Marine Conservation Zone Assessment

Site name:	Axe Estuary MCZ UKMCZ0052
Protected feature(s):	Intertidal coarse sediment Intertidal mixed sediment Intertidal mud

Fishing activities assessed at this site:

Stage 1 Assessment

Intertidal handwork: Handworking (access from vessel), Handworking (access from land)
Miscellaneous: Crab tiling
Bait collection: Digging with forks

Devon & Severn IFCA Inshore Fisheries and Conservation Authority

D&S IFCA Reference
AXE-MCZ-002

Contents

Version control history			
Author	**Date**	**Comment**	**Version**
Sarah Curtin	October 2021	Draft assessment	0.1
Sarah Curtin	February 2022	Updating assessments with call for information data	0.2
	March 2022	Reviewed by J. Stewart	0.3
	April 2022	Reviewed by JS following alterations by SC	0.4
	April	Finalised by JS and SC	0.5

1. Introduction

This assessment has been undertaken by Devon & Severn Inshore Fisheries and Conservation Authority (D&S IFCA) in order to document and determine whether management measures are required to achieve the conservation objectives of marine conservation zones (MCZs). The IFCA's responsibilities in relation to management of MCZs are laid out in Sections 124 to 126, & 154 to 157 of the Marine and Coastal Access Act 2009.

2. MCZ site name(s), and location

The Axe Estuary MCZ is an inshore site of approximately 0.404km^2. The Axe Estuary runs from Colyford to Axmouth and Seaton, opening into Lyme Bay. The sites lies adjacent to the Seaton Wetlands which are a series of local nature reserves. The Axe Estuary forms an important link between the surrounding wetlands and the sea. The costal saltmarshes, intertidal sediments and rocky habitats are important nursery grounds for juvenile fish, including sea bass. In addition, these areas act as habitats for sensitive species of birds, crustaceans and molluscs. The estuary is also home to the critically endangered European eel.

Costal saltmarshes and saline reedbeds support a wide variety of species, providing important foraging ground for wading birds, wildfowl and providing shelter at high tide. They are one of the most productive ecosystems in the world, with significant economic value. The specialised salt and flood tolerant flowering plants not only help to stabilise the sediment and prevent erosion but the damp sediment surrounding the vegetation provides an important habitat for marine worms, crustaceans and tiny snails.

The areas of intertidal sediments, consisting of mud, coarse and mixed sediment, create a mosaic of different habitats supporting a wide variety of species. The shoreline habitats protected by the MCZ, in particular the rocky areas, saltmarshes and reed beds support a diverse range of species including juvenile fish, and shrimp like sandhoppers which feed on plant material washed up (Defra, 2019)

Further information regarding the MCZ and its protected features can be found in the Axe Estuary MCZ Factsheet.

3. Feature(s) / habitat(s) of conservation importance (FOCI/HOCI) and conservation objectives

Table 1 - Protected features relevant to this assessment

Feature	**General management approach**
Intertidal coarse sediment	Maintain in favourable condition
Intertidal mixed sediment	Maintain in favourable condition
Intertidal mud	Maintain in favourable condition

The conservation objectives for these features are that they remain in, favourable condition.

4. Gear/feature interaction in the MCZ categorised as 'red' risk and overview of management measure

None - There are no gear/feature interactions in the MCZ that are categorised as 'red' risk.

5. Activities under consideration

Intertidal handwork: Handworking (access from vessel), Handworking (access from land)
There may be some minor hand gathering of peeler crabs, mussels and Pacific oysters on the eastern side of the channel, but this activity appears to be occurring at a very low level (three respondents replied out of a possible 47, to a request for information, advising they carry out this activity). One respondent advised they hand gather peeler crabs from April to September and pick two dozen oysters twice a month. The second respondent hand gathers peeler crabs once or twice a month. The third respondent hand gathers mussel and peeler crab but has not confirmed how often. D&S IFCA has attempted to find out the frequency of the third respondents' activities but has been unable to obtain this information.

Miscellaneous: Crab tiling
Crab tiling is occurring in the Axe Estuary MCZ. Surveys on the River Axe were carried in 2020, during which 245 tiles were observed on the east bank of the Axe and in a small area of the west bank under the B3172/Harbour Road bridge. This is a 46% increase relative to 2016. The rest of the west bank of the River Axe was not surveyed due to Covid-19 restrictions limiting surveys and the requirement of two officers due to muddy conditions.

Bait collection: digging with forks

D&S IFCA conducted bait digging surveys in summer and autumn of 2020. During these surveys no evidence was found of bait digging on the Axe Estuary.

D&S IFCA also circulated a request for information on bait digging to the local community and harbour master to gather evidence and better understand fishing activity within the site. The harbour master advised that little bait digging occurs on the Axe Estuary. Responses from the request for information indicate that bait digging is occurring within the Estuary, but this is likely to be at low levels (only three individuals replied out of 47, advising they dig in the MCZ on average two to three times a month).

See Curtin (2021) for more information regarding fishing activities occurring in the Axe Estuary MCZ.

6. Is there a risk that activities are hindering the conservation objectives of the MCZ?

Yes,
Evidence:
To determine whether each pressure is capable of affecting (other than insignificantly) the site's feature(s), the sensitivity assessments and risk profiling of pressures from the advice on operations section of the Natural England conservation advice package were used (Natural England, 2021). Table 2 shows the fishing activities and pressures included for assessment.

Table 2 - Fishing activities and pressures included in this assessment.

Activity	Pressures
Shore based activities: Hand working, crab tiling, bait collection	Abrasion/disturbance of the substrate on the surface of the seabed
	Habitat structure changes - removal of substratum (extraction)
	Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion
	Removal of target species
	Removal of non-target species

The relevant targets for favourable condition were identified within Natural England's conservation advice supplementary advice tables (Natural England, 2021). Table 3 shows which targets were identified as relevant to the activity assessed. The impacts of pressures on features were assessed against these targets to determine whether the activities causing the pressures are compatible with the site's conservation objectives.

Table 3 - Relevant favourable condition targets for identified pressures.

Feature	Attribute	Target
Intertidal coarse sediment; Intertidal mixed sediment; Intertidal mud	Distribution: presence and spatial distribution of biological communities	Maintain the presence and spatial distribution of intertidal sediment and mud communities
	Extent and distribution	Maintain the total extent and spatial distribution of intertidal sediment and mud
	Structure and function; presence and abundance of key structural and influence species	(Maintain OR Recover OR Restore) the abundance of listed species to enable each of them to be a viable component of the habitat
	Structure; species composition of component communities	Maintain the species composition of component communities

7. Can D&S IFCA exercise its functions to further the conservation objectives of the site?

Yes,
Evidence: Monitoring and Control Arrangements

- Monitor activity levels
- Consideration of a new Hand Working Permit Byelaw to manage the use of crab tiles, bait digging and many other hand gathering types of fishing activity.

On the 14th November 2019, the D&S IFCA Byelaw & Permitting Sub-Committee discussed the different options that exist to manage hand working types of fishing activity as set out in a report (D&S IFCA, 2019). The development of a new byelaw was the option selected, however it is envisaged that it will be a slightly different regulatory format as compared to the D&S IFCA permit based byelaws already implemented to manage other fishing activity.

The potential need for a permit to conduct the different activities will become a factor in the on-going drafting work. It is envisaged that the requirement for a permit to conduct bait collection and hand gathering will be dependent on the amounts of resource taken. The Hand Working Permit Byelaw would introduce fixed provisions that apply to all persons. Fixed provisions are expected to include a series of catch limits (bag limits) for different species (sea fisheries resources) that are targeted by different types of hand working fishing methods. The bag limits would provide an upper level of catch (a threshold) that would apply to all persons but providing the individual take of the specified species was below the levels set for personal use, it is not envisaged that a permit would be required for the collection of the resources. Commercial activity would exceed the bag limits for recreational take and would therefore be regulated by conditions of use that would be placed in the permits issued by D&S IFCA. D&S IFCA will be seeking the views of all stakeholders to better inform the decision making needed to set the initial bag limits.

The development of a Hand Working Permit Byelaw is now a longer-term commitment for D&S IFCA. As a reflection of the time and resource required and available to conduct the required elements of the work, including reporting and the decision-making of D&S IFCA's Byelaw and Permitting Sub-Committee, the development of this Byelaw is not included in D&S IFCA's 2022–2023 Annual Plan (D&S IFCA, 2022). Key Tasks for 2022-2023 reflect what is deliverable with the current level of staffing and financial resourcing available to D&S IFCA.

8. Referenced supporting information to inform assessment

Bait digging has been found to have a range of impacts on both the sediment it occurs on, and the communities within it:

Impacts on sediment

Bait digging usually occurs to depths of 30cm, unearthing a deeper sediment that would usually remain undisturbed (Jackson and James, 1979). Changes can therefore occur in sediment characteristics as a result of bait digging. Undug sediment was found to have a higher organic content than dug sediment. The process of turning over the sediment and erosion of sediment mounds by tides and wave action leads to a loss of finer fractions and associated organic material. In contrast, the basins may collect organic matter and fine sediments (Anderson and Meyer, 1986). This could have implications for local sediment load and turbidity levels (Watson *et al.*, 2017).

If the mounds of sediments are subsequently returned through the process of back- or in-filling, then the effect of the disturbance is reduced and recovery can occur within three weeks (Fowler, 1999). Recovery rates are therefore influenced by the energy of the site, and behaviour of the bait diggers. Coarse sand beaches with considerable wave action will recover more quickly than sheltered sites. Experimentally dug plots in a very sheltered location in the Menai Strait were still visible after a year, although this is thought to be due to the presence of boulder clay (Johnson, 1984). Other, less sheltered, sites have reported a timeframe of 25 days for holes to disappear (Johnson, 1984). It is not currently known whether the bait diggers on the Axe backfill holes.

Impacts on target species

Both blow lugworm (*Arenicola marina*) and king ragworm (*Alitta virens*) are targeted by bait diggers throughout the D&S IFCA's District.

Contrasting evidence exists as to the *direct* environmental effects of bait digging for lugworm. Relative to other exploited intertidal invertebrates, blow lugworms are relatively resilient to exploitation and disturbance because of their relative fecundity and widespread distribution (Fowler, 1999). In addition, *A. marina* exhibit a marked annual cycle in the numbers and condition of individuals, so that any changes in population structure correlated to bait digging, would have to control for these factors (Olive, 1993). Removal rates of 50-70% of worms in the area dug have been reported in the literature (Blake, 1979; Heiligenberg, 1987) but D&S IFCA's observations suggest this may be much lower in some areas, especially where large areas of lugworm exist and holes are relatively well spread out. A D&S IFCA bait density survey of lugworms at Burnham-on-Sea, Berrow, Brean, Weston-Super-Mare and Sand Bay found remarkably similar spatial patterns of abundance and densities to those reported in the 1970's, suggesting no long-term decline in lugworm populations (Ross, 2013).

A wide range of responses by *A. marina* to exploitation or experimental simulations of exploitation have been found, relating to local environmental conditions and the intensity and distribution of bait digging activity. Olive (1993) describes the scenario which led to complete removal of all lugworms from a large area of a National Nature Reserve in Northumberland in 1984, with densities falling from >40m^{-2} to <1m^{-2}. When the site was closed to bait digging it repopulated within a matter of months, thanks to the presence of extensive non-exploited populations nearby. Similarly, lugworm populations in the Dutch Wadden Sea appear to be unaffected by large scale commercial exploitation, with an estimated 2 x 10^7 individuals taken annually. However, Cryer et al. (1987) found no recovery in worm densities after 6 months following experimental removal, although natural densities at the test site in South Wales were low (9-16 m^{-2}) and the survey ran through the less productive winter months. The capacity of a population to withstand bait digging activities therefore relies on a number of factors including the size of the exploited area relative to the total lugworm bed, the presence of other lugworm beds nearby, the presence of nursery areas, the relative exploitation of adult and juvenile lugworms, and the intensity and seasonality of bait digging. However, on the whole they are thought to be resilient to bait digging.

King ragworm, *A. virens,* is a keystone intertidal species as prey for fish, birds and crustaceans, is a predator of other invertebrates and has an important role in bioturbation of the sediment (Watson *et al.*, 2017). *A. virens* are generally found in more sheltered sediment areas but they can also be found in more mixed sediments. Differing reports exist of the life-history and population characteristics of *A. virens.* Whilst early studies of North American populations suggested a mean age at breeding of >3 years with the population dominated by 0-group individuals, a population from the Menai Straight, Wales was thought to mature later, and to have very few 0-group individual present. The latter population was therefore seen as being vulnerable to exploitation. On the North East coast of England, a study found similar densities (~15m^2 during the summer, ~3m^2 during the winter) of *A. virens* in both exploited and unexploited populations Blake (1979), suggesting that at least some populations are unaffected by bait digging. In other cases the change in macrofaunal community has been thought to benefit *A. virens*, due to its opportunistic nature (Evans *et al.*, 2015).

Impacts on non-target species

Bait digging can have adverse effects on a wide variety of species as a result of physical damage, burial, smothering and/or exposure to desiccation or predation to non-target invertebrates. Recovery of small short-lived invertebrates will usually occur within a year, but populations of larger, long-lived invertebrates may take much longer (Fowler, 1999). In some extreme cases local diversity may be reduced, which may be especially true in physically fragile environments such as eelgrass or mussel beds (Fowler, 1999). Similarly, Beukema (1995) found that within a 1km^2 area of the Dutch Wadden Sea, the local lugworm stock declined by more than 50% over a four-year mechanical digging period. As a result of this decline, total zoobenthic biomass also declined, with short lived species showing a marked reduction during the digging period. Recovery of the benthos took several years, especially by the slower establishing species. However, if disturbance by digging is short term, benthic communities can recover within six months (Beukema, 1995).

Mosbahi et al. (2015) also explored the impacts of bait digging on the macrofauna of intertidal mudflats. The fauna of their study area (the tidal mudflats of Kneiss Islands, Tunisia) was mainly composed of polychaetes, the more abundant families being the *Nererididae*, *Arenicolidae* (fishing target species) and the *Cirratulidae*. They found the number of taxa and abundance of individuals were affected by bait digging; the abundance estimates at the control stations were significantly higher than those estimated at the three stations before and after bait collection, with some polychaete species disappearing after one month of bait digging. This indicates that the intertidal macrozoobenthic biodiversity at the impacted stations is affected by the bait digging activity, or possibly by trampling.

Jackson and James (1979) investigated the effects of bait digging on cockle populations. They found that increased digging in an area caused higher cockle mortality, particular on smaller individuals. The cause of mortality was due to burial/smothering as individuals that were buried at a depth of 10cm rarely survived.

Rossi *et al*. (2007) investigated the effects of trampling on mudflats, such as that associated with recreational activities like bait digging. They found that trampling did not influence mobile species such as *Hydrobia ulvae* and *Hediste diversicolor,* but clearly modified the abundance and population dynamics of bivalves such as the clam *Macoma balthica* and the cockle *Cerastoderma edule.* There was a negative impact on adults of both species, which was attributed to footsteps directly killing or burying the animals, leading to asphyxia. Abundance of small-sized/juvenile *C. edule* showed no response to trampling. It is likely that the population-level abundance of small animals could recover more quickly because trampling occurred during the reproductive season (April to October), which meant that there was likely a continuous supply of larvae and juveniles in the water column to replace those displaced by the trampling. In contrast, trampling seemed to indirectly enhance the recruitment rate of *M. balthica*. In an environment with little trampling, adult cockles can easily outcompete larvae and spats of other bivalves; disturbance of sediment whilst feeding or moving and high filtration of planktonic larvae can reduce the settling and recruitment of other bivalves. The direct impacts of trampling (e.g. a reduction in adult cockle abundance), can therefore indirectly increase the recruitment opportunities for other bivalve species such as *M. balthica*, which take advantage of the reduced competition from *C. edule* adults. Over the long term, this could ultimately cause a shift towards a dominance of *M. balthica* in the macrofaunal assemblage, at the cost of *C. edule*, thereby potentially affecting ecosystem functioning. Therefore, despite potentially fast recovery times, Rossi *et al*. (2007) concluded that human trampling is a relevant source of disturbance for the conservation and management of mudflats.

Wynberg & Branch (1997) assessed the impacts of trampling associated with the use of suction pumps for the collection of prawns as bait, by comparing areas that had been sucked over with a prawn pump, to areas that had been trampled only. Prawn densities were depressed six weeks following both sucking and trampling but recovered by 32 weeks. Macrofaunal numbers declined in most treatment areas and macrofaunal community composition in the most-disturbed areas was distinct from that in other areas. They determined that the trampling itself has almost the same effect as sucking for prawns, on both the prawns and on the associated biota.

It is important to note that the effects on macrofaunal communities can differ substantially between estuaries. For example, the mud content of an estuary can affect the resilience of the communities to bait digging. Although Dernie et al. (2003) found that it was not possible to predict the recovery rates of assemblages based on percentage of silt and clay in the sediment, there was a good relationship between recovery rate and infilling rate, which is linked to the physical characteristics of the sediment. Clean sand habitats were the quickest to recover both in terms of physical and biological characteristics. Other studies have also found extended recovery times for estuaries with high mud content (Carvalho *et al.*, 2013).

The site-specific nature of the impacts of bait digging was also demonstrated by Watson et al. (2017). They found that responses were both site and disturbance type specific. Their data also showed that responses were not consistent between species (e.g. *Corophium volutator* and *Peringia ulvae* or even between those within the same trophic group. They therefore concluded that bait collection alters the macrofaunal community and the associated sediment characteristics across large spatial scales, but with the caveat that the strength (and type) of the response is site specific.

9. In-combination assessment

Table 4 - Relevant activities occurring in or close to the site

Plans and Projects		
Activity	**Description**	**Potential Pressure(s)**
No other plans or	The impact of future plans or projects will	N/A

projects known to be occurring within Axe Estuary MCZ	require assessment in their own right, including accounting for any in-combination effects, alongside existing activities.	
Other activities being considered		
Activity	**Description**	**Potential Pressure(s)**
Static – pots/traps: Pots/creels, cuttlepots, fish traps	Low levels of potting do occur around the Axe Estuary. However, the activity occurs outside of the MCZ. Therefore, no in-combination effect is thought to be possible	Abrasion/disturbance of the substrate on the surface of the seabed Removal of non-target species Removal of target species Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion Changes in suspended solids (water clarity) Smothering and siltation rate changes (Light) Genetic modification & translocation of indigenous species Introduction of microbial pathogens Introduction or spread of invasive non-indigenous species
Static – fixed nets: Gill nets, Trammels, Entangling shrimp push nets, Fyke and stakenets, ring nets	This activity is currently not permitted to take place within the Axe Estuary MCZ as it falls under the D&S IFCA Netting Permit Byelaw. In the estuary landward of the coordinates set out in Annex 1, Figure 3, a permit holder or named representative is not authorised to use any net other than a seine net in accordance with paragraph 3.2 of the Netting Permit Conditions. Therefore no in-combination effect is thought to be possible	
Passive – nets: Drift nets (demersal)	This activity is currently not permitted to take place within the Axe Estuary MCZ as it falls under the D&S IFCA Netting Permit Byelaw. In the estuary landward of the coordinates set out in Annex 1, Figure 3, a permit holder or named representative is not authorised to use any net other than a seine net in accordance with paragraph 3.2 of the Netting Permit Conditions. Therefore, no in-combination effect is thought to be possible.	
Lines: Longlines (demersal)	As there is little to no level of this activity in the Axe Estuary MCZ, no in-combination effect thought to be possible.	
Seine nets & other: Beach seine	As there is little to no level of this activity in the Axe Estuary, no in-combination effect thought to be possible.	
Aquaculture	There is no evidence that this activity is currently occurring, no in-combination effect thought to be possible.	

D&S IFCA concludes there is no likelihood of significant adverse effect on the interest features from in-combination effects.

10. NE consultation response

N/A Natural England has not been consulted at this stage.

11. Conclusion

The literature detailed in section 8 found that bait digging and disturbance of sediment from other shore-based activities including crab tiling and hand gathering could influence the sediment characteristics, the populations of the target species, and the macrofaunal communities if levels of shore-based activities were sufficiently high and over a prolonged period.

Within Axe Estuary MCZ, bait digging and hand gathering is only known to occur at very low levels. There is some minor hand gathering of Peeler crabs for bait, mussels and pacific oysters from the eastern side of the channel but the harbour master has suggested that the composition of the river bed has changed from mud to an aggregation in which there is little life, and indicated that hand gathering has declined in the last few years as a result. Based on the current levels of these activities on the Axe Estuary there is not believed to be a significant impact of the shore-based activities on the protected features assessed. It is believed that these activities are occurring infrequently and at low levels, which likely gives the disturbed areas time to recover before they are revisited and disturbed again. The evidence presented in section 8 suggests recovery times for both sediment and smaller invertebrates that are impacted by trampling and digging are shorter when activity levels are low.

D&S IFCA is considering the introduction of a new Hand Working Permit Byelaw to manage the use of crab tiles, bait digging and many other hand gathering types of fishing activity in the district. The introduction of a byelaw would introduce fixed provisions that apply to all persons. Fixed provisions are expected to include a series of catch limits (bag limits) for different species (sea fisheries resources) that are targeted by different types of hand working fishing methods. The bag limits would provide an upper level of catch (a threshold) that would apply to all persons thus limiting the effort of shore-based activities on the Estuary. As outlined in section 7, the development of a Hand Working Permit Byelaw is now a longer-term commitment for D&S IFCA and has not been included in D&S IFCA’s Annual Plan for 2022–2023.

12. Summary table

Feature or habitat of Conservation interest	Conservation objectives/ Target Attributes (Natural England, 2021)	Activity	Potential pressures from activity and sensitivity of habitats to pressures. (Natural England, 2021)	Potential exposure to pressures and mechanism of impact significance	Is there a risk that the activity could hinder the achievement of conservation objectives of the site?	Can D&S IFCA exercise its functions to further the conservation objectives of the site? If Yes, list management options
Intertidal coarse sediment	Maintain the presence and spatial distribution of intertidal coarse sediment communities Maintain the total extent and spatial distribution of intertidal coarse sediment [Maintain OR Recover OR Restore] the abundance of listed species to enable each of them to be a viable component of the habitat	Commercial fishing; Intertidal handwork: Handworking (access from vessel), Handworking (access from land) Miscellaneous: Crab tiling Bait collection: digging with forks	• Abrasion/disturbance of the substrate on the surface of the seabed • Habitat structure changes – removal of substratum • Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion • Removal of non-target species • Removal of target species See Annex 2 for pressures audit trail	Bait digging usually occurs to depths of 30cm, unearthing a deeper sediment that would usually remain undisturbed (Jackson and James, 1979). Changes can therefore occur in sediment characteristics as a result of bait digging. Undug sediment was found to have a higher organic content. The process of turning over the sediment and erosion of sediment mounds by tides and wave action leads to a loss of finer fractions and associated organic material Mosbahi et al. (2015) also explored the impacts of bait digging on the macrofauna of intertidal mudflats. The fauna of their study area (the tidal mudflats of Kneiss Islands, Tunisia) was mainly composed of polychaetes, the more abundant families being the *Nereididae*, *Arenicolidae* (fishing target species) and the	Based on the current levels of these activities on the Axe Estuary there is not believed to be a significant impact of the shore-based activities on the protected features assessed	Yes, Management measures could include: 1. Monitor activity levels 2. Possible introduction of a new Hand Working Permit Byelaw to manage the use of crab tiles, bait digging and many other hand gathering types of fishing activity.

	Maintain the species composition of component communities			*Cirratulidae*. They found the number of taxa and abundance of individuals were affected by bait digging; the abundance estimates at the control stations were significantly higher than those estimated at the three stations before and after bait collection, with some polychaete species disappearing after one month of bait digging. This indicates that the intertidal macrozoobenthic biodiversity at the impacted stations is affected by the bait digging activity, or possibly by trampling. Olive (1993) describes the scenario which led to complete removal of all lugworms from a large area of a National Nature Reserve in Northumberland in 1984, with densities falling from >40m^{-2} to <1m^{-2}. When the site was closed to bait digging it repopulated within a matter of months, thanks to the presence of extensive non-exploited populations nearby. Similarly, lugworm populations in the Dutch Wadden Sea appear to be unaffected by large scale commercial exploitation, with an estimated 2 x 10^7 individuals taken annually. However, Cryer et al. (1987) found no recovery in worm densities after 6 months following experimental removal, although natural densities at the		

				test site in South Wales were low (9-16 m^{-2}) and the survey ran through the less productive winter months. The capacity of a population to withstand bait digging activities therefore relies on a number of factors including the size of the exploited area relative to the total lugworm bed, the presence of other lugworm beds nearby, the presence of nursery areas, the relative exploitation of adult and juvenile lugworms, and the intensity and seasonality of bait digging. However, on the whole they are thought to be resilient to bait digging		
Intertidal mixed sediment	Maintain the presence and spatial distribution of intertidal mixed sediment communities Maintain the total extent and spatial distribution of intertidal mixed sediment [Maintain OR Recover OR Restore] the abundance of	Commercial fishing; Intertidal handwork: Handworking (access from vessel), Handworking (access from land) Miscellaneous: Crab tiling Bait collection: digging with forks	• Abrasion/disturbance of the substrate on the surface of the seabed • Habitat structure changes – removal of substratum • Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion • Removal of non-target species	See above	See above	See above

	listed species to enable each of them to be a viable component of the habitat Maintain the species composition of component communities		• Removal of target species See Annex 2 for pressures audit trail			
Intertidal mud	Maintain the presence and spatial distribution of intertidal mud communities Maintain the total extent and spatial distribution of intertidal mud [Maintain OR Recover OR Restore] the abundance of listed species to enable each of them to be a viable component of the habitat Maintain the	Commercial fishing; Intertidal handwork: Handworking (access from vessel), Handworking (access from land) Miscellaneous: Crab tiling Bait collection: digging with forks	• Abrasion/disturbance of the substrate on the surface of the seabed • Habitat structure changes – removal of substratum • Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion • Removal of non-target species • Removal of target species See Annex 2 for pressures audit trail	See above	See above	See above

	species composition of component communities					

13. References

Anderson, F. E., and Meyer, L. M. 1986. The interaction of tidal currents on a disturbed intertidal bottom with a resulting change in particulate matter quantity, texture and food quality. Estuarine, Coastal and Shelf Science, 22: 19–29.

Beukema, J. J. 1995. Long-term effects of mechanical harvesting of lugworms Arenicola marina on the zoobenthic community of a tidal flat in the Wadden Sea. Netherlands Journal of Sea Research, 33: 219–227.

Blake, R. W. 1979. Exploitation of a Natural Population of Arenicola marina (L.) from the North-East Coast of England. Journal of Applied Ecology, 16: 663–670. [British Ecological Society, Wiley].

Carvalho, S., Constantino, R., Cerqueira, M., Pereira, F., Subida, M. D., Drake, P., and Gaspar, M. B. 2013. Short-term impact of bait digging on intertidal macrobenthic assemblages of two south Iberian Atlantic systems. Elsevier. https://digital.csic.es/handle/10261/103270 (Accessed 3 August 2021).

Curtin, S. (2021) Axe Estuary MCZ Fishing Activity Report. Devon and Severn IFCA Report.

Cryer, M., Whittle, G. N., and Williams, R. 1987. The impact of bait collection by anglers on marine intertidal invertebrates.

Defra. 2019. Axe Estuary Marine Conservation Zone factsheet. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/914337/mcz-axe-estuary-2019.pdf.

Dernie, K. M., Kaiser, M. J., and Warwick, R. M. 2003. Recovery rates of benthic communities following physical disturbance. Journal of Animal Ecology, 72: 1043–1056.

D&S IFCA. 2019. Managing Hand Working Fishing Activity: A Focus on Bait Digging. Supplementary Report for the B&PSC – Information & Evidence, V2.0. Devon & Severn Inshore Fisheries and Conservation Authourity, Brixham, Devon.

Evans, S., Moon, J., Bunker, A., and Green, M. 2015. Impacts of Bait Digging on the Gann: An Evidence Review. Evidence Report, 81. Natural Resources Wales.

Fowler, S. L. 1999. Guidelines for managing the collection of bait and other shoreline animals within UK European marine sites. UK Marine SACs Project. http://spcsrp.org/sites/default/files/csrp/ressouces_documentaires/bait%20collection.pdf (Accessed 3 August 2021).

Heiligenberg, T. van den. 1987. Effects of mechanical and manual harvesting of lugworms Arenicola marina L. on the benthic fauna of tidal flats in the Dutch Wadden sea.

Jackson, M. J., and James, R. 1979. The Influence of Bait Digging on Cockle, Cerastoderma edule, Populations in North Norfolk. Journal of Applied Ecology, 16: 671–679. [British Ecological Society, Wiley].

Johnson, G. 1984. Bait collection in a proposed marine nature reserve. University College London, London, United Kingdom.

Mosbahi, N., Pezy, J.-P., Dauvin, J.-C., and Neifar, L. 2015. Short-term impact of bait digging on intertidal macrofauna of tidal mudflats around the Kneiss Islands (Gulf of Gabès, Tunisia). Aquatic Living Resources, 28: 111–118. EDP Sciences.

Natural England (2021) Draft Conservation Advice for Axe Estuary Marine Conservation Zone (MCZ)

Olive, P. J. W. 1993. Management of the exploitation of the lugworm Arenicola marina and the ragworm Nereis virens (Polychaeta) in conservation areas. Aquatic Conservation: Marine and Freshwater Ecosystems, 3: 1–24.

Ross, E. 2013. Blow lug *Arenicola marina* density in the Severn Estuary European Marine Site: A baseline survey 2012-2013. D&S IFCA Research Report

Rossi, F., Forster, R. M., Montserrat, F., Ponti, M., Terlizzi, A., Ysebaert, T., and Middelburg, J. J. 2007. Human trampling as short-term disturbance on intertidal mudflats: effects on

macrofauna biodiversity and population dynamics of bivalves. Marine Biology, 151: 2077–2090.
Watson, G. J., Murray, J. M., Schaefer, M., Bonner, A., and Gillingham, M. 2017. Assessing the impacts of bait collection on inter-tidal sediment and the associated macrofaunal and bird communities: The importance of appropriate spatial scales. Marine Environmental Research, 130: 122–133.
Wynberg, R. P., and Branch, G. M. 1997. Trampling associated with bait-collection for sandprawns Callianassa kraussi Stebbing: effects on the biota of an intertidal sandflat. Environmental Conservation, 24: 139–148. Cambridge University Press.

Annex 1: Site Map(s)

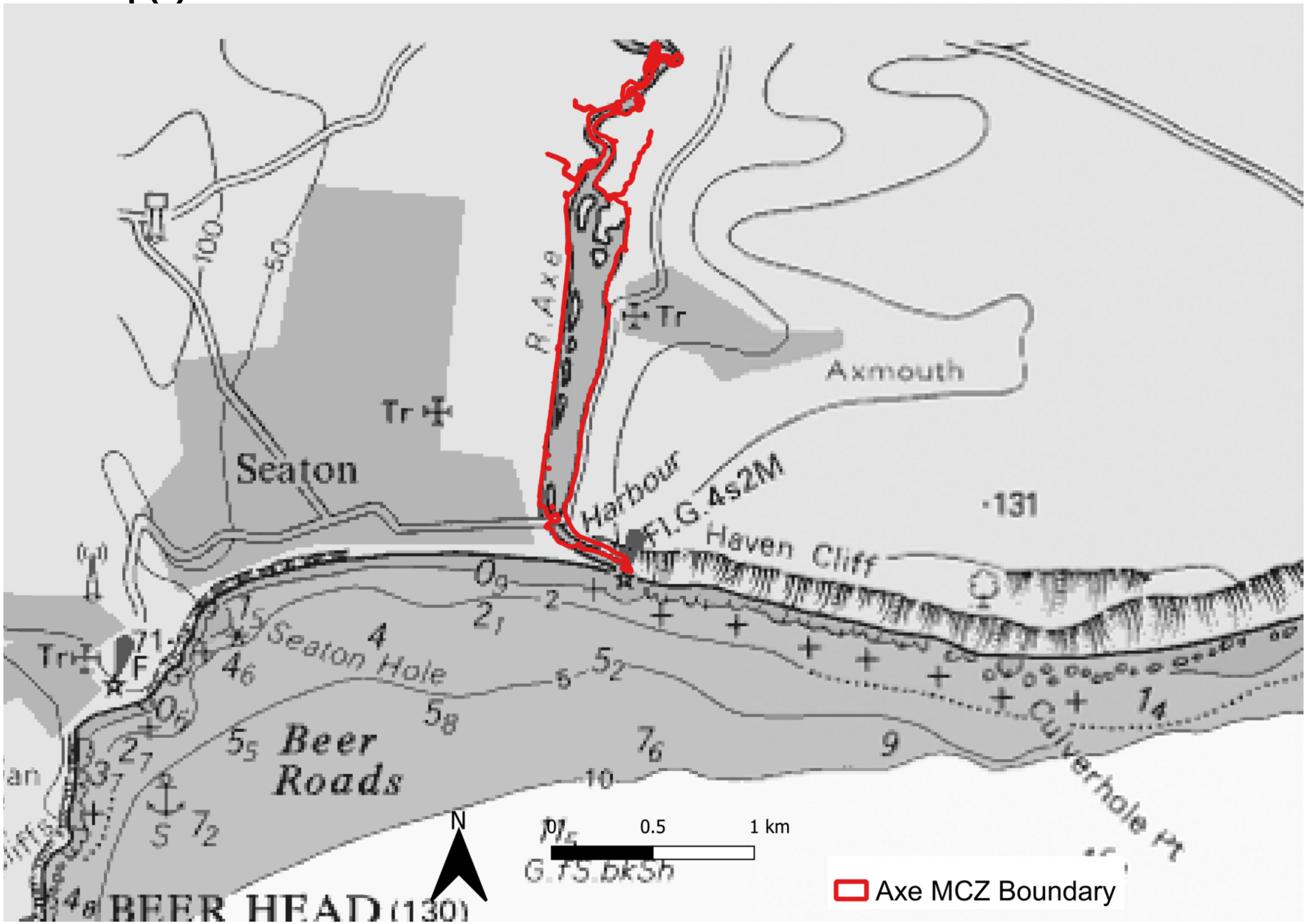

Figure 1 – Axe Estuary MCZ

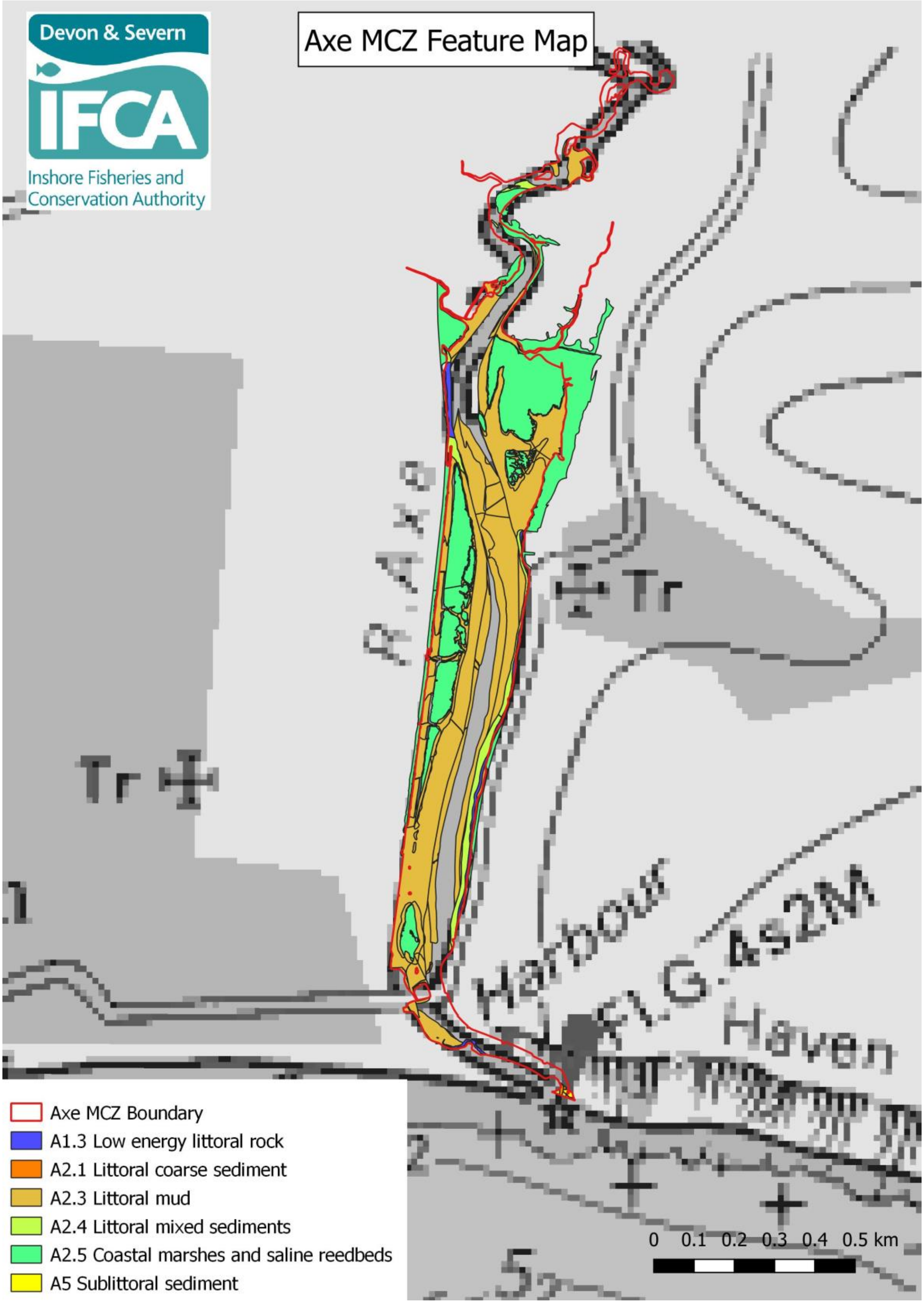

Figure 2: Extent of features (estuarine rocky habitats, intertidal coarse and mixed sediment, intertidal mud, and coastal saltmarshes and saline reedbeds) designated in the Axe Estuary MCZ

Annex 2 Chart of River Axe closing line - No access for the use of nets other than a seine net in accordance with paragraph 3.2 of the Netting Permit Conditions

Estuary closing line

River Axe closing line latitude and longitude positions:

Point	Latitude	Longitude
A	50° 42.135'N	003° 3.354'W
B	50° 42.135'N	003° 3.274'W

Figure 3: River Axe closing line latitude and longitude, from Annex 2 to the Netting Permit Byelaw. No access landward of the line to the use of nets other than a seine net in accordance with paragraph 3.2 of the Netting Permit Conditions.

Annex 2: Pressures Audit Trail

Fishing Activity Pressures: Shore based activities	**Intertidal coarse sediment**	**Intertidal mixed sediment**	**Intertidal mud**	**Screening Justification**
Abrasion/disturbance of the substrate on the surface of the seabed	NS	S	S	IN - Need to consider spatial scale/intensity of activity to determine likely magnitude of pressure
Habitat structure changes - removal of substratum (extraction)	S	S	S	IN – Need to consider spatial scale/intensity of activity to determine likely magnitude of pressure
Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion	NS	S	S	IN – Need to consider spatial scale/intensity of activity to determine likely magnitude of pressure
Removal of non-target species		S	S	IN – Need to consider spatial scale/intensity of activity to determine likely magnitude of pressure
Removal of target species		S	S	IN – Need to consider spatial scale/intensity of activity to determine likely magnitude of pressure
Deoxygenation	NS	S	NS	OUT – Insufficient activity levels to pose risk at level of concern
Hydrocarbon & PAH contamination	NA	NA	NA	OUT – Not applicable
Introduction of light		IE	NS	OUT – Not applicable
Introduction or spread of invasive non-indigenous species (INIS)		S	S	OUT – Insufficient activity levels to pose risk at level of concern
Litter	NA	NA	NA	OUT – Not applicable
Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals)	NA	NA	NA	OUT – Not applicable
Transition elements & organo-metal (e.g. TBT) contamination	NA	NA	NA	OUT – Not applicable
Underwater noise changes				OUT – Not applicable