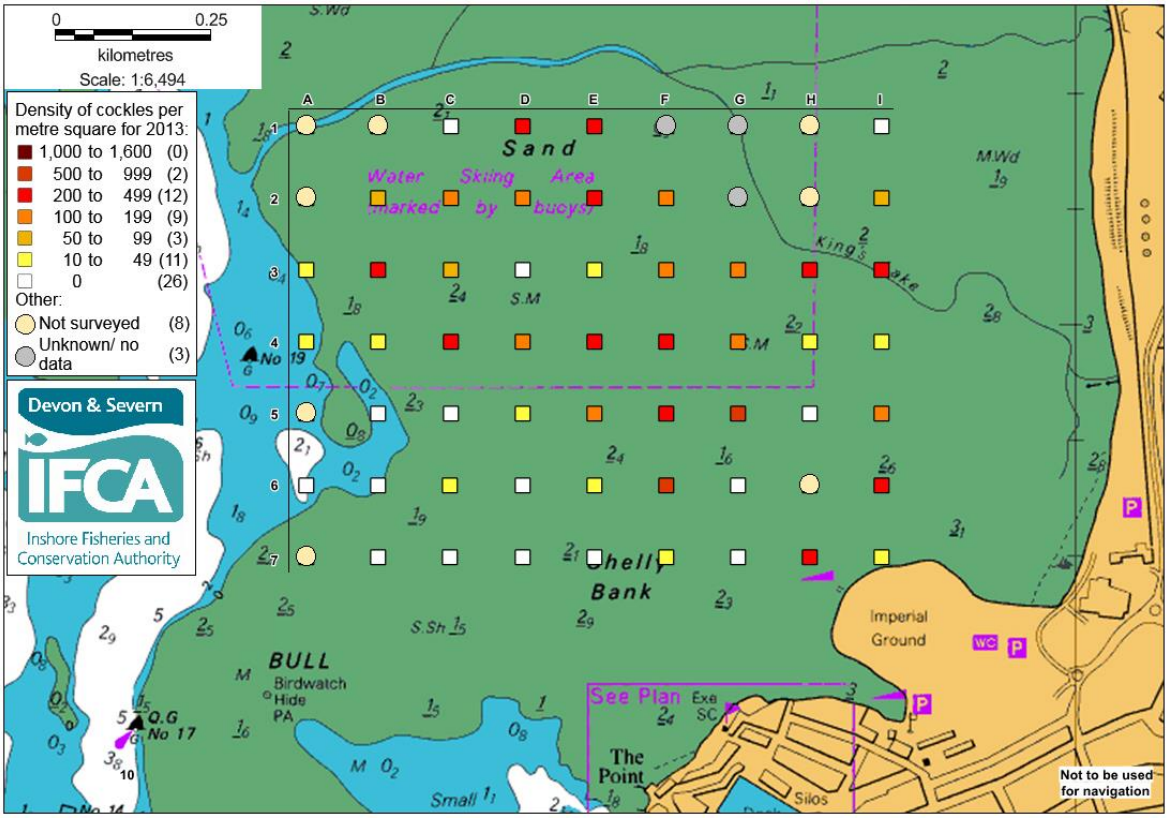

Figure 19 - Cockle density per m² for autumn 2013 of Cockle Sands on the Exe Estuary.

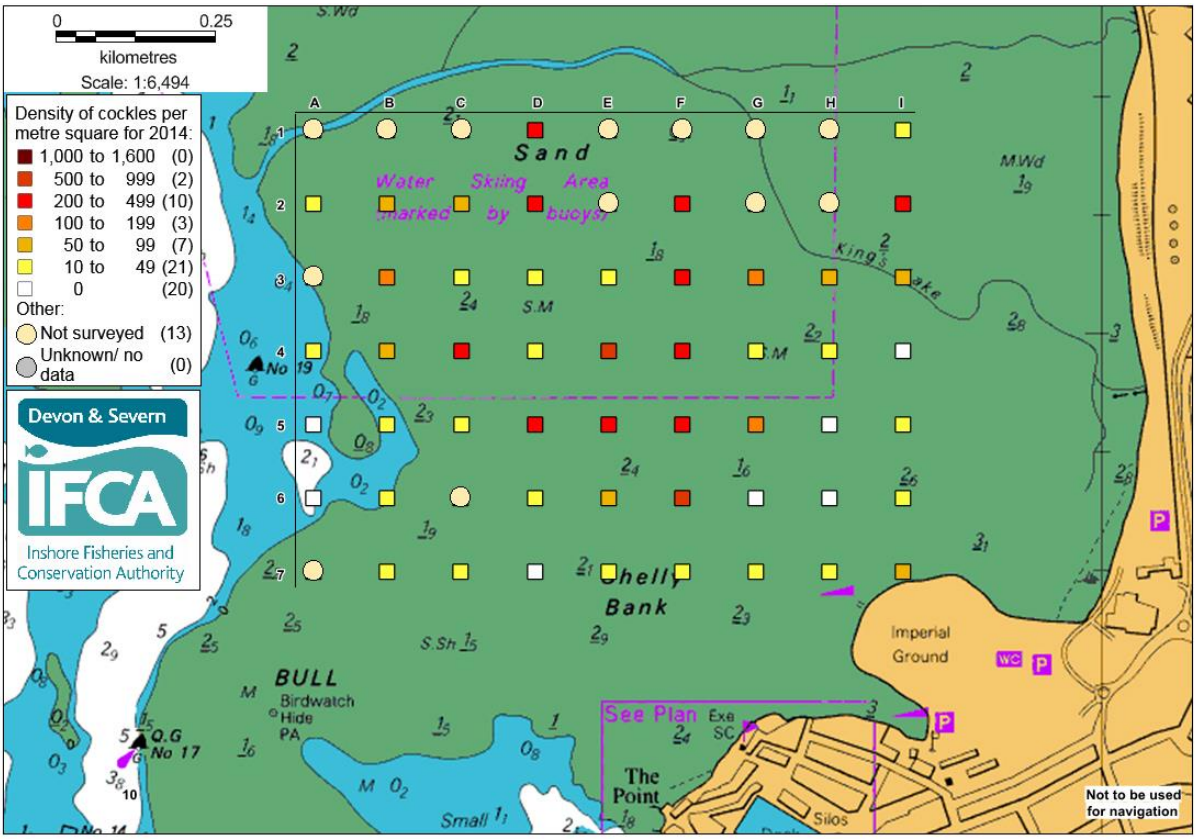

Figure 20 - Cockle density per m² for autumn 2014 of Cockle Sands on the Exe Estuary.

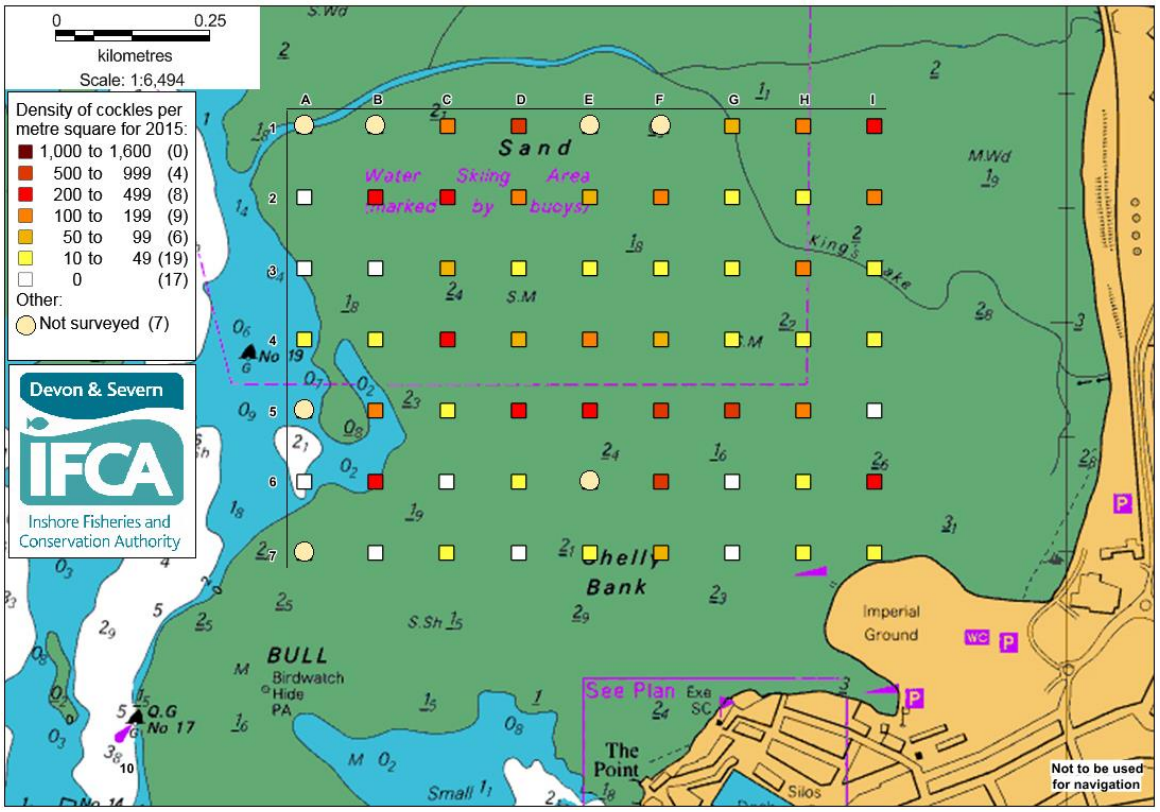

Figure 21 - Cockle density per m² for autumn 2015 of Cockle Sands on the Exe Estuary.

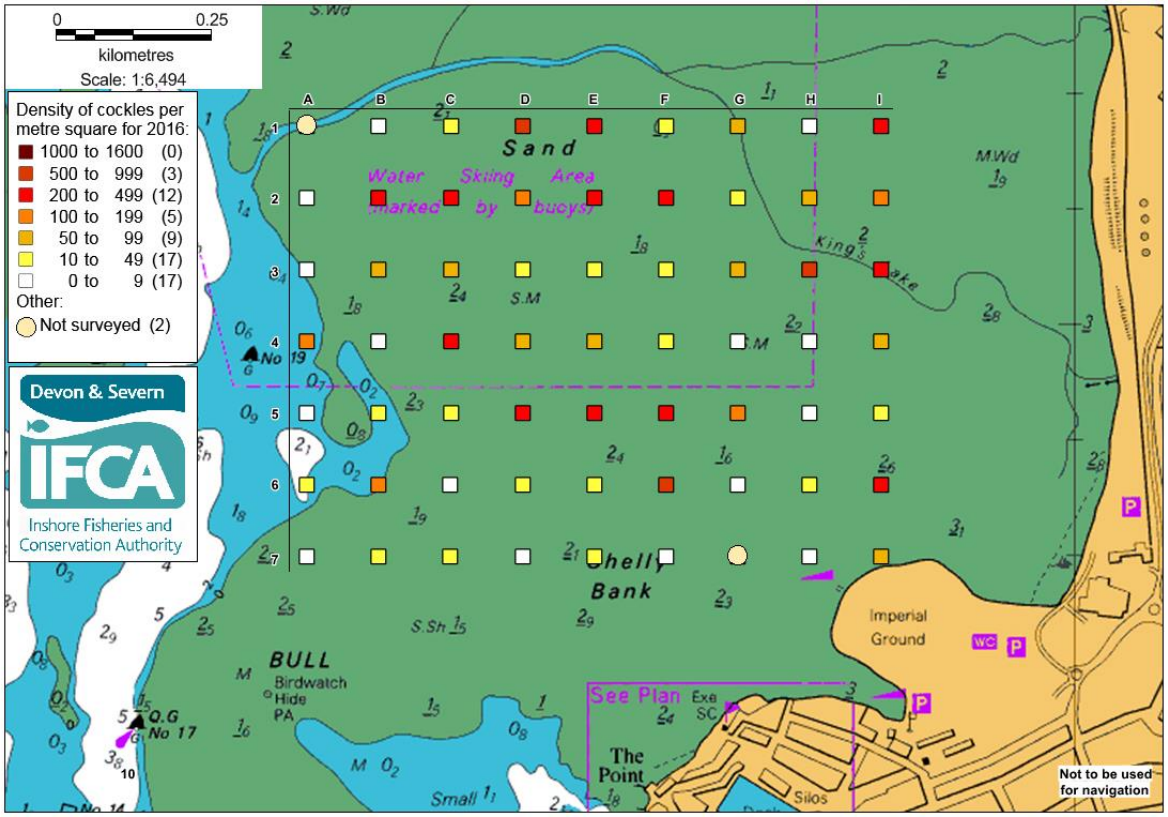

Figure 22 - Cockle density per m² for autumn 2016 of Cockle Sands on the Exe Estuary.

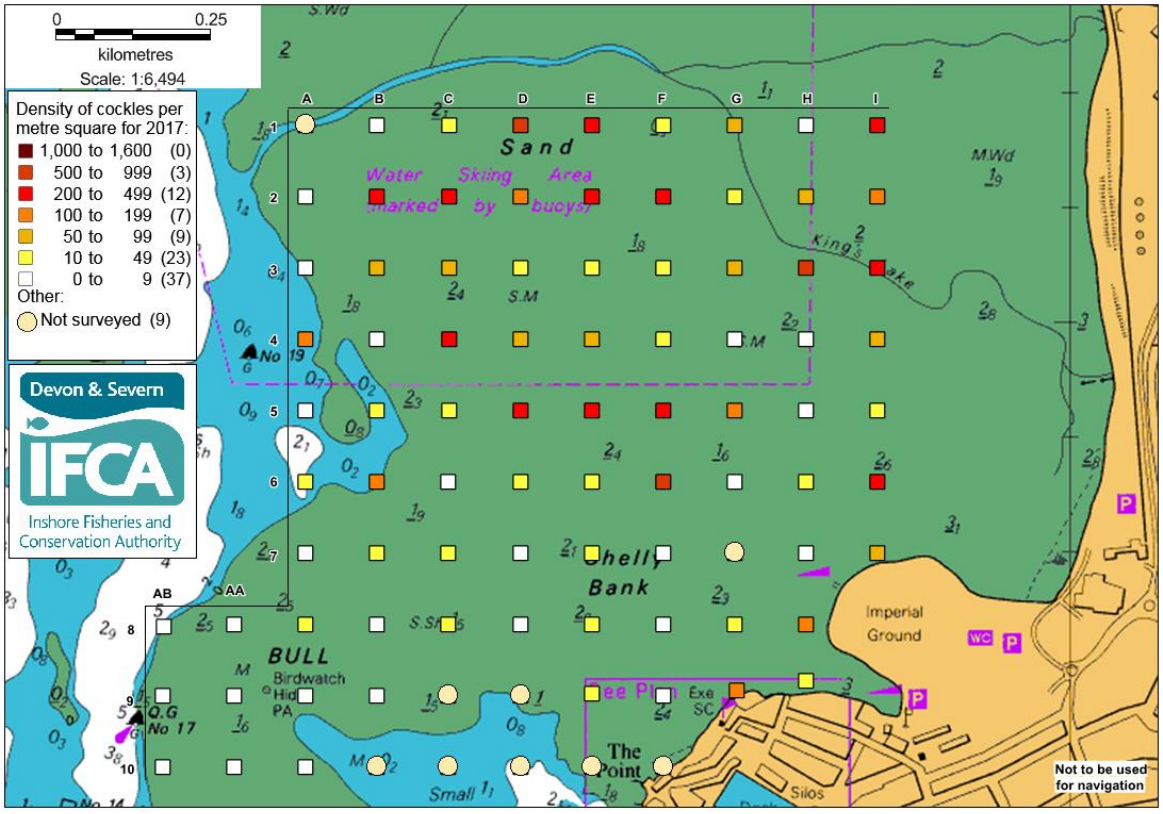

Figure 23 - Cockle density per m² for autumn 2017 of Cockle Sands on the Exe Estuary.

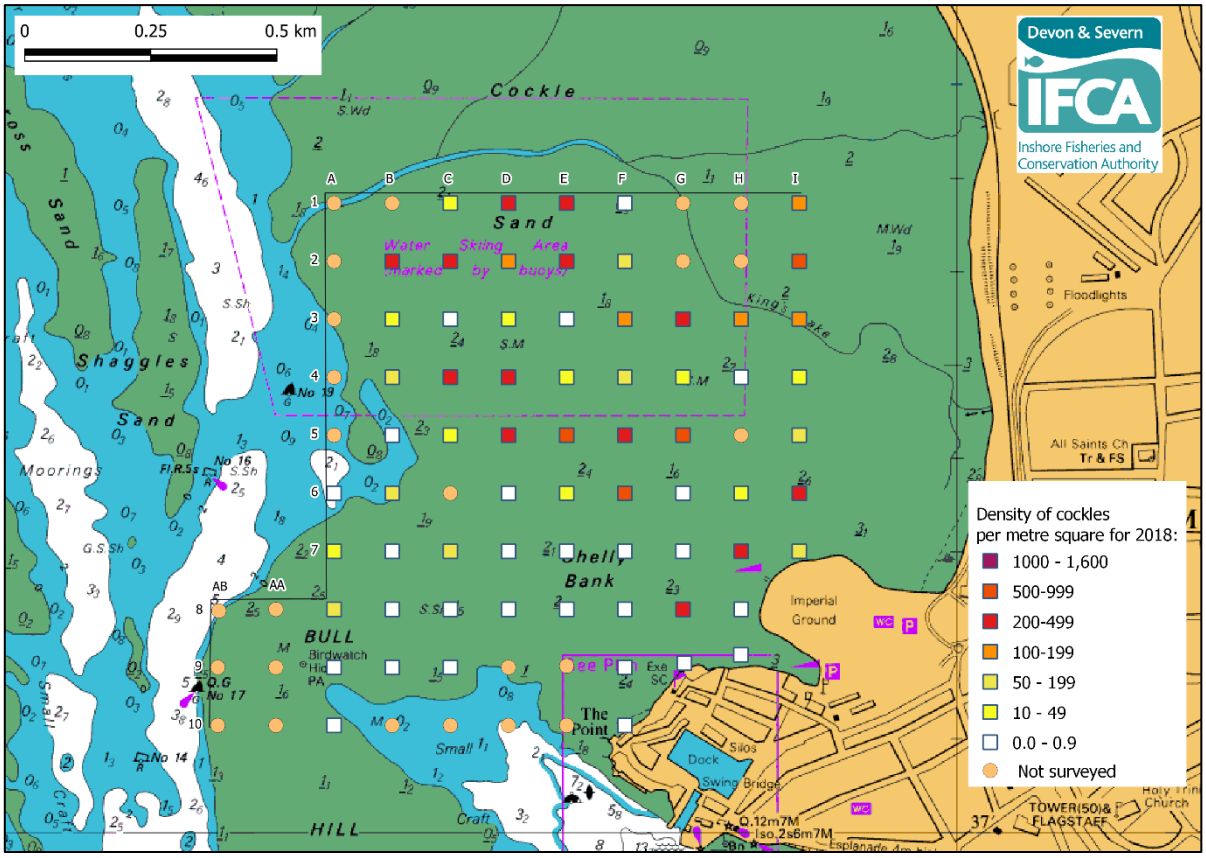

Figure 24 - Cockle density per m² for autumn 2018 of Cockle Sands on the Exe Estuary.

From these density distribution charts there appears to be larger densities per m^2 in the middle, to the north and to the east of the bed although this does fluctuate year on year. There appears to be lower densities to the west and south west of the beds each year.

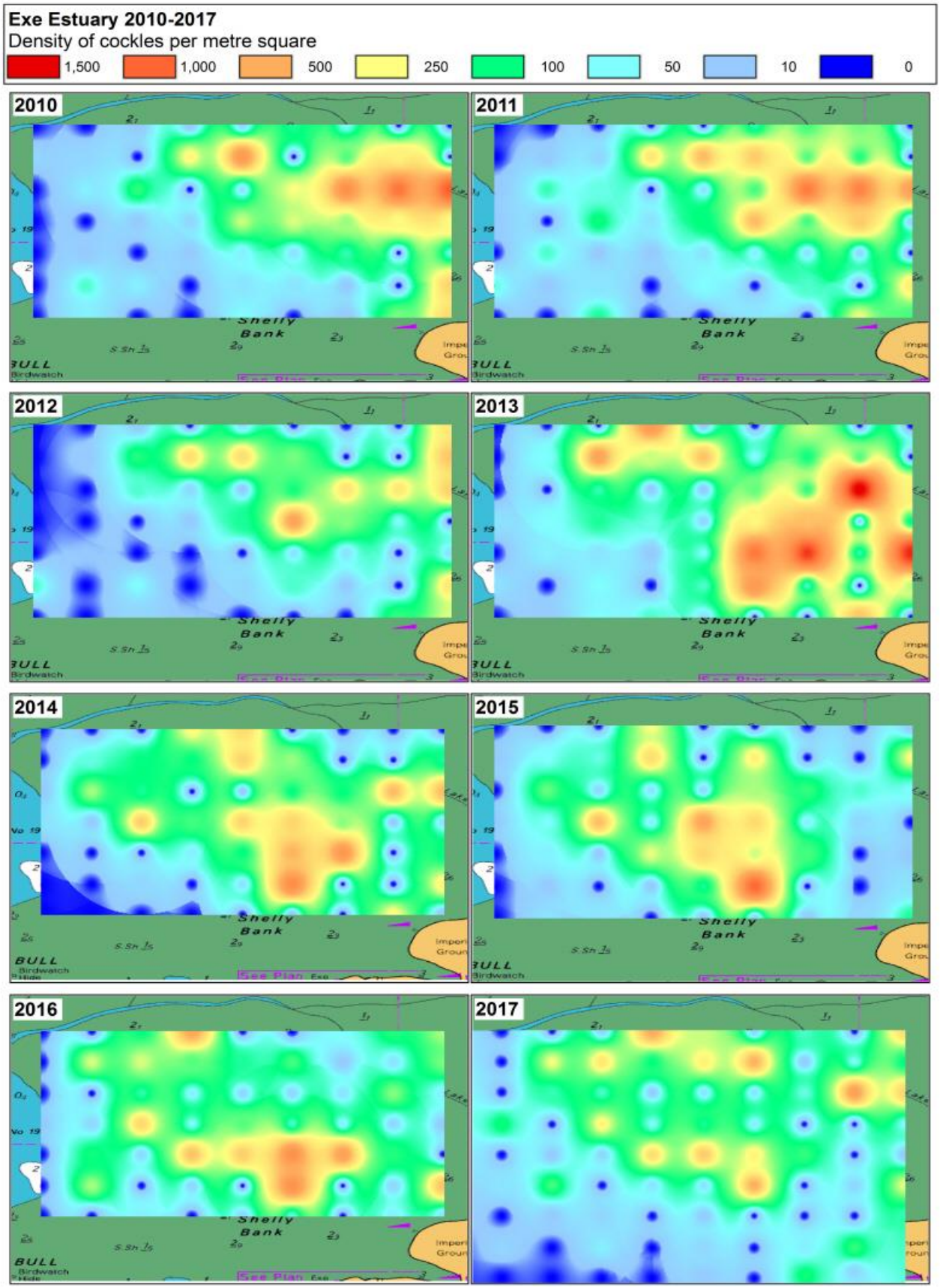

Figure 25 - Cockle density per m² using interpolator Inverse Distance Weighting for 2010-2017 of Cockle Sands on the Exe Estuary.

Discussion

Devon and Severn IFCA has carried out annual cockle surveys on Cockle Sands since 2010. Cockle density and biomass varies over the seven years making it difficult to determine a clear trend. There does appear to be an overall decrease when 2010 and 2018 mean densities are compared but the drop in 2012 and the peak in 2013 make this uncertain. There was a large increase in total counts in 2013 but there was not a corresponding highest biomass. This might be as a result of the decline in density of the over 16mm cockles which had decreased by over 44%. The density was very high in 2013 which would might have been the result of a recruitment event and a large number of small under 16mm cockles on the ground. The lowest numbers of cockles were found in 2012, after the mass mortality event in 2011. The mortality affected mostly large cockles at that time. The cockles were found to have elevated levels of two parasites that cause the cockle to gap by affecting the abductor muscle and preventing closure of the shell, leading to death. Recent communications with Exmouth Mussels suggested there had been another morality event in 2014 after the winter storms, resulting in a huge 'May Water' and depleted oxygen levels causing estuary-wide morality of all shellfish in the intertidal (M. Blood-Smyth 2017, Pers. Comm.).

Mean density and biomass were higher in December 2013 compared to October 2014. The Exe Estuary suffered from major storms in mid-December 2013 through to mid-February 2014 where there was a dramatic loss of mussels from Bull Hill (near Cockle Sands). This may explain the difference between years.

The size distributions of cockles vary over the past seven years. There has been a noticeable shift towards smaller sizes, likely to be caused by the mortality events affected the larger cockles. The mean densities of cockles 16mm and over can be seen to decrease over the first seven years of surveys but in the most recent survey in 2018, a 10% increase was observed (Table 2 and Figure 6). There is no MCRS for cockles in the Devon and Severn IFCA District but 16mm is regarded as a marketable size with high commercial value and is the MCRS for Eastern IFCA and Kent & Essex IFCA (Haywood *et al.* 2017; Jessop, 2015) making it a comparable size.

Durell et al. (2007) looked at foraging variables for six species of birds on the Exe Estuary for a model to assess the impact of disturbance and climate change. The birds which fed on medium cockles (10-19.9mm) were black-tailed godwit, bar-tailed godwit and curlew and for large cockles (15-44.9mm) were oystercatchers. The decline over seven years surveyed in mean cockle densities for 16mm and over results in a reduction in food availability for oystercatchers. This, alongside the significant reduction of mussels on the Estuary (Davies and Stephenson 2017) means there is even less food available to the oystercatchers, which are a feature of the Exe Estuary SPA.

The density of cockles per m² recorded by Durell et al. (2005) in autumn 2001 can be seen in Table 4. The cockle bed area (see map in Durell et al (2007)) covers 66 hectares and part of this overlaps with the survey grid used in this report.

Table 4 - Cockle densities from 2001 taken from Durell et al. (2007) used in their Exe Estuary model.

Cockle bed	5 - 9.9mm	10 - 14.9mm	15 - 19.9mm	20 - 24.9mm	25 - 29.9mm	30 - 34.9mm	35 - 39.9mm	40 - 44.9mm	Total
Density (n m²)	22.5	9.5	8	8.7	2.6	0	0	0	51.3

The total density of cockles from 2001 (Table 4) is significantly lower than the densities found during Devon and Severn IFCAs surveys (Table 2). However, Durell et al. (2005) study cannot be directly compared to the data presented here as the survey stations are in different locations.

Due to the mesh size cockles less than 6.35mm will most likely fall through the sieve, however, some below this are retained and these have been included in the data analysis. Therefore, the cockles recorded that are less than 7mm is not a true representation of the actual stock present at that station or during that year.

It should be highlighted that there were stations where it was unknown whether they were surveyed (either no live cockles were found or that the station was unable to be surveyed). These 53 unknown/no data stations equate to 12% of the total amount of stations over the eight years surveyed. Some stations (particularly A1, A2, A5, A7, B1, F1, G1, H1, H2 and H6) are regularly not surveyed as they are either still submerged at low water or too muddy to safely access. There was a total of 68 stations not surveyed over the years, which equates to 11% of the total. Therefore, the results displayed in this report may be an underestimate of the cockle densities for those particular stations.

This report briefly comments on the amount of 16mm cockles and over that were present but for future surveys it may be valuable to also identify the weight of cockles 16mm and over. Although there is currently no commercial fishery for cockles on the Exe Estuary, Devon and Severn IFCA will continue the annual autumn survey to monitor the cockle stocks that are harvested recreationally and form part of the SPA birds' diet. It is recommended that the data collected from these surveys should be fed into a food availability model to see how much cockles contribute in terms of food source for the overwintering birds on the Exe Estuary.

Reports of recreational gathering of cockles have increased over the few years, some of which report large quantities being removed. As larger cockles are more likely to be targeted by the recreational fishers this could continue to impact the densities and biomass of cockles greater than 16mm on the bed.

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Annex 1

Raw cockle count data

Station	2010	2011	2012	2013	2014	2015	2016	2017	2018
A1	N/A	N/A	-	-	-	-	-	-	0
A2	2	N/A	0	-	-	1	0	0	0
A3	N/A	1	0	0	1	-	0	0	0
A4	N/A	1	0	3	3	1	1	11	0
A5	N/A	N/A	-	-	-	0	-	0	0
A6	N/A	6	7	3	0	0	0	3	1
A7	N/A	N/A	0	-	-	-	-	0	4
B1	N/A	N/A	-	-	-	-	-	0	0
B2	2	1	1	5	6	5	23	25	21
B3	4	8	0	N/A	20	16	0	8	2
B4	N/A	N/A	0	5	1	5	2	0	7
B5	1	7	1	4	0	4	11	1	0
B6	7	1	0	0	0	1	20	14	6
B7	4	N/A	0	1	0	3	0	1	0
C1	1	N/A	1	0	0	-	10	2	4
C2	N/A	2	12	57	10	6	23	32	38
C3	13	6	7	8	9	2	8	7	1
C4	1	11	0	9	40	45	37	28	39
C5	N/A	1	0	3	0	1	2	2	2
C6	4	3	5	5	2	-	0	0	0
C7	N/A	9	2	5	0	3	4	2	5
D1	1	N/A	0	64	26	25	54	52	27
D2	27	32	35	22	10	35	15	10	16
D3	N/A	N/A	2	1	0	3	4	1	4
D4	2	3	1	6	14	4	5	5	28
D5	1	1	0	1	4	24	44	35	46
D6	N/A	N/A	0	0	0	1	2	3	0
D7	N/A	N/A	1	7	0	0	0	0	0
E1	2	-	3	1	36	-	-	22	33
E2	64	46	35	43	38	-	9	29	25
E3	3	3	1	1	1	2	2	3	1
E4	22	10	9	2	38	56	15	9	4
E5	4	3	0	5	10	37	40	41	56
E6	3	5	2	7	3	9	-	3	3
E7	5	-	0	3	0	1	2	1	0
F1	9	8	-	N/A	N/A	-	-	2	0
F2	-	41	17	5	19	29	14	49	10
F3	25	14	11	16	10	20	2	3	11
F4	23	46	57	27	38	36	7	4	10

Key:

N/A	Unknown/ no data
-	Not surveyed
0	No cockles found

F5	3	4	3	87	48	22	71	28	42
F6	3	N/A	7	64	73	97	69	50	52
F7	N/A	3	0	0	1	2	6	0	1
G1	5	14	N/A	22	N/A	-	5	7	0
G2	15	15	N/A	11	N/A	-	1	1	0
G3	71	84	33	13	10	13	3	6	22
G4	19	14	18	44	18	4	4	0	3
G5	8	3	3	123	66	14	59	13	57
G6	1	7	1	7	0	0	0	0	0
G7	1	N/A	0	N/A	0	1	0	-	0
H1	N/A	17	N/A	-	-	-	12	0	0
H2	29	12	N/A	15	-	-	3	5	0
H3	89	80	32	158	46	7	18	59	19
H4	26	41	5	2	1	2	2	0	1
H5	N/A	2	N/A	8	0	0	12	0	0
H6	N/A	N/A	N/A	N/A	-	0	2	2	2
H7	17	24	13	42	26	2	4	0	32
I1	N/A	N/A	32	-	0	1	20	34	0
I2	N/A	N/A	42	-	9	25	17	10	0
I3	105	59	39	28	45	5	4	38	0
I4	26	2	N/A	10	3	0	1	5	0
I5	6	N/A	3	133	10	1	0	1	0
I6	38	30	32	21	28	3	43	24	0
I7	36	14	23	N/A	1	9	3	8	0
A8	-	-	-	-	-	-	-	2	7
A9	-	-	-	-	-	-	-	0	0
A10	-	-	-	-	-	-	-	0	0
B8	-	-	-	-	-	-	-	0	0
B9	-	-	-	-	-	-	-	0	0
B10	-	-	-	-	-	-	-	-	0
C8	-	-	-	-	-	-	-	4	0
C9	-	-	-	-	-	-	-	-	0
C10	-	-	-	-	-	-	-	-	0
D8	-	-	-	-	-	-	-	0	0
D9	-	-	-	-	-	-	-	-	0
D10	-	-	-	-	-	-	-	-	0
E8	-	-	-	-	-	-	-	2	0
E9	-	-	-	-	-	-	-	1	0
E10	-	-	-	-	-	-	-	-	0
F8	-	-	-	-	-	-	-	0	1
F9	-	-	-	-	-	-	-	0	0
F10	-	-	-	-	-	-	-	-	0

Key:

N/A	Unknown/ no data
-	Not surveyed
0	No cockles found

G8	-	-	-	-	-	-	-	4	29
G9	-	-	-	-	-	-	-	11	0
H8	-	-	-	-	-	-	-	13	0
H9	-	-	-	-	-	-	-	2	0
AA8	-	-	-	-	-	-	-	0	0
AA9	-	-	-	-	-	-	-	0	0
AA10	-	-	-	-	-	-	-	0	0
AB8	-	-	-	-	-	-	-	0	0
AB9	-	-	-	-	-	-	-	0	0
AB10	-	-	-	-	-	-	-	0	0

Key:

N/A	Unknown/ no data
-	Not surveyed
0	No cockles found