6 MARINE ENVIRONMENT

Introduction

6.1 This Chapter addresses the impacts of the construction and operation of the Pembroke Dock Infrastructure (PDI) project on marine environmental receptors. The marine environment of the site has been grouped into: coastal processes, benthic ecology (intertidal and subtidal), fish and shellfish ecology, and marine mammals (including otter). Pembroke Port is referred to throughout the chapter. By definition for this chapter only, Pembroke Port is defined as the area of Milford Haven Waterway adjacent to the site located between Carr Jetty and Ferry Terminal.

Assessment Methodology

Planning Policy Context

6.2 Chapter 5: Planning Policy describes the key legislation and policies relevant to overarching and strategic policy context for the PDI project. This section deals specifically with legislation and policy relevant to marine ecology.

6.3 The Welsh National Marine Plan area covers an area of 32,000 square kilometres of sea and 2,120 km of coastline. Welsh policy to protect and safeguard the marine environment has been prepared in line with national policy (Marine and Coastal Access Act, 2009) and delivered under the Well-being of Future Generations (Wales) Act 2015 and Environment (Wales) Act 2016. The overarching aim is to support the sustainable development of the Welsh marine area by taking account of the cumulative effects of all uses of the marine environment.

Planning Policy Wales

6.4 The Welsh Government published of Planning Policy Wales Edition 10 (PPW) in December 2018, states the main planning principles for coastal places, which reflect the principles of Integrated Coastal Zone Management, are to support urban and rural development whilst at the same time being aware of, and appropriately responsive to, the challenges resulting from the dynamic interaction of natural and development pressures in coastal areas (Welsh Government, 2018). An enhanced duty to protect biodiversity and the resilience of ecosystems was introduced under the Environment (Wales) Act 2016 and recognises the key role of the planning system in achieving this duty. To this end, planning strategies, policies and individual development proposals must consider the need to:

- Promote the conservation of biodiversity, in particular the conservation of wildlife and habitats;
- Ensure action in Wales contributes to meeting international responsibilities and obligations for biodiversity and habitats;
- Ensure statutorily designated sites are properly protected and managed;

- Safeguard protected species; and existing biodiversity assets from impacts which directly affect their nature conservation interests and compromise the resilience of ecological networks and the components which underpin them such as water and soil; and
- Seek enhancement of and improvements to ecosystem resilience by improving diversity, condition, extent and connectivity of ecological networks.

Draft Welsh National Marine Plan

6.5 The Welsh National Marine Plan was developed to provide a framework to support sustainable decision-making for the marine environment. The plan has overlapping objectives with PPW in terms of the protection of biodiversity and enhancement of resilience of marine ecosystems. This includes the goal to achieve or maintain Good Environmental Status (GES) in coastal and marine waters as required under the UK Marine Strategy. The plan includes policies specific to the ports sector and to dredging and disposal of sediments and highlights the potential impacts that could occur in relation to ports (Welsh Government, 2017). The plan also highlights the potential opportunities for building in beneficial biodiversity features as part of the project design and the need to consider mitigation where environmental impacts are predicted in order to ensure the risk of disturbance or damage to species or habitats is minimised.

Technical Advice Note 5: Nature Conservation and Planning

6.6 Technical Advice Note (TAN) 5 (Welsh Assembly Government, 2009) provides advice about how the land use planning system should contribute to protecting and enhancing biodiversity and geological conservation. The TAN provides advice for local planning authorities on:

- The key principles of positive planning for nature conservation;
- Nature conservation and Local Development Plans;
- Nature conservation in development management procedures;
- Development affecting protected internationally and nationally designated sites and habitats; and
- Development affecting protected and priority habitats and species.

Local Planning Policy

6.7 The Pembrokeshire Local Development Plan (LDP) adopted February 2013 is the Development Plan for the purposes of Section 38(6) of the Planning and Compulsory Purchase Act 2004 and is being reviewed currently and will be superseded by the Replacement LDP, anticipated in 2021.

6.8 Policy GN.37 relates to the protection and enhancement of biodiversity, and states:

"All development should demonstrate a positive approach to maintaining and, wherever possible, enhancing biodiversity. Development that would disturb or otherwise harm protected species or their habitats, or the integrity of other habitats, sites or features of importance to wildlife and individual species, will only be permitted in exceptional circumstances where the effects are minimised or mitigated through careful design, work scheduling or other appropriate measures".

6.9 The LDP Proposals Map for Pembrokeshire highlights key nature conservation designations that will need to be assessed in the preparation of planning applications. In particular, where there are potential impacts identified on the designated features of protected sites, these are considered to be material considerations and will be assessed in accordance with national policy and guidance. The LDP Proposals Map highlights the presence of designated sites in the vicinity of application site. The baseline assessment in this Chapter describes the protected sites and their designated features.

Biodiversity Action Plans

6.10 The following Biodiversity Action Plans are relevant to the assessment:

- UK Post-2010 Biodiversity Framework (Joint Nature Conservation Committee, 2012); and
- Pembrokeshire Local Biodiversity Action Plan (Pembrokeshire Biodiversity Partnership, 2000).

6.11 The UK Post-2010 Biodiversity Framework supersedes the UK Biodiversity Action Plan. In 2007 the UK Biodiversity Partnership published an updated list of priority UK species and habitats covering terrestrial, freshwater and marine biodiversity to focus conservation action for rarer species and habitats in the UK. The UK priority list contains 1150 species and 65 habitats. The UK list has been used as a reference to draw up the species and habitats of principal importance in Wales under Section 42 of the Natural Environment and Rural Communities (NERC) Act 2006.

Relevant Guidance

6.12 In addition to the policy documents, action plans and management plans set out above, the following relevant guidance has been referenced during the assessment:

- Guidelines for Ecological Impact Assessment in the UK and Ireland. Terrestrial, Freshwater and Coastal (Chartered Institute of Ecology and Environmental Management; CIEEM, 2016).

Study Area

6.13 The study area defined for the marine environment baseline was the Milford Haven Waterway (MHW) as there was a substantial amount of historical data available from various studies undertaken within the MHW. In addition, the available data were used to describe the ecology within the immediate vicinity of the Dockyard where possible. Where relevant, i.e. for highly mobile receptors such as cetaceans, the ecology of the wider region, along the Pembrokeshire coastline, was described.

Baseline Methodology

6.14 A baseline desktop study was undertaken to describe the marine environment of the study area. Historical data sources from various studies and monitoring campaigns throughout the MHW were collated and these are listed in Appendix 6.1: Marine Baseline.

6.15 Information on the physical sediment conditions, used to determine the benthic ecology biotope classification, was derived from historical data from National Resources Wales (NRW) and from site-specific sediment samples collected within the proposed dredge footprints. The site-specific samples were taken at four locations, including two locations within the Graving Dock within and two locations adjacent to the slipways at the Dockyard. Further details on the sampling methodology and data analyses are provided in Appendix 6.1: Marine Baseline.

Important Ecological Features (IEFs)

6.16 An assessment of the ecological effects of a proposed development focusses on 'important ecological features' (IEFs) (CIEEM, 2016). These are species and habitats that are valued in some way and could be affected by a proposed development; other valued ecological features may occur on or in the vicinity of the site of a proposed development but do not need to be considered because there is no potential for them to be affected significantly.

6.17 The value of ecological features is dependent upon their biodiversity, social, and economic value within a geographic framework of appropriate reference (CIEEM, 2016). The most straightforward context for assessing ecological value is to identify those species and habitats that have a specific biodiversity importance recognised through international or national legislation or through local, regional or national conservation plans (e.g. Annex I habitats under the Habitats Directive, OSPAR, Biodiversity Action Plan (BAP) habitats and species, habitats/species of principal importance listed under the NERC Act 2006 and habitats/species listed as features of Marine Conservation Zones (MCZs) / recommended MCZs (rMCZs)). However, only a very small proportion of marine habitats and species are afforded protection under the existing legislative or policy framework and therefore evaluation must also assess value according to the functional role of the habitat or species. For example, some features may not have a specific conservation value in themselves but may be functionally linked to a feature of high conservation value (e.g. prey species for protected marine mammal or bird species). Table 6.1 shows the criteria applied to determining the ecological value of IEFs.

Receptor Sensitivity/Value

Table 6.1: Criteria Used to Define the Value of Receptors.

Value	Typical Descriptors
Very High	Internationally designated sites. Habitats and species protected under international law (i.e. Annex I habitats within a SAC boundary or Annex II species associated with a SAC in the study area).
High	Nationally designated sites. Species protected under national law. Annex I habitats outside a SAC boundary. Annex II species though not associated with a SAC within the study area. UK BAP priority habitats and species, NERC habitats and species of principal importance in Wales, and Nationally Important Marine Species that have nationally important populations within the study area, particularly in the context of species/habitat that may be rare or threatened in the UK. Habitats and species that are features of MCZs and rMCZs (i.e. broad-scale habitats and Features of Conservation Importance (FOCI)).

Medium	UK BAP priority habitats, NERC habitats and species of principal importance in Wales, or Nationally Important Marine Species that have regionally important populations within the study area (i.e. are locally widespread and/or abundant). Habitats or species that provide important prey items for other species of conservation or commercial value.
Low	Habitats and species which are not protected under conservation legislation which form a key component of the marine ecology within the study area.
Negligible	Habitats and species of very local importance only.

Consultation

6.18 A summary of the consultation responses from stakeholders or consultees in relation to the proposed scope of the marine ecology assessment, as presented in the Scoping Report (RPS, 2018), is set out in Table 6.2.

Table 6.2 Consultation Responses Relevant to Marine Ecology

Date	Consultee	Issues Raised	How/ Where Addressed
10 August 2012	Marine Consents Unit (MCU), Welsh Government:	Requirement for site-specific sediment sampling	Licence to undertake subtidal grab samples issued by National Resources Wales Marine Licensing Team (NRW-MLT) on 14th May 2018. Sediment samples used to inform baseline assessment (paragraphs 6.3.15 - 6.3.19).
4 October 2018	Natural Resources Wales - Screening and Scoping Opinion	Increases in sedimentation and resuspension of sediment bound contaminants from dredge disposal are to be addressed including impacts to fisheries and shellfisheries, designated shellfish waters, and intertidal and subtidal habitats	Impacts from an increase in suspended sediments is identified as part of paragraph 6.5.2 - 6.5.8 including impacts on Fisheries and Shellfish and intertidal and subtidal habitats area addressed in paragraphs 6.5.19 - 6.5.24.
4 October 2018	Natural Resources Wales - Screening and Scoping Opinion	Potential for sediment contamination within slipway, Graving Dock and Timber Pond requiring sediment sampling and analysis in accordance with OSPAR requirements and comparison to the Centre for Environmental Fisheries and Aquaculture (Cefas) action criteria to determine suitability for dredging and disposal offshore.	Sediment quality data including assessment against Cefas action criteria from collection of sediment samples within each identified area's is presented in paragraphs 6.3.15 - 6.3.19. Determination of suitability for dredging and disposal of sediments is presented in paragraphs 6.3.21 and 6.5.26 - 6.5.30.
4 October 2018	Natural Resources Wales - Screening and Scoping Opinion	Consideration for release of contaminants from land-based construction activities into the water column	The potential for contaminant release from land-based construction activities has been included in paragraph 6.5.31.
4 October 2018	Natural Resources Wales - Screening and Scoping Opinion	Noise sources should be accurately identified as either continuous (shipping, vibropiling) or impulsive (percussive piling, UXO detonation) and the correct respective metrics must be used.	Underwater noise sources have been detailed and categorised as continuous (non-impulsive or impulsive in paragraphs 6.5.42 - 6.5.49
4 October 2018	Natural Resources Wales - Screening and Scoping Opinion	Zones of influence must be constructed carefully according to the relevant receptor response thresholds – these must be informed by the most recent and relevant resources such as the US	Specified threshold criteria has been presented in Table 6.15 and Table 6.16 for marine mammals and Table 6.20, Table 6.21 and Table 6.22 for fish.

Date	Consultee	Issues Raised	How/ Where Addressed
		National Marine Fisheries Service (NMFS; NOAA) (2016) for marine mammals and Popper *et al.* (2014) for fish.	
4 October 2018	Natural Resources Wales - Screening and Scoping Opinion	From a cumulative perspective the potential threat is the impact of any activity further downstream at Milford Haven, in that migratory or travelling receptors may be exposed to stress from both the proposed works, and any existing works in the surrounding area	A cumulative assessment has been included in section 6.12.
4 October 2018	Natural Resources Wales - Screening and Scoping Opinion	Marine receptors have been scoped in to further assessment, this includes the specific mention of underwater noise impacts to fish and marine mammals. Underwater noise can have a range of effects on marine fauna, including masking of biologically important sound, auditory injury (permanent threshold shift [PTS] or temporary threshold shift [TTS]), and in extreme cases, direct or indirect mortality.	Impact assessment on fish and marine mammals has been included in paragraphs 6.5.42 to 6.5.84.
4 October 2018	Natural Resources Wales - Screening and Scoping Opinion	The report states in section 5.52 that "General activities will be considered qualitatively, and numerical assessments will be undertaken for significant works, such as piling". This section requires further clarification. Will a desk-based assessment be conducted for 'non-significant' activities, and that some form of modelling will be undertaken for 'significant' works? The use of the word 'significant' is also confusing given that it could be argued that this has been used in place of 'harmful' or 'percussive'. There may be other various noise sources proposed which would also warrant numerical assessment.	Numerical modelling has been undertaken to assess the impacts of both non-impulsive and impulsive underwater noise sources identified during construction of the project with the results presented in detail in Appendix 6.2 and in summary in paragraphs 6.5.42 to 6.5.84.
4 October 2018	Natural Resources Wales - Screening and Scoping Opinion	Excavation is proposed with the proviso that some removal of subsurface hard rock might be required. This also has the potential to generate additional underwater noise into the water column which must be assessed in the ES.	Impacts of underwater noise from dredging activities have been assessed in paragraphs 6.5.42 to 6.5.84.
4 October 2018	Natural Resources Wales - Screening and Scoping Opinion	Assessment: Considering the potential for these works to introduce significantly increased levels of noise into the marine environment, it is expected some form of underwater noise modelling will be undertaken. This is especially pertinent given the number of protected sites and species which might be affected by these works, and the relatively narrow width of the river.	Numerical modelling has been undertaken to assess the impacts of both non-impulsive and impulsive underwater noise sources identified during construction of the project with the results presented in detail in Appendix 6.2 and in summary in paragraphs 6.5.42 to 6.5.84.
4 October 2018	Natural Resources Wales - Screening and Scoping Opinion	The applicant should consult the most recent and relevant literature in conducting their EIA, for marine mammals this comprises NOAA (2016) and for fish this comprises Popper *et al.* (2014).	Specified threshold criteria including other relevant references have been presented in Table 6.15 and Table 6.16 for marine mammals and Table 6.20, Table 6.21 and Table 6.22 for fish.

Assessment Criteria and Assignment of Significance

6.19 The criteria for determining the significance of effects is a two-stage process that involves defining the sensitivity of the receptors and the magnitude of the impact on these receptors. The effect, and the significance level of that effect, is determined by correlating the magnitude of the impact to the sensitivity of the receptor.

Magnitude of Impact

6.20 The magnitude of an impact was determined using the criteria presented in Table 6.3.

Table 6.3 Criteria for Determining the Magnitude of An Impact.

Magnitude	Typical Descriptors
High	Loss of resource and/or quality and integrity of resource; severe damage to key characteristics, features or elements (Adverse).
	Large scale or major improvement of resource quality; extensive restoration or enhancement; major improvement of attribute quality (Beneficial).
Medium	Loss of resource, but not adversely affecting the integrity; partial loss of/damage to key characteristics, features or elements (Adverse).
	Benefit to, or addition of, key characteristics, features or elements; improvement of attribute quality (Beneficial).
Low	Some measurable change in attributes, quality or vulnerability; minor loss of, or alteration to, one (maybe more) key characteristics, features or elements (Adverse).
	Minor benefit to, or addition of, one (maybe more) key characteristics, features or elements; some beneficial impact on attribute or a reduced risk of negative impact occurring (Beneficial).
Negligible	Very minor loss or detrimental alteration to one or more characteristics, features or elements (Adverse).
	Very minor benefit to or positive addition of one or more characteristics, features or elements (Beneficial).
No change	No loss or alteration of characteristics, features or elements; no observable impact in either direction.

Sensitivity of the Receptors

6.21 The baseline assessment has been used to identify several IEFs for each of the broad groups assessed in this chapter (see paragraph 6.2.16 *et seq.*). Each of the IEFs has subsequently been assigned a value according to the importance of that receptor in the context of their biodiversity, social and economic value within the defined study area (see Table 6.4). The sensitivity of the IEFs takes into consideration this biodiversity/social/economic value and considers the vulnerability of the IEF to the impact and the potential for recovery of the IEF following cessation of the impact.

Table 6.4 Criteria and definitions of sensitivity for IEFs in this assessment.

Sensitivity	Typical Descriptors
Very High	Receptors of very high or high value and with high vulnerability and no ability for recovery.
High	Receptors of medium value with high vulnerability and no ability for recovery. Receptors of very high or high value with high vulnerability and low recoverability.
Medium	Receptors of low value with high vulnerability and no ability for recovery. Receptors of medium value with medium to high vulnerability and low recoverability.

	Receptors of very high or high important receptors with medium vulnerability and medium recoverability.
Low	Receptors of low value with medium to high vulnerability and low recoverability. Receptors of medium value with low vulnerability and medium to high recoverability. Receptors of very high or high value with low vulnerability and high recoverability.
Negligible	Receptor is not vulnerable to impacts regardless of value/importance. Receptors of low value with low vulnerability and medium to high recoverability.

Significance of Effects

6.22 The significance of the effect upon marine ecology and nature conservation is determined by correlating the magnitude of the impact and the sensitivity of the receptor. The specific method employed for this assessment is presented in Table 6.5. In cases where a range is suggested for the significance of effect (e.g. the range is given as minor to moderate), the final significance is based upon the expert's professional judgement as to which outcome delineates the most likely effect, with an explanation to be provided within the assessment to justify the final significance level assigned.

6.23 For the purposes of this assessment, any effects with a significance level of minor or less have been concluded to be not significant in terms of the EIA Regulations unless otherwise stated.

Table 6.5: Assessment Matrix for Determining the Significance of The Effect

		Magnitude of Impact				
		No change	**Negligible**	**Low**	**Medium**	**High**
Sensitivity of Receptor	**Negligible**	Negligible	Negligible	Negligible or minor	Negligible or minor	Minor
	Low	Negligible	Negligible or minor	Negligible or minor	Minor	Minor or moderate
	Medium	Negligible	Negligible or minor	Minor	Moderate	Moderate or major
	High	Negligible	Minor	Minor or moderate	Moderate or major	Major or substantial
	Very high	Negligible	Minor	Moderate or major	Major or substantial	Substantial

6.24 Following the approach described in Chapter 4: Environmental Assessment Methodology, the levels of significance have been defined as:

- Substantial: Only adverse effects are normally assigned this level of significance. They represent key factors in the decision-making process. These effects are generally, but not exclusively, associated with sites or features of international, national or regional importance that are likely to suffer a most damaging impact and loss of resource integrity. However, a major change in a site or feature of local importance may also enter this category.

- Major: These beneficial or adverse effects are considered to be very important considerations and are likely to be material in the decision-making process.

- Moderate: These beneficial or adverse effects may be important but are not likely to be key decision-making factors. The cumulative effects of such factors may influence decision-making if they lead to an increase in the overall adverse effect on a particular resource or receptor.
- Minor: These beneficial or adverse effects may be raised as local factors. They are unlikely to be critical in the decision-making process but are important in enhancing the subsequent design of the project.
- Negligible: No effects or those that are beneath levels of perception, within normal bounds of variation or within the margin of forecasting error.

Impacts to Coastal Processes

6.25 The scoping document (RPS, 2018) identified the potential for coastal processes to be affected by the project including increases in suspended sediment concentrations and changes to the hydrodynamic regime. The scoping document lists coastal processes as an individual chapter to discuss potential impacts. Following further consideration and for the purposes of ensuring consistency, proportionality and coherence on assessing impacts from the project on identified marine receptors, these elements are now considered within this chapter. This is because changes to each impact pathway ultimately may result in an impact to an end receptor such as a specific species or habitat. Consequently, an assessment of the impact of the project on each of these elements has now been included within relevant impact magnitude sections in this chapter rather than a standalone Coastal Processes ES chapter.

Limitations of the Assessment

6.26 This assessment is based on the results of a desktop study only. Except for the site-specific sediment sampling for sediment contamination, no site-specific surveys have been undertaken to inform the marine environment assessment. Although the data can be considered 'historic' there was a large amount of information from various field studies within the MHW as this estuary has been extensively studied over many years with corroborating evidence regarding the habitats and species present within the region. The data is therefore considered to provide a robust baseline against which to assess impacts.

Baseline Description

6.27 A summary of the existing marine environment conditions of the study area has been provided below for geomorphology and bathymetry, wave and tidal regime, water quality, sediment quality, benthic ecology, fish and shellfish ecology and marine mammals. A detailed account of the baseline is provided in Appendix 6.1: Marine Baseline.

Geomorphology and Bathymetry

6.28 The geology of the MHW consists of the red marls of the old red sandstone of Devonian age. These comprise siltstones and silty fine sandstones interbedded with fine to coarse sandstone horizons, formed as a result of the east-west alignment of major folding and faulting within the bedrock. The landscape was subjected to considerable changes through the result of ice ages, with meltwater further deepening existing river valleys.

6.29 The MHW is a deep macro-tidal ria estuary believed to have been created by the flooding of the Daugleddau river valley during the sea level rise at the end of the last Ice Age (Halcrow, 2012). The MHW main tidal channel is deep, with a typical depth of 20 m between the mouth and the Cleddau Bridge and a typical depth of 10 m upstream of the Cleddau Bridge to the confluence at Lawrenny Quay (Halcrow, 2012).

6.30 The topography of the seabed within the Milford Haven Waterway (MWH) is dominated by rugged, mainly igneous, but also sandstone and limestone, rocky reefs. Many rise to considerable heights above the surrounding deep seabed, some forming islands and islets. Between the elevated areas of seabed are extensive undulating areas of rock, such as west of the Dale peninsula, and plains and gentle slopes of sediments.

6.31 MHW comprises of a high proportion of hard substrates, flanked by areas in which there are substantial thicknesses of mud (Hobbs and Morgan, 1992). Near the mouth of the MHW, which is considered the most exposed part of the waterbody, the intertidal and subtidal areas are largely coarse sediments and bedrock, while further east where wave action is reduced, intertidal and subtidal areas are characterised more by muddy sediments. These areas of mud predominantly derive from the rivers flowing into MHW, which have accumulated primarily in sheltered mudflats, including the area between Carr Jetty (immediately to the west of the Dockyard) and Hobbs Point (to the east of the Dockyard). A substantial area of coarser sediment has been noted in the central MHW extending from Newton Noyes (to the east of the town of Milford Haven) to Carr Jetty.

Wave and Tidal Regime

6.32 The mean tidal range within the MHW varies from 6.3 m during spring tides and 2.7 m during neap tides. The tidal excursion (the horizontal distance along the estuary that a particle moves during one tidal cycle of ebb and flood) varies along the length of the estuary but increases by a magnitude of 2 between neap and spring tides. The tides in the MHW flow east during flood periods and west on the ebb with highest tidal currents is found within the central channel of the MHW. During spring tides minimum tidal flows occur around slack water (i.e. six hours before High Water (HW)) increasing to a maximum of 1.5 knots approximately 3 hours before HW. On neap tides, maximum tidal flows of up to 0.7 knots are observed approximately 2.5 hours before HW. These high tidal flows can act as transportation mechanisms for suspended sediments within the water column.

6.33 The wave and tidal regime in the immediate vicinity of the Dockyard is affected by local geological and hydrodynamic processes. The Dockyard is situated on the outside meander of the Daugleddau river and where the river opens into the MHW. Carrs Rock, immediately to the west of Carr Jetty, part of the Dockyard, is a submerged bedrock feature deflecting tidal currents. Hobbs point, to the east of the Dockyard, is a headland providing shelter in its lee. Both geological features force the tidal currents to the northern side of the MHW and away from the Dockyard, resulting in a relatively low energy environment, evidenced by the mudflats present to the east of the Dockyard.

Water Quality

Salinity

6.34 There is a complex, dynamic salinity regime with in MHW. Data suggests that offshore salinity remains relatively constant between 34.5-35‰ although some data indicates that inshore salinity is more variable, falling to 33.5‰ during winter months and rising to 36‰ in summer months (NRW, 2018).

Dissolved Oxygen

6.35 Available data suggests water column dissolved oxygen is generally 100% saturation though recent survey data suggests that parts of MHW suffers levels as low as 86% (NRW, 2018).

Suspended Sediment Concentrations

6.36 There is limited sediment input from offshore areas and the rivers that flow into the MHW, with anthropogenic factors identified as the primary source of sediment disturbance. Chronic sediment disturbance and re-suspension occur due to the continual development and industry throughout the MHW. Demolition of disused jetty structures, runoff from land disturbed, pile-driving for construction, propeller wash and bow-waves of tankers, tugs, ferries, cargo and fishing vessels, by shellfish and bait-digging, and small vessel mooring have been found to be sources of sediment re-suspension. A major ongoing anthropogenic cause of sediment re-suspension within the MHW is likely to be periodic dredging as part of the capital and maintenance dredging operations by MHPA. Sediments re-suspended affect water transparency and therefore influence biotic processes.

6.37 Near the Dockyard, the suspended sediment concentrations (SSC) as measured by the turbidity and water transparency were found to be dependent on biogenic and anthropogenic factors. Turbidity data recorded in 2012 found that values ranged between a minimum of 2.3 formazin turbidity units[1] (FTU) and a maximum of 19 FTU with a mean value over the period of 9.5 FTU. Turbidity peak values were recorded in spring and may have coincided with phytoplankton blooms, with lower values recorded during summer months potentially due to low rainfall and decreasing current speeds. Water transparency, determined by a Secchi disk, is dependent on particulate matter and dissolved substances in the water. Recorded values between 2009 and 2011 ranged from 1.2 m to 3.1 m.

Nutrients and Contaminants

6.38 Nutrient and contaminant levels are variable throughout the site. Highly dynamic water movement maintains levels of many contaminants below detectable limits although low level chronic hydrocarbon residues are present in sediment sink areas in MWH (Little *et al.,* 2015). Coastal

1 The FTU is used to determine the concentration of suspended particles in a sample of water by measuring the incident light scattered at right angles from the sample.

waters are known to have raised levels of nutrients as a consequence of diffuse agricultural sources as measured by the recent Surveying the Waterway Environment for Pollution Threats (SWEPT) project (awaiting publication). MHW has high levels of nutrients although comparison to background levels for open coasts suggest they are comparable (NRW, 2018). Water column contaminant concentrations and fluxes are poorly known. Available data suggest that these too are comparable with typical inshore background levels of Pembrokeshire (NRW, 2018).

Sediment Quality

Physical Characteristics

6.39 Marine sediments below Mean High Water Spring (MHWS) within Pembroke Port comprise mud and sand fractions. Four samples collected adjacent to the existing slipway and within the Graving Dock consisted of 74% mud with sand fractions constituting the remaining 26%. These results are typical of the sediments found in low energy environments within the MHW which are characterised by low tidal currents and reduced wave action.

Contaminants

6.40 Sediment quality has been monitored in MHW since 1998 for hydrocarbons and heavy metals, following the Sea Empress spill occurring at the mouth in 1996. Data from 2007 to 2010 found that most of the sediment contaminant concentrations, including Polyaromatic Hydrocarbon (PAH) concentrations, have generally decreased. Long-term average hydrocarbon concentrations are marginally elevated over near-shore coastal background levels. Elevated metal concentrations have been observed in the central industrialised section of the MHW and in known or inferred sediment sink areas attributed to chronic anthropogenic inputs such as propeller wash and bow-waves of tankers, tugs, ferries, cargo and fishing vessels, by shellfish and bait-digging, and by small vessel mooring. Contaminant levels in many of the estuarine inlets of MHW (e.g. Cosheston Pill, Angle, and Carew/Creswell) are above levels known to have adverse effects on biota.

6.41 Sediment samples were collected from four sites located within the proposed dredge areas to assist with understanding physicochemical properties of sediments proposed to be dredged and determine their suitability for disposal offshore. Samples were analysed by an accredited laboratory for a suite of contaminants and the results compared against Cefas Action Level 1 (AL1) and Cefas Action Level 2 (AL2) criteria. Cefas Action Levels are guideline criteria used as part of a weight of evidence approach to decision-making on the disposal of dredged material to sea. Contaminant levels found in dredged material below AL1 are of no concern and are unlikely to influence the licensing decision. However, dredged material with contaminant levels above AL2 are generally considered unsuitable for sea disposal. Dredged material with contaminant levels between AL1 and AL2 requires further consideration and testing before a decision can be made.

6.42 Sediment contamination data from sites located within areas proposed to be dredged indicate concentrations above AL1 for all heavy metals within the slipway footprint except for zinc which was elevated above AL2 at one of the sites. Within the Graving Dock area sediments displayed metal concentrations generally below AL1 except for chromium, nickel and zinc which were above AL1.

6.43 Organotin concentrations were found to be below the AL1 at all sites except for site 1 located within proposed slipway footprint. Site 1 was found exceed AL1 level for Dibutyltin and AL2 for Tributyltin.

6.44 PAH concentrations were below adopted guideline criteria for all sites and PCB concentrations were below the limit of detection at all sites and therefore below AL1 criteria for sum of 25 PCB congeners.

6.45 Total hydrocarbon concentrations were found to be above detection limits at all sites but were considered comparable to concentrations within the MWH ranging from 5 mg/kg to 34 mg/kg across all sites.

6.46 Generally, contaminant concentrations within MHW are correlated with either mud fractions or total Organic carbon (Little *et al.,* 2015). Contaminant concentrations were generally above the mean concentrations for the wider MHW area except for Cadmium (Little *et al.,* 2015).

Suitability for Offshore Disposal

6.47 Sediment contaminant concentrations indicate some low levels of contamination across both the slipway and Graving Dock area. It appears the sediments located within the slipway have higher contamination levels than those located within Graving Dock particularly for zinc and tributyl tin. Further assessment has been undertaken to determine the suitability of sediments for offshore disposal within paragraphs 6.5.26 - 6.5.30.

Intertidal Habitats

6.48 The MHW displays a variety of intertidal habitats with intertidal mudflat habitat being dominant. Sandy muddy shores (LSD.LMu.SMu) are typical of the substrate and characterised by the biotope *Hediste diversicolor* and *Streblospio shrubsolii* in littoral sandy mud (LS.LMU.Mu.HedStr) with a mosaic of shingle and algal species on the lower shore (LS.LGS/LR.Rkp.SwSed). Other soft sediment habitats include the intertidal mudflats located within the Pembroke River which are predominantly characterised by *Hediste diversicolor* and *Limecola balthica* in littoral sandy mud (LS.LMU.SMu.HedMac) biotope on the fringes and either sides of the channel, and *Zostera noltii* beds in upper to mid shore muddy sand (LS.LMS.ZOS.Znol). Other habitats including those on the north shore, opposite the Pembroke Port include typical of moderately or low exposed rocky shore within the upper littoral zone. Dominant fauna includes acorn barnacles *Semibalanus balanoides* and *Austrominius modestus* LR.HLR.MusB.Sem.Sem, LR.HLR.MusB.Sem.LitX or LR.HLR.MusB.Sem biotopes (see Appendix 6.1 for further discussion).

6.49 The intertidal habitat in the immediate vicinity of the Pembroke Port is littoral mud and low energy littoral rock. Despite the presence of a narrow anoxic layer, the littoral mud substrate supports communities of polychaetes, oligochaetes and bivalves whilst the littoral rock communities are characterised by algae and epibenthic fauna (e.g. sponges, ascidians, and bivalves). Several biotopes have been identified from the Pembroke Port area and include *Ascophyllum nodosum* on full salinity mid eulittoral mixed substrata (LR.LLR.F.Asc.X), Cirratulids and *Cerastoderma edule* in littoral mixed sediment (LS.LMx.Mx.CirCer) and *Fucus serratus* with sponges, ascidians and red seaweeds on tide-swept lower eulittoral mixed substrata (LR.HLR.FT.FserTX). Within the Graving

Dock the common biotope was classified as *Hediste diversicolor* and *Limecola balthica* in littoral sandy mud (LS.LMu.MEst.HedMac).

6.50 There are two species of seagrass present in the MHW; namely eelgrass *Zostera marina* and dwarf eelgrass *Z. noltii*. A total of 181 ha seagrass occurs within the MHW, with the majority represented in the intertidal region by *Z. noltii*. A small patch (3.29 ha) of *Z. noltii* occurs at the eastern extent to Pembroke Port at Hobbs point, located 1100 m to the east of the proposed development area (Figure 6.1). Seagrass is a UK BAP Priority Habitat, Habitat of Principal Importance under the Environmental (Wales) Act 2016, and is a sub-feature of 'large, shallow inlets and bays' and 'estuaries.'

6.51 The Annex I habitats 'Mudflats and sandflats not covered by seawater at low tide' and intertidal 'Reef', as designated features of the Pembrokeshire Marine/Sir Benfro Forol SAC lie in proximity to Pembroke Port. The intertidal habitat supports a diversity of benthic flora and fauna, which in turn provides an important food resource for wildfowl and waders within the MHW. The SAC boundary is ~50 m from the proposed PDI development.

Intertidal Benthic Important Ecological Features (IEFs)

6.52 A summary of the intertidal benthic IEFs is provided below together with an assessment of their conservation value within the study area (Table 6.6).

Table 6.6 Intertidal Benthic Ecology IEFs in the PDI Study Area.

Benthic IEF	Representative Biotopes/ Species	Conservation Value Within The Study Area	Justification
Within the PDI Development Site			
Littoral sand and mud	LS.LMu.MEst.HedMac LS.LMx.Mx.CirCer	Medium	Intertidal mudflat is listed as a priority habitat for Wales.
Littoral rock	LR.HLR.FT.FserTX LR.LLR.F.Asc.X	Medium	Estuarine littoral rocky habitat is listed as a priority habitat for Wales.
Within the MHW Wider Region			
Annex I habitat 'Mudflats and sandflats not covered by seawater at low tide'	LS.LMU.Mu.HedStr LS.LMu.MEst.HedMac LS.LMS.ZOS.Znol	Very high	Annex I habitat protected under international legislation and designated feature of the Pembrokeshire Marine SAC.
Annex I habitat 'Reefs'	LR.Rkp.SwSed LR.HLR.MusB.Sem.Sem LR.HLR.MusB.Sem.LitX LR.HLR.MusB.Sem	Very high	Annex I habitat protected under international legislation and designated feature of the Pembrokeshire Marine SAC.
Eelgrass	*Z. noltii* (intertidal distribution)	Very high	Sub-feature of 'large, shallow inlets and bays' and 'estuaries.' Seagrass beds are listed as a priority habitat for Wales and have a regionally important distribution within the area.

Subtidal Benthic Habitats

6.53 The subtidal habitats of the MHW are represented by mixed sediments, reef, and eelgrass beds. Oligochaetes, polychaetes and amphipods characterise the mixed sediments with dominant species including *Paradoneis lyra, Pholoe synophthamica, Sphaerosyllis* spp. and the non-native amphipod *Corophium sextonae*. Bivalves, such as the white furrow shell *Abra alba* are abundant towards the mouth of the MHW. Subtidal reef habitat has a patchy distribution throughout the MHW and is typically characterised by algae and bivalves on hard substrate, for example, the biotope red seaweeds and kelps on tide-swept mobile infralittoral cobbles and pebbles (SS.SMp.KSwSS.LsacR.CbPb) has been recorded at reef habitat near the Cleddau bridge. The reef building polychaete *Sabellaria spinulosa* has also been noted within the MHW and in undisturbed areas may form reef structures.

6.54 There are three populations of the subtidal seagrass *Z. marina* within MHW, the largest of which lies 7 km to the west of Pembroke Port, located in Littlewick Bay on the northern shoreline of MHW. Two smaller populations of *Z. marina* lies approximately 3 km further from the Pembroke Port to the north west of the Littlewick Bay population, near Great Castle Head in Longoar Bay and Dale Bay located approximately 14 km to the west of Pembroke Port. *Zostera marina* is typically found on sand to fine gravel in depths of up to 5 m (Figure 6.1). Seagrass is a UK BAP Priority Habitat, Habitat of Principal Importance under the Environmental (Wales) Act 2016, and is a sub-feature of 'large, shallow inlets and bays', 'estuaries' and 'subtidal sandbanks' which are designated features of the Pembrokeshire Marine SAC.

6.55 Maerl beds are formed by slow-growing coralline algae and typically occur either on the open coast or in tide-swept channels of marine inlets. Maerl forms a unique habitat that supports a diverse assemblage of infauna and epifaunal species. A previously well-established maerl bed that has become degraded in recent years lies 7 km to 9 km to the west of Pembroke Port, in the vicinity of Littlewick Bay to Stack Rock (Figure 6.1). This is the only known living maerl bed in Wales, excluding small amounts of maerl not constituting a bed. Maerl is legally protected under several designations including Annex V (b) of the EC Habitats Directive (92/43/EEC) as amended in 2010 on the Conservation of Natural Habitats and of Wild Fauna and Flora, the UK BAP for the diversity of flora and fauna (1994), and the Welsh Government's Habitats and Species of Principal Importance for Wales list. Maerl is a sub-feature of 'large, shallow inlets and bays', 'estuaries' and 'subtidal sandbanks' which are designated features of the Pembrokeshire Marine SAC.

6.56 The subtidal substrate near to Pembroke Port is mixed with varying proportions of silt/clay, fine sand, course sand and shells and cobble and rocky reef. Subtidal benthic ecological communities in this area are characterised by annelids, bivalves, and green and brown algae. A recent review of data collected between 2008 to 2017 found that the most abundant species near the Pembroke Port were the polychaetes *Melinna palmata* and *Chaetozone gibber*, seed shrimps O*stracoda* spp., and amphipods *Ampelisca diadema* and *Photis longicaudata* (Warwick, 2017).

Subtidal Benthic Important Ecological Features (IEFs)

6.57 A summary of the subtidal benthic IEFs is provided below together with an assessment of their conservation value within the study area (Table 6.7).

Table 6.7: Subtidal Benthic Ecology IEFs in the PDI Study Area.

Benthic IEF	Representative Species	Biotopes/ Conservation Value Within The Study Area	Justification
Within the PDI Development Site			
Subtidal mixed sediment	*Melinna palmata* *Ostracoda spp.* *Ampelisca diadema* *Chaetozone gibber* *Photis longicaudata*	Low	Species/habitats form a component of the subtidal community but have no conservation value.
Within the MHW Wider Region			
Subtidal reef	*Sabellaria spinulosa* SS.SMp.KSwSS.LsacR.CbPb	Very high	Annex I habitat protected under international legislation and is a designated feature of the Pembrokeshire Marine SAC.
Subtidal mixed sediment	*Paradoneis lyra,* *Pholoe synophthamica,* *Sphaerosyllis spp* *Corophium sextonae* *Abra alba*	Low	Species/habitats form a component of the subtidal community but have no conservation value.
Eelgrass	*Z. marina* (subtidal distribution)	Very high	Sub feature of 'large, shallow inlets and bays', 'estuaries' and 'subtidal sandbanks' which are designated features of the Pembrokeshire Marine SAC. Seagrass beds are listed as a priority habitat for Wales and have a regionally important distribution within the area.
Maerl	*Phymatolithon calcareum*	Very high	Sub-feature of 'large, shallow inlets and bays', 'estuaries' and 'subtidal sandbanks' which are designated features of the Pembrokeshire Marine SAC. Maerl is listed as a priority habitat for Wales and is the only known maerl bed in Wales.

Fish and Shellfish Ecology

Fish

6.58 The fish assemblages of the MHW are typical of an estuarine environment with different characterising species towards the outer reaches of the estuary compared to the inner estuary, reflecting the changes in environmental conditions, including substrate type, water flow and salinity. Gobies *Pomatoschistus* spp. are the most abundant species group with sand smelt *Atherina presbyter* and bass *Dicentrachus labrax* also occurring in relatively high numbers. Three species of thick-lipped mullet Mugilidae were also regularly recorded within the MHW. Otter trawls conducted for the Pembroke Power Station, approximately 2.5 km from Pembroke Port, recorded 19 species of fish including elasmobranchs, (thornback ray *Raja clavata*, lesser spotted dogfish *Scyliohinus caniculus*), demersal flat fish (plaice *Pleuronectes platessa*) and abundant gobies.

6.59 Several species of diadromous fish migrate through the MHW between seawater and freshwater, all of which are of conservation importance as Annex II species protected under European legislation or as Welsh BAP priority species (see Table 6.8). Four of the species of diadromous fish are qualifying features of the Pembrokeshire Marine SAC: sea lamprey *Petromyzon marinus*, river lamprey *Lampetra fluviatilis*, allis shad *Alosa alosa* and twaite shad *Alosa fallax*. River lamprey is a primary reason for selection of the Cleddau Rivers SAC and sea lamprey is a qualifying feature of this SAC. Atlantic salmon, sea trout and European eel are all listed as OSPAR threatened/declining species. All of these species are listed as UK BAP species, and species of Principal Importance under the Environment (Wales) Act 2016.

6.60 According to Ellis *et al.* (2012), spawning habitats for sandeel Ammodytidae, plaice, herring *Clupea herengus* and sole *Solea solea* may coincide with the MHW. Although all are considered to be of low intensity except for sandeel which is considered to have high intensity spawning ground within the MHW.

6.61 The sheltered estuarine conditions also provide a safe environment for juvenile fish and therefore the waters of the MHW are mapped as an important nursery area for sandeel, plaice, sole, whiting *Merlangius merlangus*, herring, mackerel Scomber scombrus, spotted ray *Raja montagui*, thornback ray and tope shark *Galeorhinus galeus* (Ellis *et al.*, 2012). The Pembroke River and the tidal waters of the Daugleddau upstream of the Cleddau Bridge have been identified as bass nursery areas, as has an area in Pembroke Bay around the old power station outfall (Pawson *et al.,* 2002).

Fish Ecology Important Ecological Features (IEFs)

6.62 A summary of fish ecology IEFs is provided below together with an assessment of their conservation value within the study area (Table 6.8).

Table 6.8: Fish ecology IEFs in the PDI study area.

Fish Vers	Representative Species	Conservation Value Within The Study Area	Justification
Estuarine fish assemblage	Gobies Mullet Sand smelt Sea bass Flounder *Platichthys flesus* Solenette *Buglossidium luteum* Lesser spotted dogfish	Low	Species that form a key component of the ecosystem: no specific protection although some species may be commercially valuable to local fisheries.
	Plaice Thornback ray	Medium	Species of Principal Importance in Wales and commonly found in the region.
Migratory fish species	Sea trout European eel Atlantic salmon	High	UK BAP Priority species and Species of Principal Importance in Wales.
	Allis shad Twaite shad River lamprey Sea lamprey	Very high	Annex II species protected under international legislation and designated features of the Pembrokeshire SAC and/or the Cleddau Rivers SAC.
Spawning or nursery grounds in the study area	Sandeel* Sole* Herring* Mackerel* Whiting* Sprat	Medium	Species known to spawn in the MHW and which have commercial value in the region. '*' denotes a Wales' Species of Principal Importance.

	Tope shark Thornback ray*		

Shellfish

6.63 Historically, MHW has been historically harvested for Pacific oyster *Crasseotrea gigas*, carpet shell clam *Ruditapes decussatus*, razor clams Pharidae spp. and native oyster *Ostrea edulis* (Cefas, 2012), although no permits for collection of native oysters have been awarded within MHW since 2010 (PNP, 2017). The large area, diverse marine habitats and sediment types, results in a variety of shellfish species, some of which have conservation and commercial interests. Pawson *et al.* (2002) describe the Pembrokeshire coast as a valuable potting ground for European lobster *Homarus gammarus*, shore crab *Carcinus maenus*, spider crab *Maja squinado* and velvet swimming crab *Necora puber*. Other abundant shellfish within along the coast include the common periwinkle *Littorina littorea*, king scallop *Pecten maximus,* common whelk *Buccinum undatum* and queen scallop *Aequipecten opercularis*.

6.64 Most of the shellfish found within the MHW also spawn within the area. Typically, these species produce very large numbers of eggs and there is a planktonic larval phase which allows dispersal over a wide area and settlement into favoured habitats both within the MHW and outside the estuary in coastal waters.

6.65 The substrates around Pembroke Port supports several common bivalve species, which are typical of estuarine environments (Table 6.9).

Shellfish Ecology Important Ecological Features (IEFs)

6.66 A summary of shellfish ecology IEFs is provided below together with an assessment of their conservation value within the study area (Table 6.9).

Table 6.9: Shellfish Ecology IEFs in the PDI Study Area

Shellfish IEFs	Representative species/habitats	Conservation value within the study area	Justification
Within the PDI Development Site			
Estuarine shellfish assemblage near Pembroke Port	Grey top shell Slipper limpet Spotted cowrie Common periwinkle Common limpet Chinaman's hat Painted top shell Variegated scallop Sea hare Arctic cowrie	Low	No specific conservation or commercial value although forms part of the epibenthic community described for the benthic habitats.
Within the MHW Wider Region			
Designated shellfish waters	Cleddau Rivers (Eastern and Western) Carew River	High	Areas designated to protect the quality of shellfish waters under the EC Shellfish Waters Directive.
	Native oyster Mussel beds	Very high	OSPAR threatened/declining species, UK BAP priority

Estuarine fish assemblage in the MHW			species and Wales' species of Principal Importance.
	Common cockle Carpet shell clam Common periwinkle King scallop European lobster Spider crab Common whelk Velvet swimming crab Green (shore) crab Common prawn	Local	Commonly recorded within the MHW but no conservation value. There may be some small-scale commercial exploitation of these species.

Marine mammals

Cetaceans

6.67 Of the 18 species of cetaceans found within Welsh coastal and offshore waters, only harbour porpoise *Phocoena phocoena* and bottlenose dolphin *Tursiops truncatus* are known to occur within the MHW. Most individuals are likely to occur within the lower reaches of the MHW with very few venturing as far as Pembroke Port.

6.68 Harbour porpoise is widespread and abundant throughout British waters and the harbour porpoise abundance for the Celtic/Irish Sea Management Unit (CIS MU) was estimated as 104,695 animals (95% Confidence Interval (CI) 56,774 to 193,065) (IAMMWG, 2015). The most recent SCANS (Small Cetacean Abundance in the North Sea) surveys (SCANS III) estimated abundance in Block D as 5,734 (95% CI = 1,697 – 12,452) with a density estimate of 0.118 animals/km^2 (coinciding with the MHW) (Hammond *et al.*, 2017). Locally, high densities of harbour porpoise are known from coastal waters off southwest Wales (Reid *et al.*, 2003), and are particularly abundant around the Pembrokeshire Islands (De Boer and Simmonds, 2003). Harbour porpoise are found in water depths of 3 m to 100 m but normally less than 50 m and are often in coastal waters, particularly during the summer months. As a species with a high metabolic rate they need to feed regularly. Key prey items include schooling gadoids (Read, 1999) such as pollack, cod, poor cod *Trisopterus minutus*, whiting and hake, and inshore shoaling fish such as herring, sandeel, sprat, mackerel, squid, octopus and crustaceans (Hutchinson *et al.*, 1995).

6.69 Bottlenose dolphin occurs regularly within Welsh waters with most sightings around Cardigan Bay, where there is a resident population (Baines and Evans, 2012). There are frequent sightings elsewhere along the Pembrokeshire coast, particularly off Skokholm and Skomer and sometimes off Strumble Head, especially between July and September. The bottlenose dolphin abundance for the Offshore Channel, Celtic Sea and South West England (OCSW) MU was estimated as 4,856 animals (95% CI = 1,638 - 14,398) (IAMMWG, 2015). During the most recent SCANS III surveys, 2,938 bottlenose dolphins were estimated within SCANS III survey Block D (95% CI = 914 – 5,867), with an estimated density of 0.06 animals/km^2 (Hammond *et al.*, 2017). Bottlenose dolphins are typically found within 10 miles of the coast and often occur in large groups of up to 60 individuals near to Cardigan Bay.

6.70 The waters near Pembroke Port are not a key area for cetacean species. Baseline data shows infrequent sightings of harbour porpoise and bottlenose dolphin within the MHW with a low likelihood of occurrence as far up as Pembroke Port.

Pinnipeds

6.71 Only one species of pinniped, the grey seal *Halichoerus grypus*, occurs in Welsh waters. The Pembrokeshire coast contains the main colony in Wales and is the most southerly in Europe of any significant size (Baines *et al.*, 1995). Grey seals haul out to rest, pup, and nurse their young and moulting and resting haul-out sites are distributed throughout the Pembrokeshire Marine SAC. Pupping takes place throughout the Pembrokeshire Marine SAC on open coast in suitable habitat (i.e. physically accessible, remote and/or undisturbed rocky coast beaches, coves and caves). The most recent estimates for pup production at the major haul-outs in Wales are 465 pups in North Pembrokeshire in 2005 (Strong *et al.,* 2006) and 345 pups born on Skomer and adjacent mainland sites on Marloes Peninsula in 2016 (NRW, 2017). Historic data suggests that grey seal may occasionally occur in low numbers within the MHW and near to Pembroke Port.

6.72 Grey seal are highly mobile, and forage widely and frequently travel up to 100 km between their haul-out sites and foraging areas, though they can travel further (SCOS, 2017). As generalist feeders, grey seal feed on a wide range of prey items including whiting, cod *Gadus mordua*, haddock *Melanogrammus aeglefinus*, ling *Molva molva* and various species of flatfish. A study of grey seal diets from scats collected in Pembrokeshire, found that gadoids (mainly whiting) and flatfish (mainly sole) dominated the diet (Strong, 1996).

Otter

6.73 Otter *Lutra lutra* inhabit freshwater, brackish and marine environments and are known to occur in Welsh coastal waters. The otter has a wide range and distribution throughout Pembrokeshire coastal waters, including within the MHW (known from spraint records and foreshore access points from watercourses with suitable breeding and feeding habitat; CCW, 2009; Liles, 2003). With a varied diet, spraints collected from the open coast of Pembrokeshire and within the MHW were analysed and found to contain remains of many different species of marine, estuarine and saltwater fish.

6.74 Boulders on the front of the dock within the ferry terminal area over 100 m from the boundary of the application site were identified as having the potential to contain gaps in which otter could rest up. The terrestrial areas of the dock are largely devoid of features of potential value for otter.

6.75 Due to the high levels of otter activity recorded within the MHW it is likely that this species occurs near Pembroke Port, although there is less likely to be breeding sites in this area due to the potential disturbance from the existing anthropogenic activities associated with Pembroke Port.

Marine Mammal Important Ecological Features (IEFs)

6.76 A summary of marine mammal IEFs is provided below together with an assessment of their conservation value within the study area (Table 6.10).

Table 6.10: Marine Mammal IEFs in the PDI Study Area

Marine Mammal Iefs	Conservation Value Within The Study Area	Justification
Harbour porpoise	Very high	Species protected under international legislation
Bottlenose dolphin	Very high	Species protected under international legislation
Grey seal	Very high	Species protected under international legislation
European otter	Very high	Species protected under international legislation

Designated Sites

6.77 Table 6.11 details internationally or nationally designated sites that occur within the vicinity of Pembroke Port or in the wider region and for which a potential receptor-impact pathway has been identified with respect to particular features within those sites.

Table 6.11: Internationally and Nationally Protected Sites Designated for Marine Ecology Features; Those Features Listed Have Been Scoped into The Assessment Based on Potential Impact-Receptor Pathways

Site Name	Distance From Project Boundary	Designated Features Scoped Into The Assessment
Pembrokeshire Marine SAC	<50 m	Primary citation features: • Estuaries • Reefs • Grey seal Qualifying citation features: • Mudflats and sandflats not covered by seawater at low tide; • River lamprey • Sea lamprey • Allis shad • Twaite shad • Otter
Cleddau Rivers SAC	11 km	Primary citation features • River lamprey Qualifying citation features • Sea lamprey
West Wales Marine cSAC	10 km	Primary citation features • Harbour porpoise
Milford Haven Waterway SSSI	<50 m	Intertidal rocky shore, sandflats, mudflats

6.78 The conservation objectives for the Milford Haven SAC, Cleddau Rivers SAC and West Wales Marine SAC under the Habitats Directive, requires that measures be designed to maintain or restore habitats and species of European Community Importance at favourable conservation status (FCS). The conservation objective for each habitat feature, is to maintain at FCS the natural range and area covered by the feature, the structures and functions necessary for the long-term maintenance of the feature, and the conservation status of the species which typically characterise the feature on a long-term basis (Burton, 2008).

Future Baseline Conditions

6.79 The Town and Country Planning (Environmental Impact Assessment) (Wales) Regulations 2017 requires that "…an outline of the likely evolution thereof without implementation of the development as far as natural changes from the baseline scenario can be assessed with reasonable effort on the basis of the availability of environmental information and scientific knowledge" is included within the Environmental Statement.

6.80 If PDI does not come forward in the short term, an assessment of the future baseline conditions has been carried out and is described within this section. The baseline environment is not static and will exhibit some degree of natural change over time, with or without the PDI development, due to naturally occurring cycles and processes. Therefore, when undertaking impact assessments, it will be necessary to place any potential impacts in the context of the envelope of change that might occur naturally over the timescale of the project.

6.81 Further to potential change associated with existing cycles and processes, it is necessary to take account of the potential effects of climate change on the marine environment. The Climate Change Risk Assessment for Wales (Welsh Government and Defra, 2012) identified the main potential threats and opportunities for the natural environment because of climate change; those of specific relevance to marine ecology are as follows:

- Changes in climate space and species migration patterns, which could result in significant changes to biodiversity;
- Changes to coastal and estuarine habitats and species, including a reduction in intertidal area; and
- Changes to the marine environment, including an increase in disease hosts and pathogens, harmful algal blooms and invasive species. The effects of ocean acidification include adverse impacts on shellfish.

6.82 Qualitative predictions for habitats which occur around PDI include the following:

- Variability and long-term changes on physical influences may bring direct and indirect changes to benthic habitats and communities in the mid to long term future (UK Offshore Energy Strategic Environmental Assessment 3 (OESEA3), 2016).
- Over the last three decades biomass has increased by at least 250 to 400%; opportunistic and short-lived species have increased; and long-living sessile animals have decreased (Krönke, 1995; Krönke, 2011).
- Increased air and sea surface temperatures have resulted in changes in the ranges and distribution of several coastal animals. Warmer water species are shifting northwards (e.g. the molluscs *Osilinus lineatus* and *Gibbula umbilicalis*).

- Warmer temperatures have resulted in changes in the timings of lifecycle events for a range of species, with the rates of change observed in marine species being greater than those observed in terrestrial and freshwater species. Warmer sea temperatures have advanced the timing of spawning of the intertidal bivalve *Limecola balthica*, resulting in a mismatch in timing between the bivalve and the phytoplankton it feeds on.

- Projected rises in sea level will have significant impacts by accelerating the natural erosion of coastal and intertidal habitats, and by changing the pace and nature of natural geomorphological processes. Soft cliffs and the vegetation that grows on them will be particularly affected.

- Coastal species and habitats will be subject to further coastal squeeze where coastal defences are maintained or enhanced, or hard infrastructure exists, preventing natural habitats rolling back inland.

- Projected future losses in the extent of saltmarshes and mudflats will have significant impacts on overwintering bird populations and invertebrates.

- Rising sea levels and coastal squeeze will result in conflict between the need to maintain intertidal and coastal habitats (such as dune systems) by allowing the natural movement of coastlines and through managed realignment and the need to protect valuable inland coastal habitats, such as grazing marsh and saline lagoons.

6.83 As such, the baseline in the study area for PDI, described in paragraphs 6.3.1 to 6.3.50, is a 'snapshot' of the present marine ecosystem within a gradual yet continuously changing environment. Any changes that may occur during the operational life of the PDI project, should be considered in the context of both greater variability and sustained trends occurring on national and international scales in the marine environment.

Mitigation Measures Adopted as Part of Project

6.84 Several mitigation measures have been considered as part of the intrinsic project design to reduce potential environmental effects. These measures are considered to be standard industry practice for this type of development.

6.85 In assessing the impacts of the PDI project, it has been assumed that these measures are in place and therefore the assessment of sensitivity, magnitude and significance includes implementation of these measures. A summary of the measures proposed is provided in Table 6.12.

Table 6.12: Designed-In Mitigation Measures Adopted as Part Of PDI

Measures Adopted	Justification
Construction Environmental Management Plan (CEMP)	Control of pollution during construction will be set out in a CEMP. This will include best practice measures to prevent accidental spillage of chemicals during construction activities.
Environmental Management Plan (EMP)	The EMP will manage the risks of all operational activities, facilities and cargos handled by the port and will include best practice measures to control

	pollution following standard guidelines such as the Environment Agency Pollution Prevention Guidelines.
Invasive and Non-Native Species (INNS) Management Plan	A document detailing how the risk of potential introduction and spread of INNS will be minimised ewill be produced. The plan will outline measures to ensure vessels comply with the International Maritime Organization (IMO) ballast water management guidelines, it will consider the origin of vessels and contain standard housekeeping measures for such vessels as well as measures to be adopted in the event that a high alert species is recorded.
Installation of a Cofferdam at the entrance to Graving Dock	To restrict the migration of sediment plumes during dredging and therefore reducing potential for increases turbidity and release of contaminants into receiving waterbody
Use of Backhoe Dredge to undertake dredging activities	This form of dredging is considered to have an action which reduces mobilisation of sediments within the area of influence
Piling actvities undertaken in daylight hours only	To provide suitable windows of opportunity for migratory fish species to pass Pembroke Port undisturbed on their migratory routes.
Soft start procedure to be implemented prior to commence of piling activity	To allow suitable time for fish and marine mammal species to avoid areas of increased noise levels from piling activities, thereby eliminating the risk of injury to these species.

Assessment of Construction Effects

6.86 A detailed description of the proposed construction activities is provided in Chapter 2: Project Description. A summary of the marine elements of the proposed PDI development is provided in Table 6.13.

Table 6.13: Summary of Proposed Marine Works

Proposed Works	Description of Works
Capital dredging around the slipways and within the Graving Dock	Pre-construction dredging within the footprint of the new slipway with up to 6 m depth sediment dredged resulting in removal of ~36,000 m^3 of material below MHWS. It is estimated that 800 m^3 of this material will comprise of concrete associated with the existing slipway, 5200 m^3 of bedrock and 30,000 m^3 of consolidated sediments. Material will be removed using combination hydraulic hammer to break out the concrete and rock and excavator to removed consolidated sediments either positioned on land/ or on a barge in the water. Dredging of silt and debris from existing Graving Dock; sediments dredged to approximately 2-3 m with the removal of up to ~7,100 m^3 in total. Likely method using a temporary cofferdam installed across entrance to dock and material removed via sludge pump and excavator in the dry. A total of up to 43,100 m^3 of spoil will therefore be removed from the footprint of the new slipway and Graving Dock and, wherever possible, will be re-used as hardcore on site. Material that is not suitable for re-use on site will be disposed of at dredging disposal site.
Creation of a single large slipway by combining the two existing westernmost slipways and extending the slipway into the Milford Haven Waterway into deeper water.	Installation of 250 m of temporary sheet piling and removal of the central section between two existing slipways and installation of a clean stone base for pre-cast concrete slipway. Slipway will extend to approximately 4 m below chart datum with a footprint area of 11,846m^2.
Infilling of the Graving Dock	Dock dewatered and infilled with crushed stone over a layer of sand. Stone revetment installed across entrance to the Graving Dock.
Infilling of timber/Timber Pond	Decommissioning of the intake and outfall pipes followed by dewatering of the Timber Pond and either treatment/removal of sediment. Infill of sand and granular material will be up to existing ground level.

Dredging, Dredge Disposal and Dewatering Resulting in Temporary Increases in Suspended Sediment Concentrations and Deposition

Magnitude of Impact

6.87 Capital dredging of the slipway footprint to allow for installation of the slipway and removal of sediments within the Graving Dock will result in dredging of a total volume of up to 44,500 m^3 of substrate. The material from the Graving Dock will be removed in dry conditions following installation of a cofferdam and associated dewatering. Following completion of dewatering the material will be removed using an excavator, with the material reused within the development footprint where possible. Material not suitable for re-use will be removed disposed at licenced inshore facility or disposal offshore within a licenced disposal ground. Material associated with construction of the slipway will require removal of 36,000 m^3 of substrate to a depth of 6 m (Table 6.13) using a backhoe excavator over a period of 3 weeks.

6.88 The sediments to be dredged around the slipway comprise sandy mud and muddy sand. During dredging, dependent on the type of material and localised hydrodynamic regime, sediments will become mobilised into the water column. Finer material (silt and clay fractions) would be carried over a larger distance than coarser material (sand and gravel fractions). Studies undertaken within MHW indicate that high concentrations of silt particles can extend up to 5 km on a spring flood tide and 1.5 km on a spring ebb tide. Longdin and Browning (2002) measured sediment plumes arising from dredging works at Valero and Petroplus Refinery (now Dragon LNG) sites within the MHW showed neap tide sediment plumes extended 500 m on an ebb tide and 1750 m on a flood tide before interacting with a third-party dredge plume which was found to extend a further 500-750 m.

6.89 For dredging of the slipway area and Graving Dock sediment plumes are unlikely to extend as far as those previously reported within MHW for the following reasons:

1. The dredging of Graving Dock will be encapsulated by a cofferdam which will restrict the migration of plumes from dredging of the Graving Dock (removal of 8,500 m3 of material);
2. The physical presence of the Carr Jetty to the west and Hobbs Point to the east will likely reduce localised tidal currents that would support plume migration;
3. Gravel and sand fractions within the sediments to be dredged will fall out of suspension more rapidly; and
4. Use of a backhoe dredge which is considered to have low physical action compared with more rigorous dredging activities such as trailing suction hopper dredge, cutter suction dredge and water injection dredging (Bray, 2008).

6.90 Therefore, mobilised sediments from dredging, of which low volumes are predicted, due to the proposed dredge methods described above, will likely become more concentrated within a constrained area adjacent to proposed dredging works.

6.91 In addition, SSC concentrations will likely return to background levels relatively quickly due to sediments falling out of suspension, low volume of dredge material to be removed and the short term, temporary nature of proposed dredging works.

6.92 Based on the proposed evidence increases in SSC will also be temporary, short-lived and largely confined to the dock area itself, the impact is predicted to be of low magnitude.

6.93 Sediment deposition as sediment particles fall out of suspension are predicted to be low. Previous dredging activities within MHW have identified deposition levels of between 1.2 mm and 4.3 mm (Little *et al.,* 2015). Generally, it is considered between 3% and 7% of fine material (mud) becomes mobilised at the dredge source during backhoe dredging which is not retained for disposal (Burt *el al.,* 2007 and Land *et al.,* 2007). Based on a volume of 22,500 m^3 of fine material (based on physical sediment sample displaying 74% silt and clay fractions) from the slipway footprint (material from the Graving Dock has been excluded due to installation of a cofferdam restricting the migration of a sediment plume) a volume of 675 m^3 and 1,575 m^3 of fine material (mud) will become mobilised and deposited outside the dredge footprint. Some potential sediment dispersion outside the footprint may also be possible from fine sand sediments not included in the calculations provided above, however, these larger fractions are likely to settle out of suspension quickly following mobilisation. Given the low volume sediments that will be mobilised and dispersed the impact is predicted to be low magnitude.

Sensitivity of Receptors

Benthic Intertidal and Subtidal Ecology

6.94 Increases in SSC and turbidity levels from dredging can, under certain conditions, have adverse effects on the marine flora and fauna. Increased SSC can affect filter feeding organisms through clogging and damaging feeding and breathing apparatus (Frid and Caswell, 2017). As mentioned, disturbance of sediments will also cause some sediment deposition outside the slipway dredge footprint potentially resulting in the smothering of benthic species and habitats. Benthic communities occurring within the vicinity of Pembroke Port are likely to have some tolerance to reduced light levels and smothering from sediment deposition due to the existing activities in the area such as propeller wash from vessel movements and maintenance dredging.

Intertidal Benthic Communities

6.95 Changes in the light penetration are not relevant to the intertidal Hediste diversicolor and *Limecola balthica* biotope (LS.LMu.MEst.HedMac) as the component species live in the sediment and are likely to be adapted to increased SSC (Tillin and Rayment, 2016). Similarly, the Cirratulid and *C. edule* intertidal biotope in the immediate vicinity of Pembroke Port is considered to be resilient to increases in SSC and sediment deposition and there may even be some benefits if the dredged material releases additional organic matter into the marine environment, which may increase food availability for suspension feeders (Tillin and Marshall, 2016). Therefore, the littoral sand and mud habitat within Pembroke Port are considered to be of low sensitivity to increases in SSC and sediment deposition, based on a receptor value of medium with low vulnerability and medium to high recoverability.

6.96 Littoral rock communities may be more vulnerable to increases in SSC and sediment deposition as their component species are characterised by algae and epifaunal suspension feeders. In turbid waters, light penetration would be decreased, inhibiting the photosynthetic activity of algae and potential slowing growth rate. Sediment deposition can also slow growth if fine particulates cover the algae fronds. Suspension feeders may be vulnerable where particles interfere with their feeding and respiration rate. A characterising biotope of littoral rock - LR.HLR.FT.FserTX – is considered to be of medium sensitivity to increases in SSC and sediment deposition (D'Avack and Marshall, 2006). LR.LLR.F.Asc.X is not considered to be sensitive as the key species are likely to be tolerant of changes in the SSC (Perry, 2015).

6.97 The LS.LMu.MEst.HedMac is also representative of Annex I 'Mudflats and sandflats not covered by seawater at low tide' benthic communities in the wider MHW and therefore, as described above, is considered to be of low sensitivity to an increase in SSC and sediment deposition. Eelgrass communities, such as the LS.LMS.ZOS.Znol biotope is likely to be sensitive to this impact since water clarity is vital for the growth and functioning of this photosynthetic plant. However, eelgrass communities are likely to survive short-term increases in turbidity and sediment deposition and sensitivity would only be high if the plants experienced a continuous burial (D'Avack *et al.*, 2015). In addition, the eelgrass in the MHW is found within a moderate energy environment where tidal currents would act to disperse sediments. Therefore, the sensitivity of eelgrass in proximity to Pembroke Port (at Hobbs Point) is considered to be medium.

6.98 Intertidal benthic communities on moderately exposed littoral rock are represented by the *S. balanoides* biotopes (e.g. LR.HLR.MusB.Sem). Whilst organic matter in SSC may provide additional food resources to filter feeders in this biotope, there is potential for increased scour and abrasion to affect vulnerable organisms and may lead to reduced spat settlement rates. Sediment deposition may be could lead to local removal of limpets. However, due to the resilience of the key species, which have high reproduction and recruitment rates, the sensitivity is assessed as low (Tilin and Hill, 2016).

Subtidal Benthic Communities

6.99 Subtidal communities within the vicinity of Pembroke Port will also be tolerant of changes in SSC and sediment deposition. Characterising species such as *Melinna palmata* and *Chaetozone gibber* are species of polychaete which have high growth rates and short life spans. Communities in the subtidal zone typify a deposit-feeding community and therefore any disturbance from smothering effects due to deposition of sediments are unlikely, with a high recovery rate following such effects. As such, the community is of low sensitivity (De-Bastos, 2016).

6.100 In the wider MHW the subtidal mixed sediment is also characterised by polychaete worms, with amphipods and bivalves also abundant. As described above the polychaetes in the community are deposit feeders and therefore are unlikely to be affected in changes in the light penetration in the water column and would recover rapidly following changes to food availability. Suspension feeders such as *Abra alba*, may be vulnerable to increases in SSC if feeding apparatus becomes clogged, however, this species can also switch to surface deposit feeding if necessary and therefore is considered to be tolerant to increases in SSC (Budd, 2007) and sensitivity is assessed as low.

6.101 Algae communities and benthic epifauna of subtidal rock habitat may have low resilience to the effects of increased SSC as reduced light availability can inhibit photosynthesis and limit the depth range at which algae grow. An increase in sediment deposition could provide a physical barrier to spat settlement and smother sessile epibenthos. *Sabellaria spinulosa*, a characteristic species of subtidal reefs found within the MHW, has high resilience to smothering and whilst there may be some curtailment of feeding and growth, recovery is likely to be almost immediately following cessation of the impact (Jackson and Hiscock, 2008). Subtidal reef habitat in the MHW is assessed as being of low sensitivity to increases in SSC and sediment deposition.

6.102 Eelgrass beds balance sediment accretion and erosion and are likely to be tolerant of fluxes in SSC that fall within the limits of natural variation. Large increases in SSC, leading to a decline in water clarity or raising of the bed which may then expose the plants at low tide will affect this habitat (Tyler-Walters, 2008). Eelgrass communities are likely to be of sensitive to this impact since water clarity is vital for the growth and functioning of this photosynthetic plant. However, eelgrass communities are likely to survive short-term increases in turbidity and sediment deposition and sensitivity would only be high if the plants experienced a continuous burial (D'Avack *et al.*, 2015). In addition, the eelgrass in the MHW is found within a moderate energy environment where tidal currents would act to disperse sediments. Therefore, the sensitivity of eelgrass in proximity to Pembroke Port (in Littlewick Bay) is considered to be medium.

6.103 The nearest known Maerl beds are a located 7 km to 9 km to the west of Pembroke Port. Given that dredging activities are shown not cause sediment plumes that will extend this far this receptor has not been considered further with respect to increases in SSC and smothering from sediment deposition.

Fish and Shellfish

6.104 Fish are sensitive to increases in SSC, both directly, through physiological and behavioural disruption, and indirectly, through habitat modification (e.g. smothering of spawning/nursey habitats). Increased SSC can impair foraging, increase mortality, affect growth, reproduction and survival at all trophic levels. However, there is also evidence to indicate that high sediment loads, and associated turbidity found in natural ecosystems can create feeding opportunities for some species such as demersal fish (Henley *et al.*, 2000).

6.105 As mobile species, fish are likely to exhibit avoidance reactions and move away from the vicinity of adverse sediment conditions, particularly if refuge conditions are present (Sigler *et al.*, 1984; Bash *et al.*, 2001). Demersal fish species including plaice and thornback ray live partially buried in sediment on the sea floor and therefore are unlikely to be sensitive to increases in sediment deposition. Therefore, most individuals could tolerate or avoid any unfavourable discharges of particulate matter (Robertson *et al.*, 2006). The sensitivity of the fish assemblage IEF to an increase in SSC and sediment deposition is therefore assessed as low.

6.106 Excessive fine sediment (in suspension or deposited) can have damaging effects on all life stages of fish and particularly on fish eggs and larvae/fry (Robertson *et al.*, 2006). Juvenile fish are more likely to be affected by habitat disturbances such as increased SSC than adult fish due to the decreased mobility of juvenile fish which makes them less able to avoid impacts. This could therefore have implications for spawning/nursery habitats and therefore sensitivity for this IEF is assessed as high.

6.107 Fish are also known to tolerate high levels of SSC and migrating fish species, such as salmonids, are commonly known to migrate through high SSC in estuaries (Salmon and Trout Association, 2015). In addition, migratory fish species, such as Atlantic salmon *Salmo salar*, often have an acute sense of smell which helps to direct them to their home grounds to spawn and therefore are not relying on visual cues to navigate (Heard, 2007). Migratory fish species are therefore assessed as being of low sensitivity to increases in SSC and sediment deposition.

6.108 Many shellfish species have a high tolerance to SSC and are likely to be insensitive to increases in turbidity; however, mobile species are likely to avoid areas of increased suspended sediment concentration as they rely on visual acuity during predation, sessile species would not be able to. Therefore, the sensitivity of the shellfish assemblages, both near to Pembroke Port and in the wider MHW, are assessed as medium.

6.109 Designated shellfish waters are important to preserving the quality of the shellfish that are harvested for human consumption. An increase in SSC could temporarily affect the clarity of the water and affect the component species. To comply with the Shellfish Waters Directive, any discharge must not cause the suspended solid content of the water column to increase by 30%. The designated shellfish waters lie to the east of Pembroke Port and due to the very low volumes of sediment to be dredged and the short term, temporary nature of the proposed dredging, it is very unlikely that SSC will increase by 30% in this area as a result of the construction activities. Therefore, the sensitivity is assessed as low.

Significance of Effect

6.110 The magnitude of impact will be low and any increases in SSC and sediment deposition are likely to be short-lived and localised, with only small volumes of sediment disturbed, and therefore unlikely to extend far into the wider MHW. Sensitivity of the receptors ranged between low to high depending on the component species present. For those receptors with a low sensitivity the significance of effect is considered to be negligible and for those with a medium or high sensitivity the significance of effect is considered to be **minor**. The effects are not significant in EIA terms for any of the receptors.

Release of Contaminants During Construction Activities

Magnitude of Impact

6.111 Capital dredging associated with the slipway and within the Graving Dock will remove up to 44,500 m^3 of substrate. Approximately 20% of the dredge material would be removed in dry conditions from the Graving Dock, which reduces the potential for release of sediments and therefore contaminants into the water column (paragraph 6.5.2). Effect on sensitive receptors may arise where contaminated sediments are re-suspended into the water column and potentially dispersed over a wider area via currents or tidal movement.

6.112 Sediment sampling of surface sediments in the footprint of the proposed slipway found metal concentrations were above the threshold at which consideration and testing may be required before a decision can be made on disposal (AL1). The concentration of zinc was above the threshold which requires further consultation and may be unsuitable for sea disposal (AL2). Heavy metal concentrations within the Graving Dock were below AL1, except for chromium and nickel which exceeded AL1 and copper and mercury which exceeded the Canadian Threshold Effect Level (TEL), above which biological effects may occur.

6.113 Organotins were also elevated within the footprint of the proposed slipway.

6.114 THC concentrations ranged between 4.97 and 42.3 mg/kg which were considered to be comparable to background THC concentrations within MHW.

6.115 PAHs were present within the sampled sediments at both the slipway and Graving Dock but in all cases the concentrations were below the AL1. The Canadian TEL was, however, exceeded for naphthalene, acenaphthene and fluorine. Concentrations of polychlorinated biphenyls (PCBs) were below the CEFAS thresholds and the Canadian benchmarks for biological sensitivity at all locations.

6.116 The contaminant concentrations identified were found to be elevated compared with levels found in the wider MHW. Sediments located below surface layers will unlikely display the concentrations observed in the surface layers as they are consolidated and will not have been exposed to anthropogenic pollution sources unlike sampled surface sediments.

6.117 While surface sediments exceed adopted guideline criteria thresholds for some heavy metals, the proposed dredge volume of these surface sediments that will be exposed to the receiving environment from the slipway area is considered small. Removal of the material by backhoe excavator will limit exposure of fine sediment to the water column and therefore the potential for contaminant elutriation. During dredge disposal increased flushing from tidal currents will assist with dilution of any contaminants released into the water column. Given that this activity will occur over a short period of 3 weeks, the volume of sediments disturbed is small (Table 6.13), the plume extent is likely to be small (as per paragraph 6.5.7) and all dredge material re-used within the development footprint where possible. Material not suitable for re-use will be removed and disposed at licenced facility onshore or placed offshore within a licenced disposal ground. The magnitude of the impact is predicted to be low.

6.118 Other potential sources of contaminant release during construction are from dewatering discharge activities associated with the Timber Pond. The water quality of the Timber Pond is found to contain low contaminant levels and have similar physical properties to that of seawater. Generally, contaminant concentration were below levels of detection. Metal concentrations were above levels of detection but were relatively low (see Appendix 6.1 for laboratory analysis results). The dewatering of the Graving Dock following installation of the cofferdam will not cause increase in contaminants in the receiving water column following discharge as sediments will be not be disturbed until dewatering has been completed. The impact from dewatering discharges on release of contaminants is therefore predicted to be of negligible magnitude.

Sensitivity of Receptors

Intertidal Benthic Communities

6.119 In the wider MHW the sediment contaminant levels are elevated due to the high levels of industrial use in this area, with tankers, refineries, ports and harbours within the estuary (Little *et al.,* 2015). The ‘Mudflats and sandflats not covered by seawater at low tide’ habitat within the wider MHW is represented by the *Hediste diversicolor* biotope. *Hediste diversicolor* has been found living in estuarine environments with high levels of copper and its resistance to toxicity is likely to depend on its ability to detoxify the metal and store it in the tissues (Tillin and Rayment, 2016). Other estuarine species such as polychaetes are also resilient to heavy metals whilst bivalves, such as *C. edule*, may decline in abundance if concentrations exceed a critical level (Tillin and Marshall, 2016). Given the tolerance of the community to existing high levels of contaminants sensitivity to increases in the release of contaminated sediments during dredging is assessed as low.

6.120 Seagrass beds, represented by the biotope LS.LMS.ZOS.Znol, also occur within this habitat and their resilience to contamination will depend on the environmental conditions after the impact. Eelgrass, *Z. noltii*, is likely to accumulate some synthetic contaminants with no observable damage, whilst other chemicals, including naphthalene may reduce nitrogen fixation in the plants. Similarly, growth of eelgrass may be inhibited by heavy metals although since the major route for uptake is through the leaves, this suggests that intertidal populations would accumulate less compared to subtidal populations due to their reduced exposure (Tyler-Walters, 2005). Increased contamination may inhibit seagrass growth although the infaunal community, characterised by polychaetes, amphipods and bivalves, may be relatively tolerant to contaminants due to baseline levels in the area. Due to the very high importance of the habitat the sensitivity of 'Mudflats and sandflats not covered by seawater at low tide' is assessed as medium and the sensitivity of the eelgrass IEF is assessed as low.

6.121 Reef habitat within the wider MHW may experience a shift in community structure of component species due to elevations in contaminants although the release of contaminants at any identifiable concentrations from the proposed dredging activities is considered to be unlikely. Any disturbance to limpets and barnacles on reef habitat is likely result in rapid recolonisation although this will depend on processes such as larval supply and recruitment between populations. Due to the very high importance of the habitat the sensitivity of 'Reefs' is assessed as medium.

Subtidal Benthic Communities

6.122 The subtidal communities within the vicinity of Pembroke Port are likely to be tolerant of increases in sediment contaminants as they exist already in a moderately disturbed environment. The characterising species are infaunal polychaetes, including *M. palmata* and *C. gibber* and amphipods *A. diadema* and *P. longicaudata*, are highly unlikely to become exposed to elevated levels of contaminants given the small volume of sediments to be dredged. These species tend to have a high reproductive capacity and therefore recovery is likely following a disturbance event. Sand and mud subtidal habitats are therefore considered to have a low sensitivity to release of contaminants (De-Bastos, 2016).

6.123 In the wider MHW the subtidal mixed sediment is also characterised by polychaete worms, with amphipods and bivalves also abundant. Contamination is ubiquitous throughout the MHW and therefore communities will be tolerant to small increases in levels of pollutants. Like the polychaetes and amphipods, bivalves will vary in their tolerance to contaminants depending on the nature of the chemical. Mercury is likely to be the most toxic heavy metal to A. alba with lead less toxic (Budd, 2007). Hydrocarbons are considered to be the least problematic for bivalves in terms of contaminants although high levels may cause decreased respiration rates and a decrease in feeding rate (Budd, 2007). Recovery rates are considered to be high for the component species of subtidal mixed sediment and therefore sensitivity to increased contaminant levels is assessed as low.

6.124 The subtidal eelgrass, *Zostera marina* is considered to be more sensitive compared to the intertidal species *Zostera noltii*. The difference between these species is a consequence of levels of exposure to contaminant toxicity. *Zostera marina* is subtidal so is exposed to any contaminants in the water column for longer periods than the intertidal species *Zostera noltii* which is only exposed when submerged during certain tidal conditions. The sensitivity of *Z. marina* is therefore assessed as medium.

6.125 The nearest known maerl beds are located 7 km to 9 km to the west of Pembroke Port. Given that dredging activities are unlikely to cause sediment plumes to migrate this distance this receptor has not been considered further with respect to release of contaminants during dredging activities.

Fish and Shellfish Ecology

6.126 The sensitivity of fish and shellfish receptors will vary depending on a range of factors including species and life stage. Due to their increased mobility, adult fish (including migratory fish species) are less likely to be affected by marine pollution although are still susceptible to potential long-term effects. For example, effects of mercury bioaccumulation have been examined for subtidal fish (i.e., flounder, dab, whiting, plaice) and a positive correlation between fish size and mercury bioaccumulation was found (Baeyens *et al.*, 2003).

6.127 Fish eggs and larvae are likely to be particularly sensitive, with potentially toxic effects of pollutants on fish eggs and larvae (Westernhagen, 1988). Effects of re-suspension of sediment bound contaminants (e.g. heavy metals and hydrocarbon pollution) on fish eggs and larvae are likely to include abnormal development, delayed hatching and reduced hatching success (Bunn *et al.*, 2000).The sensitivity of fish eggs and larvae from release of contaminants is therefore considered to be medium.

6.128 There are no spawning grounds for migratory fish near Pembroke Port, therefore, it is only migrating adults/juveniles which have the potential to be affected as described in paragraph 6.5.41.

Significance of Effect

6.129 The magnitude of impact will be low and any increases in sediment contamination are likely to be short-lived and localised and therefore unlikely to extend into the wider MHW. Sensitivity of the receptors ranged between low to medium depending on the life stage identified . For those receptors with a low sensitivity the significance of effect is considered to be negligible and for those with a medium sensitivity the significance of effect is considered to be **minor**. The effects are not significant in EIA terms for any of the identified receptors.

Underwater Noise Emissions During Construction Activities

Magnitude of Impact - Piling

6.130 Construction activities including sheet piling, dredging and vessel movements within Pembroke Port have the potential to generate underwater noise, which may result in effects on fish and marine mammal receptors (if occurring) within and outside the docks.

6.131 Sheet piling will be potentially undertaken to install a temporary barrier to support the excavation and removal of the central section between the two existing slipways to create the proposed single slipway. Approximately 250 m length of AU 25 sheet piles will be installed using an excavator mounted vibro-hammer finished with impact driver. Piling activities will be completed over a period of 20 days assuming operation of 8 hours per day and 5-10 minutes to install each pile.

6.132 Noise modelling for the proposed piling works (as the activity with the potential to result in the greatest underwater noise) has been undertaken to determine the magnitude of the impact for fish, harbour porpoise, bottlenose dolphin and grey seal. The modelling undertaken has been based on an established, peer reviewed, range dependent sound propagation model, which utilises the semi-empirical model developed by Rogers (1981; see Appendix 6.2). The acoustic source terms adopted for the modelling were:

- Sound Exposure Levels (SELs) per pulse of 192 dB re 1 µPa2.s @ 1 m for both impact and vibration piling methods.
- Zero to peak sound pressure levels (SPLs) of 210 and 198 dB re 1 µPa @ 1 m for impact and vibration piling methods, respectively (assuming exposure over a 12-hour period and rms(T90) source levels of 202 and 192 dB re 1 µPa @ 1 m for impact and vibration piling methods, respectively).

6.133 The noise signature of the proposed impact piling was based on the data recorded from studies undertaken by Matuschek and Betke 2009; De Jong and Ainslie 2008; Wyatt 2008; Nedwell *et al.* 2007; Nedwell and Howell 2004; Nedwell *et al.*, 2003; CDoT 2001; Nehls *et al.*, 2007; and Thomsen *et al.*, 2006. For vibro-piling, the source sound levels are based on those measured by Graham *et al.* (2017) during vibratory piling at Nigg Energy Park in Scotland.

6.134 The magnitude of underwater noise arising from piling will be short-term, temporary and reversible and therefore the magnitude is assessed as low.

Magnitude of Impact – Dredging and Vessel Movements

6.135 Some increase in underwater noise may also result from the movement of barges transporting dredge sediments for disposal offshore. Noise arising from vessels operating from Pembroke Port during construction may increase the risk of disturbance to marine receptors. Radiated vessel source sound pressure levels relates to factors including ship size, speed, load, condition, age, and engine type and can range from <150 dB re1µPa to over 190 dB re1µPa (McKenna *et al.* 2012). Noise from vessels is received as a low-level chronic exposure (as opposed to acute impulse and intense noises from e.g., piling operations) and can affect marine mammals, fish and shellfish receptors by masking sounds in the sea soundscape (Popper and Hastings, 2009; Richardson *et al.*, 1995). Subsea noise from barges will most likely fall within a low frequency spectrum and therefore impact magnitude will be lower than for high speed vessels in terms of masking communications of species which hear within a higher frequency spectrum (Pirotta *et al.*, 2013).

6.136 Noise source data for construction vessels and dredging activity have been estimated using proxy data from publicly available data, as set out in Table 6.14.

6.137 Noise modelling has been undertaken to determine the magnitude of underwater noise emissions associated with vessel movements and dredging on the impact for fish, harbour porpoise, bottlenose dolphin and grey seal. The modelling undertaken has been based on an established, peer reviewed, range dependent sound propagation model, which utilises the semi-empirical model developed by Rogers (1981; see Appendix 6.2).

6.138 The magnitude of underwater noise arising from dredging and vessel movements will be short-term, temporary and reversible and therefore the magnitude is assessed as low.

Table 6.14: Source Noise Data for Vessels

Item	Description/Assumptions	Data Source	Source Sound Pressure Level at 1 M	
			Rms, dB re 1 µPa	SEL(24h), dB re 1 µPa²s
Backhoe dredger	Manu Pekka used as proxy	Nedwell *et al.* (2008)	163	212
Work / safety boat	Tug used as proxy	Richardson (1995)	172	221
Tug	Tug used as proxy	Richardson (1995)	172	221

Sensitivity of Receptor

Marine Mammals

Injury

6.139 The injury threshold criteria adopted for the impulsive noise sources were based on those proposed in NOAA (NMFS, 2018) and are presented in Table 6.15. Based on the modelling undertaken and marine mammal receptors found within areas potentially affected by construction activities, the resultant PTS injury ranges for the proposed impact piling activities show that for both SEL (cumulative) and peak levels injury is not predicted except at a range of 3 m or less for high frequency cetaceans such as harbour porpoise.

Table 6.15: Summary of Injury Ranges for Marine Mammals Due to Impact Piling (N/E = Threshold Not Exceeded) In Accordance with Adopted SEL And Peak Thresholds

Species / Group	Threshold (Weighted SELcum)	Range	Threshold (Peak SPL)	Range
Mid frequency (MF) cetacean (bottlenose dolphin)	185 dB re 1 µPa²s	*N/E*	230 dB re 1 µPa (pk)	*N/E*
High frequency (HF) cetacean (harbour porpoise)	155 dB re 1 µPa²s	*N/E*	202 dB re 1 µPa (pk)	3 m
Phocid pinniped (PW)	185 dB re 1 µPa²s	*N/E*	218 dB re 1 µPa (pk)	*N/E*

6.140 The injury threshold criteria adopted for the non-impulsive noise sources such as vibro-piling, dredging and vessel movements were based on those proposed in NOAA (NMFS, 2018) and are presented in Table 6.16.

Table 6.16: NOAA SEL (Cumulative) PTS Injury Thresholds for Non-Impulsive Noise Sources

Marine Mammal Group	Threshold, dB re 1 µPa2s
Low-frequency (LF) cetaceans	199
Mid-frequency (MF) cetaceans	198
High-frequency (HF) cetaceans	173
Phocid pinnipeds (PW)	201

6.141 Based on the modelling undertaken and identified marine mammal receptors to be found within areas potentially affected by construction activities, the resultant PTS injury ranges for the non-impulsive noise sources such as dredging and vessels movements show that injury is not predicted except at a range of 25 m or less for vessel movements for high frequency cetaceans such as harbour porpoise and 4 m for pinnipeds (grey seal). For the purposes of this assessment otter can be considered at a similar sensitivity to pinnipeds although their level of sensitivity is generally considered to be lower. No injury is predicted from dredging activities except at a range of 2 m for high frequency cetaceans (Table 6.17). It should be noted that the SEL injury ranges are based on a marine mammal being within that range of the vessel or dredging activity continuously over a 24-hr period. Consequently, it is considered that these ranges are over estimates and over precautionary. Injury from vibro-piling activities which is also considered to be a non-impulsive noise source is also not predicted to occur based on modelling undertaken.

Table 6.17:Summary of Injury Ranges for Marine Mammals Due to Dredging and Vessel Movements (N/E = Threshold Not Exceeded)

Activity / Vessel	Radius Of Potential Injury Zone (Assuming Continuous Exposure Within That Radius Over 24-Hour Period)		
	MF	HF	PW
Backhoe dredger	*N/E*	*2 m*	*N/E*
Work / safety boat	*N/E*	*25 m*	*4 m*
Tug	*N/E*	*25 m*	*4 m*

6.142 Given the unlikelihood of marine mammals being in the vicinity of project activities and the modelling results discussed above the sensitivity of marine mammals to injury is assessed as low.

Behavioural Disturbance

6.143 Beyond the area in which injury may occur, the effect on marine mammal behaviour is the most important measure of impact. Significant (i.e. non-trivial) disturbance may occur when there is a risk of animals incurring sustained or chronic disruption of behaviour or when animals are displaced from an area, with subsequent redistribution being significantly different from that occurring due to natural variation.

6.144 For impulsive sound sources this assessment adopts a conservative approach and uses a precautionary level of 140 dB re 1 µPa (rms) which has been used to indicate the onset of low-level marine mammal disturbance effects for all mammal groups and the US NMFS (2005) Level B harassment threshold of 160 dB re 1 µPa (rms). Level B Harassment is defined as having the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioural patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering but which does not have the potential to injure a marine mammal or marine mammal stock in the wild. For vibro-piling, the threshold criteria adopted was based on (NMFS, 2005) guidance which sets the marine mammal level B harassment threshold for continuous noise at 120 dB re 1 µPa (rms) has been adopted.

6.145 Maximum disturbance ranges for marine mammals for impact piling activities are summarised in Table 6.18 based on the rms sound pressure level contours. For mild disturbance, up to 2.8 km is predicted and for strong disturbance 251 m is predicted.

Table 6.18: Summary of disturbance ranges for marine mammals due to impact piling

Effect	Threshold (SPL)	Range	Area
Mild disturbance	140 dB re 1µ Pa (rms)	2.8 km	5 km^2
Strong disturbance	160 dB re 1µ Pa (rms)	251 m	0.2 km^2

6.146 For vibro-piling, disturbance could occur within 4 km of the source based on the 120 dB re 1µ Pa (rms) threshold. However, it should be noted that operational noise levels will not be dissimilar to those already experienced in the area which is already heavily trafficked. Consequently, this is likely an over estimate of disturbance range for vibro-piling activities.

6.147 For dredging and vessel movements non-impulsive sound threshold criteria was adopted. Maximum disturbance ranges for marine mammals are summarised in Table 6.19. Disturbance to marine mammals could occur within 1.6 km, although as noted for vibro-piling operational noise levels will not be dissimilar to those already experienced in the area which is already heavily trafficked. Consequently, this is likely an over estimate of disturbance range for vessels and dredging.

Table 6.19: Summary of Disturbance Ranges for Marine Mammals Due to Dredging and Vessel Movements

Activity / Vessel	Radius Of Potential Disturbance – All Marine Mammals
Backhoe dredger	313 m
Work / safety boat	1.6 km
Tug	1.6 km

6.148 The waters near Pembroke Port are not a key area for marine mammal species. Baseline data shows infrequent sightings of harbour porpoise, bottlenose dolphin and grey seal within the MHW with a low likelihood of occurrence as far up as Pembroke Port.

6.149 Marine mammals would be able to avoid the disturbed area and any animals that are disturbed would quickly return. There may also be a level of habituation displayed by individuals that frequent the MHW given the ongoing operation of vessels within the MHW. Therefore, sensitivity of marine mammals to disturbance from noise produced by impulsive and impulsive noise sources is assessed as low.

Migratory fish, Estuarine fish assemblage and Fish communities

6.150 Sound plays an important role in fish and invertebrates, allowing them to communicate with one another, detect predators and prey, navigate their environment, and avoid hazards.

6.151 Recent peer reviewed guidelines have been published by the Acoustical Society of America (ASA) and provide directions and recommendations for setting criteria (including injury and behavioural criteria) for fish. For the purposes of this assessment, these Sound Exposure Guidelines for Fishes and Sea Turtles (Popper *et al.,* 2014) were considered to be most relevant for impacts of underwater noise on fish species. The Popper *et al.* (2014) guidelines broadly group fish into the following categories according to the presence or absence of a swim bladder and on the potential for that swim bladder to improve the hearing sensitivity and range of hearing (Popper *et al.*, 2014):

- Group 1: Fishes lacking swim bladders (e.g. elasmobranchs and flatfish). These species are only sensitive to particle motion, not sound pressure;
- Group 2: Fishes with a swim bladder but the swim bladder does not play a role in hearing (e.g. salmonids). These species are only sensitive to particle motion;
- Group 3: Fishes with swim bladders that are close, but not connected, to the ear (e.g. gadoids and eels). These fishes are sensitive to both particle motion and sound pressure and show a more extended frequency range than groups 1 and 2, extending to about 500 Hz; and
- Group 4: Fishes that have special structures mechanically linking the swim bladder to the ear (e.g. clupeids such as herring, sprat and shads). These fishes are sensitive primarily to sound pressure, although they also detect particle motion. These species have a wider frequency range, extending to several kHz and generally show higher sensitivity to sound pressure than fishes in Groups 1, 2 and 3.

Injury

6.152 For fish, the most relevant criteria for injury are considered to be those contained in the recent Sound Exposure Guidelines for Fishes and Sea Turtles (Popper *et al.,* 2014).

6.153 The criteria used in this noise assessment for impulsive piling are given in Table 6.20. In the table, both peak and SEL criteria are unweighted.

Table 6.20: Criteria for Onset of Injury to Fish Due to Impulsive Piling (Popper et al., 2014)

Type of Fish	Parameter	Mortality and Potential Mortal Injury	Recoverable Injury
Fish: no swim bladder (particle motion detection)	SEL, dB re 1 µPa^{2}s	>219	>216
	Peak, dB re 1 µPa	>213	>213
Fish: where swim bladder is not involved in hearing (particle motion detection)	SEL, dB re 1 µPa^{2}s	210	203
	Peak, dB re 1 µPa	>207	>207
Fish: where swim bladder is involved in hearing (primarily pressure detection)	SEL, dB re 1 µPa^{2}s	207	203
	Peak, dB re 1 µPa	>207	>207
Eggs and larvae	SEL, dB re 1 µPa^{2}s	>210	(*Near*) Moderate (*Intermediate*) Low (*Far*) Low

6.154 Based on modelling undertaken using the threshold criteria adopted, no injury to any fish groups is predicted from impulsive noise source such as impact piling.

6.155 The criteria used in this noise assessment for non-impulsive noise sources are given in Table 6.21.

Table 6.21: Criteria For Onset of Injury to Fish Due to Non-Impulsive Sound (Popper et al., 2014)

Type Of Fish	Mortality And Potential Mortal Injury	Recoverable Injury
Group 1 Fish: no swim bladder (particle motion detection)	N) Low (I) Low (F) Low	N) Low (I) Low (F) Low
Group 2 Fish: swim bladder is not involved in hearing (particle motion detection)	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low
Groups 3 and 4 Fish: swim bladder involved in hearing (pressure and particle motion detection)	(N) Low (I) Low (F) Low	170 dB rms for 48h

Type Of Fish	Mortality And Potential Mortal Injury	Recoverable Injury
Eggs and larvae	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low

6.156 Based on modelling undertaken using the threshold adopted above no injury to any fish groups is predicted for non-impulsive noise sources such as vibro-piling, dredging and vessel movements.

6.157 Therefore, the sensitivity of all fish IEFs to injury from both impulsive and non-impulsive noise sources is assessed as negligible.

Behavioural Disturbance

6.158 Behavioural effects in response to construction related underwater noise include a wide variety of responses including startle responses (also known as C-turn responses), strong avoidance behaviour, changes in swimming or schooling behaviour or changes of position in the water column. The most appropriate and up to date criteria for disturbance are considered to be those contained in Popper *et al.* (2014) which set out criteria for disturbance due to different sources of noise. The risk of behavioural effects is categorised in relative terms as "high", "moderate" or "low" at three distances from the source: "near" (i.e. in the tens of metres), "intermediate" (i.e. in the hundreds of metres) or "far" (i.e. in the thousands of metres), as shown in Table 6.22.

Table 6.22: Criteria for Onset of Behavioural Effects in Fish for Impulsive and Non-Impulsive Sound (Popper et al., 2014)

Type of Animal	Relative Risk of Behavioural Effects	
	Impulsive Piling	**Non-Impulsive Sound**
Fish: no swim bladder (particle motion detection)	(*Near*) High (*Intermediate*) Moderate (*Far*) Low	(*Near*) Moderate (*Intermediate*) Moderate (*Far*) Low
Fish: where swim bladder is not involved in hearing (particle motion detection)	(*Near*) High (*Intermediate*) Moderate (*Far*) Low	(*Near*) Moderate (*Intermediate*) Moderate (*Far*) Low
Fish: where swim bladder is involved in hearing (primarily pressure detection)	(*Near*) High (*Intermediate*) High (*Far*) Moderate	(*Near*) High (*Intermediate*) Moderate (*Far*) Low
Eggs and larvae	(*Near*) Moderate (*Intermediate*) Low (*Far*) Low	(*Near*) Moderate (*Intermediate*) Moderate (*Far*) Low

6.159 It is important to note that the Popper *et al.* (2014) criteria for disturbance to fish due to sound are qualitative rather than quantitative. Consequently, a source of noise of a particular type (e.g. piling) would result in the same predicted impact, no matter the level of noise produced or the propagation characteristics.

6.160 Therefore, the criteria presented in the Washington State Department of Transport Biological Assessment Preparation for Transport Projects Advanced Training Manual (WSDOT, 2011) are also used in this assessment for predicting the extent of behavioural effects due to impulsive piling.

The manual suggests an un-weighted sound pressure level of 150 dB re 1 µPa (rms) as the criterion for onset of behavioural effects, based on work by Hastings (2002). Sound pressure levels more than 150 dB re 1 µPa (rms) are expected to cause temporary behavioural changes, such as elicitation of a startle response, disruption of feeding, or avoidance of an area. The document notes that levels exceeding this threshold are not expected to cause direct permanent injury but may indirectly affect the individual fish (such as by impairing predator detection). It is important to note that this threshold is for onset of potential effects, and not necessarily an 'adverse effect' threshold.

6.161 Based on the modelling undertaken and threshold criteria presented behavioural effects from impact piling could be observed within 850 m of the source. For non-impulsive noise sources behavioural response is predicted within 19 m for vessel movements and 5 m for dredging. No quantitative disturbance criteria have been identified for vibro-piling for disturbance therefore the Popper *et al.* (2014) guideline criteria should be adopted.

Migratory Fish IEFs

6.162 The migratory fish species/life stages with the greatest sensitivity to underwater noise are adult twaite shad and adult allis shad (both species are fish in which the swim bladder is involved in hearing) during their upstream migrations in April to June, juvenile Atlantic salmon (fish with swim bladders in which hearing does not involve the swim bladder) during their downstream migration in April to June and European eel. Migration of Atlantic salmon smolts into the marine environment is thought to be a particularly critical stage in the life cycle of salmon, as they are vulnerable to marine predators and changes to environmental conditions which may affect food availability (Potter and Dare, 2003). Atlantic salmon post smolts also make limited use of estuarine environments as they migrate to offshore feeding grounds (Malcolm *et al.*, 2010).

6.163 Although these species are present in the estuary at other life stages (e.g. juvenile shad migrating downstream and adult Atlantic salmon), the aforementioned life stages are considered to be the most sensitive to potential barrier effects/disruption to migration because of noise and vibration. Adult Atlantic salmon and juvenile shad have less restricted upstream and downstream migration periods than the aforementioned life history stages. In addition, juvenile shad are known to use estuaries as nursery habitats. The implication of any potential short-term disruption of downstream juvenile shad migration would therefore be less significant than disruption to downstream migration of Atlantic salmon smolts, which make little use of estuarine environments. Atlantic salmon undertaking upstream migration, sea lamprey (upstream and downstream migration) and river lamprey (all life history stages) and allis and twaite shad (juvenile downstream migration and feeding) are also considered to be less sensitive (although it should be noted that these species are still considered to be sensitive at these life stages).

6.164 Based on the Popper et al. (2014) guidelines, using the magnitude of the noise likely to be generated as a result of piling, there is no risk to any fish species, including migratory fish, from mortality and potential mortal injury as a result of the continuous sound produced by the piling, even near the source (i.e., tens of metres).

6.165 Potential behavioural effects including barrier effects are possible given the narrow morphology of the MHW and may cause restrictions to the movement of migratory species. Modelling has predicted disturbance effects up to 850 m from the source during impact piling. Therefore, if piling is undertaken during the species migration periods some disturbance is likely across the width of the MHW. While disturbance effects could include restriction to migration, sound levels will highly unlikely result in a barrier to fish migrating within the MHW. At some point across the width of the MHW sound levels will be sufficient level for migratory fish species to pass. In addition, the short-term duration intermittent nature of the impact piling will ensure sufficient periods of time during the activity in which there will be no noise as impact piling will only be undertaken to finish the piling sequence. There is a moderate risk of disturbance effect within hundreds of meters from the source for vibro-piling and therefore is unlikely to restrict the passage of migrating species within the MHW.

6.166 Sea lamprey have been reported to respond to low frequencies (20-100 Hz) (Lenhardt and Sismour, 1995), though it has been suggested that sound may not be relevant to these species at all (Popper, 2005). Therefore, although uncertain, the sensitivity of sea lamprey to underwater noise and vibration is likely to be less than that for shad and Atlantic salmon.

6.167 European eel would be expected to have some sensitivity to both particle motion and sound pressure components of piling noise (Group 3 Fish) and therefore may show some behavioural responses in the near field (tens of metres) to far field (1000s metres).

6.168 In summary, it is highly unlikely that the piling will result in auditory injury. Some habituation to noise may also be anticipated for the fish assemblage in the area. However, this may not be true of migratory species and furthermore the sound levels generated by the piling, albeit intermittent, will be of greater occurrence over the short term than those associated with vessel traffic. The sensitivity of migratory fish (high to very high value receptors) to the levels of noise which will be generated is therefore considered to be low to medium.

Estuarine Fish Assemblages

6.169 As previously discussed, responses of fish to underwater noise include lethal and physical injury, auditory injury and behavioural responses, the latter of which includes a range of responses such as changes in swimming and schooling behaviour. The behavioural responses of estuarine fish will, however, depend on the life stage of the fish and the drivers for being in the area (e.g., feeding, spawning). The sensitivity of fish to underwater noise will also depend on the presence or absence of a swim bladder and on the potential for that swim bladder to improve the hearing sensitivity and range of hearing (Popper *et al.,* 2014). Some disturbance is likely from the project although maximum levels of disturbance will be observed during impact piling albeit over a short duration and will be highly intermittent. The sensitivity of the estuarine fish assemblage to the levels of noise which will be generated is therefore considered to be low.

Shellfish

6.170 There have been a few studies on the ability of aquatic invertebrates (including shellfish) to respond to noise (Wale *et al.*, 2013a; Wale *et al.*, 2013b, Roberts *et al.*, 2016), although these are insufficient to make firm conclusions about sensitivity. It is highly likely that aquatic invertebrates can detect particle motion, including seabed vibration, although what evidence there is indicates those species are primarily sensitive to particle motion at frequencies well below 1 kHz (Hawkings and Popper, 2016) which may be within the range of frequencies emitted during the dredging activities. Many aquatic invertebrates use hydrodynamic receptors to detect, localise and identify predators, prey, conspecifics or food falling to the seabed (Edmonds *et al.*, 2016) and therefore sound transmitted through the seabed may inhibit their ability to carry out normal ecological functions.

6.171 Sensitivity will therefore vary according to the hearing ability of the particular species and cannot be assessed by IEF. Given that the response is likely to be short-term behavioural or masking effects, with full and immediate recoverability likely to occur even for the most hearing/vibration sensitive species, the sensitivity of shellfish IEFs is assessed as negligible.

Significance of Effect

6.172 Disturbance/masking will occur over the short-term as discrete events and given the baseline level of vessel activity in the area, marine mammals and fish and shellfish receptors will, to some degree, be sensitised to noise from vessels. The magnitude of construction noise is assessed as low and will be reversible following cessation of the activity. The sensitivity of receptors ranges from negligible to medium and the significance of the effects of noise disturbance from vessel activity is therefore considered to be **negligible** to **minor**, which is not significant (in EIA terms).

Collision Risk from Vessel Movements

Magnitude of Impact

6.173 Movement of vessels, predominantly barges, around the PDI development could lead to an increased risk of collision with marine mammal receptors and collision is a known cause of injury and mortality in marine mammals (Laist *et al.*, 2001). During construction, most of the work will be done within the intertidal area with only dredging works to be carried out from a barge in the intertidal area. The barge is likely to remain stationary for long periods with only limited and slow movement to and from the site. The number of vessel movements during construction is likely to be very small in relation to the existing levels of vessel activity within the vicinity of Pembroke Port. Therefore, the magnitude is considered to be negligible.

Sensitivity of Receptor

Marine Mammals

6.174 Vessel strikes are known to be a cause of mortality in marine mammals although the greatest risk is usually from fast moving vessels. Whilst vessel strikes can occur for any species of marine mammals, most research has focussed on large whales. Evidence from the literature suggests that large vessels (>80 m) travelling at speeds more than 14 knots may represent the greatest threat (Laist *et al.*, 2001). Context is also an important factor in assessing risk; marine mammals at rest or feeding may be more vulnerable and there may be seasonal differences when marine mammals are using an area more intensively (Panigada *et al.,* 2006).

6.175 Whilst there has been previous concern on the use of vessels with ducted propellers posing a threat to marine mammals, recent research has shown that there is not any increased risk to animals over and above normal shipping activities (SNCBs, 2014).

6.176 As described previously (paragraph 6.3.40 *et seq.*), the waters near Pembroke Port are not a key area for marine mammals within the MHW. It is possible that individuals may venture this far up seasonally foraging on migratory fish species. However, noise from construction activities is likely to deter them from the vessels and, consequently, the sensitivity of marine mammals to collision risk is considered to be low.

Significance of Effect

6.177 Collision risk will occur over short-term events and the risk will be reduced immediately after a vessel has passed by the marine mammal receptor. Marine mammals will, to some extent, be accustomed to vessel movements due to the existing levels in area. Therefore, the effect of collision risk from construction activity on marine mammals is considered to be **negligible**.

Introduction of Invasive and Non-Native Species (INNS) during Construction

6.178 Vessels can act as a vector for INNS by allowing the colonisation of species from other geographical areas either as marine fouling on the vessel hull or following entrainment into the vessel through seawater intakes (for ballast water) that can in turn upset the ecological balance of local communities.

Magnitude of Impact

6.179 The vessels that will be used during construction will include barges for the backhoe dredge and transfer of dredge material to the licensed offshore disposal ground. While it is unlikely that the vessel used will require ballast water, which as described above can act as a vector for INNS, there is the potential for transfer via marine fouling on the vessel's hull. Vessels used during the project may need to be mobilised from elsewhere in the UK or the European Union which may allow for INNS to be transferred and introduced to the MHW.

6.180 The number of vessels that will be used and the number of movements required for the PDI project will be extremely low which will reduce the potential for transfer of INNS to MHW. In addition, the embedded mitigation which is described in Section 6.4 which includes an INNS management plan to be developed prior to vessel mobilisation which will also reduce the potential for transfer. The magnitude of the impact is therefore assessed as low.

Sensitivity of Receptors

6.181 MHW already has at least 35 marine INNS recorded within its boundaries so the potential for introduction of new INNS is low. There are however two INNS that are not yet introduced to MHW which have the potential to colonise habitats found within the MHW and are identified as Alert species in accordance with Pembrokeshire Nature Partnership. These include *Didemnum vexillum* carpet sea-squirt and *Eriocheir sinensis* Chinese mitten crab.

6.182 *Didemnum vexillum* is a highly invasive colonial ascidian, a sac-like marine invertebrate filter feeder that can form huge mats or pendulous colonies on artificial and natural hard surfaces. Introduction of *D. vexillum* can cause overgrowing substrata in the subtidal zone and rockpools, competing with and displacing native species.

6.183 *E. sinensis* burrows into river banks, affecting their integrity, the structure of the habitat and potentially impacting on species and communities which rely on the structure of the habitat to remain intact.

Subtidal Reef

6.184 Based on the identified IEFs associated with the MHW the introduction of *D. vexillum* from the project could impact on subtidal reef (identified as very high ecological value) and the species and communities associated. Therefore, the sensitivity subtidal reef IEF from introduction of *D. vexillum* is considered to be high.

Littoral sand and mud

6.185 *E. sinensis* could impact on intertidal littoral sand and mud (medium ecological value) IEF. Therefore, the sensitivity to littoral sand and mud habitats from introduction of *E. sinensis* is considered to be medium.

Annex I habitat 'Mudflats and sandflats' not covered by seawater at low tide'

6.186 *E. sinensis* could impact on Annex I habitat 'Mudflats and sandflats' not covered by seawater at low tide' (very high ecological value) IEF. Therefore, the sensitivity to this IEF from introduction of *E. sinensis* is considered to be high.

Significance of Effect

6.187 With the proposed mitigation the likelihood for introduction of identified INNS is low and therefore the magnitude is assessed as low. For MWH IEFs identified as have a high sensitivity to introduction of INNS, the overall significance is considered to be minor and for those IEFs that have been assessed as having a high and medium sensitivity, the overall significance is assessed as minor.

Accidental Release of Pollutants (e.g. Accidental Spillage) During Construction

Magnitude of Impact

6.188 There is the potential for the accidental release of pollutants into the marine environment during construction works, as a result of accidental spillage or leakage for example. Pollution may include diesel oil, leachates from cements and/or grouts used in construction.

6.189 As outlined in Table 6.12, the project would include standard measures to control pollution during construction and these would be set out in a CEMP. Adherence to these measures, standard best practice guidance and Environment Agency Pollution Prevention Guidelines would significantly reduce the likelihood of an accidental pollution incident occurring and impacting the waters of MHW. The applicant is also an environmental pollution regulator for the Waterway, so has a statutory interest in pollution prevention. Appropriate measures would include: designating areas for refuelling; storage of chemicals in secure designated areas in line with appropriate regulations and guidelines; double skinning of any tanks and pipes containing hazardous substances; and storage of hazardous substances in impervious bunds.

6.190 In the unlikely event that pollutants did enter the waters of the MHW they would likely be largely contained within Pembroke Port themselves due to the low flow currents likely within the Port area which will assist with facilitating clean-up. In the unlikely event that pollutants were to enter the wider MHW during the construction phase, they would be rapidly dispersed on the surface and in the water column and subject to twice daily tidal flushing, and so any effects on water quality would be limited. With the measures adopted as part of the project in place, the magnitude of the impact is considered to be negligible.

Sensitivity of Receptors

Intertidal Benthic Habitats

6.191 The sensitivity to the range of contaminants likely to occur during accidental pollution has been described in paragraph 6.5.32 to 6.5.34 for intertidal benthic habitats. However, accidental spills may result in a larger volume of chemicals or hydrocarbons released than those identified from construction activities. Low energy intertidal sediments are generally more susceptible to chemical pollution than high energy coastal environments. Furthermore, the low dispersion within these areas may result in them acting as sinks for pollutants and heavy metals, as a result of them becoming adsorbed onto fine sediments and organic particulates (Clark, 1997). Hydrocarbon contamination, from oil spills in particular, often results in large-scale damage to intertidal communities due to smothering of sediments which prevents oxygen exchange and leads to anoxia and subsequent death of infauna (Tyler-Walters and Marshall, 2006).

6.192 Some of the component species of the *Hediste diversicolor* and *Limecola balthica* in littoral sandy mud biotope which dominates have been found living in contaminated estuarine sediments. The intolerance of component species to impacts of this nature is typically high and bivalves, in particular, may experience mortality following an accidental contamination event. Recovery of the sediment requires dilution, biodegradation or removal of the contaminant from the sediments. Therefore, chemicals may persist for some time and it is likely that severe contamination will lead to declines in species richness although recoverability will typically be high (Tyler-Walters *et al.,* 2019). The overall sensitivity of intertidal mudflats is therefore considered to be medium.

Subtidal Benthic Habitats

6.193 The sensitivity of subtidal benthic communities within MHW to pollutants is described in paragraph 6.5.35 to 6.5.38. The communities are not considered to be sensitive to heavy metal, hydrocarbon and PAH contamination (De-Bastos and Hiscock, 2016) at the pressure benchmark that assumes compliance with relevant environmental protection standards (i.e. PELs). However, in the event of a spill, these standards may be exceeded, therefore, a precautionary approach has been adopted and the sensitivity of the benthic communities is considered to be low.

Fish

6.194 Accidental spillage of chemicals and substances from construction compounds and activities (including vehicles and equipment operating near to watercourses) may impact on fish species, resulting in behavioural effects such as avoidance of affected areas and barriers to migration.

Chemical spills may also have sub-lethal to lethal effects dependent on the spatial and temporal extent of the exposure and the level of toxicity.

6.195 The sensitivity of fish species will vary depending on a range of factors including the pollutant, species and life stage involved with fish eggs and larvae likely to be particularly sensitive (Westernhagen, 1988). As only adult and juvenile fish species are likely to be near the construction works, they are considered less likely to be affected by marine pollution due to their increased mobility. There is also evidence that fish can detect (and therefore avoid) oil contaminated waters through olfactory (smell) or gustatory (taste) systems (Claireaux, 2017). The sensitivity of fish species, including migratory fish, is therefore considered to be low.

Significance of Effect

6.196 With the mitigation measures adopted as part of the project, the likelihood of a pollution event occurring is extremely low and any spill which may occur would be largely contained within Pembroke Port. On this basis, the magnitude of the impact is considered to be negligible. The sensitivity of the receptors is considered to be low (for subtidal benthic communities, fish) to medium (for intertidal mudflats) and the effect of an accidental pollution event is therefore predicted to be of **minor** significance.

Assessment of Operational Effects

6.197 The proposed marine works are described in Table 6.13. Potential operational effect could arise from the extension of the existing slipway leading to permanent habitat loss and changes to hydrodynamic regime, which could affect both benthic and fish and shellfish receptors. The potential for an increase in noise disturbance/collision risk from vessels using the new port facilities to lead to detrimental effects on marine mammal receptors has been scoped out on the basis that the operational phase is not predicted to lead to a change in baseline vessel activities using the port.

Removal of Intertidal and Subtidal Habitats from The Presence of Infrastructure

Magnitude of Impact

Direct Footprint

6.198 Capital dredging of the slipway area and infilling of the Graving Dock will remove benthic habitat within the project footprint. Maximum habitat loss around the slipway will be within an area of 5,669 m^2, whilst dredging and infilling of the Graving Dock will remove 2,503 m^2 of habitat. This area represents 0.006% of the total seabed area of the MHW. Given the negligible area of habitat that will be removed the magnitude of this impact is assessed as low.

Sensitivity of Receptor

Intertidal Benthic Communities

6.199 The process of dredging and placement of pre-cast concrete within the slipway area and infilling of the Graving Dock will permanently remove the intertidal sand and mud habitat substrates and the characterising species.

6.200 This type of habitat is extensive throughout the MHW and therefore the removal of this habitat will not cause the extent of the habitat to significantly change as the proposed area of removal of this habitat represents removal of 0.03% of the total area of intertidal sand and mud habitat within the MHW. The habitat lost is also not within the boundary of the Pembrokeshire Marine SAC which is located 20 m from the proposed PDI footprint, and is a highly modified area due to its location within an operating port. In addition, the ability of key species to rapidly recruit following disturbance allows for rapid colonisation of the other areas that may become disturbed. The sensitivity of intertidal sand and mud habitat is therefore assessed as medium.

Subtidal Benthic Communities

6.201 Subtidal habitats that will be removed by the project are sand and mud habitats. Similarly, as for intertidal sand and mud habitats, PDI will not cause the extent of the habitat to significantly change as the proposed area of removal of this habitat represents removal of 0.02% of the total area of subtidal sand and mud habitat within the MHW.. No habitat loss will occur within the boundary of the Pembrokeshire Marine SAC. The sensitivity of subtidal sand and mud substrates is therefore considered to be medium.

Fish and Shellfish Ecology

6.202 The potential effect of loss/disturbance of fish and shellfish habitats, including spawning and nursery habitats, has been considered in relation to the permanent loss of benthic intertidal and subtidal habitat within the vicinity of Pembroke Port. The most sensitive species are likely to be those that live on or near the seabed, such as flatfish (e.g. sole, plaice, flounder) and elasmobranchs (e.g. thornback ray). However, such species are highly mobile and would be able to move away from the impacted area. Similarly, whilst of very high conservation value, migratory fish species are unlikely to be sensitive to this impact due to their ability to avoid the impacted area and their unlikely requirement to rely on the habitat that will be removed by the project for prey or recruitment and therefore their sensitivity to this impact is assessed as negligible.

6.203 Permanent loss/disturbance of benthic habitat could, however, lead to a localised decrease in prey availability or a temporary loss of spawning/nursery habitat, which could have consequences for the local abundance of fish and shellfish species following the impact.

6.204 Species that may have spawning and/or nursery grounds within the MHW include plaice, whiting, herring, sole, sandeel, mackerel, spotted ray, thornback ray and tope shark. As a demersal spawner, sandeel may be particularly vulnerable to habitat loss. Based on the medium conservation value of the species known to spawn or have nursery areas within the MHW, sensitivity is assessed as medium.

6.205 Slow moving or sessile species such as crustaceans and shellfish, , are likely to be vulnerable to habitat loss, and removal of substrate would lead to localised mortality of individuals. Recovery will depend on the ability of the species to reproduce and recolonise the habitat after the impact has ceased. Species within the impacted area, such as common periwinkle and grey top shell, are widespread and abundant throughout the MHW. Their planktonic larval phase would allow recruitment from undisturbed populations and therefore whilst resilience may be low the recoverability is likely to be high (e.g. Jackson, 2008; Rayment, 2008). Their sensitivity to permanent loss of habitat is considered low.

6.206 In summary, sensitivity of fish and shellfish receptors depends on their ability to avoid the impacted area and to recover following the impact. Conservation value of the component species varies across the IEFs and is considered when assessing sensitivity. Sensitivity of fish and shellfish receptors range from low to medium as described above.

Significance of Effect

6.207 The magnitude of impact will be low and habitat loss/disturbance will be very localised to just the footprint of the slipway and Graving Dock area. Sensitivity of the receptors ranged between low to medium depending on the component species present. For those receptors with a low sensitivity the significance of effect is considered to be negligible and for those with a medium sensitivity the significance of effect is considered to be **minor**. The effects are not significant in EIA terms for any of the receptors.

Changes to Hydrodynamic Regime from The Presence of Infrastructure

Magnitude of Impact

6.208 The project will slightly increase the bathymetry within the slipway area with the Graving Dock area infilled. It is not expected that the proposed changes will result in changes to the hydrodynamic regime of the area due to the low energy conditions that already exist as a consequence of Carrs Rock and Hobbs point that extend out into the MHW to the west and east of the proposed works, respectively. Therefore, no change is considered in the assessment of magnitude of this impact and therefore sensitivity to potential receptors has not been assessed.

Accidental Release of Pollutants (e.g. Accidental Spillage) During Operation May Impact Marine Receptors

Magnitude of Impact

6.209 There is the potential for the accidental release of pollutants into the marine environment during the routine port operations, as a result of accidental spillage or leakage for example. Pollution may include diesel oil and synthetic chemicals for example.

6.210 Pembroke Port's operation activities will also continue which are currently regulated by the Health and Safety Executive and the Environment Agency under the Health and Safety at Work Act 1974. The requirement to risk assess is carried out by MHPA under their stated compliance with the Port Safety Code. In terms of emergency or crisis management, MHPA has effective procedures in the form of spill response procedure to handle potential emergency scenarios which includes an environmental management system in place, which will be updated to incorporate the proposed upgrades to the facilities. The environmental management system will manage the risks of all operational activities, facilities and cargoes handled by the port and will include standard measures to control pollution. Adherence to these measures, standard best practice guidance and Environment Agency Pollution Prevention Guidelines would significantly reduce the likelihood of an accidental pollution incident occurring during the operation of the Port and impacting the waters of the MHW.

6.211 In the unlikely event of an accidental spill, the contaminants would likely be largely contained within the Port themselves facilitating clean-up. In the unlikely event that pollutants were to enter the MHW during the operation phase they would be rapidly dispersed on the surface and in the water column and subject to twice daily tidal flushing, and so any effects on estuarine water quality would be limited. With the measures adopted as part of the proposed development in place, the magnitude of the impact is considered to be negligible.

Sensitivity of Receptor

Intertidal Benthic Habitats

6.212 The sensitivity of intertidal benthic habitats to contaminants and accidental pollution events have been discussed in paragraphs 6.5.32 to 6.5.34 and in paragraphs 6.5.95 to 6.5.96 respectively.

Subtidal Benthic Habitats

6.213 The sensitivity of subtidal benthic habitats to contaminants and accidental pollution events have been discussed in paragraphs 6.5.35 to 6.5.38 and in paragraphs 6.5.97 respectively.

Fish

6.214 The sensitivity of fish to contaminants and accidental pollution events have been discussed in paragraphs 6.5.39 to 6.5.40 and again in paragraphs 6.5.98 to 6.5.100.

Significance of Effect

6.215 With the mitigation measures adopted as part of the project, the likelihood of a pollution event occurring is extremely low and any spill which may occur would be largely contained within Pembroke Port. On this basis, the magnitude of the impact is considered to be negligible. The sensitivity of the receptors is considered to be low (for subtidal benthic communities, fish) to medium (for intertidal mudflats) and the effect of an accidental pollution event is therefore predicted to be of **minor** significance.

Collision Risk Associated with Vessel Movements

6.216 The proposed project will unlikely cause a significant increase in vessel movements as the proposed works are considered an upgrade rather than expansion to existing facilities. Vessels using the slipway will be ad hoc and the infilling of Graving Dock will allow for more space onshore. Therefore, the risk of collision from an increase in vessel movements on marine receptors is considered neutral and is therefore considered no further.

Habitats Regulation Assessment (HRA)

6.217 The activities proposed for the PDI development have the potential to affect designated marine ecology features of the Pembrokeshire Marine SAC, West Wales SAC and the Cleddau Rivers

SAC. Information to support the HRA has been provided as a supplementary report to this Environmental Statement (Appendix 6.3).

Water Framework Directive (WFD) Compliance Assessment

6.218 If the impacts from the project on the biological, chemical or hydro morphological elements of the identified WFD waterbodies within the zone of influence from the project are considered a non-temporary/permanent effect then the impact must be carried forward for consideration in the WFD compliance assessment process. The WFD assessment report is included and has been provided as a supplementary report to this Environmental Statement (Appendix 6.4).

Further Mitigation

6.219 The measures which have been adopted as part of the PDI development, overall, provide a comprehensive means by which to protect marine ecology receptors from construction and operational effects of the development.

6.220 Surface sediment samples were collected to determine contaminant concentrations within the dredge footprint. Surface samples were collected as it was assumed that the highest contaminant concentrations would be found in sediments most recently exposed to anthropogenic sources. Sediment analysis identified elevated concentrations of some contaminants within above AL2 criteria. Given the levels of contaminants within the sediments to be dredged, further mitigation will be undertaken to test the sediment prior to disposal to ensure that sediments containing concentrations of contaminants above safe levels (i.e. exceeding AL2) are not disposed of in the wider MHW or at sea. In addition, MHPA will consult with the regulators to agree the most appropriate route for disposal of sediments where concentrations of contaminants exceed AL1.

Accidents and/or Disasters

6.221 There is the potential for the accidental release of pollutants into the marine environment during construction works, as a result of accidental spillage or collision of vessels for example. Pollution may include diesel oil, leachates from cements and/or grouts used in construction.

6.222 The project would include standard measures to control pollution during construction and these would be set out in a CEMP. Adherence to these measures, standard best practice guidance and Environment Agency Pollution Prevention Guidelines would significantly reduce the likelihood of an accidental pollution incident occurring and impacting the waters of MHW. Appropriate measures would include: designating areas for refuelling; storage of chemicals in secure designated areas in line with appropriate regulations and guidelines; double skinning of any tanks and pipes containing hazardous substances; and storage of hazardous substances in impervious bunds.

Potential Changes to The Assessment as a Result of Climate Change

6.223 Taking into account the information identified in the future baseline section in paragraphs 6.3.51 to 6.3.55, it is considered unlikely that any potential future changes baseline conditions as a result of climate change would affect any of the assessments presented for impacts to marine ecology during the operation phase.

Assessment of Cumulative Effects

6.224 The cumulative effect of the PDI project has been considered with other plans or projects within a pre-defined geographical area as part of a cumulative effects assessment (CEA). The assessment has considered developments that are at the scoping stage or later in the consenting process. Developments that are built and operational at the time of assessment have been considered as part of the baseline. These developments are described in Table 6.23 and are presented in **Figure 6.2**.

Table 6.23: Projects and Activities Considered for Assessment of Cumulative Effects

Project (Developer)	Spatial Overlap	Temporal Overlap	Description And Proposed Development Activities	Further Assessment Required?	Justification
Dredging and disposal sites	Partly (see next column in **bold**)	Yes	DML1743 – Dredge and disposal from Neyland Marina, 2017-2020 (Neyland Yacht Haven ltd.), **spatial overlap**; DML1646 – Milford Haven maintenance dredging, 2017-2022 (MHPA). Annual volume 5500 m^3, **spatial overlap**, see Figure 2. RML1462 - Dredging a 32 m x 20 m approach channel in relation to the construction of a new lock structure in relation to the proposed Martello Quays sites, 2017-2022 (The Conygar Investment Company plc). Annual volume 9500 m^3. **No spatial overlap.**	Yes	Sediment plumes generated from placement of material in identified disposal ground and dredging activities may present potential cumulative effects with Pembroke Port activities. There may also be a potential for cumulative impact from increased underwater noise from dredging and disposal activities.
Deployment of scientific equipment and marker buoys (University College of Swansea) - DEML1845	No	Yes	Deposition and subsequent removal of marker buoys with environmental monitoring and mid-water settlement plates, 2018-2019.	No	No spatial overlap and impact pathway identified.
Martello Quay (Martello Quays Ltd.) - LPA Ref: 07/0020/CA	Yes	No	Planning permission was granted by Pembrokeshire County Council in February 2008. The Project will include up to 260 marina berths and associated car parking; marine workshops and a chandlery; 450 houses and apartments; a new public promenade; shops; a pub and restaurant; a hotel; and a five-screen multiplex cinema.	No	There is a high level of uncertainty with regards to timescales, EIA and project construction works, considering no progress has been made since the permission was granted in 2008 by Pembrokeshire County Council. As a result, this project has been scoped out.
Marine Energy Test Area Phase 1 (Pembrokeshire Coastal Forum)	Yes	Yes	The project will provide five testing sites located near Pembroke Port to support testing and monitoring of marine energy components and subassemblies. Testing activities includes mobilisation and demobilisation of vessels, deployment and monitoring of components / subassemblies. Components and sub-assemblies will be deployed to the seabed, on the surface or within water column.	Yes	Testing and monitoring activities are likely to undertaken during construction and operation phase of Pembroke Port. There is also potential for cumulative impacts on identified marine receptors

Project (Developer)	Spatial Overlap	Temporal Overlap	Description And Proposed Development Activities	Further Assessment Required?	Justification
Marine Energy Test Area Phase 2 (Pembrokeshire Coastal Forum)	Yes	Yes	The project will provide three testing sites located within MHW to support testing and monitoring of marine energy devices. Testing activities includes mobilisation and demobilisation of vessels, deployment wave and tidal energy devices. Devices will be deployed to the seabed, on the surface or within water column.	Yes	Testing activities are likely to be undertaken during construction and operation phase of the PDI. There is also potential for cumulative impacts on identified marine receptors.
Pembrokeshire Wave Energy Demonstration Zone (Wave Hub Ltd.)	No	Yes	The Project entails the development of 90 km^2 of seabed with water depths of approximately 50 metres and a wave resource of approximately 19 kW/m; to support the demonstration of wave arrays with a generating capacity of up to 30MW for each project. Consent for this Project could be achieved in 2022, infrastructure could be built by 2024 and the first technology could be installed in 2025.	No	This project will not be taken forward in the CEA as no spatial overlap with the PDI has been identified.
Mixed used development (MHPA) - LPA reference: 14/0158/PA	No	Yes	Demolition of several existing buildings and the mixed-use redevelopment of Milford Waterfront comprising up to 26,266 m^2 of commercial, hotel, leisure, retail and fishery related floorspace. Up to 190 residential properties, up to 70 additional marina berths, replacement boat yards, landscaping, public realm enhancements, access and ancillary works. A decision on this application is yet to be made by the local planning authority.	Yes	Given the distance from the project and likely impact pathways. There is potential for cumulative impacts to affects the marine environment.
Cable Interconnector (Greenlink) - Welsh Government reference: qA1296053 Ground investigations - RML1827	No	Yes	The Project is a 500MW subsea electricity interconnector linking the power markets in Ireland and Great Britain and is planned for commissioning in 2023. As an EU Project of Common Interest, it is one of Europe's most important energy infrastructure projects. The interconnector is planned to make Landfall at Freshwater West beach to the south of the mouth of the MHW. A marine licence application was submitted in 2018, pending decision, for marine Ground Investigations and for the Interconnector.	No	This project is to be excluded from the CEA on the grounds that there is no spatial overlap with the PDI project.
Combined Heat and Power (CHP) Cogeneration Unit at Pembroke Refinery	No	Yes	The project is to provide the refinery's electrical power and support its steam demands. Valero has configured the project to efficiently generate electricity whilst using the waste heat arising from this combustion process to produce super-heated steam for use within the refinery. The use of waste heat and the	No	This project is to be excluded from the CEA on the grounds that there is no spatial overlap with the PDI project and no

Project (Developer)	Spatial Overlap	Temporal Overlap	Description And Proposed Development Activities	Further Assessment Required?	Justification
Welsh Government reference: qA1312073			production of steam usefully increases the overall efficiency of the electrical generation plant.		impact pathway to identified marine receptors

6.225 The following projects and their associated activities have been taken forward for cumulative assessment:

- Dredging and disposal sites associated Neyland Marina development and MHPA maintenance dredging activities;
- Marine Energy Test Area (META) Phase 1 and Phase 2; and
- Mixed used development, Milford Haven.

6.226 The potential impact pathways assessed in sections 6.5 and 6.6 (inclusive) have been considered, and the cumulative assessment undertaken is presented below.

6.227 Where a potential impact pathway has been screened out of further consideration for the PDI project alone, or the assessment for PDI concluded no impact, no cumulative impact assessment has been presented. These include:

- Collision risk of vessels on marine mammals;
- Accidental release of pollutants on all ecological receptors;
- Suspended sediment concentrations and sediment deposition during dredging on benthic habitats, fish and shellfish;
- Release of contaminants during dredging and dewatering on all ecological receptors; and
- Introduction of invasive and non-native species.

Suspended Sediment Concentrations and Sediment Deposition During Dredging

Benthic Habitats, Fish and Shellfish

6.228 PDI activities may cause localised increases in suspended sediments during dredging and dewatering activities. Increase in SSC associated with dredging and disposal CEA projects identified have the potential to spatially and temporally overlap with PDI activities, resulting in further increases in suspended sediments within Pembroke Port area. The MHW regularly experiences elevations in suspended sediments as part of construction development, maintenance dredging and from vessel activity. The duration of dredging and disposal activities vary depending on the volume and method of dredging. This can cause sediment plumes to extend for several kilometres, dependent on the velocity of tidal currents in the MHW (Little *et al.,* 2009). There is therefore an existing high baseline level of suspended sediment within the MHW. It is considered likely that suspended sediment concentrations will rapidly return to background concentrations as sediments either fall out of suspension or become widely dispersed within the MHW.

6.229 For projects where larger volumes of suspended sediments are predicted such as MHPA annual maintenance dredging (362,500 tonnes, Figure 6.2) and Neyland Marina maintenance dredging

(5,500 tonnes, Figure 6.2), consent has already been granted. While detailed information on the impact significance associated with the increases in suspended sediments is scarce for Neyland Marina, it is assumed consent has been awarded based on sufficient mitigation, and management has been adopted to ensure proposed works are compliant with environmental legislation. Similarly, maintenance dredging and disposal activities undertaken by MHPA and Neyland Yacht Haven Ltd, while substantially smaller in terms of sediment volumes to be dredged, will also be managed appropriately in accordance with licence conditions resulting in reduced environmental impacts. Plume migration from Neyland Marina will likely be further restricted from mixing with the PDI dredge plume given the dominant flow direction of currents within the MHW that flow perpendicular to the two project locations (respectively on the north and south sides of the MHW; see Figure 2). Mobilised sediments will immediately disperse east and west of the point of mobilisation dependent on the tide reducing the potential for migrating towards the opposite shoreline where the projects are located. Finally, the impacts from PDI dredging activities are considered minor compared with above mentioned projects.

6.230 Given the location of dredging activities associated with PDI and identified CEA projects or plans, increases in suspended sediments are likely to be minor should projects temporally overlap. Where projects are dredging simultaneously the potential increases in SSC will be temporary, as concentrations return to background levels on cessation of dredging and disposal.

6.231 The sensitivity of fish and shellfish assemblages and benthic habitats within MHW have been assessed as relatively insensitive to increases in SSC and sediment deposition (Section 6.5). A temporal overlap of the projects mentioned will not result in a significant cumulative impact due to the small-scale nature of dredging for PDI. The impact significance is therefore considered to be **minor** which is not significant in EIA terms.

Underwater Noise Emissions

Fish

6.232 Activities associated with identified projects for cumulative assessment may cause an increase in underwater noise from a range of sources including construction vessels and plant, barges, dredge vessels. The underwater noise emissions associated with PDI activities will be from piling, vessels and operation of dredge plant and equipment.

6.233 Cumulative underwater noise may cause some avoidance by species of fish in the short term. However, no injury or long-term effects are predicted as any animals present within the area are likely to demonstrate some degree of habituation due to already raised levels of underwater noise from existing port and industrial operations. The cumulative disturbance area and/or the period in which disturbance effects are observed may be higher/larger, however recovery rate is likely to be high. Cumulative impact associated with underwater noise from construction vessels and plant, barges, dredge vessels is therefore considered to be **minor.**

Marine Mammals

6.234 Harbour porpoise, bottlenose dolphin and grey seal are occasionally sighted in the MHW within vicinity of Pembroke Port. Minor disturbance effects such as avoidance and masking of communication are predicted for PDI activities from vessel movements and dredging, with the overall impact is considered to be minor. Similar effects may also arise due to vessel and dredge activities from all five CEA projects identified. Potential effects may extend for a longer duration and a larger area if a temporal overlap is assumed.

6.235 Piling activities associated with Neyland Marina could cause increased disturbance due to the increased noise levels emitted from piling activity associated with these projects. However, as the number of marine mammals observed within the MHW are very low, the potential for impact remains very low. Information detailing the impacts associated with Neyland Marina on marine mammals are not available, therefore it has been assumed that potential impacts from piling on marine mammals have been suitably mitigated given the project has been consented. Based on this assumption, cumulative impacts of increased underwater noise on marine mammals has been assessed as **minor significance**.

Presence of Infrastructure

Benthic Habitats

6.236 There may be a minor loss of small areas of soft sediment habitat associated with PDI activities, in particular from dredging of the slipway and infilling of the Graving Dock. Similar types of habitat may be lost from META Phase 2 (for META Phase 1, all components etc. will be placed in the water columns only, with no habitat loss effects) as part of the vessel anchoring and component and device testing and deployment. It should be noted, however, that all habitat loss associated with the META project will be temporary, with all devices and components removed following testing. Similar habitat may also be lost due to dredging footprints from MHPA maintenance dredging, particularly in Pembroke Port. Maintenance dredging activities will remove sediments that have accumulated since the previous dredging event, so these habitats will be disturbed already. Similarly, placement of dredge sediments within the disposal ground will also experience habitat loss/disturbance from the most recent disposal event. Given that these areas are small and will have previously been disturbed the cumulative effect from these activities on benthic habitat loss are considered **negligible significance**.

6.237 The potential reduction in habitat associated with third party projects is considered negligible compared with the prevalence of these types of habitat throughout the MHW. In addition, habitat loss impacts from other projects will be temporary and reversible and those habitats affected by dredging already experience a high level of disturbance, therefore potential impacts of additional disturbance are assessed as **negligible significance**.

Inter-Relationships

6.238 There are not considered to be any additional inter-relationships between marine ecology and other topics which have not already been considered in the assessment.

Summary of Effects

6.239 The proposed project was assessed with respect to impacts on marine environment receptors. During construction potential impacts were identified from increases in suspended sediments, contaminant release and underwater noise emissions. During operation the presence of proposed infrastructure and accidental spill events were identified as a key potential impact.

6.240 Following assessment of the sensitivities of a range of receptors including benthic habitats, fish, shellfish and marine mammals on each identified impact the assessment found that all impacts were of either negligible or minor significance.

6.241 A summary of the of the likely environmental effects is provided in Table 6.24.

Table 6.24: Summary of Likely Environmental Effects on Marine Environment

Receptor	Sensitivity Of Receptor	Description Of Impact	Duration	Magnitude Of Impact	Significance Of Effect	Significant /Not Significant
Intertidal benthic communities – biotope LS.LMu.MEst.HedMac	Low	Increase in suspended sediments during dredging	Short term	Low	Negligible	Not significant
Intertidal benthic communities – biotope LR.HLR.FT.FserTX	Medium	Increase in suspended sediments during dredging	Short term	Low	Minor	Not significant
Intertidal benthic communities – biotope LS.LMu.MEst.HedMac	Low	Increase in suspended sediments during dredging	Short term	Low	Negligible	Not significant
Intertidal benthic communities – biotope LS.LMS.ZOS.Znol	Medium	Increase in suspended sediments during dredging	Short term	Low	Minor	Not significant
Intertidal benthic communities – biotope LR.HLR.MusB.Sem	Low	Increase in suspended sediments during dredging	Short term	Low	Negligible	Not significant
Subtidal benthic communities – biotope mixed sediments	Low	Increase in suspended sediments during dredging	Short term	Low	Negligible	Not significant
Subtidal benthic communities – biotope reef	Low	Increase in suspended sediments during dredging	Short term	Low	Negligible	Not significant
Subtidal benthic communities – biotope eelgrass	Medium	Increase in suspended sediments during dredging	Short term	Low	Minor	Not significant
Fish Assemblage	Low	Increase in suspended sediments during dredging	Short term	Low	Negligible	Not significant
Fish larvae and eggs	High	Increase in suspended sediments during dredging	Short term	Low	Minor	Not significant
Migrating Fish	Low	Increase in suspended sediments during dredging	Short term	Low	Negligible	Not significant
Shellfish	Medium	Increase in suspended sediments during dredging	Short term	Low	Minor	Not significant
Designated Shellfish waters	Low	Increase in suspended sediments during dredging	Short term	Low	Negligible	Not significant
Intertidal benthic communities – biotope Mudflats and Sandflats	Low	Release of contaminants from dredging and dewatering	Short term	Low	Negligible	Not significant
Intertidal benthic communities – biotope LS.LMS.ZOS.Znol	Medium	Release of contaminants from dredging and dewatering	Short term	Low	Minor	Not significant

Receptor	Sensitivity Receptor	Of Description Of Impact	Duration	Magnitude Of Impact	Significance Effect	Of Significant Significant /Not
Intertidal benthic communities – IEF *Zostera noltii*	Low	Release of contaminants from dredging and dewatering	Short term	Low	Negligible	Not significant
Intertidal benthic communities – biotope Reef	Medium	Release of contaminants from dredging and dewatering	Short term	Low	Minor	Not significant
Subtidal benthic communities – biotope Mudflats and sandflats	Low	Release of contaminants from dredging and dewatering	Short term	Low	Negligible	Not significant
Subtidal benthic communities – IEF *Zostera marina*	Low	Release of contaminants from dredging and dewatering	Short term	Low	Negligible	Not significant
Fish and Shellfish	Low	Release of contaminants from dredging and dewatering	Short term	Low	Negligible	Not significant
Marine Mammals – Injury	Low	Underwater noise emissions – Impact Piling/ Vibro-piling/ Dredging/ Vessel movements	Short term	Low	Negligible	Not significant
Marine Mammals - Behaviour	Low	Underwater noise emissions – Impact Piling/ Vibro-piling/ Dredging/ Vessel movements	Short term	Low	Minor	Not significant
Fish – Injury	Negligible	Underwater noise emissions – Impact Piling/ Vibro-piling/Dredging/ Vessel movements	Short term	Low	Negligible	Not significant
Migratory Fish - Behaviour	Low / Medium	Underwater noise emissions – Impact Piling	Short term	Low	Minor	Not significant
Estuarine Fish - Behaviour	Low	Underwater noise emissions – Vibro-piling/Dredging/ Vessel movements	Short term	Low	Minor	Not significant
Shellfish	Negligible	Underwater noise emissions – Dredging/ Vessel movements	Short term	Low	Negligible	Not significant
Marine Mammals	Low	Collision risk from vessel movements	Short term	Negligible	Negligible	Not significant
Intertidal benthic communities – biotope Mudflats and Sandflats	Medium	Introduction of INNS	Long term	Low	Minor	Not significant
Subtidal benthic communities biotope Annex 1 Mudflats and sandflats not covered by seawater at low tide'	High	Introduction of INNS	Long term	Low	Minor	Not significant

Receptor	Sensitivity Receptor	Of Description Of Impact	Duration	Magnitude Of Impact	Significance Effect	Of Significant /Not Significant
Subtidal benthic communities – biotope reef	High	Introduction of INNS	Long term	Low	Minor	Not significant
Intertidal benthic habitats	Medium	Accidental release of pollutants (during construction)	Short term	Negligible	Minor	Not significant
Subtidal benthic habitats	Low	Accidental release of pollutants (during construction)	Short term	Negligible	Negligible	Not significant
Fish	Low	Accidental release of pollutants (during construction)	Short term	Negligible	Negligible	Not significant
Intertidal benthic habitats	Medium	Direct disturbance from presence of infrastructure	Long term	Low	Minor	Not significant
Subtidal benthic habitats	Medium	Direct disturbance from presence of infrastructure	Long term	Low	Minor	Not significant
Migratory Fish	Negligible	Direct disturbance from presence of infrastructure	Long term	Low	Negligible	Not significant
Fish Species - Spawning/ Nursery grounds	Medium	Direct disturbance from presence of infrastructure	Long term	Low	Minor	Not significant
Shellfish	Low	Direct disturbance from presence of infrastructure	Long term	Low	Negligible	Not significant
Intertidal benthic habitats	Medium	Accidental release of pollutants (during operation)	Short term	Negligible	Minor	Not significant
Subtidal benthic habitats	Low	Accidental release of pollutants (during operation)	Short term	Negligible	Negligible	Not significant
Fish	Low	Accidental release of pollutants (during operation)	Short term	Negligible	Negligible	Not significant

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Non-Technical Summary

6.242 Physical processes, water quality, and marine habitats, species and ecological communities were identified as part of the baseline assessment to assist with determining the level of impact from proposed PDI construction and operation activities. A desktop review was undertaken to characterise the baseline conditions supplemented by sampling of sediments within the proposed dredge footprint to characterise the physical and chemical properties of sediment proposed to be removed for disposal at sea.

6.243 Sediment contaminant concentrations within the proposed dredge area indicate some low levels of contamination across both the slipway and Graving Dock area. The sediments located within the slipway have higher contamination levels than those located within Graving Dock particularly for zinc and tributyl tin.

6.244 The MHW displays a variety of intertidal (zone between low tide and high tide mark) habitats with intertidal mudflat habitat being dominant. The intertidal habitat in the immediate vicinity of the Pembroke Port is comprised of mud and rock. The mud substrate supports communities of polychaetes, oligochaetes and bivalves whilst the rock communities are characterised by seaweed algae and other species that live on the surface of the seabed such as sponges, ascidians, and shellfish. An intertidal seagrass species known as dwarf eelgrass is found at Hobbs Point located 1100 m to the east of the proposed PDI development area and covers an area of 3.29 ha.

6.245 The subtidal (zone below low tide mark) habitats of the MHW are represented by mixed sediments, reef, eelgrass and maerl beds. Oligochaetes (worms), polychaetes (bristle worms), bivalves (shellfish) and amphipods (shrimps) characterise the mixed sediments. Subtidal reef habitat has a patchy distribution throughout the MHW and is typically characterised by algae and bivalves on hard substrate. The reef building polychaete *Sabellaria spinulosa* has also been noted within the MHW and in undisturbed areas may form reef structures.

6.246 There are three populations of the subtidal eelgrass within MHW, the largest of which lies 7 km to the west of Pembroke Port, located in Littlewick Bay on the northern shoreline of MHW. Subtidal eelgrass in MHW is typically found on sand to fine gravel in depths of up to 5 m. There is a maerl bed located 7-9 km west of Pembroke Port; in the vicinity of Littlewick Bay to Stack Rock.

6.247 Nineteen species of fish have previously been identified within the MHW including elasmobranchs (sharks and rays), flat fish (plaice), gobies, sand smelt and bass. The substrates around Pembroke Port also support several common shellfish species, which are considered typical of estuarine environments.

6.248 The waters near Pembroke Port are not a key area for marine mammal species (whales, dolphins, porpoises, seals and otter). Data shows infrequent sightings of harbour porpoise and bottlenose dolphin within the MHW with a low likelihood of occurrence as far up as Pembroke Port. Grey seal may occasionally occur in low numbers within the MHW and near to Pembroke Port. Otter is also likely to occur near Pembroke Port, although is unlikely to have breeding sites in this area due to the disturbance from the existing anthropogenic activities associated with Pembroke Port.

6.249 Several mitigation measures have been considered as part of the intrinsic project design to reduce potential environmental effects. These measures are considered to be standard industry practice for this type of development and include the following:

- Construction Environmental Management Plan (CEMP);
- Environmental Management Plan (EMP);
- Invasive and Non-Native Species (INNS) Management Plan;
- Installation of a cofferdam at the entrance to Graving Dock;
- Use of backhoe dredge to undertake dredging activities;
- Piling activities undertaken in daylight hours only; and
- Soft start procedure to be implemented prior to commence of piling activity.

6.250 A number of potential impacts associated with the installation and operation of the proposed development on marine biodiversity receptors have been assessed, including temporary and permanent habitat loss, underwater noise emissions, increased suspended sediment concentration (SSC), sediment deposition and accidental pollution events.

6.251 Some permanent and temporary loss of, or disturbance to seabed habitat as a result of construction works is expected within the proposed redevelopment area. Due to low abundance and diversity of benthic and shellfish communities, this activity is not expected to have a significant impact.

6.252 Increased suspended sediment in the water column as a result of construction activities is unlikely to affect benthic habitats, fish and marine mammal species due to the localised extent of sediment plumes that will be generated by dredging activities and the short duration predicted. Contaminant release from sediments during dredging is unlikely due to the low volume of sediment and levels of contaminants within sediments.

6.253 Impact sheet piling is likely to produce noise at higher levels than those levels produced by dredging and vessel movements. Whilst noise impacts associated with the installation of sheet piling have the potential to cause injury and disturbance to marine mammals and fish species, the densities of animals within the zone of influence are so small that populations are unlikely to be affected. Injury to marine mammals would not occur other than for harbour porpoise which would require individual animals to remain within a few metres of the noise source for a substantial length of time, and as such injury to individuals is not predicted. Noise from underwater piling will be insufficient to cause death in any fish species and no injury would be caused to fish from the piling activity as they would be expected to move away from the noise source. Disturbance to marine mammals were predicted to occur out to 2.8 km for impact piling, 4 km for vibropiling and 1.6 km for dredging activities. For fish behavioural effects including startle responses, strong avoidance behaviour, changes in swimming or schooling behaviour or changes of position in the water column from impact piling could be observed within 850 m of the source. For vessel movements and dredging, disturbance ranges of 19 m and 5 m were predicted respectively. Mitigation in the form of a soft start procedure is to be implemented prior to commencement of piling activity and will help to mitigate any disturbance predicted.

6.254 Increased collision risk to marine mammals as a result of vessel movement during the construction phase is expected to be low, primarily as the increase in number of vessels from the existing operational levels of the port is only marginal, and vessel speed within the Port will be low.

6.255 It is possible that an accidental loss of diesel from vessels involved in the PDI, could impact negatively on marine biodiversity receptor through toxicological effects or through smothering by oil. However, marine mammals and fish species are highly mobile and are able to detect these pollutants and as a result are expected to avoid areas where pollution has occurred. Immobile species that live on the seabed are more vulnerable to accidental pollution, however the likelihood of a large spill occurring is extremely low, as the risk will be managed by a CEMP and by MHPA's oil spill response procedures during the operational phase.

6.256 The potential for cumulative effects arising from the project, in association with other projects was assessed. Projects which could foreseeably overlap temporally or spatially with the proposed redevelopment, or where construction impacts may be consecutive but cumulative, were considered. Underwater noise and increased SSC impacts were found to have the widest potential impact, and therefore the location and zone of influence of other projects were assessed on this basis. Some potential overlap both spatially and temporally was identified from other projects for increases in SSC and underwater noise. For SSC, identification of the location of other dredging activities that may temporally overlap with the PDI project found SSC concentrations would likely be low due to proposed volumes to be dredged and would return to background levels rapidly on cessation of dredging resulting in a minor cumulative effect. For underwater noise the cumulative disturbance area and/or the period in which disturbance effects are observed may be greater, however given the low numbers of marine mammals and high recovery rate of fish to disturbed areas, cumulative impacts were considered to be minor.