Teign Estuary
Mussel Stock Assessment 2024

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Devon & Severn IFCA
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1. Introduction

1.1 *Mytilus edulis*

Blue mussels, *Mytilus edulis*, are cold-water mussels which can occur in brackish water (Gardner, 1996). They are found on the north Atlantic and north Pacific coast of North America, Europe and in other temperate and polar waters. Blue mussels can occur intertidally and subtidally, and on a variety of substrates, from rocks to sediments, and in a range of conditions. “Blue mussel beds on sediment” are listed as a UK Biodiversity Action Plan (BAP) Priority Habitat (JNCC, 2011). This includes a range of sediments, such as sand, cobbles, pebbles, muddy sand and mud. The ability of *M. edulis* to occupy such a range of habitats results from its ability to withstand wide variation in salinity, desiccation, temperature and oxygen concentration (Bayne & Worrall 1980, Seed & Suchanek, 1992, Andrews et al., 2011).

M. edulis beds play an important role in the healthy functioning of marine ecosystems, having a role in coastal sediment dynamics, acting as a food source to wading birds, and providing an enhanced area of biodiversity in an otherwise sediment-dominated environment (JNCC, 2011). Mussel beds support their own diverse communities as the mussel matrix, composed of interconnected mussels and accumulated sediments and debris, provides numerous microhabitats and an organically enriched environment (Andrews et al., 2011, Seed & Suchanek, 1992). Blue mussels are filter feeders, feeding primarily on micro-algae, suspended debris and zooplankton, and play a vital role in estuaries by removing bacteria and toxins.

The reproductive strategy of *M. edulis* is to deploy a large number of gametes (eggs and sperm) into the surrounding water, where fertilisation takes place (Andrews et al., 2011). Following fertilisation, the planktonic larvae undergo six stages of metamorphosis before settlement. Mussels can adapt their reproductive strategy depending on environmental conditions. For example, the release of gametes can be timed to co-occur with favourable environmental conditions, and the planktonic larval phase can last between two and four weeks depending on temperature, food supply and availability of a suitable substrate to settle on (Andrews et al., 2011). Depending on temperature and nutrient levels, spawning may occur just once or several times per year (Bayne & Worrall 1980, Seed & Suchanek 1992, Handå et al., 2011).

Current threats to *M. edulis* beds include commercial fishing, poor water quality, coastal developments, anchoring, bait digging, and intensive recreational hand gathering (JNCC, 2011).

1.2 Objectives

The objective of this project is to carry out and report on biennial surveys of the public mussel beds on the Teign Estuary, to define where the mussel beds are and accurately map, using GIS, the overall extent of each of the mussel beds. The surveys provide data for a stock assessment of the beds to estimate the density of mussels on the beds and the total stock of mussels, which can be compared to previous years. This will help inform future management of the mussel beds on the Teign and the development of shellfisheries in this part of the Devon & Severn IFCA District.

2. Methodology

2.1 Study Site: The Teign Estuary

The Teign Estuary is situated on the south coast of Devon, within the Devon and Severn Inshore Fisheries and Conservation Authority (D&S IFCA) District, and consists of an East-West aligned, broad tidal river channel. It has no current Marine Protected Area designation. Commercial harvesting of mussels (*Mytilus edulis*) and Pacific oysters (*Magallana gigas* formally known as *Crassostrea gigas*) occurs in the Teign under the River Teign Mussel Fishery Order 1966 and the River Teign Mussel Fishery (Variation) (Oysters) Order 1995, (Teign Estuary Partnership, 2004). Figure 1 shows the areas classified for *M. edulis* west of Shaldon bridge. From 1st May 2019, D&S IFCA introduced a temporary closure for the removal of mussels from the public shellfish beds in the Teign Estuary east of Shaldon Bridge due to the stocks being severely depleted.

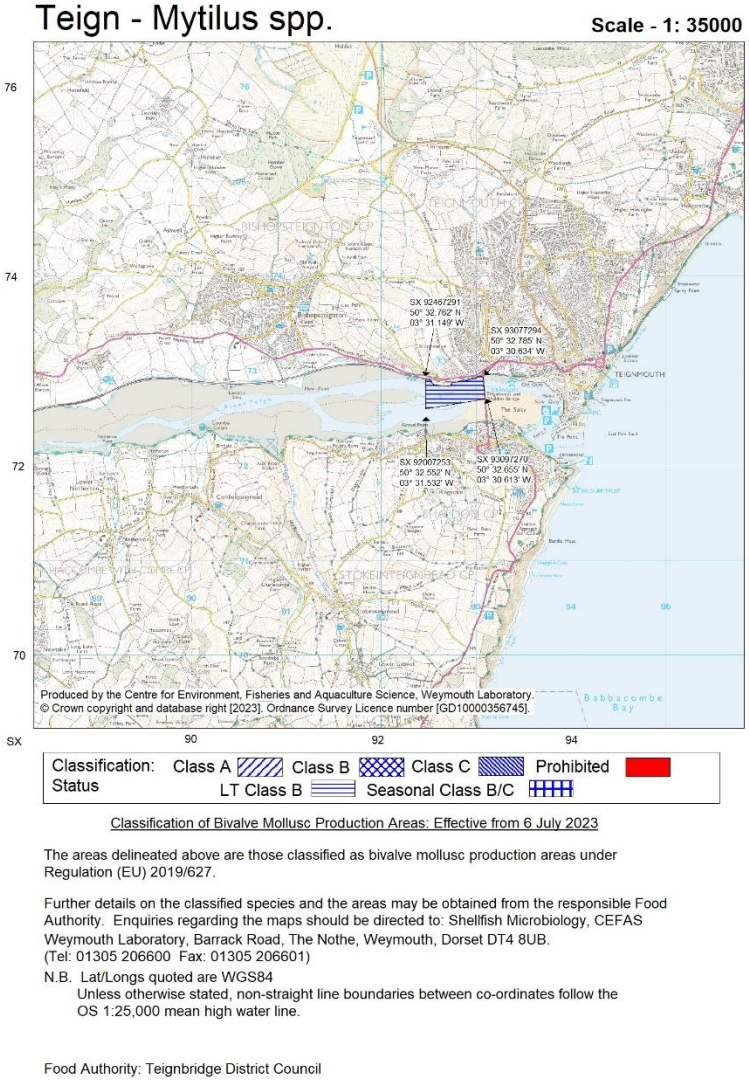

Figure 1 Classified Mussel Harvesting Areas on the Teign Estuary as they were classified during the surveys reported here (Cefas, 2023). Up to date classification zone maps are available on the Cefas website.

2.2 Survey methodology

This document reports on surveys conducted at the Salty in 2012, 2018-2020, 2022 and 2024; and at Salty East in 2022 and 2024. The Salty and Salty East were surveyed on 24th July 2024 during a spring low tide to ensure the full extent of the mussel bed was accessible. The survey area was determined based on previous survey locations and local stakeholder input as to the presence of mussel. Due to the absence of live mussel, Polly Steps was not surveyed.

Due to the varying levels of patchiness and density the area surveyed cannot always be indicative of the size of a true mussel 'bed' and is rather a representation of the area in which live mussels were located. This means that the survey area will not always be purely on mussel bed, but also on areas where mussels occur in small, dispersed patches. The perimeter of the survey area was recorded on the first visit to each bed by walking the extent of the live mussel habitat and marking coordinates with a handheld GPS. The Salty was first visited in 2012 and the perimeter was subsequently mapped in QGIS v3.2 (Figure 2).

In Figure 3 Salty East represents the perimeter of the bed walked by officers, within which mussel was present. The perimeter of the Salty was not walked by officers in 2022 or 2024 and therefore the edge of this bed has been determined using the start and end co-ordinates of the transects (Figure 3).

To determine coverage and patch density transects were walked in a zig-zag pattern across the survey area, up to the extent of live mussel bed (e.g. to the low water mark or the point at which substrate changed or mussels disappeared). The start and end coordinates of each transect were recorded using a handheld GPS. A 4 ft bamboo cane with an 11cm ring attached to the end, arranged so that the ring sits flat on the ground when held out to one side, was used to determine the mussel coverage for each transect. Every three paces (each pace consisting of a single step) along each transect the cane was placed out to one side and the presence or absence of live mussels within the ring were recorded. On every fifth hit (presence) the contents of the ring were taken as a sample, using an 11cm diameter corer. All mussel samples from the same transect were collected together in one bag and kept separate from those of other transects. This methodology is known as the Dutch Wand Method.

Once all transects are complete mussel samples are sieved and cleaned. For each transect the number of samples taken is recorded, all mussels are then measured and divided into the following size groups; 1-10mm, 11-20mm, 21-30mm, 31-40mm, 41-50mm, 51-60mm, 61-70mm, 70+mm.

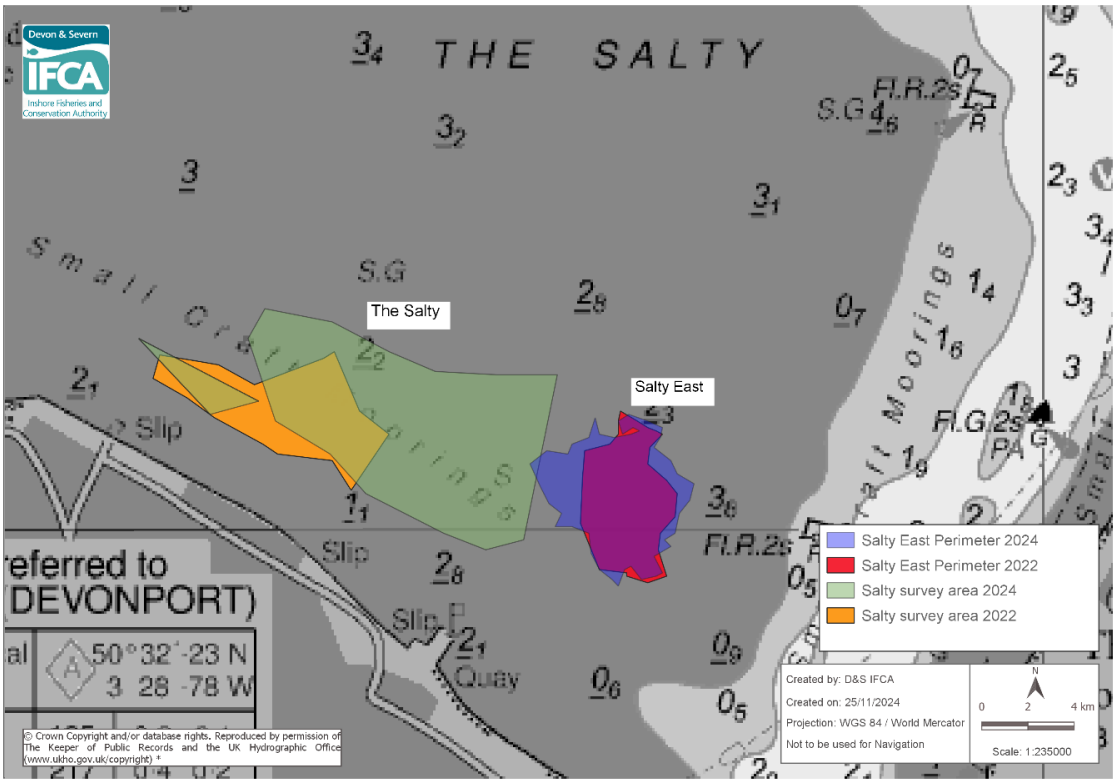

Figure 2 Area of mussel bed at the Salty in 2022 (orange) and 2024 (green) and Salty East in 2022 (red) and 2024 (blue). Bed area for the Salty was mapped generating a minimum convex polygon around the transect lines. The difference in surveyed area on the Salty between 2022 and 2024 was due in part to some areas being inaccessible due to water in 2024, while the area of the Salty adjacent to the Salty East patch was added in 2024 to ensure patches of mussel were not missed. The Salty East bed area was mapped using coordinates recorded of the edge of the bed walked by officers, within which mussel was present. * www.ukho.gov.uk/copyright

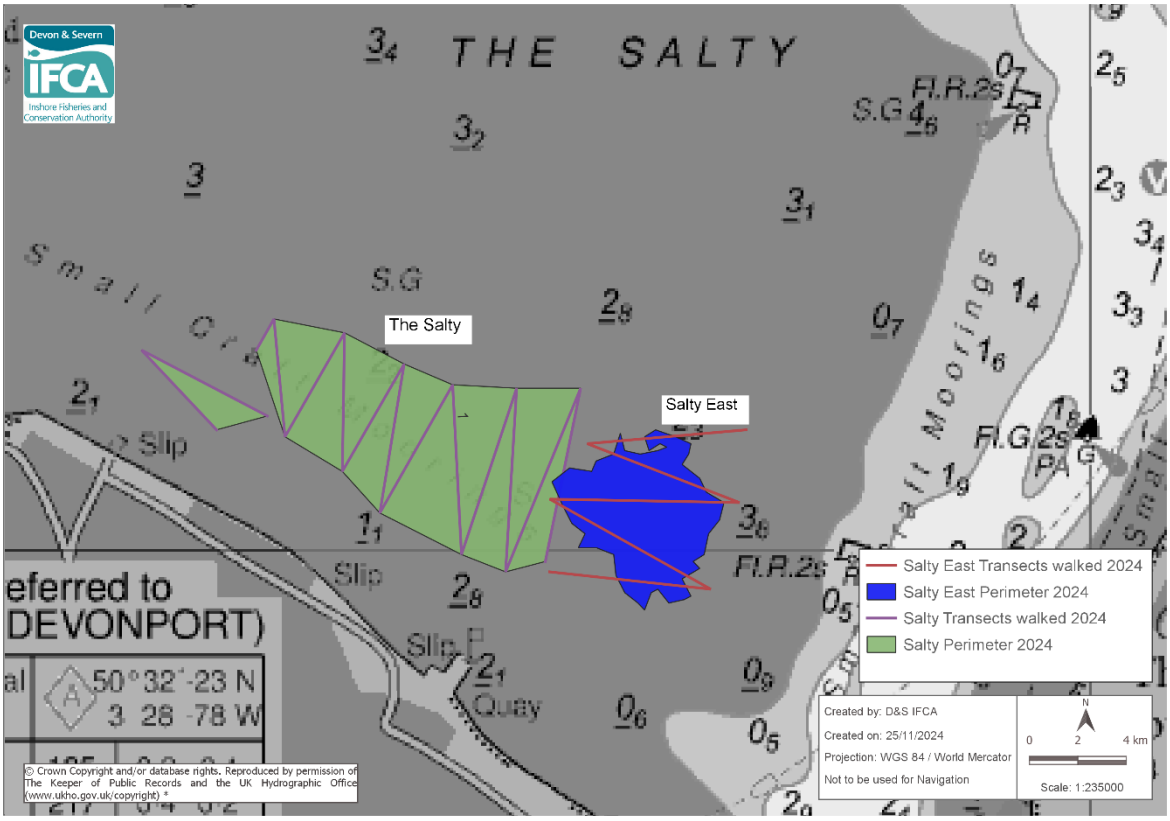

Figure 3 Area of mussel bed at the Salty (green) and Salty East (Blue) in 2024. Transect lines walked are shown in purple and red respectively. Bed area mapped by generating a minimum convex polygon around the transect lines for the Salty. The Salty East bed area was mapped using coordinates recorded of the edge of the bed walked by officers, within which mussel was present. * www.ukho.gov.uk/copyright

2.3 Data analysis

The data collected from both the transects and samples were used to calculate the percentage cover (Equation 1), density (Equation 2) and area of the survey area (by generating a minimum convex polygon around the transect lines), which were then used to estimate the mussel tonnage on each site (Equation 3). Total tonnage and survey area across all sites were calculated based on the weight of mussel in the samples taken and the metrics described above.

Equation 1: Calculation of the percentage cover of mussel

$$\%\ \boldsymbol{cover} = \frac{no.hits}{no.hits + no.misses}$$

Equation 2: Calculation of the density of mussel cover

$$\boldsymbol{Density}\ (\boldsymbol{kg/m^2}) = \frac{total\ mussel\ weight\ sampled}{surface\ area\ sampled} \times \%\ cover$$

Equation 3: Calculation of mussel tonnage

$$\boldsymbol{Tonnage\ of\ mussel} = \frac{Density\ \times 10{,}000\ \times Area(ha)}{1000}$$

3. Results

The results presented here focus on the areas in which mussels were found (The Salty and Salty East) and which were surveyed using the transect methodology outlined in section 2.2. Due to the absence of live mussel at Polly Steps this area was not surveyed.

3.1. The Salty

A total of 10 samples were collected from 14 transects on the Salty. The area surveyed has increased by 50% in 2024 compared to 2022 (Figure 4). In 2024 the surveyed mussel bed covered 1.4 hectares with an average mussel density of 3.8 kg m^{-2}, and contained a calculated 53 tonnes of mussel, compared to 36 tonnes in 2022 (Figure 4), an increase of 47%. The surveyed area has lower overall density and percentage cover than the area surveyed in 2022 (Figure 5). Of the total 53 tonnes of stock observed in 2024, 87% of this was >41mm in length, and 1.9% was spat (<30mm) (Figure 6).

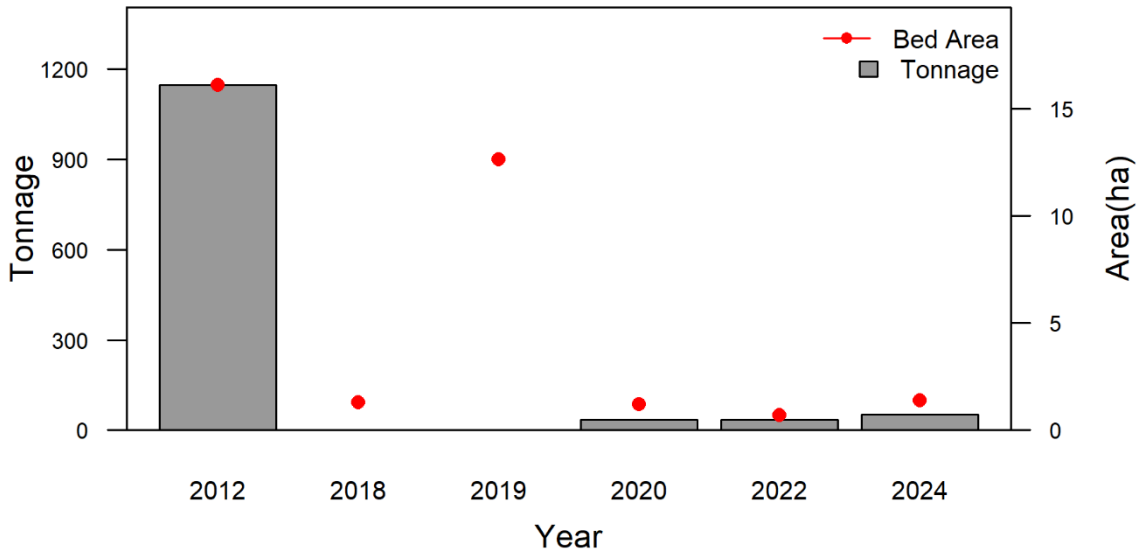

Figure 4 Total area surveyed plotted over tonnage of total stock within the Salty mussel bed in 2012 and 2018–2024. The "Bed Area" represents the surveyed area (encompassing the start and end of each transect). The perimeter of the Salty was not walked but transects were conducted over what was deemed the mussel bed by the presence and absence of live mussel.

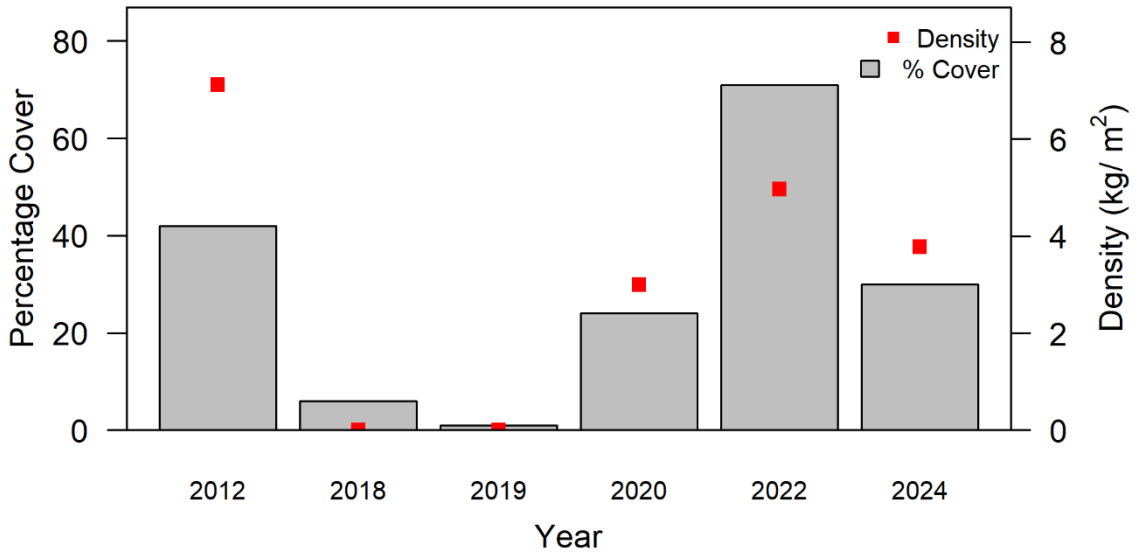

Figure 5 Percentage cover and density of mussel across the Salty in 2012 and 2018-2024. Though the average percentage cover in recent years (since 2020) has been similar to that observed in 2012, this is percentage cover over a much smaller bed area, with the remainder of the Salty bank largely devoid of mussel since the 2018 survey.

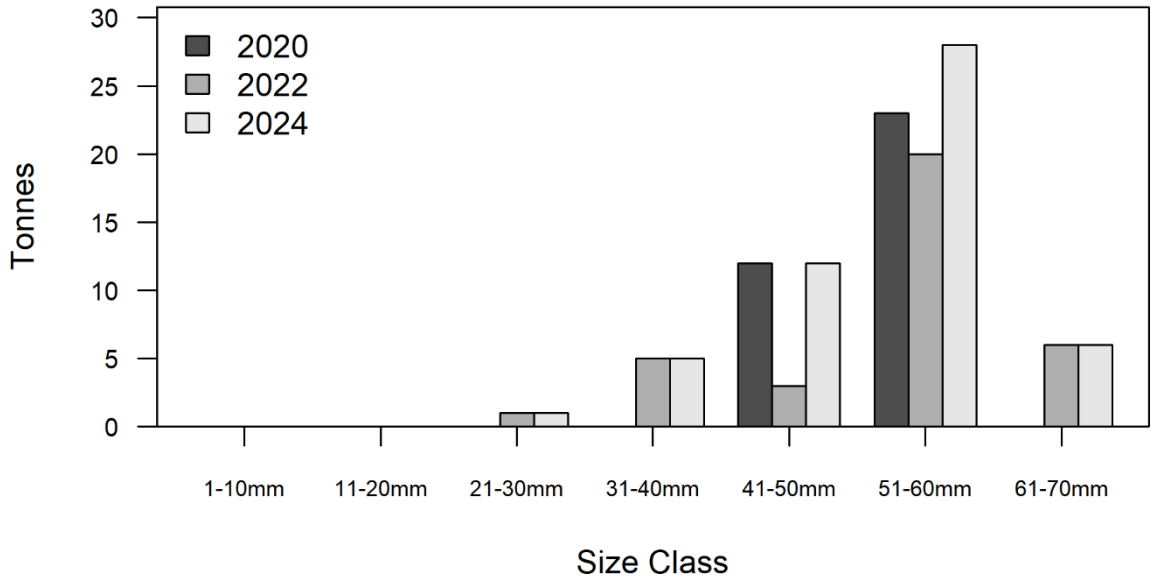

Figure 6 Tonnage of each 10mm size class for the Salty 2020, 2022 and 2024 stock.

3.2. Salty East

A total of 9 samples were collected from 5 transects on Salty East. In 2024 the surveyed mussel bed covered 0.5 hectares and contained a calculated 43 tonnes of mussel, almost four times the amount observed in 2022 (11 tonnes) (Figure 7). The surveyed area has increased in density to 8.67 kg m^{-2} of mussel compared to just 3.24 kg m^{-2} in 2022 but decreased to 47% coverage compared to 82% in 2022 (Figure 8). Of the 43 tonnes of stock

observed in 2024, 95% of this was >41mm in length and no spat (<30mm) was observed (Figure 9).

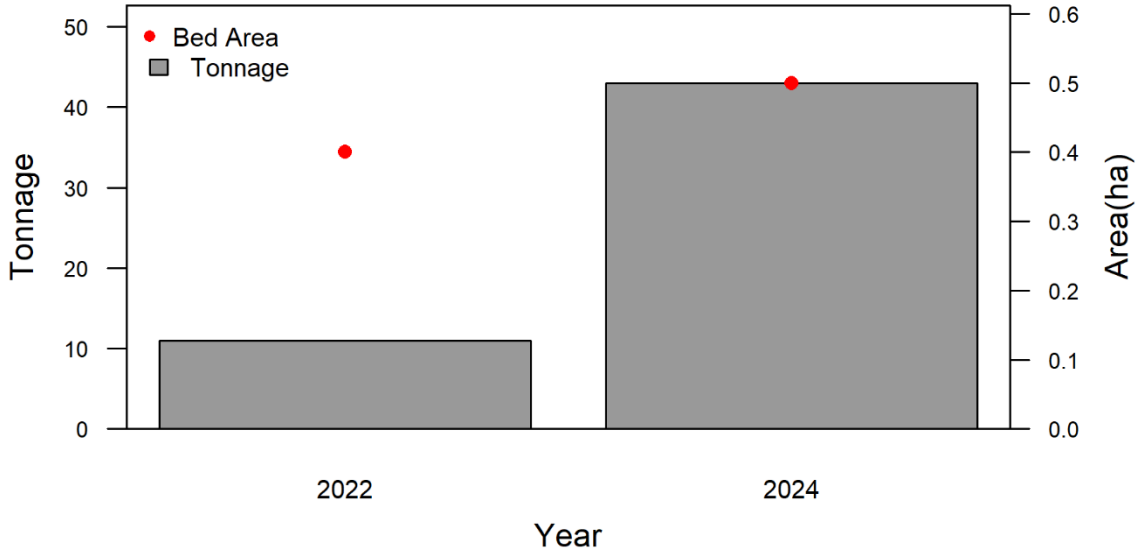

Figure 7 Total area surveyed plotted over tonnage of total stock within the Salty East mussel bed in 2022 and 2024. The “Bed Area” represents the perimeter of the bed walked by officers in which mussel was present.

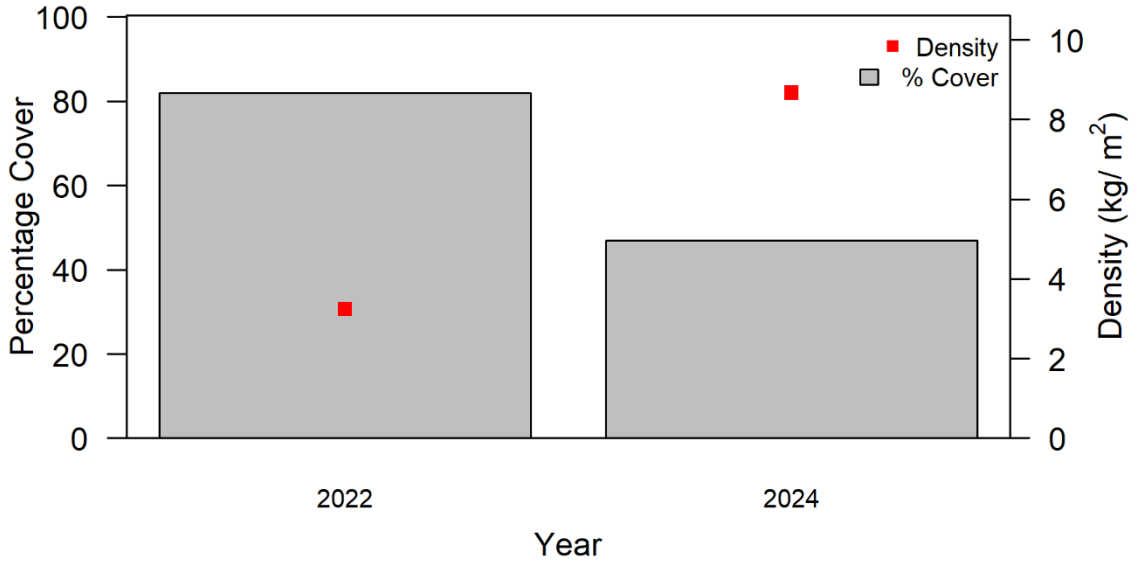

Figure 8 Percentage cover and density of mussel across Salty East in 2022 and 2024.

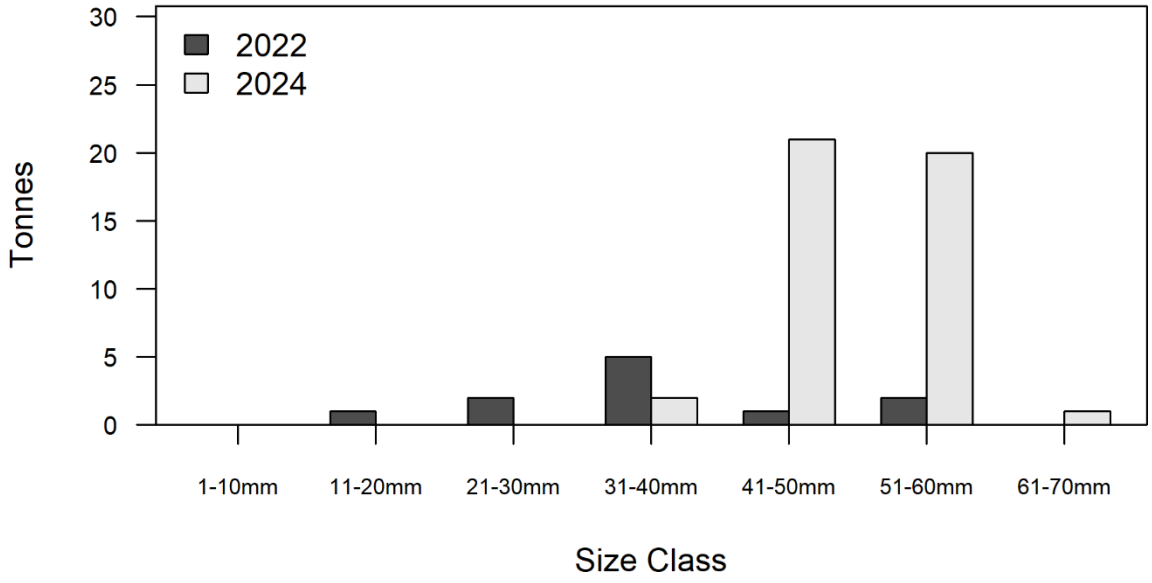

Figure 9 Tonnage of each 10mm size class for the Salty East 2022 and 2024 stock.

4. Discussion

Mussel populations within the Teign crashed between the 2012 and 2018 stock assessments, possibly due to the large storms in 2014 which may have scoured away once previously stable beds, and due to intentional removal of raised areas of mussel around boat moorings on the Salty. Mussel beds in 2012 covered 42% of The Salty, totalling 1148 tonnes (Gray, 2012). Since these events, mussel populations have been unable to recover to anywhere near the previous population estimates and both The Salty and Polly Steps are no longer areas on which large expanses of dense live mussel are found. Therefore, though the percentage cover of mussel recorded in recent years has been relatively high, thisis over a much smaller area than was surveyed in 2012, reflecting a diminished overall bed size and the lack of mussel over much of the Salty bank. Live mussel is present on the Salty but the bed has declined significantly since 2012 and the presence of live mussel has been effectively negligible at Polly Steps since 2020.

In 2012 and 2019, the majority of the accessible area on the Salty (whether mussel was obviously present or not) was surveyed, whereas in 2018, 2020, 2022 and 2024 smaller areas (only where mussel presence was obvious) were surveyed. This difference in survey methods between years has resulted in a lack of inter-annual data comparability but were useful in demonstrating the widespread absence of mussel across the Salty in years in which the survey area was large. The estimated density and percentage cover of mussels in 2018, 2020 and 2022 are likely over-estimates of overall density and percentage cover in the total area as the survey effort was focussed on areas with higher density or cover. Surveying larger areas using the same zig-zag transect method may have also caused some data comparability problems as in the larger survey areas the transect lengths would have been much longer and therefore the likelihood of acquiring the five ‘hits’ necessary to collect a sample will be greater. Although surveying smaller areas saves time, data comparability should be considered when interpreting the results and in planning future surveys. This should also be considered alongside the time constraints associated with these surveys, and the relative disadvantages of conducting longer, wider-angled transects which cover a larger

area but are prone to leaving large spaces of un-surveyed bed between transects, as discussed below.

The area of the Salty surveyed in 2024 has increased since 2022 due to some mussel being present towards the east of the bed. The perimeter of the Salty was not walked by officers, however, transects walked reflect what is deemed to be a mussel bed by the presence and or absence of live mussel. An area of mussel was surveyed to the west of the bed that was slightly separated from the main bed by a water channel (Figure 3). This area became accessible to officers due to tide conditions.

Between 2022 and 2024 there was an increase in surveyed stock sized 41-60mm. This increase in larger mussel size could suggest that mature mussel has grown into larger size classes over the last two years, or some mussel may have been missed during the survey conducted in 2022. In particular, in 2024 the Salty East area had much larger estimated tonnages in the 41-50 and 51-60mm size classes, despite there being much less mussel in these and smaller size classes observed in 2022. This suggests that the transects in 2022 may have missed a considerable amount of mussel and that the results of at least one (if not both) of the 2022 and 2024 surveys of Salty East were independently unrepresentative of the true state of this area of mussel. This may be due to the positions of transects walked by Officers relative to the presence/absence of mussel patches in each year, and highlights the potential high variability in mussel stock estimates that may arise as a result of unintentional observer bias. This appears to be more likely when fewer transects are conducted over a given area, with wider angles between the transect legs. Officers have also identified this as a potential source of uncertainty in other locations, and will aim to investigate how this uncertainty can be minimised by optimising the survey method, bearing in mind the logistical and resourcing constraints of surveying the intertidal mollusc beds.

Mussel spat (<30 mm) had previously been absent on the Salty prior to the 2022 survey. There was a small amount of spat observed in 2022, with a similar amount observed in 2024, which could indicate there has been some recruitment over the two-year period and some of the spat observed in 2022 has grown into larger size classes. The increase observed in the 41-60mm size class and the plateau in the remaining size groups is likely due to survey effort. In 2022, 14 transects were completed across an area of 0.7 hectares compared to the same number of transects in 2024 across an area twice as big. This has resulted in broader and extended transect paths across the bed, which may contribute to significant areas of mussel populations being overlooked. This would explain the decrease in density and percentage cover observed in 2024.

No spat was observed on Salty East in 2024, with all the stock being classed as mature mussel. It is unlikely that the spat observed in 2022 has grown into the larger size classes within two years. Mussels can grow up to 8cm in length in two years in optimal conditions but in high intertidal areas growth is significantly lower and it may take 15 to 20 years to reach 2 to 3 cm in length (Seed and Suchanek, 1992). Again, this could be down to survey effort as only 5 transects were completed in 2024 compared to 8 in 2022. As explained above wider transects being conducted may miss smaller spatial scales of dense mussel patches within the bed and therefore result in fewer ‘hits’ being acquired to obtain a sample. This could potentially explain the decrease in percentage cover.

The significant increase in overall tonnage on Salty East is certainly a positive development, although the absence of any spat raises concerns over rate and scale of any recovery. On-going monitoring will provide the necessary data to assess this. Data from the Taw Torridge mussel surveys in 2024 are being analysed to determine any sampling bias that may occur as a result of the methodology in order to understand the implications for data analyses. Future analysis will also consider combining Salty East with the Salty, depending on contiguity of these areas over the coming years.

5. Recommendations

It is recommended that stock assessments continue to be undertaken on a biennial basis, to monitor any future changes and to detect any signs of recovery and or seed settlement. This will help to inform any future management measures that D&S IFCA may consider for the collection of mussels.

The survey areas and methodology should be reviewed prior to future surveys and should consider how to improve interannual comparability of data sets, as well as how to ensure all sizes of mussels are being sampled. Consideration should be given to visiting the mussel beds during 2025 to attempt to identify any significant changes. In addition, engagement with local stakeholders should be continued in order to obtain information on of the state and extent of the mussel beds.

During the years where surveys are undertaken a second survey may help to detect temporal changes to spat recruitment across the year, however it must be noted that due to resources and time constraints this is most likely not feasible.

The 2019 temporary closure of the Teign Estuary's public shellfish beds should remain in place for the foreseeable future until such time where there are established mussel beds considered both dense and large enough for sustainable exploitation.

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