# Stock assessment of the blue mussel (*Mytilus edulis*) beds in the Blyth estuary - 2023

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## Summary

Annual NIFCA surveys of the mussel bed in the Blyth estuary were conducted in 2023. The perimeter of the mussel bed was mapped for five separate sectors identified in previous surveys, and percentage cover of mussels was estimated using the MarinX 'Dutch Wand' survey technique. 19 samples of mussels were collected, and shell lengths and weights of 26 individual mussels were measured.

Key results:

- Though mussel bed area has varied over time since 2015, there is no overall trend and due to the subjective nature of determining bed perimeter, confidence in these estimates is low.
- This year had lower proportions of juvenile under <25mm mussels (4%) compared to 2022 and no other spat under 5mm in length.
- The largest measured mussel was 63mm and the average size was 49.7mm, an increase from 37.4mm in 2022. However, this is not due to an increase in frequency of the larger sizes compared to last year, but the fewer juvenile mussels found.
- While density varies across the mussel bed, it is consistently low in all sectors. Overall density was the lowest in 2023 since surveys began, following three years of low density between 2020 and 2023. Overall density has decreased from 320 per $m^2$ in 2015 to 23 per $m^2$, which is an alarming cause for concern.
- Compared to 2022 (the previous lowest year) percentage cover was marginally lower throughout the mussel bed with an overall decline from 17% to 16% cover.

2023 survey results confirm the continued decline in mussel density in the Blyth estuary, particularly of the older, mature population. The lowest percentage cover and densities recorded consistently across sectors point to low health of the mussel beds overall. The decline in the adult population regardless of sporadic recruitment indicates that recruitment at current levels is not enough to sustain the population in the long-term if pressures impacting the beds are not addressed. A collaborative Masters' research project with Newcastle University, the Environment Agency and Natural England examined mussel contaminants in two mussel beds at Holy Island and Fenham Flats, finding negative correlations of percentage cover with the contaminants PBDE154 (a flame retardant), dieldrin and endrin (pesticides) which have all been banned since 2007, 1989 and 1984 respectively. Storm frequency was also negatively related to percentage cover at Fenham Flats (but not Holy Island). Biocontaminants in the Blyth estuary have also been measured by the EA but were not within the scope of this project, though the estuary's heavily industrialised past and current use

as a port mean that the potential for biocontamination impacting on mussel beds is significantly higher than at Lindisfarne beds.

Though the causes of decline are unknown, and unlikely to be elucidated, it is clear that the intertidal mussel beds in the Blyth estuary are declining in terms of percentage cover and density, and that this is driven largely by the decline in larger sizes of mussel, this size class is also targeted by bait collectors.

# Introduction

The Blyth estuary covers an area of 168 hectares, including the River Blyth east of Bebside and a beck on the northern side called Sleekburn and is adjacent to Blyth town and the Port of Blyth. The estuary has an industrial past with major industries in coal, ship building and breaking in the 20th century and is still a major port with current growth in the renewable energy sector. Ongoing redevelopment work includes a project at Bates Terminal to the south and a nearby major development for offshore energy with a new deep-water dock on the northern edge of the estuary.

The Blyth estuary is part of the Northumberland Shore Site of Special Scientific Interest (SSSI)[1] which includes most of the coastline between the Scottish border and the Tyne Estuary. The intertidal mudflats of the estuary provide important low-water feeding grounds and high-water roosting grounds for large numbers of overwintering waders including oystercatcher, ringed plover, lapwing, dunlin, redshank and turnstone. Eider duck, knot, curlew and terns (sandwich and common) also use the estuary during the summer.

Blue mussel (*Mytilus edulis*) beds are on the OSPAR (Annex V) list of threatened and declining species and habitats. The blue mussel is a suspension feeding bivalve mollusc which feeds on algae, detritus and organic material in the water column. Mussels can form dense beds in the intertidal zone, the upper limits of which are controlled by temperature and desiccation while the lower limits are controlled by predation, competition, and sand burial. Mussels spawn in spring and late summer, but larval mortality is high resulting in sporadic recruitment. Mussels are an important prey item for some species of estuarine bird such as the oystercatcher, eider and curlew.

In late 2014, Northumberland Inshore Fisheries and Conservation Authority were notified of an increase in bait collection activity in and around the mussel beds on the Blyth estuary. Due to the importance of the site for important birds and concerns from the public, NIFCA began monthly stock assessment surveys of the mussel beds to assess stock health between March 2015 and February 2016 and have conducted annual surveys in March/April since then.

# Methods

This survey was conducted on 24th March 2023. For consistency, only surveys from March/April in 2015 and 2016 were analysed for annual comparisons with later surveys.

### Study site

The study site is located on the Blyth Estuary in Northumberland. Historically, the mussel bed was divided into six sectors. Sectors 1 to 4 are based on the feeding/roosting sites defined in Holliday

[1] https://designatedsites.naturalengland.org.uk/SiteDetail.aspx?SiteCode=S2000134&SiteName=&countyCode=

(2000) and were surveyed in the 2015-16 surveys. An additional two areas of mussel bed were added to the survey as sectors 5 and 6 in 2017. Sectors 5 and 6 have not been surveyed since 2019 due to logistics, however mussel density in 2019 was so low in these areas that the area could not be estimated. Officers will continue to monitor this area and may revisit these sites in future if mussels return to the area. During the 2020 survey, a new bed area (sector 7) was discovered and surveyed in subsequent years. Mussel bed sectors surveyed in 2023 are shown in Figure 1.

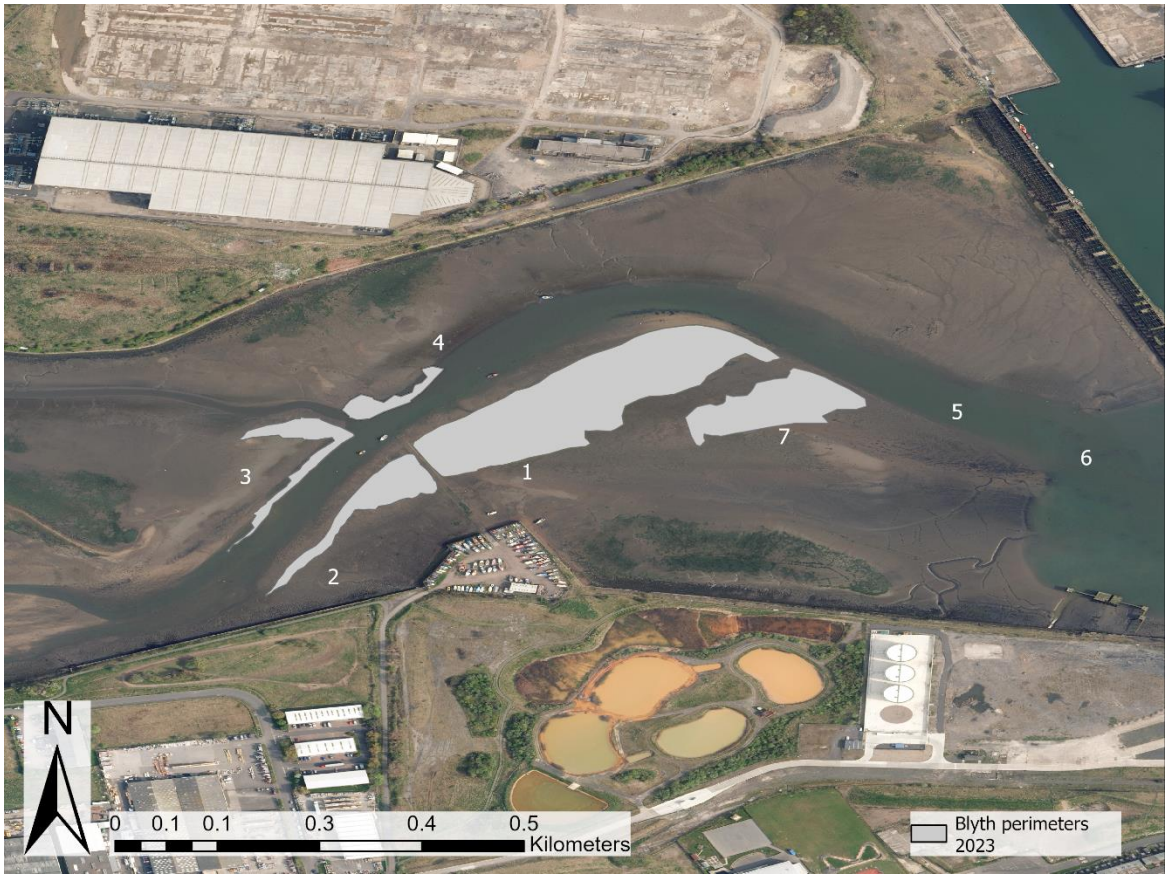



**Figure 1.** Blyth estuary mussel bed sectors surveyed in 2023.

## Survey methodology

Two Inshore Fisheries & Conservation Officers (IFCOs), one of whom had previously walked the perimeter, walked the perimeter with a handheld GPS. Confidence in the accuracy of the area is low as the area of the mussel bed is difficult to define. There is no Water Framework Directive definition of what constitutes a mussel bed so it can be subjective to define mussel bed area. Bed areas were calculated in ArcGIS from GPS perimeters.

The percentage cover of mussels on the mussel bed was estimated using the MarinX 'Dutch Wand' survey technique (McGrorty *et al.,* 1990). Surveyors walked in a zigzag across the mussel bed, in a randomly determined direction (Figure 2). The Dutch wand (a 4ft bamboo cane with an 11cm ring attached to the end) was placed out to one side every three steps and the result of

either a ‘hit’ (if the ring contained live mussels) or a ‘miss’ (if the ring did not contain live mussels) was recorded. Percentage cover was then calculated using the equation:

$$Percentage\ cover = \frac{Number\ of\ Hits}{Number\ of\ Hits + Number\ of\ Misses} \times 100$$


**Figure 2.** Officer during the survey of the mussel bed using the Dutch Wand methodology.

A mussel sample was taken from inside the 11cm ring at the site of every third ‘hit’. The total number of ‘hits’/samples taken per transect was recorded and samples were cleaned. Total shell lengths of all the mussels sampled were then measured (to the nearest millimetre) using a vernier calliper and divided into the following size groups: ≤25mm, 26-49mm and ≥50mm. The total weight (g) of mussels in each size category was also recorded for each sample. The density of mussels on the mussel bed was then calculated using the following equation:

$$Mussel\ density\ (number/m^2) = \frac{Number\ of\ mussels\ per\ m^2\ x\ Percentage\ Cover}{100}$$

Using a combination of mussel weight, density, percentage cover and bed area, the approximate total stock of mussels was calculated:

$$Mussel\ biomass\ (g/m^2) = \frac{Total\ mussel\ weight\ per\ m^2\ x\ Percentage\ Cover}{100}$$

$$Mussel\ Stock\ Biomass\ (tonnes) = \frac{Area\ of\ bed\ (m^2) \times\ Mussel\ biomass\ (g/m^2)}{1\ 000\ 000}$$

In surveys from 2019-2021, meat content was measured as an additional monitoring tool of overall bed health (see previous survey reports). However, the decision was taken not to measure this moving forward since the method was not accurate enough.

## Results

A total of 26 individual mussels from 19 samples were sampled in 2023. Overall, the percentage cover of live mussel in the beds was 16%. The total area of the surveyed beds was 30,661m². The results of individual sectors are summarised in Table 1.

Table 1. Results of the Blyth mussel survey 2023 by sector and for the overall surveyed beds.

| Sector | Area ($m^2$) | Number samples | Number of mussels | Total weight (g) | % cover | Density (mussels/$m^2$) | Biomass (kg/$m^2$) |
|---|---|---|---|---|---|---|---|
| Sector 1 | 17938 | 5 | 6 | 152 | 13% | 16.7 | 0.42 |
| Sector 2 | 3431 | 1 | 1 | 18 | 8% | 8.9 | 0.16 |
| Sector 3 | 2327 | 7 | 12 | 211 | 27% | 49.2 | 0.87 |
| Sector 4 | 1210 | 4 | 4 | 60 | 21% | 21.9 | 0.33 |
| Sector 7 | 5755 | 2 | 3 | 68 | 9% | 14.6 | 0.33 |
| **Overall** | **30 661** | **19** | **26** | **509** | **16%** | **22.8** | **0.45** |

## Bed Area

Mussel bed area has varied over time, though no overall trend is obvious (Figure 3; see previous reports for discussion of previous years). Since 2020 no major changes in area have been recorded (Figure 4). The only change in extent was in 2021 in sector 3, where an extra area of mussel bed was recorded, however this was not surveyed in 2023 therefore mussel density is assumed to be too low to accurately detect mussel bed area.

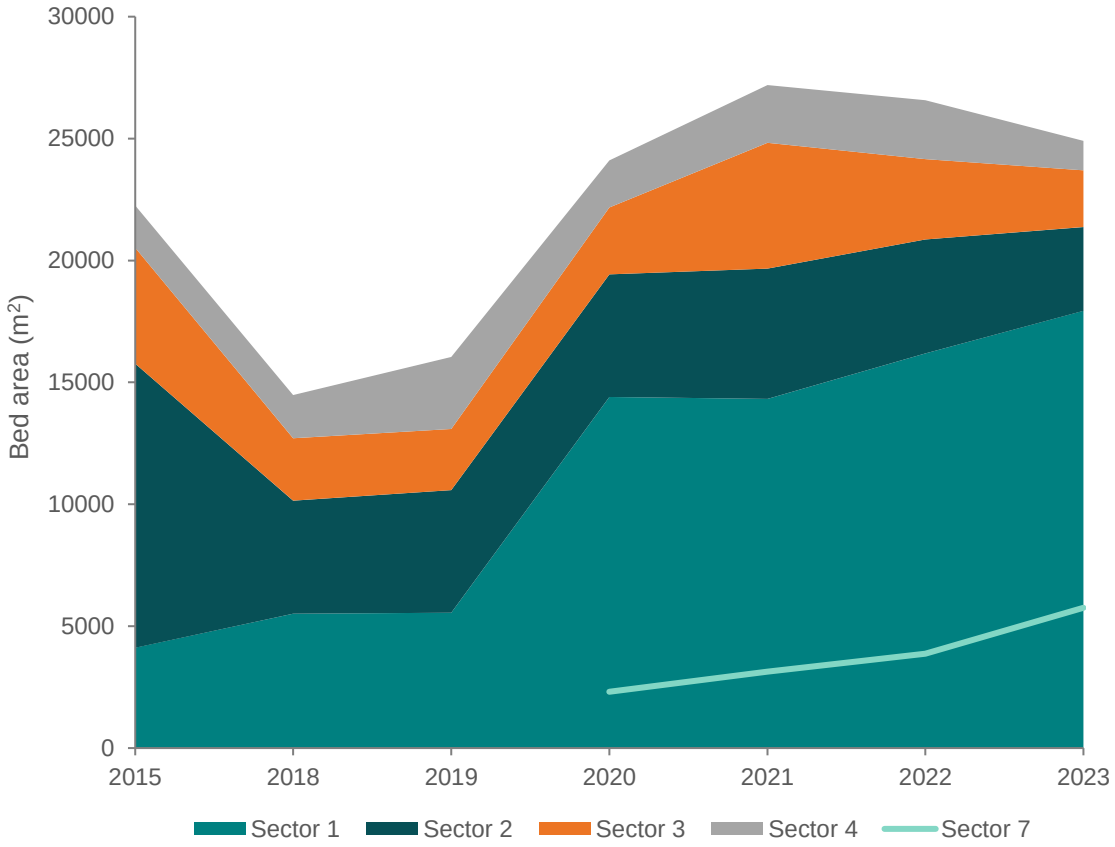



**Figure 3.** Total mussel bed area ($m^2$) of consistently surveyed Sectors 1-4 over time from 2015/16 surveys to present. Area of sector 7 in 2020-23 surveys is displayed but not included in total area. Area for sector 2 was not calculated in 2020 therefore 2019 data were used. Data were unavailable for 2016 and 2017 surveys.

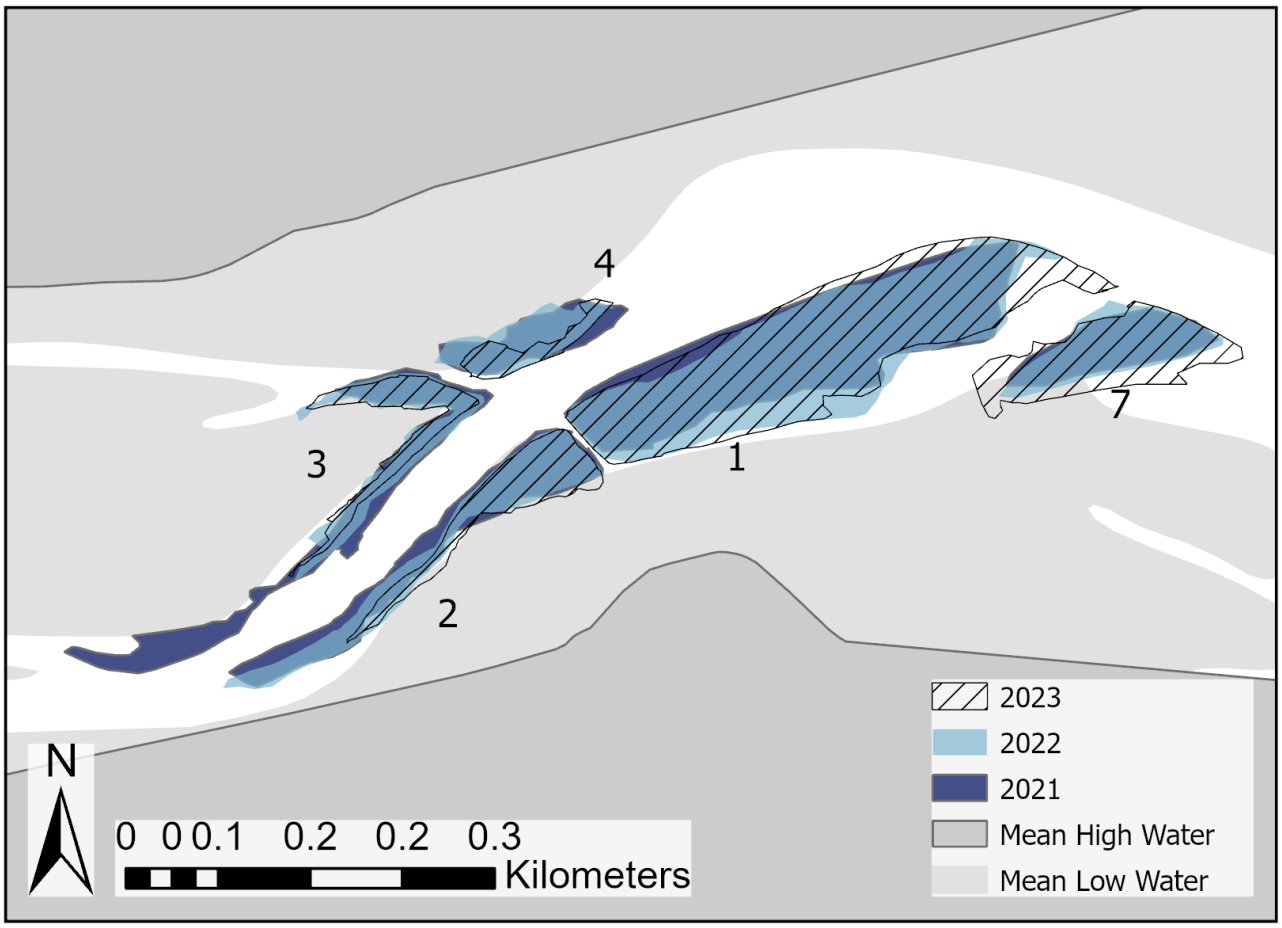



**Figure 4.** Mussel bed sectors surveyed in 2021, 2022 and 2023.

## Length Frequency

Mussel shell length varied from 6 – 63mm with a mean length of 49.7mm (Figure 5). There were no distinctive peaks in frequency, but the majority were >39mm indicating an older age class. 4% of individuals were <25mm in length, less than in 2022 and there were no size classes <5mm. (Figure 6a). The proportion above 45mm, the recommended Minimum Landing Size for bait collection, was 77% compared to 47% in 2022.

The proportions of size classes varied in different sectors (Figure 5). Sector 3 had the only proportion of juvenile mussel (<25mm) making up 4% of the total number of individuals. The majority of mussels were >39mm in all sectors with a clear decline in juvenile sized mussels across sectors. The proportion of mature mussels varied across the bed, with the largest ones being present in sector 7 (Figure 5c).

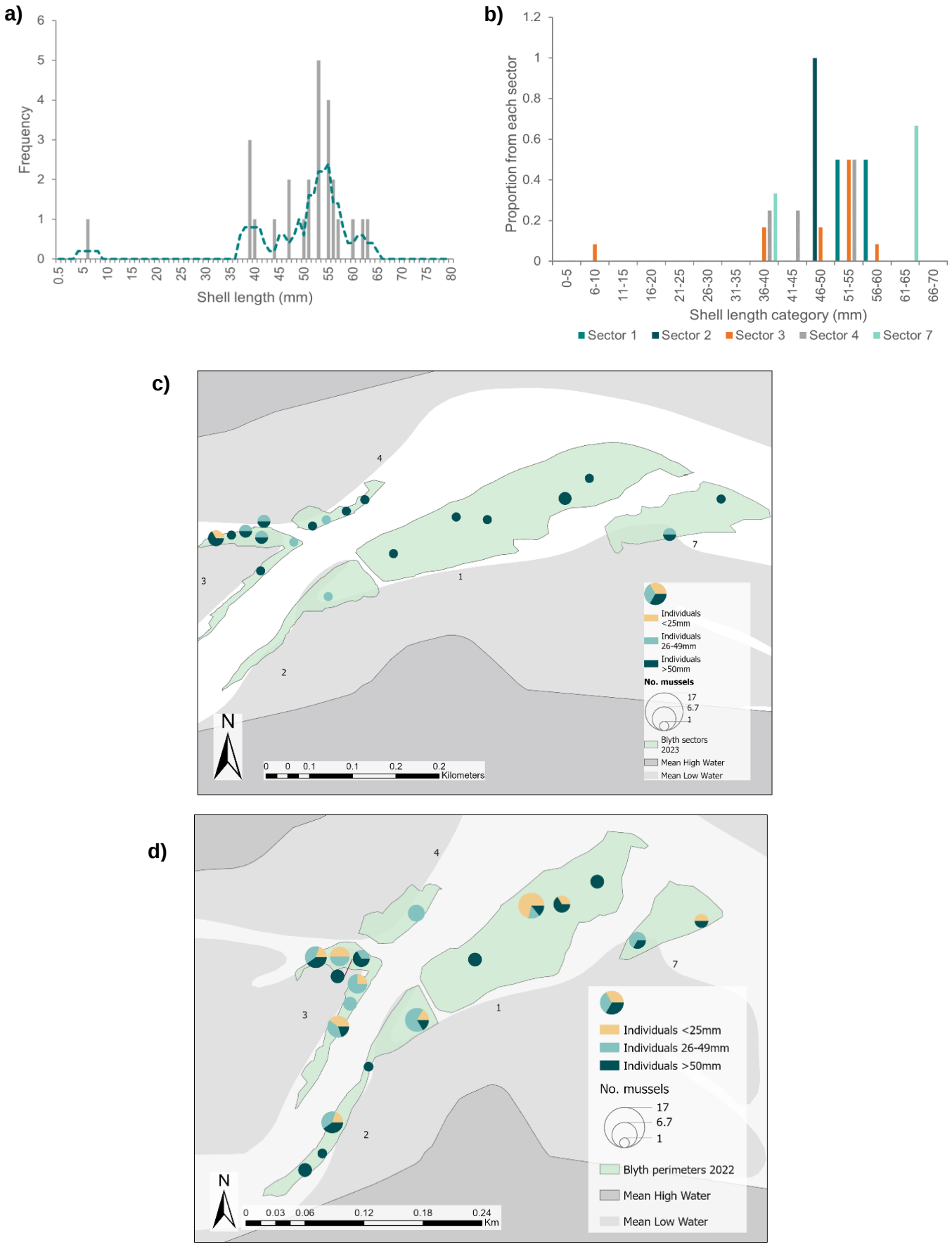
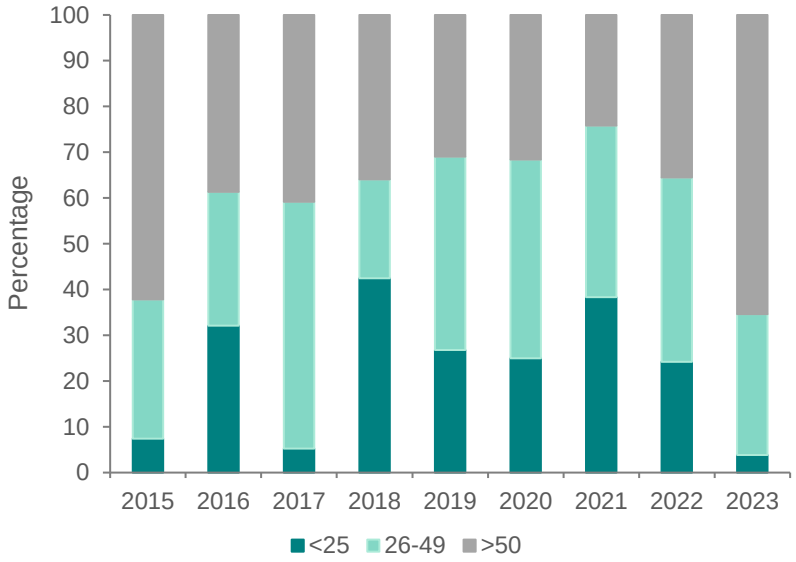



**Figure 5. Frequency and distribution of mussel shell lengths in the Blyth estuary, 2023. a) shell length frequencies of individuals in the Blyth estuary overall, with averaged trendline; b) shell**

**lengths as proportions of the total number of mussels per sector, and locations of samples in c) 2023 and d) 2022, showing number of mussels in the sample as the circle size and proportion of size classes (<25mm, 26-49mm, >50mm) per sample. Locations are not exact to ensure they do not overlap.**

Compared to previous years, proportions of size classes were similar to 2015, while there were reduced numbers of young mussel (<25mm) compared to 2018 - 2022 (Figure 6a). There were two individuals larger than 60mm which is similar to 2022, however this is still lower than in previous years. Previously, the proportion of mature mussels in the Blyth was decreasing compared to smaller size classes (Figure 6a) but this year the mean shell length of mussels increased within the estuary (Figure 6b). The proportion of smaller size classes shows very low numbers of young mussels similar to 2015 and 2017.

**a)**




**b)**

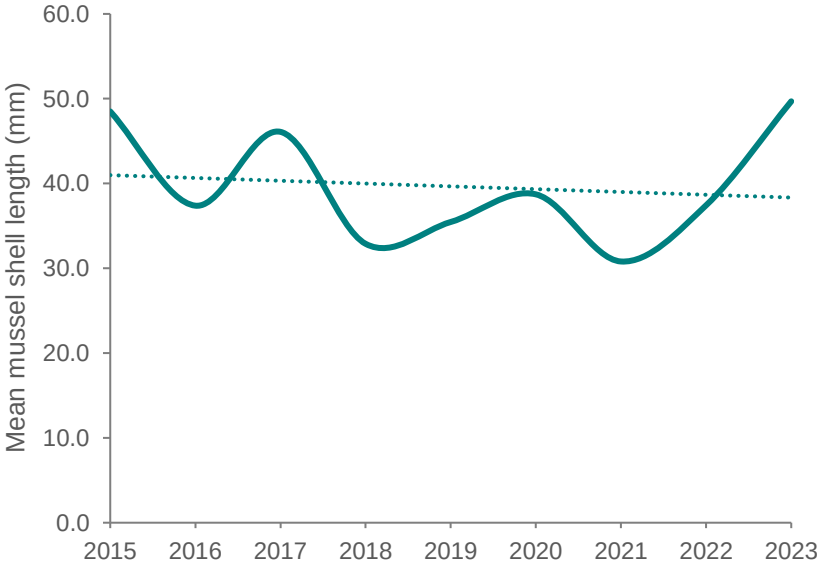


**Figure 6. a) Percentage of mussels in size classes (<25mm, 26-49mm and >50mm) and c) mean shell length, from 2015-2023.**

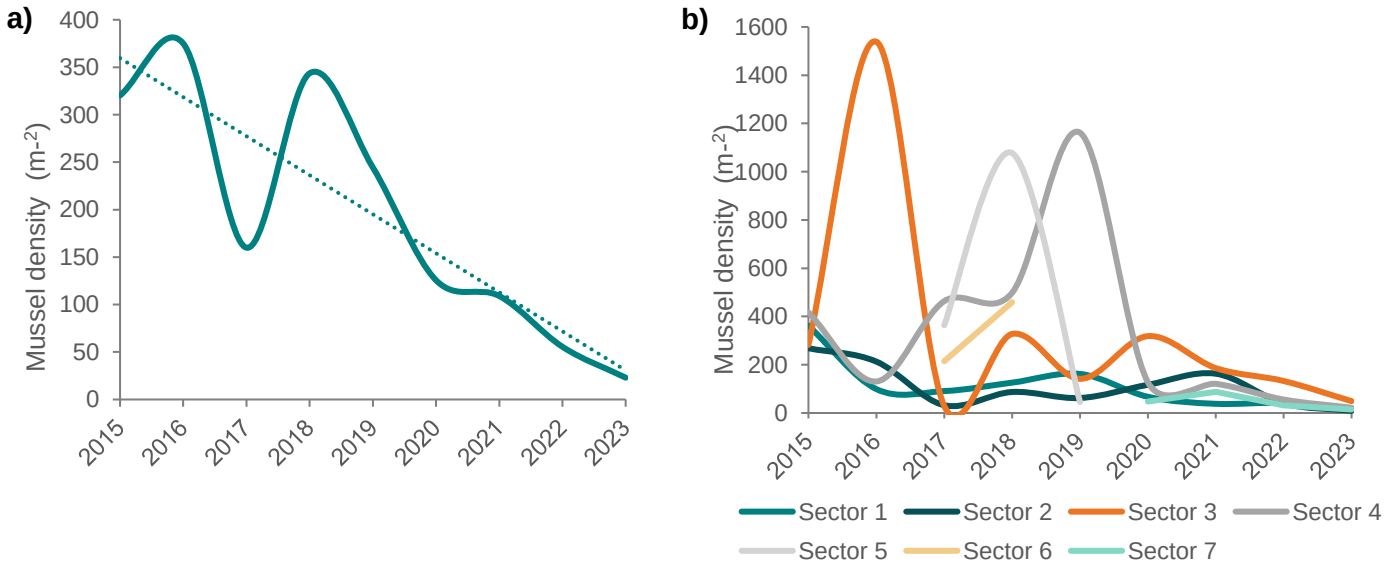
## Density

Number of mussels per sample was low across the 19 samples (Figure 5c). Compared to 2022, there were less samples taken and the number of mussels (particularly <25mm) per sample was smaller than 2022 (Figure 5d).

Density (number of mussels and percentage cover combined) varied between the sectors (Table 1). Sector 3 had the highest density overall at 49.2 mussels per $m^2$ due to the higher percentage cover. Sector 2 had the lowest overall density (8.9 mussels per $m^2$).

Density has varied over time both overall and for different sectors (Figure 7). Overall density is highly variable over time but has decreased, reaching the lowest value in 2023 after three years of low density in 2020 and 2022. See previous report[2] for a full description of results over time. Since 2019, no Sector has exhibited very high densities which explains the low densities overall in the estuary.

The densities of the different size classes have also varied over time (Figure 7c). The larger size class (>50mm) has declined tenfold since 2015, while the middle size class (26-49mm) has declined but at a slower rate. The density of the smallest size class (<25mm) has varied significantly between years with peaks in 2016 and 2018 and low densities since 2020 reaching the lowest in 2023.




[2] Analysis of the Edible Mussel (Mytilus edulis) Bed surveys in the Blyth Estuary, 2015 – 2020. NIFCA Report.

c)

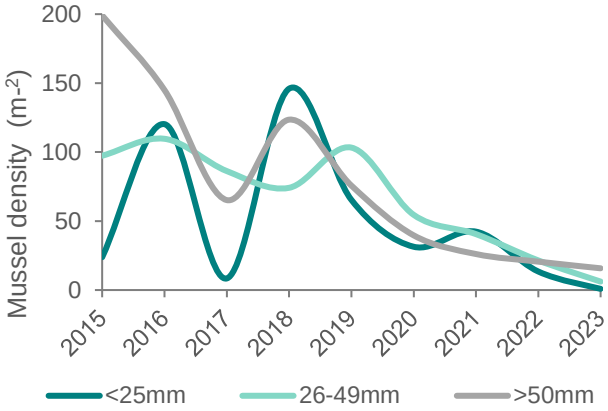



**Figure 7.** Density of Blyth estuary mussels a) overall with (nonstatistical) linear trendline, b) by sector, and c) density of individual size classes (<25mm, 26-49mm, >50mm) from 2015-2023. No samples have been taken from sectors 5 and 6 since 2019 therefore density could not be calculated however was anecdotally very low.

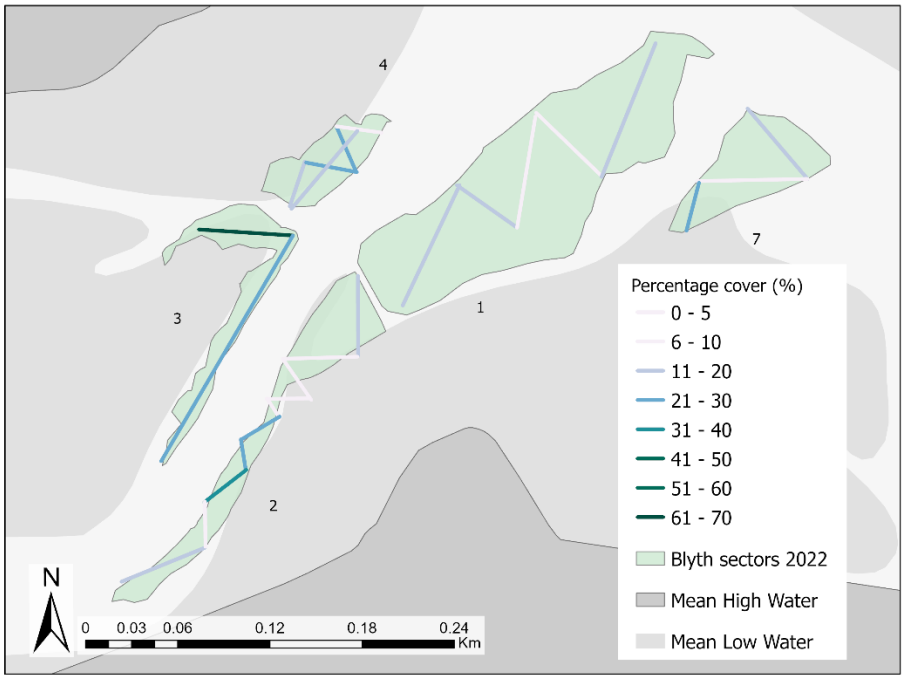
## Percentage cover

Percentage cover varied both between and within sectors across different transects (Figure 8). Percentage cover was generally below 25% with only two transects higher than this (42% and 52% in Sector 3 and 34% in Sector 4). Three transects in Sector 2, two transects in sector 4 and one transect in sector 7 had zero percentage cover.

Compared to 2022 percentage cover was much lower throughout the mussel bed with an overall slight decline from 17% to 16% which was mainly caused by the decline as in 2022 in Sector 2 from 35% in 2022 to 8% in 2023.

Overall percentage cover has varied over time though with a slight decline and the lowest recorded cover in 2023 at 16%, again slightly lower than 2022 which was the previous lowest figure at 17% (Figure 9a). Percentage cover in sectors is highly variable over time (Figure 9b); see previous report**Error! Bookmark not defined.** for a full description of results from 2015-20. In comparison to 2022, Sectors 1, 4 and 7 have remained similar overall while percentage cover in Sectors 2 and 3 decreased. Figure 8 compares transects in 2022 and 2023 and overall, the decline in percentage cover is noticeable.

a)

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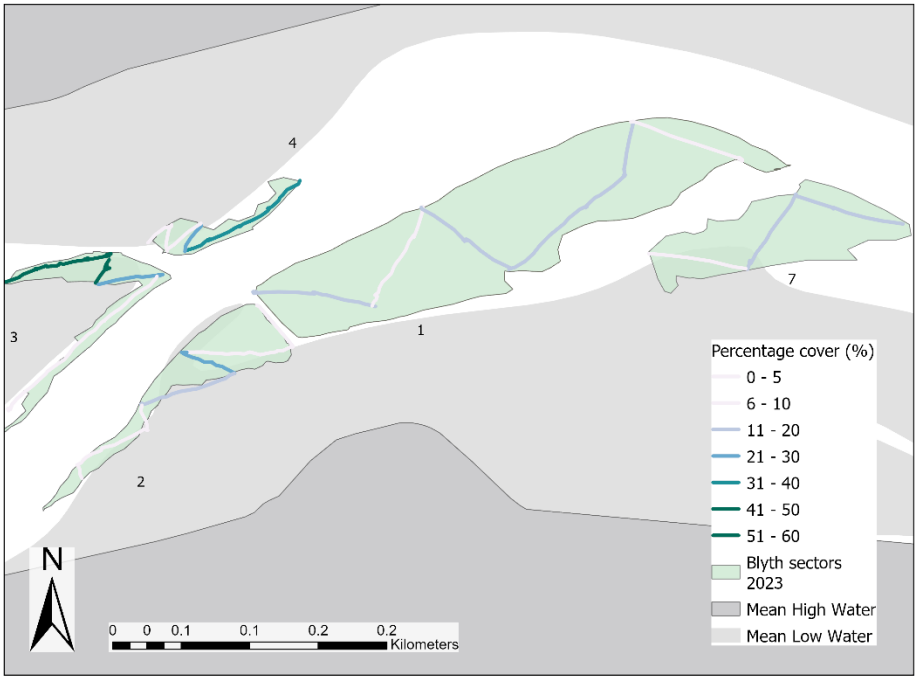


**Figure 8.** Percentage cover and locations of surveyed transects in a) 2022 and b) 2023.

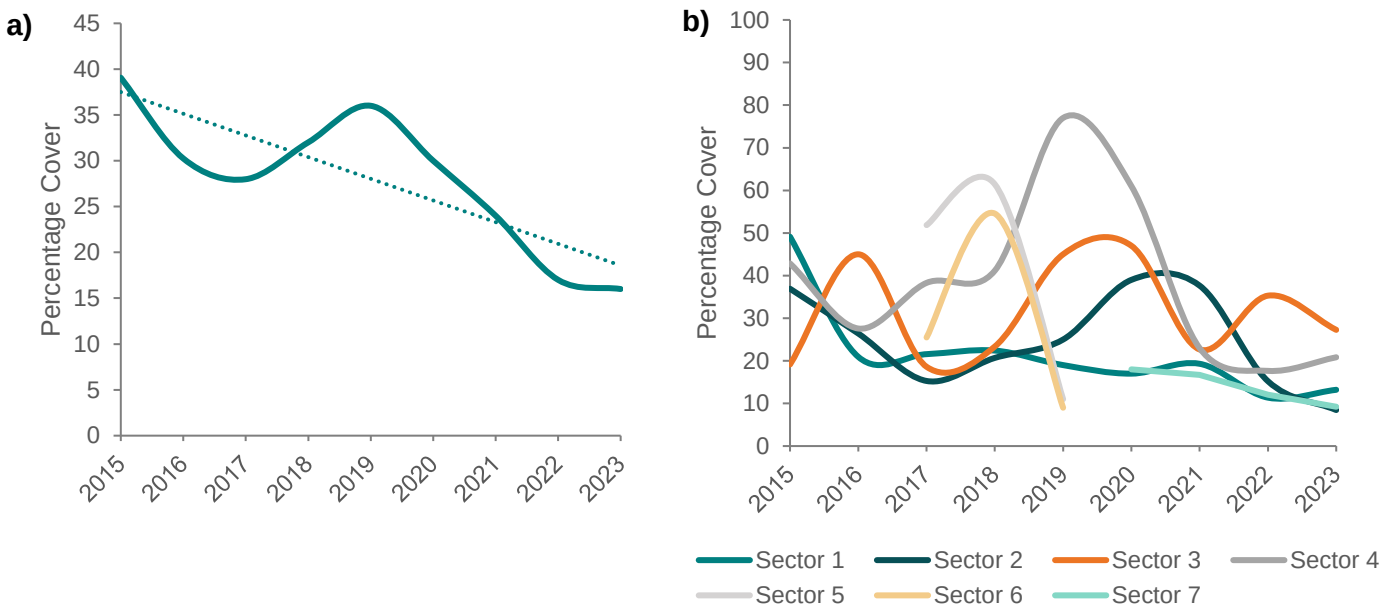


**Figure 9.** Percentage cover of Blyth estuary mussel beds a) overall with (nonstatistical) linear trendline and b) by sector, from 2015-2023.

## Mussel stock biomass

Mussel stock biomass was an estimated 14 tonnes for 2023, the lowest estimated since surveys began (Figure 10). While stock >50mm has decreased since 2022 from 18 to 12 tonnes, stock below 50mm has decreased significantly from 5 to 2 tonnes, over half of the previous lowest estimate in 2019 which was 10 tonnes. Since 2015 there has been a large decline in estimated stock biomass with consistently low values from 2019 onwards.

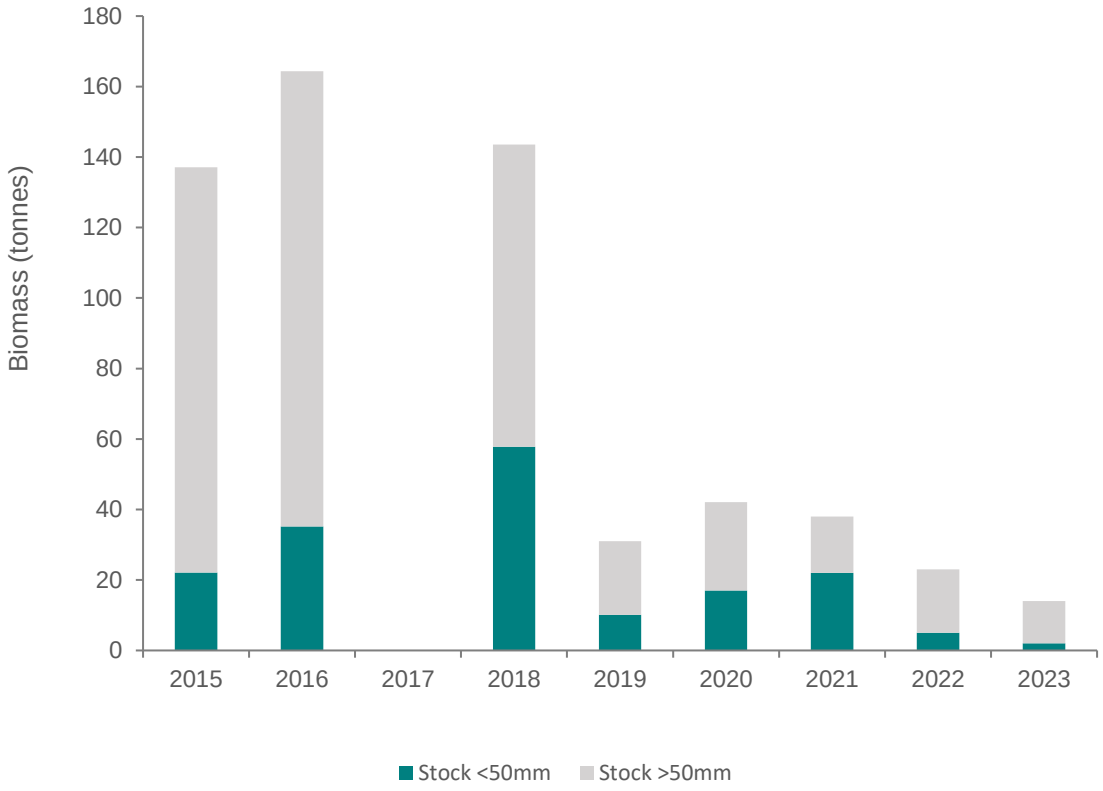


**Figure 10.** Biomass estimates for the total estimated stock of mussels in the Blyth estuary 2015-23, showing biomass greater and less than 50mm. Bed area values were unavailable for 2017 surveys therefore biomass was not calculated.

## Discussion

Mussel bed area remained similar to previous years (see previous report[3]). The 2023 survey sees continued declines in mussel stock biomass from 2019-2022 levels which were already depleted in comparison to earlier years. There was a reduction in the proportion of juvenile mussels (spat) compared to in 2022 although this has been highly variable in the past and is due to different levels of reproduction and recruitment in different years, a normal characteristic of mussel beds. However, percentage cover of live mussel and mussel density were the lowest values this year indicating a continued decline in the health of the mussel bed. The declines in density were for all size classes and continue the trends observed in previous years of a steep decline in mature (>50mm) mussels and a shallower decline in medium sized (26-49mm) mussels.

Recruitment in mussel populations is often sporadic, occurring in unpredictable pulses (Seed & Suchanek, 1992), which is the case in the Blyth estuary in surveyed years, with higher recruitment occurring roughly every two years. Persistent mussel beds can be maintained by relatively low levels of sporadic recruitment (McGrorty et al., 1990; Mainwaring et al., 2014), however the decline in

[3] Blyth Estuary Blue Mussel Stock Assessment 2022. NIFCA Report

mussel density over this time indicates recruitment is not high enough to counter the causes of decline and sustain the population.

The proportion of larger mature mussels above MCRS could indicate that recruitment of younger mussels is not occurring at the rate needed to re-stock the juvenile mussel population. Bait collection may occur but sightings of mussel collection are within the steams and also further upstream than the surveyed sectors (see Appendix Figure 1). According to anecdotal evidence the sediment characteristics in the estuary mudflats have changed recently, becoming harder and possibly less suited to mussel settlement. Work is ongoing to dredge the ash dock and improve port facilities on the northern bank which may change sediment characteristics within the estuary, though there is no proven link.

Other potential causes of decline are discussed in previous reports[4,5] (see Appendix for summary) and contextualise the declines in the Blyth estuary against widespread blue mussel declines in the UK and northeast Atlantic, the exact causes of which are currently unknown.

## Conclusions

Overall, the 2023 surveys continue the trends identified in 2015-22 surveys, and show declines in percentage cover, density and therefore total stock since 2022, continuing the trend in overall decline which is a concern. The higher proportion of juveniles found in the 2021 survey did not lead to a higher density of medium or larger size mussels in 2022 or 2023 therefore successful recruitment into the adult population may not have occurred. The decline in the adult population regardless of sporadic recruitment indicates that recruitment at current levels is not enough to sustain the population in the long-term.

## Further work

The problems in estimating mussel bed area are due to their subjective nature and the difficulty of assessing mussel bed edges on the ground. In 2021 a project in collaboration with Newcastle University used an unmanned aerial vehicle (UAV) to determine mussel bed extent and percentage cover in the Blyth estuary when compared to traditional ground-based surveys (Dutch wand) conducted by NIFCA. It was successful in determining mussel bed extent based on live and dead shell cover, however, could not differentiate between live and dead mussels unlike ground-based surveys. There is potential to use these methods to determine mussel bed extent in the Blyth estuary as well as at Fenham Flats and Holy Island to determine changes more accurately in mussel bed

[4] Blue mussel declines in the Blyth Estuary. NIFCA Report 2021.
[5] Blyth Estuary Blue Mussel Stock Assessment 2021. NIFCA Report

area over time. Though a standard operating procedure for using UAVs to determine mussel bed extent was a successful project outcome, it required the use of a more specialised (multispectral) UAV than NIFCA owns therefore the use of this method in future surveys will be evaluated.

The exact causes of mussel bed decline are unknown, both in the Blyth estuary, regionally and nationally. A Newcastle University project in 2021 used Environment Agency data on water quality and mussel contaminants to better understand the causes of decline, and found significant relationships with the biocontaminants PBDE154, Dieldrin and Endrin at Lindisfarne mussel beds, though the Blyth was not analysed. Given the remote location of Lindisfarne compared to the industrial Blyth estuary, it is likely there will be far more contamination of the mussels in the Blyth which could be having an impact. Natural England have proposed a larger project to understand more about mussel bed declines which should shed further light on both regional and national declines.

It is unlikely whether the exact causes of mussel bed decline in the Blyth estuary will be discovered as it is likely a combination of multiple factors including bait collection, changes in river hydrology and sedimentation, nutrient runoff and contaminants from the industrial past and current port expansion. In 2021 a new voluntary Bait Collection Code of Conduct for the estuary was developed in conjunction with stakeholders, and the efficacy of this needs to be evaluated before considering statutory measures.

# Appendix

**Figure 1.** NIFCA surveyed mussel bed areas in 2019 and 2020 (dashed blue) and NIFCA sightings of mussel collectors 2014-20 (dark blue points) where mussels are also present. From previous report 'Blue mussel declines in the Blyth Estuary' (2021).

Potential causes of mussel decline in the Blyth estuary:

- Overexploitation (bait collection)
- Substratum loss
- Water quality
- Nutrient enrichment
- Hydrological changes
- Climate change
- Predation
- Recruitment and juvenile survival

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