Taw-Torridge
Mussel Stock Assessment 2022

Lauren Henly
Environment Officer

Devon and Severn Inshore Fisheries and Conservation Authority
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1. Introduction

1.1 *Mytilus spp.*

Mytilus spp., mussels such as *M. edulis* and *M. galloprovincialis,* 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. *Mytilus spp.* 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 *Mytilus spp.* to occupy such a range of habitats results from its ability to withstand wide variation in salinity, desiccation, temperature and oxygen concentration (Bayne and Worrall, 1980; Seed and Suchanek, 1992; Andrews *et al.*, 2011).

Mytilus spp. 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 (Seed and Suchanek, 1992; Andrews *et al.*, 2011). *Mytilus spp.* 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 *Mytilus spp.* is to deploy a large number of gametes, approximately three million eggs, into the surrounding water where fertilisation takes place (Andrews *et al.*, 2011). Following fertilisation the zygotes, as 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 complement favourable environmental conditions, and the planktonic 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 and Worrall, 1980; Seed and Suchanek, 1992; Handå *et al.*, 2011).

Current threats to *Mytilus spp.* beds include commercial fishing, 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 annual surveys of the public mussel beds on the Taw-Torridge Estuary, to undertake a stock assessment on each of the beds to estimate the density of mussels on the beds and the total stock of mussels, including marketable mussels and those required by overwintering birds of the Taw-Torridge Site of Special Scientific Interest. Results of these surveys can be compared inter-annually. This will help inform future management of the mussel beds on the Taw-Torridge Estuary and the development of shellfisheries in this part of the Devon & Severn IFCA’s District.

2. Methodology

2.1 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).

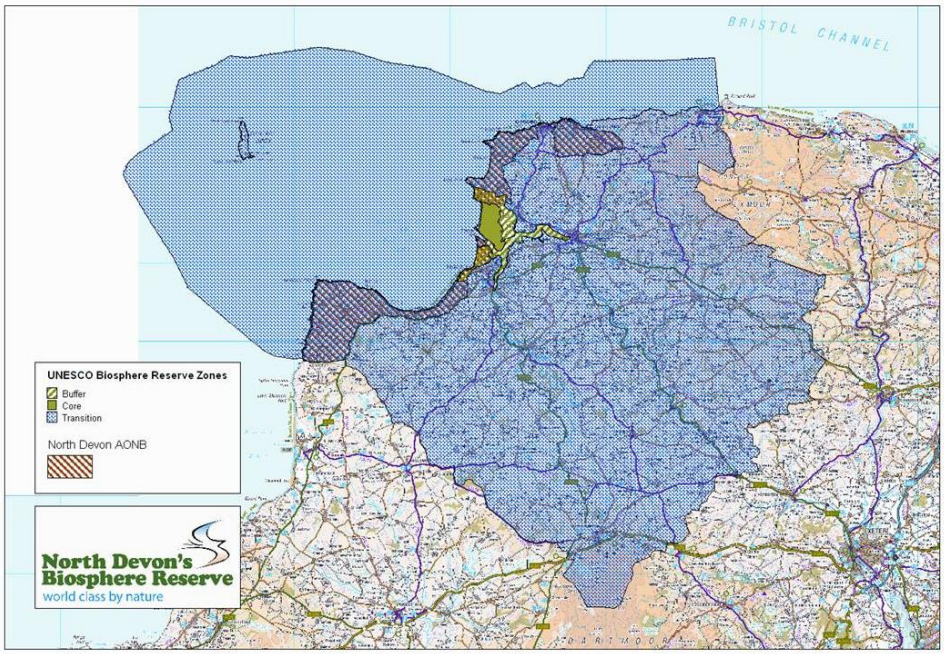

Figure 1 The location of the Taw Torridge Estuary (shown in yellow) within the North Devon Biosphere Reserve and the North Devon Coast AONB. (North Devon AONB and Biosphere Reserve Service, 2010)

The Taw Torridge Estuary is an important site for wildlife and has been designated a Site of Special Scientific Interest (SSSI) (Figure 1) for over-wintering and migratory populations of wading birds, and for the rare plants found on its shores. Upper reaches of the estuary were considered for designation as a Marine Conservation Zone (MCZ) by the Finding Sanctuary Regional Stakeholder Group (RSG) (Figure 3) for six Broad Scale Habitats; subtidal mud, subtidal sand, coastal saltmarshes and saline reed beds, intertidal coarse sediment, intertidal sand and muddy sand, low energy intertidal rock, and one Feature of Conservation Interest (FOCI) species the European eel (*Anguilla anguilla*). However, to date the site has not been designated. Parts of Taw-Torridge Estuary also lie within the Braunton Burrows Special Area of Conservation, also shown in Figure 3.

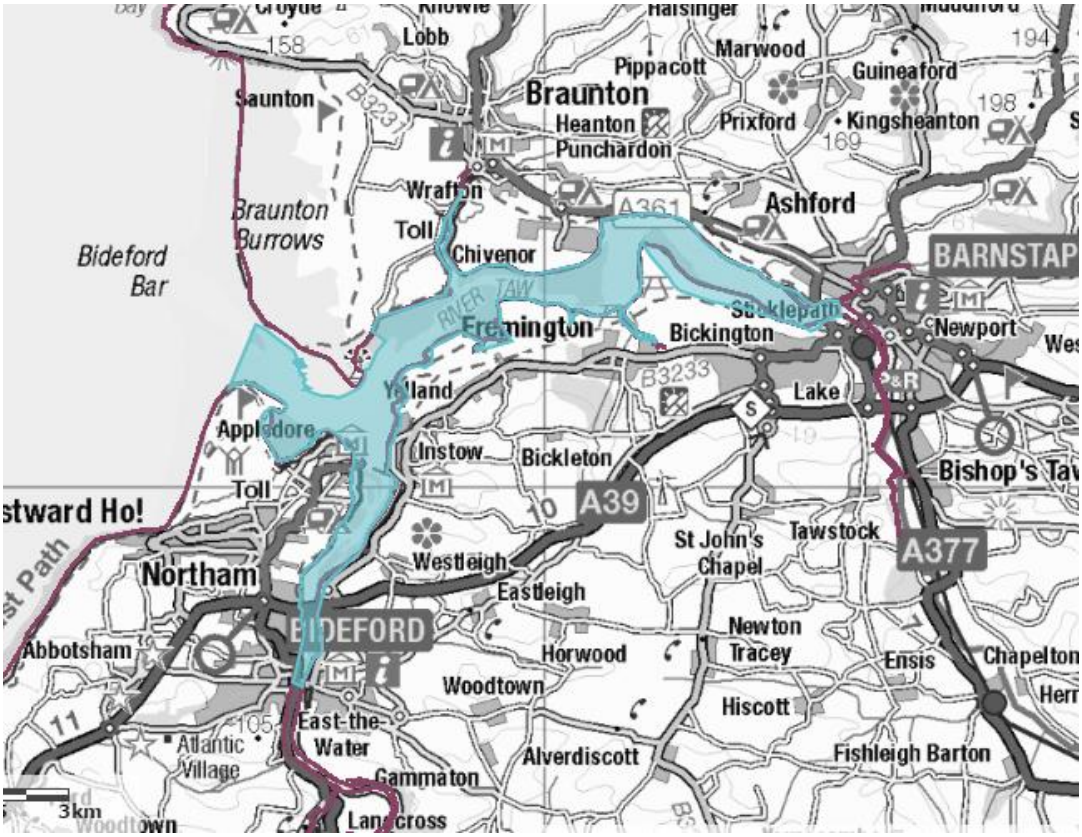

Figure 2 Taw-Torridge Estuary SSSI, shown in blue (Defra, 2020)

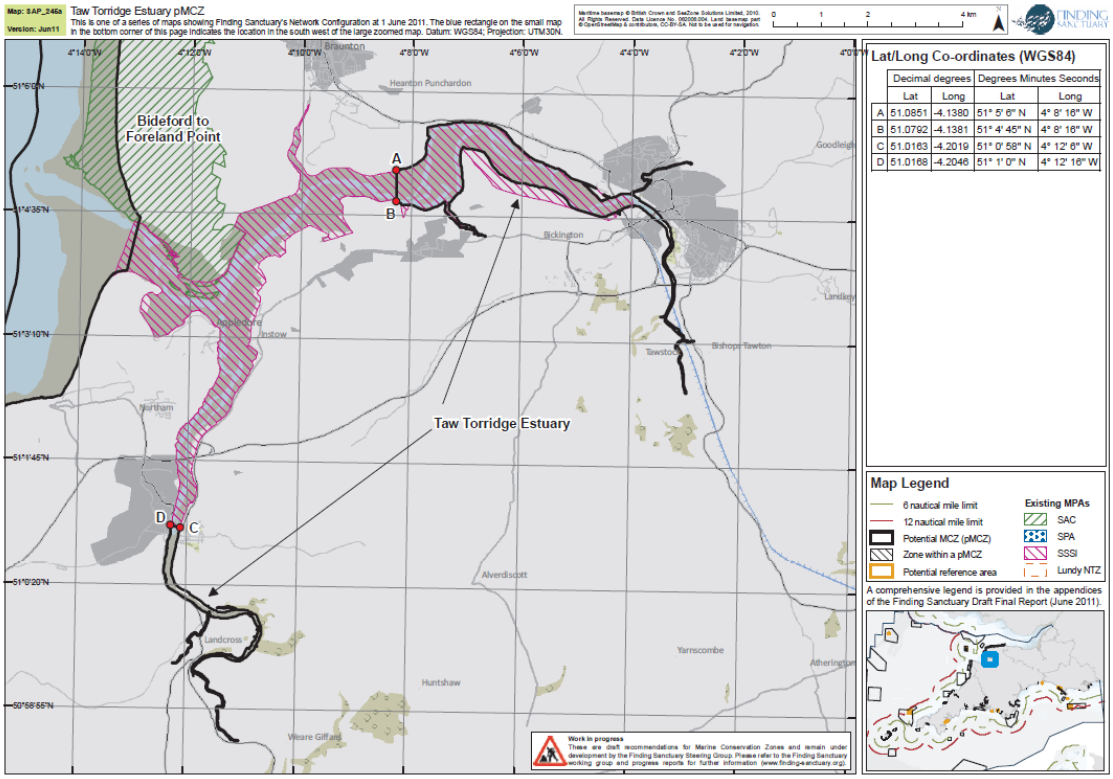

Figure 3 Area of rMCZ, outlined in black. Area of SSSI shown in red hatching, and area of SAC shown by green hatching. (Lieberknecht et al., 2011)

2.2 Survey Methodology

Surveys were conducted annually between 2012–2022. Coolstone, Yelland and Lifeboat Slip are intertidal beds accessible on foot from land, whereas Pulleys, Sprat Ridge and The Neck are mid-channel and require access by boat. In 2022, all survey sites within the estuary apart from The Neck (Figure 4) were sampled between 26th and 30th May. Tidal ranges were lower than previous years during this period, meaning The Neck (the smallest mid-channel bed) was not accessible, and the full extent of the other mid-channel beds (Pulleys and Sprat Ridge) could not be reached. Dense algal cover on the Pulleys bed during this time also meant that fewer transects could be completed due to the extra time required to remove algae to check for mussel presence. For these reasons, the mid-channel sites were revisited on 15th–16th August on a lower tide to ensure the full extent of the mussel beds were accessible. The Neck was still inaccessible on this survey, which may be indicative of topographical changes to the channel.

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 areas within the Taw-Torridge Estuary were recorded on the first visit to each bed by walking the extent of the live mussel habitat and marking coordinates with a handheld GPS. Each bed was first visited in 2012, except for the Neck which was first visited in 2020 following consultation with a local fisher. The perimeters were subsequently mapped in QGIS v3.1. For subsequent visits the perimeter is determined by using the start and end coordinates of each of the transects (Figure 4).

To determine coverage and patch density, transects were walked in a zig-zag pattern across the survey area (Figure 4), up to the extent of the 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 (one 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'.

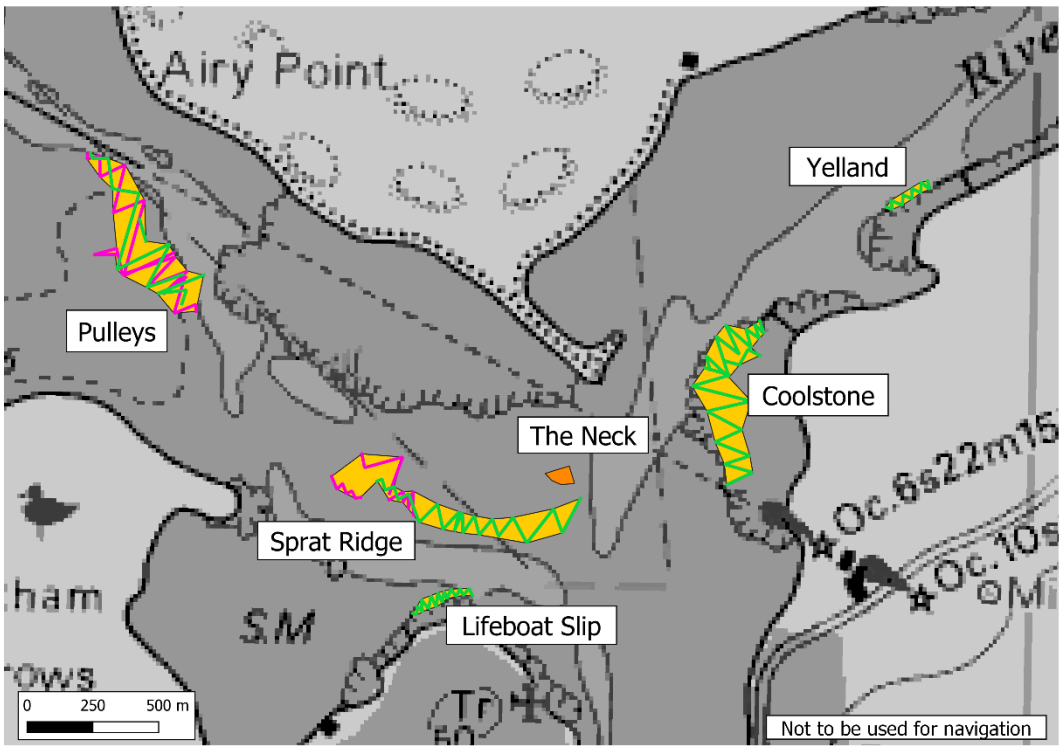

Figure 4 Area of each mussel bed (orange) and paths of transects walked in May 2022 (green) and August 2022 (pink). Pulleys, Sprat Ridge, Lifeboat Slip, Coolstone and Yelland have been surveyed annually since 2012. One additional site (The Neck) was surveyed in 2020 and 2021, but was inaccessible in 2022 (outline shown is from 2021).

Once all transects were complete the mussel samples were sieved and cleaned. For each transect the total number of samples taken was recorded, and all mussels were measured and divided into the following size groups; 1-10mm, 11-20mm, 21-30mm, 31-40mm, 41-50mm, 51-60mm, 61-70mm, 70+mm. The weight in g of each size groups was recorded. In the August surveys a large proportion of the mussels collected were <10 mm and collected in clumps. Each clump was made up of an immeasurably large number of mussels, so the number of mussels in each clump was estimated based on the known average weight of a mussel in a small clump, the proportion of mussels to sediment each clump contained, and the weight of the clump.

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). As the full extent of the Pulleys bed was surveyed both in May and August, a comparison between the summary statistics from these two occasions was made. This allowed to gauge the accuracy of the method for generating summary statistics over repeated sampling events and to highlight the potential influence of tidal range on the bed area estimates. As different sections of Sprat Ridge were surveyed on the two separate occasions, the overlapping transects from May's survey (with the lower tidal range) were removed, and the remaining transects from both surveys were combined to provide a full set of data for the whole bed. Total tonnage and survey area across all sites were calculated

based on the weight of mussel in the samples taken and scaled up by the density and the area surveyed across all sites combined was calculated. Where two surveys (May and August) occurred, these were combined to calculate the metrics below. As The Neck was inaccessible this year, the 2020 and 2021 totals were calculated both including and excluding the site.. As there is a minimum conservation reference size for mussels on the in the Taw-Torridge fishery of 2 inches (~51 mm), the tonnage of mussels available to be removed form the fishery (≥51mm) was also calculated for each bed. The totals excluding the Neck were more easily comparable to previous years. A weighted average bed density and percentage cover across all mussel beds was calculated by weighting the values based on the relative total area of the respective beds. Size distribution data were obtained from the length measurements of mussels in the retained samples.

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

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

Equation 3: Calculation of mussel tonnage

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

2.4 Shellfish Ecological Requirement Model

Natural England has provided a mathematical model that allows an estimate to be made of the ecological requirements of wading birds (specifically oystercatchers, *Haematopus ostralegus*) feeding on mussel in the areas surveyed by D&S IFCA. Using this model, it is possible to calculate the tonnage of prey-sized mussel required to sustain the bird population, to compare this to the overall tonnage of prey-sized mussel on the surveyed beds, and thereby estimate the total mussel available to the fishery. In previous years, 30–60 mm has been considered the size range of mussel that is available to overwintering birds as prey. However, evidence suggests that oystercatchers will consume mussel smaller than this (Stillman and Wood, 2013 and references therein), and as the 2022 surveys were completed in the summer (months before the shellfish are required by the bird population), mussels in the smaller size class (21–30 mm) will have grown on by the autumn/winter when the birds start feeding. It was therefore decided, in conjunction with Natural England specialists, to include 21–30 mm size mussel in the bird food availability model for years in which the mussel stock survey is conducted before September. After completing cockle surveys on the Taw Torridge estuary in 2022, it was also possible to include a tonnage of prey-sized (>15 mm) cockles in the model. This tonnage was calculated as 10.1 tonnes.

The mathematical modelling includes several parameters that may be changed between years to reflect changing conditions on the estuary. For 2022, the tonnage of prey sized

mussel was calculated to be 824 tonnes (based on mussels 21 – 60 mm), and the number of birds feeding on mussels on-site was estimated to be 1112. This estimate was provided by Natural England based on Wetland Bird Survey (WeBS) counts, using the mean five year count for the overwinter period (September – March, 2018 – 2022). Natural England also advised that the proportion of these birds that should be assumed to be feeding on mussels should be set at 70% (0.7).

3. Results

3.1 Combined Survey Sites

Since 2021 the tonnage of mussel total stock across the estuary decreased by 23.1% (

Figure **5**a) (20.1% excluding the Neck in 2020 and 2021). The combined survey area containing live mussels decreased by 19.8% (18.6% excluding the Neck). Total mean mussel density within the surveyed sites decreased 25.0% since 2021 (and only by 4.4% excluding the Neck), whilst the percentage cover of mussels decreased by 8.9% (Figure 5b) (but when excluding the Neck from 2020 and 2021, increased by 9.96%). The stock of mussels available to be removed from the fishery (≥51mm) was estimated to be 199.3 tonnes out a total 954.6 tonnes for all sites, i.e. 20.9% (Figure 5c). The mussels available to be removed from the fishery includes 25.1 tonnes of mussel in the size class ≥ 61 mm.

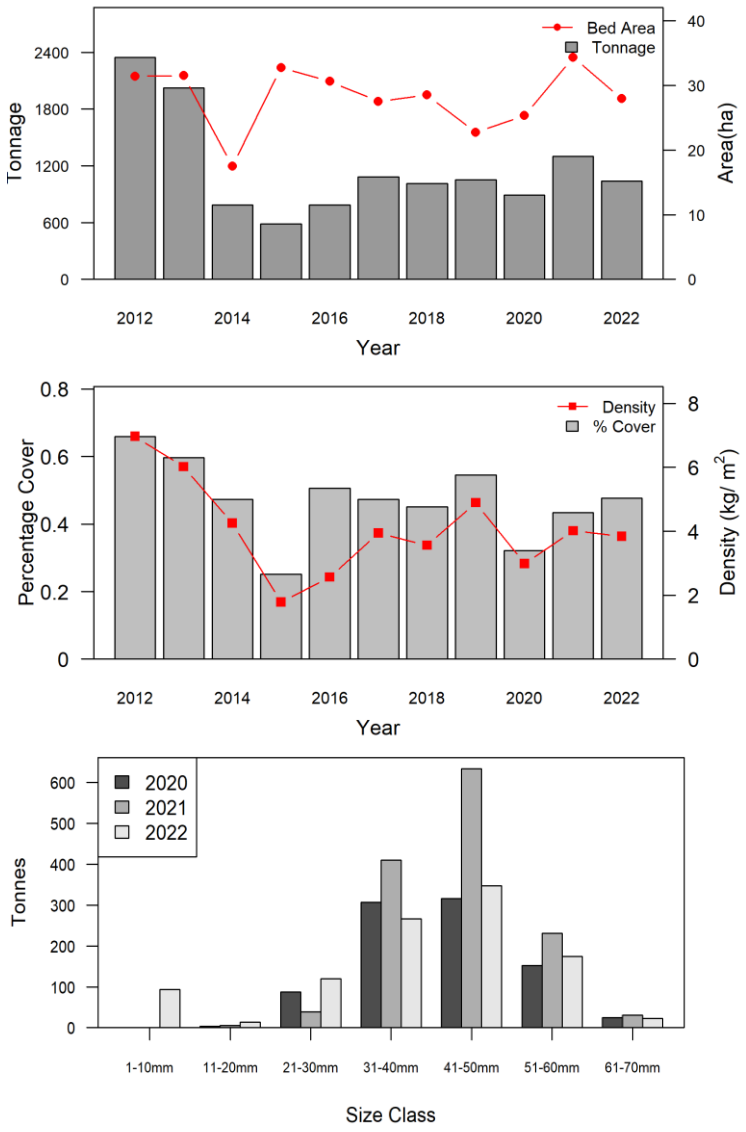

Figure 5 (a) Total area surveyed and tonnage of total stock and (b) average percentage cover and density of mussel between 2012–2022 across all sites. (c) Total stock across all survey areas of 10mm size classes for 2020-2022. Pulleys, Sprat Ridge, Lifeboat Slip, Coolstone and Yelland have been surveyed annually since 2012. One additional site (The Neck) was surveyed in 2020 and 2021.

3.2 Coolstone

Coolstone was surveyed on 30th May 2022 with 36 samples collected from 24 transects. Since 2021 the total stock tonnage and percentage cover of live mussel have increased, whereas bed area has shown a slight decrease and density of live mussel has remained relatively stable since 2021 (neither increasing nor decreasing more than 10% of the value observed in 2021) (Figure 6a, b), but all values still remain a fraction of values observed in the earlier survey years (e.g. 2012–2014). It is important to note that data are averaged for 2012-14 when the Coolstone beds were separate prior to merging into one continuous bed in 2015. Percentage cover of mussels on the Coolstone bed has increased by 56.4% of the 2021 levels (Figure 6b). The stock of mussels available to be removed from the fishery (≥51mm) was estimated to be 33.6 tonnes out a total 153.3 tonnes on the bed, i.e. 21.9% (Figure 6c). There was a substantial increase in the stock of live mussel <31 mm in length.

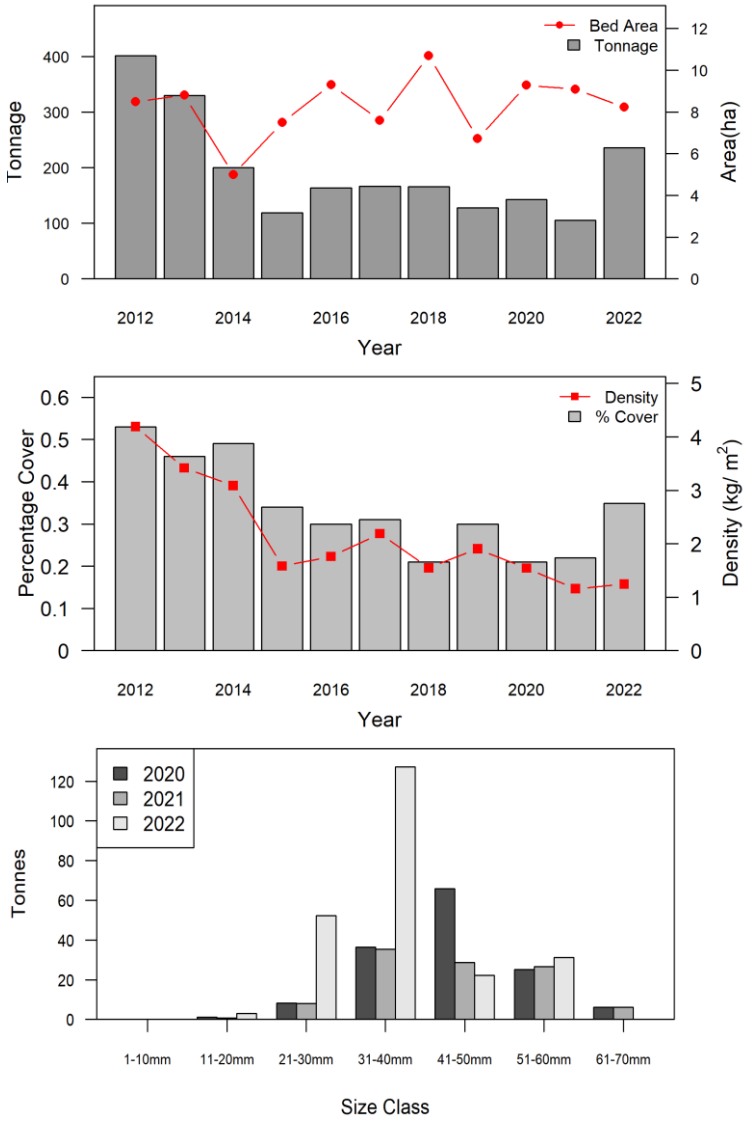

Figure 6 (a) Total area surveyed and tonnage of total stock and (b) average percentage cover and density of mussel between 2012–2022 on the Coolstone mussel bed. (c) Total stock of 10mm size classes for 2020-2022 on the Coolstone bed.

3.3 Lifeboat Slip

Lifeboat Slip was surveyed on 28th May 2022. Seven samples were collected from 17 transects. Since 2021 the total tonnage of the mussel stock decreased by 55.6%, below the tonnage calculated in 2020, and the survey area containing live mussels also decreased by 13.1% (Figure 7). Total density within the survey area and percentage mussel cover also decreased by 48.9% and 18.1%, respectively (Figure 7). The stock of mussels available to be removed from the fishery (≥51mm) was estimated to be 0.8 tonnes out a total 10 tonnes on the bed, i.e. 8.4% (Figure 7).

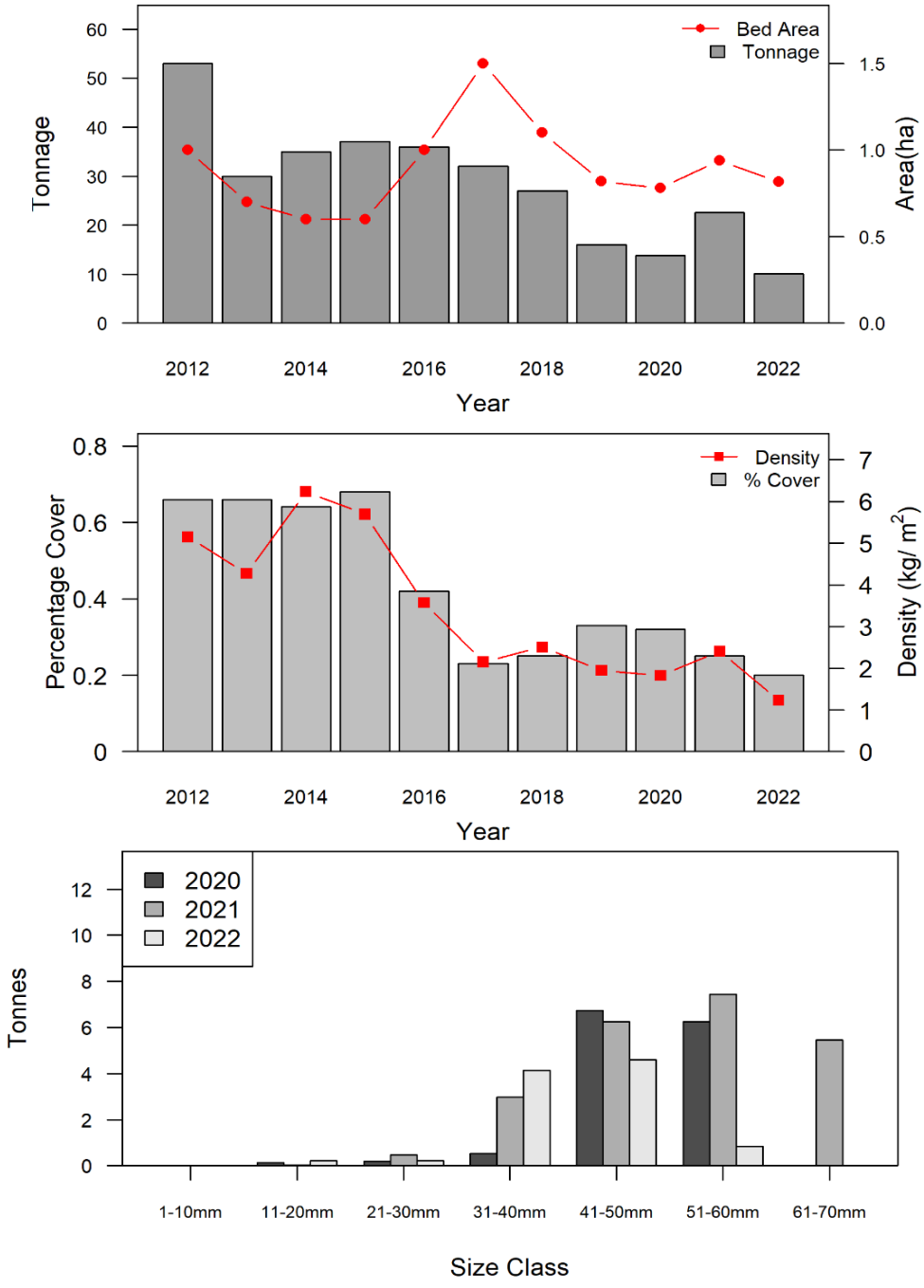

Figure 7 (a) Total area surveyed and tonnage of total stock and (b) average percentage cover and density of mussel between 2012–2022 on the Lifeboat Slip mussel bed. (c) Total stock of 10mm size classes for 2020-2022 on the Lifeboat Slip bed.

3.4 Sprat Ridge

The west side of Sprat Ridge was surveyed on 27th May 2022, where 53 samples were collected from 21 transects, and the east side surveyed on 15th August 2022, where a further 25 samples were collected from 15 transects. These surveys were combined to provide estimates of the stock composition for the bed as a whole. Since 2021 the tonnage of total stock decreased by 32.2% and the survey area containing live mussels also decreased by 24.4% (Figure 8a). Total density within the survey area decreased by 10.5%, whilst percentage cover of mussels increased by 3.9% (Figure 8b). The stock of mussels available to be removed from the fishery ≥51mm) was estimated to be 122.3 tonnes out a total 488.5 tonnes on the bed, i.e. 25.4% (Figure 8c).

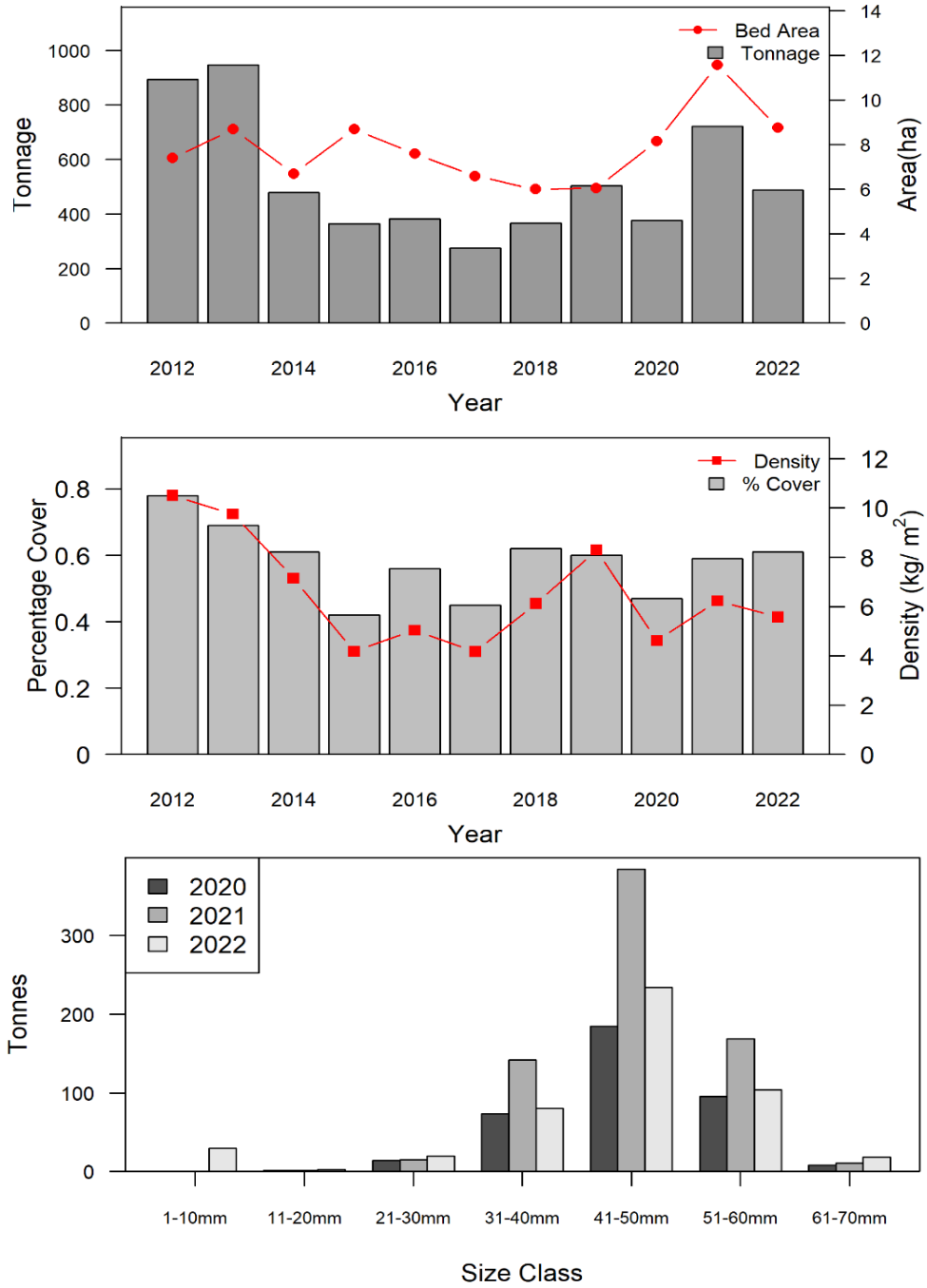

Figure 8 (a) Total area surveyed and tonnage of total stock and (b) average percentage cover and density of mussel between 2012–2022 on the Sprat Ridge mussel bed. (c) Total stock of 10mm size classes for 2020-2022 on the Sprat Ridge bed.

3.5 Pulleys

Pulleys was surveyed on 29th May 2022, where 52 samples were collected from 12 transects, and again on 16th August 2022; where 90 samples were collected from 19 transects. These surveys were combined and averaged to provide estimates of the stock composition for the bed as a whole Since 2021 the total stock tonnage decreased by 35.4% and the survey area containing live mussels decreased by 19.2% (Figure 9a). Total density within the survey area decreased by 20.1%, whilst percentage mussel cover increased by 14.9% (Figure 9b). The stock of mussels available to be removed from the fishery ≥51mm) was estimated to be 10.3 tonnes out a total 253.2 tonnes on the bed, i.e. 4.08% of the total stock (Figure 9c).

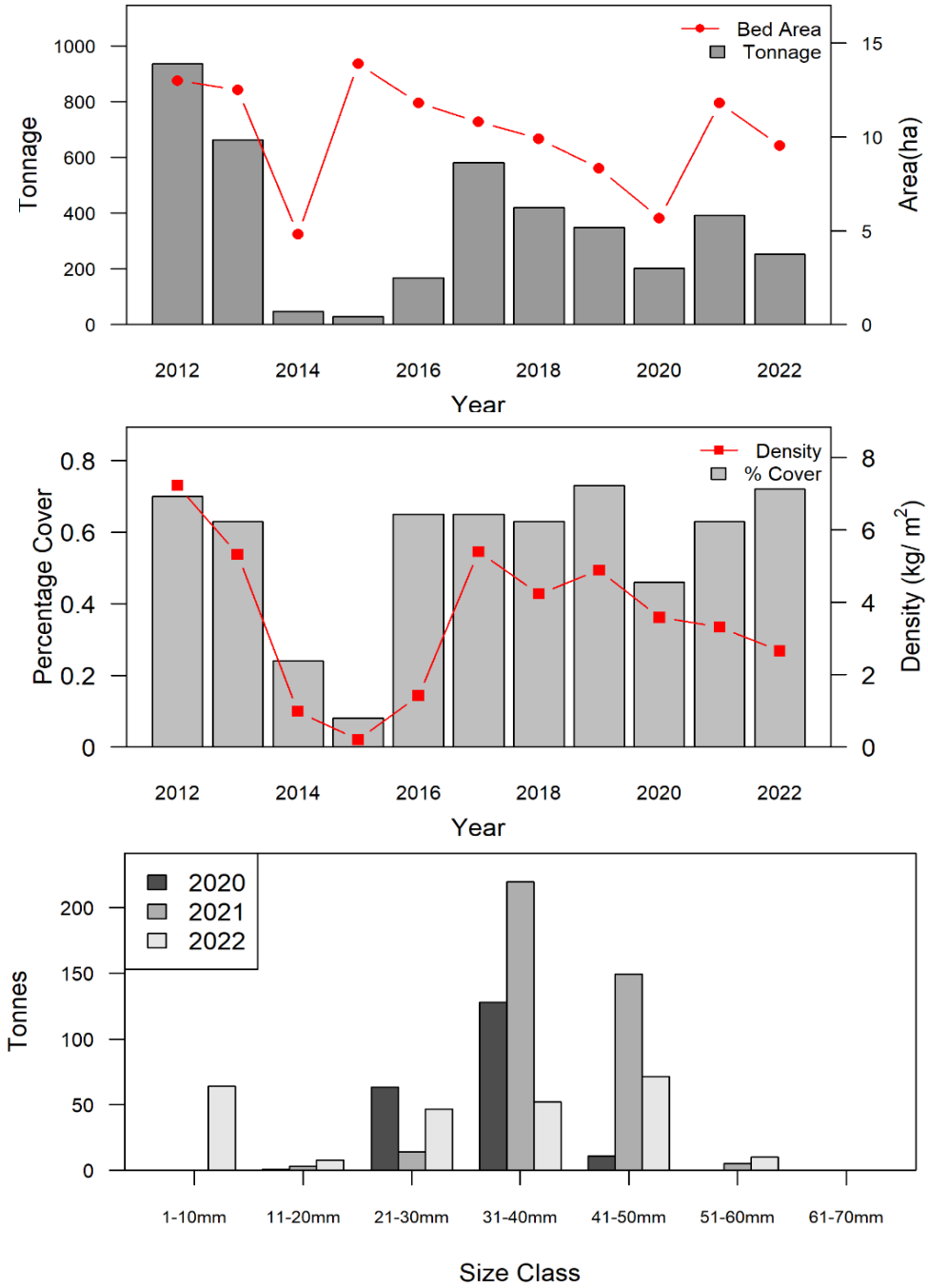

Figure 9 (a) Total area surveyed and tonnage of total stock and (b) average percentage cover and density of mussel between 2012–2022 on the Pulleys mussel bed. (c) Total stock of 10mm size classes for 2020-2022 on the Pulleys bed.

3.6 Yelland

Yelland was surveyed on 26th May 2021; 210 samples were collected from 10 transects. Since 2021 the total stock tonnage and the survey area containing live mussels decreased by 13.3% and 35.8%, respectively (Figure 10a). Both total density within the survey area and percentage cover of mussel increased by 21.9% and 3.6%, respectively (Figure 10b). The stock of mussels available to be removed from the fishery ≥51mm) was estimated to be 32.2 tonnes (a 6.3% increase compared to 2021) out of a total 49.5 tonnes on the bed, i.e. 65% of the total stock (Figure 10c).

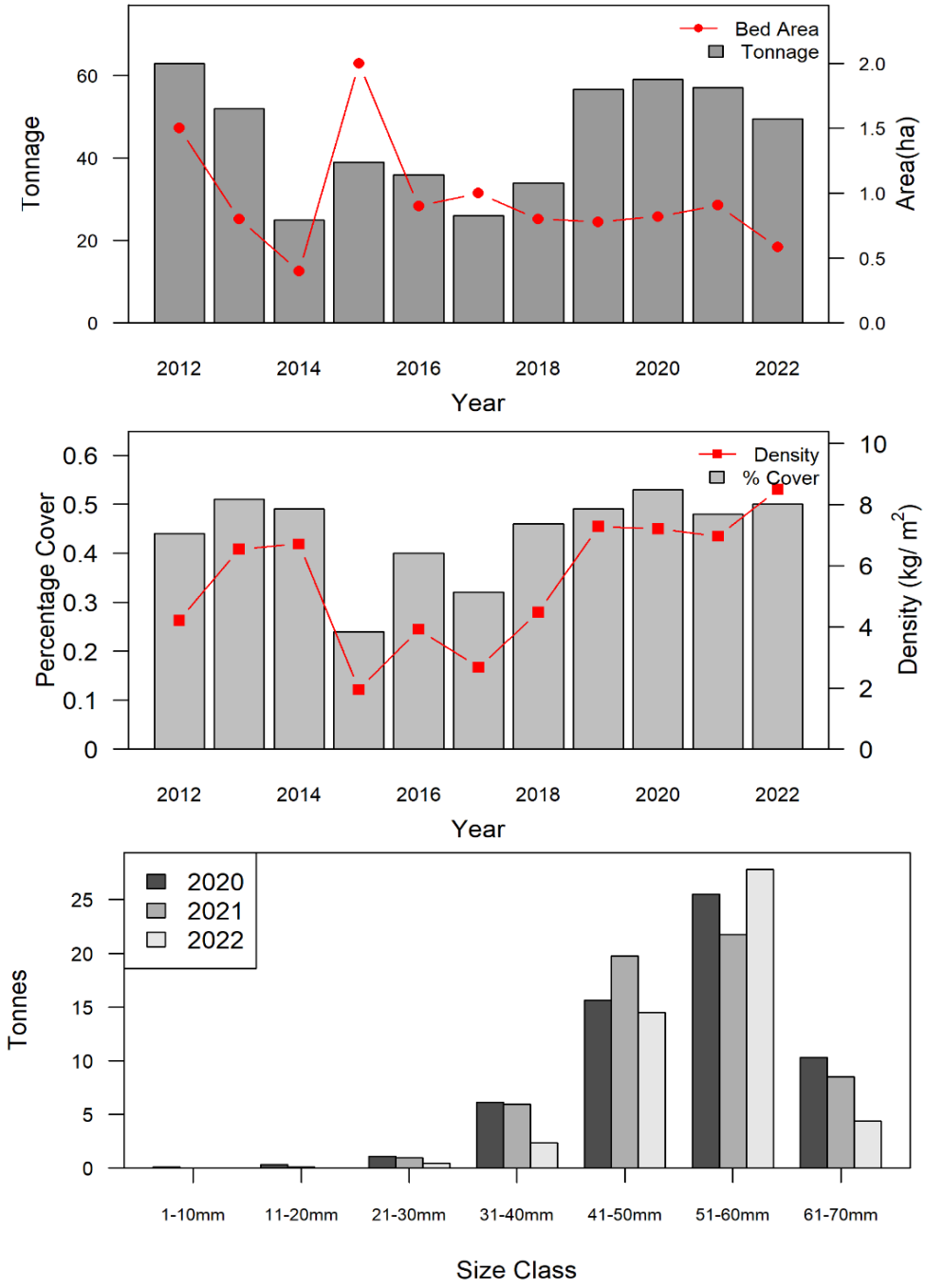

Figure 10 (a) Total area surveyed and tonnage of total stock and (b) average percentage cover and density of mussel between 2012–2022 on the Yelland mussel bed. (c) Total stock of 10mm size classes for 2020-2022 on the Yelland bed.

3.7. Comparison of May and August surveys – Pulleys

On the Pulleys bed, a total of 11 transects were surveyed in May generating an area estimate of 7.3 ha, compared to 19 transects in August, which generated an area estimate of 9.5 ha. The total mussel density, percentage cover, and total stock estimates within the site in August were also all higher than in May (by 8.8%, 41.4% and 42.3%, respectively). The scale of the differences in stock estimates for the different size classes of mussel between the May and August surveys varied, with some size classes (1–10 mm, 21–30 mm, 51–60 mm) calculated as higher in August than May, and others (11–20 mm, 31–40 mm, 41–50 mm) calculated as lower in August than May. The largest increase in tonnage of mussels was seen in the 1–10 mm size class: in May the stock of mussels in this size class was calculated as 0 tonnes, whereas in August almost 117 tonnes of mussel were recorded in this size class.

If the stock of mussels in the 1–10 mm category is excluded (i.e. excluding the effects of a suspected settlement event following the May survey), the total Pulleys stock estimate in August (147 tonnes) is 20% smaller than May (185 tonnes). The effect of excluding this size category on the percentage cover and density of the mussels on the bed cannot be calculated as all samples from a transect were pooled before measuring.

3.8 Shellfish Ecological Requirement Model Results

The mathematical model provided by Natural England projected that the ecological requirement of bird population obtained from prey-sized mussels is 815 tonnes, and 10.1 tonnes obtained from cockles on the estuary. The quantity of prey-sized mussel available is 824.4 tonnes, leaving a surplus of 9 tonnes of prey-sized mussel not required by the bird population. This 9 tonnes is in addition to the 25.1 tonnes of mussel in the size class ≥ 61 mm, which is larger than prey-size mussel.

4. Discussion

4.1 Combined Analysis of All Survey Sites

Overall, the total tonnage of mussel stock in the surveyed beds within the estuary appears to have remained relatively stable between 2017 and 2020, despite the addition of a new survey site containing dense mussel cover in 2020. In 2021 the total tonnage of mussels across the estuary increased by more than 50% of the 2020 levels, but in 2022 the tonnage returned to levels similar to those seen in 2020. However in 2022, due to topographical shifts, it was not possible to survey the Neck, so the decrease in total tonnage and area may partly be explained by this. All size classes of mussel above 30mm have shown a decrease in tonnage across the estuary compared to the 2021 levels, whereas all size classes below this have increased in tonnage. The increases in smaller size classes of mussel is likely mostly driven by the large amount of 1–10 mm mussel surveyed in August 2022 on the Pulleys and Sprat Ridge beds. This size class of mussel was not present during the May 2022 surveys, suggesting a spawning and/or settlement event occurred between these dates.

Both the average density and percentage cover of mussels across all beds have remained relatively stable since 2021, despite not surveying the Neck, which was one of the most densely covered beds in 2020 and 2021.The inclusion of the August surveys in 2022, has likely influenced the overall average density and percentage cover values as there was a large, dense settlement of small mussel (<10 mm) over both Pulleys and Sprat Ridge. .

4.2 Analysis of Individual Beds

4.2.1. Coolstone

Between 2016–2018, the tonnage of mussels on the Coolstone bed remained relatively stable, but from 2019 onwards there has been a decline of between 13–37 % in tonnage across the bed compared to the 2018 levels. During that time, the bed area has fluctuated between around 6 and 11 hectares. Following the decline in both area and tonnage in 2019, both metrics have showed an increase in 2020, but have since declined (for tonnage, this has declined to levels below the 2019 value). The density and percentage cover of mussel across the bed have shown an overall trend of decline since surveys began in 2012, however, the 2022 data have shown an increase in both metrics (although this is not dissimilar to fluctuations observed in previous years). However, the density of the Coolstone bed has been fluctuating between around 1.5 and 1.9 kg/m^2 since 2015 (Figure 9), which is when the previously separate beds were first considered to be one merged bed. Coolstone is a patchy bed due the substrate that mussel is settled on; the areas of gravel where mussel grows best on this bed are broken up by outcrops of rock running through them. The patchy nature of this bed may explain the fluctuations in the measures seen year-on-year, as the values obtained will depend on whether the transects happen to cross over the denser patches of mussel.

All size classes of mussels remained relatively stable from 2021–2022, except for mussels that were 21–40mm. These size class showed a large increase in tonnage compared to 2021 levels. It is unclear whether this has been caused by an undetected spawning event in a previous year or differences in the patches covered by the unavoidable variations in transect paths year on year.

4.2.2. Lifeboat

Similar to Coolstone, the Lifeboat Slip survey area is also patchy and thinly populated by mussels due to being broken up by rocky outcrops. The area of mussel bed, tonnage density and percentage cover of mussels decreased from the levels recorded in 2021. Mussels in the 31–40mm size class continue to show increases following their large decline in 2020, but the mussels in the larger size classes have shown a notable decline since 2021 2021 was the first year that mussels in the 61–70mm size range were found, but this size class was not seen in the 2022 survey.

4.2.3. Sprat Ridge

Sprat Ridge has seen decreases in total mussel tonnage, bed area and density of mussel compared to 2021, whereas percentage cover of mussel has increased marginally. Sprat Ridge is dense and homogenous enough (~50% live mussel cover) to be considered a true mussel bed, therefore changes in survey area may be more indicative of the change in bed size than some of the less homogeneous sites, however this is discussed in section…... 2022 was the first year that mussels in the smallest size class have been recorded. Part of Sprat Ridge was surveyed in May, and the rest surveyed in August 2022. Mussels in the smallest size class were only present in the August survey. This could be due to one of two reasons: 1) small mussels were only present on one side of the Sprat Ridge bed, or 2) there was a spawning event and settlement of mussels between the May and August surveys, which changed the composition of the whole bed. The second explanation is the most likely, as the whole of the Pulleys bed was surveyed in both May and August, and a difference in size composition of mussel was seen between the two survey, with no small mussels recorded in May, and a large proportion of the total tonnage made up of small mussels in August.

4.2.4. Pulleys

Both the tonnage of mussel and the area of the Pulleys bed have declined in comparison to the levels in 2021, however the percentage cover and density of the mussels on the bed have increased, although only slightly.

Mussels in the 31–40mm and 41–50mm size classes have shown a large decrease in tonnage when compared to 2021, but the smaller size classes have shown large increases. In previous reports it has been suggested that new settlement and recruitment could be difficult on Pulleys due to its proximity to the estuary mouth, where it is less sheltered, and the fast-flowing nature of the estuary. It was also suggested that despite declines seen in this bed over the past couple of years, the high homogeneity and stable mussel density suggest the bed may stabilise over the coming years (Bayne & Worrall 1980, Seed & Suchanek, 1992) and possibly provide a suitable area for recruitment. A spawning event and settlement seems to have occurred between May and August 2022, which has contributed to the large difference in mussel size composition seen between the two survey events.

4.2.5. Yelland

Over the 2019–2022 period, the area, biomass, density, and percentage cover of mussels on the Yelland mussel bed has remained relatively stable compared to earlier survey years, although the bed area and tonnage recorded in 2022 have shown small declines and the percentage cover has increased somewhat. The mussel population at Yelland is more homogeneous than Coolstone or Lifeboat (as the percentage cover is now around 50%) and its limits more clearly defined.

The Yelland bed seems to have a healthy stock of larger mussel that continues to remain stable or show increases (e.g. 51-60 mm) year on year. The Yelland mussel bed is one of the smallest mussel beds on the Taw-Torridge, but has been stable at a high level of biomass for the past three years. However, its small size means that its influence on broader bed dynamics may be small.

4.2.6. The Neck

The Neck was first surveyed in 2020, identified following consultation with a local fisher. The Neck is densely populated and homogenous, however it also extended into the subtidal meaning that some areas could not be included in the 2021 survey. There seemed to have been further topographical changes since the 2021 survey, meaning the majority of the bed was subtidal during the 2022 survey.

4.3. Comparison of May and August Surveys

There was a unique opportunity during the 2022 surveys to compare the same bed across two different survey dates. The Pulleys bed was first surveyed in May and then again in August, due to some uncertainty about the accuracy of the results of the May survey as a result of dense ephemeral algal cover over the mussel bed. Previous research has shown that ephemeral algae can develop on mussel beds, partially or completely covering the bed, only in the presence of reduced grazing pressure (Albrecht, 1998), but it is unclear what may have caused such a reduction in grazing pressure on the Pulleys bed.

There were some key differences in the results of the two surveys, which should be discussed further. Firstly, there was a large settlement of small <10 mm mussel following the May survey, suggesting that a spawning event may have occurred between the survey dates. A large settlement of these small mussels was also observed on Sprat Ridge in August, but the other beds (Yelland, Lifeboat, and Coolstone) were not visited in August to see if the settlement was estuary-wide. Nevertheless, the occurrence of large quantities of small mussel is a promising sign that there is good recruitment to the total mussel stock on the estuary.

Aside from the increase in stock of small mussels, there were also some differences in the estimates made for other parameters between the survey dates. Surprisingly, the area of the Pulleys bed was estimated to be more than two hectares larger in August than in May, which raises some concerns about the accuracy of the method used to calculate bed area. One possible reason for the difference in estimated bed area, is the tidal height during each survey. If the tidal range is larger (and the height of low tide is lower) on a given survey day, the observed bed area may be expected to be larger. This pattern may also be more pronounced on the mid-estuary beds, which are likely to be influenced the most by tidal action. This hypothesis was tested by gathering the tidal height data for all surveys dates from 2014 onwards and plotting this against each bed's area estimates (Figure *11*). From this, there does seem to be a trend for both of the mid-channel beds towards larger area estimates when tidal range is larger (during larger spring tides), although it was not possible to fit an appropriate statistical model to these data, so no firm conclusions can be drawn from this observation.

Other parameters also varied between the May and August surveyed. Whilst some variation (even if the surveys were conducted on the same day) is likely due to the nature of the surveys, it is unclear how much variation would be expected as replication in the same conditions (to allow for calculation of standard errors) is not possible over such short time frames.

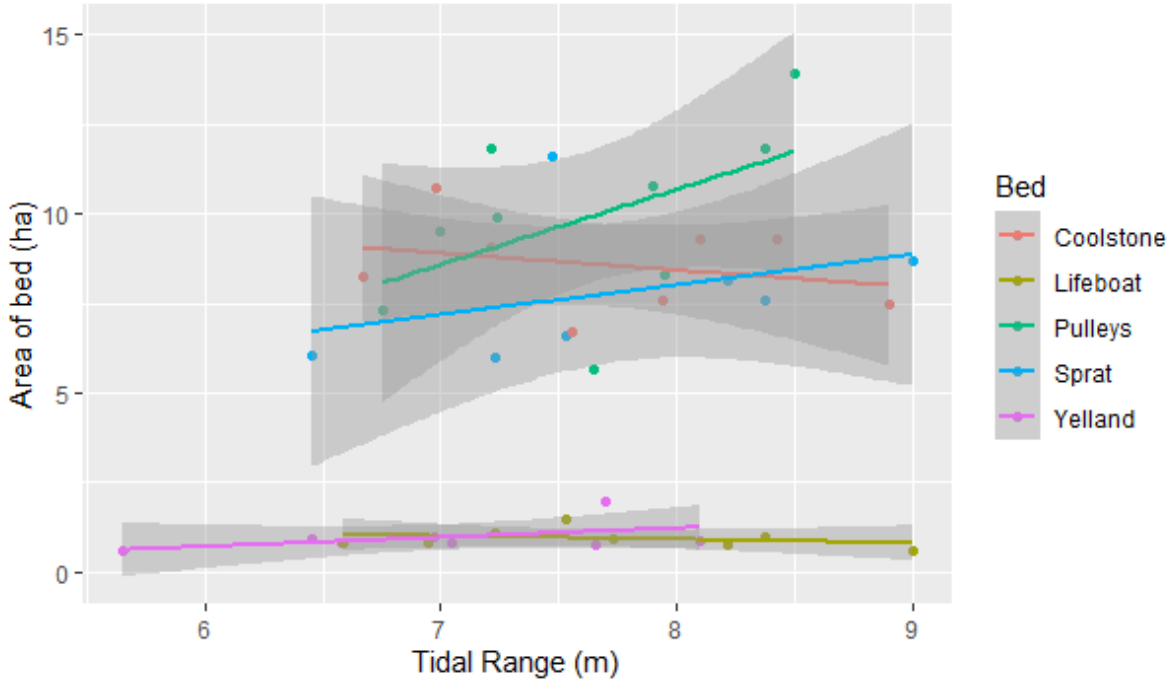

Figure 11: Tidal range (m) vs area of bed calculated from data collected during intertidal mussel surveys (ha) from 2014 to 2022.

4.3 Ecological Requirements and The Local Fishery

Following the loss of mussels between 2013 and 2014 and an increase in interest from numerous commercial harvesters, Natural England, as the regulatory body for SSSIs, working with D&S IFCA, introduced management measures to ensure that enough mussels would be available to provide an adequate food supply for the birds for which the SSSI is designated. D&S IFCA and Natural England had imposed a limit of 500kg of mussels that could be removed from the SSSI per month. The estimated mussel stock calculated in D&S IFCA's intertidal stock assessments feed into a shellfish ecological requirement model. Given recent progress in modelling food availability for the birds on the estuary, and the recently observed increases in the intertidal mussel stock, D&SIFCA and Natural England have agreed an increase to the limit for the fishery, which is now set at 750kg per month. This will continue to be reviewed on the basis of D&S IFCA's annual intertidal stock assessments.

On the basis of the data presented here, the model indicated that 9 tonnes of mussel is excess to the requirements of the oystercatchers on-site and therefore is both available to the fishery and to remain on the surveyed beds as brood stock and for further recruitment within the estuary. This is in addition to the 25.1 tonnes of mussel that is larger than prey size but which is available to be targeted by the fishery or remain on the beds. Any business wishing to remove mussels must notify Natural England and D&S IFCA of their intentions to do so by 23rd of the month prior to the month when mussel harvesting is proposed. This allows Natural England and the IFCA to determine if the planned removal will, in combination with other planned activities, be likely to result in the limit being exceeded. If this is the case, planned removal by all individuals will need to be reduced accordingly. Records of the amount of mussel removed (including location) together with copies of movement documents are submitted to Natural England and the IFCA within 14 days of harvesting.

4.4 Conclusions

This year's assessment highlighted that overall mussel bed area, tonnage and density decreased from the levels observed in 2021, whereas percentage cover increased. Some of the largest decreases in all parameters over the whole estuary were seen on the Lifeboat slip bed, but the small area of this bed means that it is likely to have one of the lowest influences on the statistics for the estuary as a whole. The next largest decreases were seen in both of the largest beds (Pulleys and Sprat Ridge), which due to their overall area will have a large influence on the weighted-average values for the bed as a whole. Despite decreases in these parameters, the values calculated in 2022 mostly still remain above those observed in 2020. Most of the smaller mussel beds either showed signs of improvement or stability, but the influence on broader bed dynamics is likely to be small as a result of their small size.

Depending on spawning times, the annual surveys may miss annual periods of heightened spat settlement (Bayne & Worrall, 1980). It should be noted the 2020 surveys were carried out later in the year than usual, due to COVID-19 lockdown restrictions, so difference in spat recruitment levels between previous years could be linked to survey timings in relation to the seasonality of mussel spawning. Additionally, spat recruitment in years prior to 2021 could have been underestimated due to the survey methodology, e.g. the smallest sizes could have been lost through the sieving process. From 2021 onwards a fine mesh sieve was used to ensure mussel spat recruitment <20mm was not being underestimated. The weights of mussels <20mm often do not register on the scales as they are <1g, so it is likely that the stock estimates for these size classes are underestimates. Future surveys should include more sensitive weighing scales to enable more accurate measurements of smaller size classes.

4.5 Recommendations

It is recommended that the Taw Torridge Estuary mussel stock assessments continue to be carried out on an annual basis, to monitor any future changes to the stock of the beds. This will help to inform any future management D&S IFCA may bring in for the collection of mussels, as part of its review of existing byelaws and development of a possible Hand Working Byelaw, as well as working with Natural England to ensure the mussel harvesting limit remains suitable to balance the environmental and economic interests in the mussel stocks.

A second bi-annual survey is also recommended 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.

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