Taw-Torridge
Mussel Stock Assessment 2021

Lauren Henly
Environment Officer

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Contents

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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 and Worrall, 1980; Seed and 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 (Seed and Suchanek, 1992; Andrews *et al.*, 2011). 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, 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 *M. edulis* 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 define where the mussel beds are and accurately map the overall extent of each of the mussel beds. Devon & Severn IFCA will undertake a stock assessment on each of the beds to estimate the density of mussels on the beds and the total stock of marketable mussels. Results of these surveys can be compared 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).

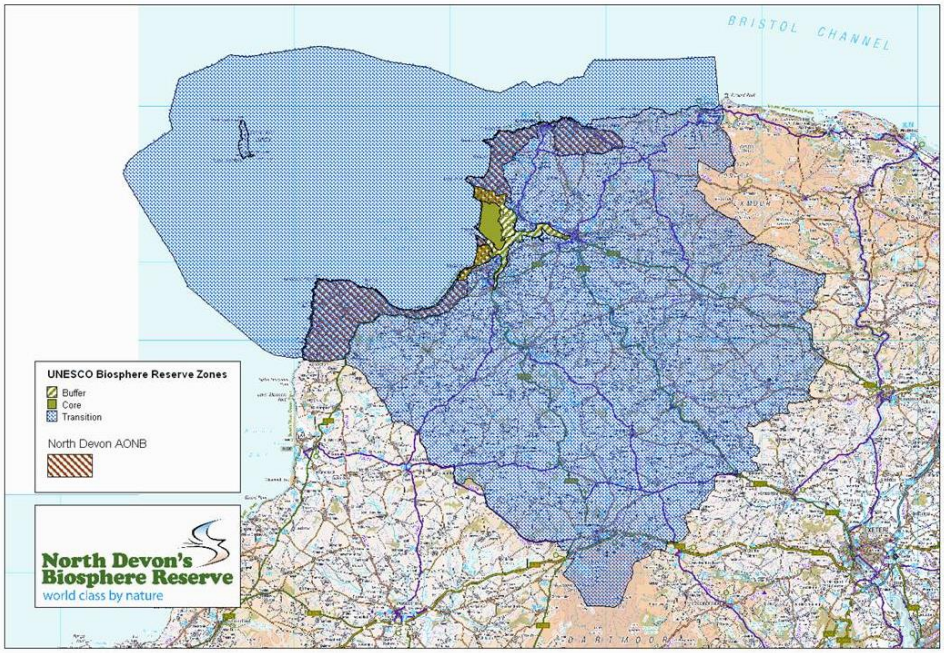

Figure 1 The location of the Taw Torridge Estuary (shown in yellow) within the North Devon Biosphere Reserve and the North Devon Coast AONB. (North Devon AONB and Biosphere Reserve Service, 2010)

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.

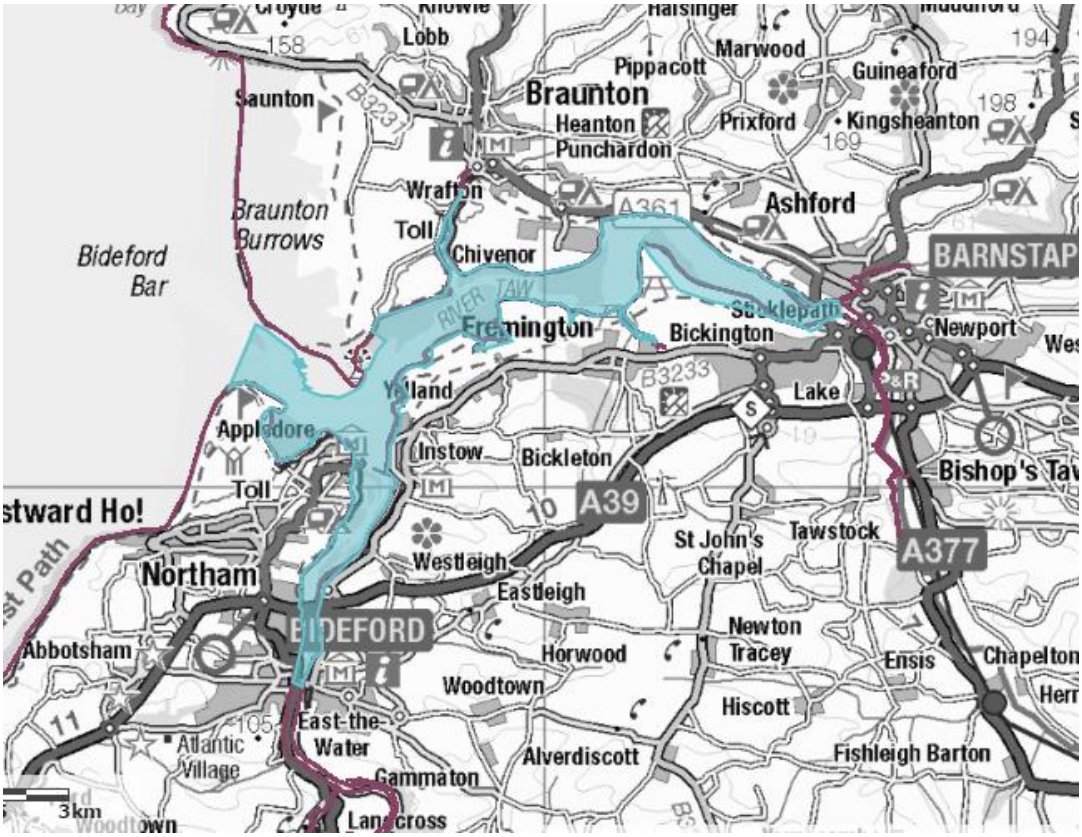

Figure 2 Taw-Torridge Estuary SSSI, shown in blue (Defra, 2020)

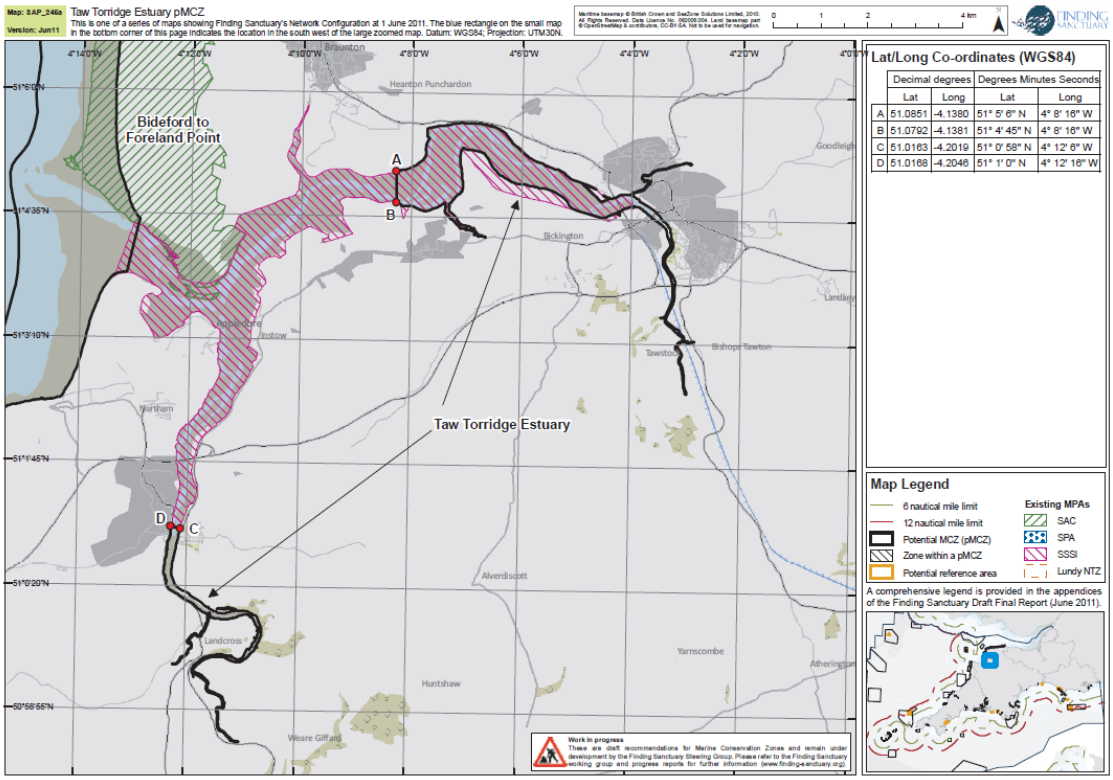

Figure 3 Area of rMCZ, outlined in black. Area of SSSI shown in red hatching, and area of SAC shown by green hatching. (Lieberknecht et al., 2011)

2.2 Survey Methodology

Surveys were conducted annually between 2012–2021. In 2021, all survey sites within the estuary (Figure 4) were sampled between 3rd and 20th September. 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. All sites are surveyed on spring tides to ensure the full extent of the mussel beds are accessible.

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'.

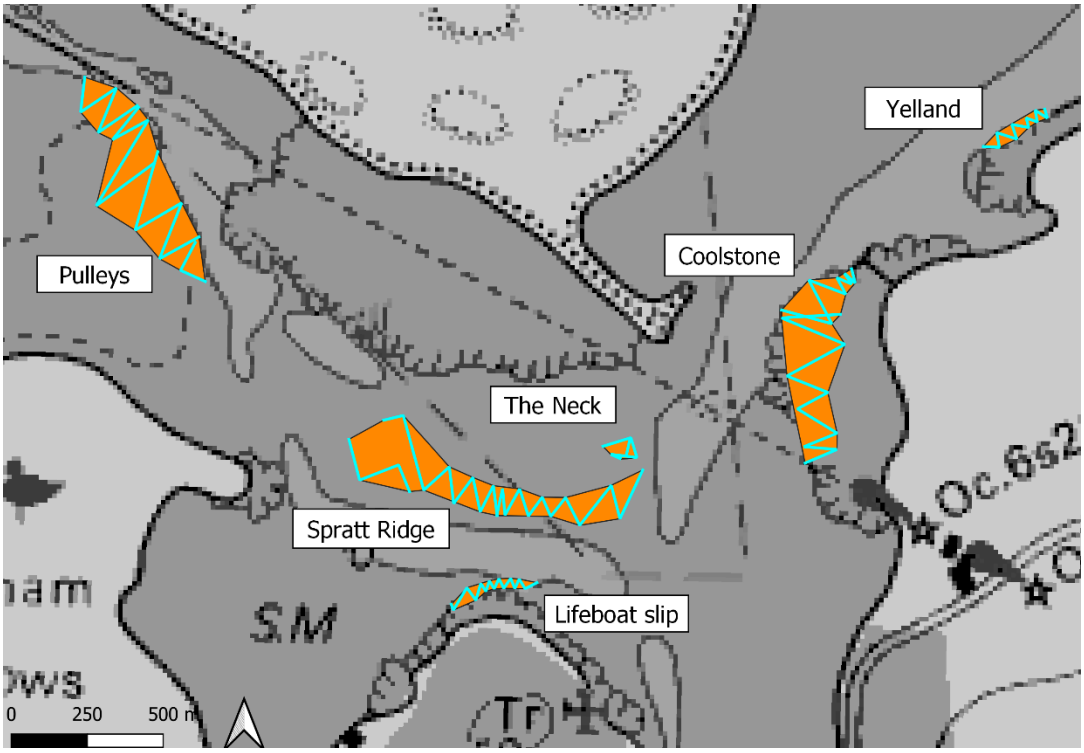

Figure 4 Area of each mussel bed (orange) and paths of transects walked (blue). Pulleys, Sprat Ridge, Lifeboat Slip, Coolstone and Yelland have been surveyed annually since 2012. One additional site (The Neck) was surveyed in 2020.

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.

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 scaled up by the density and the area surveyed across all sites combined was calculated (both including and excluding the additional 2020 survey site (the Neck)). 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

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

Equation 3: Calculation of mussel tonnage

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

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 (30-60 mm) 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.

The mathematical modelling includes several parameters that may be changed between years to reflect changing conditions on the estuary. For 2020, the tonnage of prey sized mussel was calculated to be 775 tonnes (based on mussels 31 – 60 mm rather than 30 – 60 mm, due to the survey method), and the number of birds feeding on mussels on-site was estimated to be 999. 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, 2016 – 2021). 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 2020 the tonnage of mussel total stock across the estuary increased by 51.3% (

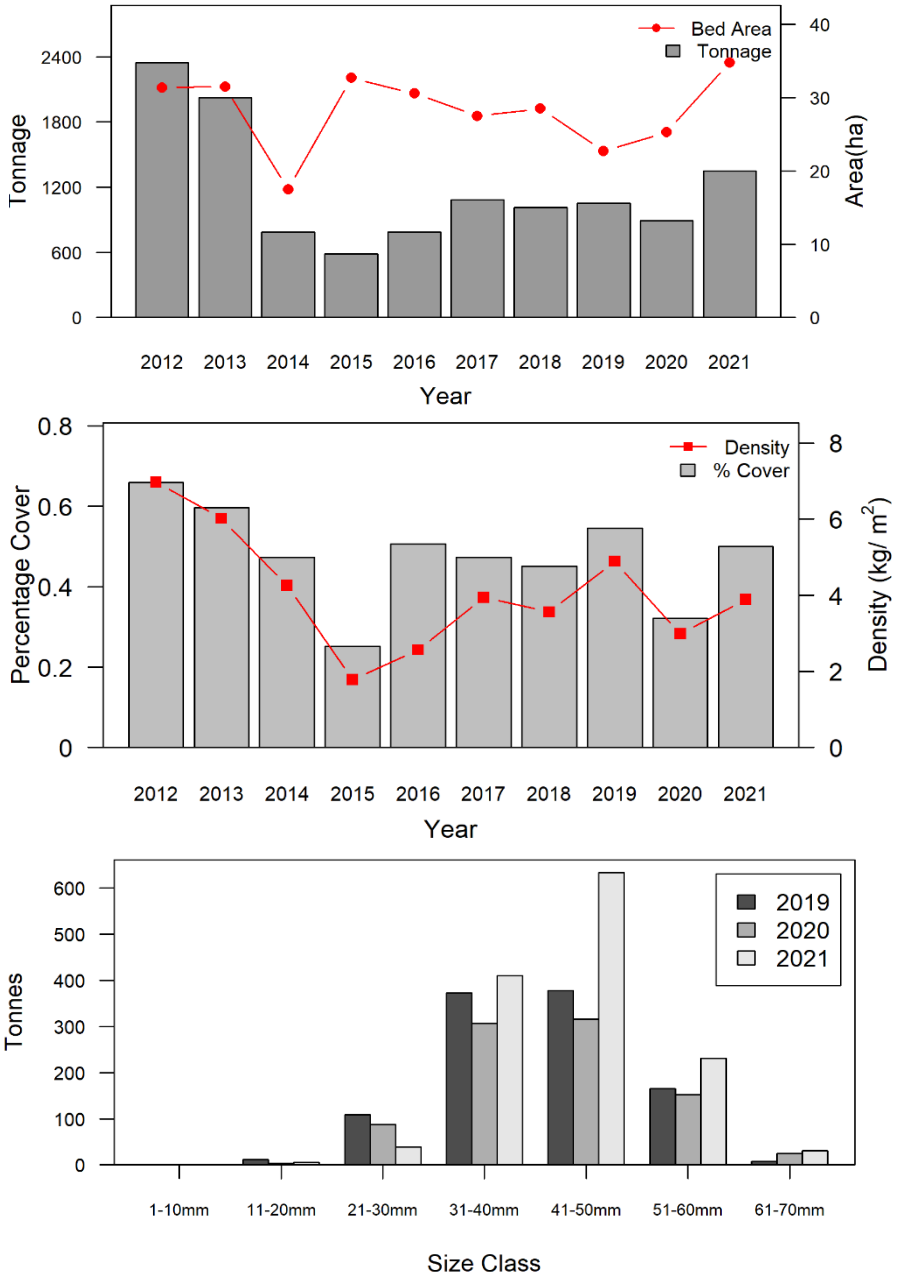

Figure **5**a). The combined survey area containing live mussels increased by 37.7%. Total mean mussel density within the surveyed sites decreased 11.5%since 2019, whilst the percentage cover of mussels increased by 55.8% (Figure 5b). The stock of mussels available to be removed from the fishery (≥51mm) was estimated to be 261.6 tonnes out a total 1349.5 tonnes for all sites, i.e. 19% (Figure 5c).

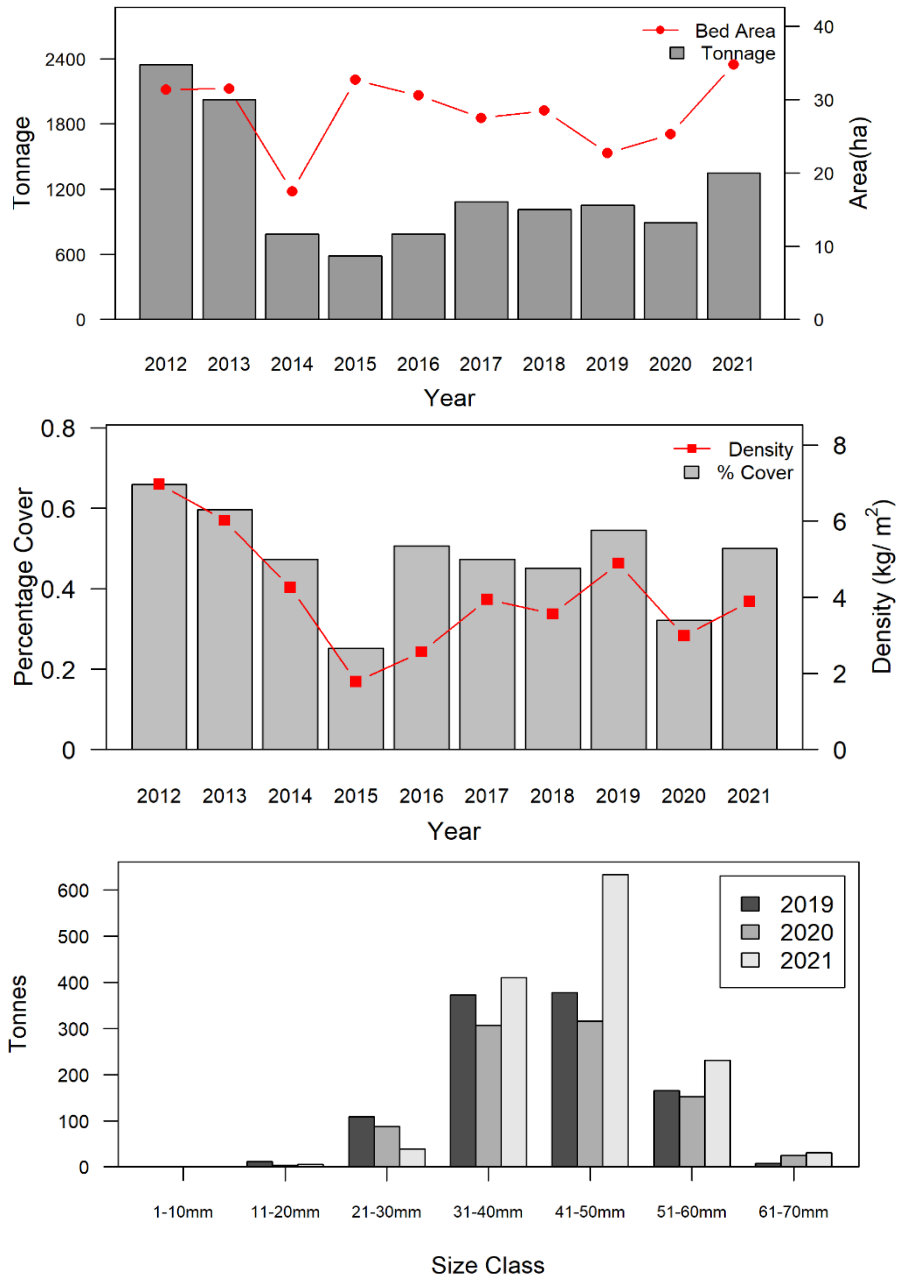

Figure 5 (a) Total area surveyed and tonnage of total stock and (b) average percentage cover and density of mussel between 2012–2021 across all sites. (c) Total stock across all survey areas of 10mm size classes for 2019-2021. Pulleys, Sprat Ridge, Lifeboat Slip, Coolstone and Yelland have been surveyed annually since 2012. One additional site (The Neck) was surveyed from 2020 onwards.

3.2 Coolstone

Coolstone was surveyed on 25th May 2021 with 290 samples collected from 17 transects. Since 2020 the total stock tonnage decreased by 26.4% and the survey area containing live mussels decreased by 2.0% (Figure 6a). Total mussel density within the survey area decreased by 24.9%, whilst percentage cover increased by 5.2% (Figure 6b). The stock of l mussels available to be removed from the fishery (≥51mm) was estimated to be 32.6 tonnes out a total 105.4 tonnes on the bed, i.e. 58.2% (Figure 6c). Data are averaged for 2012-14 when the Coolstone beds were separate prior to merging into one continuous bed in 2015.

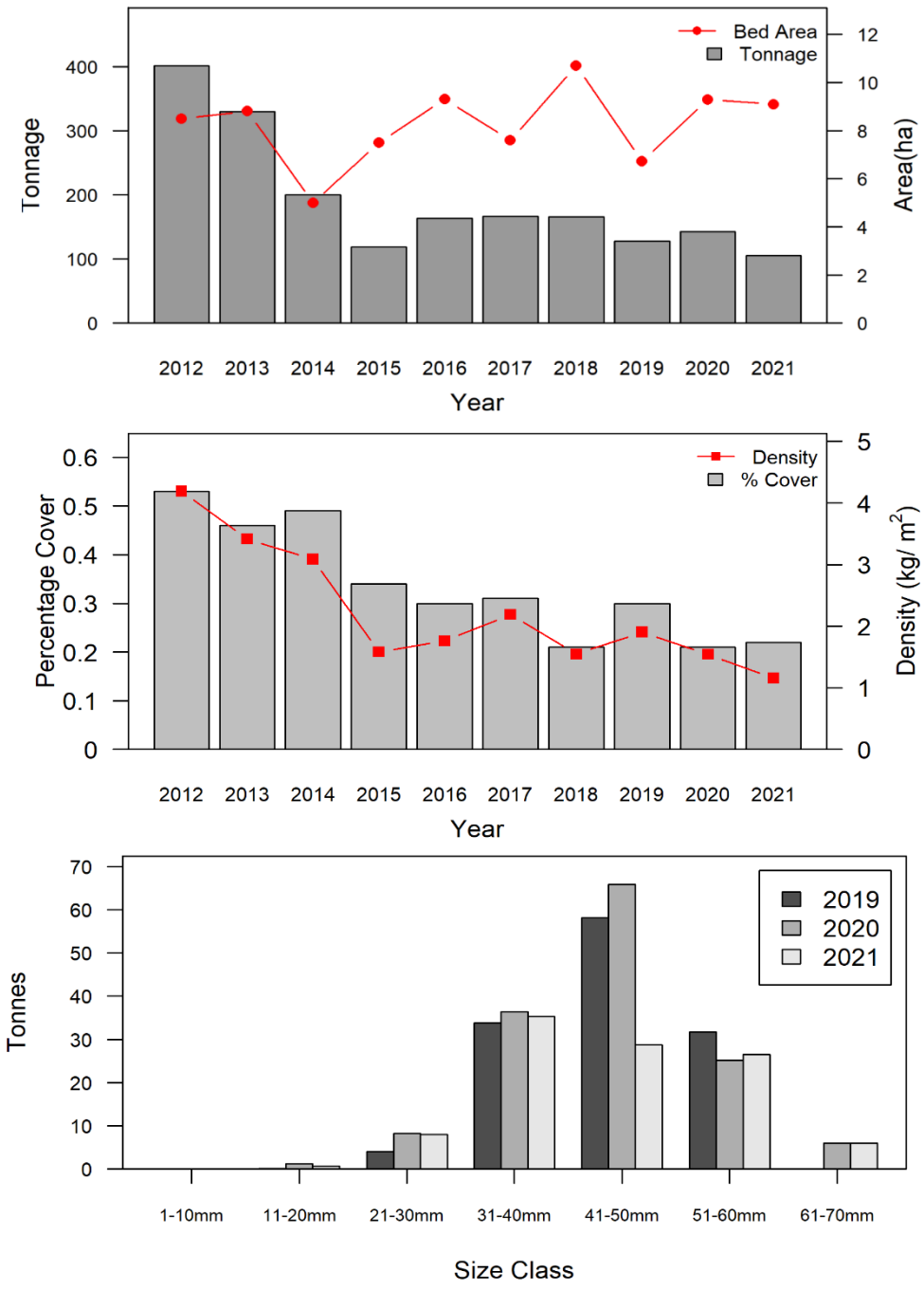

Figure 6 (a) Total area surveyed and tonnage of total stock and (b) average percentage cover and density of mussel between 2012–2021 on the Coolstone mussel bed. (c) Total stock of 10mm size classes for 2019-2021 on the Coolstone bed.

3.3 Lifeboat Slip

Lifeboat Slip was surveyed on 27th May 2021. Nine samples were collected from 14 transects. Since 2020 the tonnage of total stock increased by 63.3% and the survey area containing live mussels increased by 23.6% (Figure 7). Total density within the survey area increased by 32.2%, whilst percentage mussel cover decreased by 22.1% (Figure 7). The stock of mussels available to be removed from the fishery (≥51mm) was estimated to be 12.9 tonnes out a total 22.6 tonnes on the bed, i.e. 84.7% (Figure 7).

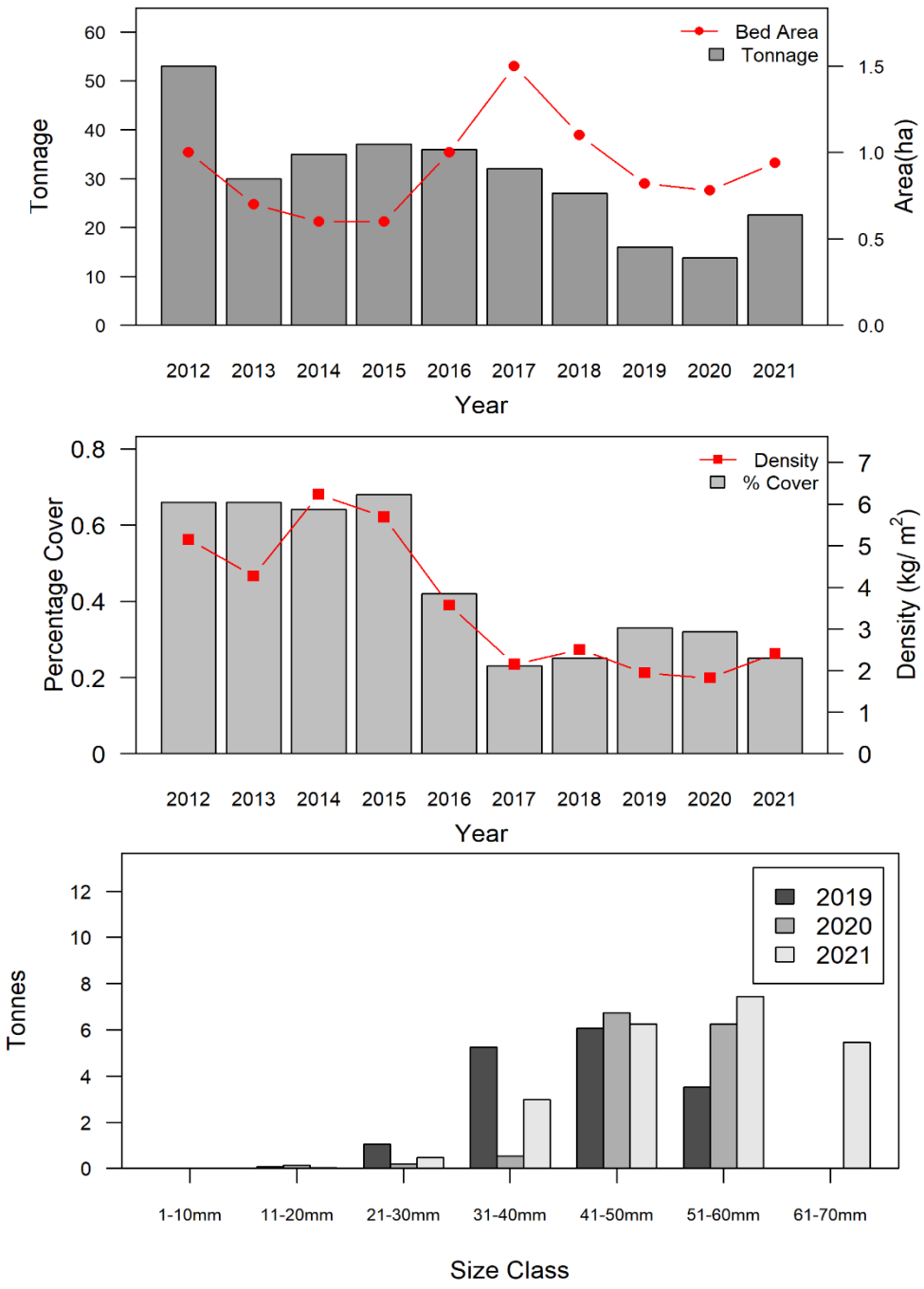

Figure 7 (a) Total area surveyed and tonnage of total stock and (b) average percentage cover and density of mussel between 2012–2021 on the Lifeboat Slip mussel bed. (c) Total stock of 10mm size classes for 2019-2021 on the Lifeboat Slip bed.

3.4 Sprat Ridge

Sprat Ridge was surveyed on 28th May 2021; 86 samples were collected from 22 transects. Since 2020 the tonnage of total stock increased by 91.2% and the survey area containing live mussels increased by 42.0% (Figure 8a, b). Total density within the survey area increased by 34.7%, whilst percentage cover of mussels increased by 26.1% (Figure 8b). The stock of mussels available to be removed from the fishery ≥51mm) was estimated to be 179.2 tonnes out a total 721.4 tonnes on the bed, i.e. 78.1% (Figure 8c).

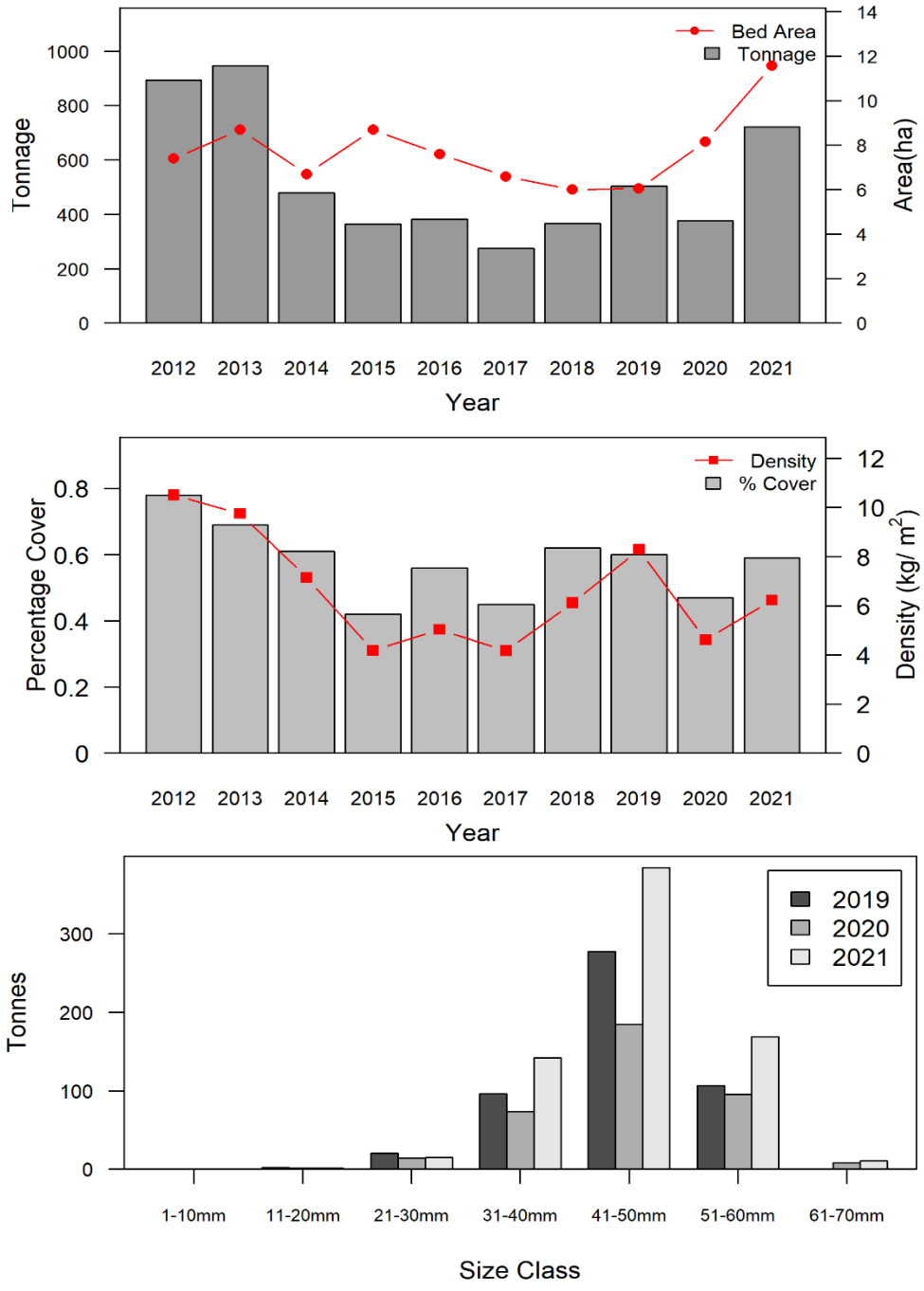

Figure 8 (a) Total area surveyed and tonnage of total stock and (b) average percentage cover and density of mussel between 2012–2021 on the Sprat Ridge mussel bed. (c) Total stock of 10mm size classes for 2019-2021 on the Sprat Ridge bed.

3.5 Pulleys

Pulleys was surveyed on 25th May 2021; 77 samples were collected from 14 transects. Since 2020 the total stock tonnage increased by 93.1% and the survey area containing live mussels increased by 108.2% (Figure 9a). Total density within the survey area decreased by 7.2%, whilst percentage mussel cover increased by 37.3% (Figure 9b). The stock of mussels available to be removed from the fishery ≥51mm) was estimated to be 5.4 tonnes out a total 392.0 tonnes on the bed, i.e. 39.5% (Figure 9c).

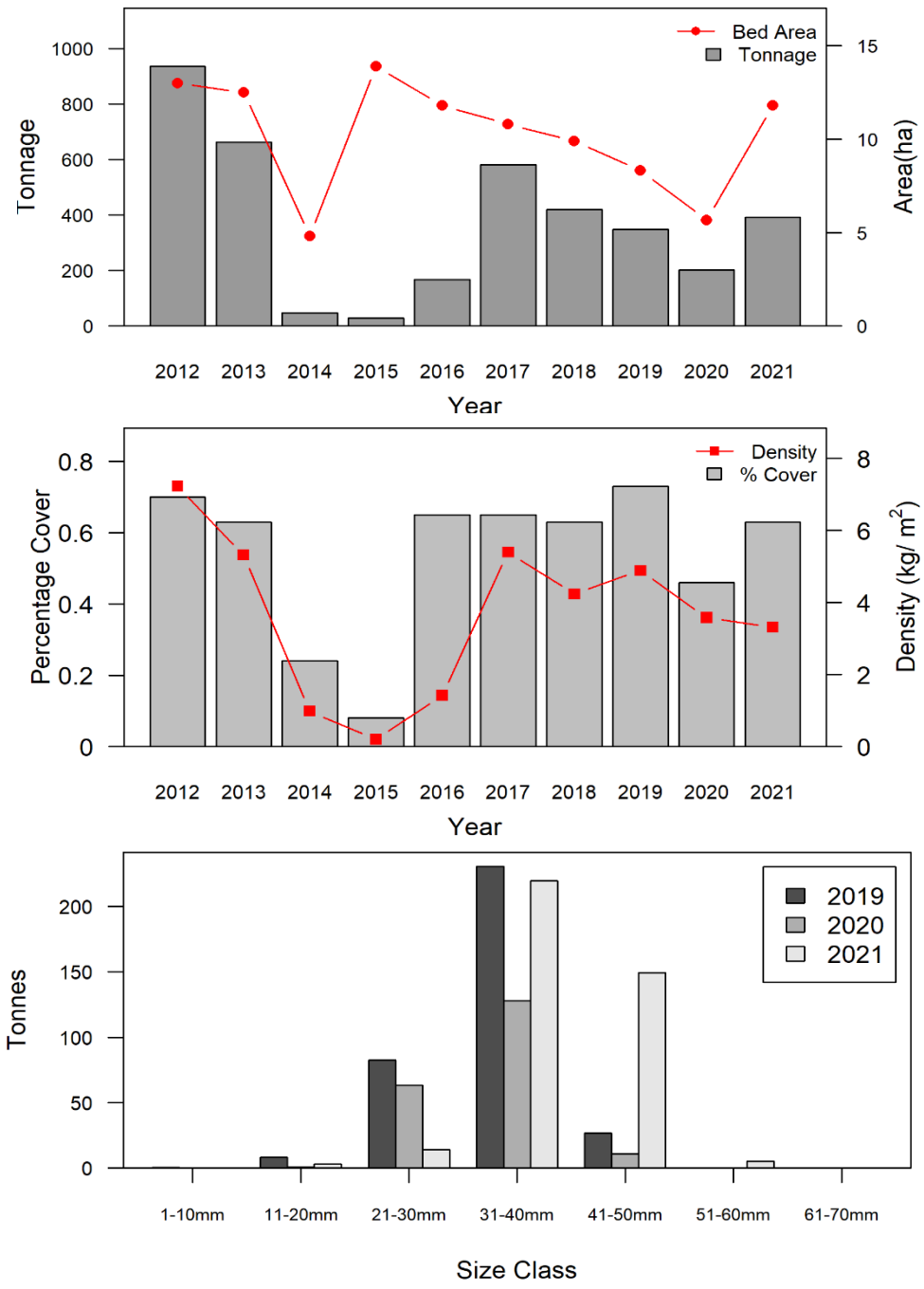

Figure 9 (a) Total area surveyed and tonnage of total stock and (b) average percentage cover and density of mussel between 2012–2021 on the Pulleys mussel bed. (c) Total stock of 10mm size classes for 2019-2021 on the Pulleys bed.

3.6 Yelland

Yelland was surveyed on 24th May 2021; 14 samples were collected from 10 transects. Since 2020 the total stock tonnage decreased by 3.4% and the survey area containing live mussels increased by 10.9% (

Figure **10**a). Total density within the survey area declined by 3.4%, whilst percentage mussel cover decreased by 8.7% (Figure 10b). The stock of mussels available to be removed from

the fishery ≥51mm) was estimated to be 30.3 tonnes out of a total 57.1 tonnes on the bed, i.e. 87.6% (Figure 10c).

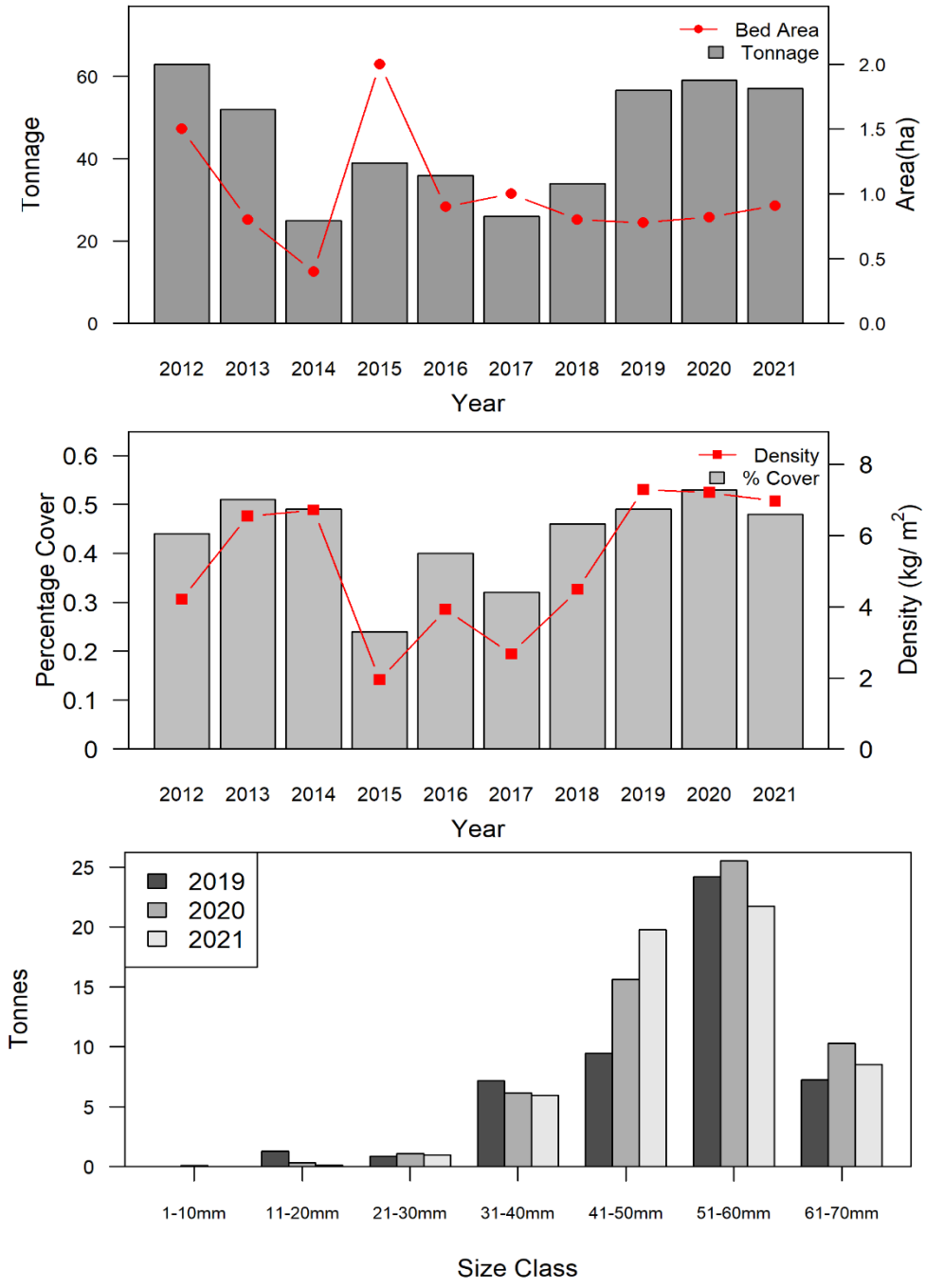

Figure 10 (a) Total area surveyed and tonnage of total stock and (b) average percentage cover and density of mussel between 2012–2021 on the Yelland mussel bed. (c) Total stock of 10mm size classes for 2019-2021 on the Yelland bed.

3.7 The Neck

The Neck was first identified and surveyed in 2020. The neck was surveyed on 27th May 2021. 12 samples were collected from 7 transects. Since 2020 the total stock tonnage decreased by 46.6% and the survey area containing live mussels decreased by 20.0%

(Figure 11). Total density within the survey area declined by 33.2%, whilst percentage mussel cover increased by 3.3% (Figure 11**Error! Reference source not found.**). The stock of mussels available to be removed from the fishery (≥51mm) was estimated to be 1.2 tonnes out a total 51.0 tonnes on the bed, i.e. 91.7% (Figure 11).

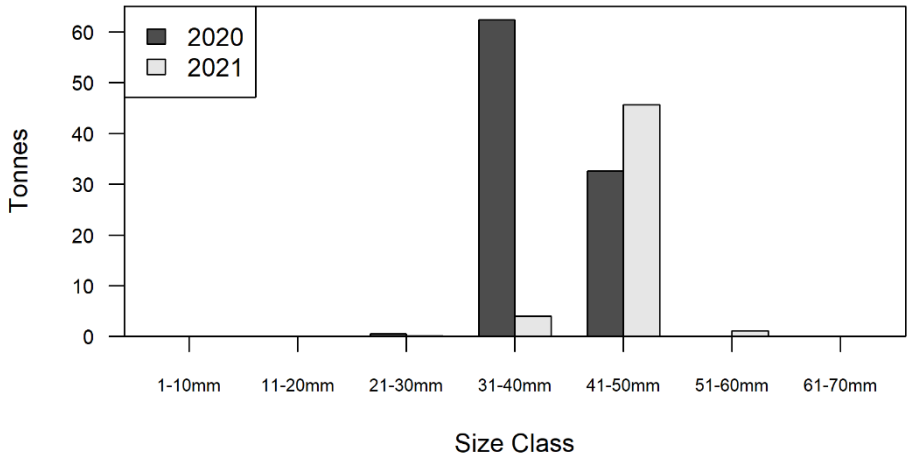

Figure 11 Tonnage of each 10mm size class for The Neck 2021 stock.

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 was 815 tonnes. This leaves 459 tonnes potentially available to remain on the mussel beds and support the fishery.

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 has increased by more than 50% of the 2020 levels. All size classes of mussel above 30mm have shown an increase in tonnage across the estuary compared to the 2020 levels. This suggests that while older mussel is continuing to grow, there has not been as much new settlement or recruitment in the last year. The 41–50 mm size class has shown a particularly large increase (by around 100% of the 2020 tonnage). The estimated area of the bed has increased by around 37% of the 2020 area. The survey area significantly increased for both Sprat Ridge and Pulleys (the two largest beds in the estuary) as well as for some of the smaller beds. The large increase in the tonnage of 41–50mm mussels across the whole estuary is likely to be driven by the mussels collected in these areas.

Both the average density and percentage cover of mussels across all beds has increased since 2020. The density and percentage cover of mussels across the estuary is now more similar to the values seen in 2019 and the years prior. It is important to note that The Neck (which has one of the highest percentage cover and density values across the estuary) was not included in the surveys prior to 2020.

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 in 2021 the bed area remained stable and tonnage 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, and this has not changed since the inclusion of the 2021 data. 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 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 2020–2021, except for mussels that were 41–50mm. This size class showed a 56% decline in tonnage compared to 2020 levels. It is unclear what the cause of this reduction in this size class of mussels could be.

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 and density of mussels increased from the levels recorded in 2020, whereas the percentage cover of mussels declined when compared to 2020. Mussels in the 31–40mm size class seem to have recovered somewhat from their large decline in 2020, although they are still

not up to the same level as was seen in 2019. 2021 is the first year that mussels in the 61–70mm size range have been found, which suggests that the mussels on this bed are able to continue to grow to larger sizes than have been attained before.

4.2.3. Sprat Ridge

Sprat Ridge has seen increases in total mussel tonnage, bed area, density and percentage cover. Sprat Ridge is dense and homogenous enough (~50% live mussel cover) to be considered a true mussel bed, therefore changes in survey area are more indicative of the change in bed size than some of the less homogeneous sites. The area of the bed has increased by 41% compared to the 2020 size. The tonnage of all mussel size classes have increased compared to the 2020 levels, and the 41–50mm size class has shown a particularly large increase. It is likely that the increase in tonnage of all mussel size classes is largely a result of the 41% increase of the bed area.

4.2.4. Pulleys

The tonnage of mussel on the Pulleys bed has increased to levels similar to that seen in 2019 following a decline in 2020, however the area of the bed has increased to levels greater than that of 2019. It is likely that this is the reason for the small decline in density of mussels on the bed. The percentage cover of mussel on the bed has increased following the decline in 2020 to levels similar to what was seen between 2016–2019 (~60% cover).This bed is still more clearly defined than some of the sparser, patchier sites in the estuary.

Mussels in the 31–40mm and 41–50mm size classes have shown a large increase in tonnage when compared to 2020, however the 21-40mm size class has continued to decline. 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. 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 year (Bayne & Worrall 1980, Seed & Suchanek, 1992). With a large population, recruitment though relatively low in 2020, may continue in the coming months.

4.2.5. Yelland

Over the 2019–2021 period, the area, biomass, density, and percentage cover of mussels on the Yelland mussel bed has remained relatively stable. 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 tonnage of most mussel size classes declined a small amount compared to the 2020 levels, apart from the 41-50mm size class, which increased by approximately 26%. 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 this survey. Therefore, the measures calculated from the survey may not reflect the true composition of the full bed. The surveyable area, tonnage and density of mussels declined compared to 2020, but the

percentage cover of mussels increased. The declines seen this year may be due to a number of reasons, including the tidal height during the survey relative to 2020. If less of the bed was exposed during the 2021 survey, then these declines would be expected.

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; on the basis of the data presented here, the model indicated that 459 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. 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. 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, density, and percentage cover mostly increased from the levels observed in 2020. The two largest beds showed the greatest increases, which were mainly driven by increases in the overall area of the bed. Most of the smaller mussel beds also showed signs of improvement, 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. In 2021 a fine mesh sieve was used to ensure mussel spat recruitment <20mm was not being underestimated. The weights of mussels under <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.

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 their 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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