Exe Estuary
Cockle Stock Assessment 2010 - 2022

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Contents:

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1. Introduction

The Exe Estuary is one of the most highly designated nature conservation sites in Devon and Severn Inshore Fisheries and Conservation Authority's (D&S IFCA's) District. It is a Ramsar Site, a Special Protection Area (SPA), and a Site of Special Scientific Interest (SSSI), and encompasses over 3,000 hectares of diverse aquatic and terrestrial habitats (EEMP, 2020). The Exe Estuary SPA (Figure 1) includes marine areas (i.e. land covered continuously or intermittently by tidal waters) as well as land which is not subject to tidal influence. The SPA was designated as the Exe Estuary supports internationally important populations of birds such as the Slavonian grebe and the Avocet, as well as Brent goose, dunlin, oystercatcher, blacktailed godwit and grey plover. 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 (D&S IFCA, 2018; Natural England, 2020). Use of the site by birds 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 and Verboven, 1993).

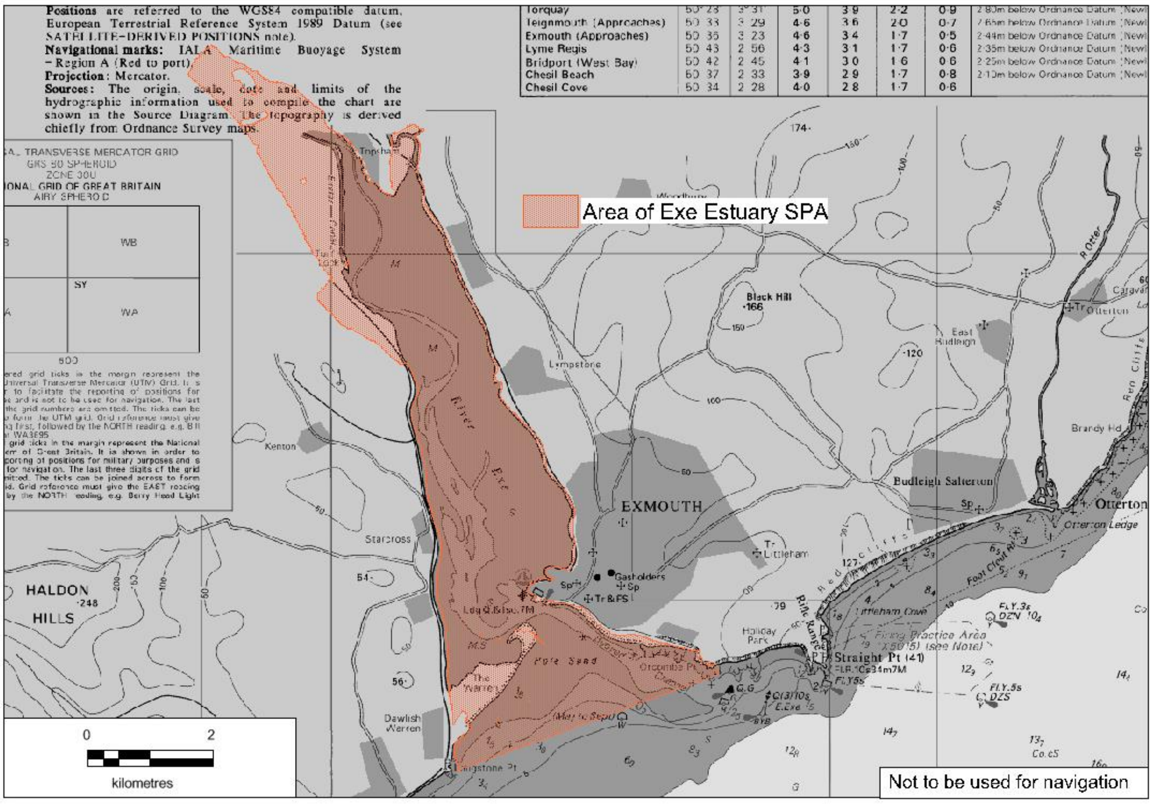

Figure 1: Area of the Exe Estuary Special Protection Area (SPA)

Cockles, *Cerastoderma edule,* are active suspension feeders. They can grow up to 5 cm 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 5 cm of surface of sediments and can tolerate changes in salinity.

D&S IFCA began assessing cockle stocks in 2010 on Cockle Sands, near Exmouth, to determine whether a sustainable cockle fishery could be established. The effects of harvesting cockles on the macrofauna, cockle populations and sediment parameters within the Exe Estuary were assessed by two masters students (Hulme, 2009; Hulme and Lee, 2010; Lee, 2010). The results concluded that the eco-elevator harvester dredge did not have an impact, meaning the fishery was permitted. However, due to a mass mortality of cockles on the Cockle Sands area of the Exe Estuary in 2011, the fishery could not continue. The stock assessment was repeated three times in 2011 and twice in 2012 to monitor the cockle density levels. As well as this, Cefas investigated the mortality event by screening for diseases to try to determine the cause. No notifiable diseases were found but the parasite profile indicated elevated presence of the haplosporidian *Minchinia spp* and the trematode *Himasthla spp*. Both can cause the cockle's shell to open (gaping) and death.

Due to the lack of a viable cockle fishery on the Exe the Cockle Sands bed was declassified as a harvesting area, and there are currently no classified harvesting areas for cockles on the Exe Estuary (Cefas, 2020). There is some small-scale recreational gathering of cockles on the estuary, which is unregulated. During the D&S IFCA's 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 autumn cockle surveys carried out by D&S IFCA between 2010 and 2022. 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.

2. Methods

2.1 Survey design

Surveys were conducted annually between 2010–2018 and then every two years since (e.g. 2020, 2022). Each survey is completed in one day between September and December at low water spring tides. The same survey stations (points that are approximately 115 m x 115 m apart) were sampled each year (Figure 2). 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 2).

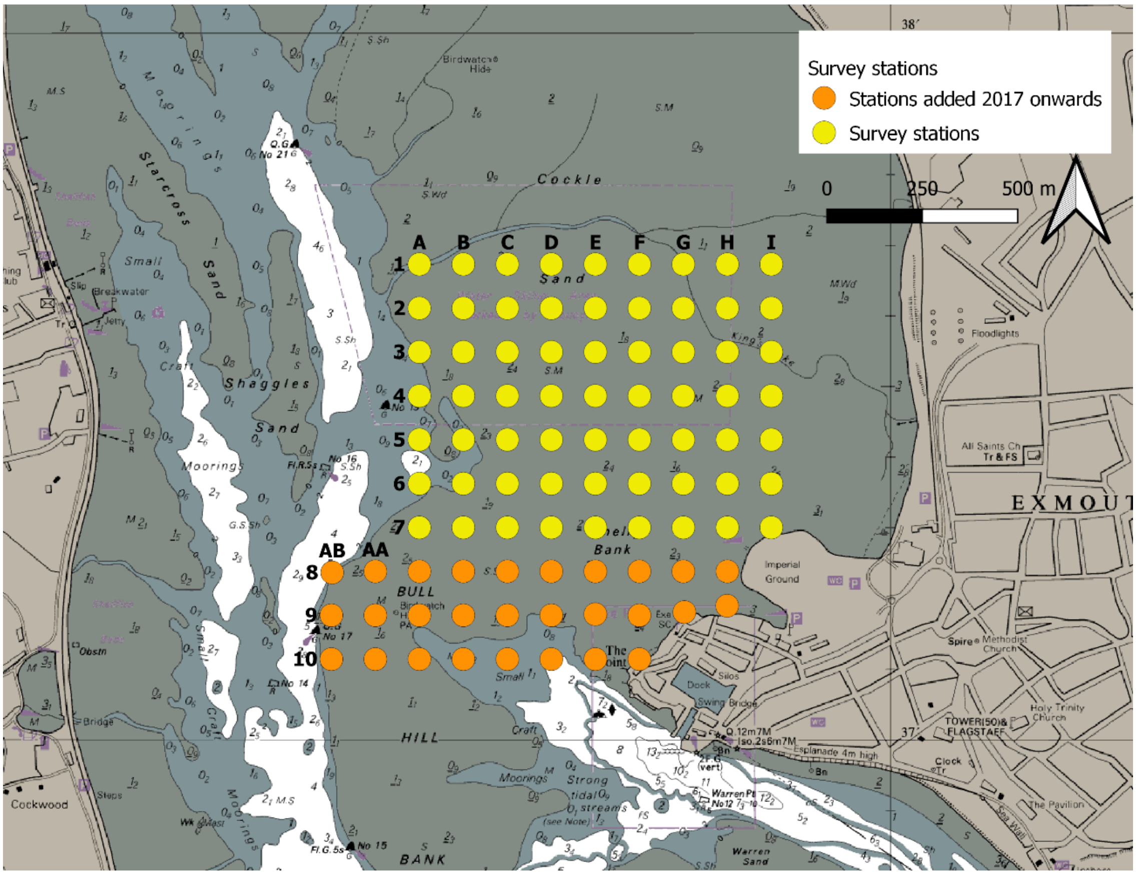

Figure 2 - Exe Estuary cockle survey stations. The sites that are (in)accessible can vary each year.

Each survey station was located using a handheld GPS. Once located, a 0.1m^2 quadrat was randomly placed within 10m of the target position for the station. Using a trowel, the sediment was dug out of the quadrat (to approximately the depth of the quadrat, ~ 6 cm) into a sieve, which was 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.

Figure 3 – Photos showing the cockle sampling method. (a) a 0.1m^2 quadrat is randomly placed within 10m of the target position for the sampling station, where sediment is dug out of the quadrat and placed in a sieve. (b) The sediment is sifted in water so that (c) the contents of the sieve are visible.

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

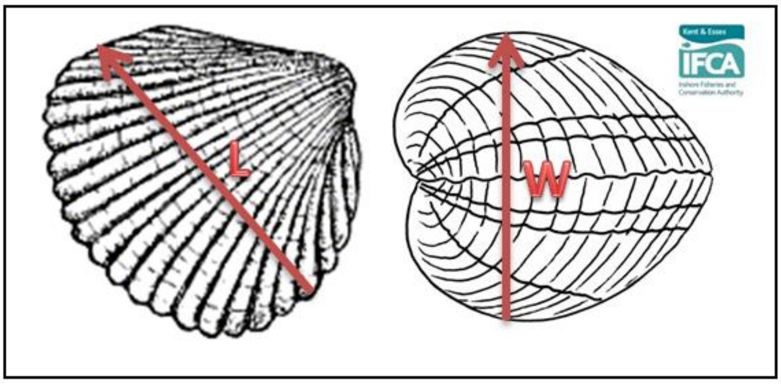

Figure 4 - Cockle length (L) and width (W) measurements.

For each station sample, after measuring, cockles were sorted into age classes by determining how many annual growth rings were present on the shell. Growth rings usually appear each winter (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.

2.2 Data analysis

R v3.6.1 or later (R Core Team, 2020) and QGIS v3.1 or later (QGIS, 2020) were used for data analyses.

Although there is no minimum size limit applied to cockles in the D&S IFCA's District, the results presented in this report divide the stocks into two size groups (cockles that are 15 mm length and over and those that are under 15 mm length). The suggested minimum size at maturity for cockles is 15mm (Tyler-Walters, 2007). These size groupings are therefore sometimes referred to in the report as "adult" (≥ 15 mm) and "juvenile" (< 15 mm) stocks, but it is important to note that cockle size and maturity can be influenced by several factors in addition to age. These size categories do, nevertheless, give an indication of the overall condition and structure of the stock.

To visualise the variation in density across the sample sites in each year, the density of cockles at each sample location was plotted on a map using Inverse Distance Weighted interpolation. Differences in the size frequency distributions (length and width) of cockles were visualised and the median length of cockles at each sample location was plotted on a map to visualise variation in the average size of cockles across survey locations.

Total biomass of cockles across the sampled area (64 ha pre-2017, and 89 ha from 2017 onwards) was calculated by scaling the mean cockle weight per station ($0.1m^2$) to the total sampled area. Only data from 2014 onwards were used for biomass calculations.

3. Results

The total number of stations surveyed varied each year (Table 1) as the number and location of inaccessible stations vary yearly and stations were added for 2017 onwards. In each year between 52.7 and 88.9% of the possible survey stations were surveyed. Table 1 provides a summary of the number of samples taken across all stations for all years surveyed. A total of 23 survey stations were consistently sampled across all years.

Table 1 – Number of stations surveyed/ not surveyed and number of stations where cockles were present in each year on the Exe Estuary. The total number of stations was 63 from 2010 – 2016, and this increased to 91 from 2017 onwards to cover a wider extent south of Cockle Sands and to capture areas where hand-gathering for cockles occurs.

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2020	2022
Number of stations surveyed	42	43	52	50	52	50	56	61	63	48	66
Number of stations with cockles present	42	43	35	45	37	43	46	46	46	37	49
Number of stations not surveyed	21	20	11	13	11	13	7	30	28	43	25

The density of adult cockles declined between 2011 and 2022 (Figure 5a). There was high variability in average adult cockle density across the bed between 2011–2014, after which the yearly average has remained relatively stable. There was high variation in total cockle density between survey stations (Figure 6), although the highest densities seem to be consistently found in either the centre or north-east corner of the surveyed stations. The average density of juvenile cockles appears to be more variable across years than that of adult cockles (Figure 5b).

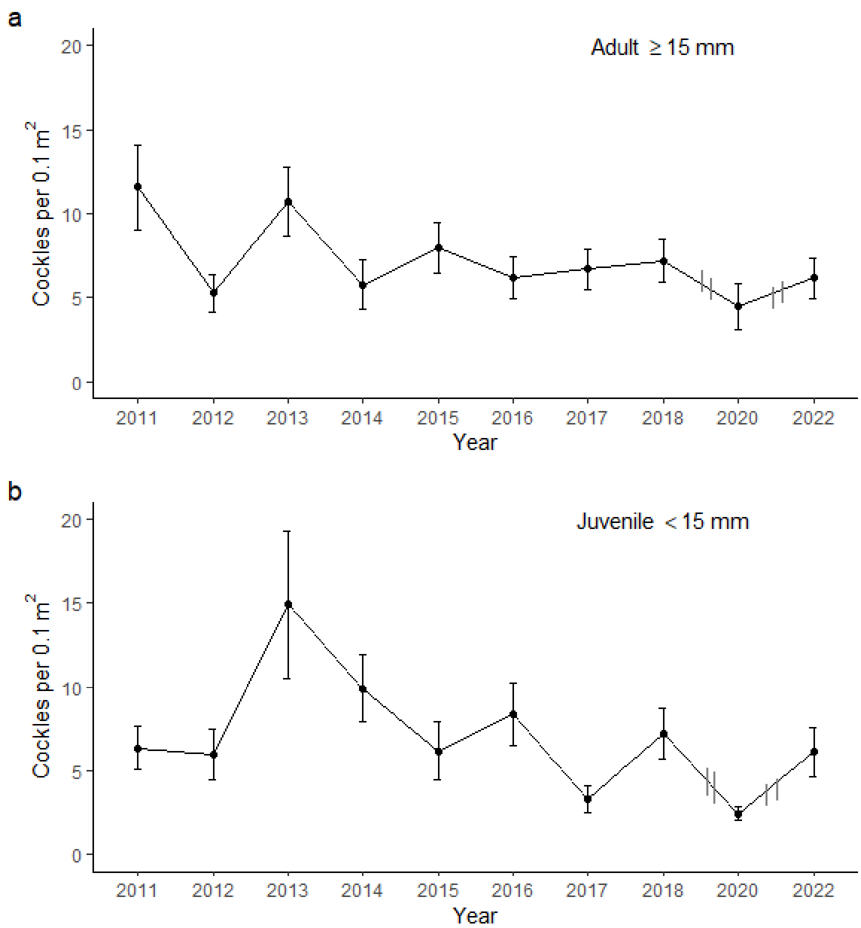

Figure 5 – Mean density (±SE) of (a) adult cockles ≥15 mm and (b) juvenile cockles <15 mm on the Exe Estuary from 2011-2022.

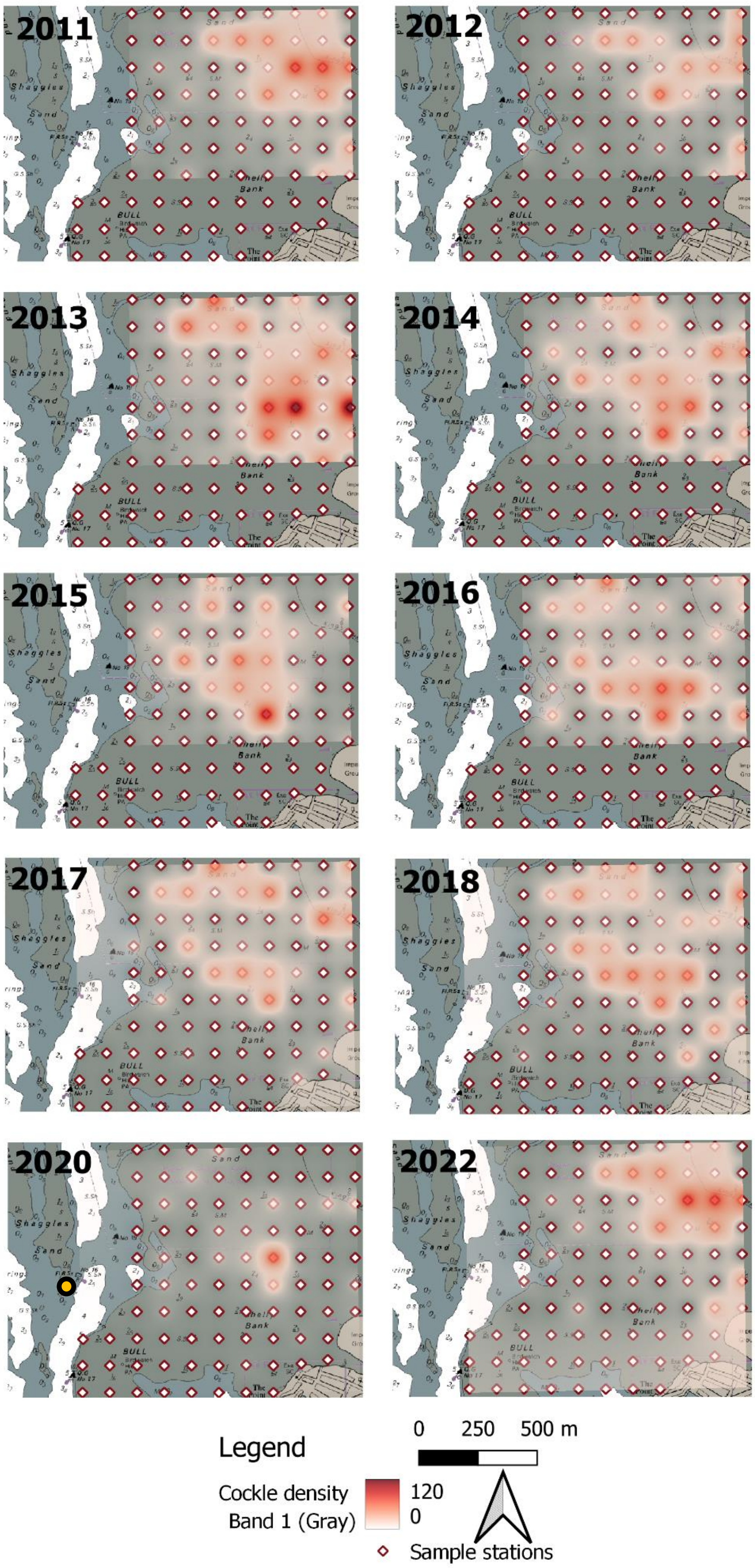

Figure 6: Cockle density (number of cockles per 0.1m^2 quadrat) on the Exe estuary in autumn 2011–2022 mapped using Inverse Distance Weighted interpolation.

The average length of cockles across all survey stations appears to vary year on year, but there is no obvious increase or decrease in average cockle lengths over time (Figure 7). The shapes of the frequency distributions of cockle length and width (Figure 8 & Figure 9) show some variations across years. In particular, there are some years where there appears to be a bimodal distribution (distribution with two clear peaks) in cockle lengths and widths (e.g. 2012, 2014, 2016, 2018, 2020), whereas other years (intervening years) show more of a unimodal distribution (distribution with one peak). The average length of cockles varies between sample locations (Figure 10). In particular, the average size of cockles tends to be smaller in the centre of the survey area, whereas the average length tends to be larger closer to the edges of the survey area, particularly in the south-west and north-east sampling stations. It appears the survey stations with the highest densities of cockles have a lower average size of cockles (Figure 6, Figure 10) however, it was not possible to test this statistically as the data did not satisfy the prerequisites for modelling with generalised linear (mixed) models.

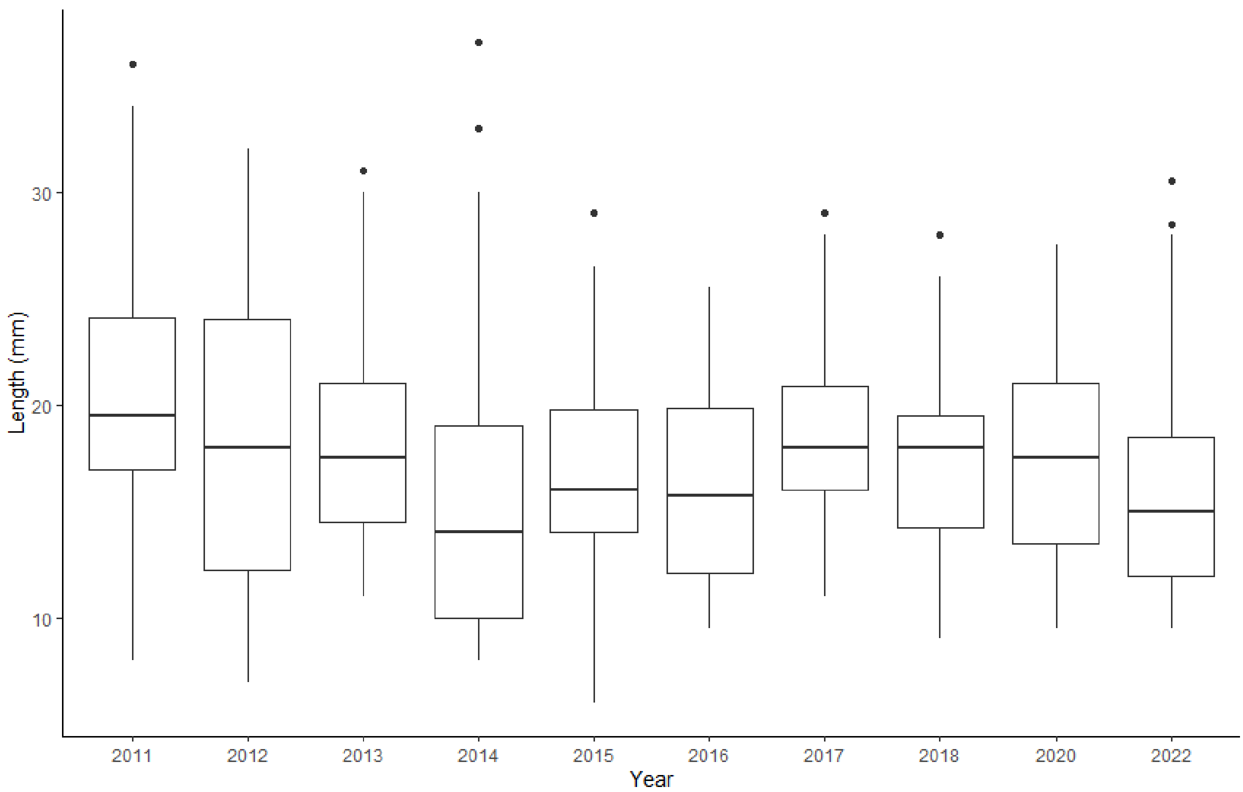

Figure 7: Length (mm) (median, inter-quartile range and range) of cockles on the Exe estuary from 2011–2022.

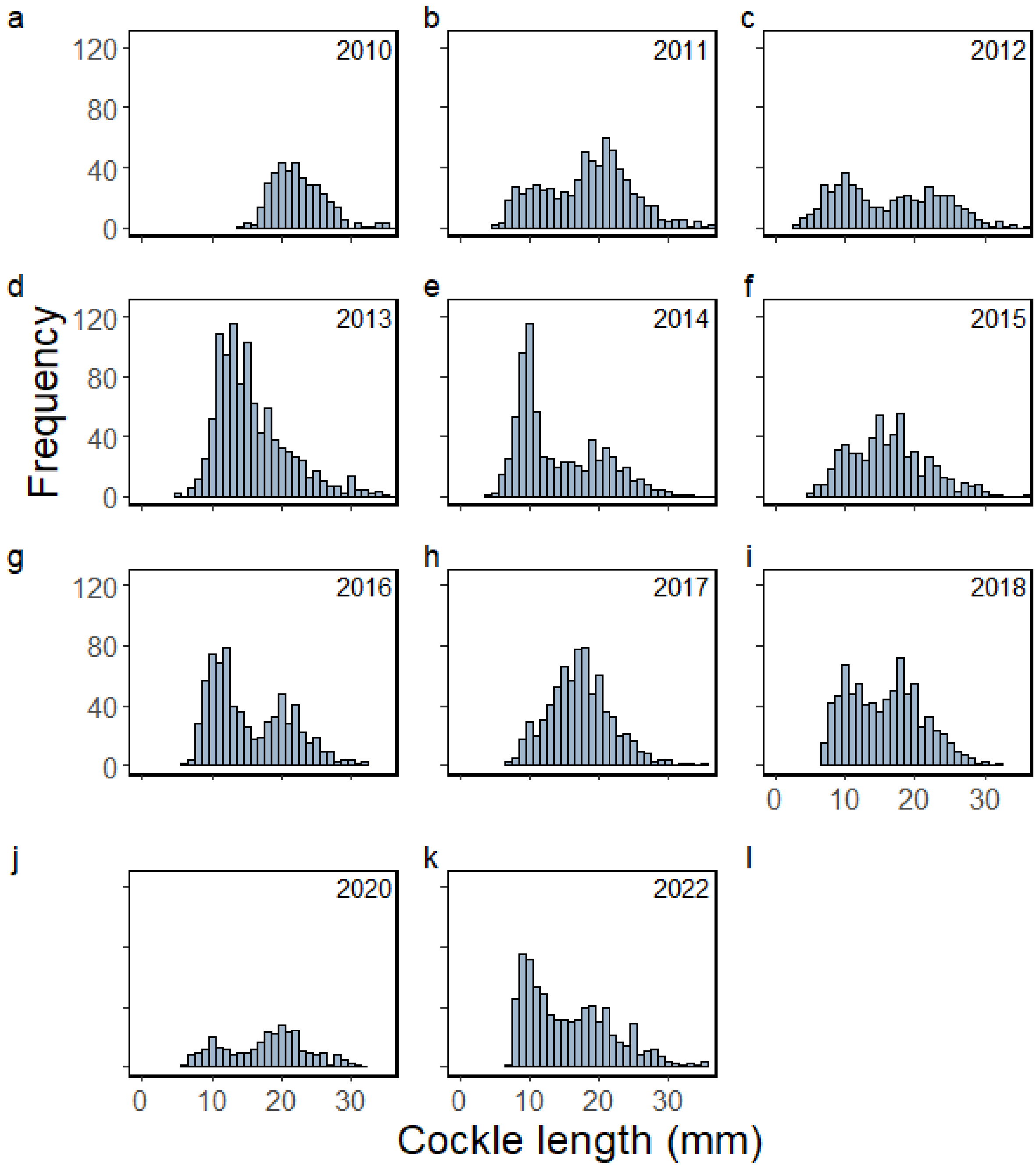

Figure 8: Frequency of cockle lengths (mm) in each survey year on the Exe Estuary. Juvenile cockles were not measured in 2010

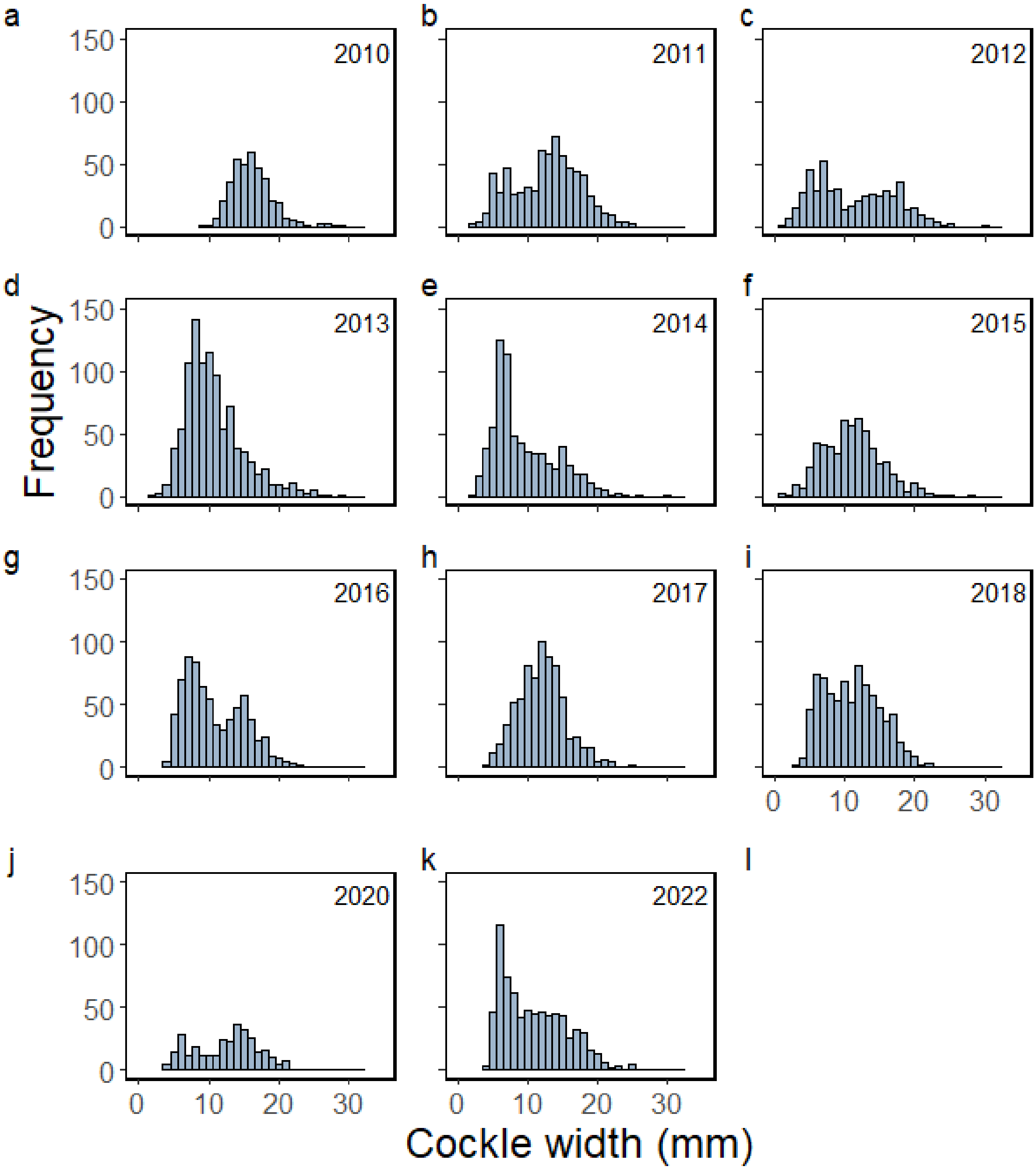

Figure 9: Frequency of cockle widths (mm) in each survey year on the Exe Estuary. Juvenile cockles were not measured in 2010

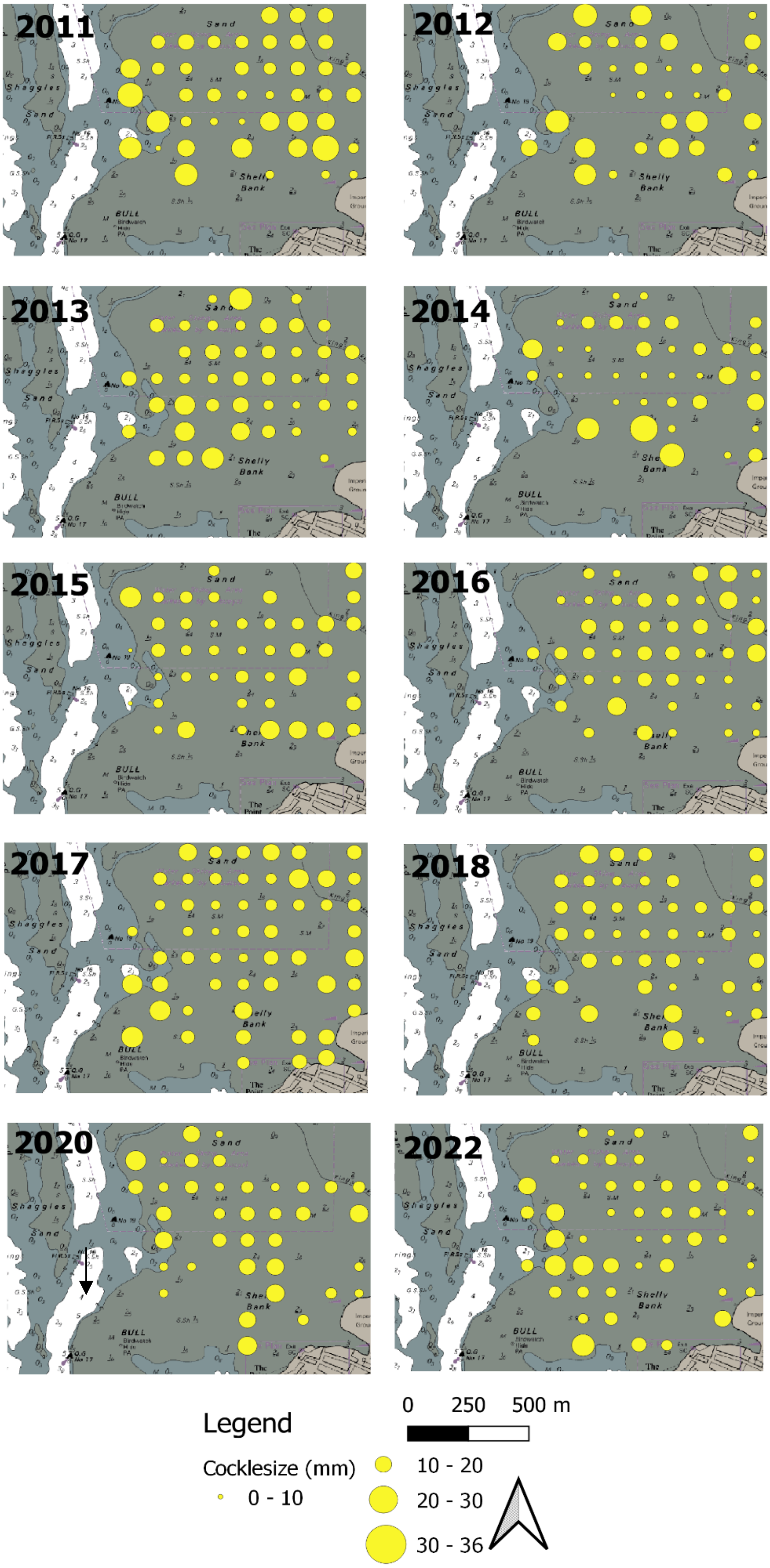

Figure 10: Median cockle size (mm) at each sampling station on the Exe Estuary in autumn 2011–2022. Sampling sites that were not surveyed or that contained no cockles are not shown on the map.

The total tonnage of cockles across the surveyed area in 2022 was 156 tonnes (Figure 11). This represents an increase in total tonnage of around 71% since the 2020 survey. The number of cockles in each year class have increased in the 2022 surveys compared to the 2020 survey, but for the early year classes, these numbers still do not reflect the numbers seen in the years prior to 2020 (Figure 12).

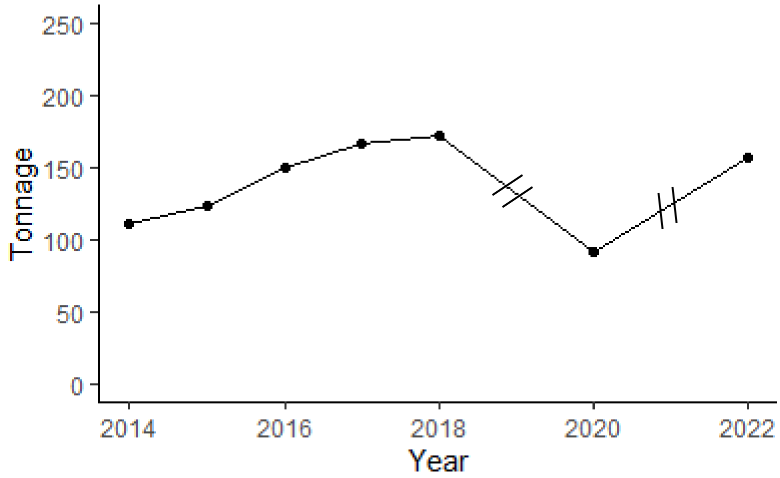

Figure 11: Total tonnage of cockles across the surveyed area (64 ha pre 2017, and 89 ha 2017 onwards 2014–2022.

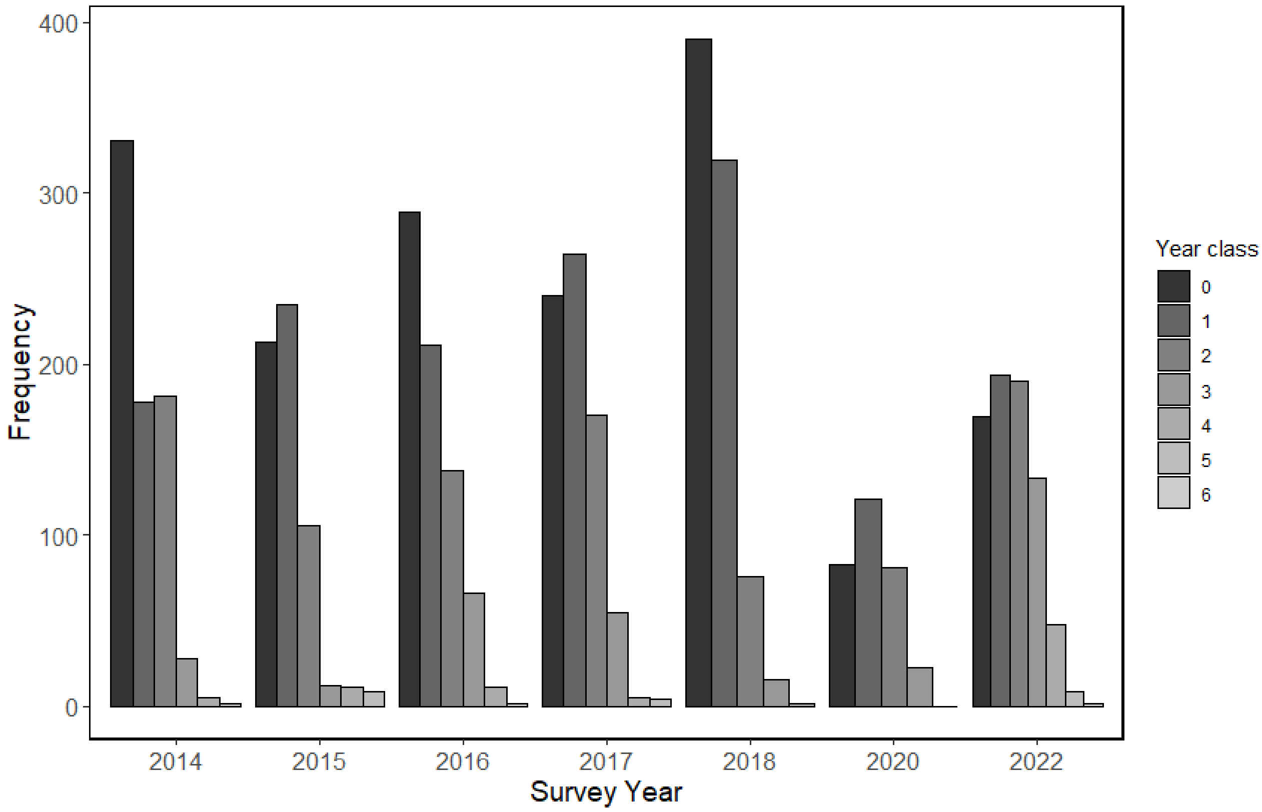

Figure 12: Number of cockles in each year class for each survey year. Year classes are determined by counting the number of growth rings on a cockle's shell (0 rings = year 0, 1 ring = year 1, etc).

4. Discussion

D&S IFCA has carried out autumn cockle surveys on Cockle Sands since 2010. This report monitors the change in density and average size of cockles across cockle sands on the Exe Estuary between 2010 and 2022 and discusses the implications for the birds that use the cockles as a prey source and the users of the estuary who gather cockles recreationally.

Although a small decline in total adult cockle density was detected across the survey locations in the previous report between 2011–2020 (an average of approximately 3% per year), the addition of data from the 2022 surveys shows that adult cockle density on the estuary seem to be relatively stable between 2014–2022. A high degree of variation in cockle density between sample sites remains. This highlights the importance of accounting for or considering the variation in cockle density across survey sites when conducting analysis or interpretation of data. There appears to be larger fluctuations in the densities of juvenile cockle density, but this should be interpreted with care as it is not possible to statistically control for variation in the surveyed sample stations. However, the apparent peak in juvenile cockle density in 2013, and the juvenile-heavy size frequency distribution in 2013 suggests that 2013 could have been a strong year for recruitment of cockles on the Exe Estuary.

There was a mass mortality event of cockles in 2011, which was caused by elevated levels of two parasites that affect the cockle's abductor muscle and preventing closure of the shell, leading to death. A further mortality event is thought to have occurred in 2014 after the winter storms (which occurred between mid-December 2013 through to mid-February 2014), resulting in depleted oxygen levels causing estuary-wide morality of all shellfish in the intertidal (Pers. comm. Blood-Smyth, 2017). These storms caused a significant loss of mussels from Bull Hill (near Cockle Sands). Despite these storms, and the corresponding loss of other bivalves (e.g. mussels) from the area, cockle densities do not seem to have been affected as dramatically. There appears to be some years with strong recruitment (highlighted by the variation in size frequency distributions and discussed below).

The variation in cockle size frequency distributions observed in this report (i.e. alternating bimodal and unimodal distributions across years) could be due to a number of reasons. Cockles are thought to have a prolonged period of reproduction, probably between May–June, annually. It is therefore likely that a particularly strong recruitment of juveniles would not be highlighted with survey data until the following year as surveys are usually carried out in October. A cockle is likely to become sexually mature at 18 months (Tyler-Walters, 2007), which means a peak in juveniles following a strong recruitment year, may not be ready to reproduce in the following year. This may lead to the alternating pattern of bimodal and unimodal size distributions across years that have been observed in this report.

However, it is also important to consider the possible variation in cockle size across years that arises from the different sampling stations that are surveyed each year. Both cockle density and size seem to show high variation between sampling locations within the survey site. Hancock and Franklin (1972) showed that local variability in growth rate can occurs within a site between areas separated by relatively short distances. It is clear from the maps showing the average size of cockles at each sampling station in each year that there is variation in cockle sizes over relatively short distances within the survey area. It appears the survey stations with the highest densities of cockles have a lower average size of cockles (Figure 6, Figure 10). Evidence from the literature suggests that cockle growth rate decreases as population density increases probably due to increased competition for food, and direct interference or disturbance due to burrowing and direct contact between individuals (Orton, 1926; Hancock and Franklin, 1972; Jensen, 1992; Montaudouin and Bachelet, 1996). Montaudouin & Bachelet (1996) reported highest juvenile growth rates at low density (160-200 adults m^{-2}) whereas adult growth rates were only depressed at the highest density examined (2000 adults m^{-2}). The data from the Exe Estuary suggests that adult cockles are present in densities ~150 adults m^{-2}, so it is unclear whether the patterns in the average size of cockles observed across sample locations is a result of reduced growth rates at higher densities or due to random variation in cockle sizes across sample sites.

Previous evidence shows that cockles on the Exe Estuary are an important food source for several species of bird, with varying preferences of cockle size between bird species (Durell *et al.*, 2007). In particular, the black-tailed godwit, bar-tailed godwit and curlew have been shown to feed on medium cockles (10–19.9 mm), whereas oystercatchers, which are a feature of the Exe Estuary SPA, feed on larger (15–44.9 mm) cockles (Durell *et al.*, 2007). Despite variations in the average cockle size over time and the small decline in adult cockle density across the years, it is unlikely that the availability of the preferred cockle sizes for these species of birds is in decline. 2020 appears to have been a poor year for cockles on the Exe estuary with a dip in both the average density and total biomass on the bed. These have shown signs of recovery between 2020 and 2022, but it is important that monitoring in future years is continued to identify any potential long-term declines. D&S IFCA has noted a significant decline in mussel density on the Exe Estuary following the two previously mentioned mortality events (Stephenson and Henly, 2021). The relatively stable cockle stocks on the Exe Estuary may be enabling the bird populations to persist in this location, despite declines in their other food sources.

Reports of recreational gathering of cockles have increased in recent years, some of which report large quantities being removed. Larger cockles are more likely to be targeted by the recreational fishers and therefore an increase in recreational landings could impact the density of adult cockles on the estuary. The cause of the small decrease in adult cockle density observed across years (2011–2020) in the Exe Estuary is unknown but is currently not a huge concern as it seems to have stabilised recently. Although there is currently no commercial fishery for cockles on the Exe Estuary, D&S IFCA will continue the autumn survey every two years 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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