Exe Estuary
Cockle Stock Assessment 2010 - 2017

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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).

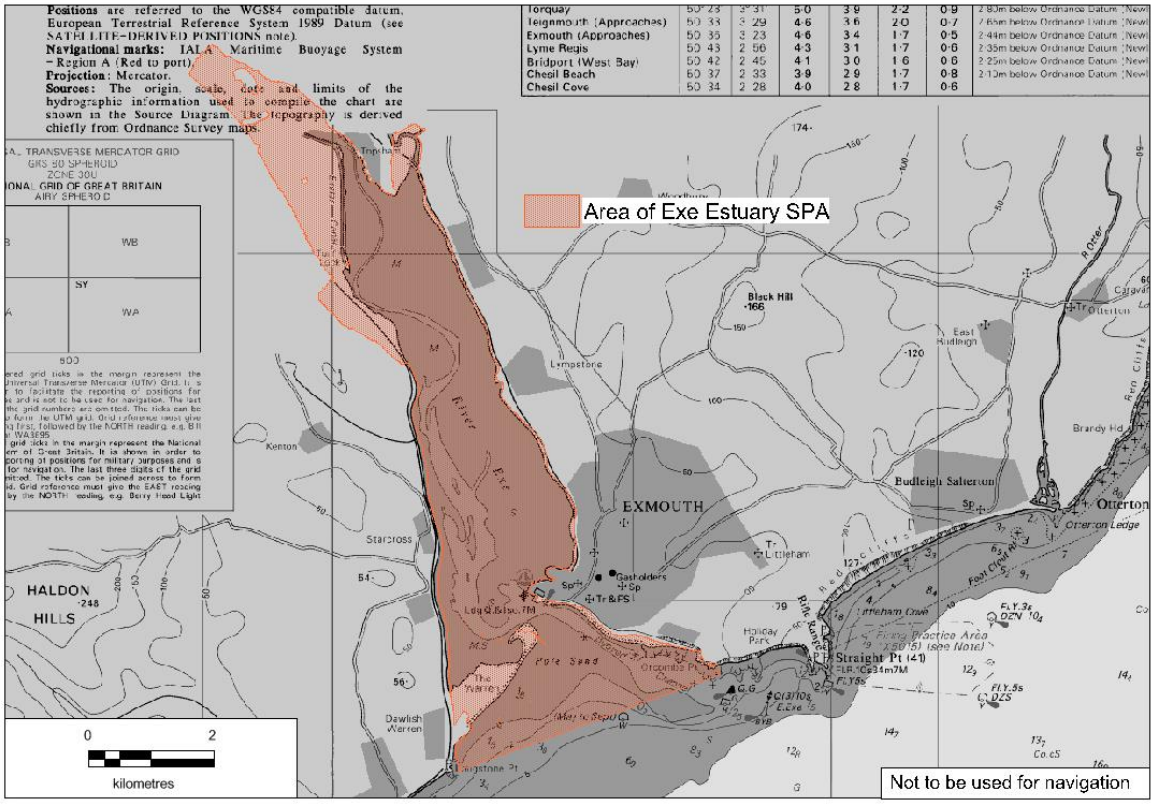

Figure 1 – Area of the Exe Estuary SPA

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 macrofaunal, 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.

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 Handworking 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 amount 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 2017. 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 2017 at low water spring tides. The same survey stations are replicated each year and the stations are 115m x 115m apart (Figure 2).
Usually the survey requires three groups of two to carry out the survey. With each group surveying three rows (e.g. A, B and C) each, see Figure 2. Some stations have been inaccessible (red on Figure 2) due to being underwater or difficult to reach as too muddy, but this changes year on year.

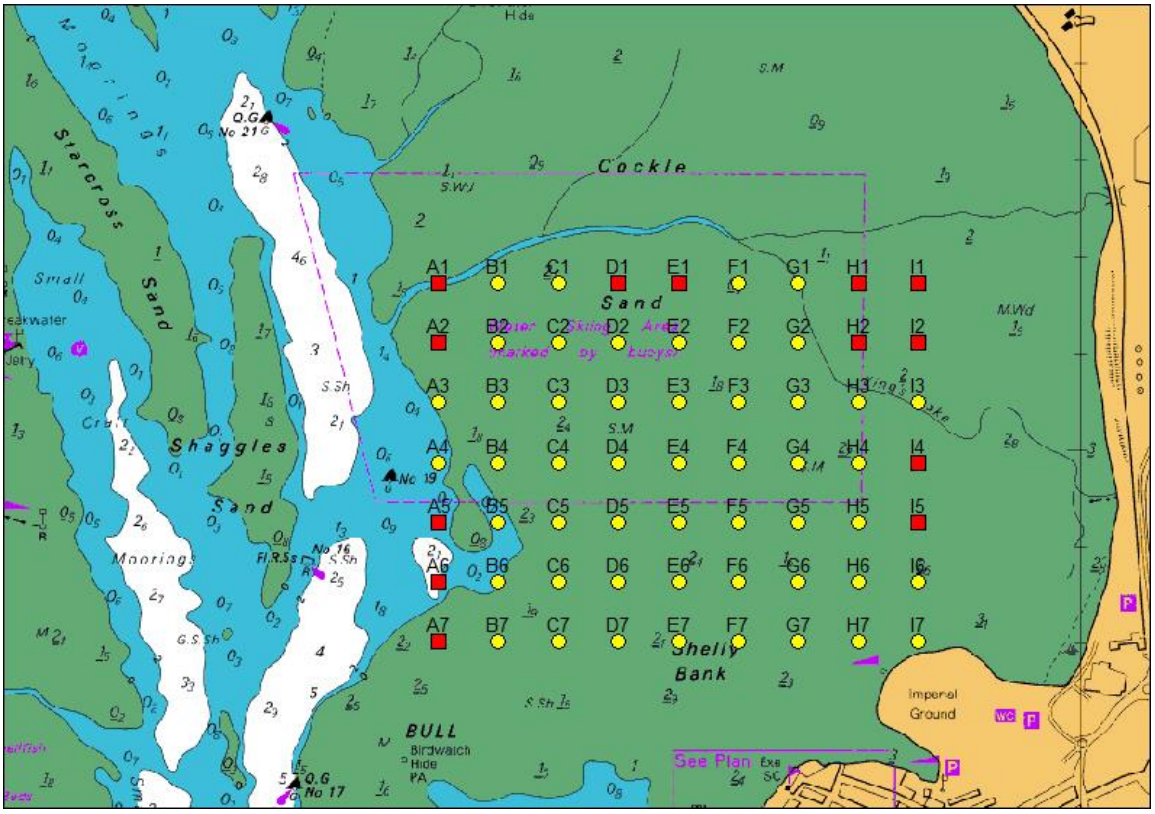

Figure 2 - Exe Estuary cockle survey stations.

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 the 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 ©L. Bullock.

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

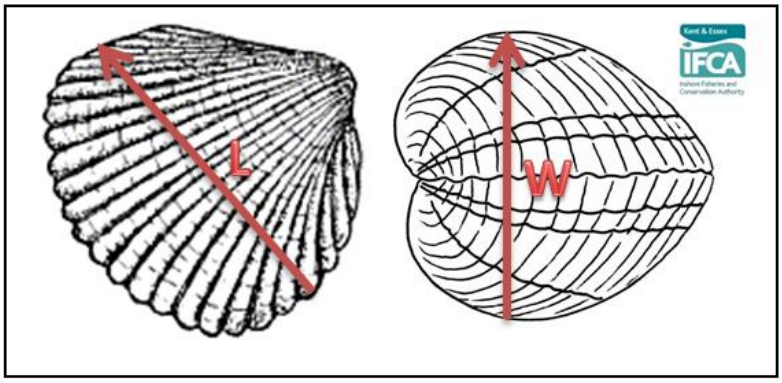

Figure 4 - Cockle length and width measurements.

After measuring, cockles were sorted into age classes by determining how many annual growth rings were on the shell e.g. 0 rings = current year, 1 ring = last year, 2 rings = year before last and so on. Each year group from that station were 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 from this size frequency and year class graphs were produced. To determine cockle density, the data was transferred into MapInfo V.16 GIS software to produce the thematic maps seen in Figure 15 to Figure 22 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 23. The minimum density used to determine the extent of coverage on the bed was 10 cockles per m^2. The biomass has been calculated from the mean weight and cockle bed area.

Survey extension

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

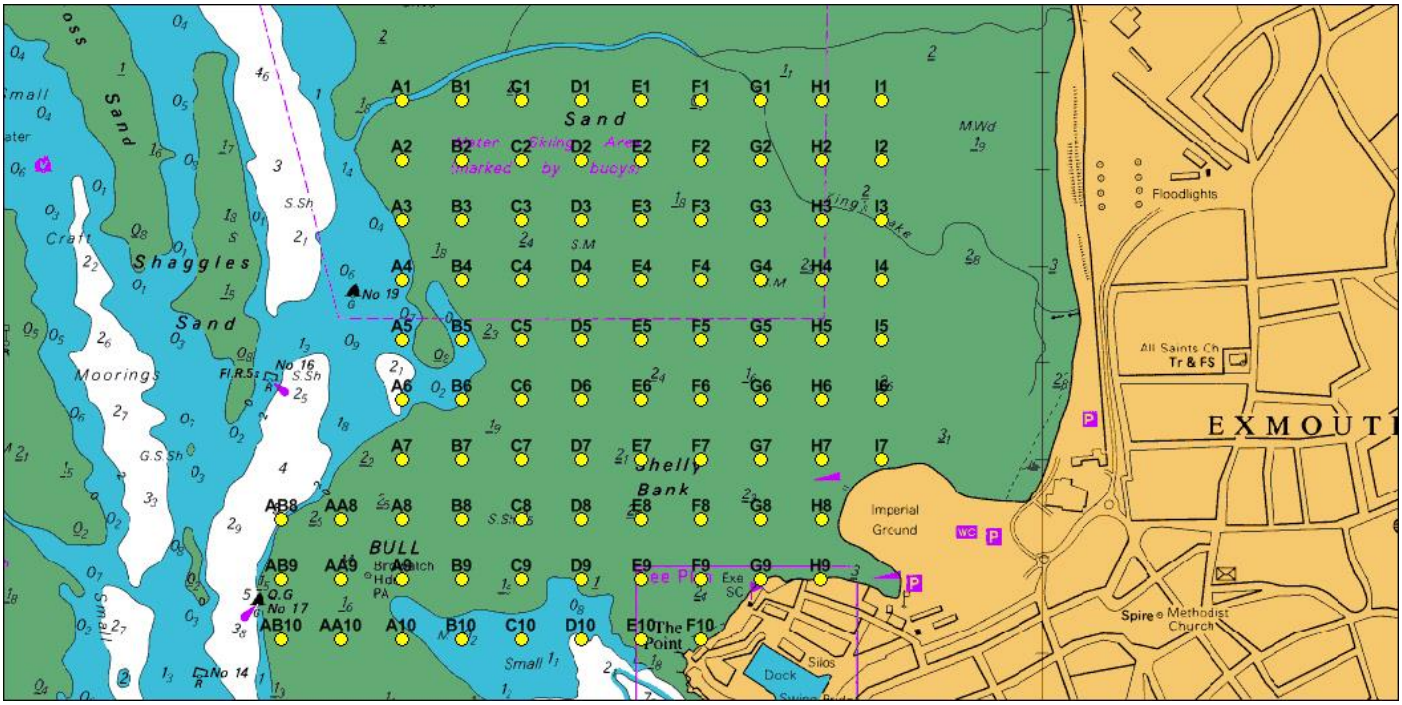

Figure 5 – Additional Exe Estuary cockle survey stations for 2017

Results

Table 1 shows a summary of the number of samples taken across the 63 stations for all years surveyed. The data from where these results have been calculated from 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
Samples taken	42	43	35	45	37	43	46	46
Stations with zero count of cockles	0	0	17	5	15	7	10	15
Not surveyed	1	2	4	8	8	13	7	2
Unknown/ no data	20	18	7	5	3	0	0	0

Table 2 shows a summary of the amount 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 a steady decline in cockles at and over 16mm.

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
Total raw counts	728	694	496	1107	724	583	715	699
Biomass (kg/ha)	59.3	61.9	31.7	57.9	32.2	30.8	61.3	33.1
Mean density (m²)	173	161	95	221	139	117	128	115
Mean density (m²) for ≥16mm	43	41	27	24	17	17	19	13
% of ≥16mm	25%	26%	28%	11%	12%	15%	15%	12%

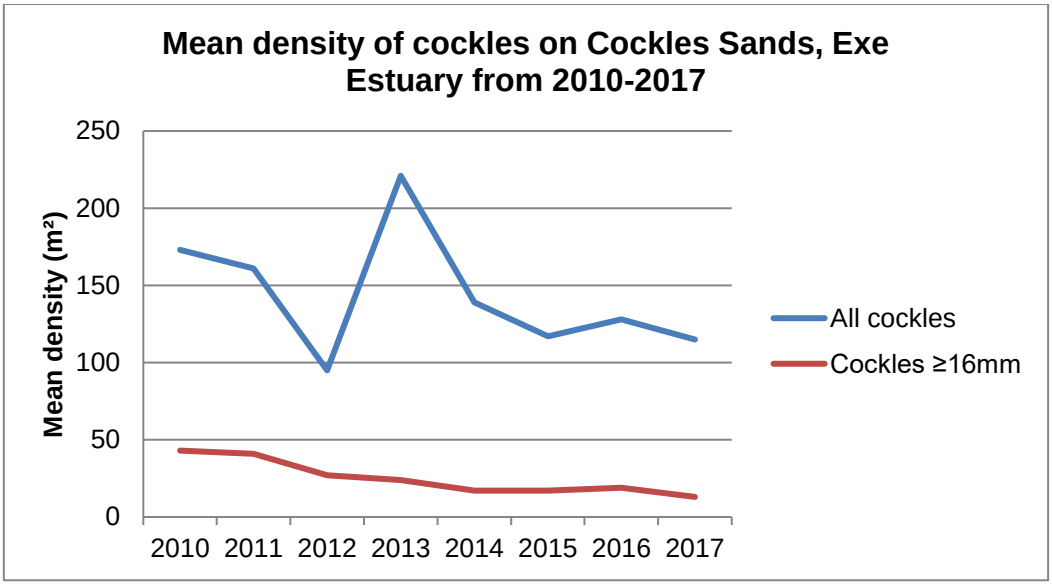

Figure 6 – Mean density of cockles on Exe Estuary from 2010-2017.

Size frequency and year class distribution:

Figure 7 to Figure 14 show cockle size and age frequencies from 2010 to 2017.

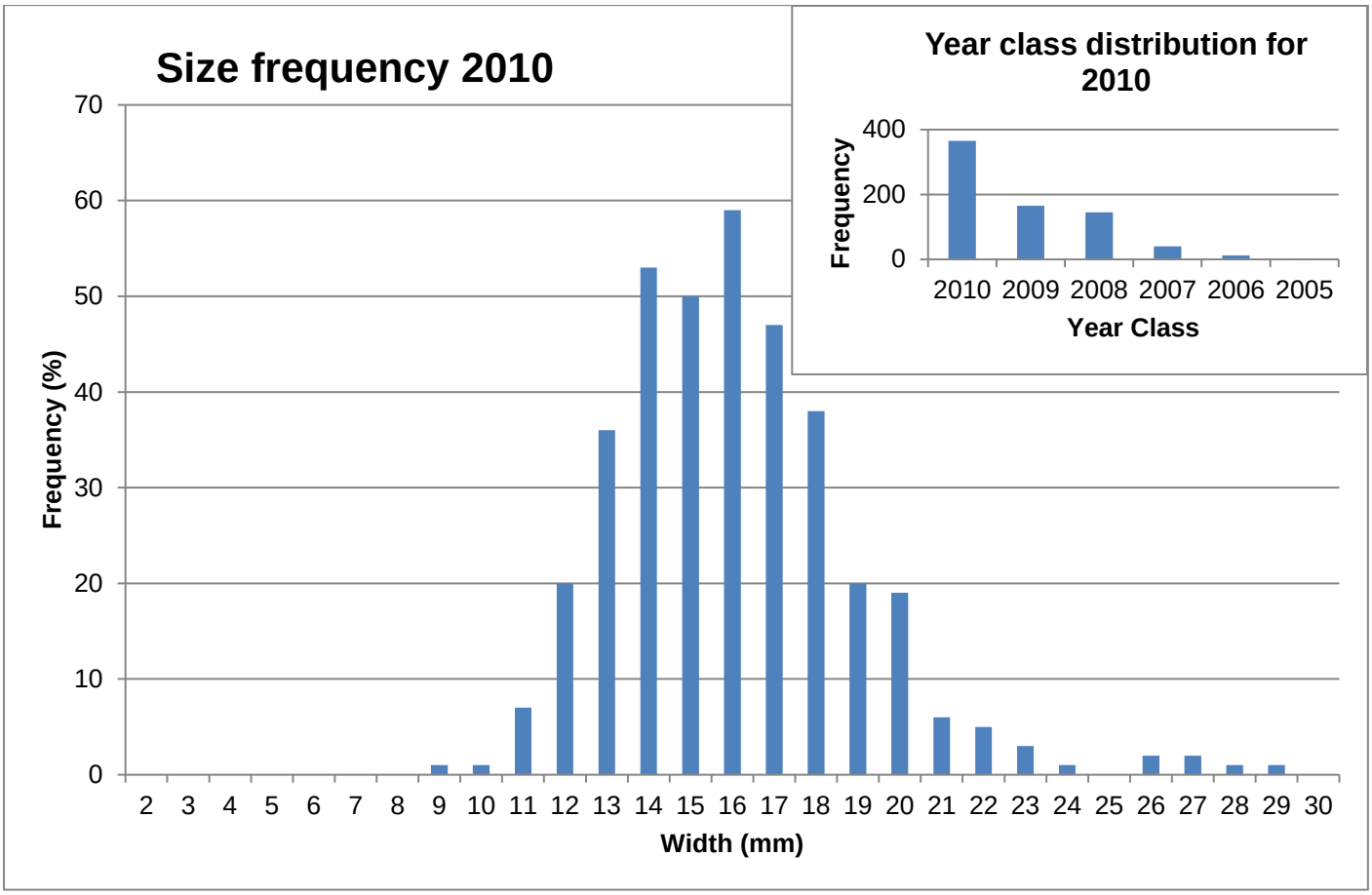

Figure 7 - Cockle size and year class distributions for autumn 2016 of Cockle Sands on the Exe Estuary (356 cockles missing from frequency graph as they were too small to measure).

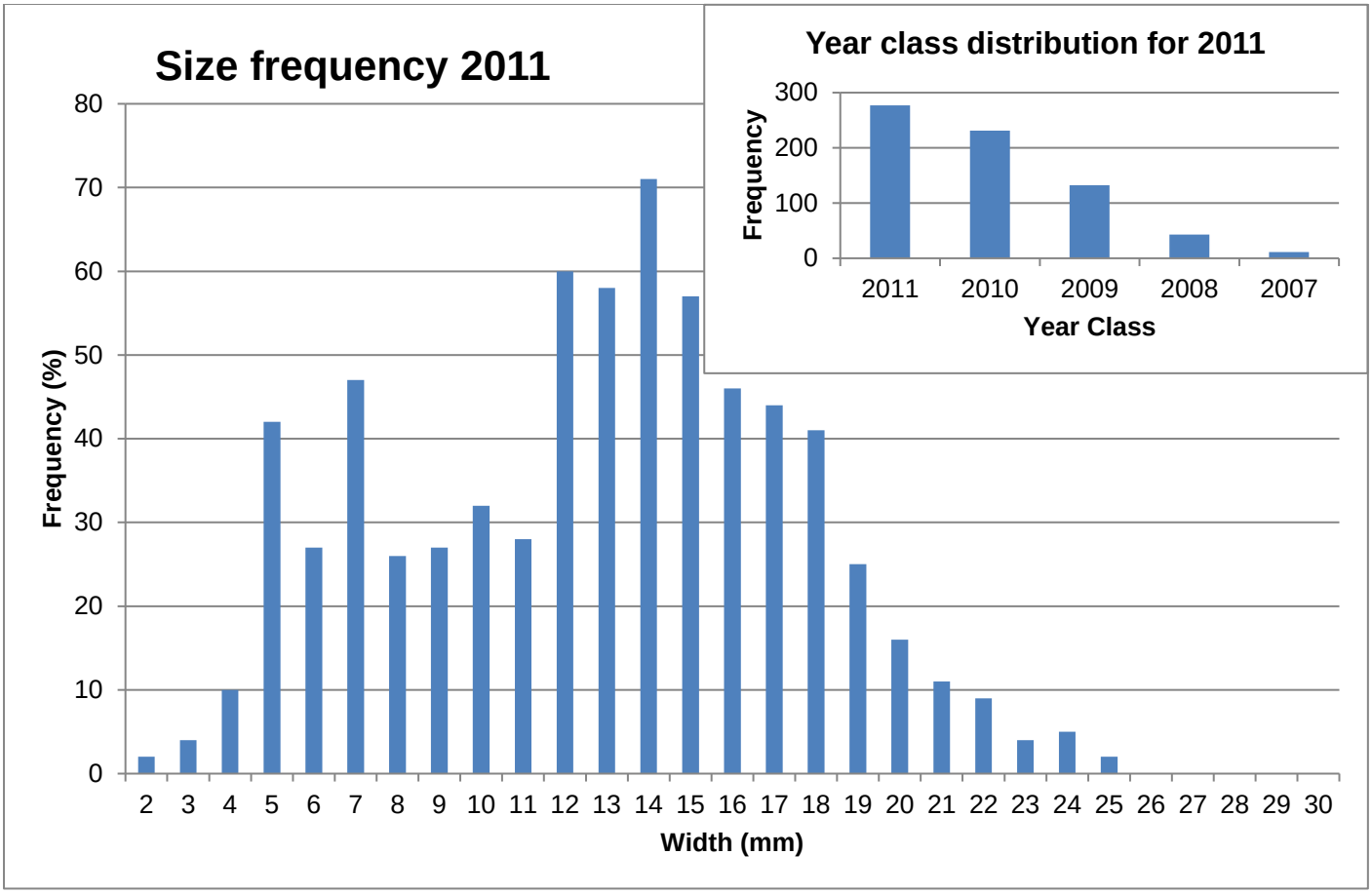

Figure 8 - Cockle size and year class distributions for autumn 2011 of Cockle Sands on the Exe Estuary.

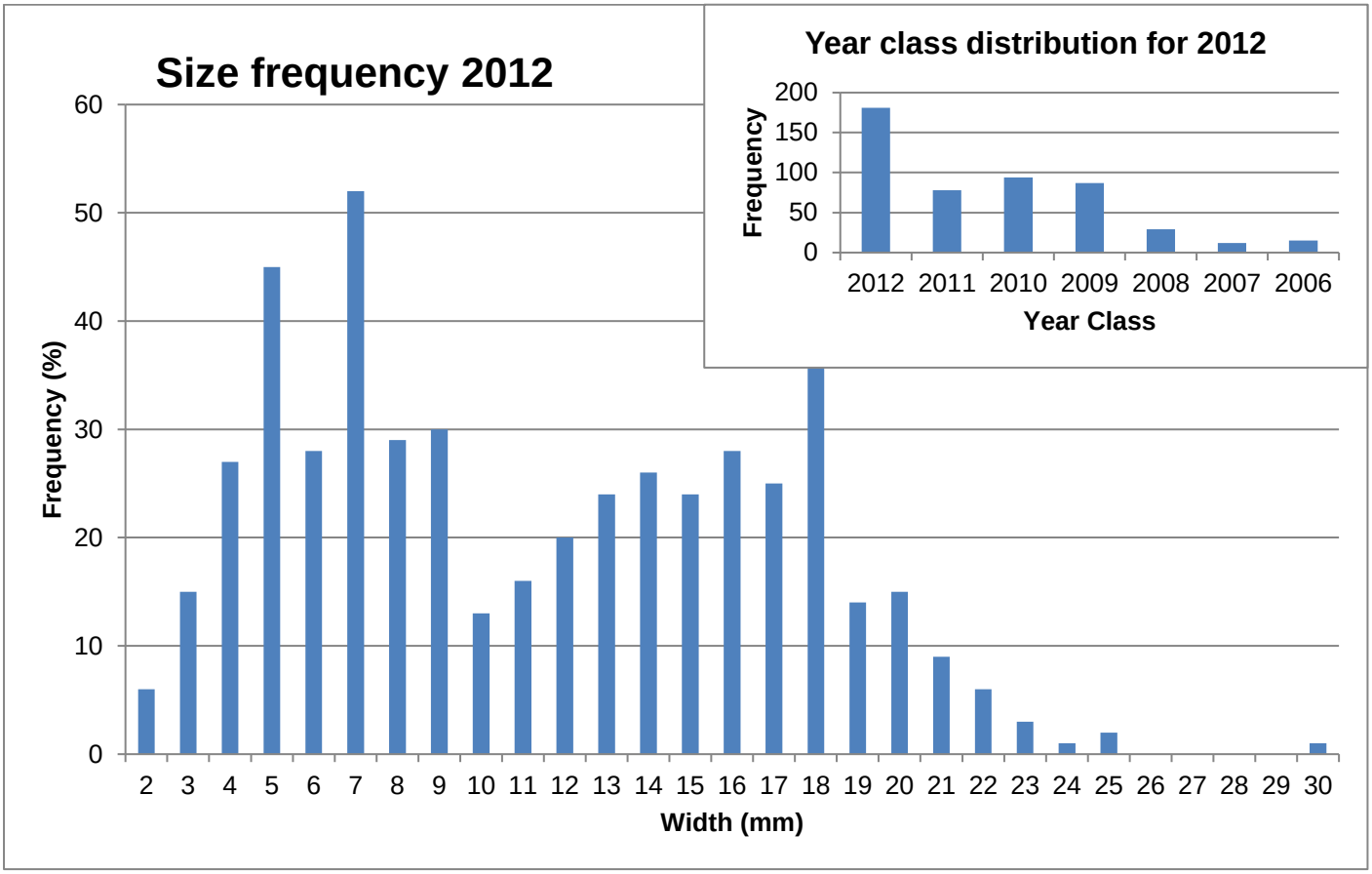

Figure 9 - Cockle size and year class distributions for autumn 2012 of Cockle Sands on the Exe Estuary.

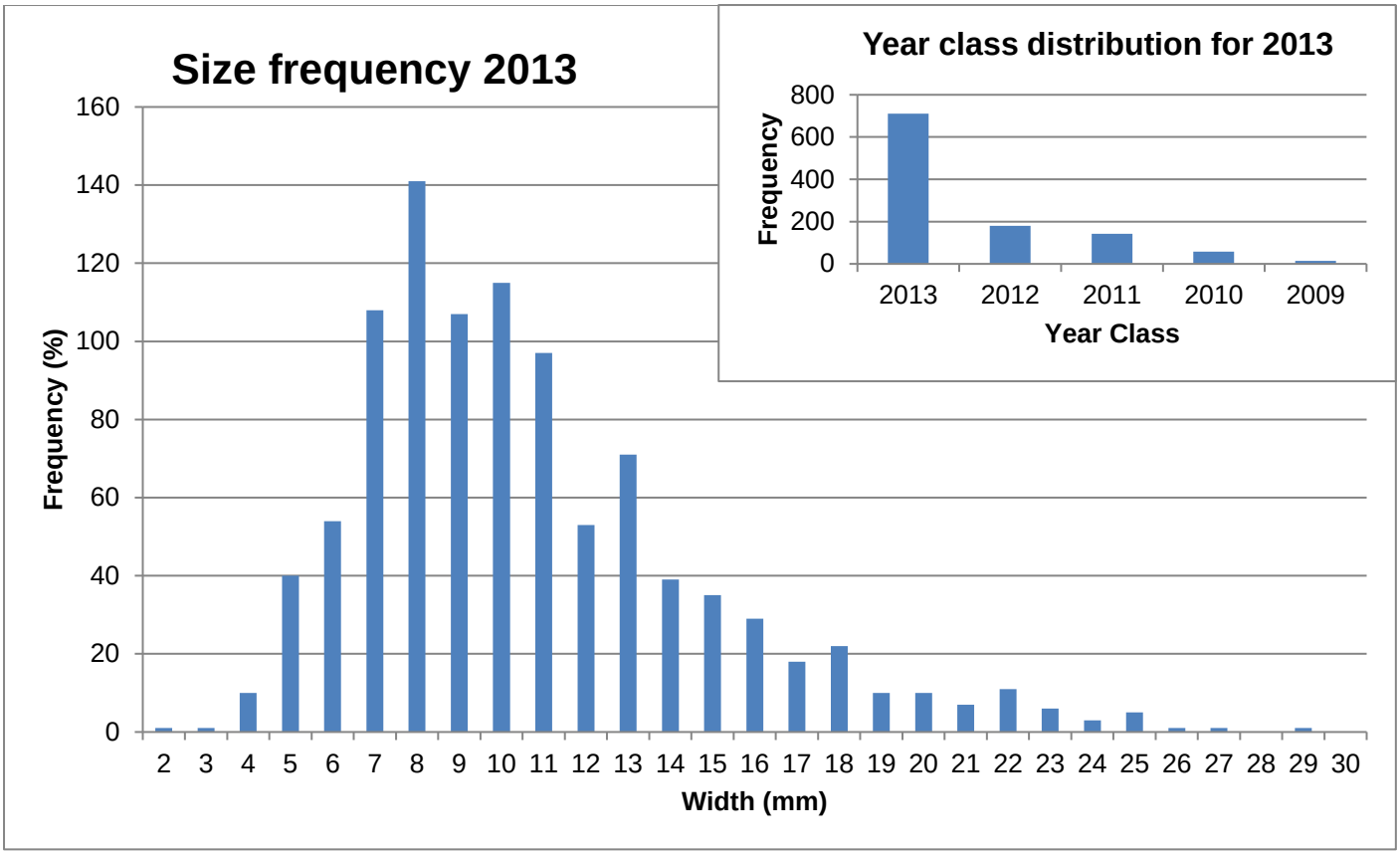

Figure 10 - Cockle size and year class distributions for autumn 2013 of Cockle Sands on the Exe Estuary (108 cockles missing from frequency graph as they were too small to measure).

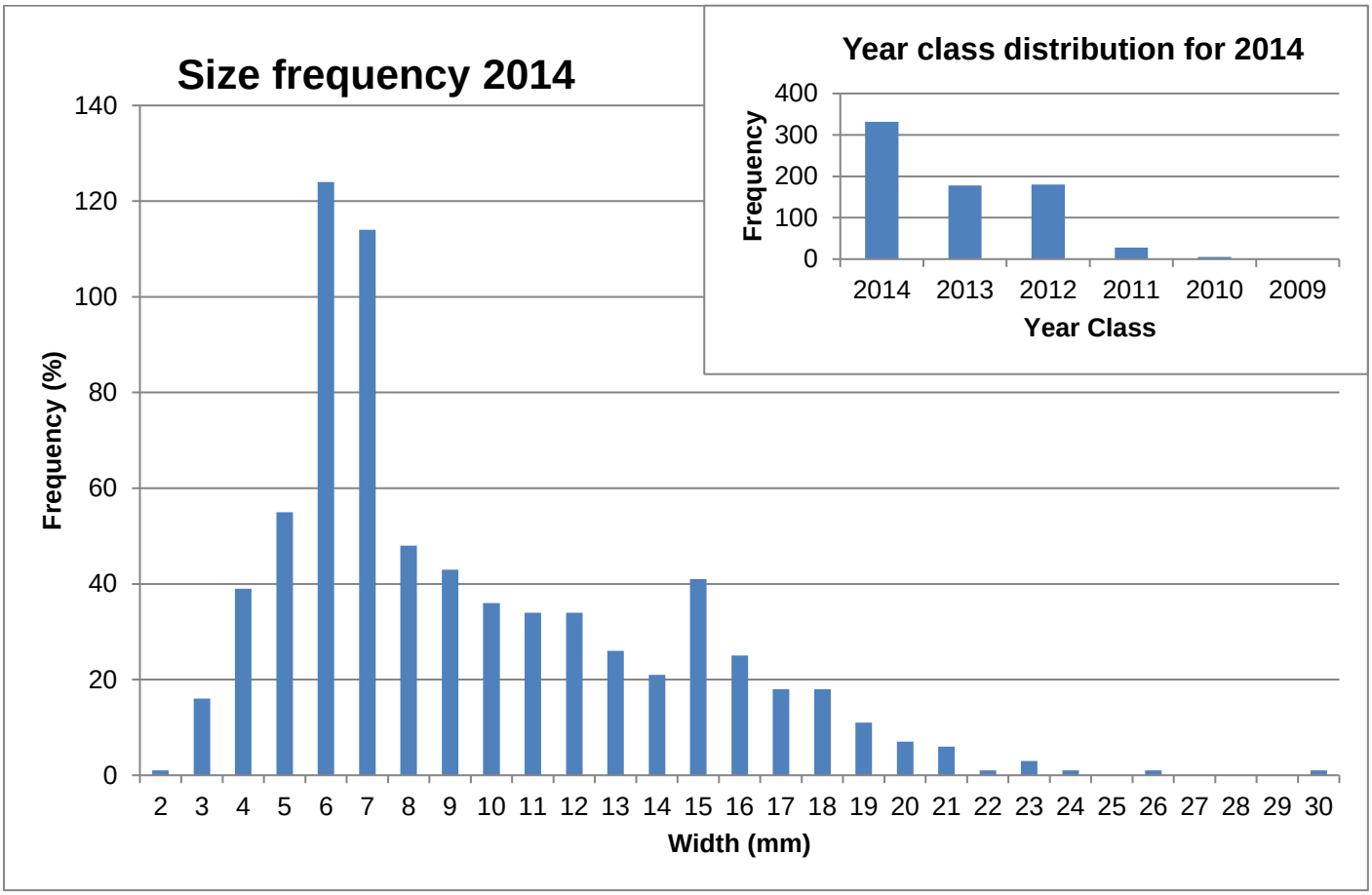

Figure 11 - Cockle size and year class distributions for autumn 2014 of Cockle Sands on the Exe Estuary.

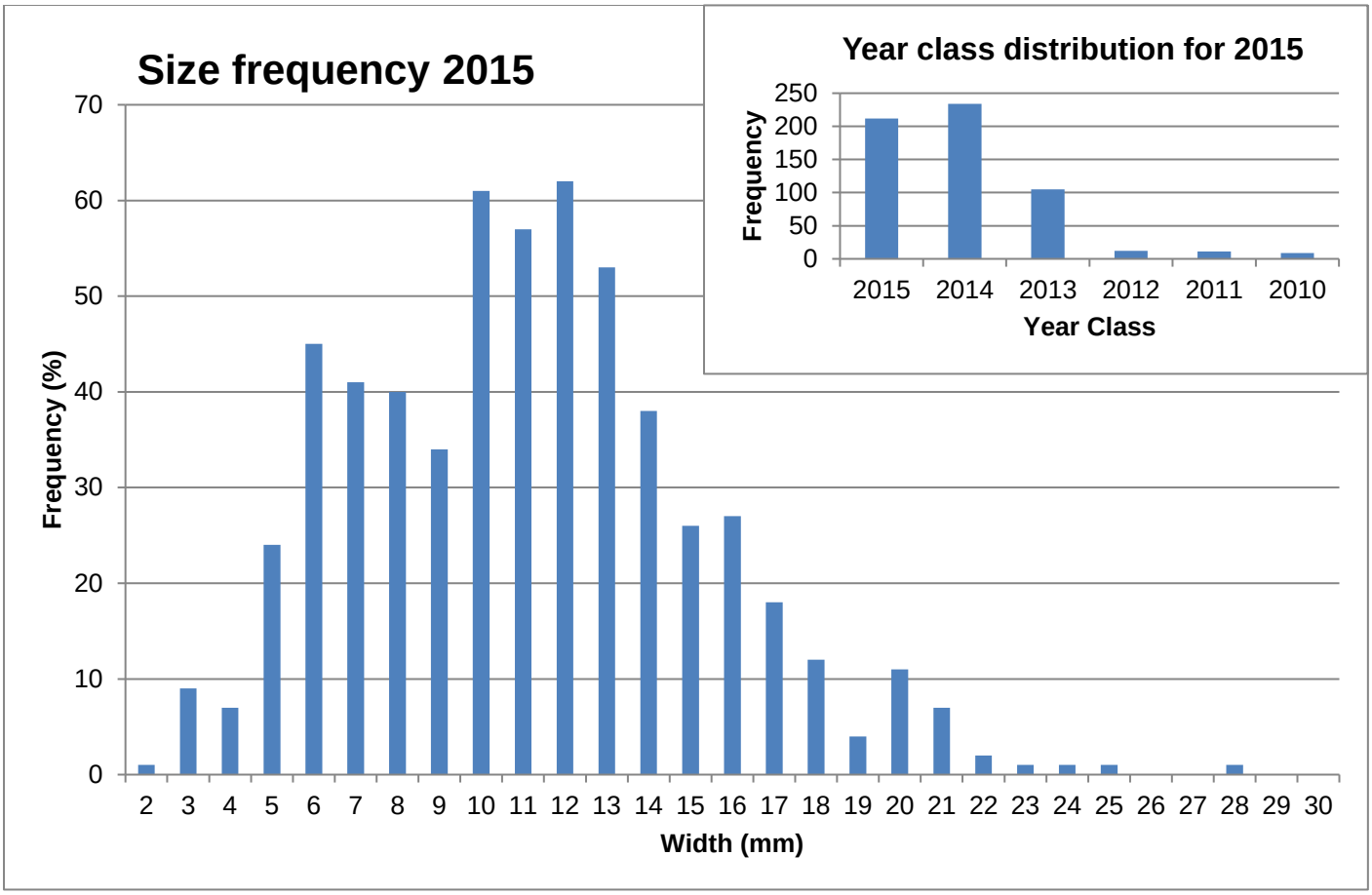

Figure 12 - Cockle size and year class distributions for autumn 2015 of Cockle Sands on the Exe Estuary.

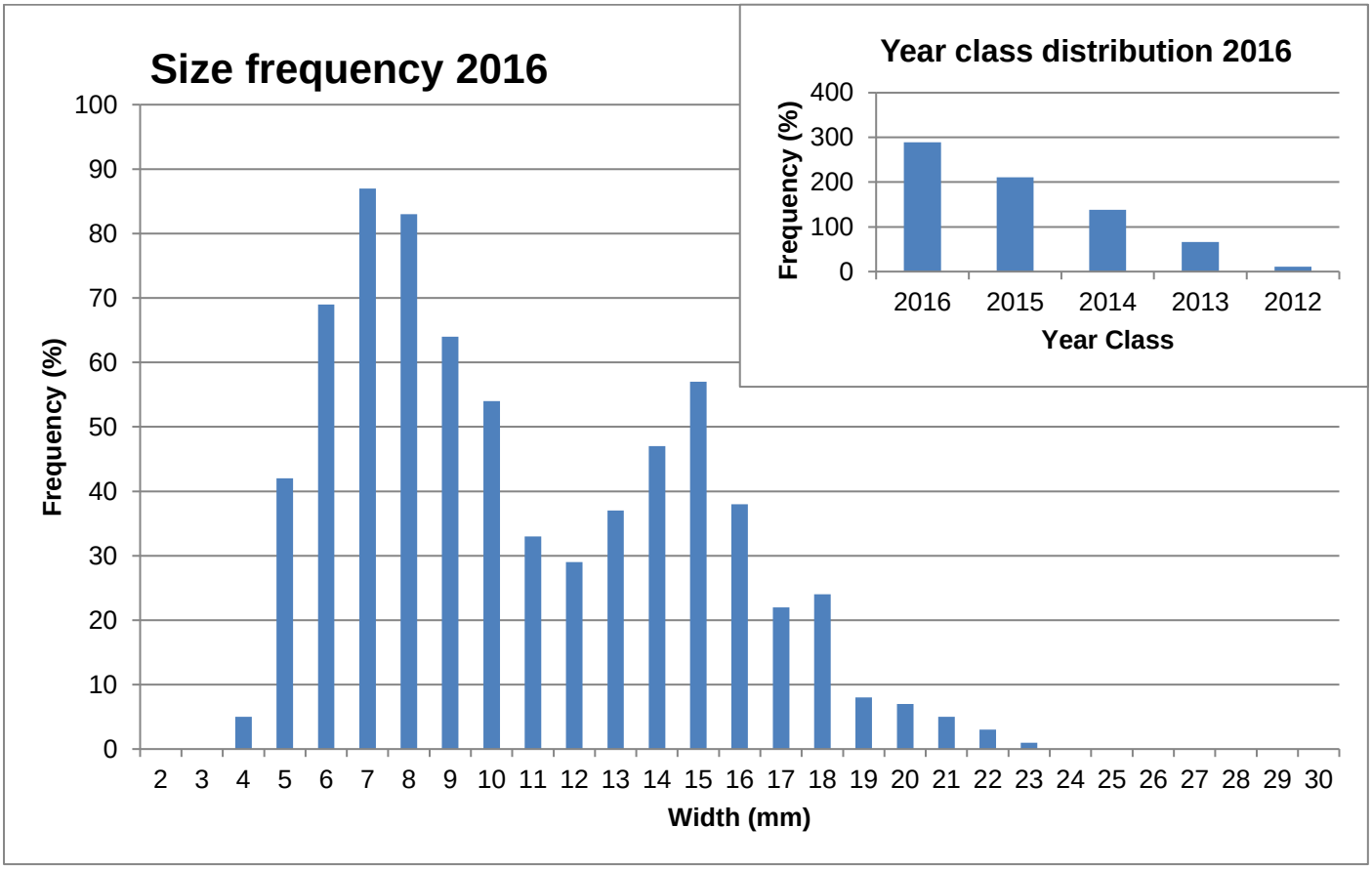

Figure 13 – Cockle size and year class distributions for autumn 2016 of Cockle Sands on the Exe Estuary.

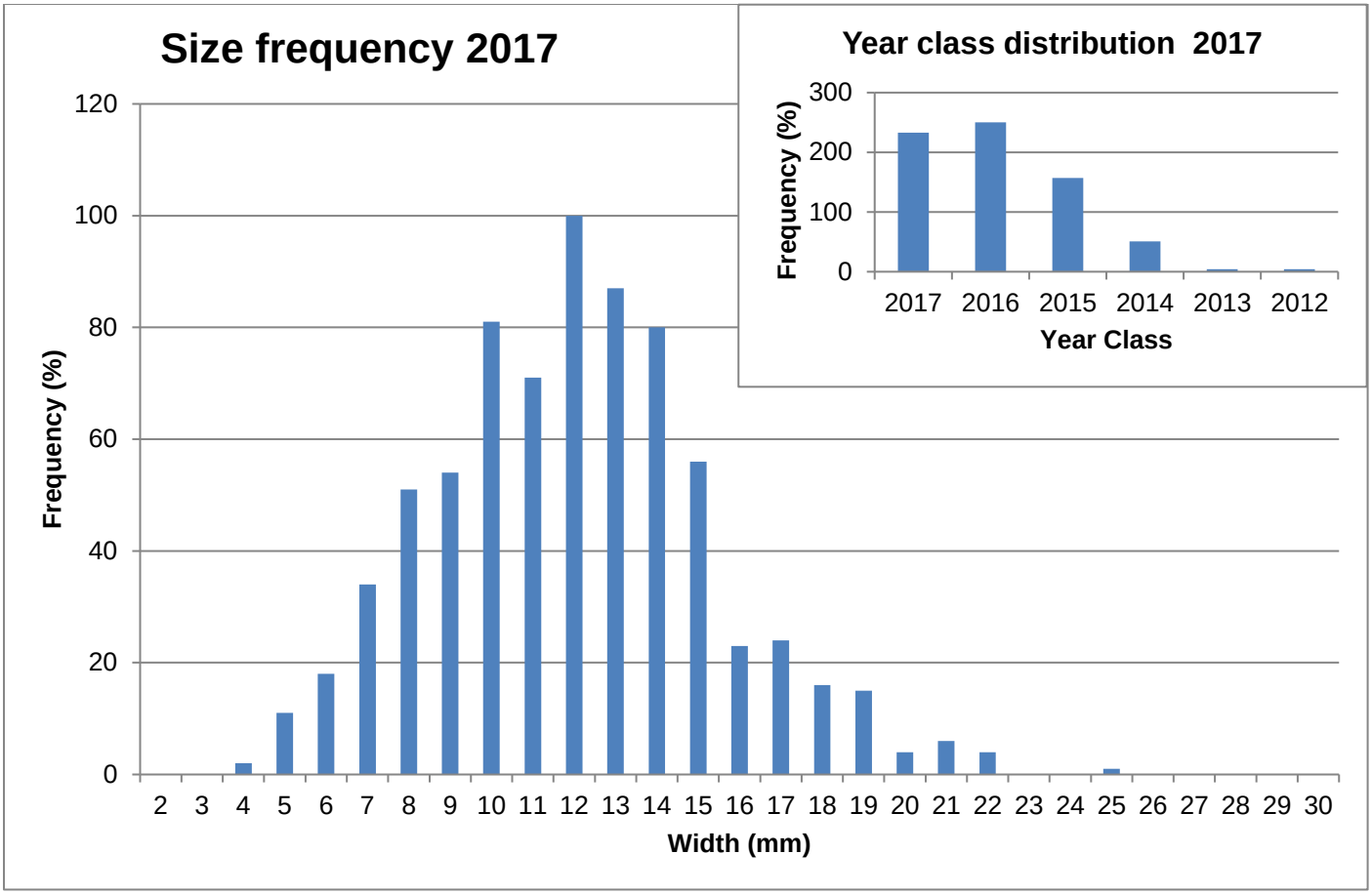

Figure 14 - Cockle size and year class distributions for autumn 2017 of Cockle Sands on the Exe Estuary (includes data from additional stations).

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 for 2010 to 2017 of Cockle Sands on the Exe Estuary.

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 15 to Figure 23 show cockle densities per m² from 2010 to 2017 which includes all year classes.

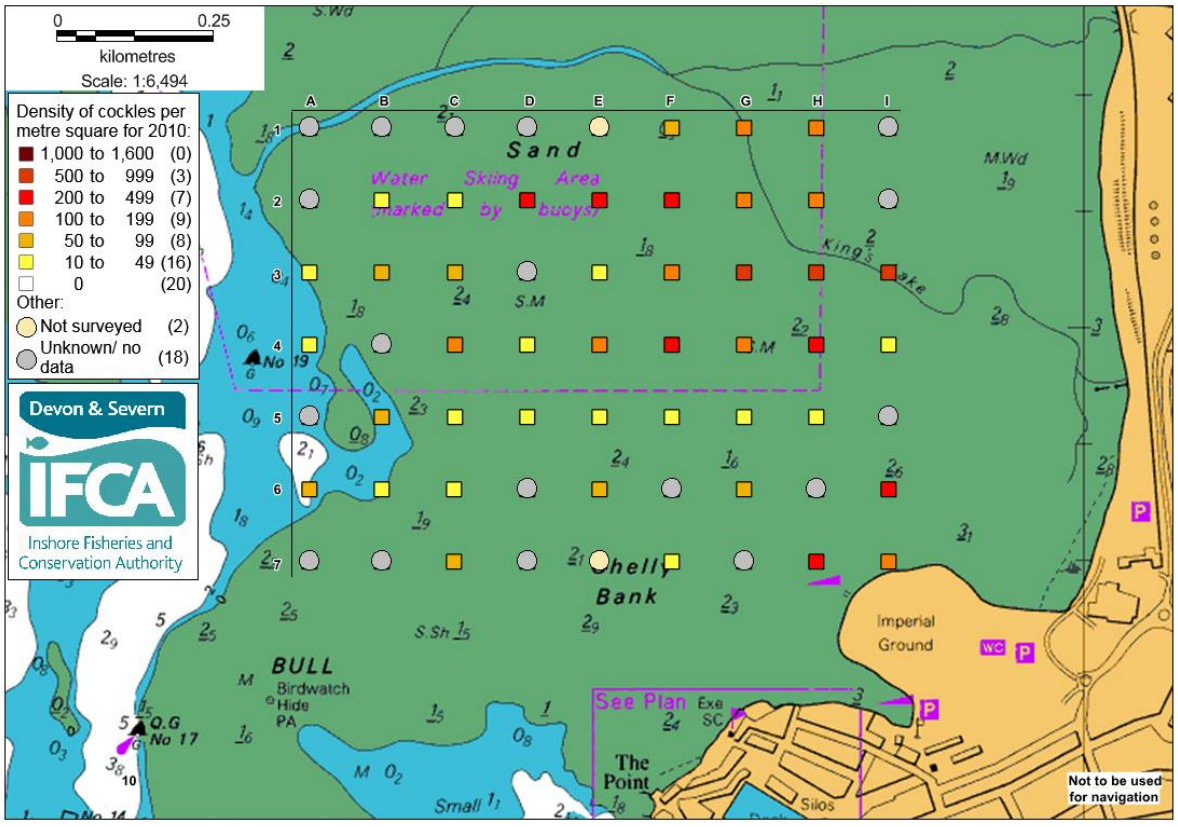

Figure 15 – Cockle density per m² for autumn 2010 of Cockle Sands on the Exe Estuary.

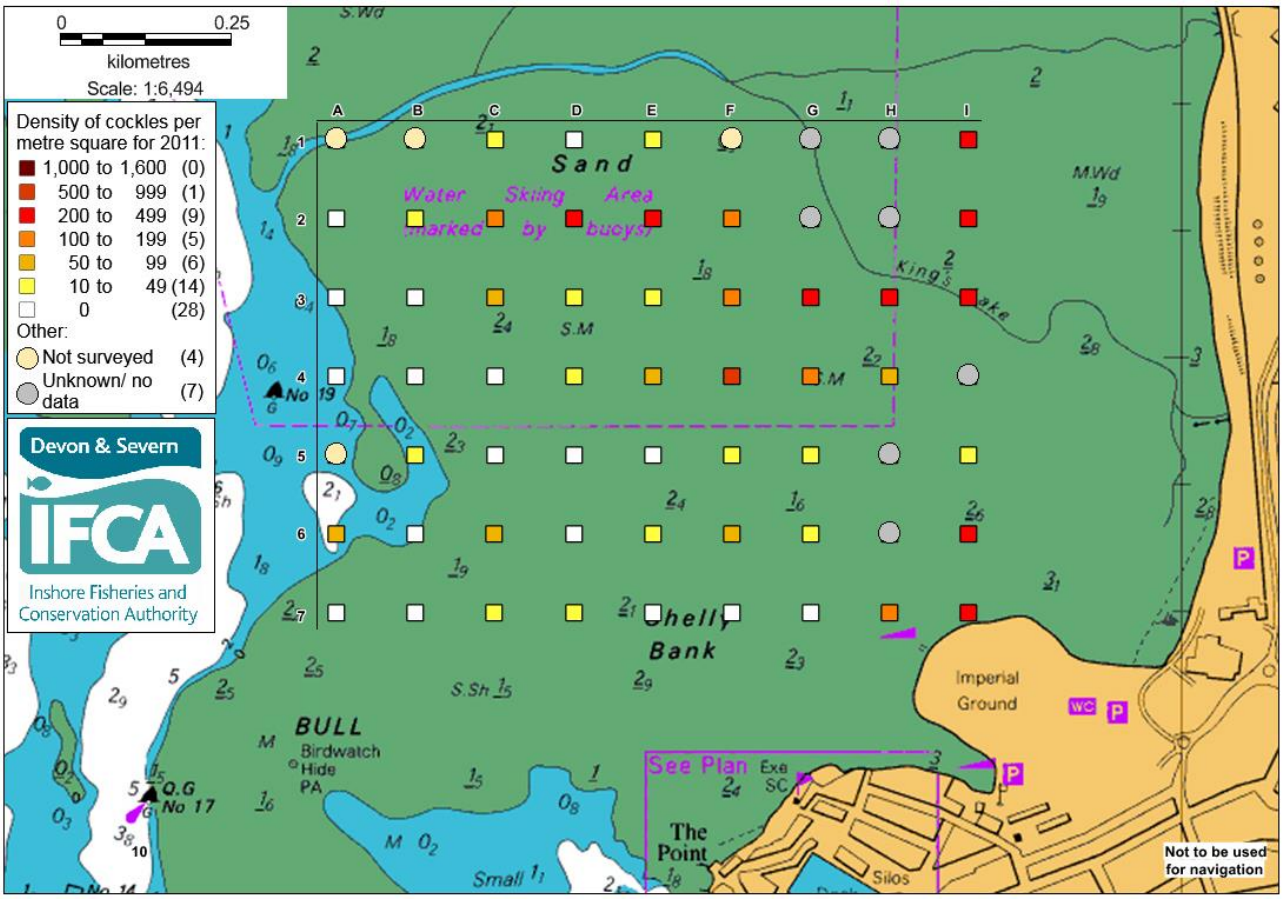

Figure 16 - Cockle density per m² for autumn 2011 of Cockle Sands on the Exe Estuary.

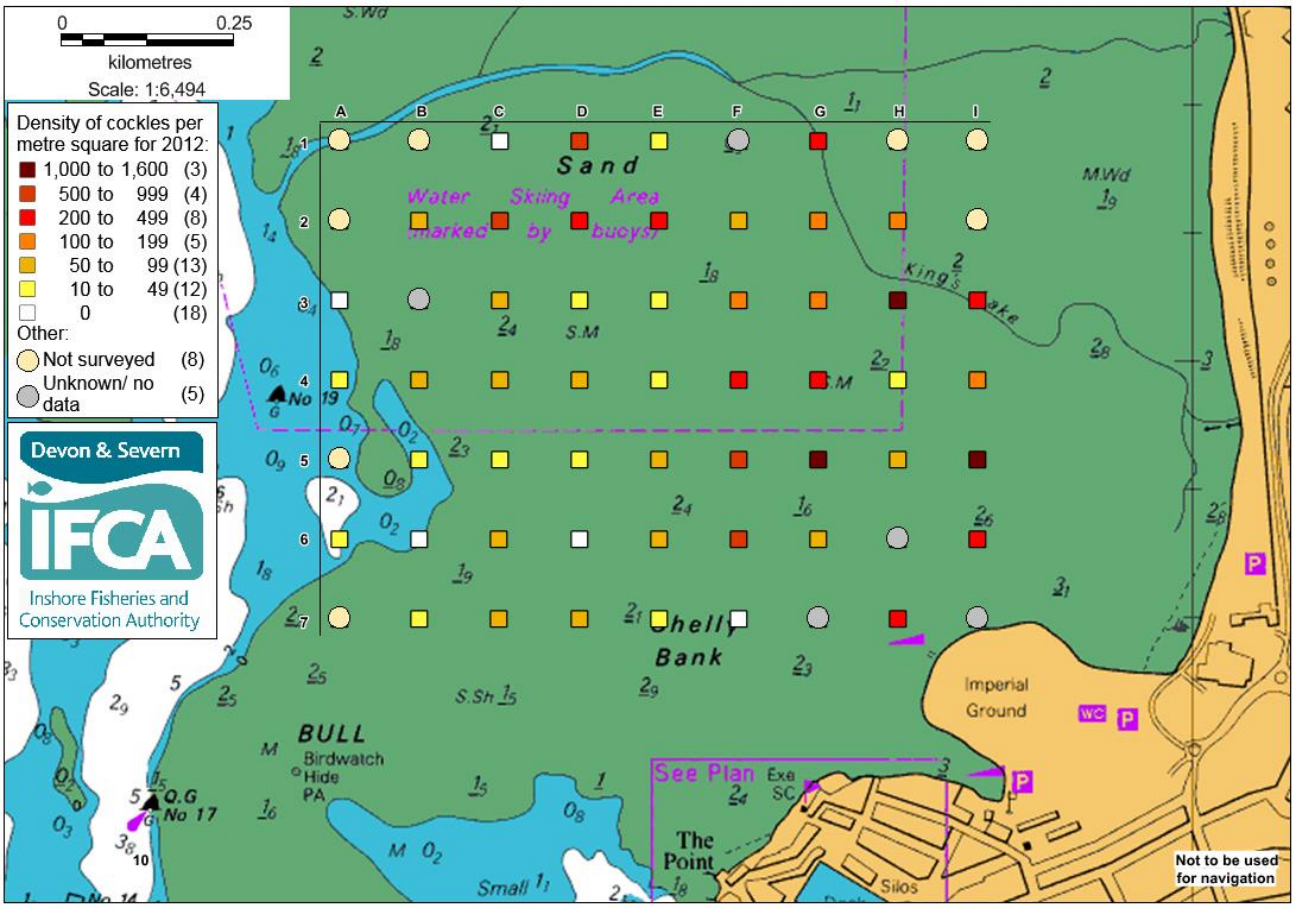

Figure 17 - Cockle density per m² for autumn 2012 of Cockle Sands on the Exe Estuary.

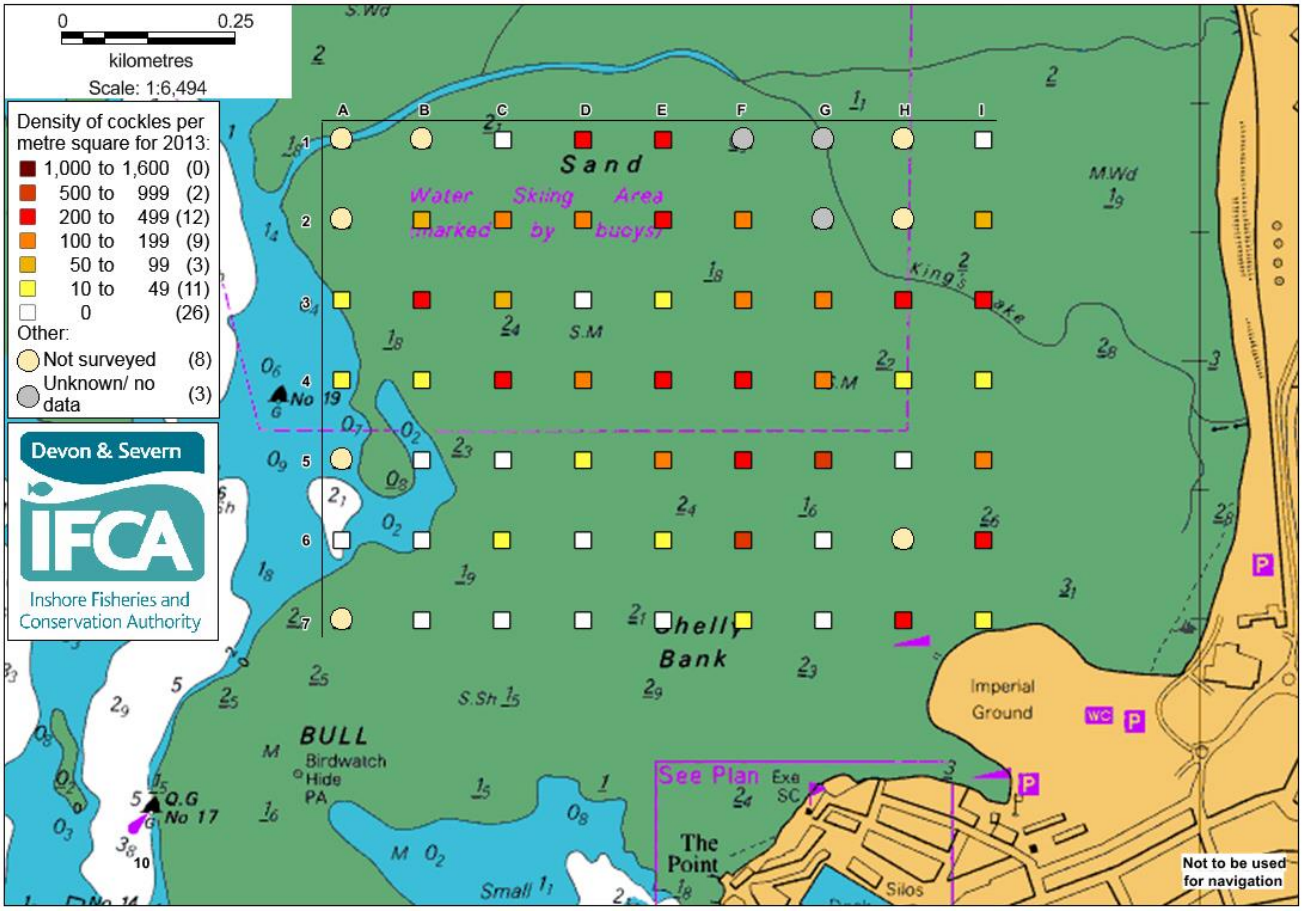

Figure 18 - Cockle density per m² for autumn 2013 of Cockle Sands on the Exe Estuary.

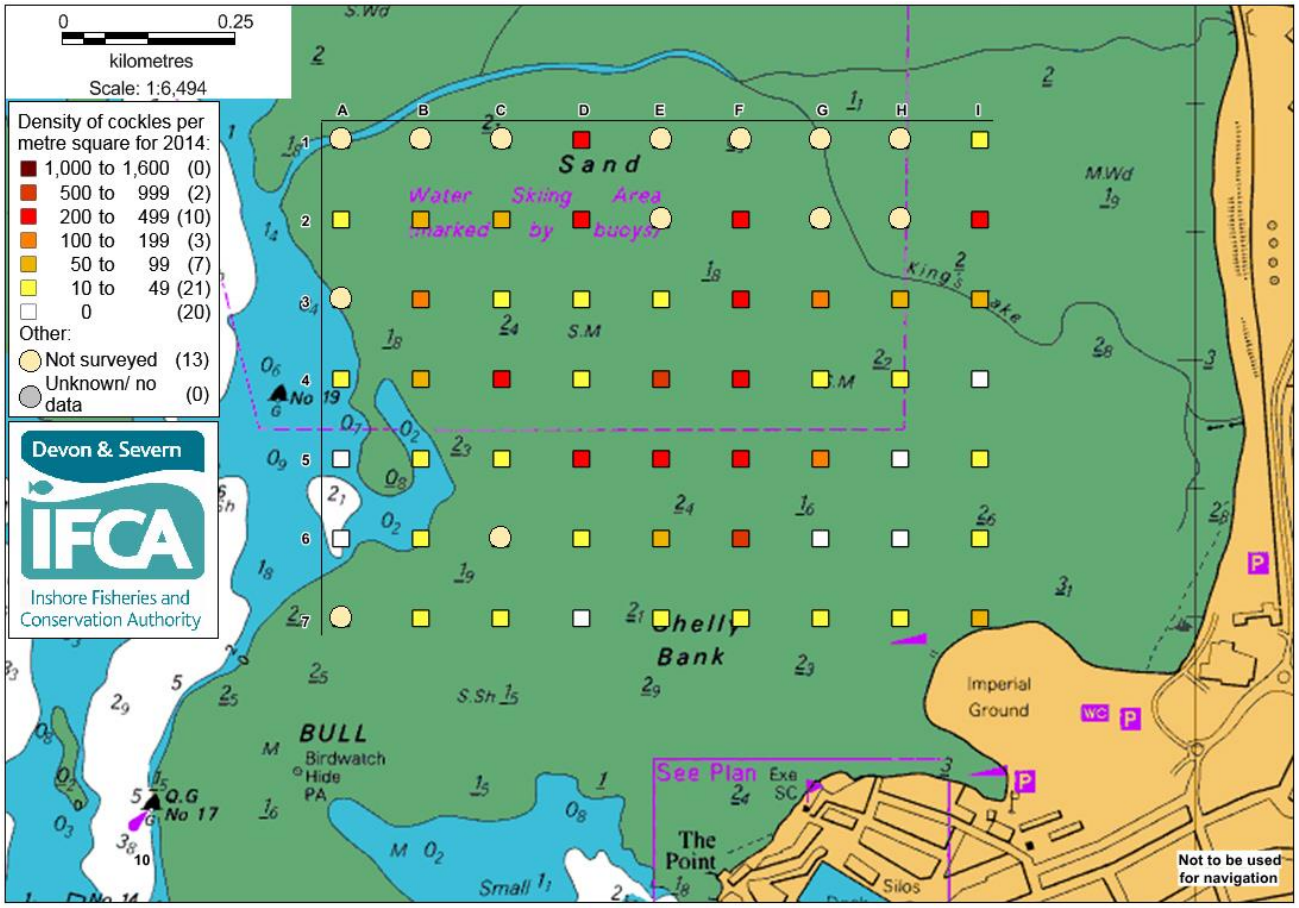

Figure 19 - Cockle density per m² for autumn 2014 of Cockle Sands on the Exe Estuary.

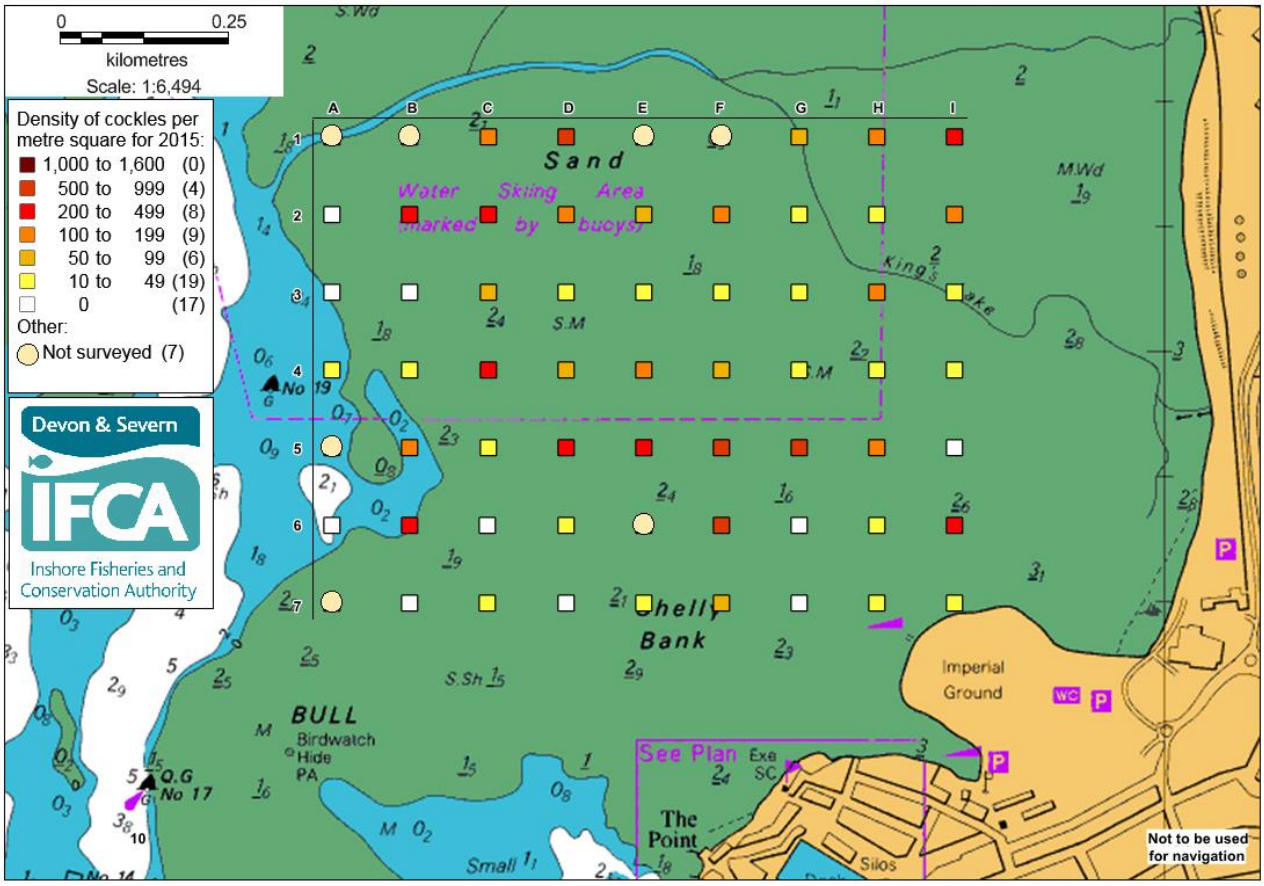

Figure 20 - Cockle density per m² for autumn 2015 of Cockle Sands on the Exe Estuary.

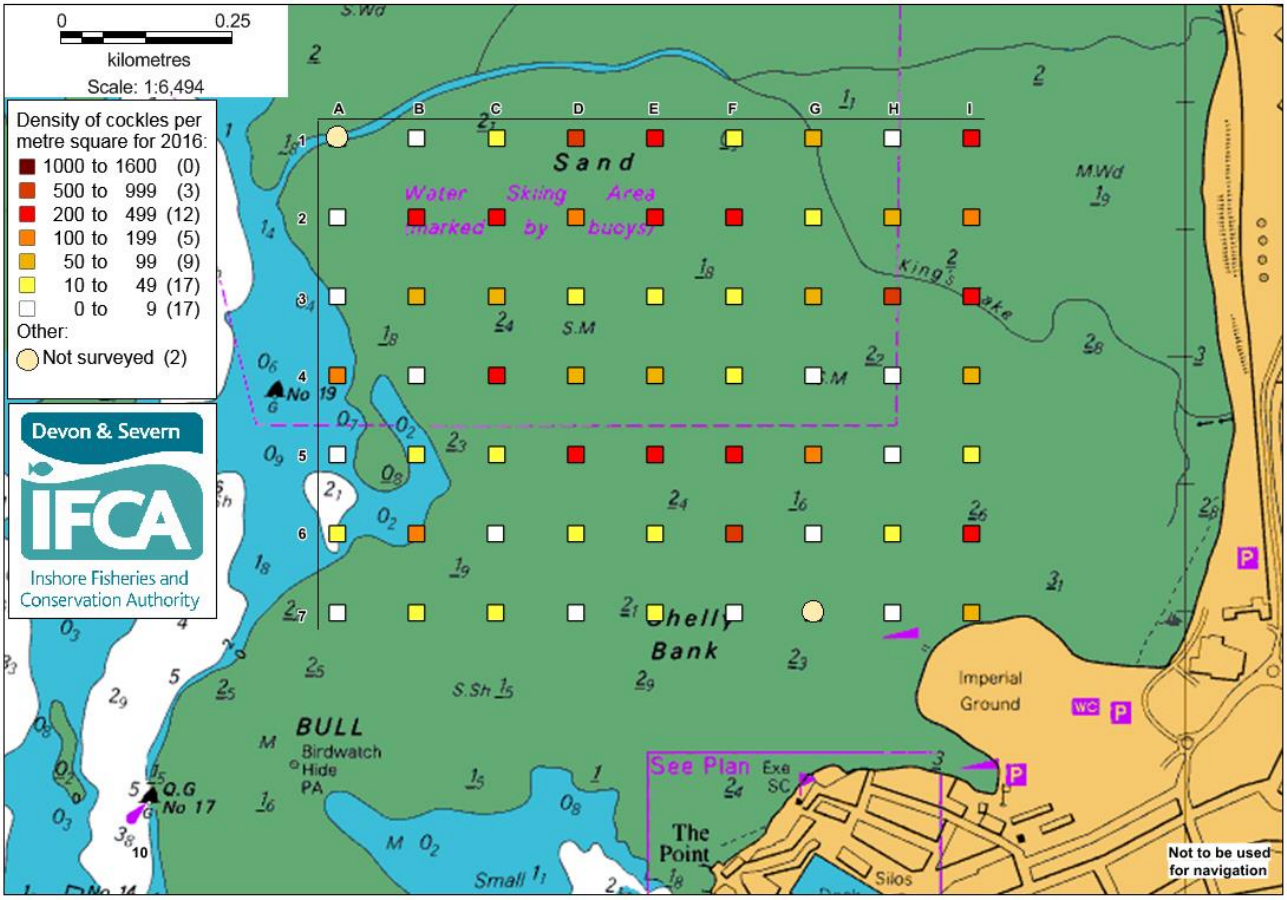

Figure 21 - Cockle density per m² for autumn 2016 of Cockle Sands on the Exe Estuary.

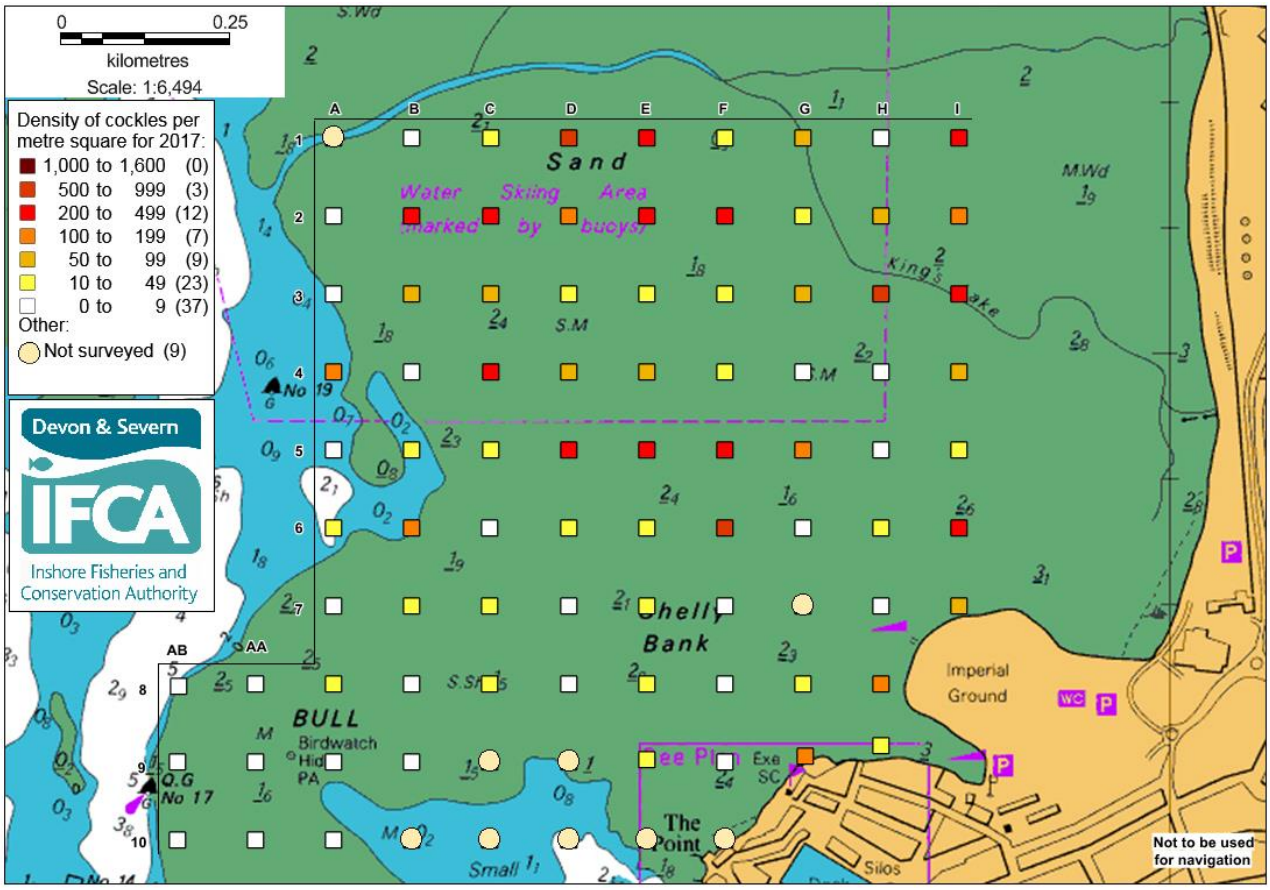

Figure 22 - Cockle density per m² for autumn 2017 of Cockle Sands on the Exe Estuary.

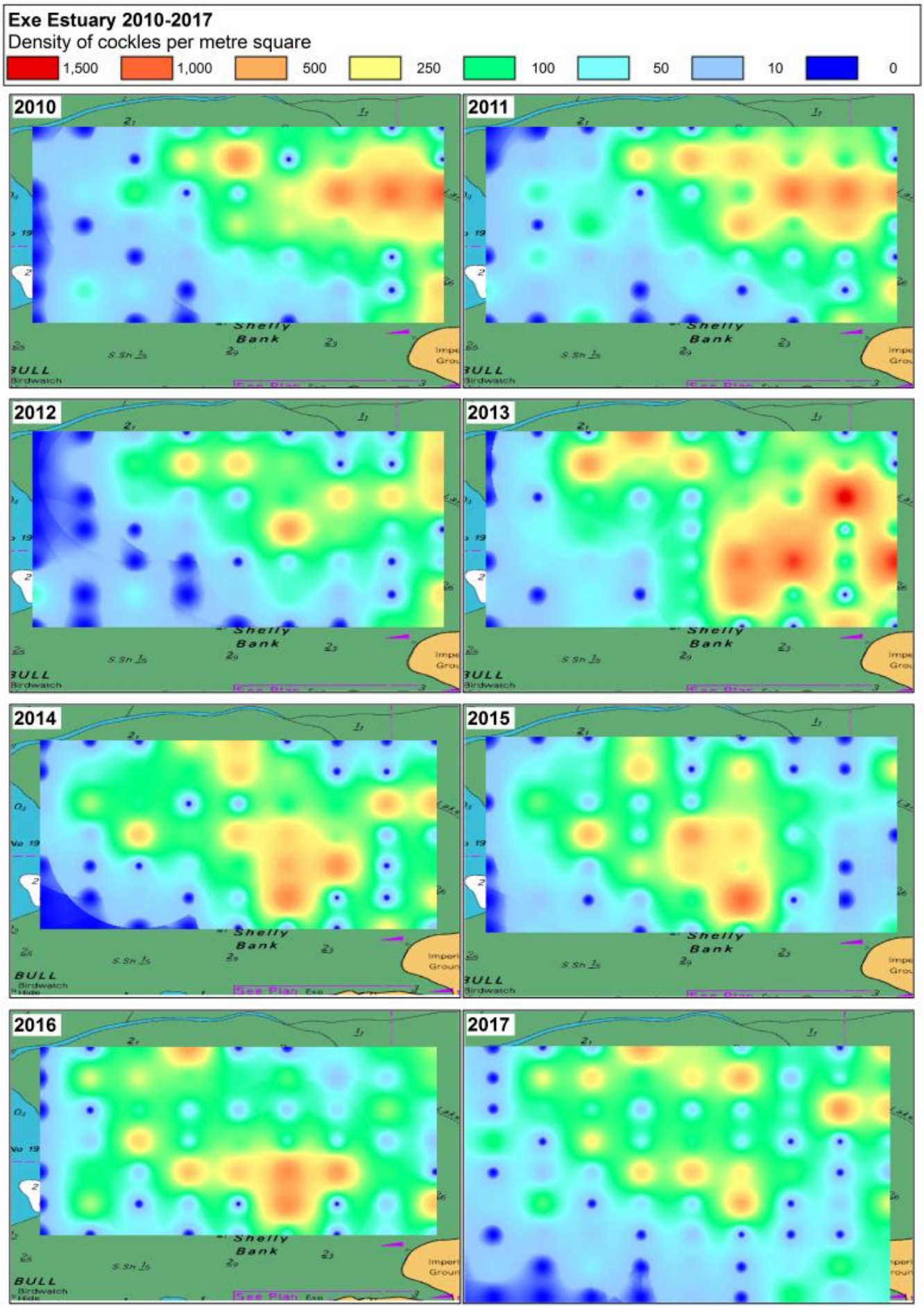

Figure 23 - Cockle density per m² using interpolator Inverse Distance Weighting for 2010-2017 of Cockle Sands on the Exe Estuary.

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 with no clear trend. The lowest numbers of cockles were found in 2012, after the mass mortality event in 2011. 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. The mean densities of cockles 16mm and over can be seen to decrease over the seven years (Table 2 and Figure 6). There is no MCRS for cockles in the Devon and Severn IFCA District as there is no commercial fishery 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 the 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 if 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 seven years surveyed. Some stations (particularly A1, A5, A7, B1, F1, H1 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 45 stations not surveyed over the years, which equates to 10% 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 accounts 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.

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Annex 1

Raw cockle count data

Station	2010	2011	2012	2013	2014	2015	2016	2017
A1	N/A	N/A	-	-	-	-	-	-
A2	2	N/A	0	-	-	1	0	0
A3	N/A	1	0	0	1	-	0	0
A4	N/A	1	0	3	3	1	1	11
A5	N/A	N/A	-	-	-	0	-	0
A6	N/A	6	7	3	0	0	0	3
A7	N/A	N/A	0	-	-	-	-	0
B1	N/A	N/A	-	-	-	-	-	0
B2	2	1	1	5	6	5	23	25
B3	4	8	0	N/A	20	16	0	8
B4	N/A	N/A	0	5	1	5	2	0
B5	1	7	1	4	0	4	11	1
B6	7	1	0	0	0	1	20	14
B7	4	N/A	0	1	0	3	0	1
C1	1	N/A	1	0	0	-	10	2
C2	N/A	2	12	57	10	6	23	32
C3	13	6	7	8	9	2	8	7
C4	1	11	0	9	40	45	37	28
C5	N/A	1	0	3	0	1	2	2
C6	4	3	5	5	2	-	0	0
C7	N/A	9	2	5	0	3	4	2
D1	1	N/A	0	64	26	25	54	52
D2	27	32	35	22	10	35	15	10
D3	N/A	N/A	2	1	0	3	4	1
D4	2	3	1	6	14	4	5	5
D5	1	1	0	1	4	24	44	35
D6	N/A	N/A	0	0	0	1	2	3
D7	N/A	N/A	1	7	0	0	0	0
E1	2	-	3	1	36	-	-	22
E2	64	46	35	43	38	-	9	29
E3	3	3	1	1	1	2	2	3
E4	22	10	9	2	38	56	15	9
E5	4	3	0	5	10	37	40	41
E6	3	5	2	7	3	9	-	3
E7	5	-	0	3	0	1	2	1
F1	9	8	-	N/A	N/A	-	-	2
F2	-	41	17	5	19	29	14	49
F3	25	14	11	16	10	20	2	3
F4	23	46	57	27	38	36	7	4
F5	3	4	3	87	48	22	71	28
F6	3	N/A	7	64	73	97	69	50
F7	N/A	3	0	0	1	2	6	0
G1	5	14	N/A	22	N/A	-	5	7
G2	15	15	N/A	11	N/A	-	1	1

Key:

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

G3	71	84	33	13	10	13	3	6
G4	19	14	18	44	18	4	4	0
G5	8	3	3	123	66	14	59	13
G6	1	7	1	7	0	0	0	0
G7	1	N/A	0	N/A	0	1	0	-
H1	N/A	17	N/A	-	-	-	12	0
H2	29	12	N/A	15	-	-	3	5
H3	89	80	32	158	46	7	18	59
H4	26	41	5	2	1	2	2	0
H5	N/A	2	N/A	8	0	0	12	0
H6	N/A	N/A	N/A	N/A	-	0	2	2
H7	17	24	13	42	26	2	4	0
I1	N/A	N/A	32	-	0	1	20	34
I2	N/A	N/A	42	-	9	25	17	10
I3	105	59	39	28	45	5	4	38
I4	26	2	N/A	10	3	0	1	5
I5	6	N/A	3	133	10	1	0	1
I6	38	30	32	21	28	3	43	24
I7	36	14	23	N/A	1	9	3	8
A8	-	-	-	-	-	-	-	2
A9	-	-	-	-	-	-	-	0
A10	-	-	-	-	-	-	-	0
B8	-	-	-	-	-	-	-	0
B9	-	-	-	-	-	-	-	0
B10	-	-	-	-	-	-	-	-
C8	-	-	-	-	-	-	-	4
C9	-	-	-	-	-	-	-	-
C10	-	-	-	-	-	-	-	-
D8	-	-	-	-	-	-	-	0
D9	-	-	-	-	-	-	-	-
D10	-	-	-	-	-	-	-	-
E8	-	-	-	-	-	-	-	2
E9	-	-	-	-	-	-	-	1
E10	-	-	-	-	-	-	-	-
F8	-	-	-	-	-	-	-	0
F9	-	-	-	-	-	-	-	0
F10	-	-	-	-	-	-	-	-
G8	-	-	-	-	-	-	-	4
G9	-	-	-	-	-	-	-	11
H8	-	-	-	-	-	-	-	13
H9	-	-	-	-	-	-	-	2
AA8	-	-	-	-	-	-	-	0
AA9	-	-	-	-	-	-	-	0
AA10	-	-	-	-	-	-	-	0
AB8	-	-	-	-	-	-	-	0
AB9	-	-	-	-	-	-	-	0
AB10	-	-	-	-	-	-	-	0