Stock Assessment of the Edible Mussel (*Mytilus edulis*) Beds in Blyth Estuary

2020

Report prepared by: Environmental IFCO Andrew Boon

Northumberland Inshore Fisheries and Conservation Authority
8 Ennerdale Road
Blyth
NE24 4RT

Tel: 01670 797676
Email: nifca@nifca.gov.uk
Website: www.nifca.gov.uk

Abstract

The purpose of this report is to assess the state of the mussel bed in the Blyth estuary. The perimeter of the mussel bed was mapped, and percentage cover of mussels was estimated using the MarinX 'Dutch Wand' survey technique. Samples of mussels were collected, and total shell length and weight were measured. In 2020, the mussel bed at Blyth estuary covered an area of 26,410 m² however percentage cover and density varied significantly across the site. The length distributions for mussels were skewed towards larger mussels, with the mean shell length increasing since 2019. This report aims to summarise data obtained during NIFCA surveys and to provide insight into the health and distribution of the mussel bed in the Blyth estuary to inform future management of the site.

Introduction

The edible mussel (*Mytilus edulis*) is widely distributed, occurring in boreal and temperate waters, in both the southern and northern hemispheres (OSPAR, 2010). *M. edulis* is tolerant of a wide range of environmental conditions (FAO, n.d.) including fluctuations in salinity (Andrews *et al.,* 2011), and therefore occurs in both marine and brackish waters (Gardner, 1996). Mussels can form dense beds on estuarine flats (Fenton, 1978) attaching to substratum using byssus threads (Babarro *et al.,* 2008). Spat (juvenile mussels) settles on existing beds, hard substrates (such as shells or stones) or may be washed as clumps to other parts of the estuary (Verwey, 1952).

M. edulis beds are included in the OSPAR (Annex V) list of threatened and declining species and habitats and are listed as a UK biodiversity action Plan (BAP) Priority Habitat (Maddock, 2008). Threats to mussel beds include bait collection (Maddock, 2008), gathering for human consumption (Fenton, 1978), pollution (Hilgerloh, 1997), coastal development, anchoring (Maddock, 2008) and wash out due to adverse weather conditions. It is currently unknown whether mussel beds are declining because of the aforementioned threats, due to bird predation or a combination of factors (Hilgerloh, 1997).

Blyth Estuary is part of the Northumberland Shore SSSI and provides important feeding and roosting grounds for overwintering waders, such as redshank, dunlin and turnstone as well as resident species such as oystercatcher, ringed plover, curlew and eider duck (Holliday, 2000). Mussels are an important dietary component for Turnstones (*Arenaria interpres*) and Oystercatchers (*Haematopus ostrelegus*) at Blyth (Eaton, 2000). There is a concern that a decline in mussels on the Blyth estuary may have negative impacts on the bird populations at the site.

In late 2014 the Northumberland Inshore Fisheries and Conservation Authority (NIFCA) was approached by Blyth Boat Club about unregulated hand gathering and bait digging amongst the mussel beds on the Blyth Estuary. Due to the importance of the site for important birds and concerns from the public, in March 2015 NIFCA began monthly stock assessment surveys of the mussel beds to assess stock health. Baseline data was collected in 2015-2016 (Wallace, 2016) and further surveys were carried out during 2016-2019 as NIFCA continue to monitor the site.

Methods

The survey was conducted in March 2020, similar to the previous surveys in April 2019, April 2018 and March 2017. These surveys were a continuation of monthly surveys undertaken by NIFCA at the site between March 2015 and February 2016. From March 2017 onwards, it was decided the bed will be monitored on an annual basis. Surveys are conducted by NIFCA staff, committee members and volunteers from partner organisations.

Study Site

The study site is located on the Blyth Estuary in Northumberland. The mussel bed extends from the Blyth Boat Club slipway upstream to just beyond the sewage outfall beneath Cowley Road. Historically, the mussel bed has been divided into six sectors. Sectors 1 to 4 are based on the feeding/roosting sites defined in

Holliday (2000) (**Error! Reference source not found.**) and were surveyed in the 2015-16 surveys. An additional 2 areas of mussel bed were previously identified and added to the survey as sectors 5 and 6. For the 2020 survey, conditions on the day the survey was carried out did not allow for sectors 5 and 6 to be surveyed. The decision was made to not return and sample these sites in 2020, as during the 2019 surveys, mussel density and overall abundance was so low in these areas, that it was not possible to calculate the area of these sites for the analysis. 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 was discovered that had not previously been recorded. This has been named sector 7, however this may change if it is decided to removed sectors 5 and 6 from future surveys.

Figure 1: A map of the Blyth Estuary mussel beds in 2012. For sector 2, the 2019 bed areas were used as the 2020 areas were unable to be calculated.

Survey Methods

Two Inshore Fisheries & Conservation Officers (IFCOs), one of whom has previously walked the perimeter, walk 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 WFD definition of what constitutes a mussel bed so it can be subjective to define mussel bed area. The information collected was exported as a GPX file from the GPS using the Garmin GPS software Basecamp and then imported into ARC GIS to map and calculate the area of the mussel bed.

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 4). 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:

$$\textbf{Percentage Cover} = \frac{\textbf{Number of Hits}}{\textbf{Number of Hits + Number of Misses}} \textbf{ X 100}$$

A mussel sample was taken from inside the 11cm ring at the site of every fifth 'hit'. All mussel samples from the same transect were collected together and the total number of samples taken per transect was recorded. The samples were sieved (6mm mesh size) and cleaned in estuarine water. Total shell lengths of all the mussels sampled were then measured (to the nearest millimetre) using a vernier caliper and divided into the following size groups: <25mm, 26-49mm and >50mm. The total weight (in grams) 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:

$$\text{Mussel Density} = \frac{\text{Number of mussels per m}^2}{\text{Percentage Cover}}$$

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

Using a combination of mussel weight, density, percentage cover and bed area, it is possible to calculate the approximate stock of mussels in the bed using the following equation:

$$\text{Mussel Stock (tonnes)} = \text{Area of bed in m}^2 \times \frac{\text{Mussel Density in m}^2}{1{,}000}$$

In 2019, it was decided to begin conducting analysis of the meat content of the mussels found within the Blyth Estuary. This was done to determine if the meat content was declining and to begin recording this data as an additional monitoring tool of overall bed health. This was done by weighing a sample of mussels, removing the meat from this sample and recording a dry weight of the meat. The meat content was calculated using the following equation:

$$\text{Meat Content (\%)} = \frac{\text{Weight of Meat}}{\text{Weight in shell}} \times 100$$

Results

Mussel Bed Extent

The mussel bed at Blyth estuary covered an estimated area of 26,410m² in April 2020 (Table 1), increasing from 20,080m² in April 2019. This is despite sectors 5 and 6 being excluded from the survey.

Table 1: Summary of the results obtained during the Blyth Estuary mussel survey April 2019. For sector 5, no samples were taken and as such, no density estimate could be calculated.

Location	Area (m^2)	Number of samples	Number of mussels in samples	Weight (g)	Percentage Cover	Density (mussels/m^2)
Blyth Estuary	26,410	20	76	964	30%	399.9
Sector 1	14,400	4	11	63	17%	289
Sector 2	5,030	5	17	234	39%	358
Sector 3	2,750	6	39	493	47%	684
Sector 4	1,920	3	4	79	61%	140
Sector 7	2,310	2	5	95	18%	263

For the consistently surveyed sectors between 2018 and 2020 (sectors 1-4), the bed area has increased from 14,480m^2 in 2018 to 24,100m^2 in 2020 (Figure 3) and shows a steadily increasing trend across all 3 years. The area calculations for sector 2 and 3 have remained stable between 2018 and 2020, with sector 4 showing a decline of 1,020m^2 from the 2019 calculations. The biggest change in sector area ca be seen in sector 1, which saw an increase in area to 14,400m^2 in 2020, increasing by over 4,000m^2 from the 20119 estimates.

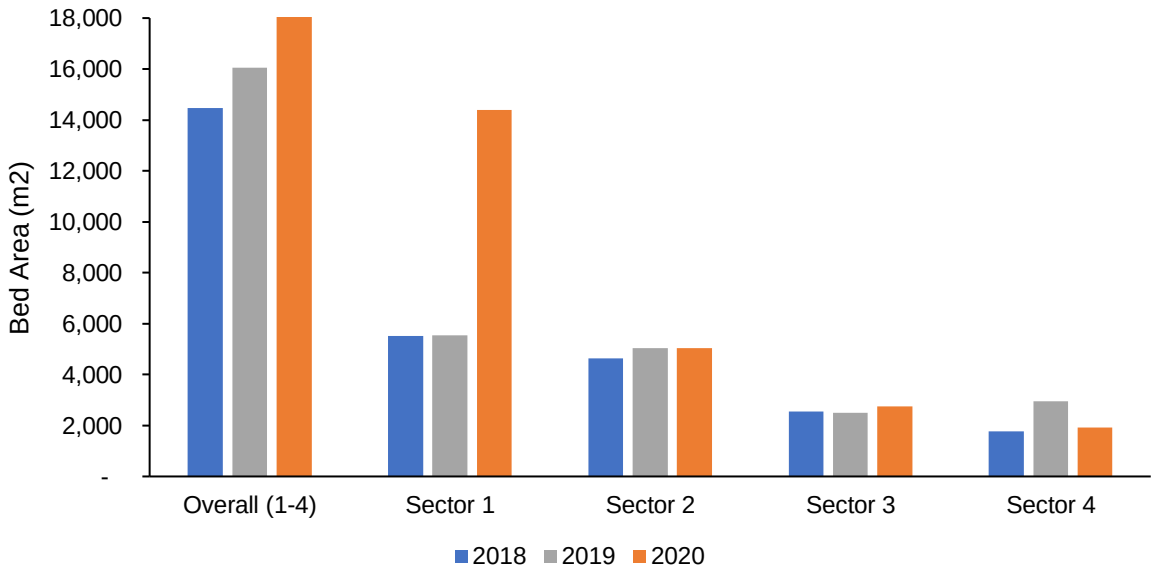

Figure 3: Bed area comparisons between 2018 and 2020 for the consistently surveyed sectors (sectors 1-4).

Percentage Cover

Percentage cover varies between the sectors surveyed (Table 1), with a high of 61% in sector 4, but dropping to just 17% in sector 1. Between 2018 and 2020, overall percentage cover in the estuary has remained relatively stable, dropping to 30% in 2020, from a peak of 36% in 2019 (Figure 4). The most notable increase in percentage cover since 2019 was observed in sector 2, with an increase of 14% in 2020. After a significant increase in percentage cover in 2019 in sector 4, the 2020 data indicates a decline, however percentage cover still remains above the 2018 value.

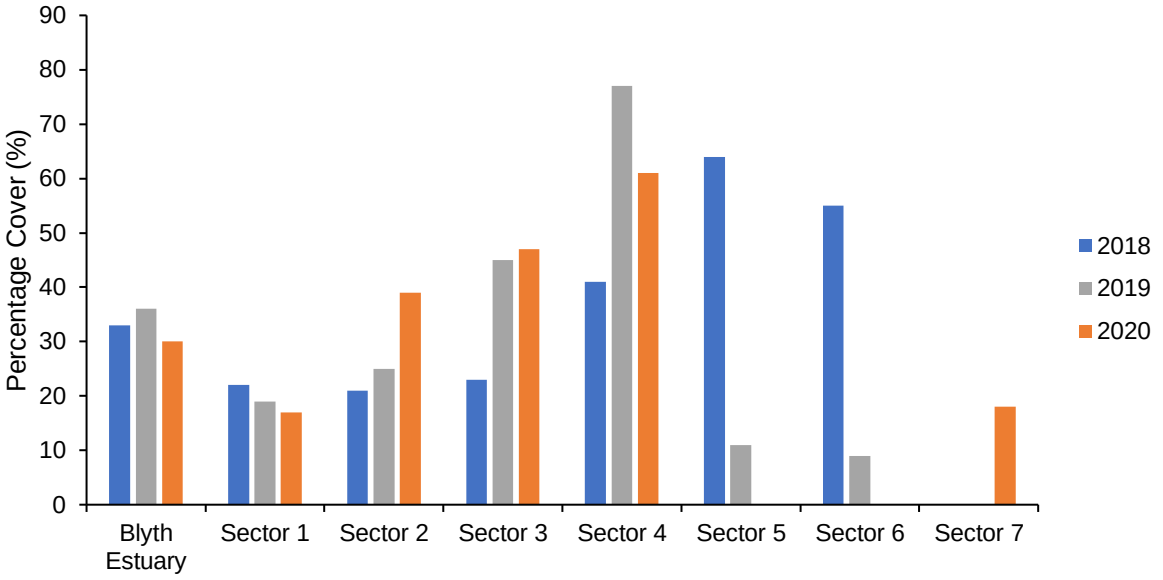

Figure 4: The percentage cover per sector and the overall estuary for 2018, 2019 and 2020.

Density

There is a high degree of variability in mussel density throughout the site, although density within the estuary as a whole has increased from 276 mussels/m^2 in 2019, to 400 mussels/m^2 in 2020 (Figure 5). This however is still a significant decline from the 575 mussels/m^2 in the 2018 survey data. Sector 4 was the only sector surveyed that showed a decline in mussel density in 2020 when compared to 2019, falling to 140 mussels/m^2. Sector 3 displayed the greatest increase in density. Something to note is the newly discovered sector 7. This will be monitored in the coming years to analyse trends. As will sectors 5 and 6, although trends in previous years do indicate a dramatic decline in the density and overall abundance of mussels in these areas.

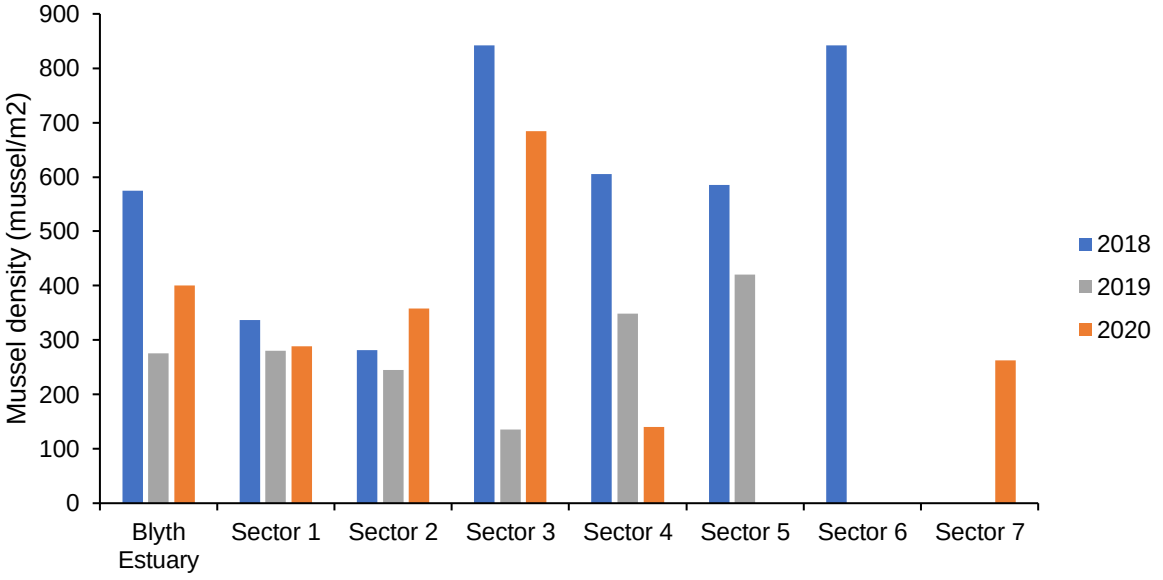

Figure 5: Mussel density per sector and the overall estuary for 2018, 2019 and 2020.

Length Frequency

A total of 76 mussels were sampled in the 2020 survey, increasing from 71 in the 2019 survey, although still significantly lower than the 153 sampled in 2018. Mean shell length of mussels sampled in 2020 was 38.72mm, an increase from the 35.46mm mean shell length and 32.89mm in 2018. The size classes of mussels sampled in the 2020 survey follow similar trends to those seen in 2019, with a greater proportion of mussels above 50mm (31% of those sampled) than below 25mm (Figure 6).

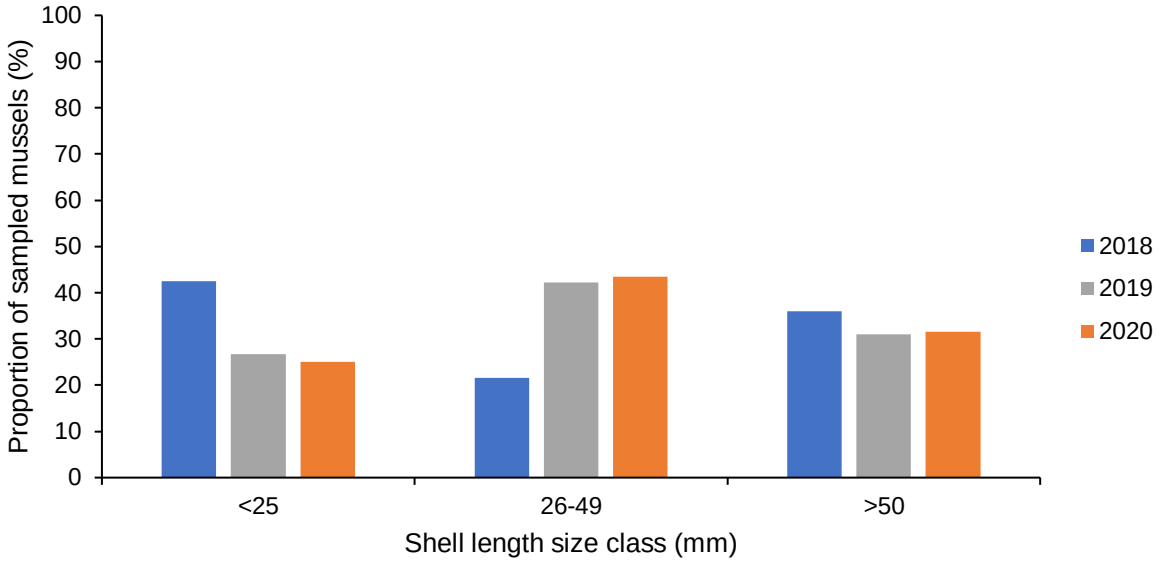

Figure 6: The proportion of the mussels sampled within each size class for the overall Blyth Estuary for 2018, 2019 and 2020.

Length frequency data for the 2020 survey shows a high frequency of individuals >45mm in length, with lower frequencies of mussels of a smaller size. This contrasts with the high frequency of smaller mussels found in the 2018 survey, although does not differ significantly from the frequencies seen in 2019. The exception to this is that there was significant increase in the frequency of mussels measuring 50mm in the 2020 survey than in 2019. The trend of increasing frequencies of larger mussels between 2018 ad 2020 would explain the increasing mean mussel size that has been observed during this time.

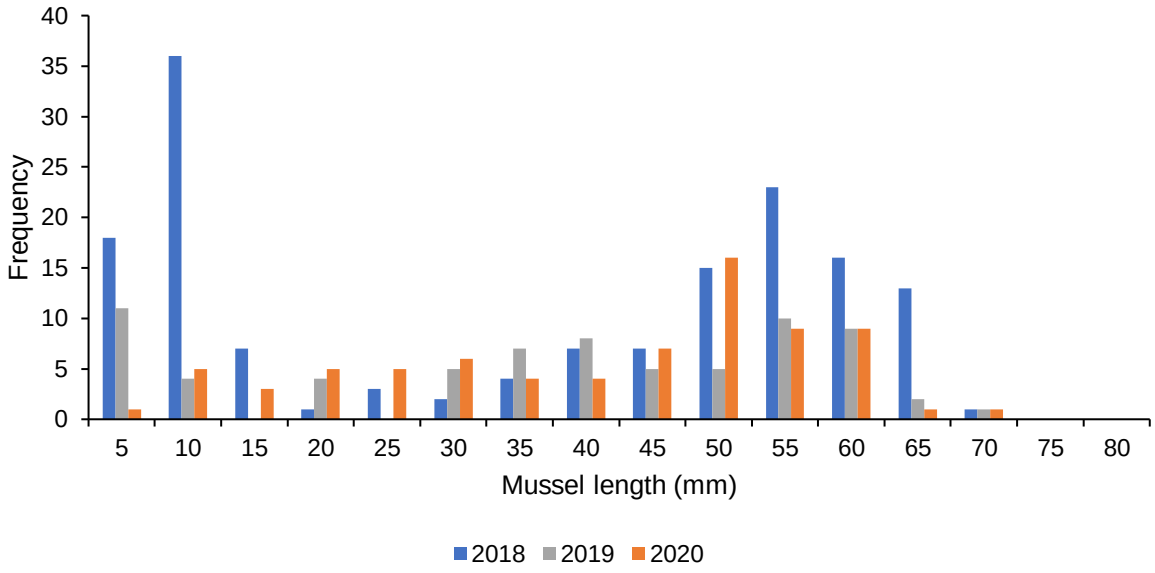

Figure 7: Length frequency distribution of mussels sampled during the Blyth Estuary surveys in 2018, 2019 and 2020.

Mussel Stock

Based on stock size estimates, the overall stock has increased since 2019, however still falls below the estimates in 2018 (Table 2).

Table 2: The mussel stock size estimations based on surveys between 2018 and 2020.

	2018	**2019**	**2020**
Stock >50mm (tonnes)	47	20	24
Total Stock (tonnes)	79	29	40

Meat Content

After analysis of the meat content in 2020, there was a slight decline in meat content in 2020 compared to 2019 (Table 3). The meat content of samples fell by 2.6% in 2020 from the previous year.

Table 3: Meat content analysis of samples taken in 2019 and 2020.

	2019	**2020**
Shell Weight (g)	933	1097
Meat Weight (g)	129	123
Meat Content (%)	13.8	11.2

Discussion

Mussel Bed Extent

For the 2020 survey, it was chosen to omit sectors 5 and 6 for logistical reasons on the day of survey. This coupled with the lack of data collected in the 2019 survey led to the decision to not survey these sites in 2020. This has obviously impacted the bed area estimates for 2020, with the 2018 estimated bed areas for sectors 5 and 6 contributing 10,500m^2 to the overall bed area. In addition to this, problems with the data for the perimeter for sector 2 in the 2020 survey meant that the 2019 bed area was used to provide an estimate of the mussel population in this sector. This may further contribute to inaccuracies of the findings associated with the bed area and density estimates.

Despite the omission of sectors 5 and 6, the bed area as a whole increased. This was attributed to the increase in the size of sector 1. At this moment, it is difficult to ascertain any trends for this sector and determine whether the significant increase from the area estimates in 2019 was down to the subjective nature of the perimeter surveying methodology or whether it was down to an actual biological change in the mussel bed.

The discovery of sector 7 in the 2020 survey was a promising addition to the mussel bed within the Blyth Estuary and may indicate the bed is spreading to new areas. As this was the first year of survey in this sector, future surveys will monitor this sector for any changes.

Percentage Cover

The mussel bed was not evenly distributed across the site, percentage cover varied between the six sectors (Table 1). Levels of predation by birds, crabs and collection of mussels for bait are likely to be the largest determinant factors of percentage cover and density found in the Blyth Estuary (Seed & Suchanek, 1992, Holt *et al.,* 1998).

In the 2020 survey, there was higher percentage cover observed in sectors 3 and 4, potentially attributed to their distance from access points for bait collectors (Aitken, 2018). These sites are less accessible than the sectors on the southern bank of the river and likely are subject to lower fishing effort when compared to other sites.

Despite the omission of sectors 5 and 6 in the 2020 survey, the declining population trends in previous surveys could be attributed to the location of these sites. They are situated downstream from a large building site and has been potentially subject to increased rates of sedimentation as a consequence of surface runoff from the site. Sedimentation has widely been attributed to a decline in mussel bed densities and percentage cover and could explain the decline within these sectors (Seed & Suchanek, 1992).

An overall decline of percentage cover in the Blyth Estuary may indicate a declining population, which despite the implementation of a code of conduct by NIFCA for this area, may need to be managed further if this trend continues.

Density

Overall site mussel density has increased since 2019. This is despite the absence of the historically densely populated sector 6. This increased density has likely come as a consequence of a significant increase in the density in sector 3, as well as the discovery of a relatively highly dense sector 7, when compared with other sectors. The overall site density estimates may have been affected by the lack of area data for sector 2 in the 2020 survey, instead the 2019 sector area was used. This may have led to an over or underestimation of the density in this sector, with the 2020 data showing a potential increase in density for this sector when compared with the 2019 data. The changes in density across the site are likely due to a number of factors, not limited to: 1) exploitation i.e. bait collection, 2) predation by birds, 3) other natural variation, 4) randomness of the survey technique.

Further analysis should be conducted on the level of bait collection recorded at the site in future years to understand the level of pressure exerted on the bed. Higher mussel density on the sectors on the north side of the river Blyth are typically subject to lower levels of bait collection, as a consequence of the lack of easy access. Monitoring of the levels of bait collection at the site would provide more information on the impact of this activity.

Predation by birds may also be a factor in the densities observed in the results however, birds are known to target a size range and so changes in density cannot be completely explained by this. Other natural variation including patterns in settlement, conditions such as temperature and pollution levels (Jones et al., 2010), and the amount of suitable ground to settle on may affect the density of the mussel at the site (Seed, 1969). These factors should be considered in future analysis at the site.

Length Frequency

In 2018, the length frequency is skewed toward smaller size classes which could mean there was a settlement of spat or smaller mussels from previous years. The results from the 2018 survey display a bimodal pattern with two peaks: one at the smaller size classes and one at the larger (Wallace, 2017, Aitken, 2018). Several studies have identified bimodal length distributions for mussels (Hilgerloh, 1997; Gray, 2011), with one theory suggesting predation of medium sized mussels (between 25 and 38mm) by birds (Gray, 2011). Meire and Ervynck (1986) found that oystercatchers select mussels between 30mm and 45mm in length. Hilgerloh (1997) suggests that dominance by one size class of mussels occurs due to larger mussels growing out of the size range exploited by predators.

It's difficult to derive any trends in shell length frequency based upon the data collected in 2019 and 2020, given the low number of mussels collected. Despite this, it is possible that the large proportion of the population found <25mm in 2018 could have resulted in the larger percentage of the population falling in the 26-50mm range in 2019 and the >50mm range in 2020.

The increase in the average shell length in 2020, when compared to 2019, highlights a potential ageing population and a lack of smaller animals within the estuary as a result of reduced juvenile settlement. Either there is reduced larval settlement to beds in the Blyth Estuary, or larval settlers are being 'washed away' before fully settling on the bed to grow. Given the low numbers recorded in 2019 and 2020, further monitoring is needed to determine the accuracy of this conclusion and assess any patterns in settlement and recruitment.

Mussel Stock

Similar to the density and mussel bed extent analysis, it is difficult to reliably estimate the overall stock biomass, as a result of the lack of contemporary area data for sector 2 in 2020. The analysis does however provide an approximate scale of the mussel bed and is a useful monitoring tool. As highlighted in the length-frequency analysis, the mussel population in the Blyth Estuary does exhibit an ageing, larger population, with almost 60% of the total stock biomass being >50mm in length. Analysis of the overall stock should continue and is a useful monitoring tool to determine whether current levels of exploitation are suitable.

Meat Content

The meat content analysis highlighted a slight decline between 2019 and 2020. This could indicate a decline in the health of the mussel population. Meat content is subject to seasonal variation (Okumus and Stirling, 1998), however as the surveys were conducted at similar times, it is unlikely this explains the change. Research has shown that meat content in mussels is indicative of food availability, with a higher meat content being observed when food is plentiful (Orban *et al.,* 2002). Therefore, this change could highlight a lack of food availability. Ongoing surveys shall monitor this trend, as only having data for 2019 and 2020 does not allow for an accurate picture to be built up.

Conclusion

The purpose of this report is to continue assessments of the state of the mussel bed in Blyth estuary by comparing 2020 data with data from previous years. This study has provided an ongoing assessment of the size and distribution of the mussel bed, length frequencies and densities of the mussels and levels of bait collection at the site and compared the results with those obtained in earlier years (Wallace, 2017).

Results show a sharp decline in the number of mussels at the site when compared to 2018, however, do seem to have levelled out and have remained stable since 2019. Sampled mussels do indicate an ageing population with a low settlement rate, which may influence the size and structure of the bed in the future. Predation and collection of mussels at this site will continue, and the site will be surveyed annually to continue to monitor the effects of this and other pressure on the bed. Management may be introduced if the mussel bed exhibits signs of significant decline.

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