# Marine Conservation Zone Assessment

**Site name:** Otter Estuary MCZ
UKMCZ0065

**Protected feature(s):**
Intertidal coarse sediment
Intertidal mud

**Fishing activities assessed at this site:**
**Stage 1 Assessment**
**Aquaculture:** Shellfish aquaculture: bottom culture, trestle culture

Devon & Severn IFCA
Inshore Fisheries and Conservation Authority

**D&S IFCA Reference**
OTT-MCZ-006

Contents



| **Version control history** | | | |
|---|---|---|---|
| **Author/ Reviewer** | **Date** | **Comment** | **Version** |
| Sarah Curtin | October 2021 | Draft assessment | 0.1 |
| Sarah Clark | January 2023 | Final Review | 1.0 |

# 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 Otter Estuary MCZ is a small inshore site covering an area of approximately 0.11km$^2$. The estuary is located on the south coast of Devon near the town Budleigh Salterton. The site extends from the mouth of the river up to the aqueduct near East Budleigh.

Although the Otter Estuary is small, it is an important ecosystem supporting a range of habitats and wildlife. It is an essential link from the sea to the River Otter where it acts as a migratory route for European eel, Atlantic salmon, Sea trout and Shad. The mouth of the estuary is dominated by a shingle bank of intertidal coarse sediment extending from the west coast of the river. The sheltered areas behind the bank consist of highly productive intertidal mudflats and saltmarshes.

The Otter Estuary is one of the most extensive saltmarsh networks in Devon, providing important foraging grounds for wading birds and wildfowl and a sheltered refuge from high tide. Several species of specialised salt and flood-tolerant flowering plants can be found within the saltmarshes as well as an abundance of worms, crustaceans, and tiny snails.

The intertidal muds are a highly productive habitat and support a diverse range of species including ragworms, mudshrimps and the commercially important cockle. At low tide these areas form vital feeding grounds for wading and migratory birds, while at high tide flatfish and others migrate to these areas to forage for food (Defra, 2019).

Further information regarding the MCZ and its protected features can be found in the Otter 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 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

- Aquaculture: shellfish: bottom and trestle culture

There is no know aquaculture taking place in the Otter Estuary. See Curtin (2021) for more information regarding fishing activities occurring in the Otter Estuary MCZ.

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

**No,**
**Evidence:**
This activity is not thought to be occurring in the Otter Estuary MCZ so there is no risk that such activities are hindering the conservation objectives of the MCZ. However, for completeness, 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. The justifications for the pressures chosen for inclusion in this assessment can be seen in Annex 2.

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

| Activity | Pressures |
|---|---|
| Aquaculture; Shellfish bottom and trestle culture | Abrasion/disturbance of the substrate on the surface of the seabed |
| | Changes in suspended solids (water clarity) |
| | Genetic modification & translocation of indigenous species |
| | Introduction of microbial pathogens |
| | Introduction or spread of invasive species non-indigenous species (INIS) |
| | Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion |
| | Removal of non-target species |
| | Removal of target species |
| | Smothering and siltation rate changes (Light) |

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<br>Intertidal mud | Distribution: presence and spatial distribution of biological communities | Maintain the presence and spatial distribution of intertidal coarse sediment communities |
| | Extent and distribution | Maintain the total extent of feature and spatial distribution |
| | 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**
Within estuaries, land may be privately owned by individual estate owners and leased to shellfishers for the cultivation of shellfish.

- Monitoring of activities in the estuary.
- Review the mariculture strategy to ensure development of aquaculture is sustainable in line with D&S IFCA's obligations under Section 153 (2) of the Marine and Coastal Access Act (2009).
- The review of D&S IFCA byelaws can gauge where any future changes or developments may occur.

# 8. Referenced supporting information to inform assessment.

Currently, blue mussels and Pacific oysters, *Magallana gigas* (*M. gigas*) (previously known as *Crassostrea gigas* (*C. gigas*), are the only mariculture species being actively farmed and harvested within the D&S IFCA's District, although scallop ranching is being developed within Torbay. These activities are not undertaken in the Otter Estuary MCZ. Literature on the environmental impacts of aquaculture is dominated by changes to sediment and associated infaunal assemblages beneath cultivation areas (Forrest et al., 2009).

**Benthic effects**
As a consequence of their filtration capabilities, oysters can reject huge amounts of pseudo-faeces and faeces (Deslous-Paoli et al., 2004). These biodeposits mostly accumulate on sediments close to or directly beneath oyster cultures (Ottmann and Sornin, 1985; Mitchell, 2006). This biodeposition may impact the benthic environment surrounding the cultures. The deposition may elevate intertidal mudflat levels (Bertin et al., 2005), enrich seabed sediments with organic matter (Mitchell, 2006), and alter the physical structure and geochemical functioning of the sediments involved (Bouchet et al., 2007). Changes in physio chemical characteristics beneath oyster cultures can lead to displacement of macrofauna and an increase in more disturbance tolerant opportunistic species (Pearson and Rosenberg, 1977). The extent of these effects mainly depends on the hydrodynamic features of the culture site but may also depend on oyster culture methods (Goulletquer and Heral, 1997). Studies investigating the interaction of shellfish cultivation in intertidal areas have reported varying levels of impact. Castel et al., (1989) reported that organic enrichment and low bottom oxygen concentrations associated with bottom cultivation of the oyster in France, resulted in significant decreases in diversity and abundance of microbenthic species. Similar effects of trestle oyster cultivation in intertidal microbenthic communities were observed in the River Exe (Nugues et al., 1996). In contrast, a study at an extensive oyster trestle farm in Dungarvan Harbour, Ireland, showed no evidence of organic enrichment (De Grave et al., 1998). The magnitude of benthic enrichment from trestle intertidal culture is generally relatively minor by comparison with suspended subtidal culture of fish (Brown et al., 1987; Forrest et al., 2009)

In the D&S IFCA's District, oysters are either cultivated directly on the sediment (bottom culture) or are placed in plastic mesh bags tied to metal trestles (trestle culture). The presence of trestles arranged in parallel rows in the intertidal area has been shown to significantly reduce the strength of tidal currents (Nugues et al., 1996). This limits the dispersal of pseudo-faeces and faeces in the water column and thus increases the natural sedimentation process by several orders of magnitude (Ottmann and Sornin, 1985).

The effects of bivalves on sediment properties depend on the density of shellfish relative to water flow. However, the majority of literature on sediment effects is in the context of suspended culture.

In terms of sediment alteration, the effects of bivalves are expected to be local (Dumbauld et al., 2009). Ysebaert et al., (2009) found that sediment grain size was smaller in cultured sites in Denmark and particulate organic carbon, nitrogen and phosphorus content was higher compared to culture free sediment. These changes on the sedimentary environment were localised and more or less limited to the mussel bed or its direct surroundings. However, the effect of mussel culture on the benthic community was positive, with an increase in the number of epibenthic species seen. Similarly, Dolmer (2002) suggested a positive relationship between mussel abundance and the number of associated species due to the complex substratum by the mussels.

**Water clarity**

Mussels and other filter feeders can improve water quality and clarity, making the marine ecosystem more suitable for organisms . (Avdelas et al., 2021). Most species of cultured bivalve molluscs clear particles from waters at rates of 1 to 4 L/h, and populations of shellfish in healthy assemblages can filter a substantial fraction of the water in coastal estuaries on a daily basis. Actively growing shellfish incorporate nitrogen and other nutrients into their tissues as they grow. On average, 16.8 g of nitrogen is removed from estuaries for every kilogram of shellfish meat harvested. In addition to removal of nutrients through shellfisheries and molluscan aquaculture, shellfish beds may act to promote removal of nitrogen from estuaries by increasing organic nitrogen deposition to the sediments that stimulate denitrification processes (Rice, 2001).

**Introduction of microbial pathogens and invasive non-native species**

Introduction of Invasive Non-Indigenous Species (INIS) as a result of aquaculture can occur in two ways; either by INIS being intentionally introduced for the purposes of aquaculture (i.e., Pacific oyster and historically, the Manila clam) or being accidentally introduced with aquaculture species (i.e. with seed or in batches of adult stock). Intentional introductions are normally due to the species providing economic benefit, fast growth and adaptation to a wide ecological niche (Cook et al., 2008), factors which often outweigh the potential ecological risk (Gozlan, 2010). Intentional introductions are usually subject to some form of testing prior to introduction to reduce the risk of environmental impacts but this does not always eliminate the risk entirely. The biggest risk comes from the accidental introduction of INIS to the marine environment. This can be through spill over, escape or accidents in operation when farming INIS (Cook et al., 2008). Where species have been introduced for aquaculture there have been documented ecological impacts on native fauna via disease introduction and direct competition with native species with no associated ecosystem benefits (Gozlan, 2010). The intentional introduction of the Pacific oyster to the Pacific north west (USA) resulted in the unintentional introduction of the invasive smooth cordgrass *Spartina alterniflora* as packing material for the transplanted oysters (Feist and Simenstad, 2000). *S. alterniflora* can re-engineer a habitat by providing biogenic structures that allow for fish, invertebrate and macroalgal recruitment and sediment accumulation (Ruesink et al., 2006). Habitat modification was also caused in South African waters following the accidental introduction of the Mediterranean mussel *Mytilus galloprovincialis* (Robinson et al., 2005). The species became the dominant intertidal mussel and modified the natural community composition by dominating rock surfaces. In addition, the faster growth, greater tolerance to desiccation and higher fecundity led to it being more dominant than the native mussel species (Robinson et al., 2005).

The introduction of oyster species including *M. gigas* and *Crassostrea virginica* have been suggested as one of the greatest single modes of introduction for other INIS species around the world and are well suited to establishing wild populations (Mckindsey et al., 2007). In the Netherlands and the German Wadden Sea, *M. gigas* introduced for aquaculture has formed natural, self-sustaining populations which have caused issues for mussel culture and conservation (Mckindsey et al., 2007). However, the introduction of *M. gigas* has also been documented to have benefits to local ecosystems. The presence of *M. gigas* on the intertidal was seen to increase the abundance of infauna and epifauna as well as bird species relative to a control site (Escapa et al., 2004). Also, a study in Washington State showed that diversity and abundance of benthic

organisms in mud flats were increased by the presence of *M. gigas* and on rocky shores in British Columbia, *M. gigas*, occupying the high intertidal zone, increased the surface area for barnacle species (Ruesink et al., 2005).

Shellfish diseases have been demonstrated to be spread by movement of animals. A parasite that deteriorates digestive tissues of host organisms, known as the paramyxean parasite, *Marteilia refringens*, has been documented to cause mass mortalities in the European native oyster *Ostrea edulis* where movements of shellfish appear to have spread the disease between France, Spain and the Netherlands. In addition, the disease, bonamiasis, caused by the haplosporean parasite *Bonamia ostreae*, was also introduced to Europe via introduction of infected native oyster, *Ostrea edulis* from North America. First mapped in France, it has spread across Europe including the UK and is regarded as a major threat to oyster stocks (Gozlan et al., 2006).

**Genetic modification and translocation of indigenous species**

Species hybridisation is an issue pertinent to the Southwest as there is mixing and hybridisation of two species of blue mussel: the native *Mytilus edulis* and non-native *M. galloprovincialis*. For the majority of England M. edulis is the dominant species with low to negligible spatial competition with other blue mussel species. In the Southwest *M. galloprovincialis* is also established. M. edulis and *M. galloprovincialis*, both occupy similar environmental niches and can hybridise with one another to produce viable offspring. These hybrids have only been found in areas of high aquaculture activity where the two species mix (Michalek et al., 2016)

The impacts of hybridisation of differing mussel species even within UK waters although largely unknown can be negative. One such example, *M. trossulus* is a non-native species of mussel present in parts of in Scotland that is currently having a negative economic impact on local shellfish farms due to hybridisation with stock mussels. Unlike *M. edulis*, *M. trossulus* have very thin and brittle shells making them unsuitable for commercial sale. They have managed to successfully hybridise with other Mytilus species producing offspring with the same traits. The difficulty in being able to tell either species apart means that mariculturists may unknowingly produce large volumes of the unsellable M*. trossulus* alongside *M. edulis* (Michalek et al., 2016; Vendrami et al., 2020). The long-term effects of hybridisation of *M. galloprovincialis* with *M. edulis* remain to be seen, and though they may not be as potentially negative as the case seen in Scotland's with *M. trossulus*, decreased intra reproductive fitness as is sometimes seen in hybridisation of distinct populations in other species (Vendrami et al., 2020).

Hybridisation is also occurring between the Portuguese oyster (*Crassostrea angulata*) and the Pacific oyster (*M. gigas*) between France and Portugal (OSPAR Commission, 2009). Another example of the negative effects of mixing of distinct populations is in farmed salmon. Escape and accidental release of reared salmon has resulted in global instances of interbreeding of reared stock with wild stock. The resulting wild/reared hybrids tend to have decreased reproductive fitness which as a result threatens the stability of wild populations (Sylvester et al., 2019). Similar consequences should be considered for wild finfish populations in the District if finfish mariculture becomes established.

# 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 projects known to be occurring within Otter Estuary MCZ | The impact of future plans or projects will require assessment in their own right, including accounting for any in-combination effects, alongside existing activities. | N/A |

| Other activities being considered | | |
|---|---|---|
| **Activity** | **Description** | **Potential Pressure(s)** |
| Crab tiling | There is no evidence that this activity is currently occurring. Additionally, as the activities assessed (section 5) are not occurring, it is thought there is no in-combination effect. | Abrasion/disturbance of the substrate on the surface of the seabed<br><br>Habitat structure changes - removal of substratum (extraction)<br><br>Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion.<br><br>Removal of non-target species<br><br>Removal of target species<br><br>Changes in suspended solids (water clarity)<br><br>Smothering and siltation rate changes (Light)<br><br>Genetic modification & translocation of indigenous species<br><br>Introduction of microbial pathogens<br><br>Introduction or spread of invasive non indigenous species |
| Bait digging | There is no evidence that this activity is occurring. Additionally, as the activities assessed (section 5) are not occurring, it is thought there is no in-combination effect | |
| Static – fixed nets: Gill nets, Trammels, Entangling | This activity is currently not permitted to take place within the Otter 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. Therefore, no in-combination effect is thought to be possible. Additionally, as the activities assessed (section 5) are not occurring, it is thought there is no in-combination effect. | |
| Passive – nets: Drift nets (demersal) | This activity is currently not permitted to take place within the Otter 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. Therefore, no in-combination effect is thought to be possible. Additionally, as the activities assessed (section 5) are not occurring, it is thought there is no in-combination effect. | |
| Seine nets and other; Shrimp push nets, fyke and stakenets, ring nets | This activity is currently not permitted to take place within the Otter 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. Therefore, no in-combination effect is thought to be possible. Additionally, as the activities assessed (section 5) are not occurring, it is thought there is no in-combination effect. | |
| Hand working (access from land/access from vessel) | There is no evidence that this activity is currently occurring. Additionally, as the activities assessed (section 5) are not occurring, it is thought there is no in-combination effect. | |
| Beach seine netting | There is no evidence that this activity is currently occurring. Additionally, as the activities assessed (section 5) are not occurring, it is thought there is no in- | |

| | | |
|---|---|---|
| | combination effect. | |
| Static – pots/traps: Pots/creels, cuttlepots, fish traps | As there is little to no level of this activity in the Otter Estuary MCZ, no in-combination effect thought to be possible. Additionally, as the activities assessed (section 5) are not occurring, it is thought there is no in-combination effect. | |

D&S IFCA concludes there is no likelihood of significant adverse effect on the interest features from in-combination effects addressed within Table 4.

# 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 aquaculture could influence sediment characteristics and the associated infaunal assemblages beneath cultivation areas. However, changes in sediments characteristics will depend on the density of shellfish relative to water flow. In addition, aquaculture may result in the introduction of non-native indigenous species as well as disease.

However, Shellfish harvesting is not believed to be occurring within the Otter Estuary and the waters are not classified for shellfish harvesting. In addition, the estuary is privately owned and therefore any future shellfish farming is unlikely to be approved. D&S IFCA will continue to monitor activities on the estuary and ensure any future development of aquaculture is sustainable in line with D&S IFCA's obligations under Section 153 (2) of the Marine and Coastal Access Act (2009). As the activities assessed are not believed to be occurring within the MCZ, D&S IFCA concludes that there is no significant risk of the activities hindering the achievement of the conservation objectives for Otter Estuary MCZ.

## 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?**<br><br>**If Yes, list management options** |
|---|---|---|---|---|---|---|
| Intertidal coarse sediment | Maintain the presence and spatial distribution of intertidal coarse sediment communities<br><br>Maintain the total extent and spatial distribution of intertidal coarse sediment<br><br>(Maintain OR Recover OR Restore) the abundance of listed to enable each of them to be a viable component of the habitat<br><br>Maintain the species composition of | Commercial fishing;<br><br>Aquaculture; Shellfish bottom culture / shellfish trestle culture | • Abrasion/disturbance of the substrate on the surface of the seabed<br>• Changes in suspended solids (water clarity)<br>• Genetic modification & translocation of indigenous species<br>• Introduction of microbial pathogens<br>• Introduction or spread of invasive species non-indigenous species (INIS)<br>• Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion<br>• Removal of non-target species<br>• Removal of target species<br>• Smothering and siltation rate changes (Light)<br><br>See Annex 2 for pressures audit trail | No exposure<br><br>Shellfish farming is not currently occurring within the Otter estuary and no CEFAS classification maps. | Activities not believed to be occurring<br><br>D&S IFCA conclude that there is no significant risk of the activities hindering the achievement of the conservation objectives. | Yes,<br><br>Management measures could include:<br><br>1. Monitoring of activities in the estuary.<br>2. Review the mariculture strategy to ensure development of aquaculture is sustainable in line with D&S IFCA's obligations under Section 153 (2) of the Marine and Coastal Access Act (2009).<br>3. The review of D&S IFCA byelaws can gauge where any future changes or developments may occur. |

| | | | | | | |
|---|---|---|---|---|---|---|
| | component communities | | | | | |
| Intertidal mud | Maintain the presence and spatial distribution of intertidal mud communities<br><br>Maintain the total extent and spatial distribution of intertidal mud<br><br>[Maintain OR Recover OR Restore] the abundance of listed species to enable each of them to be a viable component of the habitat<br><br>Maintain the species composition of | Commercial fishing;<br><br>Aquaculture; Shellfish bottom culture / shellfish trestle culture | • Abrasion/disturbance of the substrate on the surface of the seabed<br>• Changes in suspended solids (water clarity)<br>• Genetic modification & translocation of indigenous species<br>• Introduction of microbial pathogens<br>• Introduction or spread of invasive species non-indigenous species (INIS)<br>• Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion<br>• Removal of non-target species<br>• Removal of target species<br>• Smothering and siltation rate changes (Light)<br><br>See Annex 2 for pressures audit trail | See above | See above | See above |

| | | | | | | |
|---|---|---|---|---|---|---|
| | component communities | | | | | |

# 13. References

Avdelas, L., Avdic-Mravlje, E., Borges Marques, A. C., Cano, S., Capelle, J. J., Carvalho, N., Cozzolino, M., *et al.* 2021. The decline of mussel aquaculture in the European Union: causes, economic impacts and opportunities. Reviews in Aquaculture, 13: 91–118.

Bertin, X., Chaumillon, E., Sottolichio, A., and Pedreros, R. 2005. Tidal inlet response to sediment infilling of the associated bay and possible implications of human activities: the Marennes-Oléron Bay and the Maumusson Inlet, France. Continental Shelf Research, 25: 1115–1131.

Bouchet, V. M. P., Debenay, J.-P., Sauriau, P.-G., Radford-Knoery, J., and Soletchnik, P. 2007. Effects of short-term environmental disturbances on living benthic foraminifera during the Pacific oyster summer mortality in the Marennes-Oléron Bay (France). Marine Environmental Research, 64: 358–383.

Brown, J. R., Gowen, R. J., and McLusky, D. S. 1987. The effect of salmon farming on the benthos of a Scottish sea loch. Journal of Experimental Marine Biology and Ecology, 109: 39–51.

Castel, J., Labourg, P.-J., Escaravage, V., Auby, I., and Garcia, M. E. 1989. Influence of seagrass beds and oyster parks on the abundance and biomass patterns of meio- and macrobenthos in tidal flats. Estuarine, Coastal and Shelf Science, 28: 71–85.

Cook, E. J., Ashton, G., Campbell, M., Coutts, A., Gollasch, S., Hewitt, C., Liu, H., Minchin, D., Ruiz, G. and Shucksmith, R. 2008. 'Non-native aquaculture species releases: implications for aquatic ecosystems', In: Holmer, M., Black, K., Duarte, C. M., Marba, N. and Karakassis, I. (Eds.), Aquaculture in the Ecosystem, Springer, Netherlands, pp. 155-184

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

Defra. 2019. Otter Estuary Marine Conservation Zone factsheet. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/915660/mcz-otter-estuary-2019.pdf

De Grave, S., Moore, S. J., and Burnell, G. 1998. Changes in benthic macrofauna associated with intertidal oyster, Crassostrea gigas (Thunberg) culture. Journal of Shellfish Research, 17: 1137–1142.

Deslous-Paoli, J., Lannou, A.-M., Geairon, P., Bougrier, S., Raillard, O., and Héral, M. 2004. Effects of the feeding behavior of Crassostrea gigas (Bivalve Molluscs) on biosedimentation of natural particulate matter. Hydrobiologia.

Dolmer, P. 2002. Mussel dredging: Impact on epifauna in Limfjorden, Denmark. Journal of Shellfish Research, 21: 529–538.

Dumbauld, B. R., Ruesink, J. L., and Rumrill, S. S. 2009. The ecological role of bivalve shellfish aquaculture in the estuarine environment: A review with application to oyster and clam culture in West Coast (USA) estuaries. Aquaculture, 290: 196–223.

Escapa, M., Isacch, J. P., Daleo, P., Alberti, J., Iribarne, O., Borges, M., Santos, E. P. D., *et al.* 2004. The distribution and ecological effects of the introduced pacific oyster *Crassostrea Gigas* (Thunberg, 1973) in Northern Patagonia. Journal of Shellfish Research, 23: 8.

Feist, B. E., and Simenstad, C. A. 2000. Expansion rates and recruitment frequency of exotic smooth cordgrass, Spartina alterniflora (Loisel), colonizing unvegetated littoral flats in Willapa Bay, Washington. Estuaries: 267–274.

Forrest, B. M., Keeley, N. B., Hopkins, G. A., Webb, S. C., and Clement, D. M. 2009. Bivalve aquaculture in estuaries: Review and synthesis of oyster cultivation effects. Aquaculture, 298: 1–15.

Goulletquer, P., and Heral, M. 1997. Marine Molluscan Production Trends in France: From Fisheries to Aquaculture. NOAA Tech. Rep. NMFS, 129. NOAA. https://archimer.ifremer.fr/doc/00000/2391/ (Accessed 23 August 2021).

Gozlan, R. 2010. The cost of non-native aquatic species introductions in Spain: Fact or fiction? Aquatic Invasions, 5: 231–238.

Gozlan, R. E., Peeler, E. J., Longshaw, M., St-Hilaire, S., and Feist, S. W. 2006. Effect of microbial pathogens on the diversity of aquatic populations, notably in Europe. Microbes and Infection, 8: 1358–1364.
Mckindsey, C. W., Landry, T., O'Beirn, F. X., and Davies, I. M. 2007. Bivalve aquaculture and exotic species: a review of ecological considerations and management issues. Journal of Shellfish Research, 26: 281–294.
Michalek, K., Ventura, A., and Sanders, T. 2016. Mytilus hybridisation and impact on aquaculture: A minireview. Marine Genomics, 27: 3–7.
Mitchell, I. M. 2006. In situ biodeposition rates of Pacific oysters (Crassostrea gigas) on a marine farm in Southern Tasmania (Australia). Aquaculture, 257: 194–203.
Natural England (2017) Draft Conservation Advice for Otter Estuary Marine Conservation Zone (MCZ)
Nugues, M. M., Kaiser, M. J., Spencer, B. E., and Edwards, D. B. 1996. Benthic community changes associated with intertidal oyster cultivation. Aquaculture Research, 27: 913–924.
OSPAR Commission. 2009. Assessment of Impacts of Mariculture. Biodiversity Series. OSPAR Commission. https://qsr2010.ospar.org/media/assessments/p00442_Impacts_of_Mariculture.pdf (Accessed 23 August 2021).
Ottmann, F., and Sornin, J.-M. 1985. Observations on sediment accumulation as a result of mollusk culture systems in France.
Pearson, T., and Rosenberg, R. 1977. Pearson TH, Rosenberg R.. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. Oceanogr Mar Biol Ann Rev 16: 229-311. Oceanography and Marine Biology, 16.
Rice, M. 2001. Environmental Impacts of Shellfish Aquaculture: Filter Feeding to Control Eutrophication.
Robinson, T., Griffiths, C., McQuaid, C., and Rius, M. 2005. Marine alien species of South Africa — status and impacts. African Journal of Marine Science, 27: 297–306. Taylor & Francis.
Ruesink, J., Lenihan, H., Trimble, A., Heiman, K., Micheli, F., Byers, J., and Kay, M. 2005. Introduction of Non-Native Oysters: Ecosystem Effects and Restoration Implications. Annual Review of Ecology, Evolution, and Systematics, 36: 643–689.
Ruesink, J., Feist, B., Harvey, C., Hong, J.-S., Trimble, A., and Wisehart, L. 2006. Change in productivity associated with four introduced species: ecosystem transformation of a 'pristine' estuary. Marine Ecology-Progress Series, 311: 203–215.
Sylvester, E. V. A., Wringe, B. F., Duffy, S. J., Hamilton, L. C., Fleming, I. A., Castellani, M., Bentzen, P., *et al.* 2019. Estimating the relative fitness of escaped farmed salmon offspring in the wild and modelling the consequences of invasion for wild populations. Evolutionary Applications, 12: 705–717.
Vendrami, D. L. J., De Noia, M., Telesca, L., Brodte, E.-M., and Hoffman, J. I. 2020. Genome-wide insights into introgression and its consequences for genome-wide heterozygosity in the Mytilus species complex across Europe. Evolutionary Applications, 13: 2130–2142.
Ysebaert, T., Hart, M., and Herman, P. M. J. 2009. Impacts of bottom and suspended cultures of mussels Mytilus spp. on the surrounding sedimentary environment and macrobenthic biodiversity. Helgoland Marine Research, 63: 59–74.

## Annex 1: Site Map(s)

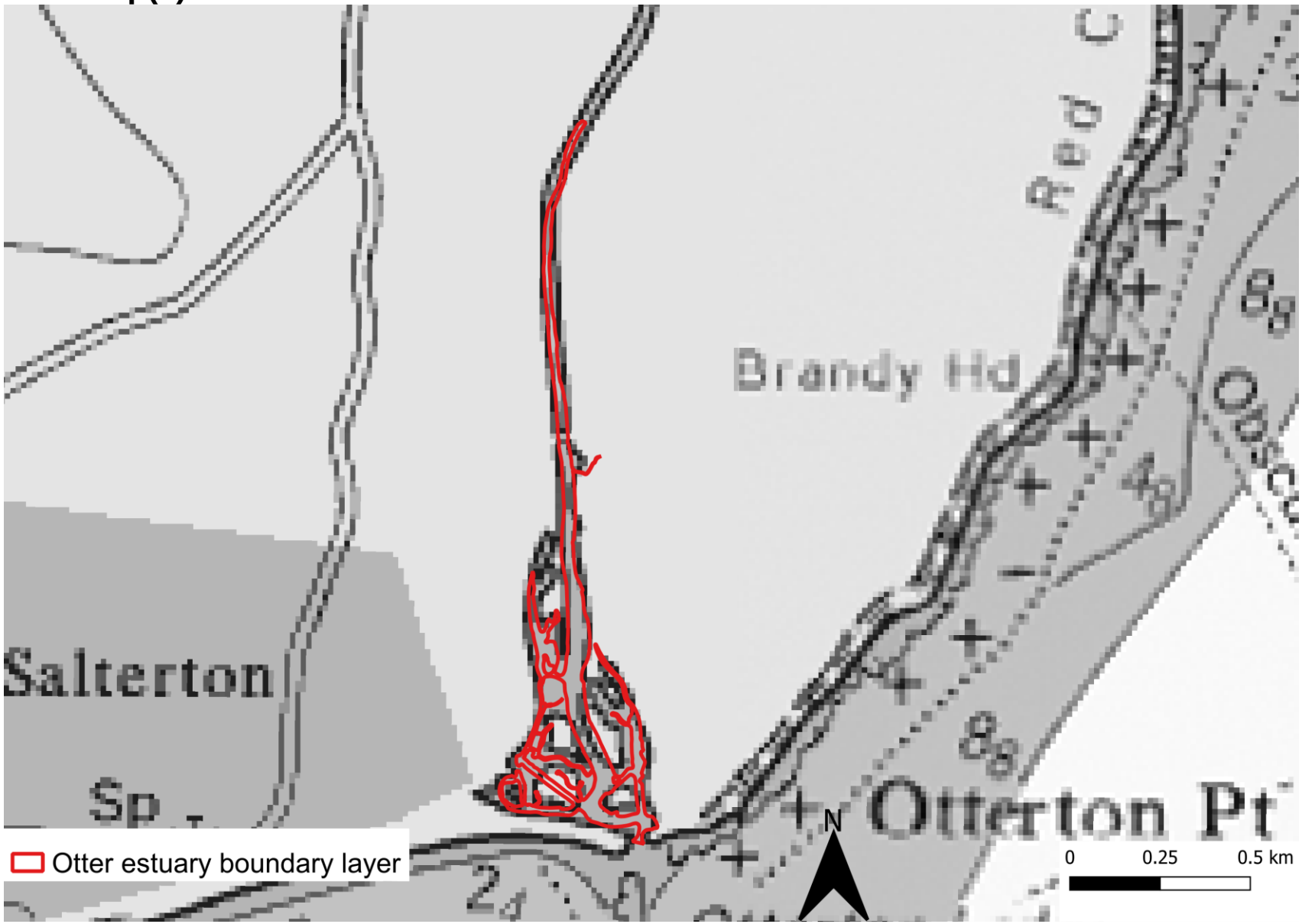



**Figure 1 – Otter Estuary MCZ**

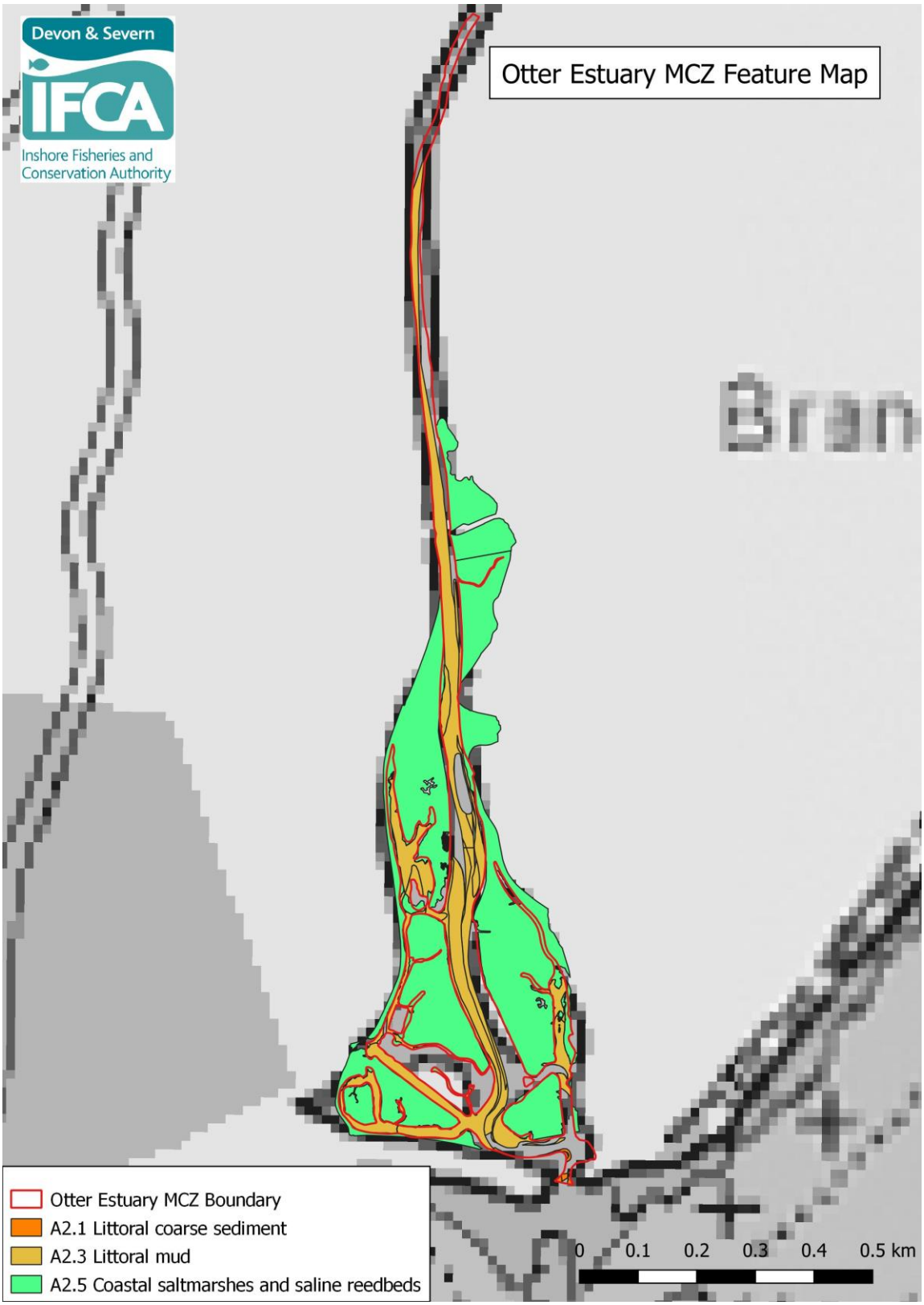
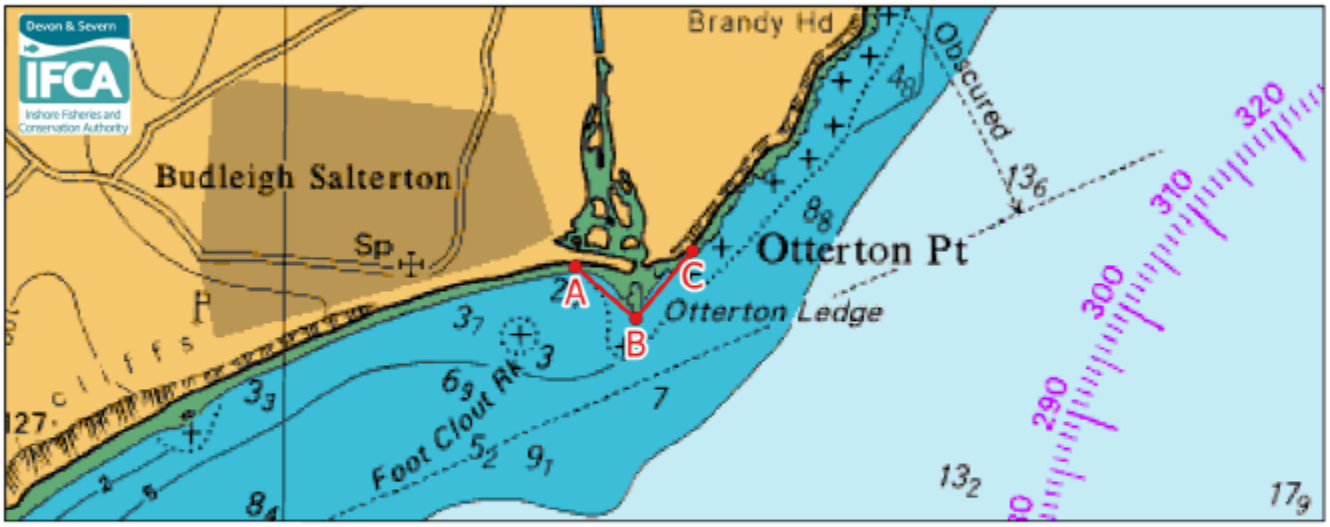



**Figure 2: Extent of features designated in the Otter Estuary MCZ**

**Annex 2 Chart of River Otter 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 Otter closing line latitude and longitude positions:

| Point | Latitude | Longitude |
|---|---|---|
| A | 50° 37.791'N | 003° 18.676'W |
| B (Otterton Ledge) | 50° 37.626'N | 003° 18.399'W |
| C (Otterton Point) | 50° 37.821'N | 003° 18.143'W |

**Figure 3: River Otter 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:** Aquaculture | Intertidal coarse sediment | Intertidal mud | Screening Justification |
|---|---|---|---|
| Abrasion/disturbance of the substrate on the surface of the seabed | NS | S | OUT – Insufficient activity levels to pose risk at level of concern |
| Changes in suspended solids (water clarity) | NS | S | OUT – Insufficient activity levels to pose risk at level of concern |
| Introduction of microbial pathogens | | NS | OUT – Insufficient activity levels to pose risk at level of concern |
| Introduction or spread of invasive non-indigenous species (INIS) | | S | OUT – Insufficient activity levels to pose risk at level of concern |
| Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion | NS | S | OUT – Insufficient activity levels to pose risk at level of concern |
| Removal of non-target species | | S | OUT – Insufficient activity levels to pose risk at level of concern |
| Smothering and siltation rate changes (Light) | NS | S | OUT – Insufficient activity levels to pose risk at level of concern |
| Deoxygenation | NS | NS | OUT – Insufficient activity levels to pose risk at level of concern |
| Hydrocarbon & PAH contamination | NA | NA | OUT – Not applicable |
| Introduction of light | | NS | OUT – Not applicable |
| Litter | NA | NA | OUT – Not applicable |
| Nutrient enrichment | NS | NS | OUT – Insufficient activity levels to pose risk at level of concern |
| Organic enrichment | NS | NS | OUT – Insufficient activity levels to pose risk at level of concern |
| Physical change (to another sediment type) | S | S | OUT – Insufficient activity levels to pose risk at level of concern |
| Physical loss (to land or freshwater habitat) | S | S | OUT – Not applicable |
| Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals) | NA | NA | OUT – Not applicable |
| Water flow (tidal current) changes, including sediment transport considerations | NS | S | OUT – Not applicable |
| Wave exposure changes | NS | NS | OUT – Not applicable |
| Transition elements & organo-metal (e.g., TBT) contamination | NA | NA | OUT – Not applicable |