Lugworm density surveys 2022 – 2023

Katy Smart

NORTHUMBERLAND INSHORE FISHERIES AND CONSERVATION AUTHORITY
8 Ennerdale Road, Blyth, NE24 4RT
www.nifca.gov.uk

Contents

Summary

The impacts of bait digging on lugworm populations in the NIFCA district are not well known and need to be better understood to complete assessments of Marine Protected Areas (MPAs). This study used the methodology from a PhD which was carried out in March 2014 at Boulmer and Newton. For this study another location with high levels of collection (Berwick) was added. Lugworm casts were counted in randomly placed quadrats on the lower shore where bait digging occurs, with faecal casts used as a proxy for the number of lugworms. Cast diameter was also measured to compare average lugworm sizes.

The study found:

- In March 2023, Boulmer had a lugworm density of 17.7 per m^2, compared to much lower lugworm densities at Berwick and Newton of 4.3 per m^2 and 1.1 per m^2 respectively.
- Average faecal diameter size in March 2023, showed similar values across sites with the largest average found at Boulmer (3.50mm), followed by Newton (3.36mm), and Berwick (3.33mm).
- Compared to 2014, lugworm density decreased at Boulmer and Berwick with a significant decrease at Newton. The reasons for this are unknown but biotic factors such as the movement of lugworms to the higher shore, predation from birds, weather conditions and tide times may affect the results. Abiotic factors such as bait digging activity deteriorating habitats and removing worms may also be a factor here.

Introduction

The long-term impacts of bait digging on lugworm populations are not known in the NIFCA district, including in the Berwickshire and North Northumberland Coast SAC and Coquet to St Mary's MCZ. The impacts of bait digging on the protected features (intertidal mud, and intertidal sand and muddy sand) is being assessed, which includes impacts on invertebrate communities.

A PhD (Tinlin-Mackenzie, 2018) conducted a comparative study and baseline surveys of lugworm densities at Boulmer, Newton and Fenham Flats at Holy Island (high, medium and low collection intensity respectively) in 2014, finding lugworm densities and species richness were not related to collection pressure. However, Boulmer had less than half the average infaunal abundance of the other sites despite it being muddier and expected to have higher abundance. Their experimental study found a reduction in lugworm abundance after bait digging compared to controls, with incomplete recovery in the more intensely dug plots. Moreover, there was no baseline data to compare with, so they recommended continued monitoring of the lugworm densities over time.

This study used methods in Tinlin-Mackenzie (2018) to measure lugworm densities at Boulmer, Newton and an additional site, Berwick, which has similarly high levels of collection to Boulmer and has been highlighted as a potential area of concern in protected area assessments. NIFCA patrols record intertidal activities along the coast and recorded an average of 2.65 bait diggers per patrol at Berwick, 1.95 at Boulmer and 0.21 at Newton. Fenham Flats was not included due to it being an uncollected site and not in need of assessment.

Methods

Three sites were selected (Boulmer, Berwick and Newton) within the NIFCA district to survey lugworm population densities. Surveys were conducted in July 2022 (survey trialled), November 2022 and March 2023 using ground-based monitoring. Ten 1x1m quadrats were randomly placed on the lower shore from which four photos were taken at each quarter and GPS waypoint marked at each location. Counts of lugworm casts were taken by eye in each quadrat and five casts were randomly selected, and individual diameter measured to the closest mm using a ruler.

Results

Comparison between sites

There was a statistically significant difference in the mean number of lugworms per quadrat (m^2) between the three sites (Figure 1; ANOVA, $F=30.83$, $df=2$, $p<0.0001$). Boulmer had significantly higher lugworm numbers (mean of $17.7m^{-2}$) than Berwick and Newton.

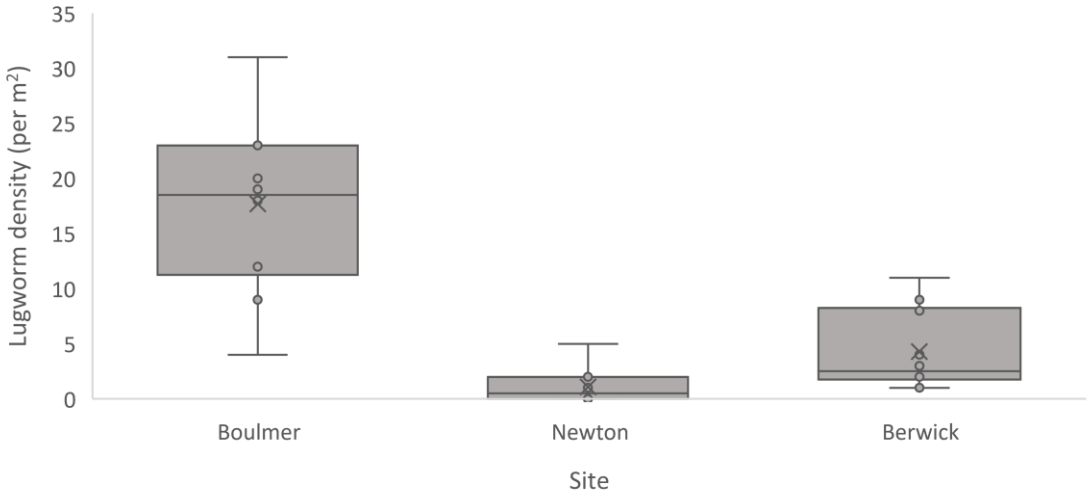

Figure 1. Lugworm density (per m^2) from three sites of varying collection pressure, sampled in March 2023; n=10 for all sites.

There was not a significant difference between the median cast sizes in different locations (Figure 2; ANOVA, F= 17.7, df=2, p<0.0001). The largest was at Boulmer (3.53mm mean size) and the smallest, followed by Newton (3.36mm) at Berwick (3.33mm). The proportion of juvenile casts (2mm and under) was highest at Newton (27%) and Berwick (22%) compared to Boulmer (8%).

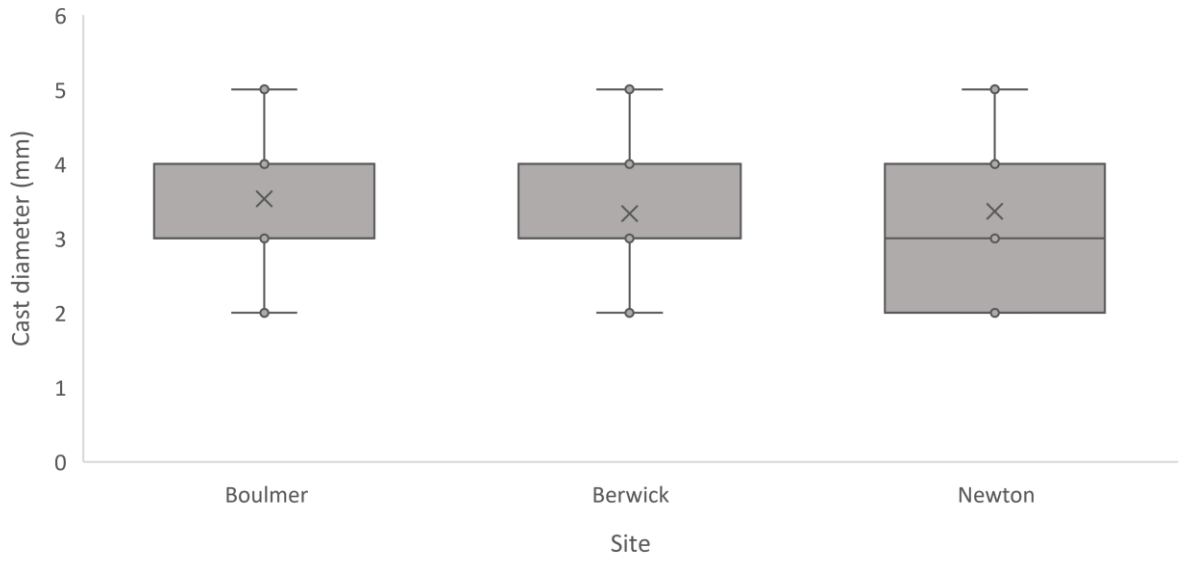

Figure 2. Lugworm cast diameter (mm) from three sites of varying collection pressure, sampled in March 2023 with a maximum of 5 casts per m^2 quadrat; n=49 at Boulmer, n=27 at Berwick, and n = 11 at Newton.

Comparison over time

There was a significant difference in the mean lugworm densities (m^2) over time at Newton, from a study in March 2014 (Tinlin-Mackenzie, 2018) to March 2023 (Figure 3). The mean lugworm density decreased from 28.4 m^{-2} to1.1m^{-2} at Newton (t-test, t=8.66, df=9, p<0.05). There was no statistically significant difference in the mean lugworm population density in Boulmer, with a mean decrease from 21.7m^{-2} to 17.7m^{-2} over the same time period (t-test, t= 1.05, df=17, p0.30).

In terms of cast size, there were no significant differences in the mean sizes over time at Boulmer (t-test, t=-0.96, df=95, p0.33) and Newton (t-test, t=-0.009, df=14, p0.99) (Figure 4) or between Boulmer and Newton over time.

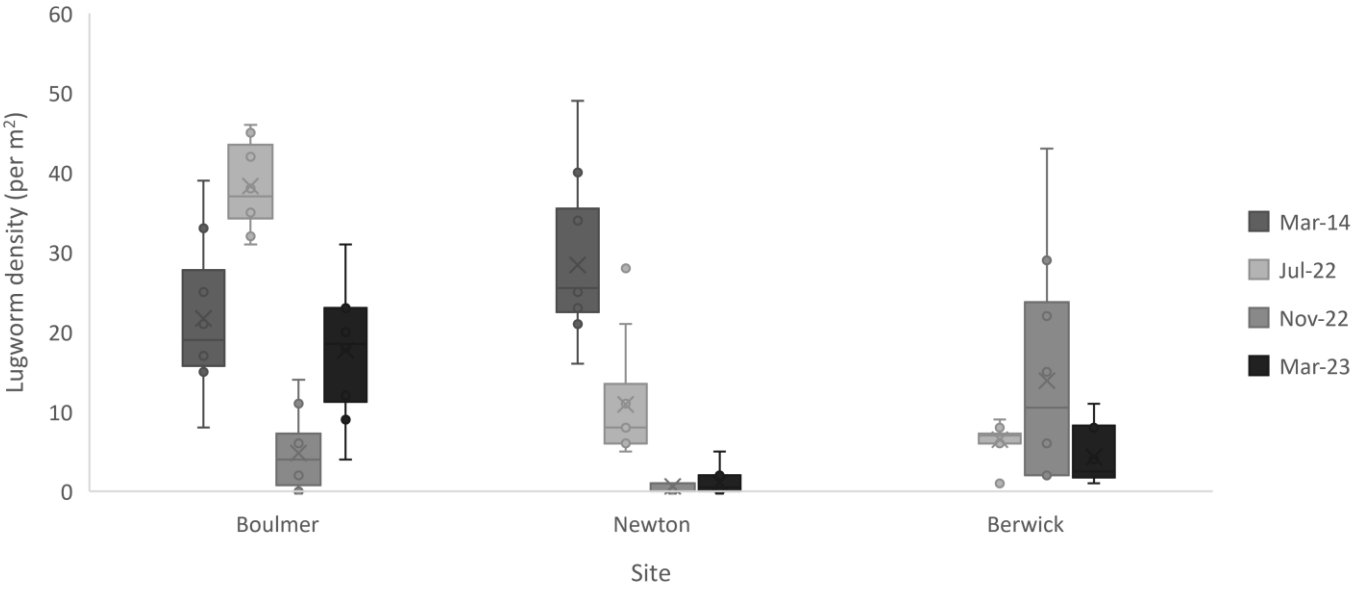

Figure 3. Lugworm density per m^2 over time at Boulmer and Newton, sampled in March,2014, July 2022, November 2022 and March 2023 using quadrats ($1m^2$); n=10 for all sites.

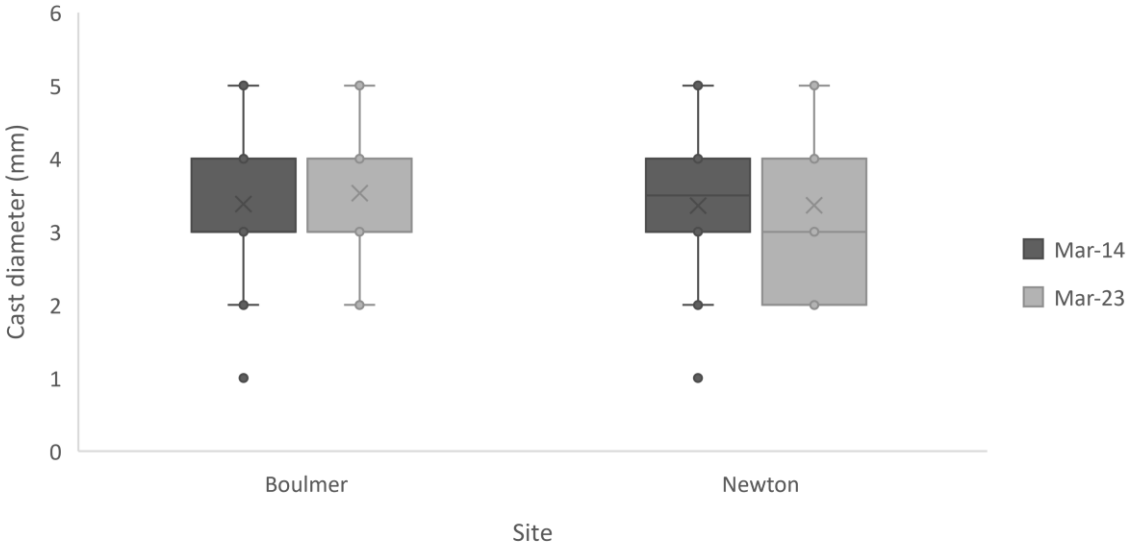

Figure 4. Cast diameter (mm) of lugworms at Boulmer and Newton, from March 2014 to March 2023; n=50 at Boulmer in 2014 and n=49 at Boulmer in 2023, and n=50 at Newton in 2014 and n=11 at Newton in 2023.

Discussion

Comparison between sites

In March 2023, lugworm density was significantly higher at Boulmer compared to Berwick or Newton. Though both Berwick and Boulmer are targeted by collectors they have very different densities, while Newton has lower collection pressure but has similar lugworm density to Berwick.

There is therefore no relationship overall between lugworm densities and collection pressure at these sites, which supports the findings of Tinlin-Mackenzie (2018). Other reasons for site variability could be down to different parameters including sediment type, migration, nutrient availability, spawning periods, population size and collection pressure.

In general, densities observed in lugworm populations are determined by environmental factors e.g. sediment characteristics (Longbottom, 1970) and food availability (e.g. organic matter content) more than collection pressure. The lower number of lugworms in Newton may be attributed to a lack of nutrient reserves in the mature lugworms. However, with the nutrient needs being low for this species this is one of the less likely drivers.

The lugworm density differences between sites could also be influenced by juvenile proportions, spawning patterns, and sediment type. Newton and Berwick had the highest proportion of juveniles in the survey which could offer an explanation to low density levels; juveniles migrate towards the upper shore (out of the survey designated box locations) (Fowler, 1999); in sites such as Boulmer maturing worms move down the shore towards adult beds while juveniles migrate up indicating a healthy sustainable lugworm population. Lugworm density differences may be due to different spawning times; all worms spawn for 3-4 days on the same beach but the spawning events differ between sites depending on environmental parameters (low pressure, drop in temperature, spring tides) and endocrine mechanisms controlling the induction of spawning (Watson, et al 2000). Sediment type may play a part in distribution and abundance of lugworms. Tinlin-Mackenzie (2018) found lugworms preferred muddy sand compared to coarser sediment types. Mud is more stable than sand and supports longer lived species that are slower to recover from disturbance (D.S. MacDonald *et al.*1996). As a result, muddy shores are more sensitive than sandy shores to bait digging disturbance. At the three site locations Boulmer holds the largest amount of muddy sand compared Berwick and Newton, which could be a contributing factor to Boulmer displaying the highest lugworm density.

It is not clear how much of impact bait collection has on lugworm populations. The discrepancy between Boulmer and Berwick, despite similar collection pressures, could be due to Berwick having slightly higher collection pressure in addition to being over a smaller area compared to Boulmer where the bay is much larger and lugworm populations perhaps less likely to decline. The larger area at Boulmer means collection is more spread out and that there is a larger population to recolonise from which could increase recovery rates. It is likely that the different conditions at each of these sites is influencing the densities of lugworms over and above and collection pressure impacts.

Cast diameters show no significant difference between sites with a variability of 0.20mm across sites. Larger worms have a greater reproductive output per individual (Watson et al. 1998), so the slightly largest lugworm average at Boulmer (3.53mm diameter) could demonstrate more successful recoverability and higher population density than other sites.

Comparison of lugworm densities over time

There is no baseline information on lugworm densities at Berwick, though both Boulmer and Newton were surveyed in 2014 by Tinlin-Mackenzie (2018) therefore results can be compared to see if there were any changes in lugworm population sizes and cast sizes between 2014 and 2023. While there were no significant to lugworm cast sizes over time at Newton or Boulmer, there were significant changes to lugworms densities at Newton. While Newton both saw a significant decrease from 2014 to 2023.

Shore observations by Tinlin-Mackenzie (2018) in 2014 recorded an average of 2.38 collectors per observation at Boulmer, similar to the average number of 1.95 collectors per NIFCA patrol. At Newton there were 0.94 collectors per observation, higher than the 0.21 per NIFCA patrol. Tinlin-Mackenzie also carried out observations at night-time recording activity at Newton which NIFCA patrols would not include, therefore there may not have been a significant change in collection activity from 2014-2023, though possibly a decrease at Newton or a slight increase at Boulmer. Therefore, changes in lugworm densities cannot be attributed to changing collection pressure with confidence.

Locations may differ in their resilience to activities such as bait digging, and lugworms are able to rapidly increase population numbers from migration and recruitment despite bait digging and collection pressures (Blake, 1979; Rees and Eleftheriou, 1989). Boulmer is a site with higher organic content compared to Newton which could explain the high population density (Tinlin-Mackenzie, 2018) although this does not explain the change in density at Newton over time. Newton could be a less resilient site to bait digging pressures than Boulmer. Lugworms also have a subtidal population which remains uncovered at low tide and therefore protected from collection pressure as subtidal populations can recolonise collected intertidal areas. Tinlin-Mackenzie (2018) modelled the sensitivity of the sites to collection, based on characteristics such as sediment type, lugworm abundance and size, and importance to birds, finding low-moderate sensitivity at Boulmer, Berwick and Newton which does not explain the differences seen over time at Newton.

One consideration/explanation is that the survey areas were not well-defined in the original study, therefore quadrats may have been placed in slightly different locations in 2023 compared to 2014, offering a different snapshot of the lugworm population. At Newton surveyors noticed that the majority of lugworm casts on the beach were higher up the shore than the survey area, which

could explain the reduced lugworm densities if the previous survey was higher up the shore. The purpose of the original study however was to survey the 'lower shore where bait digging primarily occurs' which is what we aimed to do. The tides may have been slightly different enabling us to survey lower down the shore than Tinlin-Mackenzie (2018).

There are changes in lugworm breeding or migratory behaviour in response to environmental changes, with the number of lugworm casts changing throughout the year (M. Southerton, pers. comms) which might explain the differences in lugworm densities compared to the previous surveys. This however does not explain the different trends in the three locations. To enable a better comparison over time the locations can be surveyed in the future.

Using faecal casts as a proxy for lugworm densities presents some challenges because there are many factors influencing their complex habitat selection. Without being able to determine these factors, the survey results carry a low level of confidence making it difficult to make a reliable conclusion.

Conclusions

Lugworm densities varied between sites. Boulmer, a highly collected site, had much greater lugworm density than Newton or Berwick, another highly collected site although from a much smaller area. It is possible these variations are natural, defined by the environment and food availability. Compared to March 2014, lugworm density decreased at Boulmer and Newton, the causes of which are unknown. Since lugworm populations vary throughout the year at different sites, future analysis may be more beneficial to focus on individual sites to understand more about the population drivers rather than comparison of sites for the same time period. Continuation of this survey will not provide further information on the impacts of bait digging on lugworm populations as there are too many variables determining the presence of faecal casts. NIFCA will look for alternative options to determine any impacts of bait digging on lugworm populations.

References

Blake, R.W. (1979) 'Exploitation of a natural population of *Arenicola marina* from the northeast coast of England', *Journal of Applied Ecology*, 16(3), pp. 663-670.

D.S. MacDonald, M. Little, M.C. Eno, K. Hiscock, (1996) Disturbance of benthic species by fishing activities: a sensitivity index, Aquat. Conserv. Mar. Freshw. Ecosyst. 4

Fowler, S.L., 1999. Guidelines for managing the collection of bait and other shoreline animals within UK European marine sites. English Nature (UK Marine SACs Project). 132 pages. Guidelines for managing the collection of bait and other shoreline animals within UK European marine sites, 3, p.3.

Longbottom, M.R. (1970) 'The distribution of *Arenicola marina* (L.) with particular reference to the effects of particle size and organic matter of the sediments', *J. exp. mar. Biol. Ecol.*, 5, pp. 138-157.

Rees, H.L. and Eleftheriou, A. (1989) 'North Sea benthos: A review of field investigations into the biological effects of man's activities', *Journal du Conseil: ICES Journal of Marine Science*, 45(3), pp. 284-305

Tinlin-Mackenzie, A.R., 2018. Intertidal collection within the Berwickshire and North Northumberland Coast European Marine Site: investigating the scale, locale, and ecological impacts of harvesting Arenicola marina, Arenicola defodiens, and Littorina littorea (Doctoral dissertation, Newcastle University).

Watson, G., Williams, M. & Bentley, M. Can synchronous spawning be predicted from environmental parameters? A case study of the lugworm Arenicola marina. Marine Biology 136, 1003–1017 (2000). https://doi.org/10.1007/s002270000283

Watson, G.J., Cadman, P.S., Paterson, L.A., Bentley, M.G. and Auckland, M.F. (1998) 'Control of oocyte maturation, sperm activation and spawning in two lugworm species: Arenicola marina and A. defodiens', *Marine Ecology Progress Series*, 175, pp. 167-176.