Morecambe Offshore Windfarm: Generation Assets

Environmental Statement

Volume 5

Appendix 9.2 Marine Evidence-based Sensitivity Assessment

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Glossary of Acronyms

EUNIS	European nature information system
FOCI	Feature of Conservation Interest
MarESA	Marine Evidence-based Sensitivity Assessment
MarLIN	Marine Life Information Network
OWF	Offshore Windfarm
WTG	Wind turbine generator
ZoI	Zone of Influence

Glossary of Unit Terms

km	Kilometre
m	Metre
m/s	Meter per second
cm	Centimetre

Glossary of Terminology

Generation Assets (the Project)	Generation assets associated with the Morecambe Offshore Windfarm. This is infrastructure in connection with electricity production, namely the fixed foundation wind turbine generators (WTGs), inter-array cables, offshore substation platform(s) (OSP(s)) and possible platform link cables to connect OSP(s).
Inter-array cables	Cables which link the wind turbine generators to each other and the offshore substation platform.
Landfall	Where the offshore export cables would come ashore.
Offshore export cables	The cables which would bring electricity from the OSP(s) to the landfall.
Offshore substation platform(s) (OSP(s))	A fixed structure located within the windfarm site, containing electrical equipment to aggregate the power from the WTGs and convert it into a more suitable form for export to shore.
Platform link cable	An electrical cable which links one or more OSP(s).
Study area	This is an area which is defined for each Environmental Impact Assessment (EIA) topic which includes the offshore development area as well as potential spatial and temporal considerations of the impacts on relevant receptors. The study area for each EIA topic is intended to cover the area within which an effect can be reasonably expected. For the purpose of benthic ecology assessment, this is in an area which includes the windfarm site and the Zone of Influence (ZoI) (see below), as well as wider areas within the Eastern Irish Sea from which contextual benthic data can be reported.
Windfarm site	The area within which the WTGs, inter-array cables, OSP(s) and platform link cables will be present.
Wind turbine generator (WTG)	A fixed structure located within the windfarm site that converts the kinetic energy of wind into electrical energy.
Zone of Influence (ZoI)	This is a refined area within the wider study area covering the maximum anticipated spatial extent of a given potential impact. As such, the ZoI for this topic is intended to cover the area within which an effect can be reasonably expected.

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1 Introduction

1. The impact assessment presented in **Chapter 9 Benthic Ecology** (Document Reference 5.1.9) identifies receptors for which there is a pathway for effect, and the sensitivity of those receptors to each effect. The definitions of sensitivity used are based on Marine Life Information Network (MarLINs) Marine Evidence based Sensitivity Assessment (MarESA) (Tyler-Walters *et al.*, 2018), which determines sensitivity based on resistance (tolerance) and resilience (recoverability):

   - Resistance: the likelihood of damage (termed intolerance or resistance) due to a pressure
   - Resilience: the rate of (or time taken for) recovery (termed recoverability, or resilience) once the pressure has abated or been removed

2. The MarESA assessments allot a rating 'level' for both resistance and resilience. Definition of each level is described in **Table 1.1**.

Table 1.1 Definitions of resistance and resilience levels used in MarESA (Tyler-Walters et al., 2018)

Level	Definition
Resistance (tolerance)	
None	Key functional, structural, characterising species severely decline and/or physicochemical parameters are also affected e.g. removal of habitats causing a change in habitat type. A severe decline/reduction relates to the loss of 75% of the extent, density or abundance of the selected species or habitat component (where this can be sensibly applied).
Low	Significant mortality of key and characterising species, with some effects on the physicochemical character of habitat. A significant decline/reduction relates to the loss of 25-75% of the extent, density, or abundance of the selected species or habitat component.
Medium	Some mortality of species (can be significant where these are not keystone structural/functional and characterising species), without change to habitats, relates to the loss of less than 25% of the species or habitat component.
High	No significant effects on the physicochemical character of habitat and no effect on population viability of key/characterising species, but may affect feeding, respiration and reproduction rates.
Resilience (recovery)	
Very low	Negligible or prolonged recovery possible; at least 25 years to recover structure and function.
Low	Full recovery within 10-25 years.
Medium	Full recovery within 2-10 years.
High	Full recovery within 2 years.

3. The MarESA assessment of sensitivity is guided by the presence of key structural or functional species/assemblages and/or those that characterise the biotope groups. Physical and chemical characteristics are also considered, where they structure the community. MarESA uses a matrix approach to determine sensitivity, based on both recovery and resilience. This matrix is presented in **Table 1.2**.

Table 1.2 MarESA sensitivity matrix

		Resistance			
		None	**Low**	**Medium**	**High**
Resilience	**Very low**	High	High	Medium	Low
	Low	High	High	Medium	Low
	Medium	Medium	Medium	Medium	Low
	High	Medium	Low	Low	Not sensitive

4. MarESA has been used in order to determine sensitivity of specific biotopes recorded during the Morecambe Offshore Windfarm site-specific benthic characterisation survey in May/June 2022, and other biotopes present within the 15km Project Zone of Influence (ZoI), as demonstrated by other studies set out in **Chapter 9 Benthic Ecology**.

5. Confidence in baseline characteristic definition, at the EUNIS level 3 habitat level, is higher than it is at level 5 biotope level, hence the assessment set out in **Chapter 9 Benthic Ecology** assesses the sensitivity of overarching EUNIS level 3 habitats, alongside the constituent biotopes. MarESA assessments are not provided specifically for level 3 habitats; however, sensitivity at habitat level reflects the highest level of sensitivity for the constituent biotopes.

6. MarESA sensitivities, whilst useful, do not take into account local evidence regarding community composition and habitat resilience/resistance. Where such information is available from other studies within the general area (e.g. post-construction benthic monitoring at other offshore windfarms (OWFs) in the Eastern Irish Sea), sensitivities have been modified accordingly in the assessment presented in **Chapter 9 Benthic Ecology**.

2 Sensitivity assessment

7. **Table 2.1** sets out the sensitivity assessment from direct effect (i.e. effects confined to the footprint of the Project) for the following biotopes, recorded during the Morecambe OWF site-specific benthic characterisation survey:

- A5.252 *Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand (Tillin, 2016a)
- A5.351 *Amphiura filiformis, Mysella bidentata* and *Abra nitida* in circalittoral sandy mud (De Bastos and Hill, 2016)

8. **Table 2.2** sets out the sensitivity assessment from indirect effects (i.e. effects that extend beyond the footprint of the Project) for the above biotopes, plus the following biotopes, recorded during other studies within 15km of the windfarm site:

- Sublittoral coarse sediment biotopes
    - A5.133 *Moerella* spp. with venerid bivalves in infralittoral gravelly sand (Tillin, 2016b)
    - A5.135 *Glycera lapidum* in impoverished infralittoral mobile gravel and sand (Tillin, 2016c)
    - A5.145 *Branchiostoma lanceolatum* in circalittoral coarse sand with shell gravel (Tillin, 2016d)
- Sublittoral sand biotopes
    - A5.242 *Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand (Tillin and Rayment, 2016)
    - A5.251 *Echinocyamus pusillus*, *Opehlia borealis* and *Abra prismatica* in circalittoral fine sand (Tillin, 2022)
    - A5.261 *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment (Tillin and Budd, 2016)
- Sublittoral mud biotopes
    - A5.355 *Lagis koreni* and *Phaxus pellucidus* in circalittoral sandy mud (De Bastos, 2016)

9. Given the potential presence of the Feature of Conservation Interest (FOCI) 'Sea-pens and burrowing megafauna communities' within the windfarm site and further afield, **Table 2.1** and **Table 2.2** also sets out the sensitivity assessment of the following proxy biotope:

- A5.361 Sea-pens and burrowing megafauna in circalittoral fine mud (Hill *et al*., 2020)

Table 2.1 Sensitivity, resistance and resilience of biotopes recorded at the Project windfarm site to direct effects of the Project, taken from MarESA

Broadscale habitat	Biotope (EUNIS level 4)	Resistance (tolerance)	Resilience (recovery)	Sensitivity	Justification (as set out in respective MarESA)
Habitat structure changes – removal of substratum (extraction)					
Sublittoral sand	A5.252	None	Medium	**Medium**	Resistance is assessed as 'None', as extraction of the sediments would remove the characterising and associated species present. Resilience is assessed as 'Medium', as some species may require longer than two years to re-establish and sediments may need to recover (where exposed layers are different). Biotope sensitivity is therefore assessed as 'Medium' (Tillin, 2016a).
Sublittoral mud	A5.351	None	Medium	**Medium**	Extraction of 30cm of sediment would remove the characterising biological component of the biotopes, so resistance is assessed as 'None'. Local hydrodynamics (currents and wave action) and sediment characteristics (mobility and supply) strongly influence the recovery of soft sediment habitats. The biotopes occur in low energy environments, so resilience is therefore judged as 'Medium'. Sensitivity has been assessed as 'Medium' (De Bastos and Hill, 2016).
	A5.361	None	Low	**High**	Extraction of sediment to 30cm (the benchmark) could remove most of the resident sea-pens present. Hence, their resistance is probably 'None', and their resilience is at least 'Low', resulting in a sensitivity of 'High' (Hill *et al.*, 2020).
Abrasion/disturbance of the surface of the substratum or seabed					
Sublittoral sand	A5.252	Medium	High	**Low**	Abrasion is likely to damage epifauna and flora and may also damage a proportion of the characterising species, therefore, biotope resistance is assessed as 'Medium'. Resilience is assessed as 'High', as opportunistic species are likely to recruit rapidly and some damaged characterising species may recover or recolonize. Biotope sensitivity is assessed as 'Low' (Tillin, 2016a).

Broadscale habitat	Biotope (EUNIS level 4)	Resistance (tolerance)	Resilience (recovery)	Sensitivity	Justification (as set out in respective MarESA)
Sublittoral mud	A5.351	Low	Medium	**Medium**	Although burrowing life habits may provide some protection from damage by abrasion at the surface, a proportion of the population is likely to be damaged or removed. Significant impacts in population density would be expected if such physical disturbance were repeated at regular intervals. Furthermore, the nature of the soft sediment, where the biotopes occur, means that objects causing abrasion are likely to penetrate the surface and cause further damage to the characterising species. Resistance is therefore assessed as 'Low' and resilience as 'Medium', so sensitivity is assessed as 'Medium' (De Bastos and Hill, 2016).
	A5.361	Medium	Low	**Medium**	*Virgularia mirabilis* and *Pennatula phosphorea* can avoid abrasion, by withdrawing into the sediment, but a frequent disturbance would probably reduce feeding time and hence viability. Surface abrasion is unlikely to affect *Virgularia mirabilis* and *Pennatula phosphorea* adversely. Abrasion is likely to remove a proportion of sea-pens from the sediment, and, if damaged, they are likely to die, but if undamaged, displaced and/or returned to suitable sediment, *Virgularia mirabilis* and *Pennatula phosphorea* can probably recover relatively quickly. The evidence of the effect of abrasion on *Halipteris willemoesi* in Alaskan waters, suggests that sea-pens can recover from physical abrasion, but that specimens that are dislodged or fractured are likely to die, especially in the presence of predators. Therefore, a resistance of 'Medium' is suggested for *Pennatula phosphorea* and *Virgularia mirabilis* that can withdraw into the sediment and avoid direct effects. As the resilience is probably 'Low', the sensitivity of this biotope is assessed as 'Medium' (Hill *et al.*, 2020).

Broadscale habitat	Biotope (EUNIS level 4)	Resistance (tolerance)	Resilience (recovery)	Sensitivity	Justification (as set out in respective MarESA)
Penetration or disturbance of the substratum subsurface					
Sublittoral sand	A5.252	Medium	High	**Low**	The biological assemblage present in this biotope is characterised by species that are relatively tolerant of penetration and disturbance of the sediments. Either species are robust, or buried within sediments, or are adapted to habitats with frequent disturbance (natural or anthropogenic) and recover quickly. A reduction in physical disturbance may lead to the development of a community with larger, more fragile, species, including large bivalves. Biotope resistance is assessed as 'Medium', as some species would be displaced and may be predated or injured and killed. Biotope resilience is assessed as 'High', as most species would recover rapidly, and the biotope is likely to still be classified as the same type following disturbance. Biotope sensitivity is therefore assessed as 'Low' (Tillin, 2016a).
Sublittoral mud	A5.351	Low	Medium	**Medium**	A large proportion of the characterising species is likely to be lost, or severely damaged, depending on the scale of the activity. Therefore, a resistance of 'Low' is suggested. Muddy sand habitats have been reported as having the longest recovery times, whilst mud habitats had an 'intermediate' recovery time (compared to clean sand communities which had the most rapid recovery rate). Resilience is probably 'Medium', and therefore the biotope's sensitivity to this pressure is likely to be 'Medium' (De Bastos and Hill, 2016).
	A5.361	Low	Low	**High**	Penetrative activity is likely to remove a greater proportion of the sea pen population (than abrasive activity), as it may remove them from their burrows, within the footprint of the activity. Therefore, resistance is assessed as 'Low' for all sea pen species. As resilience is probably 'Low', sensitivity is assessed as 'High' (Hill *et al.*, 2020).

Broadscale habitat	Biotope (EUNIS level 4)	Resistance (tolerance)	Resilience (recovery)	Sensitivity	Justification (as set out in respective MarESA)
Smothering and siltation rate changes (heavy)					
Sublittoral sand	A5.252	Low	Medium	**Medium**	The character of the overburden is an important factor determining the degree of vertical migration of buried bivalves. Individuals are more likely to escape from a covering similar to the sediments in which the species is found, than a different type. Resistance is assessed as 'Low', as few individuals are likely to reposition. Resilience is assessed as 'Medium', and sensitivity is assessed as 'Medium' (Tillin, 2016a).
Sublittoral mud	A5.351	Low	Medium	**Medium**	Beyond re-establishing burrow openings, or moving up through the sediment, there is evidence of synergistic effects on burrowing activity of marine benthos and mortality, with changes in time of burial, sediment depth, sediment type and temperature. Bivalve and polychaete species have been reported to migrate through depositions of sediment greater than the benchmark (30cm of fine material added to the seabed in a single discrete event). However, it is not clear whether the characterising species are likely to be able to migrate through a maximum thickness of fine sediment, because muds tend to be more cohesive and compacted than sand. Some mortality of the characterising species is likely to occur. Resistance is, therefore, assessed as 'Low' (25-75% loss), but with low confidence. Resilience is assessed as 'Medium' and the biotope is considered to have 'Medium' sensitivity to a 'heavy' deposition of up to 30cm of fine material in a single discrete event (De Bastos and Hill, 2016).
	A5.361	High	High	**Not sensitive**	*Pennatula phosphorea* and *Virgularia mirabilis* can burrow and move into and out of their own burrows. It is probable, therefore, that deposition of 30cm of fine sediment would have little effect, other than to temporarily suspend feeding and the energetic cost of burrowing. *Funiculina quadrangularis* cannot withdraw into a burrow but can stand up to two metres above the substratum, and so would probably

Broadscale habitat	Biotope (EUNIS level 4)	Resistance (tolerance)	Resilience (recovery)	Sensitivity	Justification (as set out in respective MarESA)
					not be affected adversely. However, no direct evidence was found. Therefore, a resistance of 'High' is suggested, resulting in a resilience of 'High' and sensitivity of 'Not sensitive' at the benchmark level (Hill *et al.*, 2020).
Physical change (to another seabed type)					
Sublittoral sand	A5.252	None	Very low	**High**	Based on the loss of the biotope, resistance is assessed as 'None', recovery is assessed as 'Very Low' (as the change at the pressure benchmark is permanent), and sensitivity is assessed as 'High' (Tillin, 2016a).
Sublittoral mud	A5.351	None	Very low	**High**	Resistance to the pressure is considered 'None', and resilience 'Very Low', given the permanent nature of this pressure. Sensitivity has been assessed as 'High'. Although no specific evidence is described, confidence in this assessment is 'High', due to the incontrovertible nature of this pressure (De Bastos and Hill, 2016).
	A5.361	None	Very low	**High**	Resistance to the pressure is considered 'None', and resilience 'Very low' or 'None' (as the pressure represents a permanent change) and the sensitivity of this biotope is assessed as 'High' (Hill *et al.*, 2020).
Electromagnetic changes					
Sublittoral sand	A5.252	**No evidence**			
Sublittoral mud	A5.351	**No evidence**			
	A5.361	**No evidence**			
Temperature increase (local)					
Sublittoral sand	A5.252	Medium	High	**Low**	Little evidence was available to assess this pressure. Assemblages in fine sands and muddy sands contain many of the characterising species that occur in the Mediterranean, where temperatures are

Broadscale habitat	Biotope (EUNIS level 4)	Resistance (tolerance)	Resilience (recovery)	Sensitivity	Justification (as set out in respective MarESA)
					higher than experienced in the UK. It is considered likely, therefore, that a chronic change in temperature at the pressure benchmark would be tolerated by species with a wide distribution, or that some species or groups of species would be resistant. An acute change may exceed thermal tolerances, or lead to spawning, or other biological effects. These effects may be sub-lethal or result in the removal of only a proportion of less tolerant species. Biotope resistance is therefore assessed as 'Medium' and resilience is assessed as 'High'. Biotope sensitivity is therefore assessed as 'Low' (Tillin, 2016a).
Sublittoral mud	A5.351	High	High	**Not sensitive**	The characterising species of the biotope are widely distributed, and likely to occur both north and south of the British Isles, where typical surface water temperatures vary seasonally from 4-19°C. No information was found on the maximum temperature tolerated by the characterising species. Elevated temperatures may affect growth of some of the characterising species, but no mortality is expected. It is therefore likely that the characterising species are able to resist a long-term increase in temperature of 2°C. Resistance is therefore assessed as 'High' for this biotope. Resilience is likely to be 'High', so this biotope is considered 'Not Sensitive' (De Bastos and Hill, 2016).
	A5.361	Medium	Low	**Medium**	The distribution of sea-pens suggests that they are probably resistant to a 2°C change in temperature. However, sea-pens are subtidal, and occur at depth, where wide and rapid variations in temperature are not common, and so may be less resistant of a short-term increase of 5°C. Therefore, a resistance of 'Medium' is suggested, but with low confidence. Resilience is probably 'Low', so that sensitivity is assessed as 'Medium' (Hill *et al.*, 2020).

Table 2.2 Sensitivity, resistance and resilience of biotopes recorded within 15km of the Project windfarm site to indirect effects of the Project, taken from MarESA

Broadscale habitat	Biotope (EUNIS level 4)	Resistance (tolerance)	Resilience (recovery)	Sensitivity	Justification
Smothering and siltation rate changes (light)					
Sublittoral coarse sediment	A5.133	Medium	High	**Low**	This biotope is exposed to tidal streams, which may remove some sediments, but the bivalves and polychaetes are likely to be able to survive short periods under sediments and are also able to reposition. However, as the pressure benchmark refers to fine material, this may be cohesive, and species characteristic of sandy habitats may be less adapted to move through this than sands. Biotope resistance is assessed as 'Medium', as some mortality of characterising, and associated species, may occur. Biotope resilience is assessed as 'High' and biotope sensitivity is assessed as 'Low' (Tillin, 2016b; Tillin, 2016c).
	A5.135	Medium	High	**Low**	
	A5.145	Low	High	**Low**	Although some individuals may reposition within sediments, resistance is assessed as ‘Low’ (loss of 25-75 % of exposed individuals) at the pressure benchmark, due to the depth of the overburden. Resilience is assessed as ‘High’ (following sediment restoration). Sensitivity is therefore categorised as ‘Low’ (Tillin, 2016d).
Sublittoral sand	A5.242	Medium	High	**Low**	Bivalves and polychaetes, and other species, are likely to be able to survive short periods under sediments and are also able to reposition. However, as the pressure benchmark refers to fine material, this may be cohesive, and species characteristic of sandy habitats may be less adapted to move through this than sands. Biotope resistance is assessed as 'Medium', as some mortality of characterising, and associated species, may occur. Biotope resilience is assessed as 'High' and biotope sensitivity is
	A5.251	Medium	High	**Low**	
	A5.252	Medium	High	**Low**	

Broadscale habitat	Biotope (EUNIS level 4)	Resistance (tolerance)	Resilience (recovery)	Sensitivity	Justification
	A5.261	Medium	High	**Low**	assessed as 'Low' (Tillin and Rayment, 2016; Tillin, 2016a; Tillin and Budd, 2016; Tillin, 2022).
Sublittoral mud	A5.351	High	High	**Not sensitive**	Beyond re-establishing burrow openings, or moving up through the sediment, there is evidence of synergistic effects on burrowing activity of marine benthos, and mortality, with changes in time of burial, sediment depth, sediment type and temperature. However, the biotopes are likely to resist smothering at the benchmark level since the majority of associated fauna are burrowing infauna. Resistance is therefore assessed as 'High', and resilience is also 'High' (by default), so the biotopes are considered 'Not Sensitive' to a 'light' deposition, of up to 5cm of fine material, added to the seabed in a single, discrete event (De Bastos and Hill, 2016).
	A5.355	High	High	**Not sensitive**	The evidence suggests that characterising species *Lagis koreni* and *Phaxas pellucidus* are likely to be able to burrow through sediment, although sudden smothering would temporarily halt feeding and respiration, compromising growth and reproduction, owing to energetic expenditure. Beyond re-establishing burrow openings, or moving up through the sediment, there is evidence of synergistic effects on burrowing activity of marine benthos, and mortality, with changes in time of burial, sediment depth, sediment type and temperature (Maurer et al., 1986). However, the biotope is likely to resist smothering at the benchmark level. Resistance is therefore assessed as 'High', and resilience is also 'High' (by default), so that the biotope is considered 'Not Sensitive' to a 'light' deposition, of up to 5cm of fine material, added to the seabed in a single, discrete event (De Bastos, 2016).

Broadscale habitat	**Biotope (EUNIS level 4)**	**Resistance (tolerance)**	**Resilience (recovery)**	**Sensitivity**	**Justification**
	A5.361	High	High	**Not sensitive**	Sea pen species occur in deep, sheltered, muddy habitats, where the accretion rates are potentially high. Both *Pennatula phosphorea* and *Virgularia mirabilis* can burrow and move into and out of their own burrows. It is probable, therefore, that deposition of 5cm of fine sediment would have little effect, other than to temporarily suspend feeding and the energetic cost of burrowing. *Funiculina quadrangularis* cannot withdraw into a burrow but can stand up to two metres above the substratum, and so would probably not be affected adversely. However, no direct evidence was found. Therefore, a resistance of 'High' is suggested, resulting in a resilience of 'High' and sensitivity of 'Not sensitive' at the benchmark level (Hill *et al.*, 2020).
Changes in suspended solids (water clarity)					
Sublittoral coarse sediment	A5.133	Medium	High	**Low**	No direct evidence was found to assess impacts on the characterising and associated species. The characterising, suspension-feeding bivalves are not predicted to be sensitive to decreases in turbidity and may be exposed to, and tolerant of, short-term increases in turbidity, following sediment mobilisation by storms and other events. An increase in suspended solids at the pressure benchmark may have negative impacts on growth and fecundity, by reducing filter-feeding efficiency and imposing costs on clearing. Biotope resistance is assessed as 'Medium', as there may be some shift in the structure of the biological assemblage, and resilience is assessed as 'High' (following restoration of typical conditions). Biotope sensitivity is assessed as 'Low' (Tillin, 2016b).
	A5.135	High	High	**Not sensitive**	No direct evidence was found to assess impacts on the characterising and associated species. The characterising, suspension-feeding bivalves are not predicted to be sensitive to

Broadscale habitat	Biotope (EUNIS level 4)	Resistance (tolerance)	Resilience (recovery)	Sensitivity	Justification
					decreases in turbidity and may be exposed to, and tolerant of, short-term increases in turbidity, following sediment mobilisation by storms and other events. An increase in suspended solids at the pressure benchmark may have negative impacts on growth and fecundity, by reducing filter-feeding efficiency and imposing costs on clearing. However, the key characterising and denominated species *Glycera* is a scavenger/predator and is unlikely to be adversely affected by changes in suspended solids. Biotope resistance and resilience are therefore assessed as 'High', and the biotope considered 'Not Sensitive' (Tillin, 2016c).
	A5.145	High	High	**Not sensitive**	Resistance is assessed as 'High', and resilience as 'High' (no effect to recover from). This group is therefore assessed as 'Not sensitive' (Tillin, 2016d).
Sublittoral sand	A5.242	Medium	High	**Low**	No direct evidence was found to assess effects on the characterising and associated species. The characterising, suspension-feeding bivalves are not predicted to be sensitive to decreases in turbidity and may be exposed to, and tolerant of, short-term increases in turbidity, following sediment mobilisation by storms and other events. An increase in suspended solids at the pressure benchmark may have negative effects on growth and fecundity, by reducing filter-feeding efficiency and imposing costs on clearing. Biotope resistance is assessed as 'Medium', as there may be some shift in the structure of the biological assemblage, and resilience is assessed as 'High' (following restoration of typical conditions). Biotope sensitivity is assessed as 'Low' (Tillin and Rayment, 2016; Tillin, 2016a; Tillin and Budd, 2016; Tillin, 2022).
	A5.251	Medium	High	**Low**	
	A5.252	Medium	High	**Low**	
	A5.261	Medium	High	**Low**	

Broadscale habitat	Biotope (EUNIS level 4)	Resistance (tolerance)	Resilience (recovery)	Sensitivity	Justification
Sublittoral mud	A5.351	High	High	**Not sensitive**	An increase in the suspended matter settling out from the water column, to the substratum, may increase food availability. On the other hand, decreased siltation is unlikely to affect the mainly deposit-feeding community that occur in this biotope. Resistance of the biotopes is likely to be 'High', but with low confidence, as no direct evidence was found. Resistance is likely to be 'High' (by default) and the biotope is, therefore, assessed as 'Not sensitive' to a change in suspended solids at the pressure benchmark level (De Bastos and Hill, 2016).
	A5.355	High	High	**Not sensitive**	Resistance and resilience of the biotope are assessed as 'High', so the biotope is considered 'Not Sensitive' to a change in suspended solids at the pressure benchmark level (De Bastos, 2016).
	A5.361	High	High	**Not sensitive**	If feeding is reduced, by increases in suspended sediment, the viability of the population would be reduced. Once siltation levels return to normal, feeding would be resumed, therefore, recovery would be immediate. Similarly, burrowing megafauna are unlikely to be affected adversely by changes in suspended sediment in the water column. Overall, resistance is probably 'High', hence, resilience is also 'High', and the sea-pens are probably 'Not sensitive' at the benchmark level (Hill *et al.*, 2020).
Underwater noise changes					
Sublittoral coarse sediment	A5.133	**Not relevant**			
	A5.135	**Not relevant**			
	A5.145	**Not relevant**			

Broadscale habitat	Biotope (EUNIS level 4)	Resistance (tolerance)	Resilience (recovery)	Sensitivity	Justification
Sublittoral sand	A5.242	**Not relevant**			
	A5.251	**Not relevant**			
	A5.252	**Not relevant**			
	A5.261	**Not relevant**			
Sublittoral mud	A5.351	**Not relevant**			
	A5.355	**Not relevant**			
	A5.361	**Not relevant**			
Introduction or spread of invasive non-indigenous species					
Sublittoral coarse sediment	A5.133	None	Very low	**High**	The sediments characterizing this biotope are likely to be too mobile, or otherwise unsuitable, for most of the recorded invasive, non-indigenous, species currently recorded in the UK. The slipper limpet may colonise this habitat, resulting in habitat change and, potentially, biotope reclassification. *Didemnum* sp. and non-native predatory gastropods may also emerge as a threat to this biotope, although more mobile sands may exclude *Didemnum*. Based on *Crepidula fornicata*, biotope resistance is assessed as 'None' and resilience as 'Very low' (as removal of established non-natives is unlikely), so biotope sensitivity is assessed as 'High' (Tillin, 2016b).
	A5.135	None	Very low	**High**	The sediments characterising this biotope are likely to be too disturbed, or otherwise unsuitable, for most of the recorded invasive, non-indigenous, species currently recorded in the UK. However, the slipper limpet may colonise this habitat, resulting in habitat change and, potentially, reclassification of the biotope. *Didemnum* sp. and non-native predatory gastropods may also emerge as a threat to this biotope, although more mobile sands

Broadscale habitat	Biotope (EUNIS level 4)	Resistance (tolerance)	Resilience (recovery)	Sensitivity	Justification
					may exclude *Didemnum*. Based on *Crepidula fornicata*, biotope resistance is assessed as 'None' and resilience as 'Very low' (as removal of established non-natives is unlikely), so biotope sensitivity is assessed as 'High' (Tillin, 2016c).
	A5.145	**No evidence**			
Sublittoral sand	A5.242	None	Very low	**High**	The sediments characterising these biotopes are likely to be too mobile, or otherwise unsuitable, for most of the recorded invasive, non-indigenous, species currently recorded in the UK. However, the slipper limpet may colonise these habitats, resulting in habitat change and, potentially, biotope reclassification. *Didemnum* sp. and non-native predatory gastropods may also emerge as a threat to these biotopes, although more mobile sands may exclude *Didemnum*. Based on *Crepidula fornicata,* biotope resistance is assessed as 'None' and resilience as 'Very low' (as removal of established non-natives is unlikely), so that biotope sensitivity is assessed as 'High' (Tillin and Rayment, 2016; Tillin 2016a; Tillin and Budd, 2016; Tillin, 2022).
	A5.251	None	Very low	**High**	
	A5.252	None	Very low	**High**	
	A5.261	None	Very low	**High**	
Sublittoral mud	A5.351	**No evidence**			
	A5.355	**No evidence**			
	A5.361	**No evidence**			
Water flow (tidal current) changes (local)					
Sublittoral coarse sediment	A5.133	High	High	**Not sensitive**	These biotopes occur in areas subject to moderately strong water flows and these are a key factor maintaining the clean sand habitat. Changes in water flow may alter the topography of the habitat and may cause some shifts in abundance. However, a
	A5.135	High	High	**Not sensitive**	

Broadscale habitat	Biotope (EUNIS level 4)	Resistance (tolerance)	Resilience (recovery)	Sensitivity	Justification
	A5.145	High	High	**Not sensitive**	change at the pressure benchmark (increase or decrease) is unlikely to affect biotopes that occur in mid-range flows and biotope resistance is, therefore, assessed as 'High' and resilience is assessed as 'High', so the biotope is considered to be 'Not sensitive' (Tillin, 2016b; Tillin, 2016c; Tillin, 2016d).
Sublittoral sand	A5.242	High	High	**Not sensitive**	These biotopes occur in areas subject to moderately strong water flows and these are a key factor maintaining the clean sand habitat. Changes in water flow may alter the topography of the habitat and may cause some shifts in abundance. However, a change at the pressure benchmark (increase or decrease) is unlikely to affect biotopes that occur in mid-range flows and biotope resistance is, therefore, assessed as 'High' and resilience is assessed as 'High' so that the biotope is considered to be 'Not sensitive' (Tillin and Rayment, 2016; Tillin, 2016a; Tillin and Budd, 2016; Tillin, 2022).
	A5.251	High	High	**Not sensitive**	
	A5.252	High	High	**Not sensitive**	
	A5.261	High	High	**Not sensitive**	
Sublittoral mud	A5.351	High	High	**Not sensitive**	Sand particles are most easily eroded, and likely to be eroded, at about 0.20m/s. Although having a smaller grain size than sand, silts and clays require greater critical erosion velocities, because of their cohesiveness. The biotope occurs in stable areas of very weak (negligible) and weak (>0.5m/s) tidal streams. Although changes in water flow (above the benchmark) would be likely to change the sedimentary regime in the biotope, the cohesive nature of the sandy muds that characterise the biotope is likely to provide some protection to changes in water flow at the pressure benchmark. Additionally, the characterising species are likely to resist an increase in water flow at the benchmark level. Resistance and resilience are, therefore, assessed as 'High', and the biotopes considered 'Not Sensitive' to a change in water flow at the pressure benchmark level (De Bastos and Hill, 2016).

Broadscale habitat	Biotope (EUNIS level 4)	Resistance (tolerance)	Resilience (recovery)	Sensitivity	Justification
	A5.355	High	High	**Not sensitive**	Sand particles are most easily eroded, and likely to be eroded, at about 0.20m/s. Furthermore, a change in water flow could potentially change the sediment type, given that the cohesive nature of muddy sediments is likely to be lessened in this biotope, due to its high sand content (approx. 50%) and due to the instability resulting from feeding and sediment reworking activities of *Lagis koreni*. However, the biotope occurs in sandy muds in strong, moderately strong, weak and very weak tidal steams, and a change at the benchmark level of 0.1-0.2m/s is likely to fall within the range experienced by the biotope. Resistance and resilience are, therefore, considered to be 'High' and the biotope is assessed as 'Not Sensitive' to a change in water flow rate at the pressure benchmark level (De Bastos, 2016).
	A5.361	Low	Low	**High**	The biotope occurs in weak to negligible flow, so that a decrease in flow is not relevant. An increase in flow is probably directly detrimental to sea-pens and may alter the sediment type in the long-term. An increase in water flow of 0.1-0.2m/s for a year may result in an increase in overall flow, outside the preferred range for the sea-pens, depending on location. Therefore, an increase in water flow may result in the removal, or death, of a proportion of the population of *Virgularia mirabilis*, and as the other sea-pens are probably less tolerant of change, a resistance of 'Low' is suggested, with a resilience of 'Low', resulting in a sensitivity of 'High' (Hill *et al.*, 2020).

Broadscale habitat	Biotope (EUNIS level 4)	Resistance (tolerance)	Resilience (recovery)	Sensitivity	Justification
Wave exposure changes (local)					
Sublittoral coarse sediment	A5.133	High	High	**Not sensitive**	The range of wave exposures experienced by this biotope is considered to indicate, by proxy, that the biotope would have 'High' resistance and, by default, 'High' resilience to a change in significant wave height at the pressure benchmark. The biotope is therefore classed as 'Not sensitive' (Tillin, 2016b).
	A5.135	High	High	**Not sensitive**	This biotope is defined by an energetic hydrographic regime. A decrease in wave exposure could potentially allow for the development of a more stable community, leading to reclassification of the biotope to a more diverse version. However, the biotope occurs in a range of wave exposures, and a change at the pressure benchmark level (3-5% in significant wave height) is considered to fall within the natural range experienced by the biotope, so that resistance and resilience are assessed as 'High', and the biotope is, therefore, classed as 'Not sensitive' (Tillin, 2016c).
	A5.145	High	High	**Not sensitive**	The range of wave exposures experienced by the biotope is considered to indicate, by proxy, that the biotope would have 'High' resistance and, by default, 'High' resilience to a change in significant wave height at the pressure benchmark. The biotope is, therefore, classed as 'Not sensitive' (Tillin, 2016d).
Sublittoral sand	A5.242	High	High	**Not sensitive**	The range of wave exposures experienced by this biotope, and similar infralittoral and circalittoral biotopes, is considered to indicate, by proxy, that the biotope would have 'High' resistance and, by default, 'High' resilience to a change in significant wave height at the pressure benchmark. The biotope is, therefore, classed as 'Not sensitive' (Tillin and Rayment, 2016; Tillin, 2016a; Tillin and Budd, 2016; Tillin, 2022).
	A5.251	High	High	**Not sensitive**	
	A5.252	High	High	**Not sensitive**	

Broadscale habitat	Biotope (EUNIS level 4)	Resistance (tolerance)	Resilience (recovery)	Sensitivity	Justification
	A5.261	High	High	**Not sensitive**	
Sublittoral mud	A5.351	High	High	**Not sensitive**	No direct evidence of the specific tolerances of the characterising species to changes in wave exposure was found. A Force 8 Gale could result in oscillatory wave induced water flow at 80m of 0.09m/s, or ca0.4 m/s at 50m. A change in significant wave height of 3-5% is roughly equivalent to a change from force 3-4. Therefore, it is unlikely to be significant in deep water biotopes. This biotope occurs in moderately exposed conditions, and a change at the benchmark level is likely to fall within the range experienced by this particular biotope. Resistance and resilience are, therefore, assessed as 'High', and the biotope is considered 'Not sensitive' at the benchmark level.
	A5.355	High	High	**Not sensitive**	Records indicate that the biotope occurs in a range of wave exposures, including exposed and moderately wave exposed conditions. However, wave action reduces with depth, and the biotope occurs below 10m, where wave mediated flow would be reduced. Although the evidence suggests that the characterising species are excluded from areas of intense disturbance, and are likely to be dislodged by increased disturbance, a change in wave height at the pressure benchmark is unlikely to be significant. Resistance and resilience are, therefore, assessed as 'High', and the biotope is considered 'Not sensitive' at the benchmark level (De Bastos, 2016).
	A5.361	High	High	**Not sensitive**	An increase in wave exposure is likely to affect sea-pen species adversely, limiting or removing the shallower proportion of the population, and potentially modifying sediment and, therefore, habitat preferences in the longer-term. In some cases, areas suitable for *Pennatula phosphorea* and *Funiculina quadrangularis*

Broadscale habitat	Biotope (EUNIS level 4)	Resistance (tolerance)	Resilience (recovery)	Sensitivity	Justification
					may become more suitable for *Virgularia mirabilis*. However, a 3-5% increase in significant wave height (the benchmark) is unlikely to be significant. The benchmark level of change may be no more than expected during winter storms, even in the sheltered waters favoured by this biotope. Alternatively, such a small change in wave action may not penetrate to the depths at which this biotope occurs. Therefore, resistance is recorded as 'High' at the benchmark level. Hence, resilience is 'High', and the biotope is assessed as 'Not sensitive' at the benchmark level (Hill *et al.*, 2020).

3 References

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