



Marine
Management
Organisation

Marine Non-Licensable Activities Impacts Evidence: Benthic sediments and associated species (DRAFT)

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Executive Summary

This document collates and analyses the best available evidence on the impacts of marine Non-Licensable Activities (mNLA) on marine protected area (MPA) features and will inform site level assessments of the impact of mNLA on MPAs as part of the Marine Management Organisation's (MMO) work to manage MPAs.

MNLA have the potential to impact benthic sediments and associated species therefore management of these activities may be required within an MPA. For each MPA, a site level assessment considering the site conservation objectives, spatial and temporal activity levels and exposure to natural disturbance will be completed to determine whether management will be required.

Available evidence indicates that mNLA can cause physical pressures on seabed habitats, including abrasion, penetration and disturbance of sediments. In some cases, activities could also alter habitat structure or sediment composition. The level of impact depends on the type of activity, how often it occurs, the habitat affected, and the ability of habitats and species to recover.

Among the recreational activities assessed, anchoring poses the greatest risk to benthic sediment habitats due to its direct interaction with the seabed, causing abrasion, penetration and sediment disturbance. Sensitive habitats, particularly peat and clay exposures, are most vulnerable and could experience long-lasting or irreversible damage. Motorised watercraft, including personalised motorised watercraft can also affect sediment habitats through wake action, propeller wash and launching activities, especially in shallow or sheltered areas. In contrast, diving, snorkelling, sailing and non-motorised watercraft generally result in localised and lower-intensity impacts, primarily through trampling, launching or landing activities. Hovercraft typically have limited effects because they operate on a cushion of air, although sensitive habitats may still be vulnerable where activity overlaps with these features.

1 Introduction

The Marine Management Organisation (MMO) is the principal regulator for England's seas, including leading the assessment and management of marine Non-Licensable Activities (mNLA) for marine protected areas (MPAs) inshore of 12 nautical miles (nm). This document forms part of MMO work to achieve the government's aim of identifying and implementing appropriate management measures in place for all inshore MPAs in English waters by the end of 2030. It is one of a suite of documents which focus on the interaction of designated features with mNLA, and it will support the delivery of site level assessments.

The potential for pressures resulting from mNLA and their impacts on designated features within MPAs have been assessed by gathering and analysing the available evidence for activity-feature interactions.

This document describes the pressures resulting from mNLA which could impact benthic sediments and associated species. The Marine Non-Licensable Activity Impacts Evidence: Summary¹ provides further background information and details of other documents produced and the features and activities included within the scope of this programme of work.

1.1 Key definitions

A separate glossary in the Marine Non-Licensable Activity Impacts Evidence: Methodology¹ includes the important terms used in this document. Wherever possible these are taken from [Natural England's Glossary of terms used within conservation advice packages \(CAPs\)](#)².

The following terms are particularly important when reading this document:

Designated Feature ('feature') - A species, habitat, geological or geomorphological entity for which an MPA is identified and managed, this includes both designated and qualifying features.

Sensitivity - The sensitivity of a feature (species or habitat) is a measure that is dependent on the ability of the feature (species or habitat) to resist change and its ability (time taken) to recover from change (**Error! Reference source not found.**).

¹ Marine Non-Licensable Activity Impacts Evidence documents are available: <https://www.gov.uk/government/calls-for-evidence/marine-non-licensable-activities> (last accessed 30 September 2026)

² Natural England MPA Conservation Advice - Glossary of Terms: designatedsites.naturalengland.org.uk/pdfs/MPA_CAGlossary_March2019.pdf (last accessed 3 July 2026).

Pressure - the mechanisms through which an activity has an effect on a feature.

Impact - the consequence of a pressure/pressures (such as habitat degradation) where a change occurs that is different to that expected under natural conditions.



Figure 1: The approach to determine sensitivity from pressures for each feature and activity interaction.

1.2 Structure of this document

Section 0 lists the MPA features considered and references the evidence sources used in this document.

Section 0 describes the types of mNLA considered in this document.

Sections 4 to 10 describe the available evidence of the pressures resulting from the mNLA and impacts on the designated features. Where a feature is potentially sensitive to mNLA (based on its resistance to the pressure and ability to recover) the interaction is considered. Each section lists the pressures to which the features could be sensitive, using Natural England's conservation advice packages and MMO judgement. It also lists those pressures which have not been assessed or where insufficient evidence has been found to assess sensitivity. Each section also details available evidence about the designated feature, its ability to resist and recover from change, and its resultant sensitivity.

Section 11: summarises the conclusions of the assessed pressure feature interactions within this review.

Annex 1 describes how feature-pressure interactions have been identified; and provides a table of all the potential pressure-feature interactions and the sensitivity assessment for each.

2 Overview of benthic sediment features and associated species

This section describes the different features which are considered in this document under the broad terminology of 'benthic sediments and associated species' including those considered potentially sensitive to mNLA.

Table 1 provides links to descriptions of the features and their sensitivity to pressures. **Table 1** and the descriptions below draw on information the Marine Life Information Network (MarLIN, 2026) and the Joint Nature Conservation Committee Marine Habitat Classification (JNCC, 2022). **Annex 1: mNLA pressures on sensitive features - benthic sediments and associated species** provides a summary of the pressures associated with mNLA and the sensitivities of the MPA features described in this document to those pressures. Where a feature is potentially sensitive to pressures from mNLA (based on its resistance to the pressure and ability to recover) the interaction is considered in **Section 4 to 11**. Each section lists the relevant pressures to which the features are sensitive as well as those for which insufficient evidence is available to assess sensitivity. This approach has been taken to identify pressure-feature interactions which are generally considered to be applicable for all mNLA site level assessments. However, there may be site specific factors which will require additional pressures to be screened in or out of an individual site assessment.

The following features are referred to as subtidal sediments and have been grouped in this review as they are all are sediment features found in the subtidal area, with similar sensitivity to the pressures associated with anchoring:

- subtidal coarse sediment;
- subtidal mixed sediments;
- subtidal mud;
- subtidal sand;
- subtidal macrophyte-dominated sediment.

The following features are referred to as intertidal sediments and have been grouped in this review as they are all are sediment features found in the intertidal area, with similar sensitivity to pressures associated with anchoring:

- intertidal coarse sediment;
- intertidal mixed sediments;
- intertidal mud;
- intertidal sand and muddy sand;
- sheltered muddy gravels.

Where there are differences between the features or the potential impacts of different pressures on features within this group, this has been highlighted.

Table 1. Benthic sediment feature descriptions which are included within this literature review.

Feature name	Feature description (website link)
Intertidal coarse sediment	Littoral coarse sediment ³
Intertidal mixed sediments	Littoral mixed sediment ⁴
Intertidal mud	Littoral mud ⁵
Intertidal sand and muddy sand	Littoral sand ⁶ Infralittoral muddy sand ⁷
Peat and clay exposures	Peat and clay communities ⁸
Sheltered muddy gravels	Sheltered muddy gravels ⁹
Subtidal coarse sediment	Sublittoral coarse sediment ¹⁰
Subtidal macrophyte-dominated sediment	Sublittoral macrophyte-dominated communities on sediments ¹¹
Subtidal mixed sediments	Sublittoral mixed sediment ¹²
Subtidal mud	Sublittoral cohesive mud and sandy mud ¹³

³ JNCC – Littoral coarse sediment:

<https://mhc.jncc.gov.uk/biotopes/jncmncr00000269> (last accessed: 18 September 2026)

⁴ JNCC - Littoral mixed sediment: mhc.jncc.gov.uk/biotopes/jncmncr00000313 (last accessed 15 September 2026).

⁵ JNCC - Littoral mud: mhc.jncc.gov.uk/biotopes/jncmncr00000277 (last accessed 15 September 2026).

⁶ JNCC - Littoral sand: mhc.jncc.gov.uk/biotopes/jncmncr00000275 (last accessed 15 September 2026).

⁷ JNCC - Infralittoral muddy sand: mhc.jncc.gov.uk/biotopes/jncmncr00001559 (last accessed 15 September 2026).

⁸ MarLIN - *Ceramium* sp. and piddocks on eulittoral fossilised peat:

www.marlin.ac.uk/habitats/detail/369 (last accessed 22 June 2026).

⁹ JNCC - Sheltered muddy gravels: data.jncc.gov.uk/data/6e4e3ed1-117d-423c-a57d-785c8855f28c/UKBAP-BAPHabitats-52-ShelteredMuddyGravels.pdf (last accessed 15 September 2026).

¹⁰ JNCC - Sublittoral coarse sediment:

<https://mhc.jncc.gov.uk/biotopes/jncmncr00002034> (last accessed 15 September 2026).

¹¹ JNCC - Sublittoral macrophyte-dominated communities on sediments:

mhc.jncc.gov.uk/biotopes/jncmncr00002039 (last accessed 15 September 2026).

¹² JNCC - Sublittoral mixed sediment: mhc.jncc.gov.uk/biotopes/jncmncr00002038 (last accessed 15 September 2026).

¹³ JNCC – Sublittoral cohesive mud and sandy mud:

mhc.jncc.gov.uk/biotopes/jncmncr00002037 (last accessed: 18 September 2026).

2.1 Intertidal coarse sediment

Intertidal coarse sediment habitats occur on exposed and moderately exposed shorelines where wave and tidal action prevent the accumulation of finer sediments. They are typically composed of gravel, pebbles, cobbles and coarse sand, creating a highly mobile environment that is subject to drying between tides and supports relatively few species³.

Despite their low biodiversity, these habitats support specialised organisms adapted to unstable conditions. Gravelly sediments may contain crustaceans such as amphipods living between sediment particles, while larger cobbles can provide attachment surfaces for juvenile barnacles, seaweeds and other epifaunal species when conditions are stable³.

Intertidal coarse sediment habitats are important feeding areas for fish and shorebirds and contribute to natural coastal processes by facilitating sediment transport and maintaining shoreline stability. They also form transitional zones between rocky shores and sandy beaches, supporting ecological connectivity across the coastal environment (Brazier et al., 2019; Natural Resources Wales, 2021).

2.2 Intertidal mixed sediment

Intertidal mixed sediment habitats are found on sheltered to moderately exposed shores and contain a mixture of mud, sand, gravel, pebbles and cobbles. Because these sediments vary in size and composition, they create a range of microhabitats and form important transition zones between mudflats, sandy beaches and rocky shores⁴.

These habitats support a diverse range of wildlife. Burrowing animals such as polychaete worms, cockles and other bivalves live within the sediment, while larger, more stable cobbles and boulders provide attachment surfaces for seaweeds and other marine organisms).

Intertidal mixed sediments are valuable feeding and nursery areas for fish and wading birds. They also play an important role in nutrient cycling, sediment stabilisation and maintaining ecological links between surrounding coastal habitats, making them a key component of healthy coastal ecosystems (Natural Resources Wales, 2021).

¹⁴ JNCC – Sublittoral sands and muddy sands:
<https://mhc.jncc.gov.uk/biotopes/jnccmncr00002036> (Last accessed: 18 September 2026).

2.3 Intertidal mud

Intertidal mud habitats are found in sheltered coastal environments such as estuaries, bays and tidal creeks, where fine sediments like silt and clay accumulate. These areas are regularly exposed and submerged by the tides, creating a soft, waterlogged substrate that supports a rich and specialised community of organisms. The mud is often anaerobic below the surface, which influences the types of species that can thrive there. Typical infaunal species include burrowing polychaete worms, oligochaetes, and bivalves such as *Macoma balthica* and *Scrobicularia plana*, which play key roles in nutrient cycling and sediment mixing⁵.

Despite appearing barren at first glance, intertidal mudflats are highly productive ecosystems. They provide vital feeding grounds for wading birds, which forage for invertebrates in the sediment, and serve as nursery areas for fish and crustaceans. The surface may also support microalgae and diatoms, contributing to primary production. These habitats are sensitive to pollution, physical disturbance and changes in tidal regimes, making them important targets for conservation and monitoring. Their ecological functions - including supporting biodiversity, stabilising shorelines and filtering water - make intertidal mudflats essential components of healthy coastal systems (The Wildlife Trusts, n.d.; WHSRN, 2026).

2.4 Intertidal sand and muddy sand

Intertidal sand and muddy sand habitats are found along sheltered to moderately exposed coastlines, typically between the high and low tide marks. These areas are composed of fine to medium sand, sometimes mixed with silt or mud, and are regularly influenced by tidal movements. The sediment is often mobile, shaped by wave and current action, creating a dynamic environment that supports a range of burrowing and surface-dwelling organisms. These habitats are common in estuaries, bays and open coastal flats⁶.

Biologically, intertidal sand and muddy sand habitats support diverse infaunal communities, including polychaete worms, amphipods, bivalves like *M. balthica*, and crustaceans such as *Corophium volutator*. These species play a key role in nutrient cycling and serve as food for wading birds and fish. The surface may also host microalgae and diatoms, contributing to primary production. These habitats are ecologically rich and important for coastal food webs, sediment stability, and as nursery grounds for marine life⁶ (Gerdol & Hughes, 1994; Méléder et al., 2020).

2.5 Peat and clay exposures

Peat and clay exposures are distinctive coastal habitats where ancient peat and clay layers are exposed in the intertidal zone (BRIG, 2008a). These soft substrates support specialised communities, including *Ceramium* red algae and burrowing piddocks such as *Petricolaria pholadiformis* and *Barnea candida*. By boring into peat

and clay, piddocks create holes that provide microhabitats for other marine species, increasing local biodiversity⁸ (BRIG, 2008)

Peat forms from the accumulation of partially decomposed vegetation under waterlogged, oxygen-poor conditions (International Peatland Society, 2019). Rich in organic matter, peat often preserves plant remains, pollen and archaeological evidence, making it valuable for carbon storage and the reconstruction of past environments. Variations in peat composition and thickness reflect changes in vegetation and hydrology over time.

Clay exposures consist of fine-grained sediments deposited in low-energy environments such as floodplains, lakes and estuaries. Peat commonly develops above clay because clay's low permeability restricts drainage, helping to maintain the waterlogged conditions required for peat formation (BRIG, 2008a; International Peatland Society, 2019).

2.6 Sheltered muddy gravels

Sheltered muddy gravels are coastal and estuarine habitats found in areas protected from strong wave action and tidal currents, such as rias, sea lochs, and estuaries. These habitats are composed of a mix of mud, gravel, and shell fragments, creating a complex substrate that supports a rich diversity of marine life. In fully saline conditions, they can be exceptionally species-rich, with communities dominated by polychaete worms and bivalve molluscs, alongside a wide range of other marine phyla. The habitat supports both infaunal species living within the sediment and epifaunal species attached to surface materials like stones and coarse gravel. Species such as the carpet shell clam (*Venerupis senegalensis*), the truncate soft-shell clam (*Mya truncata*), and various tube-dwelling polychaetes are commonly found here, with the sediment composition and salinity playing a key role in determining community structure⁹ (Maddock, 2011).

As salinity decreases further into estuaries, species richness declines, but distinctive communities persist (Maddock, 2011). In low-salinity zones, species like the lagoon cockle (*Cerastoderma glaucum*) and ragworm (*Hediste diversicolor*) become more prominent⁹.

2.7 Subtidal coarse sediment

Subtidal coarse sediment habitats occur below the low-water mark and are typically composed of coarse sand, gravel, pebbles, shingle and cobbles. These sediments are often unstable due to strong tidal currents and wave action and are commonly found along open coastlines, in tide-swept channels and within marine inlets.

Subtidal coarse sediments support a diverse assemblage of infaunal and epifaunal species including polychaete worms, amphipods and bivalve molluscs, particularly venerid clams, which are well adapted to the shifting sediment¹⁰ (JNCC, 2022).

These habitats play an important ecological role by supporting marine food webs, providing feeding grounds for fish and mobile invertebrates, and contributing to nutrient cycling and sediment dynamics. As one of the most widespread subtidal sediment habitats around the UK, they are an important component of seabed biodiversity and ecosystem functioning¹⁰.

2.8 Subtidal macrophyte-dominated sediment

Subtidal macrophyte-dominated sediments are found in sheltered to moderately exposed coastal areas, typically within the infralittoral zone (0 to 20m depth). These habitats are characterised by soft sediments such as sand, mud, gravel, or mixed substrates often colonised by large, photosynthetic organisms. These include seaweeds like kelps (*Saccharina latissima*), filamentous and foliose red and green algae, and angiosperms such as seagrasses. The presence of these macrophytes creates structurally complex environments that support a wide range of marine life, including epifaunal species living on the surface and infaunal species burrowing within the sediment¹¹.

The biological richness of these habitats contributes significantly to coastal ecosystem functioning, offering food, shelter, and nursery grounds for numerous species. Notable features include maerl beds, which are formed by calcareous red algae and are particularly biodiverse and sensitive. As noted previously, maerl beds are being considered alongside seagrass beds, separate to this review. Subtidal macrophyte-dominated sediments play a vital role in nutrient cycling, sediment stability, and carbon sequestration, making them important targets for marine conservation and habitat monitoring¹¹.

2.9 Subtidal mixed sediments

Subtidal mixed sediments are dynamic marine habitats found below the low tide mark, typically in sheltered to moderately exposed coastal areas such as estuaries, bays and open coasts¹². These habitats consist of a variable mix of sand, gravel, mud and shell fragments, creating a complex and diverse substrate. The diversity of the sediment allows for a wide range of ecological niches, supporting both infaunal species (those living within the sediment) and epifaunal species (those living on the surface). Characteristic species include polychaete worms, bivalves, amphipods, brittlestars, and burrowing anemones such as *Cerianthus lloydii*¹².

Subtidal mixed sediments are ecologically important due to their high biodiversity. These habitats often support rich benthic communities and serve as feeding and nursery grounds for fish and other marine organisms. The biological composition varies depending on factors such as depth, salinity and sediment characteristics¹². For example, in tide-swept areas species such as hornwrack (*Flustra foliacea*) and oaten pipe hydroid (*Hydrallmania falcata*) may dominate, while in more sheltered, muddy zones burrowing holothurians and tube-dwelling polychaetes are common (Readman & Watson, 2024).

2.10 Subtidal mud

Subtidal muds are soft sediment habitats found below the low tide mark in sheltered marine environments such as sea lochs, estuaries, and bays. These habitats are typically composed of fine silts and clays that accumulate in areas with low water movement¹³. The oxygen levels in these sediments are often low, especially below the surface, creating conditions suitable for specialised infaunal communities. These include burrowing polychaete worms, bivalves, and crustaceans, which play a key role in nutrient cycling and sediment mixing. The surface of the mud may also support tube-building species and occasional epifauna, contributing to the structural complexity of the habitat¹³.

Subtidal muds are ecologically important for their role in supporting biodiversity and providing feeding grounds for fish and birds (The Wildlife Trusts, n.d.). They also act as nursery areas for juvenile marine species and contribute to carbon storage due to the high organic content of the sediments (The Wildlife Trusts, n.d.).

2.11 Subtidal sand

Subtidal sand habitats occur below the low tide mark and are among the most common seabed habitats around the UK. They are mainly composed of sand, although gravel and shell fragments may also be present. Waves and tidal currents continually shape these habitats, creating a dynamic environment¹⁴ (BRIG, 2008)

Despite their simple appearance, subtidal sands support a diverse range of burrowing animals, including polychaete worms, bivalves, amphipods and heart urchins. Species such as sand mason worm (*Lanice conchilega*) and razor shells are commonly found within these sediments¹⁴ (BRIG, 2008; McQuillan et al., 2024).

These habitats provide important feeding and nursery grounds for fish and other marine wildlife. The activities of burrowing species help recycle nutrients and maintain healthy seabed ecosystems, making subtidal sands an important contributor to marine biodiversity (BRIG, 2008).

2.12 Features scoped out of this review

The following designated benthic sediments are not included within this document:

- *Salicornia* and other annuals colonising mud and sand. *Salicornia* is a pioneer saltmarsh habitat which forms on intertidal mud and sandflats in sheltered coastal areas. Natural England advised that it is unlikely that mNLA will occur in these intertidal areas therefore no pathway for impact has been identified (Natural England, pers. comms. 17 December 2025).
- Atlantic salt meadows are coastal habitats found in the upper zones of saltmarshes, typically in sheltered estuaries, bays and coastal inlets. Natural England advised that it is unlikely that mNLA will occur in these intertidal

areas therefore no pathway for impact has been identified (Natural England, pers. comms. 17 December 2025).

- *Spartina* swards are pioneer saltmarsh habitats dominated by species of *Spartina*, particularly *Spartina anglica*, which thrive in the upper reaches of sheltered coastal environments. Natural England advised that it is unlikely that mNLA will occur in these intertidal areas therefore no pathway for impact has been identified (Natural England, pers. comms. 17 December 2025).
- Coastal and floodplain grazing marsh is a predominantly terrestrial wetland habitat found along the coast and inland river valleys. Natural England advised that it is unlikely that mNLA will occur in these intertidal areas therefore no pathway for impact has been identified (Natural England, pers. comms. 17 December 2025).
- Coastal reed beds are wetland habitats dominated by dense stands of common reed (*Phragmites australis*), typically found in extremely sheltered freshwater-influenced environments, such as enclosed water bodies, and where the water remains at or above ground level for most of the year. Natural England advised that it is unlikely that mNLA will occur in these intertidal areas therefore no pathway for impact has been identified (Natural England, pers. comms. 17 December 2025).

3 mNLA detail of activities

Within MMO remit there are eight types of mNLA which are listed and defined below.

1. Anchoring
2. Diving and snorkelling
3. Hovercraft
4. Motorised personal watercraft
5. Motorised watercraft
6. Non-motorised watercraft
7. Non-motorised sailing
8. Wildlife watching from the sea (commercial)

There may be additional activities or categories of activities which are identified at a site level which would be considered and included in a site assessment.

3.1 Anchoring

This activity involves the dropping of an anchor by any vessel (with or without an engine) to secure the vessel to the seabed temporarily, in order to prevent it drifting with the wind or current (Griffiths et al., 2017). Anchors are generally heavy metal objects designed to dig into, or hook onto, the seabed. To create hold, the anchor is dropped and a length of chain is laid out on the seabed (Griffiths et al., 2017). The anchor is 'set' (fixed in position) as some pulling force is exerted on the chain (Griffiths et al., 2017). As the vessel drifts, the dragging anchor carves furrows into the seabed, or scrapes on the surface of firm seabed, or the anchor may move sideways along the benthos (Griffiths et al., 2017). In addition, vessels at anchor in the intertidal area will impact the seabed when the hull/keel rests on the seabed as the tide goes out, also known as beaching.

The non-physical disturbance impacts whilst a boat is at anchor will be covered by motorised watercraft and sailing sections below.

3.2 Diving and snorkelling

Diving and snorkelling refer to swimming, either underwater or on the surface, using self contained underwater breathing apparatus (Scuba) or snorkelling equipment. This activity excludes the any extraction of any sea fisheries resources during the activity (such as spearfishing).

As divers and snorkelers will generally be positioned above the seabed, interaction between diving/snorkelling activity and the features covered in this review will be limited. However, there is potential for divers to make contact with the seabed during participation, and during entry if the diver enters the water by shore.

Anchoring pressures which are associated with dive boats are covered in the anchoring activity section.

3.3 Hovercraft

A hovercraft, also known as an air-cushion vehicle (ACV), is a craft capable of travelling over land, water, mud, ice or other surfaces. Hovercraft are primarily used in sheltered environments, typically with large expanses of flat, intertidal areas such as mudflats or sandflats (Natural England, 2017)

This activity could impact benthic features if operated over the intertidal area when exposed.

3.4 Motorised personal watercraft

A motorised personal watercraft (MPW) is a recreational watercraft that the rider rides or stands on. Some models have an inboard engine driving a pump jet that has a screw-shaped impeller to create thrust for propulsion and steering. These craft are often referred to by the brand names such as Jet Ski. The MPW category includes e-foils, 'jet ski' and electric powered vessels. This can also include hydroflying. A hydroflyer is a water sports device that allows a person to "fly" above the water, propelled by the force of water jets. It connects to a motorised personal watercraft, like a jet ski, via a long hose, and the rider controls the thrust and direction by shifting their weight. The high pressure water jets propel the person on the hydroflyer above the water and below.

As participants will be positioned above the water, interaction between MPW activity and benthic features will be limited. However, there could be abrasion to features if the activity is launched from the shore, through dragging of equipment or craft over the intertidal area. There could also be abrasion impacts within the intertidal area from the use of trailers and the vehicles used to tow MPW. MPW also have the potential to interact with designated features included in this review from propeller wash.

3.5 Motorised watercraft

The use of motorised vessels, including motorboats (powerboats), sailing vessels and yachts with a motor in marine and estuarine waters. The motorised watercraft category includes water sports that involve being towed behind a motorised vessel, such as wakeboarding, waterskiing, parascending and parasailing as well as the impact of vessels carrying participants for other mNLA such as diving and snorkelling.

As participants will be positioned above the water, interaction between motorised watercraft activity and benthic features will be limited. However, there may be abrasion to features from propeller wash and if the activity is launched from the shore, through dragging of equipment or craft over the intertidal area. There could also be abrasion impacts in the intertidal area from the use of trailers and vehicles used to tow motorised watercraft.

3.6 Sailing

This category includes sailing boats without a motor as well as sailing vessels with motors that remain unused while under sail. Sailing boats include dinghies, day boats, keelboats or yachts which may or may not be taken out of water at end of use.

Interaction between sailing activity and benthic features will be limited as participants will be positioned at the surface of the water. However, there could be abrasion to features if the activity is launched from the shore, through dragging of equipment or craft over the intertidal area.

3.7 Non-motorised watercraft

Non-motorised personal watercraft category covers a wide variety of paddle- or wind-propelled sports. This includes canoeing (all types), kayaking (all types), kitesurfing, kite boarding, kite foiling, windsurfing, wingsurfing, wingfoiling, winging, kite winging, dinghies, stand-up foil boarding and stand-up paddle boarding.

Interaction between non-motorised personal watercraft activity and benthic features will be limited as participants will be positioned above the water. However, there could be abrasion to features if the activity is launched from the shore, through dragging of equipment or craft over the intertidal area.

3.8 Wildlife watching from the sea (commercial)

This category covers wildlife watching from any commercial organised trip at sea from any vessel, this includes organised trips and excursions and refers to paid-for activities undertaken for the purpose of observing, photographing, or experiencing marine and coastal wildlife in its natural environment. These activities are typically delivered by a commercial operator using a motorised or non-motorised vessel and may target species such as cetaceans, seabirds, seals, basking sharks or other marine fauna.

These trips can often access remote locations such as offshore islands or remote cliffs where birds and seals seek sanctuary from disturbance. Repeated wildlife-watching tours can impact seals and seabirds especially through disturbance, particularly when vessels approach too closely, visit colonies frequently, or operate during sensitive periods such as breeding, pupping, moulting or overwintering.

This activity is not in scope for this literature review, impacts from vessels on benthic sediments are considered in the sections above.

4 Anchoring

This section brings together and analyses the available evidence on the impacts of anchoring on benthic sediment and associated species features; this includes recreational and commercial anchoring.

Natural England's Advice on Operations was used to identify potential pressures from anchoring and to inform the understanding of feature sensitivity to the pressure. Where a sensitivity assessment has not been undertaken or the evidence base is insufficient to assess sensitivity, the activity-pressure-feature combination has been included to capture all possible evidence that could impact the features. **Marine Non-Licensable Activity Impacts Evidence: Methodology**¹ details the process of how MMO judgement refined pressures for assessment.

The following pressures have been included in this review as they have been determined to be pressures commonly induced by anchoring at a level that has the potential to cause significant impacts on benthic features.

- abrasion/disturbance of the substrate on the surface of the seabed;
- penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion;
- physical change (to another sediment type);
- physical change (to another seabed type) note: only relevant to sheltered muddy gravels.

The following pressures have not been included in this review as they generally do not occur at a level of concern as a result of anchoring. Pressures associated with participation of vessels will be considered in the relevant activity sections. Should site level factors increase the risk of impacts from anchoring due to the pressures below, these pressures would be considered in the individual site assessment.

- hydrocarbon and polycyclic aromatic hydrocarbon (PAH) contamination;
- introduction of light;
- introduction or spread of invasive non-indigenous species (INIS);
- organic enrichment;
- synthetic compound contamination (including pesticides, antifoulants, pharmaceuticals);
- transition elements and organo-metal (for example, TBT) contamination.

4.1 Summary of the effects of anchoring on subtidal and intertidal sediments

Sensitivity of subtidal and intertidal sediments to anchoring will depend on several factors, including the sediment type, presence of particularly sensitive biotopes and levels of anchoring activity. Exposure to natural disturbance will also influence the scale of impact, with communities less accustomed to high hydrodynamic

disturbance impacted at a greater extent than those frequently subject to high levels of hydrodynamic disturbance (Ellis et al., 2000; Mazek & Smyth, 2013).

Organisms colonising sands are generally adapted to a higher level of natural disturbance compared to those colonising muddy sediments, which are more sheltered (Mazek & Smyth, 2013). In general, larger, fragile and longer-lived species will be more greatly affected by impacts of abrasion. For example, species colonising sandbanks such as surf clams (*Spisula solida*) are likely to be more tolerant of abrasion than thin-shelled species found in stable muds (Griffiths et al., 2017). Similarly, species which protrude from sediments will be at greater risk than species which lay flat or burrow within sediment, as they are at greater risk of being damaged (Griffiths et al., 2017).

Physical recovery of sediment means a return to the previous distribution of grain size and density, infilling of any pits, and recovery to baseline organic content (Mazek & Smyth, 2013). Biological recovery of sediment is influenced by recruitment of new individuals, growth of surviving biota, and active immigration from adjacent habitat (Collie et al., 2000).

Sand communities are likely to recover from abrasion impacts most quickly (Collie et al., 2000). Whereas communities from gravel (subtidal coarse sediment) and muddy sand habitats tend to have the slowest physical and biological recovery rates (Dernie et al., 2003; Kaiser et al., 2006). Little evidence is available regarding the recovery of subtidal mixed sediments but, in general terms, the more physically stable habitats are, such as subtidal mud and coarse sediments like gravel, the longer recovery is likely to take (Collie et al., 2000). As such, the sediment composition of subtidal mixed sediments, for example the ratio of sand, to mud, to gravel etc is likely to determine its ability to recover.

Recovery in intertidal zones tends to be faster due to higher species turnover and opportunistic colonisers (Ellis et al., 2000). In areas subject to greater wave exposure, or areas of high sediment mobility, biotopes are likely to be the least sensitive to physical pressures. In these dynamic environments, species such as sediment-dwelling and burrowing amphipods are adapted to unstable sediments, and high resistance to physical disturbance has been observed (Griffiths et al., 2017).

The deployment, dragging and recovery of anchors and associated chains can have both physical and biological impacts on sediment features and associated species, with direct impacts caused by abrasion and sub-surface penetration including tangling and snagging of erect epifauna that protrude from the substrate (Griffiths et al., 2017). Physical disturbance to benthic communities can cause removal, displacement and migration of species, which alters the community structure. Subsurface pressure caused by anchoring can collapse burrows and reduce the pore space between particles, which then affects further burrowing activity and reduces stability and oxygen content (Griffiths et al., 2017). Communities which are

damaged could be more susceptible to disease, predation and parasites, which in turn can impact the wider ecosystem function (Mazek & Smyth, 2013).

During anchor 'setting', the anchor is dropped onto the substratum and is dragged to set (firmly lodging it in the sediment by motoring backwards), resulting in penetration and disturbance of sediments within its footprint (Griffiths et al., 2017). Whilst at anchor, the chain could drag across the substratum as the position of the vessel changes in response to wind or tide, leading to abrasion, or the anchor could move laterally ('crabbing') within the sediment (Davis et al., 2025). Anchors that are poorly set could also drag through or on the sediment (Griffiths et al., 2017). When retrieving the anchor, the anchor and chain are dragged along the substratum as the vessel manoeuvres, resulting in an anchor scar (Griffiths et al., 2017).

Several factors affect the footprint and depth of penetration and disturbance of the sediment by an anchor, including size, weight and type of anchor (smaller anchors have smaller footprints) (Griffiths et al., 2017). The footprint of chain abrasion during an anchoring event by a vessel will depend on a range of factors that influence the level of swing, for example the length of chain deployed and resting on the seabed, and the size and weight of the chain (Griffiths et al., 2017).

While a vessel is at anchor in intertidal or shallow subtidal areas, there is potential for a vessel to ground, therefore causing further penetration of the seabed from the weight of the vessel. This is more likely to occur with smaller vessels that can reach shallower waters, which could then cause additional damage through attempts to move the boat (The Green Blue, 2021).

Reported anchoring impacts range from direct anchor footprints of approximately 0.16m² in seagrass habitats (Creed and Amado Filho, 1999) to seabed furrows reportedly up to 5m wide; however, these furrows were only attributed to anchoring and this could not be confirmed, and no information on furrow length was provided (Fader and Miller, 1990). Chain abrasion for recreational vessels in 0 to 5m water depths was conservatively estimated to be 60m², with a worst-case scenario estimate of 482m² (Griffiths et al., 2017). In a study conducted by Backhurst and Cole (2000) in which the duration of recreational anchoring scars on soft sediments was quantified, it was reported that anchor holes reduced from 90mm deep to 1 to 13mm deep over a three-month period in a wave sheltered site with no appreciable tidal flow. However, it is recognised that the study may underestimate the effects of anchoring as the anchor was dropped but not set, and the boat was not left to swing at anchor, which leads to chain abrasion. Soft sediments such as mud are likely to be more deeply penetrated than firmer sediments such as soft sands (Griffiths et al., 2017). In more dynamic environments, infilling would likely occur at a greater rate. In less dynamic environments with lower levels of wave and tidal energy, anchoring scars could persist for longer because sediment redistribution occurs more slowly. However, recovery times are also influenced by habitat characteristics and are likely to be longer for fragile or slow-growing habitats (Bolam, 2011; Wilber & Clarke, 2007).

Generally, intertidal sediments experience more frequent, short-term physical disturbances through tidal exposure, wave action and anthropogenic trampling, and therefore could be more resilient to abrasion (Ellis et al., 2000).

Griffiths et al., (2017) concluded that impacts from anchoring on sediment features are likely to be localised and of short duration, and recovery can begin when the anchor is removed (although length of recovery will be habitat and/or species-specific). The impact of an individual anchoring event depends on the type of vessel or anchor deployed and specific conditions such as duration, level of swing, and deployment events such as difficulties with setting or retrieval of anchor and whether the boat dragged the anchor (Griffiths et al., 2017).

There is a notable gap in literature regarding the impacts of anchoring from large commercial vessels, for example container vessels, which can exceed lengths of 300 m. In comparison to recreational vessels, commercial vessels require much larger anchors, which have a significantly greater potential for damage (Watson et al., 2022). (Davis et al., 2025) present the impacts of anchoring from larger commercial vessels where anchors can exceed weights of 20 tonnes (t), with chains up to hundreds of metres in length. Calculated penetration depths by Hoshina and Featherstone (2001) as cited in (Griffiths et al., 2017) indicate that anchor penetration varies strongly with sediment type - up to 9.2m in mud and silt and 2.9m in sand and gravel. Experimental anchor-drop testing in the German Bight (Luger and Harkes, 2013) recorded shallower penetrations, with large commercial anchors not exceeding 1m penetration into seabed sediments during tests. When extrapolated to very large anchors (29t), penetration was estimated to be greater than 1m, but less than the depths suggested by Hoshina and Featherstone. Similarly, a report by Dorset Wildlife Trust (2021) describes shallower penetration depths of up to 0.6m deep and 0.05m wide within a popular anchorage site for commercial vessels in Weymouth Bay. Subtidal soft sediments near ports are often designated as a suitable anchoring location, providing a suitable holding substratum for heavy tonnage vessels whilst they wait to berth (Davis et al., 2025).

Davis et al (2025) conclude that the study area subject to anchoring of large commercial vessels resulted in increased invertebrate abundance but a slightly reduced diversity of species. A negative impact on abundance of suspension feeders was observed, whilst assemblages of scavenger and predator species increased in abundance.

In summary, anchoring on sediments can cause physical damage to both the physical structure and biological communities present. The scale of the impact is highly dependent on the size and intensity of anchoring. However, recovery of physical sediments and associated benthic communities is expected where disturbance is infrequent and natural sediment mobility supports infilling and recolonisation. Recovery rates depend on habitat type, disturbance intensity and local hydrodynamic conditions (Dernie et al., 2003; Kaiser et al., 2006). The rate of sediment infilling is closely linked to benthic sediment recovery, with faster physical

infilling generally supporting more rapid recolonisation (Dernie et al., 2003). In sandy sediments, which are typically more mobile and subject to frequent waves and currents, disturbed areas often infill rapidly, with physical recovery occurring over days to weeks and associated benthic communities recovering comparatively quickly (Dernie et al., 2003; Lambert et al., 2014). In contrast, muddy and silty sediments tend to exhibit slower physical recovery due to lower shear strength and reduced sediment transport; anchor scars and depressions may persist for months to years, and benthic recolonisation can be slower, particularly for longer-lived or deep-burrowing taxa (Wilber & Clarke, 2001).

Management may be required for anchoring on subtidal sediments where activity is significant in intensity and hinders the ability for the feature to recover, particularly where a site is colonised by slow-recovering biotopes.

Dragging and recovery of anchors and associated chains can have direct impacts on subtidal sediment features via abrasion and sub-surface penetration. This has the potential to result in physical change to another sediment type for sediments through disturbance and re-suspension of fine particles and organic matter, which can subsequently be removed by tidal currents (Griffiths et al., 2017). The presence and quantity of fine particles within these sediment types determines the cohesiveness of the substrate and their susceptibility to grinding or alteration of particle size.

Physical change captures the impact of a permanent change to the sediment type, generally due to the placement of a permanent structure. Griffiths et al (2017) do not consider that anchoring has the potential to cause a physical change, in comparison to mooring activity, where the infrastructure is permanent. As anchors are a temporary fixture, and depressions in sediment caused by anchors are expected to infill, it is unlikely that a physical change to the sediment structure will occur as a result of anchoring, unless a site is exposed to a significant level of activity or anchoring of very large commercial vessels which limit recovery.

Impacts will be site dependent and site specific factors such as sediment type, local tidal and wave conditions and frequency of activity could result in increased risk in certain locations.

MMO conclude that anchoring on subtidal and intertidal features is likely to result in a significant risk of hindering achievement of the conservation objectives of the MPA at any level of activity. This is because the impacts of abrasion/disturbance of the substrate on the surface of the seabed and penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion, and physical change (to another sediment type) caused by this activity even at low levels are likely to present a significant risk of hindering achievement of the site's conservation objectives.

4.2 Summary of the effects of anchoring on peat and clay exposures

Peat and clay exposures are regarded as irreplaceable habitats, as the underlying substrate forms over extremely long timescales and cannot realistically be recreated once lost. As a result, resilience to physical loss is considered very low, with recovery expected to exceed 25 years and potentially be irreversible (Tillin et al., 2025).

Due to the inability to recover when removed, sensitivity to physical pressures such as penetration or disturbance of the substratum subsurface is considered high, and resilience is very low where there is physical loss of, or change to, the seabed or sediment⁷. Whilst peat and clay exposures are more often distributed in the shallow intertidal area, characterised by covers of dense algal mats and shallow pools forming in crevices⁷, this is not an area compatible with anchoring of vessels and this section therefore relates to subtidal areas of peat and clay.

Piddocks are characterising species of subtidal peat and clay, with *Pholas dactylus* being the most widespread and abundant (BRIG, 2008). Piddocks are specialised borers, and their burrows and shells can provide habitats for other colonising species (Pinn et al., 2008). Recovery of piddocks is reliant upon recolonisation by juveniles due to the immobility of adults, and dependent on the successful growth of adults. This growth stage can take between two and ten years, with adults generally reaching sexual maturity at two years old and living to approximately twelve years⁷. For this reason, and because the substratum (peat and clay) cannot recover, resilience of piddocks (the biotope 'Piddocks with a sparse associated fauna in sublittoral very soft chalk or clay') to abrasion is very low (over 25 years to recover)⁷.

As discussed in **section 4.1**, the deployment, dragging and recovery of anchors and associated chains can have direct impacts on subtidal features via abrasion and sub-surface penetration.

In a 2015 report JNCC describes peat and clay exposures as soft and fragile. This fragility means that peat and clay exposures are vulnerable to physical pressures, such as those caused by anchoring. Any damage to the physical structure of peat and clay is unrecoverable and will be lost permanently (BRIG, 2008). Peat and clay exposures are characterised by species that bore into the soft substrate, however detailed information on species composition in subtidal peat is limited. It is expected that communities associated with subtidal peat and clay will be different to those associated with intertidal exposures, with documented piddocks, hydroids and crabs present in subtidal examples (BRIG, 2008). A 2024 study within Cromer Shoal Chalk Beds MCZ in North Norfolk, frequently observed piddock holes both within subtidal exposed outcrops - described as rugged peat and clay exposures - and within subtidal flat exposures (Eastern IFCA, 2024).

The sessile species which characterise peat and clay could be directly removed or destroyed during an anchoring event, which could alter the community structure. Subsurface pressure caused by anchoring could expose or collapse burrows, affecting those species which remain in burrows through their adult stage. This could also further impact biodiversity, as piddocks are key structuring species whose boring activities leave burrows which allow for colonisation by other species (Pinn et al., 2008).

The biota colonising subtidal peat and clay - predominantly piddocks - may be able to recover from anchoring activity, provided there is opportunity for recovery through breaks in activity pressure allowing for successful juvenile recolonisation. However, abrasion and penetration impacts as a result of anchoring activity have the potential to permanently alter or destroy the physical structure of the peat and clay, which is unrecoverable⁸. Impacts of abrasion through anchoring could be further exacerbated by the structural complexity of the substrate, such as the rugged structures (seabed features with an uneven, irregular or complex surface, often characterised by hard substrates such as rock, ridges, boulders, reefs, or outcropping formations) found offshore on the North Norfolk Coast. Anchors are more likely to become caught on rugged structures, limiting vessel movement and restricting chain sweep to a smaller area, although repeated abrasion could occur within a more confined area. In contrast, on flat substrates, anchors are less likely to become lodged within seabed features, allowing the vessel to swing more freely in response to wind, waves, and tidal currents. As the vessel swings, the attached chain can move repeatedly across the seabed over a broad arc, increasing the spatial extent of abrasion and disturbance (Schulze et al., 2025; Watson et al., 2022).

Abrasion and sub-surface penetration caused by anchoring has the potential to result in physical change of peat and clay exposures to another sediment type through disturbance and re-suspension of fine particles and organic matter, which can subsequently be removed by tidal currents (Griffiths et al., 2017). There is potential for anchoring to cause increased levels of fine particles to flow into areas where peat and clay are exposed, resulting in smothering. Impacts of smothering will vary depending on the size of the anchor, level of anchoring activity and hydrodynamics in the location of the peat and clay area.

Given the irreplaceable nature of peat and clay exposures and their negligible recoverability following physical damage, even low-intensity disturbance has the potential to result in long-term habitat loss.

MMO conclude that anchoring on peat and clay exposures is likely to result in a significant risk of hindering achievement of the conservation objectives of the MPA at any level of activity. This is because the impacts of abrasion/disturbance of the substrate on the surface of the seabed and penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion, and physical change (to another sediment type)

caused by this activity even at low levels are likely to present a significant risk of hindering achievement of the site's conservation objectives.

5 Diving and snorkelling

This section brings together and analyses the available evidence on the impacts of diving and snorkelling on benthic features.

Natural England's Advice on Operations was used to identify potential pressures from diving and snorkelling and to inform the understanding of feature sensitivity to the pressure. Where a sensitivity assessment has not been undertaken or the evidence base is insufficient to assess sensitivity, the activity-pressure-feature combination has been included to capture all possible evidence that could impact the features. **Marine Non-Licensable Activity Impacts Evidence: Methodology**¹ details the process of how MMO judgement refined pressures for assessment.

The following pressures have been included in this review as they have been determined to be pressures commonly induced by diving and snorkelling at a level that has the potential to cause significant impacts on benthic features.

- abrasion/disturbance of the substrate on the surface of the seabed;
- penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion.

The following pressures have not been included in this review as these pressures generally do not occur at a level of concern as a result of diving/snorkelling. Pressures associated with vessel use for diving or other purposes will be considered in the relevant activity sections. Should site level factors increase the risk of impacts from diving and snorkelling due to the pressures below, these pressures would be considered in the individual site assessment.

- hydrocarbon and PAH contamination;
- introduction of light;
- INIS;
- litter;
- synthetic compound contamination;
- transition elements and organo-metal contamination; and
- underwater noise changes.

5.1 Summary of the effects of diving and snorkelling on subtidal and intertidal sediments

Pressures caused by diving and snorkelling activity on subtidal and intertidal sediments are listed in **Table A1.2**.

Sensitivity of subtidal and intertidal sediments to diving and snorkelling will depend on several factors, including the sediment type, presence of particularly sensitive biotopes and levels of diving and snorkelling activity.

Research into the impact of abrasion and penetration from diving and snorkelling is historically focused on coral reef damage, however, there has been an increase in research into the physical disturbance of seabed sediments caused by diver abrasion and contact.

Abrasion occurs primarily through direct contact between divers and the seabed, including fin kicks, hand placement, kneeling, and equipment dragging. These actions can disturb surface sediments, resuspend fine particles, and alter sediment structure (Natural England, 2017). Studies consistently show that most recreational divers make some form of contact with the substrate during dives, often multiple times, increasing the likelihood of sediment disturbance (Lin, 2021).

However, while diving and snorkelling can result in accidental damage, this is beyond the scope of the mNLA literature review as impacts of the mNLA activity are being assessed when the activity is carried out correctly and responsibly.

Most recreational diving in estuaries and sheltered bays requires shore access, often via intertidal flats and saltmarsh margins. Trampling from diving and snorkelling activity occurs when divers and snorkellers stand, walk, or push off on the seabed during entry, exit, or manoeuvring. Repeated foot traffic across pioneer zones can crush shoots, compact sediments, and reduce vegetation cover (Glaeser G and Abed-Navandi, 2023; Sumanapala et al., 2023).

Fine sands, muds, and mixed sediments are particularly sensitive because their structure is easily disrupted by mechanical contact (for example fin kicks, hand contact, or equipment drag), shallow penetration associated with divers kneeling or pushing off the seabed, and sediment disturbance resulting in sediment plumes. These disturbances can destabilise the sediment surface, resuspend fine particles, and damage associated biological communities, especially where fragile infauna or surface-dwelling species are present (Collie et al., 2000; Thrush et al., 1995). Coarser sediments such as gravels and cobbles tend to have slightly higher resistance; however, repeated contact can result in the displacement or compaction of gravel and cobble particles (Davis and Tisdell, 1995; Rouphael and Inglis, 2002). These patterns mirror MarLIN's sensitivity assessments (MarLIN, 2026), which emphasise that even habitats with moderate natural mobility can become sensitive when exposed to repeated or chronic disturbance.

Fine cohesive sediments, for example muds, often exhibit low recoverability from abrasion caused by diving as disturbance can alter sediment structure, increase erosion, and remove slow-growing infaunal assemblages. Recovery could take years where hydrodynamic conditions do not rapidly replenish or re-sort the sediment. This is supported by studies showing that soft-sediment communities can take extended periods to return to pre-disturbance conditions following physical impacts, particularly where key species have long generation times or limited dispersal (Dernie et al., 2003). In contrast, non-cohesive sands and mobile sediments may show moderate to high recoverability, as natural sediment transport processes can restore surface

structure relatively quickly, and associated fauna often have rapid recolonisation rates (Newell et al., 1998). However, repeated or chronic disturbance such as frequent diver contact at popular sites can slow recovery by continually resuspending sediments and preventing the re-establishment of stable biological communities (Clemon et al., 2022). As a result, even habitats with moderate natural resilience can become highly sensitive when exposed to sustained recreational pressure.

Marine Evidence-based Sensitivity Assessments (MarESA) (MarLIN, 2026), recognise trampling as a source of surface abrasion and sub-surface penetration in intertidal and shallow subtidal sediments. These pressures are particularly relevant in intertidal areas where there is public access for recreational activity to occur.

Where shore-based access occurs across intertidal mud habitats, trampling could result in abrasion, compaction and sediment disturbance. Intertidal muds have low resistance to these pressures because their stability relies on fine sediment structure and bioturbation. Trampling can compact sediments, reducing pore space and restricting air and water movement, while also causing the collapse of burrows and negatively affecting infaunal communities (Chandrasekara and Frid, 1996; Hsu et al., 2009). Penetration could also occur as footfall can break through the cohesive surface layer, damaging infaunal species, such as *Arenicola marina* and *H. diversicolor*, which are key to sediment turnover and recovery. Recovery is typically low to medium, depending on hydrodynamic conditions and recolonisation rates (Dernie et al., 2003). However, for most recreational shore dives, access is typically via beaches, slipways, rocky shores, shingle, or hard substrates rather than extensive intertidal mudflats although shore-based access can occur across intertidal mud particularly in estuaries, sheltered bays and inlets and lagoons.

Sandy intertidal sediments show moderate sensitivity to trampling (Tillin and Tyler-Walters, 2014). Sands are naturally mobile and therefore more resilient to surface abrasion, but repeated trampling can flatten bedforms, disturb surface infauna, and compact sediments, reducing permeability and altering sediment sorting (Tillin and Tyler-Walters, 2014). Mixed sediments exhibit higher sensitivity due to the presence of fine fractions and more complex faunal communities (Tillin and Tyler-Walters, 2014). Penetrative disturbance can displace sediment particles and damage shallow-burrowing infauna, resulting in changes to sediment structure and community composition (Chandrasekara & Frid, 1996; Hsu et al., 2009).

Coarse intertidal sediments have low sensitivity to trampling-related abrasion due to their physical robustness (Tillin and Tyler-Walters, 2014). However, epifaunal species attached to coarse substrates, such as barnacles, fucoid algae, and small mussels, are vulnerable to crushing and dislodgement (Tillin and Tyler-Walters, 2014). Penetration impacts are generally low because coarse sediments resist compaction, but repeated trampling can still alter surface heterogeneity and reduce habitat complexity.

Trampling in subtidal sediments could occur primarily in very shallow subtidal zones, such as during wading or snorkelling access with similar mechanisms of impact to those in intertidal habitats, though effects are often moderated by water cover.

Soft sediments in shallow subtidal zones are vulnerable to compaction and disturbance from seabed contact, including standing, kneeling, or repeated foot contact during shallow-water activities. Compaction can reduce pore space, alter sediment permeability, and disrupt infaunal communities (Defeo et al., 2009; Schratzberger & Warwick, 1998).

Subtidal macrophyte-dominated sediments are among the most sensitive habitats to these disturbances. They are easily damaged by direct physical contact, with trampling shown to break or uproot rhizomes, reduce canopy height, and impair structure (Nadiarti et al., 2021). Comparable effects have been documented in coral reef systems, where trampling by snorkellers and divers increases bare substrate, reduces live coral cover, and fragments biogenic structures (Hawkins and Roberts, 1993). These findings collectively demonstrate that even brief or unintentional contact can degrade macrophyte-dominated sediments and associated biota.

Impacts will be site dependent and site specific factors such as sediment type, local tidal and wave conditions and frequency of activity could result in increased risk in certain locations.

MMO conclude that diving and snorkelling on intertidal sediments could result in a significant risk of hindering achievement of the conservation objectives of the MPA, dependent on site specific sensitivities and the level of activity within a site. This is because of the impacts of abrasion/disturbance of the substrate on the surface of the seabed, and penetration and/or disturbance of the substratum below the surface of the seabed (including abrasion) caused by trampling, launching and recovery during this activity. However, as trampling, launching and recovery is not within MMO remit, these impacts will not be assessed or managed by MMO.

MMO conclude that diving and snorkelling on intertidal and subtidal sediments is not likely to result in a significant risk of hindering achievement of the conservation objectives of an MPA at any level of activity. This is because the impacts of abrasion/disturbance of the substrate on the surface of the seabed, and penetration and/or disturbance of the substratum below the surface of the seabed (including abrasion) caused by this activity, even at high levels, are unlikely to present a significant risk of hindering achievement of MPA conservation objectives.

5.2 Summary of the effects of diving and snorkelling on peat and clay exposures

Peat and clay exposures in intertidal and shallow subtidal environments are recognised as highly sensitive habitats due to their soft, easily crumbled structure and the presence of piddock communities that weaken the substrate through extensive burrowing. These habitats are easily damaged by even low levels of physical disturbance, with surface abrasion leading to the collapse of burrows, loss of structural integrity, and long-term habitat degradation; (JNCC, 2016).

Pressures caused by diving and snorkelling activity on peat and clay exposures are listed in **Table A1.2**.

While recreational diving on peat and clay exposures is rare, scientific and commercial diving does occur, but typically under controlled conditions due to the high sensitivity of these substrates. Recreational divers typically avoid peat and clay exposures because these substrates offer poor visibility, low structural complexity, and are highly susceptible to disturbance, making them unattractive and impractical for general diving (Edmonds et al., 2016). Fine particles within peat and clay exposures resuspend easily when disturbed by fin movements, rapidly reducing visibility and impairing diver safety and enjoyment (BRIG, 2008). As a result, recreational diving on these substrates is considered unlikely.

In contrast, scientific and archaeological diving does occur on peat and clay exposures where these deposits contain paleoenvironmental, geological, or cultural information. Submerged prehistoric peat beds, submerged forests, and clay exposures containing fossils or archaeological artefacts are frequently investigated by specialist diving teams (Bailey, 2004); (Bailey & Flemming, 2008). These dives are typically highly controlled due to the fragility and scientific value of the deposits.

Peat deposits often contain preserved organic material and archaeological remains, while both peat and clay are structurally weak and prone to erosion when disturbed (Armstrong et al., 2016). Diver contact such as kneeling, finning, or equipment placement can create gouges, pits, and scours that accelerate natural erosion processes (Roche et al., 2016). Studies on diver impacts in soft-sediment environments show that even low-intensity contact can resuspend fine particles, destabilise the substrate, and alter benthic conditions (Rouphael & Inglis, 2002).

Sensitivity assessments consistently classify these habitats as having very low resistance to abrasion because the consolidated peat or clay matrix can be rapidly damaged by even light surface contact (Church et al., 2016). Where piddock species such as *P. dactylus* and *B. candida* are present, the substrate becomes further weakened by extensive boring, increasing susceptibility to shear stress and surface fragmentation (BRIG, 2008).

Unlike biogenic habitats that can regenerate through biological growth, peat and clay exposures form over long geological timescales, and once material is removed, it cannot reform within ecologically meaningful periods (Church et al., 2016). MarLIN sensitivity assessments similarly note that recovery is negligible because erosion removes irreplaceable substrate and may eliminate the stable surfaces required for piddock recolonisation⁸. Where piddock communities are lost, recovery is further constrained by the need for suitable settlement surfaces, which may no longer exist after abrasion. Consequently, even small-scale abrasion from snorkelling or diving can result in long-term or permanent habitat loss.

Abrasion and penetration could occur during shore entry through trampling. Divers may need to walk across exposed or shallow, submerged peat and clay surfaces. The Assessing Welsh Fisheries Activities Project (Welsh Government, 2022) identifies peat and clay exposures as soft, easily penetrated, and structurally fragile, emphasising their limited spatial extent and irreplaceable nature. Their surfaces often contain voids created by piddock activity, which further reduces mechanical resistance and increases susceptibility to collapse under even modest pressure. This fragility means that trampling can rapidly deform, compact, or fragment the substrate. Peat and clay exposures erode easily when subjected to mechanical pressure such as compression or disturbance (Koster et al., 2018) commonly associated with trampling. Research on trampling in soft sediment environments, although not directly peat and clay, demonstrates that even low-intensity human footfall or similar pressure (for example, from divers during shore entry) can produce measurable and often severe physical alterations (Rossi et al., 2007).

MMO conclude that diving and snorkelling on intertidal peat and clay exposures could result in a significant risk of hindering achievement of the conservation objectives of the MPA, dependent on site specific sensitivities and the level of activity within a site. This is because of the impacts of abrasion/disturbance of the substrate on the surface of the seabed, and penetration and/or disturbance of the substratum below the surface of the seabed (including abrasion) caused by trampling, launching and recovery during this activity. However, as trampling, launching and recovery is not within MMO remit, these impacts will not be assessed or managed by MMO.

MMO conclude that diving and snorkelling on peat and clay exposures is not likely to result in a significant risk of hindering achievement of the conservation objectives of an MPA at any level of activity. This is because the impacts of abrasion/disturbance of the substrate on the surface of the seabed, and penetration and/or disturbance of the substratum below the surface of the seabed (including abrasion) caused by this activity, even at high levels, are unlikely to present a significant risk of hindering achievement of MPA conservation objectives.

6 Hovercraft

This section brings together and analyses the available evidence on the impacts of hovercraft on benthic features.

Natural England's Advice on Operations was used to identify potential pressures from hovercraft and to inform the understanding of feature sensitivity to the pressure. Where a sensitivity assessment has not been undertaken or the evidence base is insufficient to assess sensitivity, the activity-pressure-feature combination has been included to capture all possible evidence that could impact the features. **Marine Non-Licensable Activity Impacts Evidence: Methodology**¹ details the process of how MMO judgement refined pressures for assessment.

The following pressures have been included in this review as they have been determined to be pressures commonly induced by hovercraft at a level that has the potential to cause significant impacts on benthic features.

- abrasion/disturbance of the substrate on the surface of the seabed;
- penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion.

The following pressures have not been included in this review as these pressures generally do not occur at a level of concern as a result of hovercraft activity. Should site level factors increase the risk of impacts from hovercraft activity due to the pressures below, these pressures would be considered in an individual site assessment.

- hydrocarbon and PAH contamination;
- introduction of light;
- INIS;
- litter;
- synthetic compound contamination;
- transition elements and organo-metal contamination; and
- underwater noise changes.

6.1 Summary of the effects of hovercraft on subtidal and intertidal sediments

Hovercraft are vehicles that travel on a cushion of air, allowing them to move across water, mud, sand and other coastal surfaces. Because they can operate in very shallow water and across mudflats, they are often used in estuaries and intertidal areas that are inaccessible to conventional boats (Natural England, 2017c). Unlike traditional boats, hovercraft do not normally come into direct contact with the seabed or sediment surface (The Hovercraft Society, 2025).

The literature suggests that hovercraft have a relatively low impact on intertidal sediments compared with other vehicles. However, they have been identified as a potential source of abrasion and disturbance when operating over intertidal and shallow subtidal areas. This disturbance could occur through a combination of skirt contact, air-jet downwash and manoeuvring activities, such as turning, slowing and landing, which can affect the upper sediment layer and associated biota (Brooks, 2014, cited in Natural England, 2017). Their low operating pressure of approximately 50 kgm^{-2} and clearance above the substrate mean that sediment penetration is expected to be minimal, with impacts largely restricted to superficial disturbance of the sediment surface rather than deeper subsurface layers (Brooks, 2010). Natural England (2017) found little evidence that recreational hovercraft cause significant damage to mudflats or sandflats. Nevertheless, some disturbance could occur. Air escaping from the cushion and propulsion system can temporarily disturb loose surface sediments, particularly on exposed mudflats (Natural England, 2017). Fine-grained sediments are especially susceptible to resuspension, whereby sediment particles become suspended in the water column, increasing turbidity (Gray and Elliott, 2009). However, the Environmental Impact of Leisure Hovercraft report argues that these effects are likely to be minor because hovercraft travel above the surface and exert very low pressure on the ground (Brooks, 2010). Unlike conventional boats, they also avoid impacts associated with propeller wash, grounding and wake generation.

The impacts of hovercraft on subtidal sediments also appear to be lower than those associated with conventional motorised watercraft. As hovercraft do not use underwater propellers, they do not create propeller scour, a common source of seabed disturbance in shallow waters (Brooks, 2010). In addition, hovercraft produce very little wake during normal operation, reducing the likelihood of sediment erosion and disturbance to shallow seabed habitats. Although repeated use in sensitive areas could potentially affect sediments through localised turbulence, there is little evidence to suggest that such effects are widespread or long-lasting (Natural England, 2017).

Although hovercraft themselves are considered to have limited impacts on sediments, the launch and recovery phase could result in localised disturbance where vehicles and trailers are used to access the foreshore. This could include trampling of sediments at access points (UK CEED, 2000, cited in Natural England, 2017). However, because recreational hovercraft are typically launched from existing slipways, (Natural England, 2017) suggests that any additional sediment impacts associated with launching activities are likely to be minimal.

Impacts will be site dependent and site specific factors such as sediment type, local tidal and wave conditions and frequency of activity may result in increased risk in certain locations.

MMO conclude that hovercraft on intertidal sediments may result in a significant risk of hindering achievement of the conservation objectives of the

MPA, dependent on site specific sensitivities and the level of activity within a site. This is because of the impacts of abrasion/disturbance of the substrate on the surface of the seabed, and penetration and/or disturbance of the substratum below the surface of the seabed (including abrasion) caused by trampling, launching and recovery during this activity. However, as trampling, launching and recovery is not within MMO remit, these impacts will not be assessed or managed by MMO.

MMO conclude that hovercraft on intertidal and subtidal sediments is not likely to result in a significant risk of hindering achievement of the conservation objectives of an MPA at any level of activity. This is because the impacts of abrasion/disturbance of the substrate on the surface of the seabed and penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion caused by this activity, even at high levels, are unlikely to present a significant risk of hindering achievement of MPA conservation objectives.

6.2 Summary of the effects of hovercraft on peat and clay exposures

There is currently no available literature that directly examines abrasion impacts of hovercraft on peat and clay exposures. However, several sources do document hovercraft operating over soft intertidal sediments, including areas where peat and clay exposures occur, and the sensitivity of peat and clay exposures to surface abrasion from vehicles, vessels, or mechanical disturbance (Amyot, 1989; Natural England, 2017) Although these sources do not discuss peat and clay specifically, they do demonstrate that hovercraft activity overlaps with the types of soft, cohesive sediment environments in which peat and clay exposures are commonly found.

As discussed in **Section 6.1**, hovercraft can exert surface abrasion through a combination of skirt contact, air-jet downwash and manoeuvring (turning, slowing, landing), which can disturb the upper sediment layer and associated biota (Brooks, 2014 as cited in Natural England, 2017).

A Natural England commissioned report (Natural England, 2024) describes peat and clay exposures as fragile, easily eroded, and sensitive to physical disturbance, with even light mechanical contact capable of removing material. Peat and clay substrates are described as easily scoured and prone to long-term erosion once disturbed (BRIG, 2008). These findings apply to any activity that causes surface shear, downwash, or scraping, including hovercraft skirts and air-jet turbulence. Importantly, peat exposures are an irreplaceable resource. Any material lost through erosion or disturbance cannot be replaced, meaning that even relatively minor damage could result in a permanent loss of valuable habitat.

Impacts will be site dependent and site specific factors such as sediment type, local tidal and wave conditions and frequency of activity could result in increased risk in certain locations.

MMO conclude that hovercraft activity on peat and clay exposures is likely to result in a significant risk of hindering achievement of the conservation objectives of the MPA at any level of activity. This is because the impacts of abrasion/disturbance of the substrate on the surface of the seabed and penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion caused by this activity caused by this activity even at low levels are likely to present a significant risk of hindering achievement of the site's conservation objectives.

7 Motorised personal watercraft

This section brings together and analyses the available evidence on the impacts of motorised personal watercraft (MPW) activity on benthic features.

Natural England's Advice on Operations was used to identify potential pressures from motorised personal watercraft and to inform the understanding of feature sensitivity to the pressure. Where a sensitivity assessment has not been undertaken or the evidence base is insufficient to assess sensitivity, the activity-pressure-feature combination has been included to capture all possible evidence that could impact the features. **Marine Non-Licensable Activity Impacts Evidence: Methodology**¹ details the process of how MMO judgement refined pressures for assessment.

The following pressures have been included in this review as they have been determined to be pressures commonly induced by motorised personal watercraft at a level that has the potential to cause significant impacts on benthic features.

- abrasion/disturbance of the substrate on the surface of the seabed;
- penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion.

The following pressures have not been included in this review as these pressures generally do not occur at a level of concern as a result of MPW activity. Should site level factors increase the risk of impacts from MPW activity due to the pressures below, these pressures would be considered in an individual site assessment.

- hydrocarbon and PAH contamination;
- introduction of light;
- INIS;
- litter;
- synthetic compound contamination;
- transition elements and organo-metal contamination;
- underwater noise changes.

Pressures caused by MPW activity by any vessels on subtidal and intertidal sediments are listed in **Table A1.2**.

7.1 Summary of the effects of motorised personal watercraft on subtidal and intertidal sediments

The ability of subtidal and intertidal sediments to resist and recover from the impacts of MPW activity will depend on several factors, including the sediment type, presence of particularly sensitive biotopes and levels of MPW activity.

MPWs, including jet skis and hydroflying activities such as flyboarding and jetpacking, are increasingly used in coastal and estuarine environments and are

recognised as a source of physical disturbance to sedimentary habitats. Although MPWs rarely make direct contact with the seabed, their operation in shallow waters can generate abrasion (surface disturbance) and penetration (sub-surface disturbance) through jet thrust, propeller wash, hull scour, wake action, and repeated launching and landing. These mechanisms can disturb sediment structure, resuspend fine particles, and damage benthic communities across a range of intertidal and subtidal sediment types (Ailstock et al., n.d.; Bishop, 2004). The downward water jets used to generate lift during hydroflying can also disturb the seabed and resuspend fine sediments, particularly in shallow areas (Guarnieri et al., 2021).

Intertidal coarse sediments (gravels, cobbles) and mixed sediments exhibit moderate resistance to physical disturbance, but MPW activity can still cause displacement of surface particles, compaction, and disruption of biogenic structures. Jet thrust in shallow water can mobilise coarse grains, while repeated launching and manoeuvring can abrade the sediment surface (Newell et al., 1998). Coarse subtidal sediments are generally more resilient, but MPW wake and thrust can still mobilise surface particles in shallow areas. Disturbance can damage epifaunal communities and displace shell hash or gravel layers that provide habitat complexity (Jennings & Kaiser, 1998).

Intertidal and subtidal mixed sediments, which often contain fine fractions, are particularly vulnerable to resuspension and increased turbidity (Collie et al., 2000). Mixed sediments are sensitive to repeated disturbance because jet thrust can resuspend fine fractions and alter sediment heterogeneity. Collie et al (2000) also describe how changes in grain size distribution can affect infaunal community structure and reduce biodiversity.

Intertidal muds are among the most sensitive habitats to disturbance from MPW. Their cohesive, fine-grained structure is easily eroded by wake waves and thrust-generated shear, which can remove surface layers, destabilise the substrate, and accelerate erosion rates (Safak et al., 2021). MarLIN identifies abrasion resulting in disturbance of the seabed surface as a key pressure affecting mud habitats, with potential to damage or remove surface-dwelling and shallow-burrowing fauna and alter habitat structure through physical disturbance (Moyse et al., 2026). Penetration effects could occur where high-velocity jets excavate shallow depressions or disturb burrow systems. MPW-induced resuspension increases turbidity, reduces light penetration, and can smother filter feeders (Newell et al., 1998). Disturbance could also disrupt bioturbation processes and oxygen penetration into sediments (Bolam, 2011).

Sands and muddy sands in subtidal and intertidal zones are more mobile and could recover more quickly from disturbance, but MPWs can still cause significant short-term impacts. Jet thrust can resuspend sediments, increase turbidity, and disrupt feeding and respiration in suspension feeders (Thrush et al., 1995).

Repeated disturbance can prevent natural sediment sorting and reduce habitat stability (Dernie et al., 2003).

Sheltered muddy gravels combine coarse particles with fine cohesive sediments, making them vulnerable to both abrasion and penetration. Disturbance from MPWs can alter sediment structure and reduce habitat suitability for infaunal communities. Sediment deposition and burial may impair the survival and recovery of benthic macrofauna, with responses varying according to sediment characteristics and species traits (Bolam, 2011). These habitats often occur in estuaries which are areas heavily used by MPWs due to sheltered conditions (Ailstock et al., 2002).

Macrophyte-dominated sediments are particularly vulnerable to MPW disturbance. Jet thrust can uproot plants, abrade leaves, and increase turbidity, reducing light availability (Short & Wyllie-Echeverria, 1996). Damage to macrophytes also destabilises sediments, increasing susceptibility to erosion and reducing habitat quality for associated fauna.

MMO conclude that MPW on intertidal sediments could result in a significant risk of hindering achievement of the conservation objectives of the MPA, dependent on site specific sensitivities and the level of activity within a site. This is because of the impacts of abrasion/disturbance of the substrate on the surface of the seabed, and penetration and/or disturbance of the substratum below the surface of the seabed (including abrasion) caused by trampling, launching and recovery during this activity. However, as trampling, launching and recovery is not within MMO remit, these impacts will not be assessed or managed by MMO.

MMO conclude that MPW on subtidal and intertidal sediments could result in a significant risk of hindering achievement of the conservation objectives of the MPA, dependent on site specific sensitivities and the level of activity within a site. This is because of the impacts of abrasion/disturbance of the substrate on the surface of the seabed and penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion caused by this activity. A site level assessment will determine whether the activity is hindering the achievement of MPA conservation objectives.

7.2 Summary of the effects of motorised personal watercraft on peat and clay exposures

Peat and clay exposures are highly specialised intertidal habitats typically found in sheltered estuaries, embayment's, and soft-sediment coastal margins. These habitats are characterised by very shallow water depths, irregular topography, and soft, unstable substrates that are frequently exposed at low tide (Church et al., 2016). Their physical structure is often weakened by piddock burrows and natural erosion, making them particularly fragile and susceptible to damage from physical disturbance. In addition, the shallow water depths and irregular topography

associated with these habitats can make them unsuitable for activities requiring safe navigation or stable operating conditions. As a result, the likelihood of MPW - such as jet skis operating over these habitats is extremely low.

Recreational studies show that MPW are used in open, deeper waters, where users can manoeuvre safely and maintain speed (Burger, 2003). MPW require sufficient depth to avoid hull or jet-intake contact, and operators typically avoid shallow, obstacle-rich environments due to the risk of grounding, loss of control, or equipment damage (Bishop, 2004). Intertidal peat and clay exposures, by contrast, occur in areas where water depth at high tide is often only a few centimetres to tens of centimetres, below the safe operational threshold for MPW.

Peat and clay substrates are unstable which also makes them unsuitable for launching or landing MPW, which typically require firm surfaces or slipways (Pye and French, 1993). The combination of shallow depth, substrate instability and exposure at low tide creates a barrier to MPWC use. Therefore, MPW activity is not considered likely to result in abrasion and penetration of peat and clay exposures.

Impacts will be site dependent and site specific factors such as sediment type, local tidal and wave conditions and frequency of activity could result in increased risk in certain locations.

MMO conclude that motorised personalised watercraft activity on peat and clay exposures is not likely to result in a significant risk of hindering achievement of the conservation objectives of an MPA at any level of activity. This is because the impacts of abrasion/disturbance of the substrate on the surface of the seabed and penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion caused by this activity, even at high levels, are unlikely to present a significant risk of hindering achievement of MPA conservation objectives.

8 Motorised watercraft

This section brings together and analyses the available evidence on the impacts of motorised watercraft activity on benthic features.

Natural England's Advice on Operations was used to identify potential pressures from motorised watercraft and to inform the understanding of feature sensitivity to the pressure. Where a sensitivity assessment has not been undertaken or the evidence base is insufficient to assess sensitivity, the activity-pressure-feature combination has been included to capture all possible evidence that could impact the features **Marine Non-Licensable Activity Impacts Evidence: Methodology**¹ details the process of how MMO judgement refined pressures for assessment.

The following pressures have been included in this review as they have been determined to be pressures commonly induced by motorised watercraft at a level that has the potential to cause significant impacts on benthic features.

- abrasion/disturbance of the substrate on the surface of the seabed;
- penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion;
- physical change (to another sediment type).

The following pressures have not been included in this review as these pressures generally do not occur at a level of concern as a result of motorised watercraft activity. Should site level factors increase the risk of impacts from motorised watercraft activity due to the pressures below, these pressures would be considered in an individual site assessment.

- hydrocarbon and PAH contamination;
- introduction of light;
- INIS;
- litter;
- synthetic compound contamination;
- transition elements and organo-metal contamination
- underwater noise changes.

Pressures caused by motorised watercraft activity by any vessels on subtidal sediments are listed in **Table A1.2**.

8.1 Summary of the effects of motorised watercraft on subtidal and intertidal sediments

Sensitivity of subtidal and intertidal sediments to motorised watercraft will depend on several factors, including the sediment type, presence of particularly sensitive biotopes and levels of motorised watercraft activity.

Use of motorised watercraft can be a source of surface abrasion and disturbance in shallow coastal waters. In intertidal and shallow subtidal zones, abrasion pressure arises from the grounding and hull contact on shallow flats, propeller wash and jet thrust mobilising surface sediments, and repeated use of access routes and channels in confined estuaries.

These processes disturb the upper sediment layer, damage epifauna and shallow infauna, and can alter sediment structure and stability (Kennish, 2002). Sensitivity to abrasion and penetration varies strongly with sediment type and biological community. Natural England identifies surface abrasion and sediment scour as key pressures associated with MPW use on intertidal mudflats and low-energy shores, with repeated use of shallow routes and informal access points leading to localised habitat degradation (Natural England, 2017). This would also be relevant to other motorised watercraft.

Intertidal sands are generally more physically resilient than cohesive sediments but could still be disturbed by repeated abrasion from hull contact and propeller wash. Disturbance of surface sediments can resuspend material, increase turbidity and affect benthic communities (Kennish, 2002). Mixed sediments containing sand, mud and gravel may be more sensitive because physical disturbance can displace coarser particles while compacting finer sediments and affecting associated epifauna and infauna. Sensitivity and recovery are site and biotope specific, but mobile sandy habitats typically exhibit relatively high resilience where natural tidal and wave processes promote sediment reworking and recolonisation, whereas mixed sediments could show lower resilience depending on their faunal communities and sediment characteristics (Tillin and Tyler-Walters, 2014).

Coarse intertidal sediments (gravel, pebble, cobble) are physically robust; abrasion from hulls mainly causes displacement of surface material and damage to epifaunal assemblages. These habitats are typically assessed as having high resilience and quick recovery, with low to medium sensitivity to surface abrasion (Tillin and Tyler-Walters, 2014).

In shallow subtidal muds, propeller wash, jet thrust and hull turbulence can resuspend fine sediments, erode the bed surface and damage infaunal communities. Workshop findings on motorised boats in shallow systems highlight that propeller-induced sediment resuspension has consequences for turbidity, benthic habitats and biota (Kennish, 2002). Subtidal muds generally have low resistance and low resilience to surface abrasion and disturbance, particularly where long-lived infauna and bioturbators structure the habitat (Tillin and Tyler-Walters, 2014). Sensitivity is therefore high, and repeated disturbance can shift communities towards more opportunistic, disturbance-tolerant species.

Subtidal sands are naturally mobile and generally more resilient to abrasion. Motorised craft can still cause local scour beneath propellers and jets, disturbance of bedforms and surface infauna and increased turbidity in confined or shallow areas.

However, physical structure often recovers quickly where hydrodynamic energy is high. Tillin and Tyler-Walters (2014) state medium to high resilience of subtidal sands, resulting in low to medium sensitivity to surface abrasion.

Subtidal mixed sediments exhibit moderate sensitivity to abrasion: disturbance can disrupt surficial layers and epifaunal communities, particularly where fine fractions dominate, yet physical recovery is often relatively rapid due to natural sediment mobility and the presence of resilient or fast-recruiting species (Tillin and Tyler-Walters, 2014). Tillin and Tyler-Walters (2014) also suggest coarse sediments are relatively robust, with high resilience, and sensitivity to surface abrasion from motorised craft is generally considered low.

Motorised watercraft use can lead to trampling when passengers disembark into shallow water. This is the same as a result of the use of MPW when riders enter or exit the craft in shallow water.

Repeated use of access points can lead to cumulative trampling and sediment compaction, resulting in reduced habitat quality and changes to infaunal communities (Hsu et al., 2009). Motorised watercraft are often launched from trailers, although they may also be carried short distances where access is restricted. Launching from formal or purpose-built access points generally poses little risk to marine habitats, except in cases where trampling or surface scouring occurs. However, if these facilities attract heavy use, the conservation value of the area may still be compromised (Natural England, 2017). In contrast, launching from informal or unconstructed access points can lead to sediment compaction, erosion, and damage to shoreline vegetation (UK CEED, 2000).

Motorised watercraft have the potential to alter the physical characteristics of intertidal and subtidal sediments through propeller wash, jet thrust, hull turbulence, wake action, and beaching. These processes can change sediment grain size, erode cohesive substrates, and shift habitats from one sediment type to another (for example, mud to sand; sand to mixed sediments) (Tillin and Tyler-Walters, 2014)

Propeller wash generates high-velocity jets that can erode fine sediments, remove cohesive mud layers and expose underlying sands or gravels (Kennish, 2002). In shallow water, propeller jets can penetrate the seabed by several centimetres, causing mud to sand transitions where fine particles are removed (Ahmed et al., 2026). The formation of scour pits can change local hydrodynamics and expose underlying coarser sediment layers. These processes are well documented in estuarine and lagoon environments where motorised vessels operate in close proximity to the seabed (Kennish, 2002; Natural England & Marine Management Organisation, 2017).

When waves or boat wakes pass over the bottom, the water close to the seabed pushes and drags against it. This dragging force can lift and move sediment, especially finer particles like mud, mobilising fine sediments and promoting erosion

of muds and muddy sands (Scotland's Marine Assessment, 2020). Boat wakes can resuspend sediments and increase turbidity; where repeated or prolonged, this could result in short-term disturbance to benthic communities in shallow, low-energy environments (Safak et al., 2021; Watson et al., 2022). Repeated exposure to vessel wakes can generate increased stresses that flatten existing bedforms, selectively erode fine surface mud layers, and increase sand content, ultimately driving transitions from muddier to sandier or mixed-sediment habitats (Kibler et al., 2022). Grounding of motorboats on intertidal flats can also cause direct abrasion, removing surface layers and compacting sediments (Natural England, 2017).

Impacts will be site dependent and site specific factors such as sediment type, local tidal and wave conditions and frequency of activity could result in increased risk in certain locations.

MMO concludes that operating motorised watercraft on intertidal and subtidal sediments is likely to result in a significant risk of hindering achievement of the conservation objectives of the MPA at any level of activity. This is because the impacts of abrasion/disturbance of the substrate on the surface of the seabed, and penetration and/or disturbance of the substratum below the surface of the seabed (including abrasion), caused by this activity even at low levels are likely to present a significant risk of hindering achievement of the site's conservation objectives.

MMO conclude that motorised watercraft on intertidal sediments may result in a significant risk of hindering achievement of the conservation objectives of the MPA, dependent on site specific sensitivities and the level of activity within a site. This is because of the impacts of abrasion/disturbance of the substrate on the surface of the seabed, and penetration and/or disturbance of the substratum below the surface of the seabed (including abrasion) caused by trampling, launching and recovery during this activity. However, as trampling, launching and recovery is not within MMO remit, these impacts will not be assessed or managed by MMO.

8.2 Summary of the effects of motorised watercraft on peat and clay exposures

Although no studies have directly examined abrasion from motorised watercraft on peat and clay exposures, the mechanisms associated with vessel operation such as propeller wash, hull turbulence, wake scour and beaching are well documented as sources of surface abrasion on soft cohesive sediments (Kennish, 2002; Natural England, 2017). These forces are similar to those known to damage peat and clay substrates when generated by other activities, including fishing gear and vehicle traffic, which can remove fine material, destabilise the substrate and expose underlying layers (NRW, 2020). Given that motorised watercraft routinely operate in subtidal, estuarine and coastal environments where sublittoral peat and clay

exposures occur, there is a risk of surface abrasion leading to habitat degradation or loss.

In shallower littoral peat and clay habitats the risk is lower as motorised watercraft use is less likely. Access-related trampling is also considered unlikely because peat and clay exposures are generally unsuitable for launching or recovering vessels due to their soft, unstable nature. As such, both vessel use and access across these habitats are expected to be limited.

Peat and clay exposures have very low resistance to such disturbance, with surface layers easily eroded and biogenic structures (for example, piddock burrows) highly susceptible to damage (BRIG, 2008). Once disturbed, these habitats exhibit low resilience, as erosion can accelerate and recovery is slow or may not occur without sediment deposition (Tillin and Tyler-Walters, 2014). In addition, peat and clay exposures are effectively irreplaceable within management timescales, as their formation occurs over long geological and ecological timescales and lost habitat cannot readily be recreated.

Impacts will be site dependent and site specific factors such as sediment type, local tidal and wave conditions and frequency of activity could result in increased risk in certain locations.

MMO conclude that motorised watercraft activity on peat and clay exposures is likely to result in a significant risk of hindering achievement of the conservation objectives of the MPA at any level of activity. This is because the impacts of abrasion/disturbance of the substrate on the surface of the seabed and penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion caused by this activity even at low levels are likely to present a significant risk of hindering achievement of the site's conservation objectives.

9 Sailing

This section brings together and analyses the available evidence on the impacts of sailing activity on benthic features.

Natural England's Advice on Operations was used to identify potential pressures from non-motorised sailing and to inform the understanding of feature sensitivity to the pressure. Where a sensitivity assessment has not been undertaken or the evidence base is insufficient to assess sensitivity, the activity-pressure-feature combination has been included to capture all possible evidence that could impact the features. **Marine Non-Licensable Activity Impacts Evidence: Methodology**¹ details the process of how MMO judgement refined pressures for assessment.

The following pressures have been included in this review as they have been determined to be pressures commonly induced by non-motorised sailing at a level that has the potential to cause significant impacts on benthic features.

- abrasion/disturbance of the substrate on the surface of the seabed;
- penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion.

The following pressures have not been included in this review as these pressures generally do not occur at a level of concern as a result of non-motorised sailing activity. Should site level factors increase the risk of impacts from sailing activity due to the pressures below, these pressures would be considered in an individual site assessment.

- hydrocarbon and PAH contamination;
- introduction of light;
- INIS;
- litter;
- synthetic compound contamination;
- transition elements and organo-metal contamination.

9.1 Summary of the effects of non-motorised sailing on subtidal and intertidal sediments

Pressures caused by sailing activity on subtidal and intertidal sediments are listed in **Table A1.2**.

Sensitivity of subtidal and intertidal sediments to sailing will depend on several factors, including the sediment type, presence of particularly sensitive biotopes and levels of sailing activity.

Most sailing vessel activity occurs in relatively sheltered areas. Vessels are typically launched from slipways or sheltered beaches using trailers or trolleys. Activity is

commonly concentrated around sailing clubs, activity centres, harbours and marinas (Natural England and MMO EIN028, 2017).

Sailing vessels operate in coastal and estuarine environments and are recognised as a source of physical disturbance to sedimentary habitats. Although sailing vessels rarely make direct contact with the seabed, sailing activity could result in abrasion of benthic habitats primarily through grounding and low-level seabed contact by keels (beaching), rudders or centreboards in shallow water. Indirect disturbance could also occur through wake-generated hydrodynamic forces that resuspend sediment in sheltered, shallow environments (Davis et al., 2025; Griffiths et al., 2017; Kibler et al., 2022). These disturbances are comparable to those caused by motorised vessels; including effects from sailing vessel thrust, hull scour, wake action, and repeated launching and landing (Kibler et al., 2022). However, as sailing vessels are generally smaller in size and less powerful the magnitude of these impacts is likely to be lower than those from motorised vessels.

Dinghy and small sailboat activity could result in abrasion of benthic habitats through repeated low-level seabed contact, particularly where vessels operate in shallow waters or at low tide (Davis et al., 2025; Griffiths et al., 2017).

There is limited published literature relating specifically to the impact of sailing activity on benthic habitats (with the exception of anchoring which is assessed in **Section 4.1**).

Impacts will be site dependent and site specific factors such as sediment type, local tidal and wave conditions and frequency of activity could result in increased risk in certain locations.

MMO conclude that non-motorised sailing on intertidal sediments could result in a significant risk of hindering achievement of the conservation objectives of the MPA, dependent on site specific sensitivities and the level of activity within a site. This is because of the impacts of abrasion/disturbance of the substrate on the surface of the seabed, and penetration and/or disturbance of the substratum below the surface of the seabed (including abrasion) caused by trampling, launching and recovery during this activity. However, as trampling, launching and recovery is not within MMO remit, these impacts will not be assessed or managed by MMO.

MMO conclude that non-motorised sailing activity on intertidal and subtidal sediments could result in a significant risk of hindering achievement of the conservation objectives of the MPA, dependent on site specific sensitivities and the level of activity within a site. This is because of the impacts of abrasion/disturbance of the substrate on the surface of the seabed and penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion caused by this activity. A site level assessment will determine whether the activity is hindering the achievement of MPA conservation objectives.

9.2 Summary of the effects of non-motorised sailing on peat and clay exposures

Peat and clay exposures typically occur in very shallow, sheltered environments with soft, unstable substrates that are frequently exposed at low tide. These conditions make them unsuitable for navigation, launching, or landing of sailing vessels, which generally require greater water depths and firmer substrates (Kazemian et al., 2011). Therefore, sailing activity is not considered likely to result in abrasion or penetration of peat and clay exposures.

Impacts will be site dependent and site specific factors such as sediment type, local tidal and wave conditions and frequency of activity could result in increased risk in certain locations.

MMO conclude that non-motorised sailing activity on peat and clay exposures is not likely to result in a significant risk of hindering achievement of the conservation objectives of an MPA at any level of activity. This is because the impacts of abrasion/disturbance of the substrate on the surface of the seabed and penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion caused by this activity, even at high levels, are unlikely to present a significant risk of hindering achievement of MPA conservation objectives.

10 Non-motorised watercraft

This section brings together and analyses the available evidence on the impacts of non-motorised watercraft activity on benthic features.

Natural England's Advice on Operations was used to identify potential pressures from non-motorised watercraft and to inform the understanding of feature sensitivity to the pressure. Where a sensitivity assessment has not been undertaken or the evidence base is insufficient to assess sensitivity, the activity-pressure-feature combination has been included to capture all possible evidence that could impact the features. **Marine Non-Licensable Activity Impacts Evidence: Methodology**¹ details the process of how MMO judgement refined pressures for assessment.

The following pressures have been included in this review as they have been determined to be pressures commonly induced by non-motorised watercraft at a level that has the potential to cause significant impacts on benthic features.

- abrasion/disturbance of the substrate on the surface of the seabed;
- penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion.

The following pressures have not been included in this review as these pressures generally do not occur at a level of concern as a result of non-motorised watercraft activity. Should site level factors increase the risk of impacts from non-motorised watercraft activity due to the pressures below, these pressures would be considered in an individual site assessment.

- hydrocarbon and PAH contamination;
- introduction of light;
- INIS;
- litter;
- synthetic compound contamination;
- transition elements and organo-metal contamination;
- underwater noise changes.

Where there are differences between the features or the potential impacts of different pressures within this group, this has been highlighted. Pressures caused by non-motorised watercraft activity on subtidal and intertidal sediments are listed in **Table A1.2**.

10.1 Summary of the effects of non-motorised watercraft on intertidal sediments

Non-motorised watercraft encompass a wide range of recreational activities, including paddleboarding, kayaking, canoeing, surfing, windsurfing, kitesurfing. Although these activities are often perceived as low-impact due to their lack of

engines, literature shows that they can cause abrasion and penetration of benthic habitats.

A comprehensive review by Brooker et al (2024) identifies equipment-related contact as a cause of physical disturbance, across multiple craft types. Boards, hulls, fins, rudders, centreboards, daggerboards, hydrofoils, and paddles can all contact the seabed in shallow water, causing scraping, gouging, or planing of sediments, algal mats, and biogenic structures. These impacts occur during manoeuvring, grounding, capsizing, launching or when participants intentionally skim over shallow flats.

Another mechanism for abrasion caused by non-motorised watercraft is hydrodynamic disturbance. Even without direct contact, the movement of hulls and boards through shallow water generates pressure waves, turbulence and wake energy, capable of mobilising fine sediments. Brooker et al (2024) report that high speed wind-powered craft such as kitesurfers and windsurfers can produce sufficient turbulence to resuspend surface sediments, indirectly abrading benthic organisms such as microphytobenthos, seagrass epiphytes, and early-successional algal films. Although paddleboards, kayaks, and canoes generate smaller wakes, studies of non-motorised craft in estuarine systems show that even low-energy displacement can disturb unconsolidated sediments, contributing to surface scouring and increased turbidity in shallow habitats. These hydrodynamic effects are particularly relevant in sheltered bays and estuaries where water depth is limited, and sediment cohesion is low.

Intertidal muds are among the most sensitive habitats to surface abrasion due to their fine grain size, high water content, and cohesive structure. Natural England identifies mudflats as particularly vulnerable to abrasion from non-motorised watercraft, noting that repeated launching can cause surface scouring, compaction, and erosion (Natural England, 2017). MarESA assessments generally identify intertidal mud biotopes as having low resistance to surface abrasion, with resilience ranging from low to medium depending on the biological community present. As a result, many mud biotopes exhibit moderate to high sensitivity to abrasion pressures. Recovery may be relatively slow because mudflats rely on bioturbating fauna, including the lugworm (*Arenicola marina*) and ragworm (*Hediste diversicolor*), to restore sediment structure and ecological functioning. Recolonisation and recovery can take months to years depending on the intensity, frequency and spatial extent of disturbance. Intertidal sands are less cohesive and therefore more physically resilient to abrasion¹⁵. Dragging of kayaks or other small craft across sandy habitats may disturb the upper sediment layer, displace surface-dwelling fauna and locally

¹⁵ Budd, G.C., Ashley, M., Lloyd, K.A., Watson, A.J., and Maleed, M., 2025. *Hediste diversicolor* in littoral mud. In Tyler-Walters H. Marine Life Information Network: Biology and Sensitivity Key Information Reviews, Plymouth. Available from: <https://www.marlin.ac.uk/habitat/detail/1135>

alter sediment structure (Natural England, 2017). Where launching and landing activities are concentrated, repeated abrasion can result in localised disturbance. However, MarESA assessments generally indicate medium resistance and medium to high resilience to abrasion for many sandy sediment biotopes, supporting their capacity for relatively rapid recovery through sediment reworking and recolonisation by opportunistic species¹⁶.

Mixed sediments (sand, mud and gravel) exhibit sensitivities of both fine and coarse sediment habitats. Abrasion can displace gravel and cobbles, disturb finer sediment fractions, and damage surface-dwelling epifauna and shallow infauna. Sensitivity is highly dependent on sediment composition and the biological communities present, particularly where biogenic structures contribute to habitat complexity. MarESA assessments generally indicate low to moderate sensitivity to abrasion, with resistance and recovery varying between biotopes. Recovery following disturbance may be slower where communities contain longer-lived species or structurally complex assemblages. (Dernie et al., 2003; Tillin and Tyler-Walters, 2014).

Coarse sediments are physically robust and abrasion from non-motorised watercraft generally causes limited structural damage. However, displacement of stones can destroy microhabitats used by amphipods, small polychaetes, and juvenile fish. MarESA assessments describe medium resistance and high resilience for coarse sediment biotopes to abrasion (Tillin and Tyler-Walters, 2014)

Activity from non-motorised watercraft could also result in trampling pressure on benthic habitats. Access to water from land can cause increased pressure from abrasion on the intertidal and shallow subtidal areas. During the use of non-motorised watercraft, trampling arises mainly during launching and landing, where users step onto intertidal sediments, often repeatedly in the same locations. Natural England notes that non-motorised craft users frequently wade in shallow water, causing footfall on mudflats, sandflats, and saltmarsh edges (Natural England, 2017). Impacts of trampling on intertidal sediments are covered in **Section 5**.

Impacts will be site dependent and site specific factors such as sediment type, local tidal and wave conditions and frequency of activity could result in increased risk in certain locations.

MMO conclude that non-motorised watercraft on intertidal sediments could result in a significant risk of hindering achievement of the conservation objectives of the MPA, dependent on site specific sensitivities and the level of activity within a site. This is because of the impacts of abrasion/disturbance of

¹⁶ Tyler-Walters, H., Tillin, H.M., d'Avack, E.A.S., Perry, F. and Stamp, T. (2023) Marine Evidence-based Sensitivity Assessment (MarESA) Guidance Manual. Plymouth: Marine Life Information Network (MarLIN), Marine Biological Association of the UK. Available at: <https://www.marlin.ac.uk/publications>

the substrate on the surface of the seabed, and penetration and/or disturbance of the substratum below the surface of the seabed (including abrasion) caused by trampling, launching and recovery during this activity. However, as trampling, launching and recovery is not within MMO remit, these impacts will not be assessed or managed by MMO.

MMO conclude that non-motorised watercraft on subtidal and intertidal sediments could result in a significant risk of hindering achievement of the conservation objectives of the MPA, dependent on site specific sensitivities and the level of activity within a site. This is because of the impacts of abrasion/disturbance of the substrate on the surface of the seabed and penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion caused by this activity. A site level assessment will determine whether the activity is hindering the achievement of MPA conservation objectives.

10.2 Summary of the effects of non-motorised watercraft on peat and clay exposures

As described in **Section 4.2**, peat and clay exposures are recognised as highly sensitive intertidal and shallow-subtidal habitats. MarESA sensitivity assessments similarly classify peat and clay exposures as highly susceptible to surface disturbance, with recovery potential considered low because substrate erosion cannot be reversed once material is lost.

There is no literature that examines the effects of non-motorised watercraft specifically on peat and clay exposures. However, intertidal peat and clay exposures are frequently exposed at low tide and are still shallow at high tide. Such physical conditions make them unsuitable for recreational activities requiring stable, navigable water surfaces. Studies of non-motorised watercraft use show that activities such as kayaking, canoeing and paddleboarding typically occur in navigable channels, lagoons and open coastal waters, where users can maintain buoyancy and manoeuvrability (Natural England, 2017). These activities require a minimum water depth to avoid grounding, and participants generally avoid shallow, muddy or vegetated intertidal flats because they pose safety risks and limit movement. As with motorised craft, the physical constraints of peat and clay exposures such as shallow water, soft substrate, and exposure at low tide act as barriers to prevent non-motorised watercraft use (Natural England, 2017). The shallow water depths over intertidal peat and clay exposures - often only a few centimetres even at high tide - pose a significant risk of board grounding and falls, discouraging recreational use.

However, non-motorised watercraft can also occur in shallow estuarine and nearshore environments where peat and clay exposures could be present locally (Natural England, 2017). In such areas, particularly during launching, landing or

wading activities, hulls, paddles and feet could occasionally come into contact with the seabed, creating a potential pathway for abrasion where these habitats are accessible (Natural England, 2017)

Given the extreme fragility and irreplaceability of peat and clay exposures, the same levels of abrasion that might be considered minor on sand or gravel can be significant in these habitats. Even light contact from hulls or paddles in shallow subtidal areas has the potential to chip, flake or shear the exposed peat or clay surface, damaging piddock galleries and creating fresh faces that are more easily eroded by currents and waves (BRIG, 2008; Natural Resources Wales, n.d.)

Reviewing literature on non-motorised watercraft show it as a source of low-intensity but potentially significant abrasion pressure on subtidal peat and clay exposures where spatial overlap occurs, due to the combination of high habitat sensitivity and the demonstrated ability of these craft to disturb soft cohesive sediments⁸ (Natural England, 2017)

Impacts will be site dependent and site specific factors such as sediment type, local tidal and wave conditions and frequency of activity could result in increased risk in certain locations.

MMO conclude that non-motorised watercraft on intertidal peat and clay exposures could result in a significant risk of hindering achievement of the conservation objectives of the MPA, dependent on site specific sensitivities and the level of activity within a site. This is because of the impacts of abrasion/disturbance of the substrate on the surface of the seabed, and penetration and/or disturbance of the substratum below the surface of the seabed (including abrasion) caused by trampling, launching and recovery during this activity. However, as trampling, launching and recovery is not within MMO remit, these impacts will not be assessed or managed by MMO.

MMO conclude that non-motorised watercraft activity on peat and clay exposures could result in a significant risk of hindering achievement of the conservation objectives of the MPA, dependent on site specific sensitivities and the level of activity within a site. This is because of the impacts of abrasion/disturbance of the substrate on the surface of the seabed and penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion caused by this activity. A site level assessment will determine whether the activity is hindering the achievement of MPA conservation objectives.

11 Conclusion

This literature review has collated the best available evidence on the interactions between mNLA and benthic features within MPAs. The evidence demonstrates that mNLA can generate a range of physical pressures on the seabed sediment habitats, most notably abrasion, penetration and disturbance of the substratum, and, in certain circumstances, physical change of sediment type. The likelihood and severity of impacts vary considerably according to the nature of the activity, its intensity and frequency, the sensitivity and recoverability of the benthic sediment feature affected and any management already in place.

Activities that involve direct or repeated interaction with the seabed, including anchoring and motorised watercraft, present the greatest potential risk to benthic habitats where spatial overlap occurs. More mobile sediment habitats, such as sands, typically exhibit a higher degree of resistance and resilience to low-level disturbance, particularly in naturally dynamic environments. In contrast, cohesive muds, mixed sediments, macrophyte-dominated sediments and intertidal habitats often show lower resistance and slower recovery, rendering them more vulnerable to repeated or chronic pressure.

The evidence consistently identifies peat and clay exposures as being among the most sensitive benthic features. These habitats are irreplaceable on ecological timescales, and even limited physical damage could result in permanent habitat loss.

While the evidence indicates that low-intensity or infrequent mNLA is often unlikely to result in significant adverse effects, particularly where features have capacity to recover, the potential for cumulative impacts is evident. Repeated disturbance, even from activities generally considered low impact, can inhibit recovery and alter benthic community structure, especially in sheltered systems or where natural disturbance regimes are low. Site specific assessments will consider levels of activity, the habitats present, and any existing management, and appropriate management will be implemented accordingly.

References

- Ahmed, A., Zhang, X., & Zhang, H. (2026). Propeller-Induced Seabed Scour: A Review of Hydrodynamic Mechanisms, CFD Modeling, and Coastal Engineering Implications. *Open Journal of Marine Science*, 16(01), 39–56.
<https://doi.org/10.4236/ojms.2026.161003>
- Ailstock, M. S., Hornor, S. G., Norman, C. M., & Davids, E. M. (n.d.). *Resuspension of Sediments by Watercraft Operated in Shallow Water Habitats of Anne Arundel County, Maryland*.
- Amyot, J. R. (1989). *Hovercraft technology, economics, and applications* (1st ed., Vol. 11). Elsevier.
- Armstrong, K., Darvill, T., & Cheetham, P. (2016). Archaeological geophysical prospection in peatland environments: Case studies and suggestions for future practice. *ArchéoSciences*, 33 (suppl.(February 2022)), 251–253.
<https://doi.org/10.4000/archeosciences.1646>
- Backhurst, M. K., & Cole, R. G. (2000). Biological impacts of boating at Kawau Island, north-eastern New Zealand. *Journal of Environmental Management*, 60(3), 239–251. <https://doi.org/10.1006/JEMA.2000.0382>
- Bailey, G. (2004). The wider significance of submerged archaeological sites and their relevance to world prehistory. In *Submarine prehistoric archaeology of the North Sea: Research Priorities and Collaboration with Industry* (pp. 3–10).
- Bailey, G. N., & Flemming, N. C. (2008). Archaeology of the continental shelf: Marine resources, submerged landscapes and underwater archaeology. *Quaternary Science Reviews*, 27(23–24), 2153–2165.
<https://doi.org/10.1016/J.QUASCIREV.2008.08.012>
- Bishop, M. J. (2004). A Posteriori Evaluation of Strategies of Management: The Effectiveness of No-Wash Zones in Minimizing the Impacts of Boat-Wash on Macrobenthic Infauna. *Environmental Management*, 34(1).
<https://doi.org/10.1007/s00267-004-0135-5>
- Blue, T. G. (2021). *The Green Guide to Anchoring and Moorings*. 1–8.
- Bolam, S. G. (2011). Burial survival of benthic macrofauna following deposition of simulated dredged material. *Environmental Monitoring and Assessment*, 181(1–4), 13–27. <https://doi.org/10.1007/s10661-010-1809-5>
- Brazier, D. P., Kirkham, E., Hiorns, N., Singfield, C., Street, M., Steel, L., & Kent, F. (2019). *Guidelines for the Selection of Biological SSSIs. Part 2: Detailed Guidelines for Habitats and Species Groups. Chapter 1b Marine Intertidal and Shallow Subtidal Habitats*.

BRIG. (2008). *Peat and clay exposures on piddocks (UK BAP Priority Habitat description)*. <http://jncc.defra.gov.uk/page-5706><http://www.jncc.defra.gov.uk/page-5155><http://webarchive.nationalarchives.gov.uk/20150302161254/http://jncc.defra.gov.uk/page-5706>

Brooker, R. M., Carnell, P. E., Pocklington, J. B., Antos, M. J., & Weston, M. A. (2024). A review of the potential effects of recreational wind-powered craft on coastal habitats and wildlife. In *Journal of Environmental Planning and Management*. <https://doi.org/10.1080/09640568.2023.2228475>

Brooks, I. (2010). Environmental Impact Assessment for Langstone Harbour Board. In *Hovercraft Club of Great Britain*. [https://hoverclub.org.uk/langstone/Assessments_reports/Langstone Environmental Impact Assessment.pdf](https://hoverclub.org.uk/langstone/Assessments_reports/Langstone%20Environmental%20Impact%20Assessment.pdf)

Burger, J. (2003). Personal watercraft and boats: Coastal conflicts with common terns. *Lake and Reservoir Management*. <https://doi.org/10.1080/07438140309353986>

Chandrasekara, W. U., & Frid, C. L. . (1996). Effects of human trampling on tidal flat infauna. *Ecosystems*, 6, 299–311.

Church, N. J., Carter, A. J., Tobin, D., Edwards, D., Eassom, A., Cameron, A., Johnson, G. E., Robson, L. M., & Webb, K. E. (2016). JNCC Pressure Mapping Methodology. Physical Damage (Reversible Change) - Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion. *JNCC Report No. 515*, (December).

Clemo, W. C., Giles, K. D., & Dorgan, K. M. (2022). Biological influences on coastal muddy sediment structure following resuspension. *Limnology and Oceanography*, 67(11), 2466–2482. <https://doi.org/10.1002/lno.12213>

Collie, J. S., Hall, S. J., Kaiser, M. J., & Poiner, I. R. (2000). A quantitative analysis of fishing impacts on shelf-sea benthos. *Journal of Animal Ecology*, 69, 785–798. <https://doi.org/10.3354/meps085009>

Creed, J. C., & Amado Filho, G. M. (1999). Disturbance and recovery of the macroflora of a seagrass (*Halodule wrightii* Ascherson) meadow in the Abrolhos Marine National Park, Brazil: an experimental evaluation of anchor damage. *Journal of Experimental Marine Biology and Ecology*, 235(2), 285–306. [https://doi.org/10.1016/S0022-0981\(98\)00188-9](https://doi.org/10.1016/S0022-0981(98)00188-9)

Davis, A. R., Broad, A., Steele, C., Woods, C., Przeslawski, R., Nicholas, W. A. (Tony), Maher, W., Krikowa, F., Morris, B., Ingleton, T. C., O’Hea Miller, S., & Rees, M. J. (2025). Dragging the chain: anchor scour impacts from high-tonnage commercial vessels on a soft bottom macrobenthic assemblage. *Frontiers in Conservation Science*, 6. <https://doi.org/10.3389/fcosc.2025.1487428>

- Davis, D., & Tisdell, C. (1995). Recreational scuba-diving and carrying capacity in marine protected areas. *Ocean & Coastal Management*, 26(1), 19–40.
[https://doi.org/10.1016/0964-5691\(95\)00004-L](https://doi.org/10.1016/0964-5691(95)00004-L)
- Defeo, O., McLachlan, A., Schoeman, D. S., Schlacher, T. A., Dugan, J., Jones, A., Lastra, M., & Scapini, F. (2009). Threats to sandy beach ecosystems: A review. *Estuarine, Coastal and Shelf Science*, 81(1), 1–12.
<https://doi.org/10.1016/j.ecss.2008.09.022>
- Dernie, K. M., Kaiser, M. J., & Warwick, R. M. (2003). Recovery rates of benthic communities following physical disturbance. *Journal of Animal Ecology*, 72(6), 1043–1056. <https://doi.org/10.1046/j.1365-2656.2003.00775.x>
- Dorset Wildlife Trust. (2021). *Impacts of large vessel anchoring on seabed habitats and Marine Protected Areas A report by Dorset Wildlife Trust Protecting Wildlife for the Future*. <https://www.dorsetwildlifetrust.org.uk/sites/default/files/2021-06/ShipsReport2021.pdf>
- Eastern IFCA. (2024). *Cromer Shoal Chalk Beds Marine Conservation Zone 2024 Review of habitat data*.
- Edmonds, C., Bennett, M., Lippmann, J., & Mitchell, S. (2016). Diving and Subaquatic Medicine, 5th edition. *Underwater Technology*, 33(4), 245–246.
<https://doi.org/10.3723/ut.33.245>
- Ellis, J. I., Norkko, A., & Thrush, S. F. (2000). Broad-scale disturbance of intertidal and shallow sublittoral soft-sediment habitats; Effects on the benthic macrofauna. *Journal of Aquatic Ecosystem Stress and Recovery*, 7(1), 57–74.
<https://doi.org/10.1023/A:1009923530894>
- Gerdol, V., & Hughes, R. G. (1994). Effect of *Corophium volutator* on the abundance of benthic diatoms, bacteria and sediment stability in two estuaries in southeastern England. *Marine Ecology Progress Series*, 114(1–2), 109–116.
<https://doi.org/10.3354/meps114109>
- Glaeser G, & Abed-Navandi, D. (2023). *Ecosystems of the Mediterranean Sea*. Springer International Publishing.
- Gray, J. S., & Elliott, M. (2009). *Ecology of marine sediments : from science to management*. Oxford University Press.
- Griffiths, C. A., Langmead, O. A., Readman, J. A. J., & Tillin, H. M. (2017a). *Anchoring and Mooring Impacts in English and Welsh Marine Protected Areas: Reviewing sensitivity, activity, risk and management. A report to Defra Impacts Evidence Group from the Marine Biological Association of the United Kingdom*. www.marlin.ac.uk/assets/pdf/14267_ME6003_MBA_Report.pdf
- Guarnieri, A., Saremi, S., Pedroncini, A., Jensen, J. H., Torretta, S., Vaccari, M., & Vincenzi, C. (2021). Effects of marine traffic on sediment erosion and accumulation

- in ports: a new model-based methodology. *Ocean Science*, 17(2), 411–430. <https://doi.org/10.5194/os-17-411-2021>
- Hawkins, J. P., & Roberts, C. M. (1993). Effects of recreational scuba diving on coral reefs: trampling on reef-flat communities. *Journal of Applied Ecology*, 30(1), 25–30. <https://doi.org/10.2307/2404267>
- Hsu, C., Chen, C., & Hsieh, H. (2009). Effects of sediment compaction on macroinfauna in a protected coastal wetland in Taiwan. *Marine Ecology Progress Series*, 375, 73–83. <https://doi.org/10.3354/meps07686>
- International Peatland Society. (2019). *Peat formation*. <https://peatlands.org/peat/peat-formation/>
- Jennings, S., & Kaiser, M. J. (1998). The effects of fishing on marine ecosystems. *Advances in Marine Biology*, 43, 201–352.
- JNCC. (n.d.-a). *Infralittoral coarse sediment. Marine Habitat Classification for Britain and Ireland*. Retrieved <https://mhc.jncc.gov.uk/biotopes/jnccmncr00002035>
- JNCC. (n.d.-b). *Circalittoral coarse sediment. Marine Habitat Classification for Britain and Ireland*. Retrieved <https://mhc.jncc.gov.uk/biotopes/jnccmncr00002088>
- JNCC. (2016). *UK Biodiversity Action Plan Priority Habitat Descriptions - Peat and Clay Exposures with Piddocks*. (November).
- JNCC. (2022). *The Marine Habitat Classification for Britain and Ireland Version 22.04*. <https://mhc.jncc.gov.uk/>
- Kaiser, M. J., Clarke, K. R., Hinz, H., Austen, M. C. V., Somerfield, P. J., & Karakassis, I. (2006). Global analysis of response and recovery of benthic biota to fishing. *Marine Ecology Progress Series*, 311, 1–14. <https://doi.org/10.3354/meps311001>
- Kazemian, S., K Huat, B. B., Prasad, A., Barghchi, M., & Malaysia, P. (2011). Effect of peat media on stabilization of peat by traditional binders. *International Journal of the Physical Sciences*, 6(3), 476–481. <https://doi.org/10.5897/IJPS10.478>
- Kennish, M. (2002). Impacts of Motorized Watercraft on Shallow Estuarine and Coastal Marine Environments. *Journal of Coastal Research*, 37, 202.
- Kibler, K. M., Pilato, C., Walters, L. J., Donnelly, M., & Taye, J. (2022). Hydrodynamic Limitations to Mangrove Seedling Retention in Subtropical Estuaries. *Sustainability*, 14(14), 8605. <https://doi.org/10.3390/su14148605>
- Koster, K., Lange, G. De, Harting, R., de Heer, E., & Middelkoop, H. (2018). Characterizing void ratio and compressibility of Holocene peat with CPT for assessing coastal-deltaic subsidence. *Quarterly Journal of Engineering Geology and Hydrogeology*, 51(2), 210–218. <https://doi.org/10.1144/qjegh2017-120>

Lambert, G. I., Jennings, S., Kaiser, M. J., Davies, T. W., & Hiddink, J. G. (2014). Quantifying recovery rates and resilience of seabed habitats impacted by bottom fishing. *Journal of Applied Ecology*, 51(5), 1326–1336. <https://doi.org/10.1111/1365-2664.12277>

Lin, B. (2021). Close encounters of the worst kind: reforms needed to curb coral reef damage by recreational divers. *Coral Reefs*, 40(5), 1429–1435. <https://doi.org/10.1007/s00338-021-02153-3>

Luger D, & Harkes, M. (2013). Anchor Tests German Bight - Detecting the Penetration Depth of Ship Anchors. *Hydrographische Nachrichten*. <https://www.iscpc.org/information/marine-resources/anchors-and-anchoring/>

Maddock, A. (2011). UK Biodiversity Action Plan; Priority Habitat Descriptions. *JNCC Research Report*, (December), 1–103. http://www.jncc.gov.uk/page-5155%0Ahttp://www.jncc.gov.uk/page-5155%0Ahttp://jncc.defra.gov.uk/_ukbap/UKBAP_BAPHabitats-49-SeagrassBeds.doc

MarLIN. (2026). *The Marine Life Information Network (MarLIN)*. Marine Biological Association of the United Kingdom. www.marlin.ac.uk

Mazek, M., & Smyth, K. (2013). *Is “minimising the footprint” an effective intervention to maximise the recovery of intertidal sediments from disturbance?* (March). <http://publications.naturalengland.org.uk/publication/5091106>

McQuillan, R. M., Tillin, H.M. & Watson, A. (2024). Dense *Lanice conchilega* and other polychaetes in tide-swept infralittoral sand and mixed gravelly sand. In Tyler-Walters H. and Hiscock K (Ed.), *Marine Life Information Network: Biology and Sensitivity Key Information Reviews*. https://www.marlin.ac.uk/habitats/detail/116/dense_lanice_conchilega_and_other_polychaetes_in_tide-swept_infralittoral_sand_and_mixed_gravelly_sand

Méléder, V., Savelli, R., Barnett, A., Polsenaere, P., Gernez, P., Cugier, P., Lerouxel, A., Le Bris, A., Dupuy, C., Le Fouest, V., & Lavaud, J. (2020). Mapping the Intertidal Microphytobenthos Gross Primary Production Part I: Coupling Multispectral Remote Sensing and Physical Modeling. *Frontiers in Marine Science*, 7(July), 1–16. <https://doi.org/10.3389/fmars.2020.00520>

Moyse, E. M., Hill, J. M., Tyler-Walters, H., Garrard, S. L., & Watson, A. J. (2026). Seapens and burrowing megafauna in circalittoral fine mud. In H. Tyler-Walters (Ed.), *Marine Life Information Network: Biology and Sensitivity Key Information Reviews*. www.marlin.ac.uk/habitats/detail/131

Nadiarti, N., La Nafie, Y. A., Priosambodo, D., & Husain, A. A. A. (2021). Significant effect of human trampling on subtidal seagrass beds. *AACL Bioflux*, 14(2), 910–917.

Natural England. (2017). *EIN036 Marine recreation evidence briefing: diving and snorkelling*. (November). <https://www.gov.uk/government/collections/conservation-advice-packages-for-marine-protected->

Natural England. (2017). *Marine Recreation Evidence Briefing: Hovercraft - EIN031*. file:///C:/Users/fd000013/Downloads/EIN031 edition 1 Marine recreation evidence briefing hovercraft.pdf

Natural England. (2017). *Natural England Evidence Information Note EIN026 - Marine Recreation Evidence Briefing: Motorised Personal Watercraft*. (November), 1–17. <https://www.gov.uk/government/collections/conservation-advice-packages-for-marine-protected->

Natural England. (2017). *Natural England Evidence Information Note EIN028 Marine recreation evidence briefing: non-motorised watercraft including paddlesports*. (November), 1–17. <https://www.gov.uk/government/collections/conservation-advice-packages-for-marine-protected-areas>

Natural England. (2024). *Yarmouth to Cowes MCZ Phase I and II Baseline Survey*. (May).

Natural Resources Wales. (n.d.). *Beam trawl on peat and clay exposures. AWFA assessment proforma*.

Natural Resources Wales. (2021). *Benthic habitat assessment guidance: A guide to characterising and monitoring intertidal sediment habitats*. <https://naturalresourceswales.gov.uk/media/693110/gn030b-intertidal-sediments-final-24jun2019-accessible.pdf>

Newell, R. C., Seiderer, L. J., & Hitchcock, D. R. (1998). THE IMPACT OF DREDGING WORKS IN COASTAL WATERS: A REVIEW OF THE SENSITIVITY TO DISTURBANCE AND SUBSEQUENT RECOVERY OF BIOLOGICAL RESOURCES ON THE SEA BED. In *Annual Review* (Vol. 36).

Pinn, E. H., Thompson, R. C., & Hawkins, S. J. (2008). Piddocks (Mollusca: Bivalvia: Pholadidae) increase topographical complexity and species diversity in the intertidal. *Marine Ecology Progress Series*, 355, 173–182. <https://doi.org/10.3354/meps07248>

Pye, K., and French, P. (1993). *Erosion & Accretion Processes on British Salt Marshes Volume One: Introduction: Saltmarsh process & morphology*. Cambridge Environmental Research Consultants.

Readman, J. A. J., & Watson, A. (2024). *Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment. In H. Tyler-Walters & K. Hiscock (Eds.), *Marine Life Information Network: Biology and Sensitivity Key Information Reviews*. www.marlin.ac.uk/habitats/detail/74

Roche, R. C., Harvey, C. V., Harvey, J. J., Kavanagh, A. P., McDonald, M., Stein-Rostaing, V. R., & Turner, J. R. (2016). Recreational Diving Impacts on Coral Reefs

and the Adoption of Environmentally Responsible Practices within the SCUBA Diving Industry. *Environmental Management*, 58(1), 107–116.
<https://doi.org/10.1007/s00267-016-0696-0>

Rossi, F., Forster, R. M., Montserrat, F., Ponti, M., Terlizzi, A., Ysebaert, T., & 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(6), 2077–2090. <https://doi.org/10.1007/s00227-007-0641-0>

Roupheal, A. ., & Inglis, G. (2002). Increased spatial and temporal variability in coral damage caused by recreational scuba diving. . *Ecological Applications*, 12, 427–440.

Safak, I., Angelini, C., & Sheremet, A. (2021). Boat wake effects on sediment transport in intertidal waterways. *Continental Shelf Research*, 222, 104422.
<https://doi.org/10.1016/j.csr.2021.104422>

Schratzberger, M., & Warwick, R. M. (1998). Effects of physical disturbance on nematode communities in sand and mud: a microcosm experiment. *Marine Biology*, 130(4), 643–650. <https://doi.org/10.1007/s002270050286>

Schulze, I., Schönke, M., Feldens, P., & Papenmeier, S. (2025). Temporal evolution of anchor tracks on a silty seafloor (Eckernförde Bay/Baltic Sea). *Frontiers in Remote Sensing*, 6. <https://doi.org/10.3389/frsen.2025.1576192>

Short, F. T., & Wyllie-Echeverria, S. (1996). Natural and human-induced disturbance of seagrasses. *Environmental Conservation*, 23(1), 17–27.
<https://doi.org/10.1017/S0376892900038212>

Sumanapala, D., Dimmock, K., & Wolf, I. D. (2023). A review of ecological impacts from recreational SCUBA diving: Current evidence and future practice. *Tourism and Hospitality Research*, 23(4), 564–577. <https://doi.org/10.1177/14673584221112602>

The Hovercraft Society. (2025). *Introduction to the Hovercraft Society*.
<https://www.thehovercraftsociety.org.uk/>

The Wildlife Trusts. (n.d.). *Mud*. Retrieved September 17, 2026, from
<https://www.wildlifetrusts.org/habitats/marine/mud>

Thrush, S., Hewitt, J., Cummings, V., & Dayton, P. (1995). The impact of habitat disturbance by scallop dredging on marine benthic communities: what can be predicted from the results of experiments? *Marine Ecology Progress Series*, 129, 141–150. <https://doi.org/10.3354/meps129141>

Tillin, H. M., Hill, J. M., Harris, O., & Tyler-Walters, H. (2025). Piddocks with a sparse associated fauna in sublittoral very soft chalk or clay. In H. Tyler-Walters & K. Hiscock (Eds.), *Marine Life Information Network: Biology and Sensitivity Key Information Reviews*. www.marlin.ac.uk/habitats/detail/152

Tillin, H. M., & Tyler-Walters, H. (2014). Assessing the sensitivity of subtidal sedimentary habitats to pressures associated with marine activities: Phase 2 Report

– Literature review and sensitivity assessments for ecological group. In *JNCC Report No. 512B*.

Tillin, H. M., & Watson, A. (2024). *Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel. In H. Tyler-Walters (Ed.), *Marine Life Information Network: Biology and Sensitivity Key Information Reviews*. www.marlin.ac.uk/habitats/detail/382

Waggitt, J. J., Evans, P. G. H., Andrade, J., Banks, A. N., Boisseau, O., Bolton, M., Bradbury, G., Brereton, T., Camphuysen, C. J., Durinck, J., Felce, T., Fijn, R. C., Garcia-Baron, I., Garthe, S., Geelhoed, S. C. V., Gilles, A., Goodall, M., Haelters, J., Hamilton, S., ... Hiddink, J. G. (2020). Distribution maps of cetacean and seabird populations in the North-East Atlantic. *Journal of Applied Ecology*, 57(2), 253–269. <https://doi.org/10.1111/1365-2664.13525>

Watson, S. J., Ribó, M., Seabrook, S., Strachan, L. J., Hale, R., & Lamarche, G. (2022). The footprint of ship anchoring on the seafloor. *Scientific Reports*, 12(1), 7500. <https://doi.org/10.1038/s41598-022-11627-5>

Welsh Government. (2022). *Scallop (Queen) Dredge on Peat and Clay Exposures*.

Western Hemisphere Shorebird Reserve Network (WHSRN). (2026). *Why Mud Matters*. <https://whsrn.org/why-mud-matters/>

Wilber, D. H., & Clarke, D. G. (2001). Biological Effects of Suspended Sediments: A Review of Suspended Sediment Impacts on Fish and Shellfish with Relation to Dredging Activities in Estuaries. *North American Journal of Fisheries Management*, 21(4), 855–875. [https://doi.org/10.1577/1548-8675\(2001\)021<0855:BEOSSA>2.0.CO;2](https://doi.org/10.1577/1548-8675(2001)021<0855:BEOSSA>2.0.CO;2)

Wilber, D. H., & Clarke, D. G. (2007). Defining and assessing benthic recovery following dredging and dredged material disposal. *Proceedings XXVII World Dredging Congress 2007*, 603–618. https://www.westerndredging.org/phocadownload/ConferencePresentations/2007_WODA_Florida/Session3D-EnvironmentalAspectsOfDredging/3 - Wilber - Defining Assessing Benthic Recovery Following Dredged Material Disposal.pdf

Annex 1: mNLA pressures on sensitive features - benthic sediments and associated species

This annex summarises the pressures resulting from mNLA and their potential impact on benthic sediments and associated species features described in this document.

Natural England's Conservation Advice packages provide generic information on pressures that may be exerted by all marine industries and their potential impact on designated features within the Advice on Operations (AoO) section. Natural England's AoO is an evidence-based product which can be used to guide MPA assessments, together with bespoke advice from JNCC and Natural England. This is explained further in [Natural England's conservation advice guidance](#)¹⁷.

The sensitivities of designated features to mNLA pressures were derived using a staged approach.

Stage 1

Natural England's conservation advice packages (CAP), including Natural England's AoO have been used by MMO to determine the sensitivities of each feature to the potential pressures from mNLA, based on actual or representative sites to highlight subject areas for evidence gathering. This has been done by identifying the 98 marine protected areas that are in scope for this mNLA programme of work that contain benthic sediments and associated species features and reviewing the AoO available for each site. The information from the AoO was collated (**Table A1.1**), with the highest sensitivity for each pressure-feature interaction being recorded (Table 1.1 for the sensitivity categories). Natural England also provided additional guidance about pressure/feature interactions that should be considered.

Stage 2

An evidence-gathering activity was then carried out. Evidence gathering and analysis was focussed on interactions that were deemed sensitive (**Table A1.2**) and high risk, as these are likely to be the most relevant interactions to be considered at each site level assessment (**Table A1.1**). Interactions where there is insufficient evidence (IE) are not considered further here, but these interactions will be considered in site level assessments. In addition, site specific sensitivities for each pressure-feature interaction will be used at the site level assessment stage.

All the pressures from the mNLA categories described in **Section 0** and the potential sensitivity of benthic features are displayed in **Table A1.2**. This table summarises all

¹⁷ Natural England MPA Conservation Advice - Guidance and Supporting Material: designatedsites.naturalengland.org.uk/MarineGuidance.aspx#advice (last accessed 14 September 2026).

the interactions according to the key in **Table A1.1**. The pressures listed in are defined in within Natural England's AoOs.

Where multiple sensitivities exist for features, the most precautionary sensitivity has been displayed. Site specific sensitivities will be used at the site level assessment stage.

Table A1.1: Interaction sensitivity key for mNLA and designated features.

Key	
S	Indicates the feature is sensitive.
IE	Indicates there is insufficient evidence to make sensitivity conclusions, or a sensitivity assessment has not been made for this feature to this pressure.
NS	Indicates feature is not sensitive to pressure.
NA	Indicates that a sensitivity assessment has not been made for this interaction, this interaction should not, however, be precluded from consideration.
NR	Indicates the pressure is not relevant for the gear type.
	Indicates no pathway/no interaction between feature and pressure.

Table A1.2: Summary of the highest sensitivity levels of designated benthic features to potential pressures. Pressures relate to anchoring, diving and snorkelling, hovercraft, MPW, motorised watercraft, non-motorised watercraft and non-motorised sailing.

Potential pressure	Intertidal coarse sediment	Intertidal mixed sediments	Intertidal mud	Intertidal sand and muddy sand	Peat and clay exposures	Sheltered muddy gravels	Subtidal coarse sediment	Subtidal mixed sediments	Subtidal mud	Subtidal sand	Subtidal macrophyte dominated sediment
Abrasion/disturbance of the substrate on the surface of the seabed	S	S	S	S	S	S	S	S	S	S	S
Hydrocarbon and PAH contamination			S	S		S		S	S		S
Introduction of light	IE	IE	NS	S	IE	IE	S	IE	NS	S	S
Introduction or spread of invasive non-indigenous species (INIS)	IE	S	S	S	S	S	S	S	S	S	S

Potential pressure	Intertidal coarse sediment	Intertidal mixed sediments	Intertidal mud	Intertidal sand and muddy sand	Peat and clay exposures	Sheltered muddy gravels	Subtidal coarse sediment	Subtidal mixed sediments	Subtidal mud	Subtidal sand	Subtidal macrophyte dominated sediment
Organic enrichment	NS	NS	NS	NS	IE	S	S	S	S	S	S
Penetration and/or disturbance of the substratum below the surface of the seabed, including abrasion	S	S	S	S	S	S	S	S	S	S	S
Physical change (to another seabed type)						S					S
Physical change (to another sediment type)					S		S	S	S	S	S
Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals)			S	S		S		S	S		S
Transition elements and organo-metal (e.g. TBT) contamination			S	S		S		S	S		IE