Exe Estuary
Cockle Stock Assessment 2010 – 2026



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Research Report
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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).

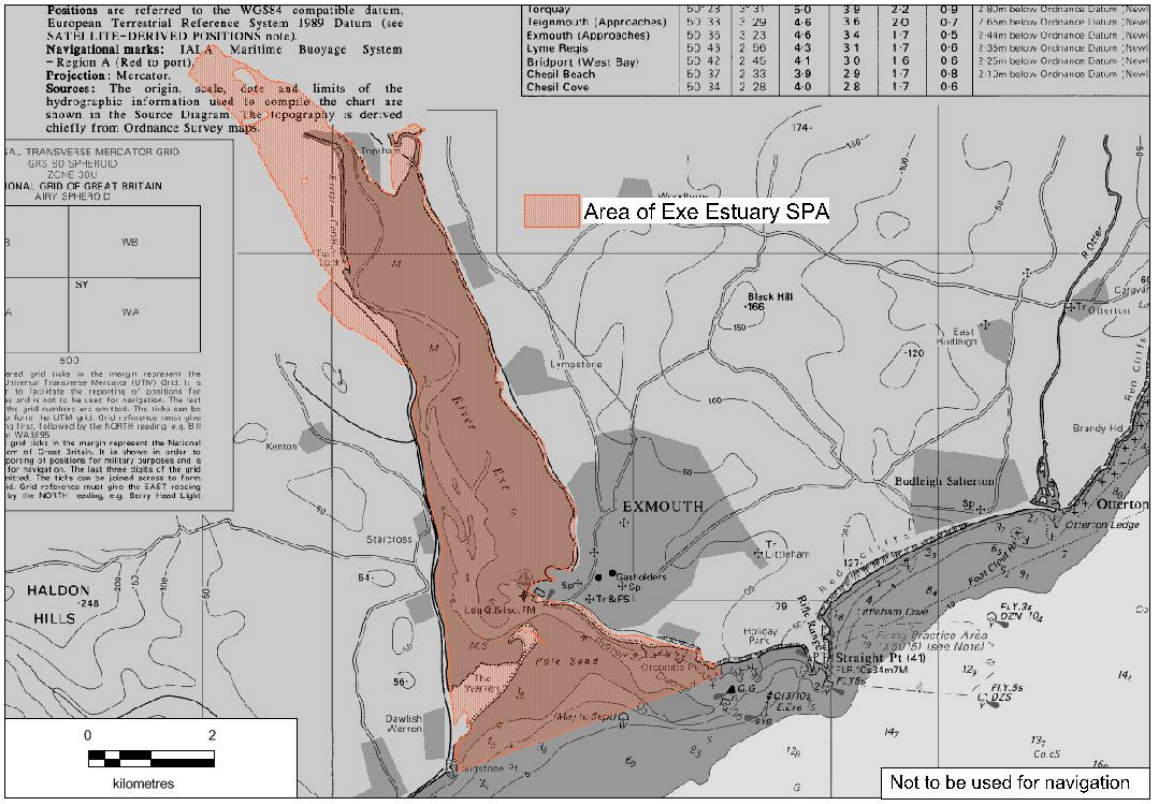

Figure 1: Area of the Exe Estuary Special Protection Area (SPA)

Cockles (*Cerastoderma edule*) are active suspension-feeding bivalves that can attain a maximum shell length of approximately 5 cm. Their shells exhibit prominent growth lines, which reflect successive periods of growth. The species is typically associated with a range of sediment habitats, including clean sand, muddy sand, mud and muddy gravel. They predominantly occur within the middle to lower intertidal zone, with occasional occurrence in subtidal environments. *C. edule* is particularly abundant in estuarine habitats. Individuals generally inhabit the upper 5cm of the sediment surface and can tolerate fluctuations in salinity (Tyler-Walters 2007).

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.

This report provides details of the autumn cockle surveys carried out by D&S IFCA between 2010 and 2026. 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. The 2026 survey was conducted on 13th August during low water spring tide. Previous years surveys have been conducted between September and December. The variation in survey timing reflects the need to coordinate these surveys with other molluscan surveys conducted throughout the year. 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).

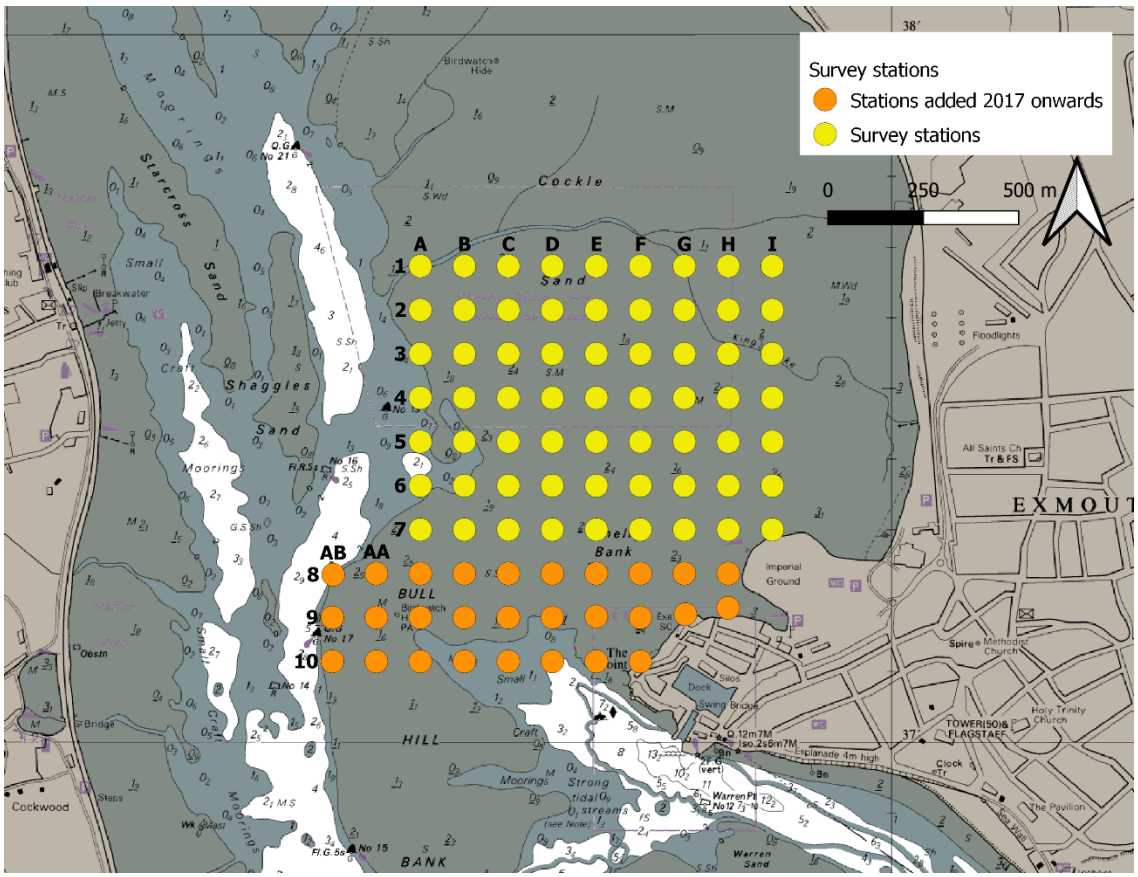

Figure 2 - Exe Estuary cockle survey stations. Some sites are (in)accessible, and these can vary between surveys.

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).

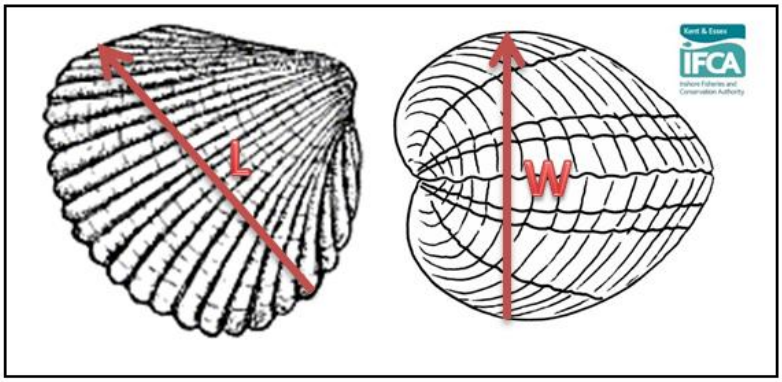

Figure 4 - Cockle length (L) and width (W) measurements.

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 v4.4.2 or later (R Core Team 2024) and QGIS v3.44 or later (QGIS 2022) 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 (IDW) interpolation of per station density. For 2011-2022 this was calculated on all sampling stations whether cockle was present or not. In 2024 and 2026, density across the stations only where cockle were present were

visualised using IDW interpolation (distance coefficient 2, pixel size 0.00005) around a buffer of 57.5m (half of the distance between stations) from the sampled stations. Differences in the size frequency distributions (length and width) of cockles were visualised using a histogram 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 total bed area (64 ha pre-2017, and 89 ha from 2017 onwards) was estimated by scaling the mean cockle weight per sampled station ($0.1m^2$) (whether cockle was present or not) to the total cockle bed area. Any stations which could not be surveyed were not included in the calculation, but the calculation assumes a homogeneous density across the whole bed (including sampled and non-sampled areas). 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 48.35 and 88.9% of the possible survey stations were surveyed, with the variation largely attributable to access difficulties associated with the tide and position/depth of the main water channel. Table 1 provides a summary of the number of samples taken across all stations for all years surveyed.

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 potential 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**	**2024**	**2026**
Number of stations surveyed	42	43	52	50	52	50	56	61	63	48	66	52	44
Number of stations with cockles present	42	43	35	45	37	43	46	46	46	37	49	35	32
Number of stations not surveyed	21	20	11	13	11	13	7	30	28	43	25	39	47

Mean adult cockle density declined over the survey period, from approximately 12 cockles per 0.1 m² in 2011 to less than 4 cockles per 0.1 m² in 2026 (Figure 5a). Following considerable interannual variation between 2011 and 2014, observed densities remained broadly within 6–8 cockles per 0.1 m² between 2014 and 2018, before declining to approximately 4–6 cockles per 0.1 m² from 2020 onwards. Juvenile density was more variable between years, with the highest mean density recorded in 2013 (approximately 15 cockles per 0.1 m²) and the lowest in 2020 (approximately 3 cockles per 0.1 m²; Figure 5b). Juvenile density increased between 2020 and 2022 but appeared to decline slightly in 2024 and remained similar in 2026. The between-year variation in average adult and juvenile cockle density was often within the error range of adjacent years (Figure 5); it is therefore unclear whether these perceived declines and increases are significant.

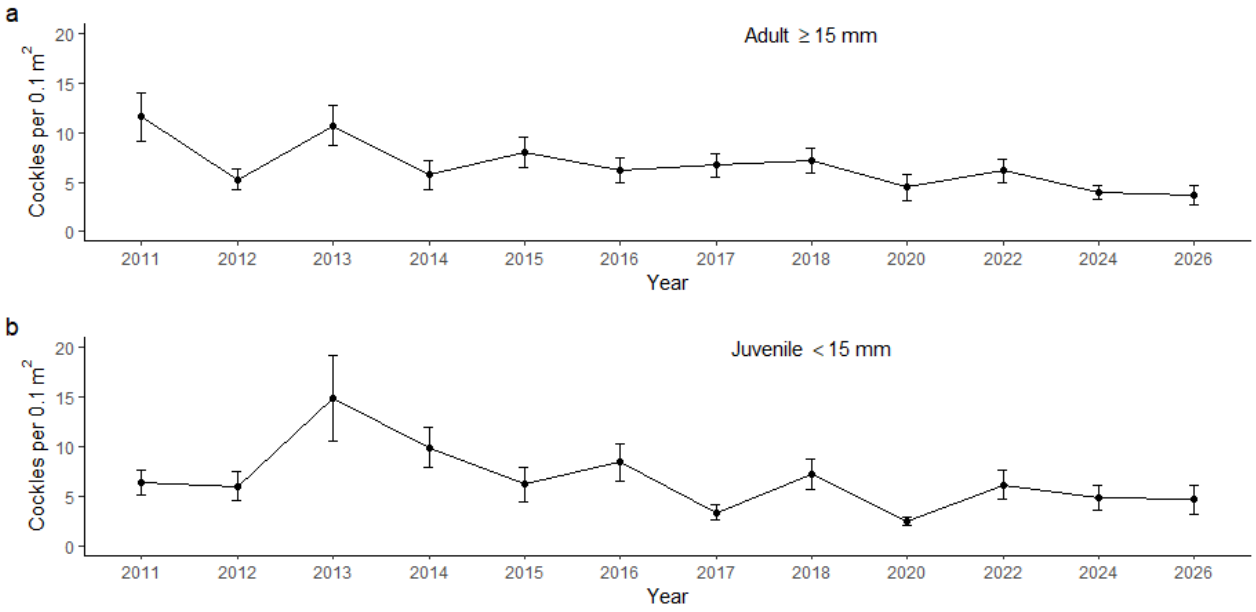

Figure 5 – Mean density (±SE) of (a) adult cockles ≥15 mm and (b) juvenile cockles <15 mm on the Exe Estuary from 2011-2026

Cockle density varied substantially among sampling stations and between survey years (Figure 6 and 7). Higher-density areas were generally concentrated in the central and eastern parts of the survey area, although their location and magnitude varied between years. A pronounced area of higher density occurred in the central/south-eastern area during 2013–2015, while densities were more diffuse during 2016–2022. The 2020 survey showed comparatively low densities across much of the surveyed area. In 2022, higher densities were concentrated towards the eastern and north-eastern areas, while the 2024 survey showed relatively low and diffuse densities. In 2026, the highest-density areas were concentrated towards the eastern and north-eastern edge of the survey area (Figure 7).

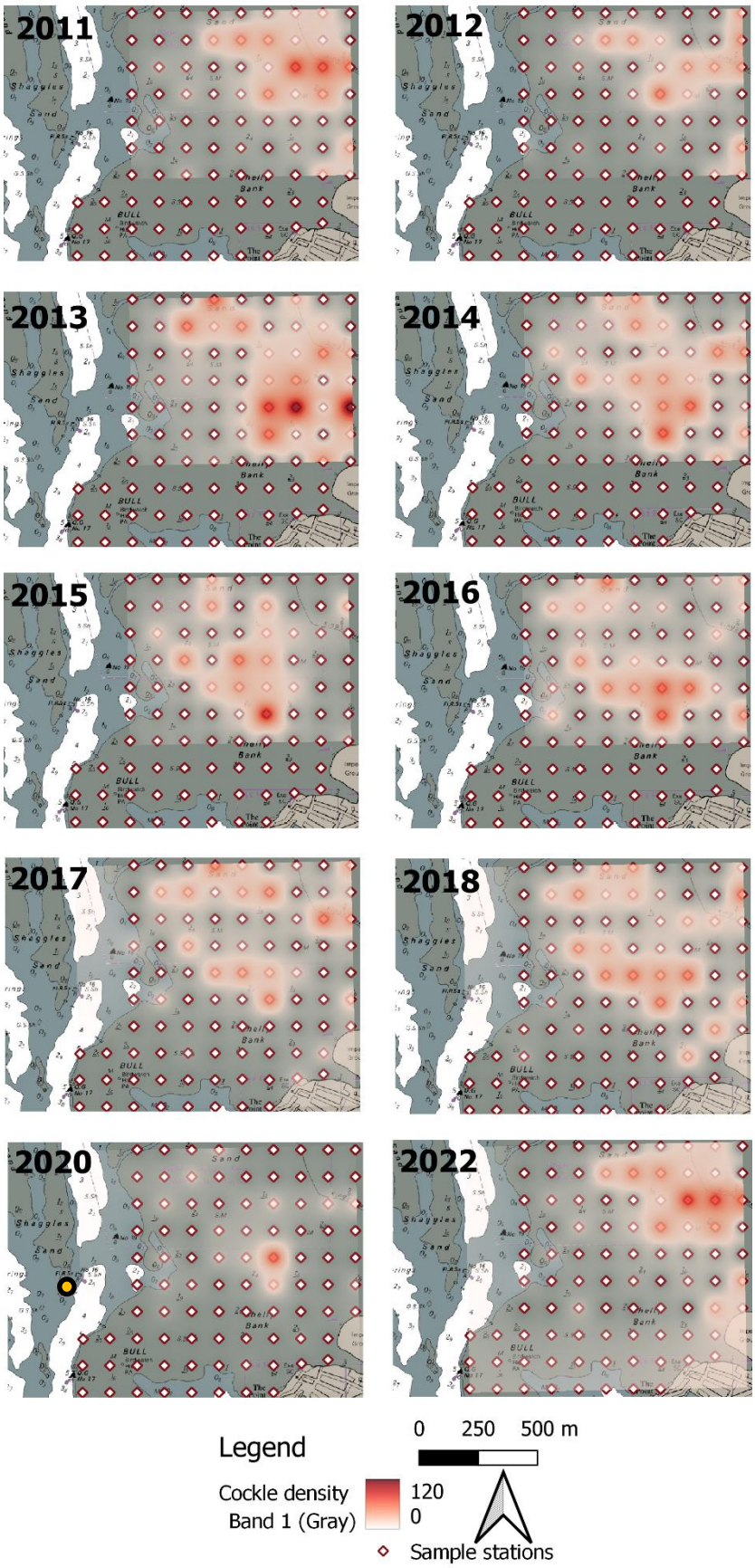

Figure 6: Cockle density (number of cockles per 0.1m^2 quadrat) on the Exe estuary in autumn 2011–2022 mapped using Inverse Distance Weighted interpolation on all surveyed stations.

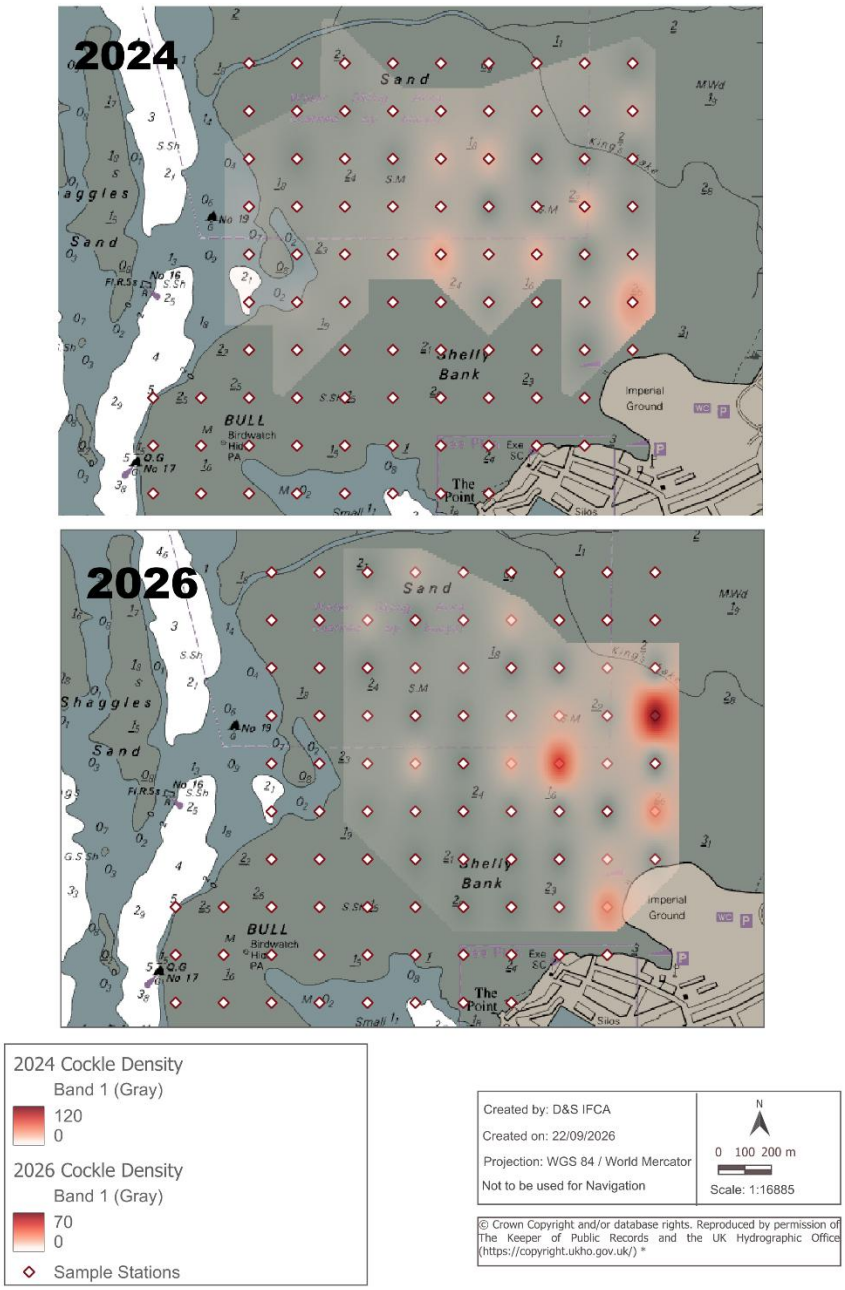

Figure 7: Cockle density (number of cockles per 0.1m^2 quadrat) on the Exe Estuary in 2024 and 2026. Mapped using Inverse Distance Weighted interpolation based around a buffer of 57.5m (half of the distance between stations) on the stations sampled where cockle were present. Note the different scale for 2026
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Median cockle length varied between survey years, but there was no clear directional trend in size over the survey period (Figure 8). The boxplots indicate that the median length varied from 11 to 22mm, with 2014 showing the lowest median length and 2010 the highest. Larger individuals (>25 mm) occurred in most survey years but generally represented a relatively small proportion of the population, particularly in 2026.

The size-frequency distributions showed considerable variation in the size structure of the cockle population between survey years (Figures 9 and 10). Cockle size also varied spatially across the survey area, with smaller cockles generally occurring towards the centre of the bed and larger individuals more frequently occurring towards the edges, particularly in the south-western and north-eastern areas (Figure 11 and 12). Areas of higher density appeared to be generally associated with smaller cockles (Figures 6, 11 and 12). However, this relationship was not statistically tested because it was not possible to fit an appropriate generalised linear (mixed) model.

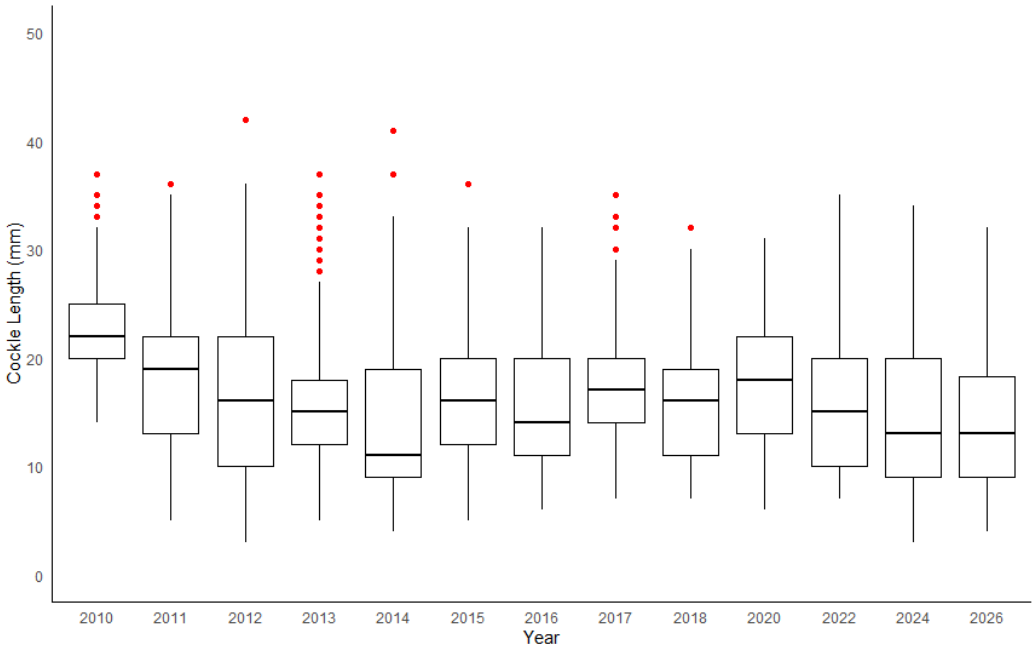

Figure 8: Length (mm) (median, inter-quartile range and range) of cockles on the Exe Estuary from 2011–2026

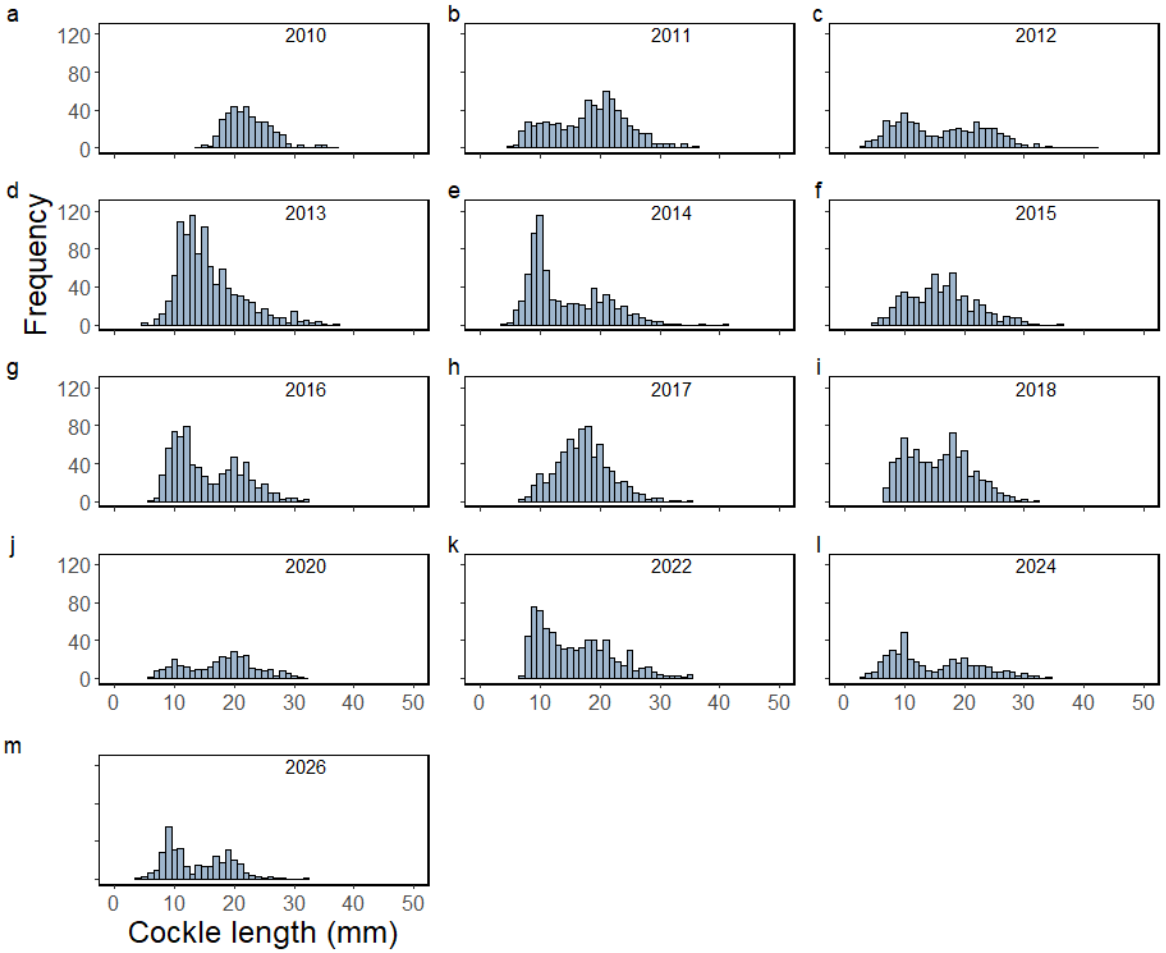

Figure 9: Frequency of cockle lengths (mm) in each survey year on the Exe Estuary. Juvenile cockles were not measured in 2010

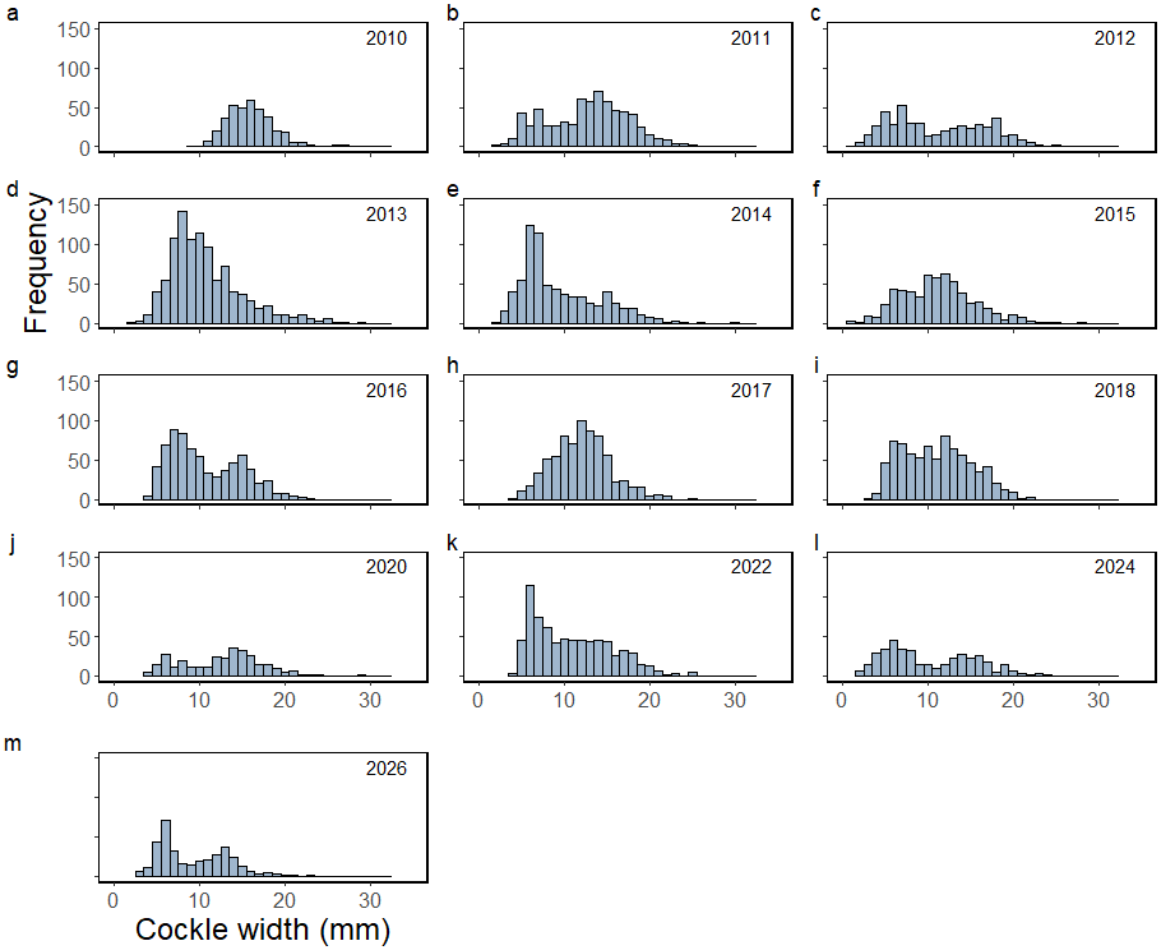

Figure 10: Frequency of cockle widths (mm) in each survey year on the Exe Estuary. Juvenile cockles were not measured in 2010

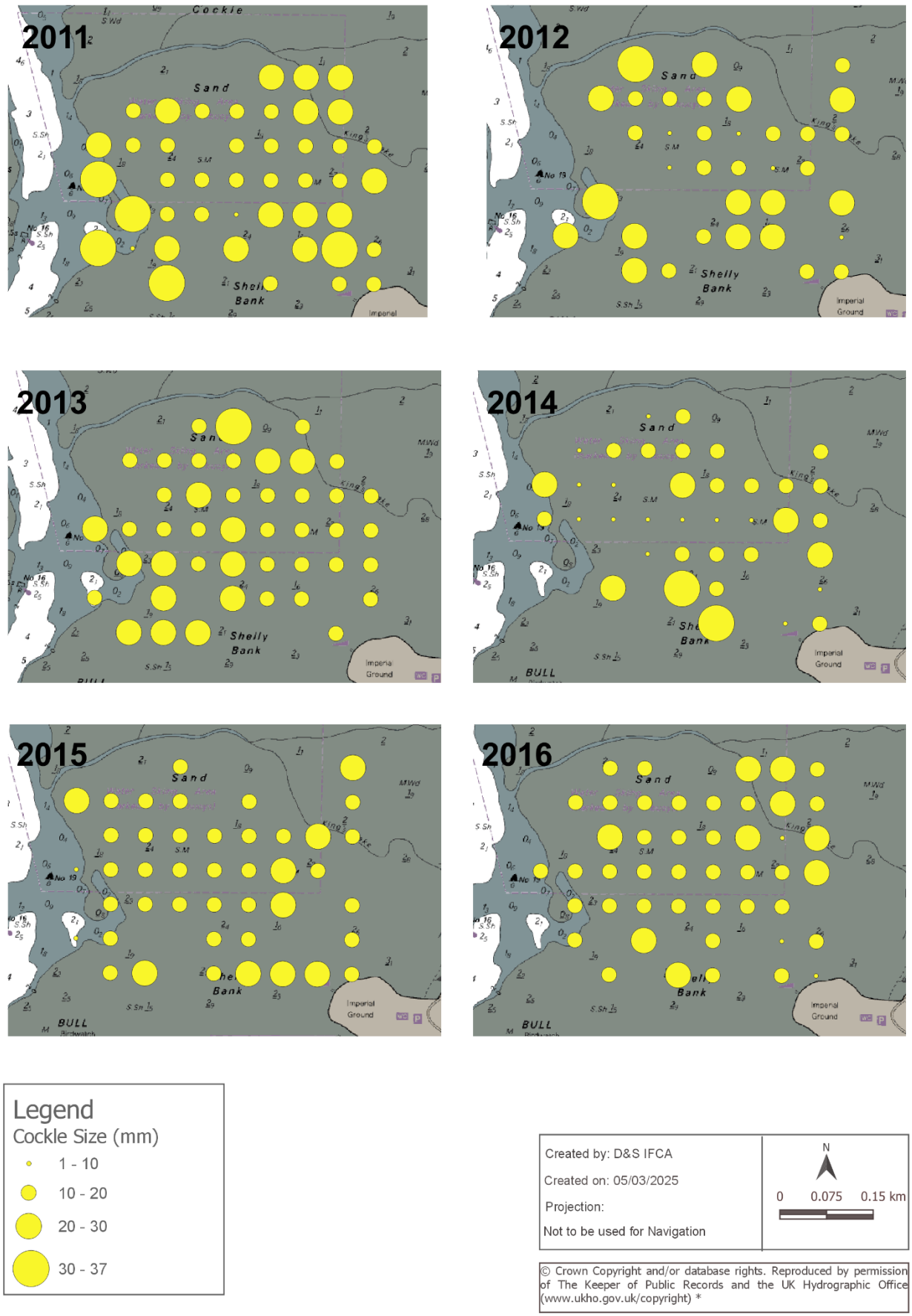

Figure 11: Median cockle size (mm) at each sampling station on the Exe Estuary in autumn 2011–2016. Sampling sites that were not surveyed or that contained no cockles are not shown on the map. * www.ukho.gov.uk/copyright

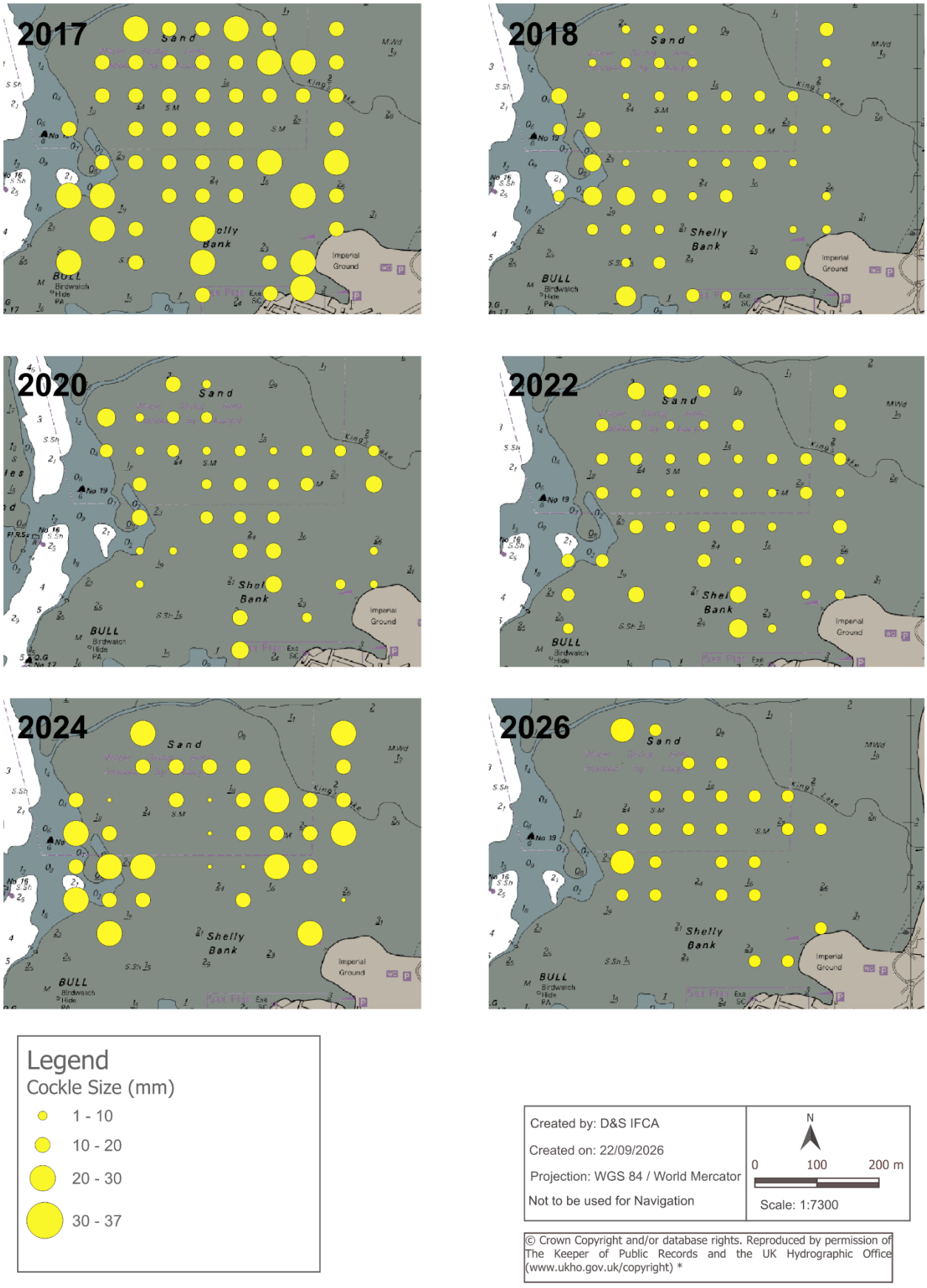

Figure 12: Median cockle size (mm) at each sampling station on the Exe Estuary in autumn 2017–2026. Sampling sites that were not surveyed or that contained no cockles are not shown on the map. * www.ukho.gov.uk/copyright

The total estimated tonnage of cockles across the surveyed area in 2026 was 97 tonnes (Figure 13). This represents an apparent decrease of approximately 36% compared with the 2024 survey, when total biomass was estimated at 151 tonnes. However, this apparent decrease should be interpreted with caution. In particular, survey effort was lower in 2026, with fewer stations sampled due to staff availability. Although the biomass calculation attempts to account for survey effort, the cockle biomass is not evenly spread across the site and the biomass calculation cannot account for how reduced survey effort may result in lower probability of sampling high-density areas.

To account for differences in survey coverage, biomass estimates were also compared using only the stations sampled in both 2024 and 2026. On this basis, estimated tonnage was 90 tonnes in 2024 and 97 tonnes in 2026, indicating an apparent increase in biomass across the common set of stations. This comparison suggests that the lower total biomass estimate in 2026 is attributable to differences in survey coverage and heterogeneous distribution of cockle across the site, rather than necessarily reflecting a true decrease in the underlying cockle population.

Figure 14 shows the frequency of cockles in each year class observed across all quadrat samples in each survey year 2014 – 2026. These frequencies are not corrected for variable survey effort between years, but show the overall pattern of year classes in each survey.

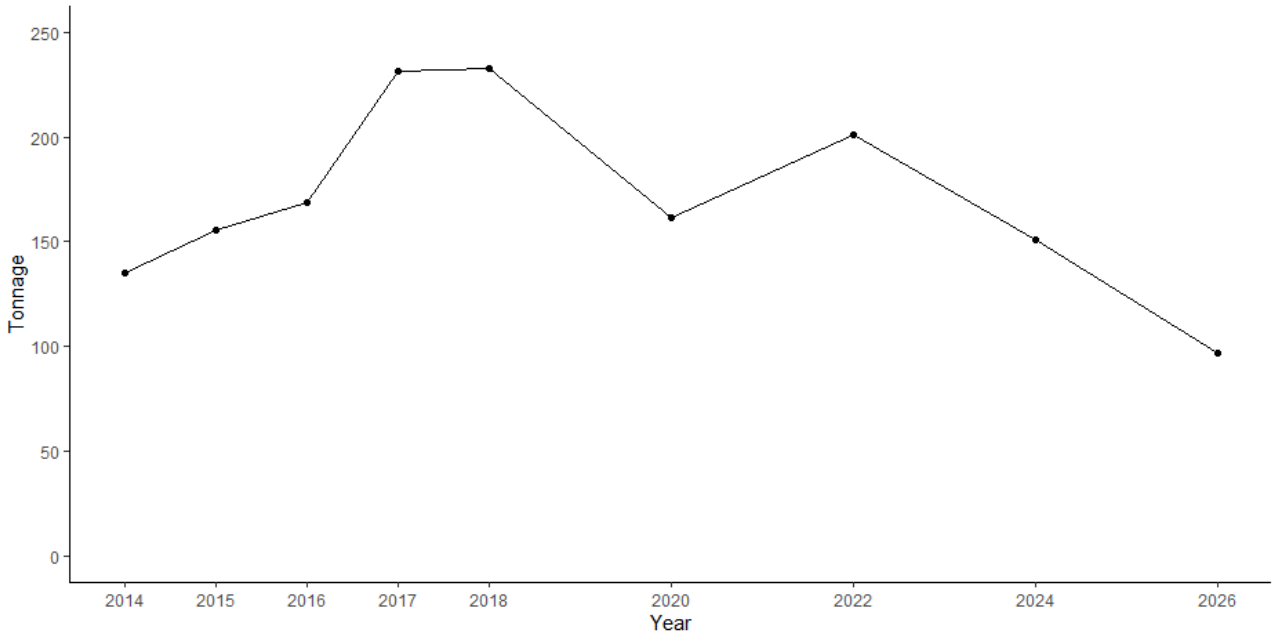

Figure 13: Total tonnage of cockles across the total cockle bed, not showing between-year variation in surveyed area which affects total tonnage estimate.

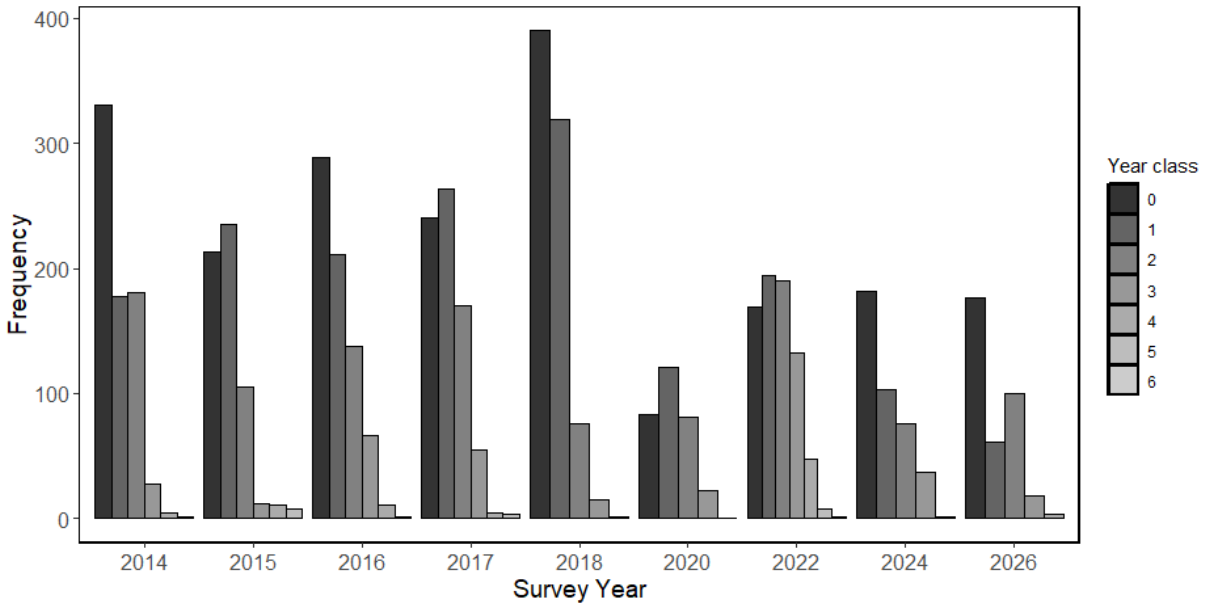

Figure 14: Number of cockles in each year class for each survey year. Year classes are determined by counting the number of growth rings on a cockle's shell (0 rings = year 0, 1 ring = year 1, etc).

4. Discussion

D&S IFCA has carried out autumn cockle surveys on Cockle Sands since 2010 to monitor changes in cockle density, size and biomass across the Exe Estuary. The 2026 survey indicates that cockles remain widely distributed across the surveyed bed and that recruitment continues to occur, but the stock has changed considerably since the beginning of the surveys. In particular, densities are relatively stable but fairly low compared to the densities observed in the early 2010s. Densities are also high relative to recently-surveyed cockles in the Teign Estuary (D&S IFCA, 2026). Whilst biomass appears low compared to the biomass peak observed in 2017 – 2018, it is important to recognise that these years also had a relatively high number of successfully-surveyed stations compared to other years, which may have sampled more high-density stations. The tonnage was also relatively high in 2022, which also had a large number of successfully surveyed stations, including some stations of particularly high density.

The spatial distribution of cockles varied considerably between years, with areas of high density occurring at different locations across the bed. This spatial variability is important when interpreting temporal changes, particularly given differences in sampling effort between surveys.

Juvenile density was more variable between years than adult density, with particularly high densities recorded in 2013 and further fluctuations throughout the survey period. The relatively high juvenile density recorded in 2013, together with the predominance of smaller cockles in the corresponding size-frequency distribution, suggests that 2013 may have followed a relatively strong recruitment event. More recently, juvenile density increased between 2020 and 2022 before appearing to decline slightly in subsequent surveys. However, variation in juvenile density should be interpreted cautiously because recruitment is often spatially patchy and differences in sampling effort and station coverage can influence the estimated mean density.

Variation in the size-frequency and year-class distributions provides further evidence of intermittent recruitment. The strong representation of smaller individuals in some survey years, including 2026, is consistent with recent recruitment events, while the relatively low frequency of older year classes suggests that fewer individuals are persisting into larger size classes. However, size and age should be interpreted cautiously because cockle growth rates can vary spatially and between years.

Cockle size and density varied considerably between sampling locations. The apparent dominance of smaller cockles in higher-density areas may reflect the presence of recently recruited individuals rather than density-dependent effects on growth. Density-dependent reductions in cockle growth have been demonstrated elsewhere, potentially through competition for food and space (Orton 1926; Hancock and Franklin 1972; Jensen 1992, 1993; Montaudouin and Bachelet 1996; Guenole and Masski 1999). However, the densities observed on Cockle Sands are generally below those at which substantial reductions in adult growth have been reported. The observed relationship between density and size should therefore not be interpreted as evidence of density-dependent growth without further analysis.

The considerable spatial variation in both density and size also demonstrates the importance of accounting for the distribution of cockles when interpreting changes in the stock. Local differences in recruitment, growth conditions and survival may contribute to the patterns observed across the bed. The inability to statistically model the relationship between density and size further limits the extent to which causal relationships can be inferred from the survey data.

Cockles are an important prey resource for several species of wading bird on the Exe Estuary, with different species selecting different size classes. Black-tailed godwit, bar-tailed godwit and curlew have been reported to feed on medium-sized cockles (10–19.9 mm), while oystercatchers can exploit larger cockles (15–44.9 mm) (Durell et al., 2007). Consequently, changes in both cockle abundance and size structure have potential implications for prey availability.

The continued presence of smaller cockles suggests that cockles remain available as a prey resource, but the relatively low densities in recent years compared to earlier surveys suggests that the total quantity of cockle available to predators has decreased. This is particularly relevant given previous evidence of declines in other bivalve prey resources on the Exe Estuary, including mussels (Stephenson and Henly 2021). The consequences for overwintering birds cannot, however, be determined from the cockle survey data alone, as prey availability will also depend on other food resources, bird abundance and distribution, and the accessibility of cockles.

The 2026 results highlight the importance of considering biomass, density, size structure and recruitment together when assessing the status of the cockle stock. Density alone may not fully capture changes in the quantity of cockle available, particularly where the population becomes increasingly dominated by smaller individuals.

Given the use of Cockle Sands by recreational cockle gatherers and the importance of cockles as a prey resource for designated bird species, it will be important for D&S IFCA to continue the autumn cockle surveys biennially using consistent sampling methods and effort wherever possible. Maintaining comparable sampling coverage will improve the ability to distinguish genuine changes in stock abundance and cohort survival from variation associated with spatial distribution. The long-term dataset could also contribute to future food-availability modelling to assess the contribution of cockles to the prey resources available to overwintering birds on the Exe Estuary.

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