Taw Torridge

Cockle Stock Assessment 2025

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Contents

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1. Introduction

1.1 The Taw-Torridge Estuary

The Taw-Torridge Estuary is located on the North Devon coast, within the Area of Outstanding Natural Beauty (AONB) and the North Devon UNESCO Biosphere Reserve (Figure 1).

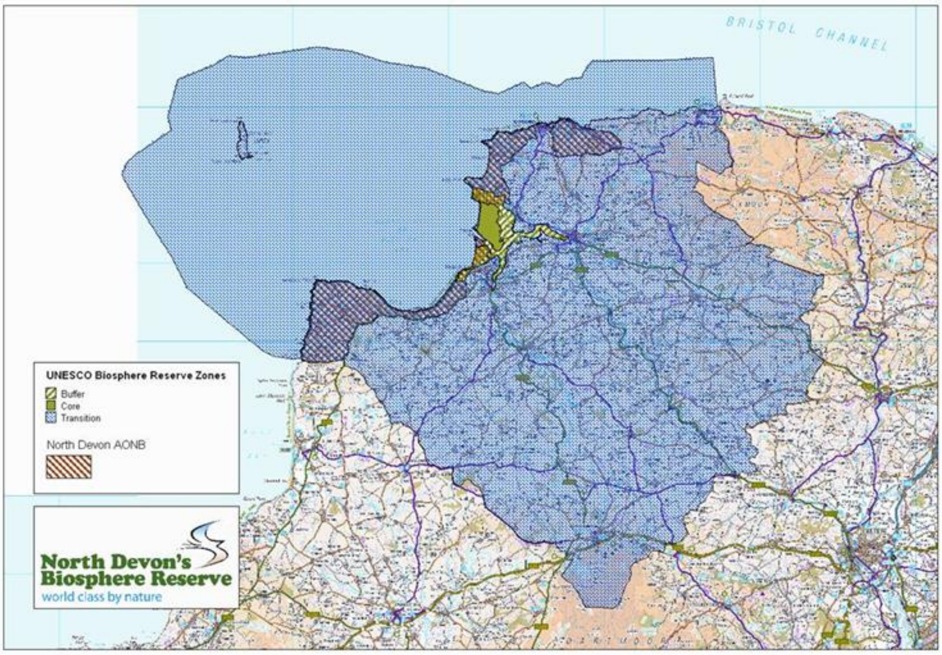


Figure 1 The location of the Taw Torridge Estuary (shown in yellow) within the North Devon Biosphere Reserve and the North Devon Coast AONB. (North Devon AONB and Biosphere Reserve Service, 2010)

The Taw Torridge Estuary is an important site for wildlife and has been designated a Site of Special Scientific Interest (SSSI) (Figure 2) for over-wintering and migratory populations of wading birds, and for the rare plants found on its shores. Parts of the Estuary also lie within the Braunton Burrows Special Area of Conservation (SAC) (Figure 3). The qualifying habitats on the intertidal section of the SAC are mudflats and sandflats not covered by seawater at low tide; intertidal mudflats and sandflats.

Cockles, *Cerastoderma edule,* are present within the estuary and are known to be collected at low levels both historically and to the present day (Cefas, 2013, 2020). Unlike the mussels in the Taw Torridge Estuary which have been harvested at a commercial level, the cockle stock has never reached a large enough level to be harvested commercially.

Devon and Severn Inshore Fisheries and Conservation Authority (D&S IFCA) understands the social and ecological importance of these beds and has undertaken survey work to establish the population structure, biomass, and distribution of cockles within the areas of the estuary where cockles are known to be present. The biomass of cockles estimated as a result of these surveys can be fed into a shellfish ecological requirement model developed by Bournemouth University, which allows an estimate to be made of the ecological requirements of wading birds (specifically oystercatchers, *Haematopus ostralegus*) feeding on shellfish in the areas surveyed by D&S IFCA.

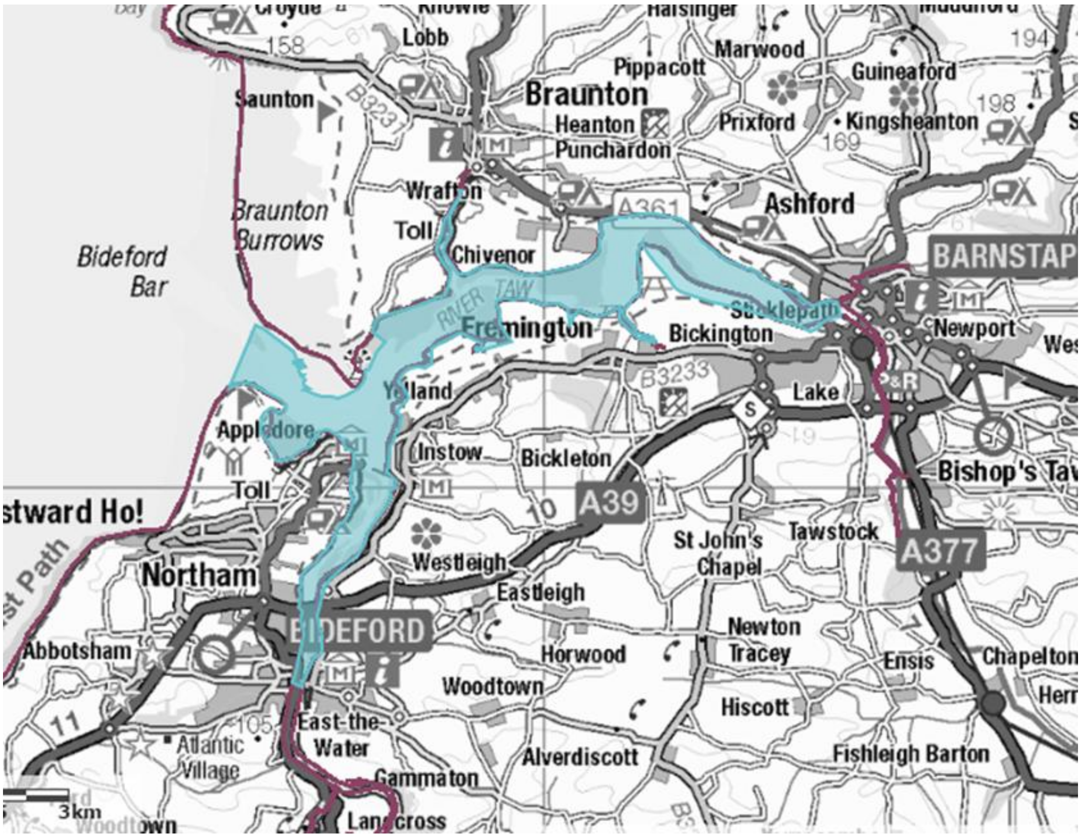
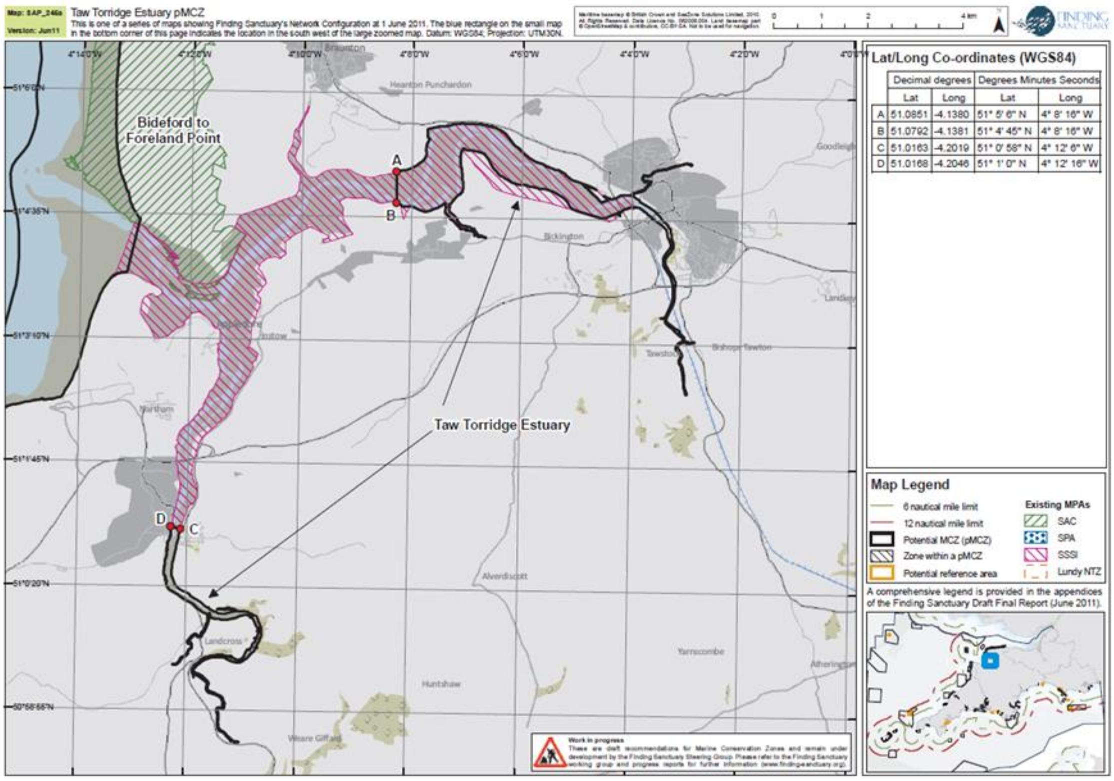


Figure 2 Taw-Torridge Estuary SSSI, shown in blue (Defra, 2020)



	Decimal degrees		Degrees Minutes Seconds	
	Lat	Long	Lat	Long
A	51.0851	-4.1380	51° 5' 6" N	4° 8' 16" W
B	51.0792	-4.1381	51° 4' 45" N	4° 8' 16" W
C	51.0163	-4.2019	51° 0' 58" N	4° 12' 6" W
D	51.0168	-4.2046	51° 1' 0" N	4° 12' 16" W

Figure 3 Area of Taw-Torridge SSSI shown in red hatching, and area of Braunton Burrows SAC shown in green hatching (Lieberknecht L.M et al. *2011)*

2. Methods

2.1 Survey Method

Cockle surveys were carried out at Instow on 6th October 2025 (Figure 4). The survey was carried out at low water spring tides. Survey locations were originally identified from anecdotal information of where harvesting was known to be carried out in the past. The Instow survey area remained the same for 2025 as in previous years. Surveys were not conducted at Old Walls in 2025 due to the overall low tonnage of cockles present in previous surveys, balanced against limited Officer time.

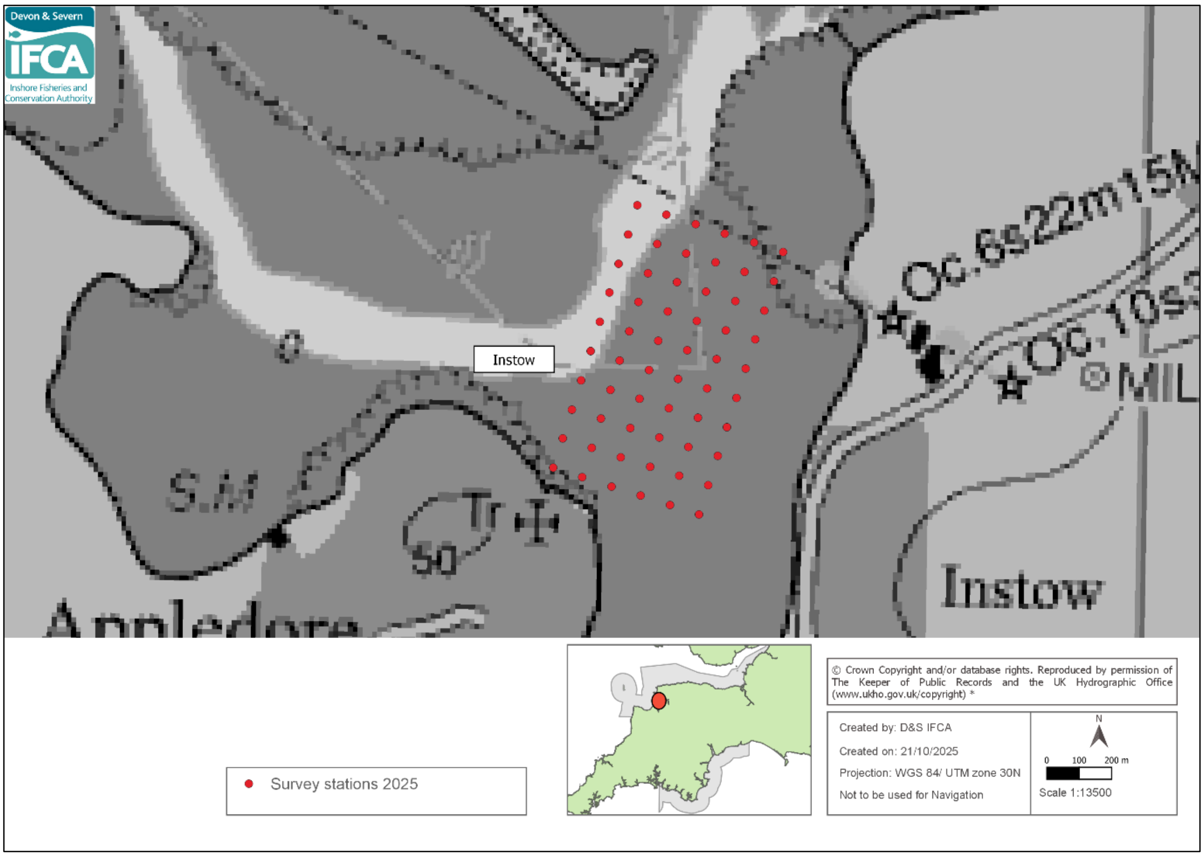


*Figure 4 Survey locations at Instow. Old walls site (not shown) was not surveyed in 2025. *www.ukho.gov.uk/copyright*

Each survey station was located using a handheld GPS. A 0.1m^2 quadrat was randomly placed within 10m of the target position for the station. Using a trowel, the sediment was removed from the quadrat to approximately the depth of the quadrat (~ 6cm) into a sieve. The contents were then sieved in nearby pools of water (Figure 5). Any cockles in the sample were put into a sample bag with a label of the station name. If no cockles were found or if the station wasn't accessible to be surveyed, it was noted as such.

Figure 5 Photos showing cockle sample method. Images taken from Exe cockle survey

For each station sample collected, each cockle was measured using callipers to the nearest millimetre for length and width (Figure 6).

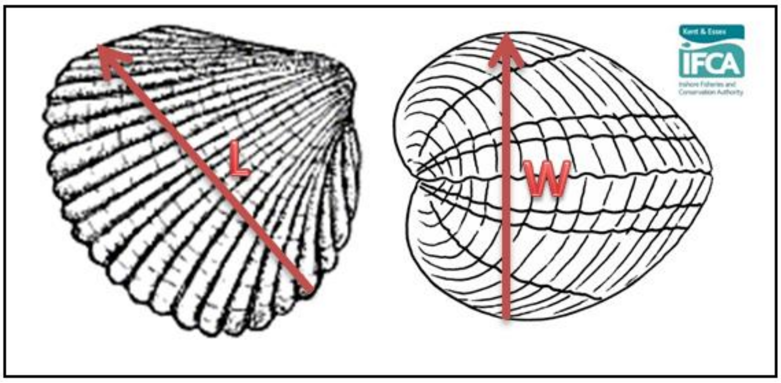


Figure 6 Cockle length (L) and width (W) measurements.

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 therefore 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 gram 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 v3.22 or later (QGIS 2022) were used for data analyses.

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.

Generalised linear mixed models (GLMMs) with survey station included as a random effect and year as a fixed effect were used to assess whether there was any variation in average adult and juvenile cockle density between years whilst accounting for variation in cockle density between survey stations. The best-fitting GLMM structure for models of both adult and juvenile cockle density used poisson family and log link (R package *lme4*; (Bates *et al.* 2015)). The relevant contrasts (comparisons between years) were evaluated using the 'emmeans' package (Lenth, 2024), to establish which years were significantly different from one another.

To visualise the variation in density across the sample sites, the density of cockles at each sample location was plotted on a map using Inverse Distance Weighted interpolation of per-station density (distance coefficient 2, pixel size 0.00005), using an external buffer of half of the distance between sampling points. The size frequency distributions (length and width) of cockles were visualised using histograms 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 sample area was calculated by scaling the mean cockle weight per station ($0.1m^2$) (whether cockle was present or not) to the total cockle bed area. Any points which could not be surveyed were not included in the calculation. The tonnage of prey-sized cockles (>15 mm) for wading birds on the estuary was calculated by multiplying the total tonnage by the proportion of prey sized cockles on the bed.

Due to no survey being conducted at Old Walls in 2025, only data for Instow from 2022-2025 have been used for the purpose of comparisons in this report.

3. Results

The total number of stations surveyed at Instow each year from 2022–2025 is shown in Table 1 and Figure 7. In each year between 62% and 73% of the possible survey stations were surveyed, with the variation being 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 the 2023–2025 period.

Table 1. Number of stations surveyed/not surveyed and number of stations where cockles were present in each year at Instow. The total number of potential stations was 60.

	2022	**2023**	**2024**	**2025**
Number of stations surveyed	37	44	43	44
Number of stations with cockle present	27	27	28	30
Number of stations not surveyed	23	16	17	16

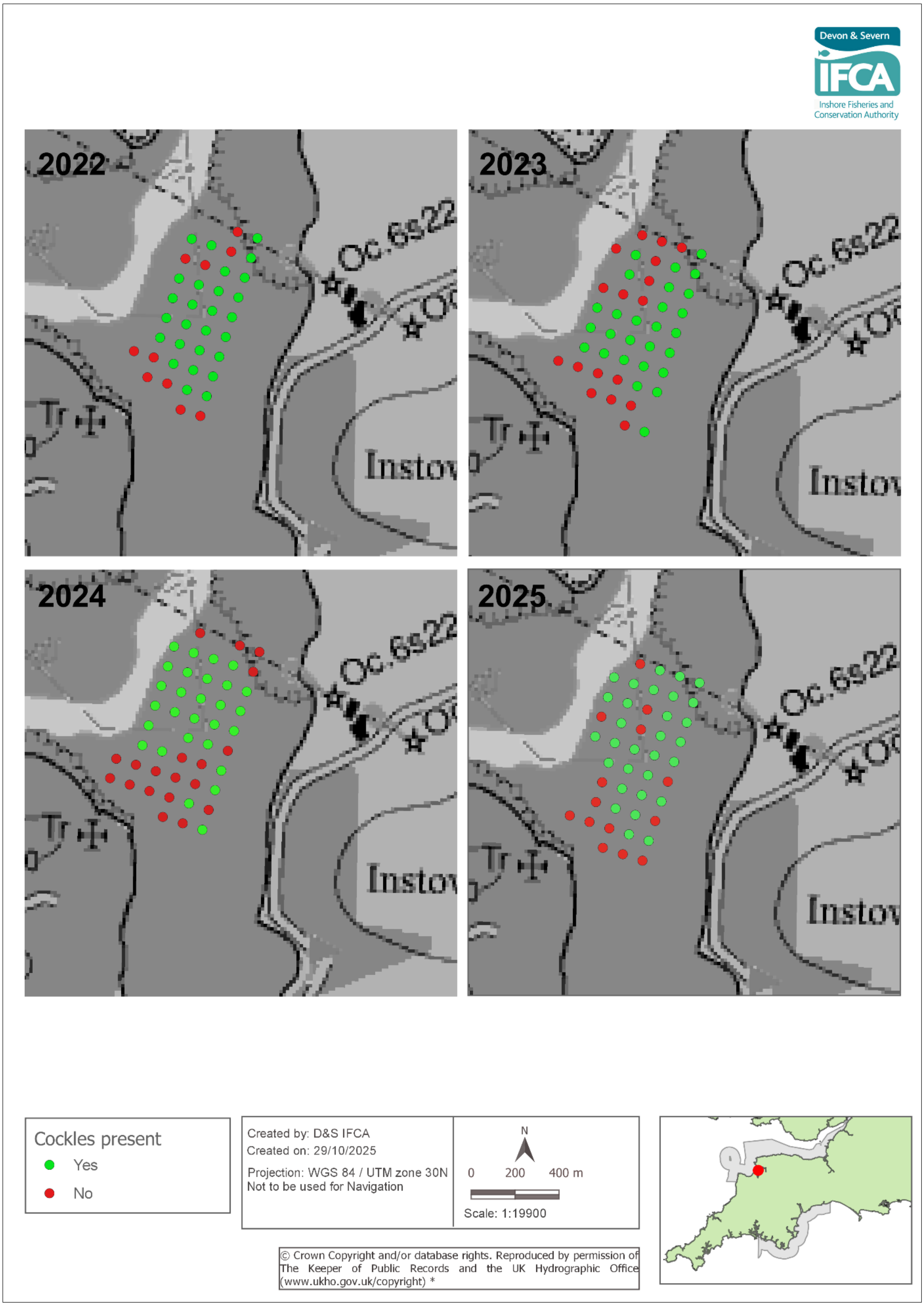


Figure 7 Survey stations from 2022 – 2025 with cockles present (green) or absent (red).
*www.ukho.gov.uk/copyright

The density of adult and juvenile cockles appears to follow a similar pattern in that density has declined from 2022-2024 and then slightly increased in 2025 (Figure 8a,b; Table 2a,b). Post-hoc analysis suggests that both the decrease in adult and juvenile cockle density between 2022 and 2024 and the slight increase from 2024 to 2025 is significant (Table 3a,b). It should be noted that there is high variation within years (between survey stations) as demonstrated by the error bars (Figure 8a, b) and reasonably variance in the 'station' part of the model which was included as a 'random effect' (denoted σRE in Table 2).

The area of highest cockle density appears to have varied across the survey site since 2022 (Figure 9).

Table 1. Summary of AIC analyses for GLMMs explaining the variation in (a) adult and (b) juvenile cockle density (number of cockles per 0.1m^2 quadrat) from 2022–2025. M_{test} denotes the model testing for an effect of year on cockle density. Also presented for comparison is the null model (M_{null}). Parameter estimates (with standard errors) are shown for the intercept (β_0), and year (Year). K is the number of parameters, LL is the log-likelihood of the model and σRE is the variance of the random effect (sample station). ΔAIC is the difference in AIC between M_{null} and M_{final}. All models fitted with Poisson error distribution and log link function. * denotes the most parsimonious model.

(a)

Model	β_0	$Year_{2022}$	$Year_{2023}$	$Year_{2024}$	$Year_{2025}$	k	LL	σRE	ΔAIC
M_{test}*	0.536 (0.195)	0.884 (0.063)	-0.265 (0.081)	-0.653 (0.090)	-0.034 (0.072)	5	-438.3	1.476	0
M_{null}	0.611 (0.195)	-	-	-	-	2	-539.2	1.49	195.84

(b)

Model	β_0	$Year_{2022}$	$Year_{2023}$	$Year_{2024}$	$Year_{2025}$	k	LL	σRE	ΔAIC
M_{test}*	0.009 (0.288)	0.525 (0.069)	-0.708 (0.098)	-0.434 (0.101)	0.617 (0.068)	5	-428.2	2.828	0
M_{null}	0.137 (0.000)	-	-	-	-	2	-509.8	2.848	157.19

Table 3. Estimated marginal means of pairwise comparisons for cockle density of (a) adults and (b) juveniles between years. Significant differences are denoted with *. Negative values for 'estimate' suggest that the focal year has lower cockle density than the comparison year; for example, in table (a) 2025 has higher density than 2024 (first row), while 2025 has lower density than 2022 (third row).

(a)

Contrast	Estimate	SE	Z ratio	*p* value
2025 - 2024	0.686	0.136	5.037	<0.0001*
2025 - 2023	0.298	0.126	2.375	0.0818
2025 - 2022	-0.851	0.102	-8.321	<0.0001*
2024 - 2023	-0.388	0.147	-2.638	0.0415*
2024 - 2022	-1.537	0.129	-11.947	<0.0001*
2023 - 2022	-1.149	0.114	-10.045	<0.0001*

(b)

Contrast	Estimate	SE	Z ratio	*p* value
2025 - 2024	1.2330	0.138	8.925	<0.0001*
2025 - 2023	0.9597	0.143	6.732	<0.0001*
2025 - 2022	-0.0917	0.094	-0.978	0.7623
2024 - 2023	-0.2735	0.1730	-1.585	0.3875
2024 - 2022	-1.3250	0.1380	-9.603	<0.0001*
2023 - 2022	-1.0514	0.1420	-7.429	<0.0001*

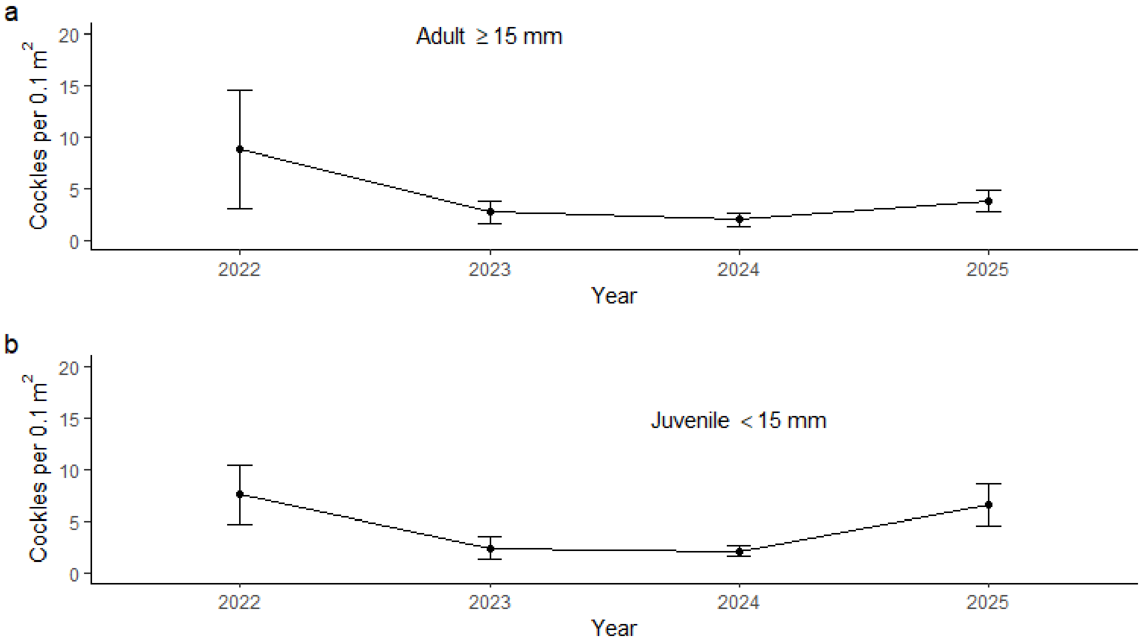


Figure 8 Mean density (± SE) of (a) adult cockles ≥15mm and (b) juvenile cockles <15mm at Instow 2022-2025

The average length of cockles across all survey stations has varied over the four years of sampling. (Figure 10). The shapes of frequency distributions of cockle length and width (Figure 11 and Figure 12) show some variations across years. In particular, 2022 and 2025 there appears to be a unimodal distribution (distribution with one peak) in cockle length and width, whereas 2023 shows more of a bimodal distribution (distribution with two clear peaks) and 2024 had relatively low frequency peaks (Figures 11 and 12). The average length of cockles varies between sample locations and years (Figure 13). In 2022 larger cockles were found in the north and west part of the survey site and smaller cockles were found in the east of the survey site. In 2023, average cockle sizes appeared to be larger across most of the survey site. In 2024 and 2025, on average, larger cockles were found in the south of the survey site, whereas smaller cockles were found in the east of the survey site (Figure 13).

Figure 9 Cockle density (number of cockles per 0.1m² quadrat) at Instow 2022-2025, mapped using Inverse Distance Weighted Interpolation.

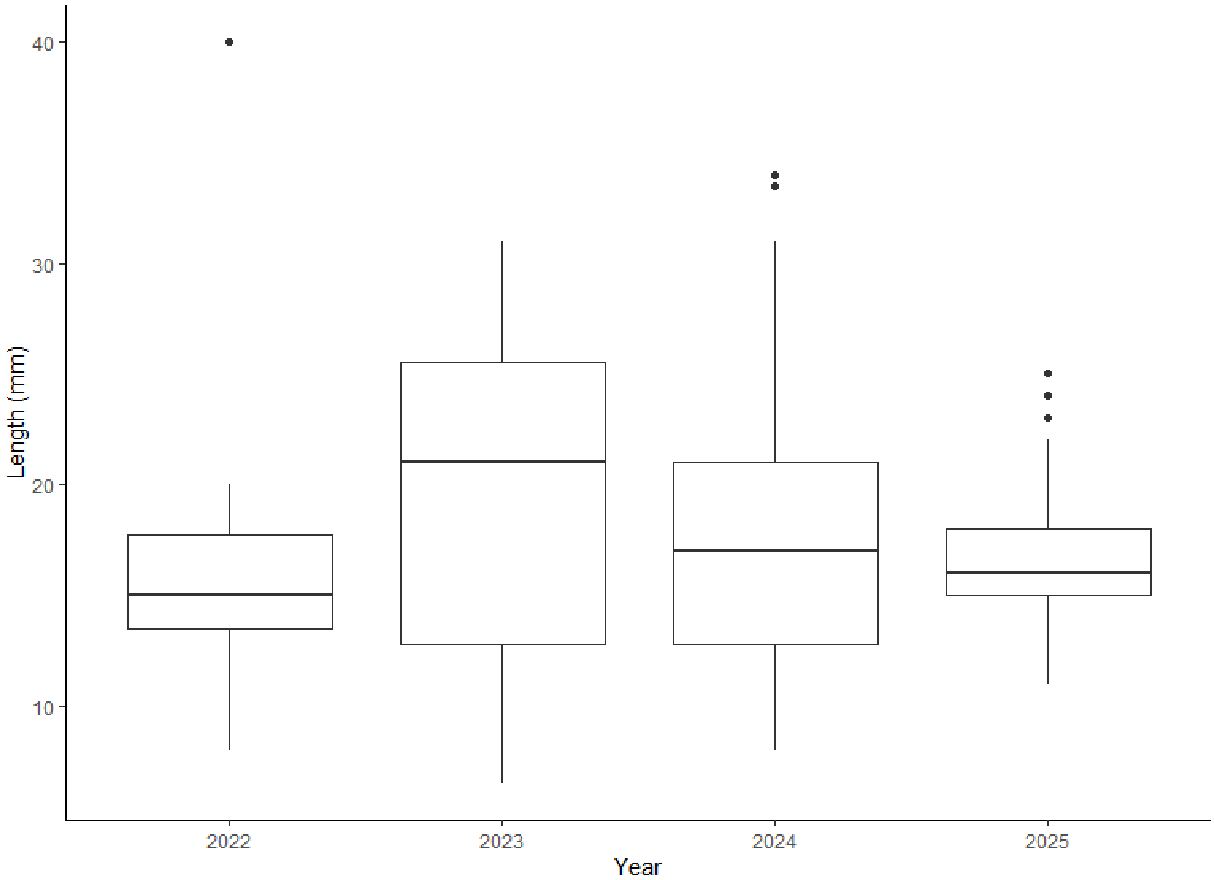


Figure 10 Length (mm) (median, inter-quartile range and range) of cockles at Instow 2022-2025

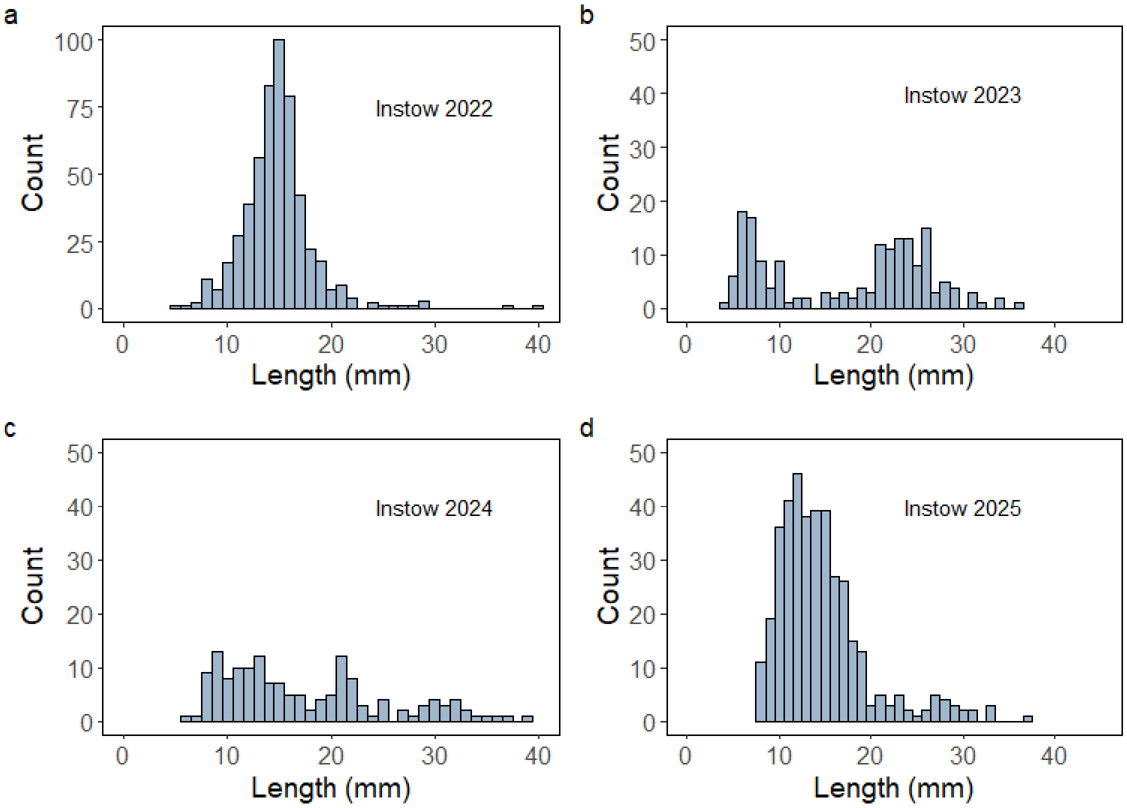


Figure 11 Frequency of cockle lengths (mm) at Instow 2022-2025

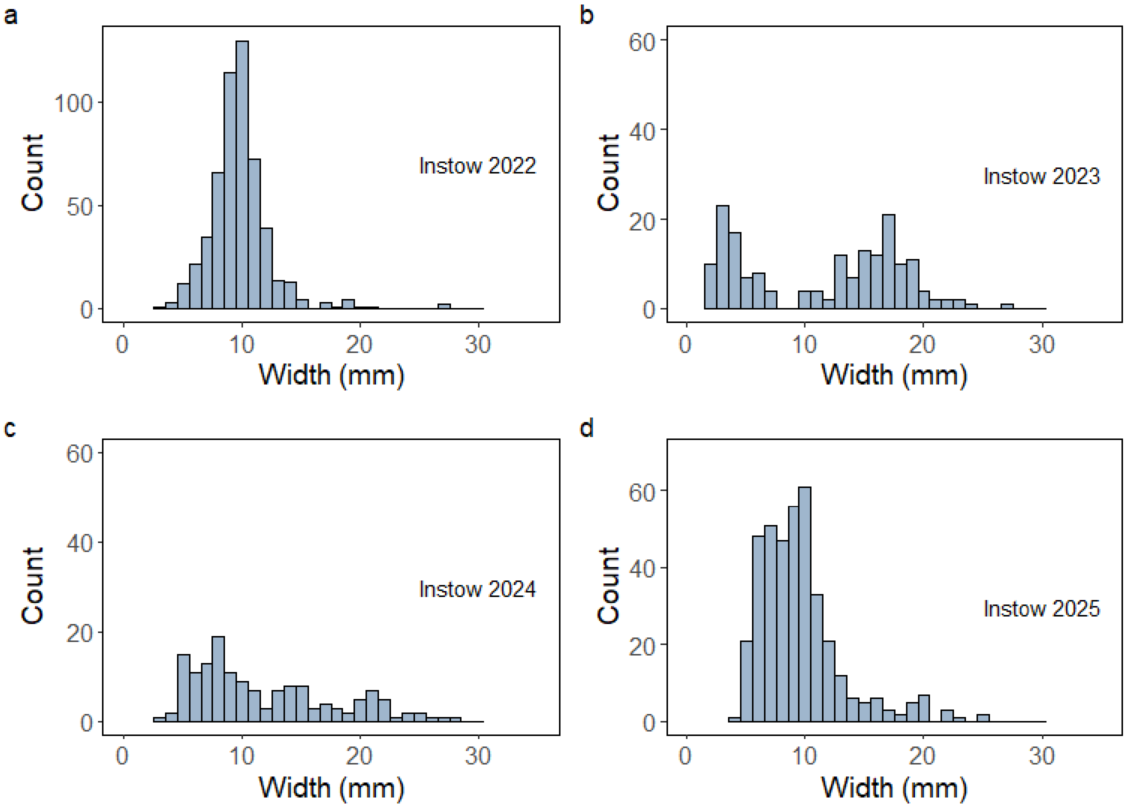


Figure 12. Frequency of cockle widths (mm) at Instow 2022-2025

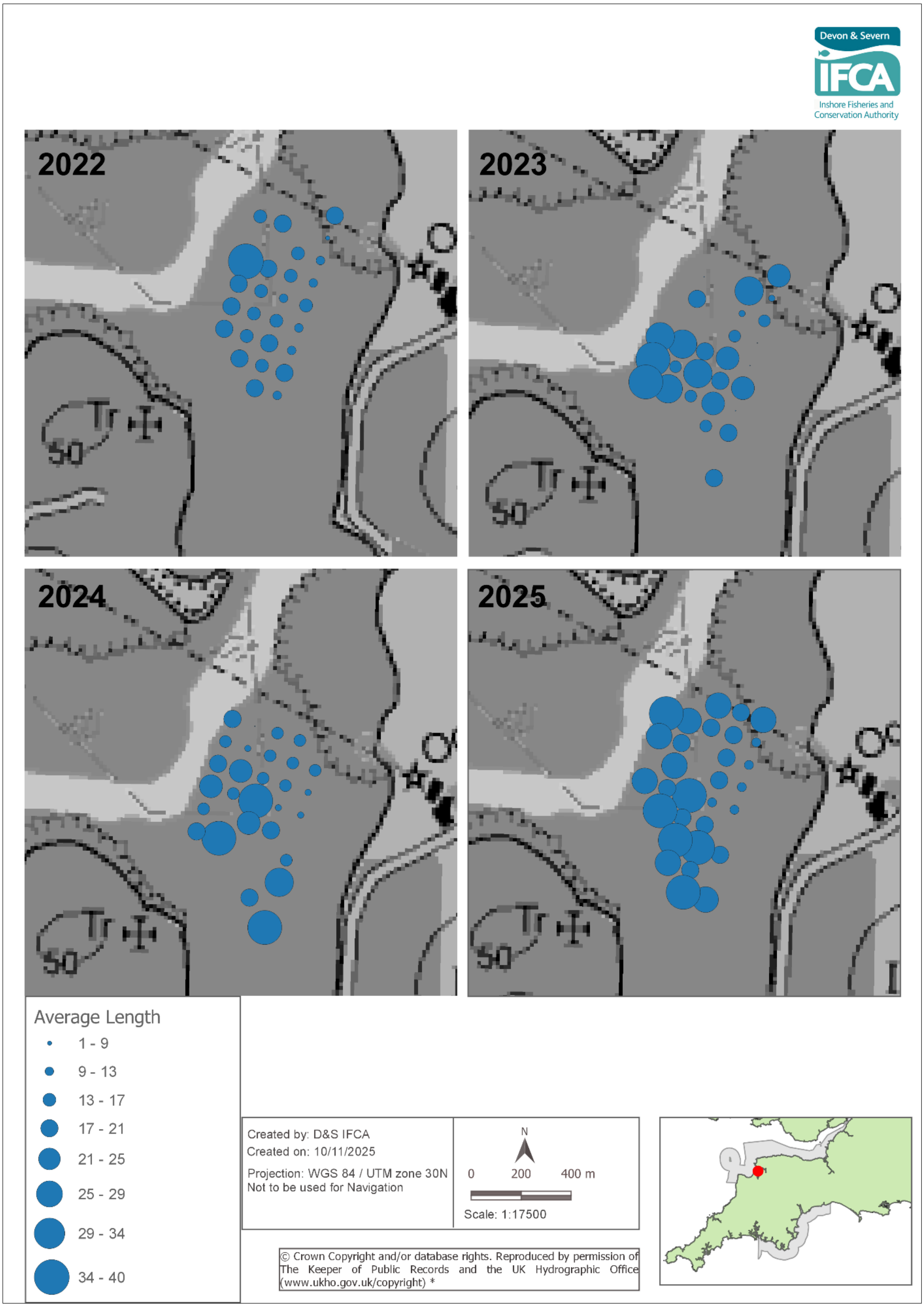


Figure 13. Median cockle size (mm) at each sampling station at Instow 2022-2025

There has been a decrease in estimated tonnage of cockles across the surveyed area from 2022-2024 and an increase from 2024-2025 (Figure 14). The total tonnage of cockles across the surveyed area in 2025 was estimated at 26.97 tonnes, 11 tonnes of which was >15mm. This is an apparent increase of around 25% in estimated total tonnage since the 2024 survey, where the total biomass was estimated at 21.56 tonnes. Despite the increase in overall tonnage, the proportion of cockles that are >15mm has decreased from 12.07* tonnes in 2024 to 11 tonnes in 2025. There is interannual variation in year class size (Figure15).

*The value reported in the 2024 report of 19.70 tonnes was identified as incorrect during the current analysis. The value has been corrected here.

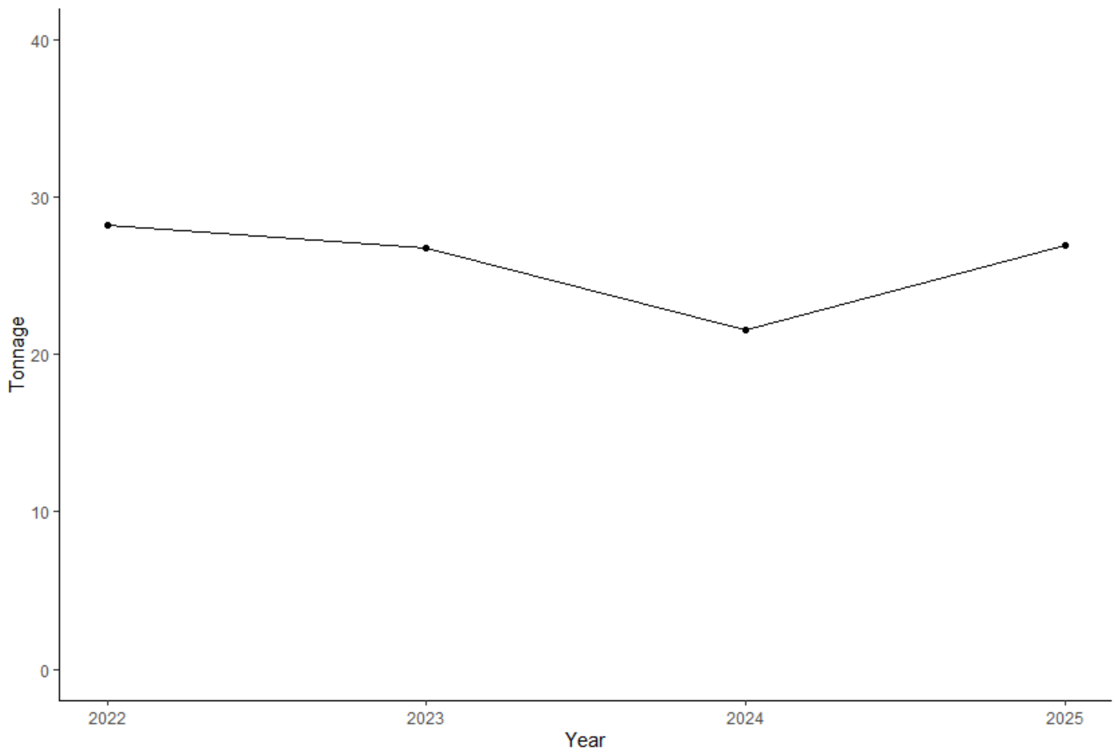


Figure 14. Total tonnage of cockles across survey area at Instow 2022-2025

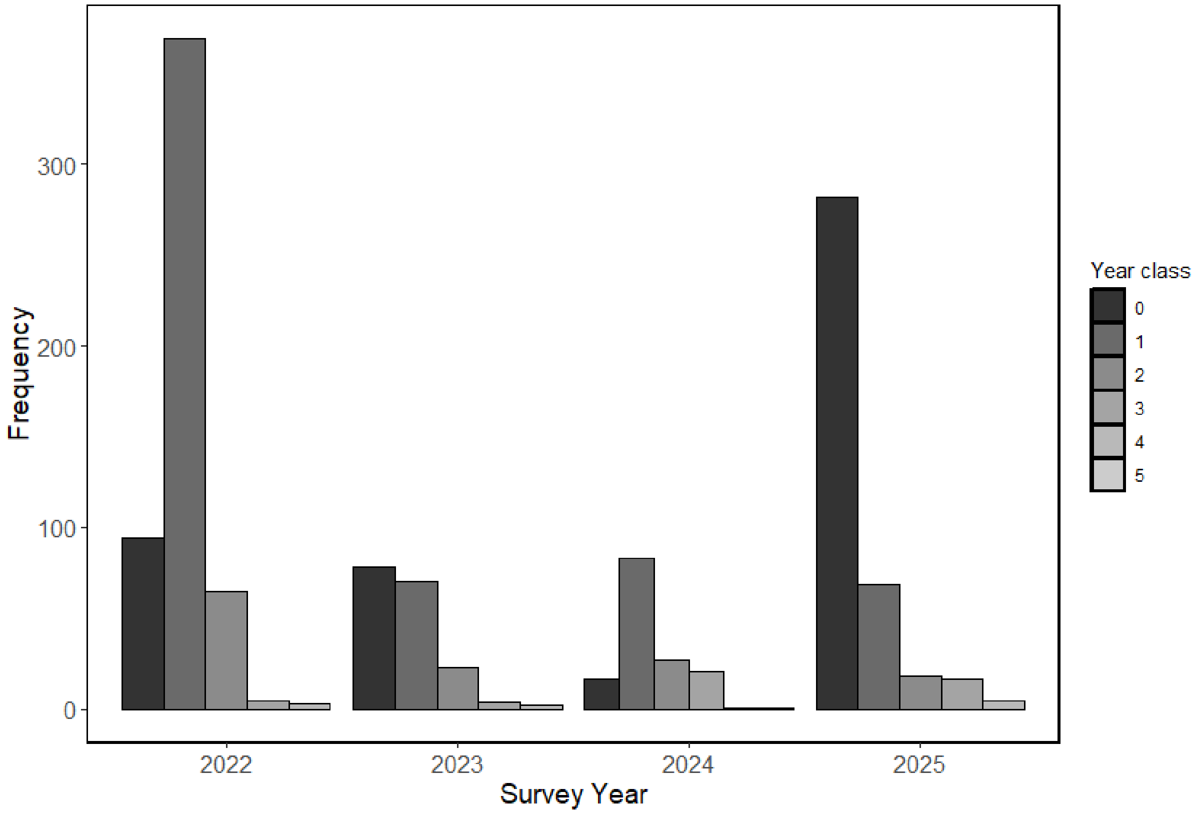


Figure 15. Number of cockles in each year class for each survey year at Instow 2022-2025

4. Discussion

D&S IFCA has carried out cockle surveys on the Taw-Torridge Estuary since 2022. The survey stations at Instow have been consistent since 2022 however, due to a lack of cockles found at the Old Walls survey stations in 2022 the survey stations were repositioned in 2023, and surveys were not conducted in 2025. Therefore, this report focuses on the density and sizes of cockles across Instow between 2022 and 2025.

The density of adult and juvenile cockles has decreased significantly between 2022 and 2024 but has increased between 2024 and 2025. The more recent increase in juvenile cockle density is to levels similar to that observed in 2022, however there was a high degree of variation within years (between survey stations). The apparently juvenile-heavy size frequency distribution in 2025 suggests that this may have been a strong year for recruitment of cockles on the Taw Torridge.

The density of cockles appears to be highest around the centre and eastern areas of the survey site but varies between years. Differences in hydrology across the study area could explain the variation in cockle density, as cockles prefer moderately strong (1-3 knots) tidal flow (Tyler-Walters 2007). Cockle density is also shown to be higher when in proximity to and within local hydrological features such as channels and tidal pools (Tyler-Walters 2007). Cockles typically display a preference towards stable submerged or intertidal muddy sandy habitats, where if conditions are favourable (salinity, access to food, temperature, recruitment of juveniles can be facilitated etc) then populations can thrive (Boyden and Russell, 1972; Brock, 1979; Correia *et al.*, 2025; Guillou and Tartu, 1994; Whitton *et al.*, 2015;). The sediment over the entire survey area is sand and muddy sand but may be more stable around the centre of survey site as opposed to the fringing sediments that may be more subject to increasing scour by the tide making it more mobile (Dalrymple and Rhodes 1995).

Evidence from the literature suggests that at high population densities, cockle growth rate is lower, 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 Taw-Torridge Estuary suggest that the average density of adult cockles is ~432 individuals m^{-2}. Therefore, the patterns in the average size of cockles observed across sample locations could partly be attributed to reduced growth rates at higher densities, particularly for juveniles, or due to random variation in cockle sizes across sample sites. Higher average sizes but lower densities tend to be seen in areas nearer the main channels of both the Taw and Torridge, whereas lower sizes and higher densities are found in areas further up the shore. One possible explanation is the difference in tidal inundation. Low shore areas near the main estuary channels remain submerged for longer during each tidal cycle and are therefore exposed to shorebird predation for shorter periods. Reduced exposure to predation by oystercatchers (*Haematopus ostralegus*) may allow a greater proportion of cockles to survive and grow to larger sizes. In contrast, higher shore areas remain exposed for longer and may experience greater predation pressure on cockles that fall within the preferred prey size for wading birds. These areas may still support high densities of smaller cockles, which are less profitable and therefore less-frequently targeted prey.

Predation plays an important role in the recruitment and population dynamics of the common cockle. (Sanchez-Salazar *et al.,* 1987). Sanchez-Salazar *et al*. (1987) reported that cockles on the lower shore experienced high mortality (96%) at small sizes, largely due to summer predation by shore crabs (*Carcinus maenas*), which preferentially consume cockles smaller than 15 mm. Mortality decreased as individuals grew larger. In contrast, cockles higher on the shore showed moderate first-year mortality (around 47%), but mortality increased with size due to winter predation by oystercatchers, which typically select cockles larger than 20 mm. Consequently high-shore areas consisted mainly of smaller individuals and low-shore ones of a transient spatfall, plus a few larger and older individuals

Tidal exposure may further influence these patterns, as increased exposure generally leads to smaller and more slowly growing cockle populations due to reduced immersion time limiting feeding opportunities (Montaudouin, 1996). These combined effects of tidal exposure and predation may therefore help explain the size and density patterns observed in cockle populations across the Taw Torridge Estuary.

The variation in cockle size frequency distributions observed in this report 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 some of the alternating patterns of unimodal and bimodal size distributions seen between 2022-2023 and 2024-2025.

However, it is also important to consider the possible variation in cockle size across years that may arise from the small differences in 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 occur 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 (**Error! Reference source not found.** 9 and 13), as discussed above.

In addition to the variation in cockle size and density, the total biomass of cockles on the bed has also varied year on year. However, when interpreting the results it is important to consider the high variability between stations and across years, as these factors may hinder the accurate detection of subtle changes in the cockle population. Cockle populations are naturally subject to high levels of variation, which is considered a normal feature of their populations. Therefore, long-term monitoring is required to detect potential trends in the population dynamics of any given cockle population (Jensen, 1992; Whitton *et al.*, 2015).

D&S IFCA has conducted annual surveys to monitor the cockle stocks on the estuary, alongside annual surveys of mussel stocks, in order to inform the annual assessment of the shellfish available for use as a prey resource by the overwintering birds of the Taw-Torridge SSSI. The size of the cockle stock is consistently low compared to the mussel stock and is relatively less important for the overwintering birds. There is also currently no commercial fishery for cockles on the Taw-Torridge Estuary. D&S FCA will consider whether continued surveys of the small cockle stocks on this estuary are feasible in the context of the scientific need and the limited resource available to D&S IFCA.

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