Milford Haven Port Authority

Pembroke Dock Infrastructure Project

Marine Environmental Baseline

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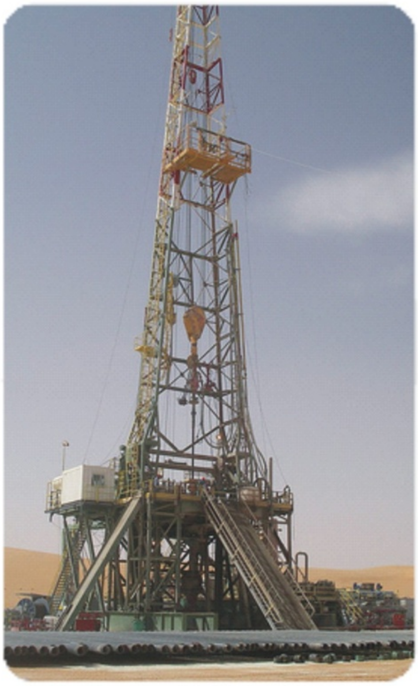

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1 Introduction

1.1 Project Background

RPS has been commissioned by Milford Haven Port Authority (MHPA) to undertake an Environmental Impact Assessment (EIA) for the Pembroke Dock Infrastructure project which seeks to improve existing facilities at Pembroke Port, Pembroke Dock, Pembrokeshire (Figure 1-1).

Pembroke Dock Infrastructure Project will create a flexible port-related industrial area capable of meeting the needs of the modern blue economy that will provide a significant contribution to the Swansea Bay City Deal proposals for a Marine Energy Engineering Centre of Excellence in south west Wales. This will involve the intensive use of land side areas for fabrication, repair and servicing of boats, renewable energy devices, transporting cargo and other works requiring marine access, served by an appropriately structured highly flexible enlarged slipway.

To realise the vision of a centre of excellence, several modifications are required to the layout of the Gate 4 area, including:

- Widening of the existing slipway and extension of the quayside towards deeper water;
- Provision of large areas of hardstanding in proximity to the quayside; and
- Areas of flat land for use either as ‘laydown’ or capable of being developed to create buildings in response to time-sensitive business requirements.

The proposed development will enable the provision of an enlarged single slipway at Gate 4 to facilitate the efficient transfer of vessels and marine renewable devices between land and sea, together with the formation of large ‘lay down’ open areas to facilitate working on boats and devices without occupying slipways.

At the southern boundary, areas and buildings for the importation and storage of goods and raw materials by land for fabrication activities on site will be required. To achieve this, the following will be necessary:

- Creation of open space laydown in brownfield areas within the curtilage of the dockyard.
- Infilling the graving dock;
- Creation of a single large slipway by combining the two westernmost slipways and extending the slipway into the Milford Waterway (MHW);
- Infilling the timber pond;
- Demolition of some buildings which are no longer fit for purpose~~;~~ and
- Dredging to provide sufficient depth and create a suitable profile for construction of the new slipway.

The project is the subject of an outline planning application for the erection of buildings, extension to the slipway and associated development at the port, as well as a Marine Licence application to the Natural Resources Wales Marine Licensing Team (NRW-MLT).

1.2 Aims and Objectives

The aim of this report is to provide a summary of the marine baseline conditions in the study area to inform the EIA for the proposed Pembroke Dock Infrastructure project with respect to the marine environment and in particular the marine ecology and coastal processes of MHW.

The objectives of the study are to:

- Collate and review available information on the marine environment under the following receptor groups:

- Geomorphology and bathymetry;
- Wave and tidal regime;
- Water quality;
- Sediment quality;
- Intertidal habitats;
- Subtidal habitats
- Fish and shellfish; and
- Marine mammals.

- Summarise the findings of site-specific marine sediment contamination surveys undertaken in support of the project; and
- Identify key relevant marine designations in the area.

1.3 Study Area Overview

The desktop study considered a study area representative of the receptor groups that could potentially be impacted by the project. Professional judgement was applied to determine the extent of the study area for each receptor group. The study area defined for each receptor group is provided below in Table 1.1.

Table 1.1: Study area identified for each receptor group

Receptor Group	Study Area Extent
Geomorphology and Bathymetry	MHW
Wave and Tidal Regime	MHW
Water Quality	MHW
Sediment Quality	MHW
Intertidal Habitats	MHW
Fish and Shellfish	MHW
Marine Mammals	South West Wales

1.4 Structure of Report

This report is structured as follows:

- Section 2 - Describes the data sources utilised for this assessment, including desktop research and site-specific surveys;
- Section 3 - Describes the key relevant marine designations, specifically the Pembrokeshire Marine Special Area of Conservation (SAC), Cleddau Rivers SAC, West Wales Marine candidate SAC and the MHW Site of Special Scientific Interest (SSSI);
- Section 4 - Details the results of the desktop review and sit specific surveys;
- Section 5 – Provides the conclusions of the study; and
- Section 6 – Provides the list of references from the study.

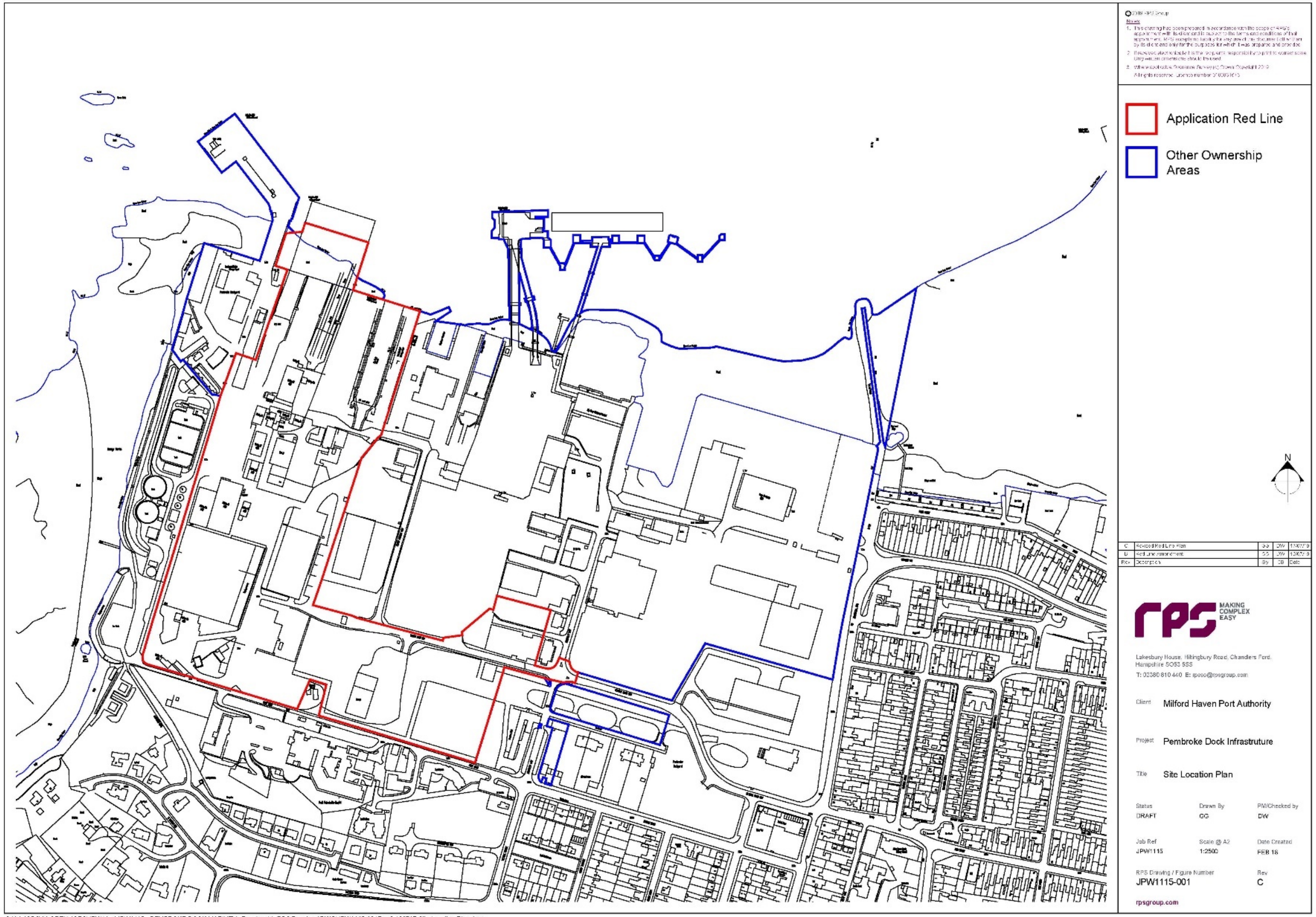

Figure 1-1: Pembroke Dock Infrastructure site location

2 Data Sources

2.1 Desktop Data

There is a substantial amount of historical data from various studies and monitoring campaigns undertaken in MHW as presented in Figure 2-1. The key data sources for the marine baseline desktop study were as follows:

- Historic mapping of intertidal and subtidal habitats within Milford Haven including mapping of intertidal habitats by the Countryside Council for Wales (CCW) (now Natural Resource Wales (NRW); Brazier *et al.* (2007)), data from the Mapping European Seabed Habitats (MESH) mapping programme (EUSeaMap2016) and data from http://magic.defra.gov.uk;
- Data and reports from the MHW Environmental Steering Group (MHWESG) including Carey et al. (2015), Little *et al.* (2009) and Warwick (2006);
- Relevant marine ecological information presented in reports and data from developments within Milford Haven, including studies undertaken by RPS in the vicinity of Pembroke Power Station (RPS, 2007) and South Hook Liquid Natural Gas (LNG) terminal and Combined Heat and Power (CHP) station Development Consent Order (DCO) submission (RPS, 2013);
- Relevant historic information from Milford Haven Port Authority, including maintenance dredging assessments (Hebog, 2006);
- Information on fish spawning and nursery habitats from Cefas (e.g. Ellis *et al.,* 2012; Coull *et al.,* 1998), academic studies on Milford Haven (e.g. Hobbs and Morgan, 1992; Clarke and King, 1985) and developments within Milford Haven (e.g. Pembroke Power Station; RPS, 2007);
- Background information on the features of SACs/SSSIs outlined in section 30 from NRW supporting documents for those designated sites; and
- Reports and data on the distribution of marine mammals in the UK and in Wales (e.g. SCOS, 2017 Strong *et al.,* 2005; Baines and Evans, 2009; Reid *et al.,* 2003; Small Cetaceans in the European Atlantic and North Sea I, II and III, Hammond *et al.,* 1995; 2006; 2017).

NRW (historically Environment Agency Wales) have undertaken routine Water Framework Directive (WFD) sediment monitoring within the Milford Haven Inner and Milford Haven Outer waterbodies since 2007, comprising particle size analysis (PSA) and benthic infaunal data. RPS submitted a data request to NRW in March 2018 for the most up-to-date data for the Milford Haven Waterway (MHW) in order to inform this baseline. NRW advised that, due to technical issues with their database, they would be unable to provide any benthic infauna data although PSA data was received. As such, this characterisation has used data which RPS previously obtained from NRW in 2012 for MHW which comprises water and sediment quality and benthic infaunal sampling undertaken between 1997 and 2012.

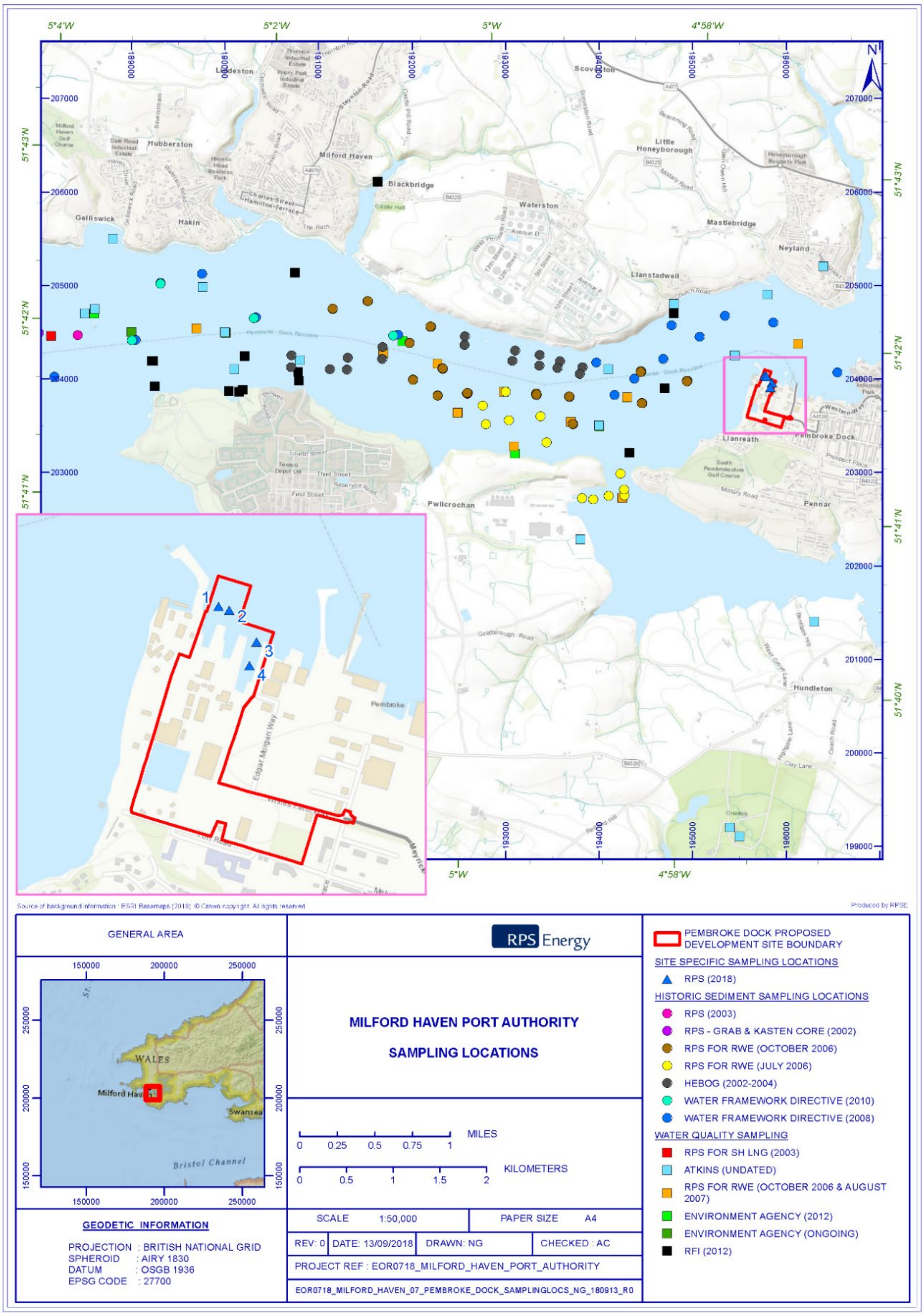

Figure 2-1: Site-specific and historical sampling locations

2.2 Site-specific Surveys

As discussed in section 2.1, following consultation with the statutory consultees; site-specific survey work was undertaken to assess the existing status of sediment contamination in the vicinity of the slipway and the Graving Dock in order to inform the assessment of effects of re-suspension of contaminated sediments on marine ecological receptors. Grab/core sampling was undertaken from a survey vessel in spring/summer 2018. Samples were then compared to Centre for Environment, Fisheries and Aquaculture Science (CEFAS) and Canadian environmental quality guidelines. A total of six samples were taken, four grab samples and two core samples, from four locations (Figure 2-2):

- One grab sample was taken from each location; and
- A single core sample was taken from each of the sites (3 and 4) from within the Graving Dock in order to assess potential for historical contamination

All sampling occurred around high tide to ensure adequate clearance beneath the vessel. The vessel arrived on site and ensured the proposed sampling position were correct and deployed the grab/core sampler using standard methodology provided in OSPAR 2014. Sediment was retrieved onto the deck of the vessel (up to 20 litres) and a subsample of sediment (<5 litres per sample) was retained for laboratory analysis. All remaining sediment was then returned to the sea over the side of the vessel. Where sediment was removed, an infilling of sediment into a hole/depression occurred. Sediment removed was expected to predominately be composed of silt and sand, and mud.

Four surface grabs were successfully collected. Core samples at site 3 and 4, were collected to a depth of 0.75 m. Target depth of 1.5 m was not achieved due to refusal on rock. Sediment collected from each core sample was returned and subsequently analysed.

The six sediment samples were then analysed by RPS an International Organisation for Standardisation (ISO) accredited lab and QUSIMEME participant to undertake a full suite of physical and chemical parameters, suitable to inform an EIA. The suite included:

- Physical parameters: Total Organic Carbon (TOC), PSA, dry matter, visual inspection;
- Total Hydrocarbons (THC) by fluorescence spectrometry in sediment samples by UVF;
- 25 Polychlorinated Biphenyls (PCB) congeners and International Council for the Exploration of the Sea (ICES) 7;
- Polycyclic aromatic hydrocarbons (PAHs);
- Polybrominated Diphenyl Ethers (PBDE) Suite;
- Organotin sediment suite;
- Organochlorine pesticides;
- Total Petroleum Hydrocarbons (TPHs) (speciated aliphatic and aromatic); and
- Metals.

The RPS 2018 sediment data collected was then compared to the CEFAS action levels and Canadian environmental quality guidelines (CCME, 1999) which are now commonly used as the standard for marine sediment environmental quality analysis. This data is interpreted in section 4.2.1, and presented in Annex B.

The CEFAS action levels were developed to be used as part of a ‘weight of evidence’ approach to assessing dredged material for sea disposal. Any material with contaminants levels below CEFAS action level (AL) 1 is deemed no concern and unlikely to influence any licensing decisions for dredging. Any material containing contaminates above the CEFAS AL2 will require further consultation before disposal and it would be considered unsuitable for at-sea disposal. Any material contamination that lies between CEFAS AL 1 and 2 will require further consideration and testing before a decision can be made on disposal.

The Canadian sediment quality guidelines were developed by the Canadian Council of Minister of the Environment. The guidelines are based on empirical evidence collected through field research programmes that have demonstrated associations between chemicals and biological effects by establishing cause and effect relationships in particular organisms. The resulting guidelines recommends threshold effect levels (TELs), below which adverse biological effects are not expected to occur and the probable effect levels (PELs) for contaminants in which adverse biological effects are more likely to occur. Therefore, the possible effect range lays between the thresholds for the lower limit (TEL) and upper limit (PEL).

Both CEFAS and Canadian guidelines values are derived from available scientific information on biological effects of sediment-associated chemicals and are intended to support the functioning of healthy ecosystems. The standards used are internationally accepted standards, adopted by the Environment Agency.

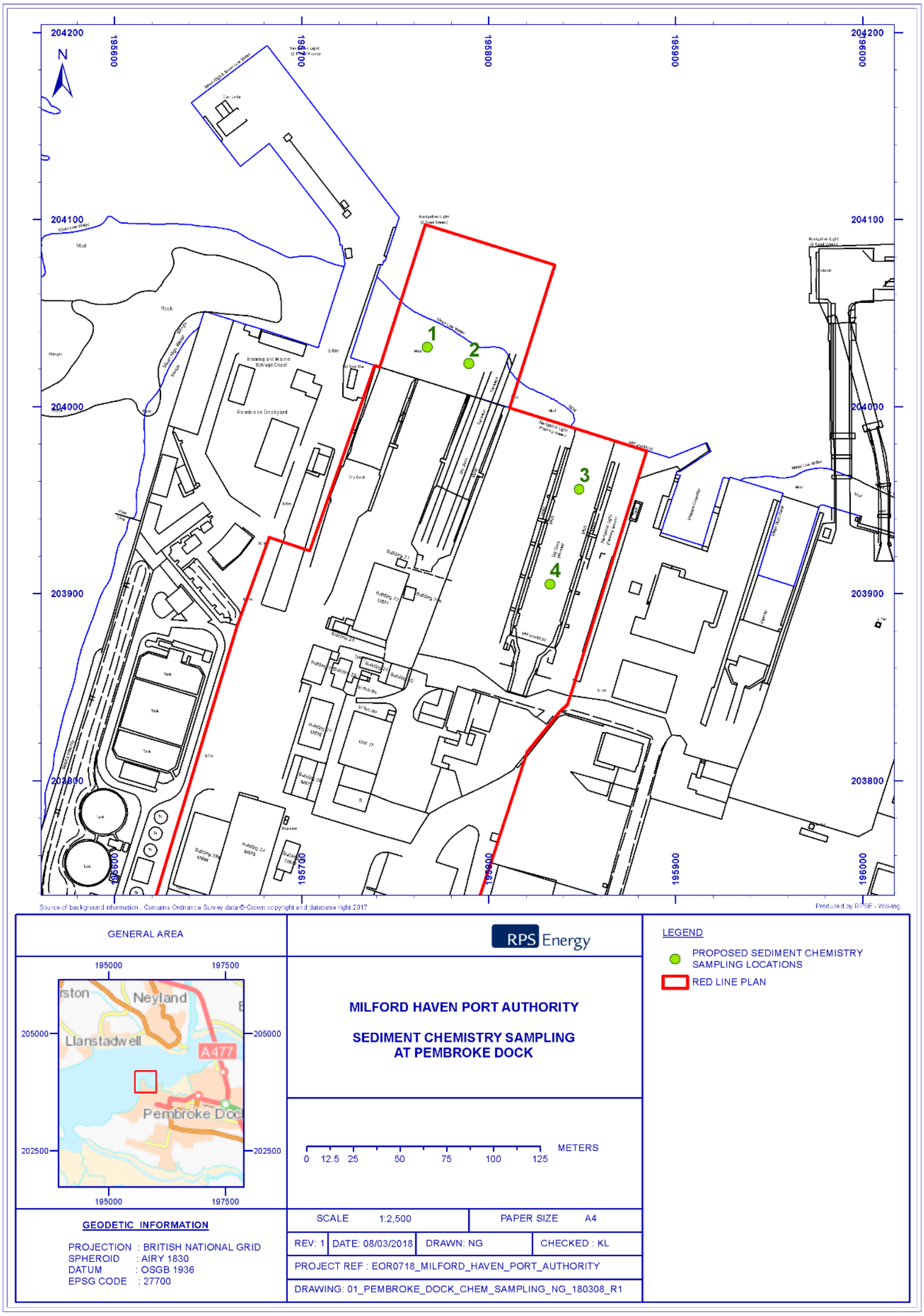

Figure 2-2: Site-specific sample locations

3 Nature Conservation Designations

3.1 European Designations

The following European Designated sites have been identified based on the potential impact the Pembroke Dock Infrastructure project may have on the features associated with each site. The designated sites identified do not include Special Protection Areas (SPAs) as no impact pathway was identified from the project for the following reasons:

1. Site features were assessed as not having a spatial overlap with the project; and/or
2. No impact pathways were identified for the featured species populations of the SPAs from the Pembroke Dock Infrastructure project.

Pembrokeshire Marine/Sir Benfro Forol Special Area of Conservation (SAC)

As shown in Figure 3-1, the proposed development is in close proximity (<50 m) to the Pembrokeshire Marine / Sir Benfro Forol SAC. Qualifying features that have the potential to be affected by the project include:

- Annex I habitats given as a primary reason for the selection of this site as a SAC:
    - Estuaries: The MHW is described as an inlet-estuary complex with a wide range of environmental conditions due to seabed substrata, tidal streams and salinity gradients. A sub feature of the SAC includes *Zostera spp* which is a sub feature of the designation under this habitat type. The Waterway supports a diverse range of communities and individuals;
    - Large shallow inlets and bays: The wide range of environmental conditions, particularly seabed substrates, tidal streams and salinity gradients, supports high community and species diversity, particularly eelgrass *Zostera angustifolia*. A wide range of subtidal and intertidal rocky habitats are present, from rocky reefs and boulders to rich underboulders, crevices, overhangs and pools.
    - Reefs: Rocky reef habitats are found throughout the MHW and due to varying environmental conditions support a wide diversity of biological communities, particularly the subtidal communities of bryozoans, soft coral and anemones. Sheltered reefs support a diversity of sponge and tunicate communities.
- Annex I habitats given as qualifying features, but not a primary reason for the selection of this site as a SAC:
    - Mudflats and sandflats not covered by seawater at low tide: These intertidal habitats provide excellent feeding grounds for wildfowl and waders and are found throughout the MHW and approximately 650 m from the proposed development.
- Annex II species given as a primary reason for the selection of this site as a SAC:
    - Grey seal *Halichoerus grypus*: The islands within Pembrokeshire support the largest breeding colony of seals on the UK's West Coast south of the Solway Firth, representing approximately 3.3% of the UK annual pup production. The closet haul out site and pupping site to the proposed development are located approximately 21.5 km to the west and 31 km to the north west. This species is also listed as a UK Biodiversity Action Plan (BAP) Priority Species.
- Annex II species present as a qualifying feature, but not a primary reason for the selection of this site as a SAC:
    - River lamprey *Lampetra fluviatilis*: River lamprey are primitive jawless fish that closely resemble eels. They migrate into rivers from the sea to spawn in beds of deposited silt. Inferences about the status of the river lamprey population in the SAC are based on condition monitoring of the Cleddau Rivers SAC. Lampreys rarely return home to their natal river, so lampreys using this SAC should be viewed as

a protected component of a larger population covering the Bristol Channel and possibly a wider area. This species is also listed as a UK Biodiversity Action Plan (BAP) Priority Species;

- Sea lamprey *Petromyzon marinus*: Sea lamprey are similar in physiology to the river lamprey but larger. They inhabit coastal waters of the North Atlantic and migrate to rivers to spawn. Both species of lamprey migrate through the SAC to reach the Cleddau River on their spawning migration. This species is also listed as a UK BAP Priority Species;
- Allis shad *Alosa alosa*: Allis shad are a member of the herring family. Relatively little is known about the habitat requirements of this species, although it is known to grow in coastal estuaries before migrating into rives to spawn. The SAC is primarily used as an access corridor between the sea and riverine breeding habitat This species is also included in Schedule 5, Sections 9(1) and 9(4)(a) of the Wildlife and Countryside Act (1981) (Amended 1998) and is listed as a UK BAP Priority Species; and
- Twaite shad *Alosa fallax*: Twaite shad are also members of the herring family. Like allis shad, their habitat requirements are not fully understood, although they are known to migrate into rivers to spawn in March through to May. This species is also included in Schedule 5, Section 9(4)(a) of the Wildlife and Countryside Act (1981) (Amended 1998) and is listed as a UK BAP Priority Species.
- Otter *Lutra lutra*: Otters are semi-aquatic mammals, occurring in a range of habitats including inland freshwater and coastal areas. Marine areas are often used as feeding grounds, freshwater for bathing and the terrestrial environment for resting and breeding. Otter are widespread throughout the SAC and close to the coastline, both on the coast and within the MHW. This species is protected under Schedule 5 of the Wildlife and Countryside Act (1981) (Amended 1998) and is listed as a UK BAP Priority Species.

Cleddau Rivers/Afonydd Cleddau SAC

The Cleddau Rivers/Afonydd Cleddau SAC covers an area of 750.7 ha and is of European importance because of its population of migratory and resident fish species. The SAC is comprised of the Eastern and Western arms of the River Cleddau and as shown in Figure 3-2, the proposed development is approximately 11 km to the south of the SAC. Qualifying features that have the potential to be affected by the project include:

- Annex II species given as a primary reason for the selection of this site as a SAC:
    - River lamprey: The Cleddau Rivers in south-west Wales arise at fairly low altitude, and this moderate to low-gradient catchment with a mixture of gravels and silts provides large areas of good lamprey habitat. Electrofishing data indicates that Lamprey are widespread throughout the SAC, and adult river lampreys are evident during the spawning season.
    - Otter: The Eastern and Western Cleddau Rivers flow through a largely lowland landscape, eventually joining and flowing into Milford MHW, which is part of the Pembrokeshire Marine SAC. These slow-flowing rivers have a diversity of bank-side habitats, and good water quality ensures good stocks of otter prey species. The otter population on these rivers has shown excellent signs of recovery during the last 10–20 years.
- Annex II species present as a qualifying feature, but not a primary reason for the selection of this site as a SAC
    - Sea lamprey: Similar in physiology to the river lamprey but larger and will spawn in similar conditions to the river lamprey;

West Wales Marine / Gorllewin Cymru Forol SAC (SAC)

The West Wales Marine / Gorllewin Cymru Forol SAC extends from the tip of the Llŷn Peninsula southwards across much of Cardigan Bay to the Pembrokeshire coast. As shown in Figure 3-2, the proposed development is approximately 10 km to east of the West Wales Marine / Gorllewin Cymru Forol SAC.

- Annex II species given as a primary reason for the selection of this site as a SAC:
    - Harbour porpoise *Phocoena phocoena*: The West Wales Marine SAC is designated for the protection of harbour porpoise, supporting an estimated 5.4% of the UK Celtic and Irish Seas Management Unit (MU) population. The SAC provides an important summer habitat for harbour porpoise, while part of the site in Cardigan Bay is also identified as important during the winter.

Conservation objectives

The conservation objectives for the Pembrokeshire Marine 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). For example, with respect to water and sediment chemistry the objective specifies that inputs of nutrients and contaminants to the water column and sediments derived from human activity should remain: at or below levels at the time the site became an SAC; at or below existing statutory guideline concentrations; within ranges that are not potentially detrimental to the long-term maintenance of MHW species populations for nutrients; and below levels that would potentially result in an increase in contaminant concentrations within sediments or biota for contaminants (CCW, 2005).

The conservation objective for each species feature is to maintain at FCS the long-term population viability of the feature, the natural range of the feature and the structure and function of the feature’s habitat within the SAC site (Burton, 2008).

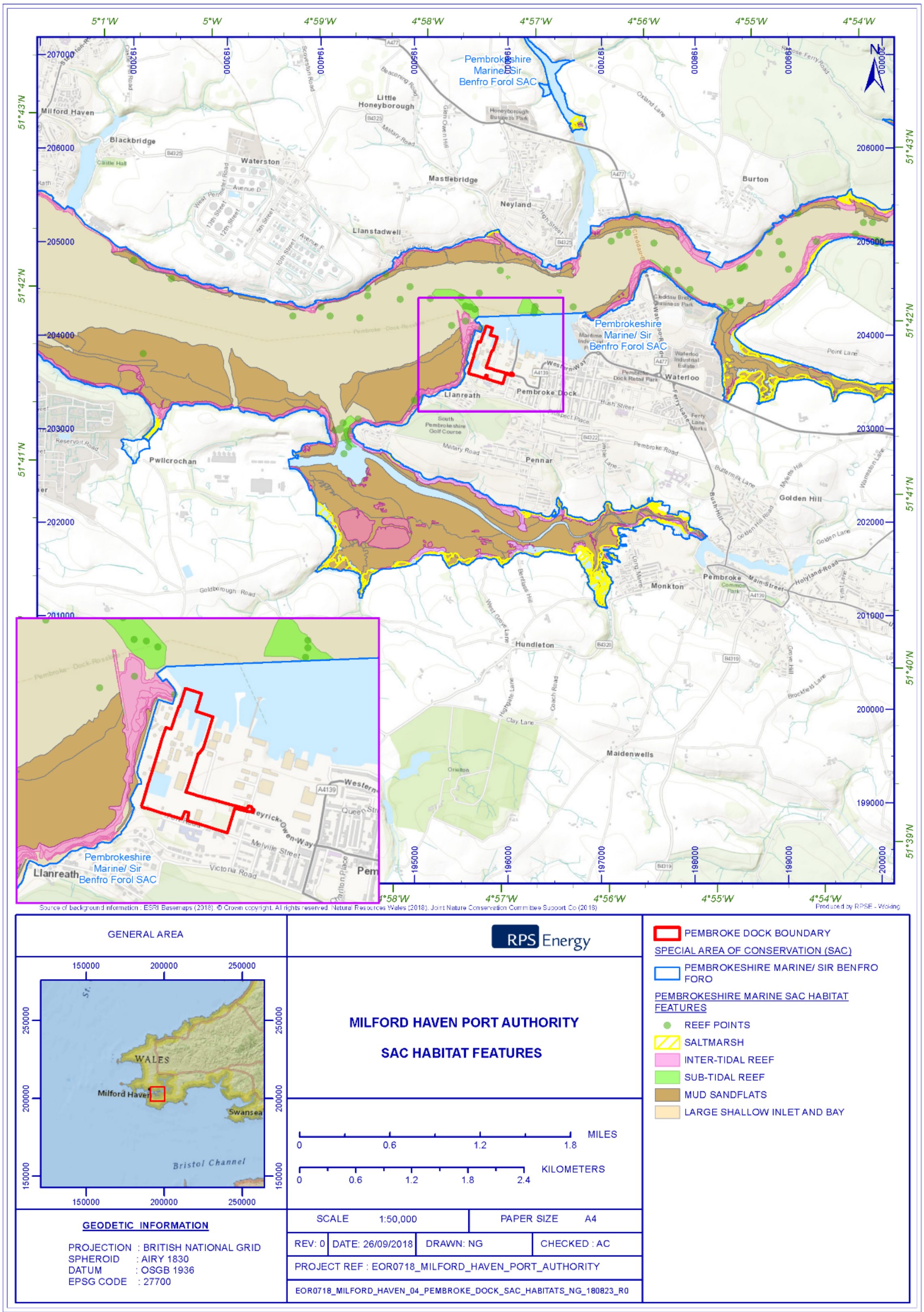

Figure 3-1: Pembrokeshire Marine SAC habitat features

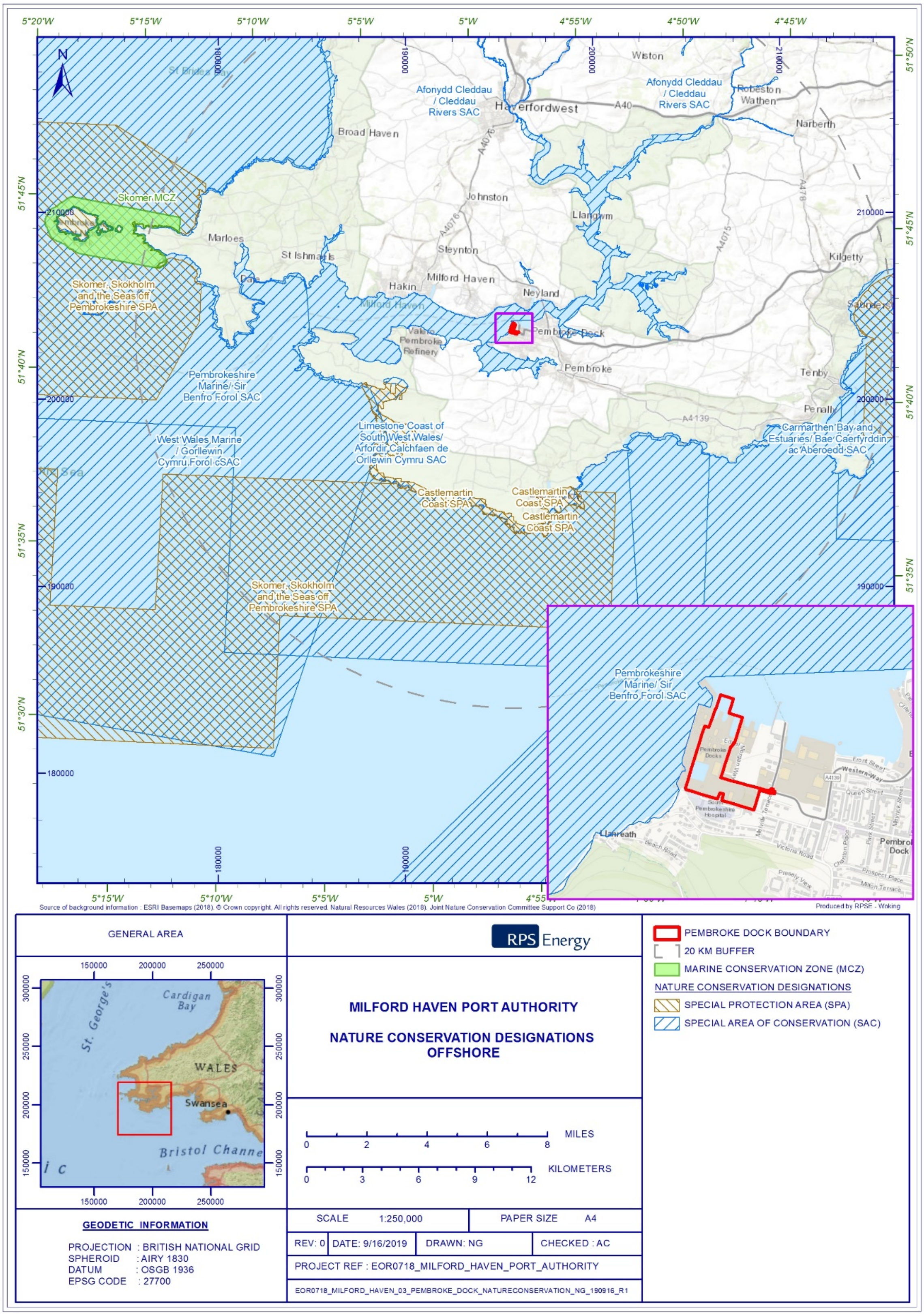

Figure 3-2: European designations within 20km of Pembroke Dock

3.2 National Designations

Under the Wildlife and Countryside Act 1981 (as amended by the Countryside and Rights of Way Act 200), the UK designates any land which is of special interest for any of its flora, fauna, geological or physiographic features as Sites of Special Scientific Interest (SSSIs). Marine Conservation Zones (MCZs) can be designated under the Marine and Coastal Access Act 2009 for marine sites of outstanding wildlife or geological importance. In addition, Natural England may also declare similar sites as National Nature Reserves (NNR) under the National Parks and Countryside Act 1949 or the Wildlife and Countryside Act 1981 to protect the best examples of a particular habitat (Section 16 to 29). Under the National Parks and Countryside Act 1949, Local Authorities must designate Local Nature Reserves (LNR) for areas of interest to the locality. SSSI's within 20 km of the proposed development include Milford Haven Waterway SSSI (Figure 3-3).

Milford Haven Waterway SSSI

For management purposes the SSSI has been divided into eleven sections: Angle Bay, Carew and Cresswell Rivers, Cosheston Pill, Dale Point to Musselwick Point, The Daugleddau, Littlewick Point to Brunel Quay, Milford Haven South, Pembroke River, Sandy Haven, Lawrenny Wood and Musselwick Point to Littlewick Point, and covers an area of approximately 2,192.1 ha. The Milford Haven South section is the only nationally designated site in close proximity (<50 m west) to the proposed development (Figure 3-3). It should be noted that the proposed works will fall outside of the SSSI boundary.

The SSSI citation gives a number of biological reasons for the designation of the MHW as a SSSI. The marine ecological features of interest include intertidal rocky shores, sandy beaches, mudflats and muddy creeks. Intertidal sediments and substrates (including muddy gravels, sheltered mud, moderately exposed sand and sheltered rock) provide habitat for a diverse range of intertidal communities, including species rich rockpools, eelgrass *Zostera* spp. beds, overhang and under-boulder communities. Tidal movements are strong in some areas, allow for development of tide swept lower shore communities which are particularly rich.

Biodiversity Action Plan

Local Action Plans (LAPs) identify local priorities and contribute towards the implementation of the UK BAP Habitat and Species Action Plan targets. The goal of the Pembrokeshire LBAP is:

'To co-ordinate existing and initiate and co-ordinate new actions to conserve and enhance biodiversity in Pembrokeshire, taking account of local and national priorities.'

A wide range of habitats covered by the UK BAP occur in Pembrokeshire and those of coastal/marine interest include:

- Coastal saltmarsh;
- Coastal sand dunes;
- Coastal vegetated shingle;
- Blue mussel beds;
- Estuarine rocky habitats;
- Fragile sponge and anthozoan communities on subtidal rocky habitats;
- Intertidal boulder communities;
- Intertidal mudflats;
- Maerl beds;
- *Musculus discors* beds;
- *Sabellaria alveolata* reefs;
- Saline lagoons;

- Seagrass beds;
- Sheltered muddy gravels;
- Subtidal mixed muddy sediments;
- Subtidal sands and gravels; and
- Tide swept channels.

The Pembrokeshire Priority LBAP species include the cushion star *Asterina phylactica*, grey seal, lagoon snail *Paludinella Littorina* and sea grass *Zostera* spp.

The NBN Gateway was used to identify other UK BAP species found within 5 km of the proposed development. Those identified included one species of marine mammal: common dolphin *Delphinus delphis*. UK BAP fish species known to occur in the area include: herring *Clupea harengus*; plaice *Pleuronectes platessa* and tope *Galeorhinus galeus*. The UK BAP species European eel *Anguilla anguilla*, brown/sea trout *Salmo trutta* and smelt *Osmerus eperlanus* are also known to occur within the vicinity of the proposed development. Native oyster *Ostrea edulis* and otter are also UK BAP species.

Marine Conservation Zones

The Marine and Coastal Access Act (2009) created the framework required to create a new type of Marine Protected Area (MPA) called a Marine Conservation Zone (MCZ). MCZ's aim to protect marine wildlife, habitats, geology and geomorphology. The nearest MCZ is at Skomer which is over 20 km from the proposed development (Figure 3-3).

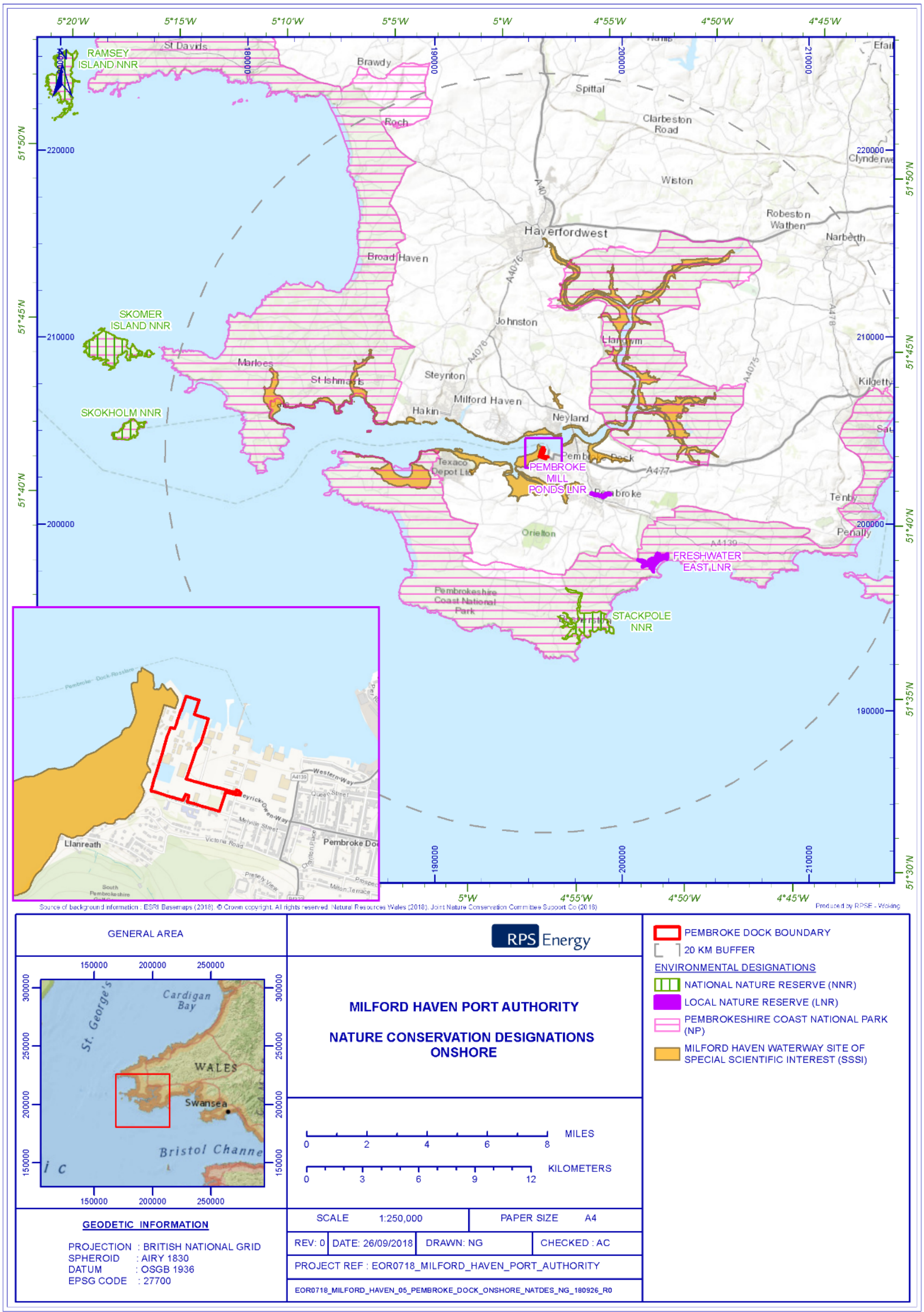

Figure 3-3: National designations within 20 km buffer of the proposed development.

4 Marine Environment Baseline

4.1 Geomorphology and Bathymetry

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.

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).

The topography of the seabed within the site 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.

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 the rivers flowing into the 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.

4.2 Wave and Tidal Regime

The estuary is approximately 35 km in length from its mouth at St Anne's Head, to the tidal limits near Haverfordwest and Canaston Bridge. The mean tidal range for the MHW varies from 6.3 m at mean springs tide to 2.7 m at mean neap tide. Predictions by the Proudman Oceanographic Laboratory for the period 2005 to 2025 gives a highest astronomical tide height of 7.83 m

The high tidal range within MHW means that water movements in the estuary are extensive. 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 and is approximately twice as great for springs as for neaps. Strong south-westerly winds, the prevailing wind direction for the MHW, can cause noticeable variations in the heights and times of the tide. Tidal currents within the estuary are, however, much lower than along the open coast. The estuary currents are higher within the main channel than within the embayments and over the shallower intertidal areas adjacent to the main channel.

The tidal flow within the lower reaches of the MHW can be generally summarised as flowing east up the MHW on the flood and west out of the MHW on the ebb. The maximum flow is encountered in the middle of the main channel. A tidal stream study of the MHW was undertaken by The Coastal Surveys Group of Hyder Laboratories and Sciences between January 1997 and October 1999 (Hyder Consulting, 1999). The aim of the study was to monitor current velocities within MHW to provide a more comprehensive understanding of the nature of the prevailing tidal regime within the port limits. Data was recorded between the approaches to the MHW in order to produce a series of tidal stream atlases for this region. The atlas for the Lower Reaches of the MHW showed that minimum tidal flows occur around slack water (i.e. six hours before High Water (HW)) increasing to a maximum of 1.5 knots ~3 hours before high water on a spring tide with the tidal flow in an easterly direction. On neap tides, maximum tidal flows of up to 0.7 knots in a predominantly westerly direction, ~2.5 hours before high water, were mapped. These high tidal flows are able to act as transportation mechanisms for suspended sediments within the water column.

Monitoring of spoil during dredging at Neyland marina showed that silt-grade, fluorescent tracers were found in high concentrations (>100,001 particle counts/ml) from dredging plumes and these reached Garron Pill 5 km up-estuary on spring flood tides and Llanstadwell 1.5 km down-estuary on the ebb (Little *et al*., 2016). These represent sediment transport rates of 110-455 m/day (flood tide) and 150-335 m/day (ebb). Medium tracer concentrations (10,001-100,000 counts/ml) reached Llangwm Pill 7 km up-estuary, and Wear Point, Pwllcrochan and Pennar Gut (3-4 km) down-estuary, representing transport rates of 280-2,300 m/day (flood) and on the ebb 120-500 m/day (ETS 2002). Due to the meandering nature of the MHW, natural geological formations can slow the rate of tidal flow.

Carrs Rock, immediately to the west of Carr Jetty and Pembroke Port, is a submerged bedrock feature which deflects tidal currents and forces the flow to the north side of the MHW. Headlands such as Carrs Rock and Hobbs Point (to the east of Pembroke Dock) appear to deflect tidal currents, providing shelter in their lee. To the mouth of the MHW, the area is exposed to the prevailing westerly and south-westerly swell waves, but St Ann’s Head and the Angle Peninsula reduce wave penetration into the MHW itself.

4.3 Water Quality

Salinity

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

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

MHW has the capacity to be a large sediment sink based on its morphology, however, there is limited sediment input from offshore areas and the rivers flowing into the MHW are not thought to contribute large volumes of sediment (Halcrow, 2012). Within the catchment are the two main rivers of the Western and Eastern Cleddau, which merge to form the Daugleddau before entering the MHW. Pembroke River contributes suspended sediment and freshwater into the MHW west of Pembroke Dock.

A study by Little *et al.* (2016), found chronic sediment disturbance and re-suspension occur by propeller wash and bow-waves of tankers, tugs, ferries, cargo and fishing vessels, by shellfish and bait-digging, and by small vessel mooring. Demolition of disused jetty structures, runoff from land disturbed, and pile-driving for construction were sources of sediment re-suspension between 2003 and 2005. Increased suspended sediment concentrations generated by effluent outfall channel scour has contributed to the sediment re-suspension in the estuary, peaks were recorded in 2006 and 2010. A major anthropogenic ongoing 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. This was augmented by dredging at Neyland Yacht Haven marina, which peaked between 2007-2008 and discharged directly off Neyland. Additionally, changing land management practice in the MHW catchment area is likely to have a substantial impact on sediment loads and turbidity i.e. a shift from arable farming to livestock farming (Hooda, 2000).

Previous studies in the MHW have shown that total suspended solids (TSS) concentrations are generally low when compared to other estuaries (Nelson-Smith, 1965; Little *et al*., 2016). TSS relates to turbidity which is a measurement of the amount of suspended materials in the water column. These suspended materials include silt, clay and sand, the phytoplankton community and detritus (decaying organic materials). Turbidity is also a function of the energy of the environment and the water quality of any inflows to the environment. The amount of suspended sediment is important as these particles are a medium to which contaminants may adhere to and areas of high deposition may lead to contaminant sinks within the estuarine sediments. TSS will also affect water transparency and will therefore influence phytoplankton and algal production. The characteristic low turbidity of the estuary is a key factor in its species richness and diversity.

RPS obtained water quality data for the MHW from NRW (then Environment Agency Wales (EAW)) in 2012. As the data represents a large amount of spatial and temporal data throughout the MHW, much of which is designed to monitor site specific discharges, for the purpose of this desktop study data obtained from the closest sampling point to Pembroke Dock has been reviewed. Specifically, this relates to EAW Urban Waste Water Treatment Directive (UWWTD) sample location 39659 based near Pennar Mouth, Milford Haven.

Turbidity data recorded by NRW at location 39659 located within the Vicinity of Pembroke Port was recorded monthly for the period January 2012 to September 2012 and, as shown in Figure 4-1, the 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. Peaks in turbidity were observed in spring, potentially coinciding with phytoplankton blooms, with the lowest turbidity values recorded during summer months.

Water transparency, as typically determined by Secchi disk measurements, is dependent on the amount of particulate matter and dissolved substances in the water. Values of transparency were recorded by NRW between 2009 and 2011 ranged from 1.2 m to 3.1 m with a mean value over the period of 2.0 m. Figure 4-2 below shows the variability in transparency over this period.

Nutrients and Contaminants

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 St Bride’s Bay (CCW, 2009). Coastal waters are considered to have raised levels of nutrients as a consequence of diffuse agricultural sources. MHW has high levels of nutrients although comparison to background levels for open coasts suggest they are comparable. Water column contaminant concentrations and fluxes are poorly known. Available data suggest that these too are comparable with typical inshore background levels.

[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.

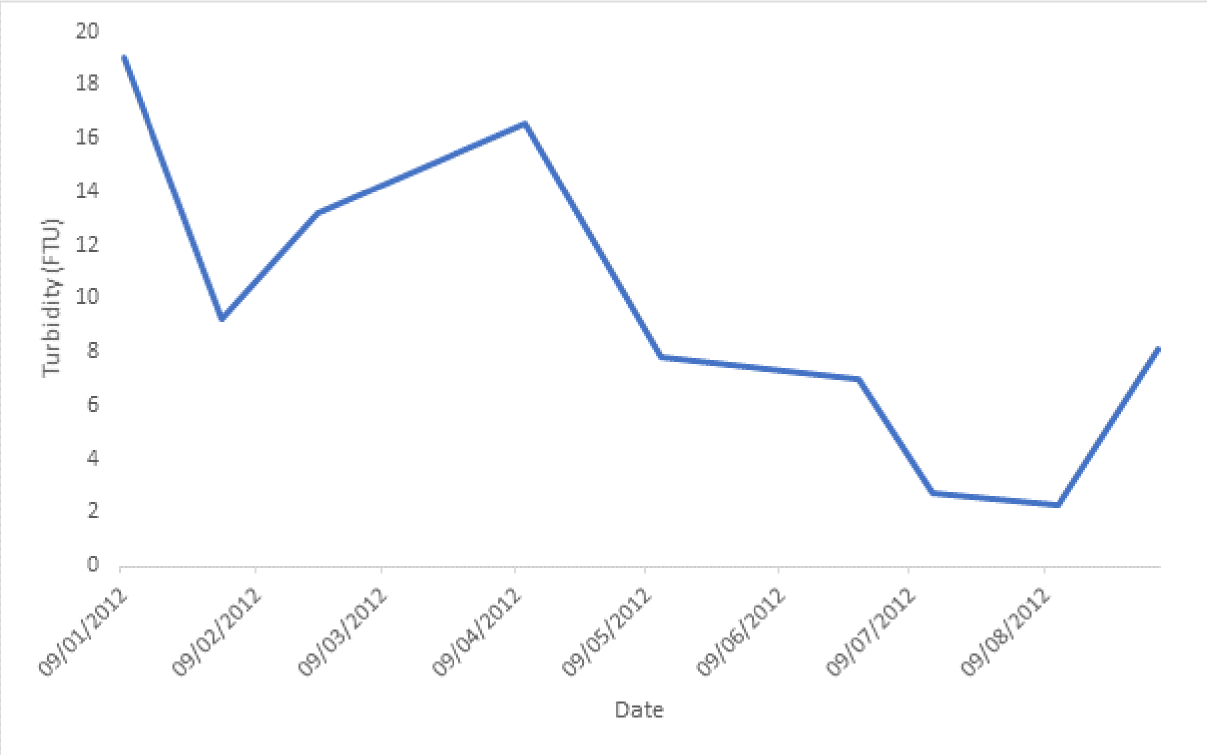

Figure 4-1: Turbidity at Pennar Mouth (location 39659)

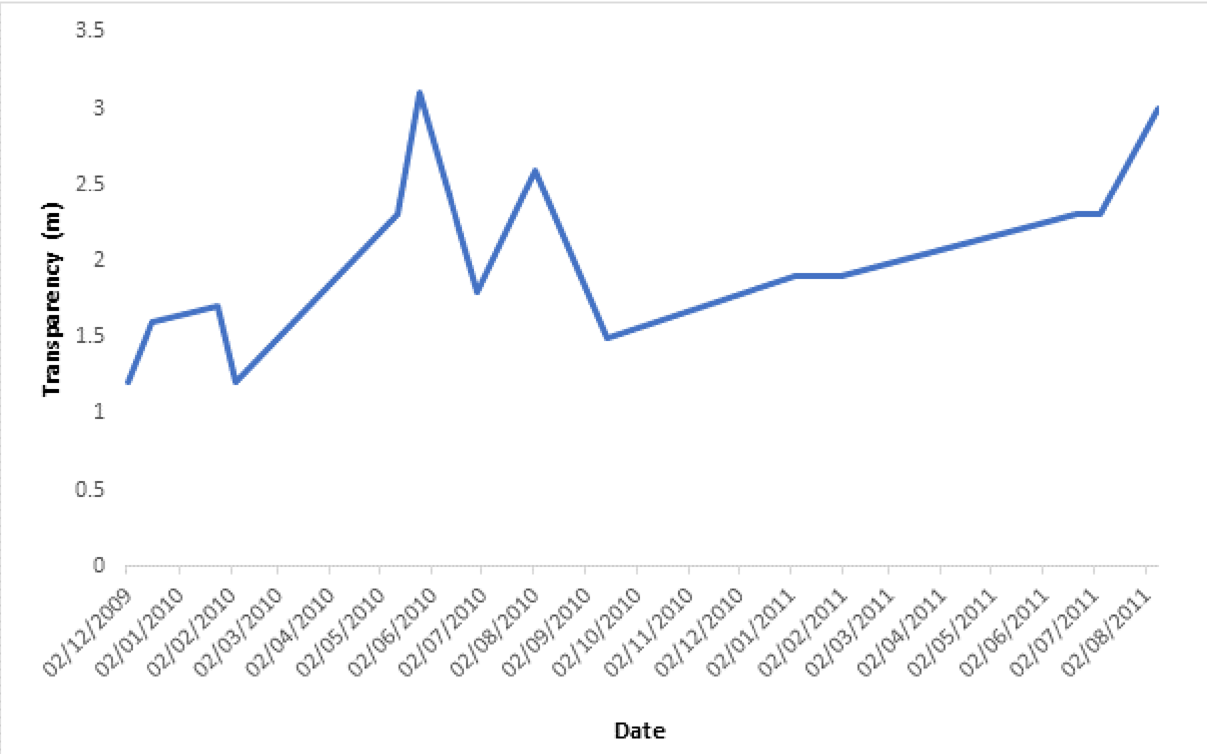

Figure 4-2: Transparency at Pennar Mouth (location 39659)

4.4 Sediment Quality

Physical Characteristics

Physical sediment conditions in the MHW

Hobbs and Morgan (1992) describe the geomorphological processes that have resulted in the unusually high proportion of hard substrates within the MHW, flanked by areas in which there are substantial thicknesses of mud. Near the mouth of the MHW, which is exposed to the greatest wave action, the intertidal and subtidal areas are largely coarse sediments and bedrock, while further up the MHW where wave action is reduced, intertidal and subtidal areas are characterised more by muddy sediments. These areas of mud were derived from the rivers and have accumulated primarily in sheltered mudflats, including the area between Carr Jetty (immediately to the west of Pembroke Dock) and Hobbs Point (to the east of Pembroke Dock). 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.

In 2012, the MHWESG completed its most extensive project to date which involved sediment profile imaging (SPI) of 559 stations throughout the MHW (Carey *et al*., 2015). The results showed that the sediments within MHW were highly variable ranging from cobbles to silt/clays. Despite the variation, the major groupings of sediment types observed were consistent with previous investigations (e.g. Little, 2009). The channel at the mouth of the lower waterway was shown to be characterised by medium to very coarse sand and gravel (equivalent to the EUNIS habitats A5.13 Infralittoral coarse sediment and A5.44 Circalittoral mixed sediments) surrounded by bedrock, while the intertidal flats ranged from very fine sand to silt clay and back to very fine sand in the shallowest portion. The MHW (from Sandy Haven Bay through Angle Bay and Gelliswick Bay) was dominated by very fine to fine sand, often overlying silt/clay with only limited areas of coarse sand. The central MHW channel, north of Carrs Rock, was lined with very coarse cobbles, pebbles, and shell lying over sand or mud (equivalent to the EUNIS habitat A5.42 Sublittoral mixed sediment in variable salinity (estuaries)) while the flats of the Pembroke River contained silt/clay. East of Pembroke Dock, the central MHW channel almost exclusively comprises very coarse sand and gravel (a few shells) with little deposition of silt, equivalent to the EUNIS habitat A5.42 Sublittoral mixed sediment in variable salinity (estuaries) (Carey *et al*., 2015).

Physical sediment conditions in the vicinity of Pembroke Dock

Warwick (2017) carried out a macrobenthic review with sediment analysis on eight stations throughout the MHW. Located at the mouth of the MHW and throughout up to Blacktar point. One station (MH10) was found to be in the vicinity of the proposed development, approximately 800 m west of Carrs Rock. The mean percentage particle size fraction at this station in 2013 found sediment was predominately silt and clay (here after referred to as mud) <63 µm (60%), sand (30%) and gravel (10%). Stations located above and below Pembroke dock returned a higher mean percentage of sand and pebbles throughout the MHW.

Little (2017) conducted a timeline review, between 1978 to 2014, of the contaminant concentrations with PSA data for the MHW. The purpose of the project was to establish the long-term trends in the sediment contaminants of MHW by inter-calibrating and comparing the historical and more contemporary analytical methods that have been used. A review of the samples that were taken from a total of 30 stations throughout the MHW, with the closest sample taken in the vicinity of the proposed development was at station MH10. Two replicates were taken from station MH10 in 2014 to determine the particle size and descriptive sediment type. The mean percentage of mud returned for the two replicates was 48% and 53.9% with sediment classifications of gravelly mud and slightly gravelly sandy mud.

The results from both studies suggest the Pembroke Dock area and natural features of the estuary (i.e. Carrs Rock and Hobbs Point) may act as a form of silt trap by dissipating local current hydrodynamics and aiding settlement of suspended particles in the water column.

Pembroke Dock (Site specific sediment survey)

As described in Section 2.2 a detailed sediment survey was undertaken in the vicinity of the Pembroke Dock in 2018. PSA was carried out on the four grab samples at Site 1 through 4 and two core samples at site 3 and 4 (Figure 4-3). The PSA identified the sediment characteristics and sorted them into Folk and Ward Classifications (Long, 2006).

Grab samples taken at site 1, were found to consist of sand and mud (73.99%) and (26.03%) respective, with no gravel present. The mean Folk and Ward description given to site was very poorly sorted fine sand. Site 2 present a far higher percentage of mud (88.32%) and less sand (11.78%) than site 1, no gravel was recorded at this site. Folk and Ward mean description was given as very poorly sorted medium silt. Site three was represented by mud (90.80%) and sand (9.11%), site four comprised of mud (90.59%) and sand (9.47%). No gravel was present at either site 3 and 4, both within the Graving Dock, and given a Folk and Ward description of very poorly sorted medium silt. The reason for a higher sand percentage in site 1 may be due to the jetty acting as a barrier to wave and tidal action resulting in eddies forming. The eddies then act to mobilise smaller sediment partials resulting in re-suspension, leaving behind larger and heavier sand particles. Sites 2 to 4 may have sufficient sheltering from wave and tidal action, resulting in a far higher percentage of mud sediment particles.

Core sampling taken at sites 3 returned mud (92.50%) and sand (7.49%). Site 4 returned similar results of mud (88.22%) and sand (11.79%). Both sites returned no gravel within the samples, mean Folk and Ward description was very poorly sorted medium silt. The results of the core samples show a uniform vertical sediment distribution within the Graving Dock.

The average PSA across all surface grab samples was found to be primarily composed of mud and sand (Figure 4-4). Sand and mud were found to represent 26.09% (±7.09) and 73.94% (±6.22) respective. Mud and sand dominated the sediments within the planned slipway footprint and within the Graving Dock indicating relatively low energy environments. Surface and sediments at depth were classed as being very poorly to poorly sorted, with a Folk and Ward description of fine and medium silt and suggesting a EUNIS classification of A5.32 Sublittoral mud in variable salinity (estuaries). The Port itself, and its position in lee of Hobbs Point and Carrs Rock, may act as a form of silt trap and as a result all tidal energy will be dissipated allowing suspended solids to fall out of suspension.

The average PSA across all core sample returned a composition of mud (90.36% ±5.11) and sand (18.83% ±2.40) (Figure 4-5). No gravel was present throughout the samples. Mean Fold and Ward description is very poorly sorted medium silt and a suggested EUNIS habitat classification of A5.32 Sublittoral mud in variable salinity (estuaries).

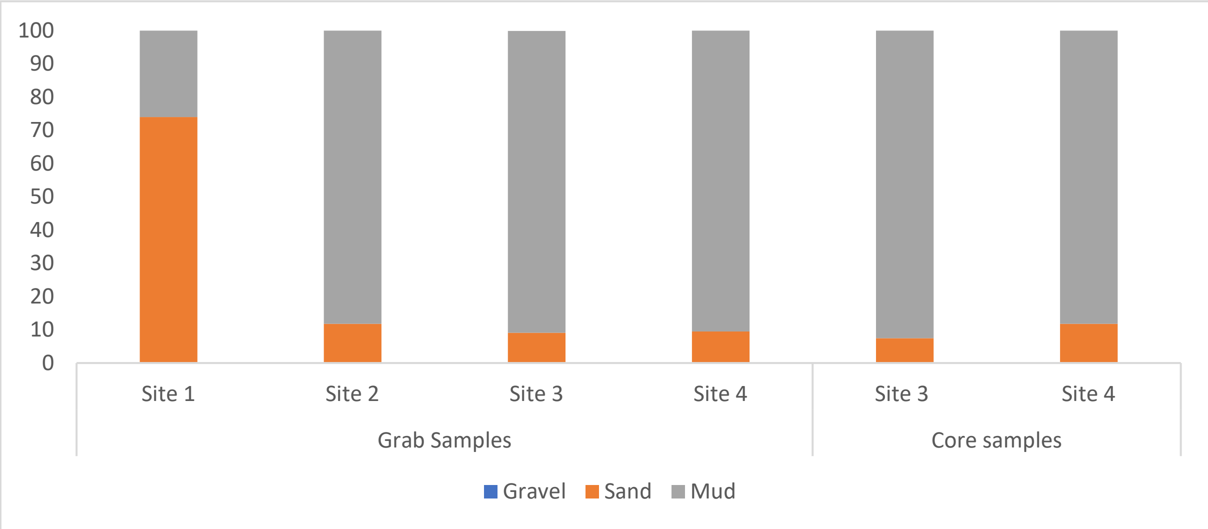

Figure 4-3: PSA across all sites and techniques.

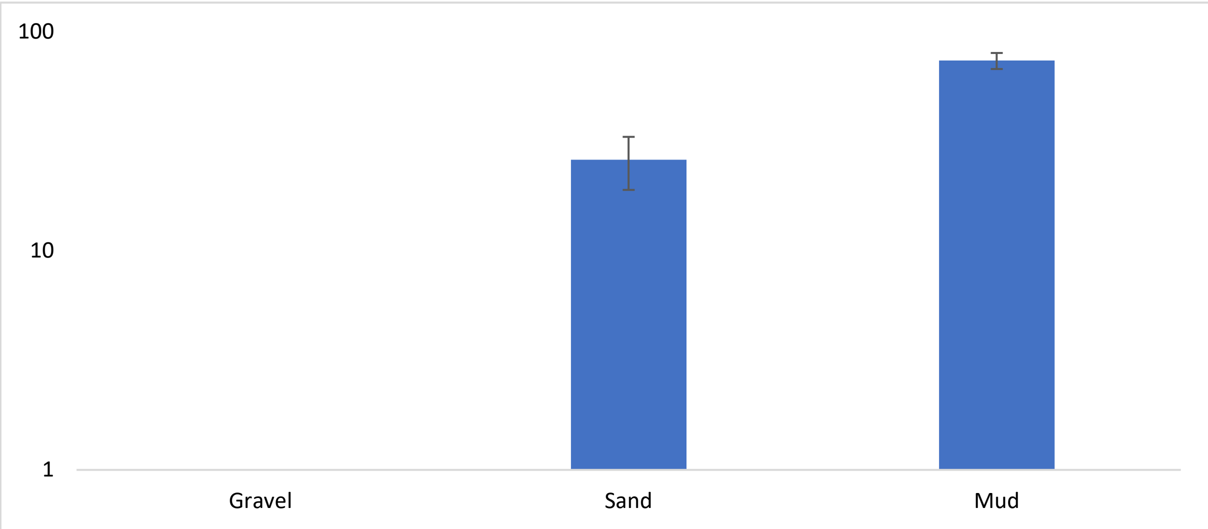

Figure 4-4: Average PSA across grab sediment samples (Note: logarithmic scale).

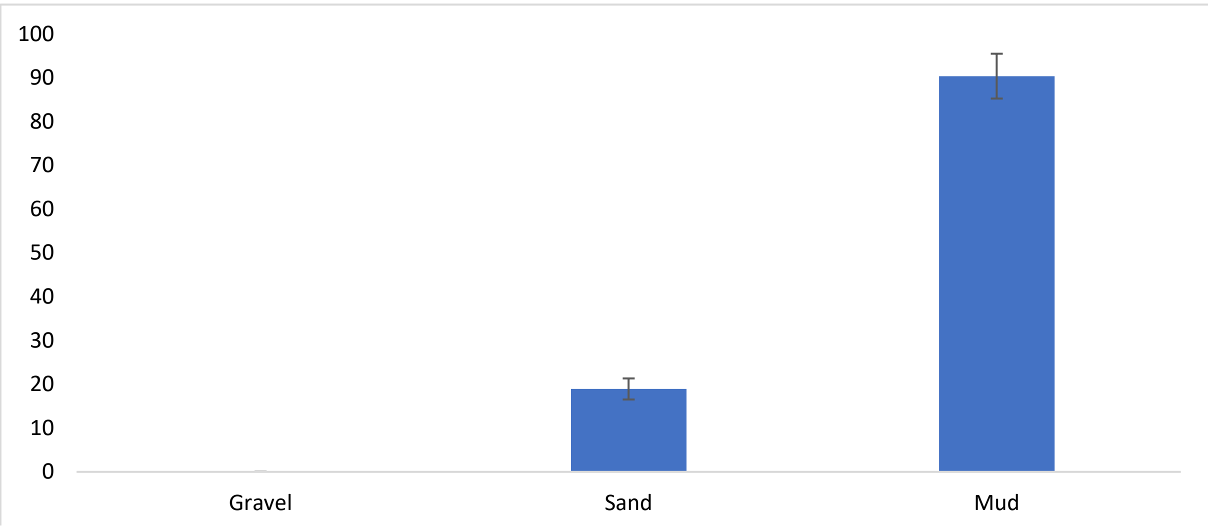

Figure 4-5: Average PSA across all core samples

Chemical Sediment Conditions

Sediment contaminants in the MHW

Sediment contaminants have been monitored in MHW since 1978 for hydrocarbons and since 1982 for metals, although only datasets between 2007-2012 have been comparable. From 2007 to 2010 most of the sediment contaminant concentrations, including total Polycyclic Aromatic Hydrocarbons (PAH) concentrations, have generally decreased by dilution (Little *et al.,* 2016). Between 2010 and 2012, PAH concentrations in the lower to mid parts of the MHW decreased at the same time as upstream stations increased by very similar amounts, suggesting re-suspension and transport of a pulse of historically PAH-contaminated sediment moving up-estuary. Concentrations between 2010 and 2012 have increased only when sediment has continued to be disturbed and where sediment transport pathways lead to depositional sinks.

In 2007, 2010 and 2012 the individual and total PAH concentrations at almost all stations in the MHW exceeded accepted sediment quality guidelines published by the National Oceanic and Atmospheric Admiration (NOAA) (now the Canadian sediment quality guidelines developed by the Canadian Council of Minister of the Environment described in Section 2.2), PAHs that exceeded the TEL declined only slightly from >87% in 2007 to 80% in 2012. For the metals Copper, Lead, and Zinc, in both 2007 and 2012 the TELs were exceeded in at least 47% of stations, the station exceeding the TELs saw only a slight decrease from 2007 to 2012. No metals or PCBs concentrations exceeded PEL guidelines. In 2012, only Pembroke River Upper had any PAH concentrations in excess of PEL. The exceedance zones occurred where flood-dominated tidal currents transport fine sediment from industrial reaches into tributary inlets with deposition at high tide slack-water, in high and inner flats (e.g. Angle Bay and Pembroke River).

PAHs are ubiquitous environmental contaminants. Although they can be formed naturally (e.g., forest fires), their predominant source is anthropogenic emissions, and the highest concentrations of PAH are generally found around urban centres. Low concentrations of naturally occurring background PAH are derived from natural fires, eroded shale/coal, and early diagenesis processes predating modern anthropogenic activities. The use though of fossil fuels over the last 200 years has altered the loading of hydrocarbons to the environment. The resulting residues and combustion by-products from these fuels have contributed a modern anthropogenic background to sediments in both urban and remote locations. (Knapp *et al.*, 1982).

Concentrations of PAHs in the aquatic environment are generally highest in sediment, intermediate in biota and lowest in the water column (CCME, 1992). PAHs have a low water solubility and hydrophobic nature and so they will tend to be associated with inorganic and organic material in suspended solids and sediments. In general, most PAHs (with the exception of some low-molecular weight compounds, such as naphthalene) will be strongly adsorbed by particulate matter and subsequently taken up by biota in the aquatic environment (CCME, 1992).

Hobbs and Morgan (1992) reviewed published information on hydrocarbons in Milford Haven sediments and suggested that sediment hydrocarbon loads were probably anthropogenic. Higher levels were found in finer sediments with values being similar to other moderately polluted estuaries. Since 1992 hydrocarbon data have been collected as supporting information to macroinvertebrate studies and also in response to the Sea Empress oil spill. Historic data shows a wide range of THC concentrations in Milford Haven (Level et al., 1997) which the authors related to percentage mud content and possible sinks of pollution.

Previous studies of the hydrocarbon content of Milford Haven sediments have recorded a range of 8 mg/kg to 1,870 mg/kg (after the Sea Empress spill). Earlier data for the area indicates that hydrocarbons in the sediment ranged from <1 mg/kg to 615 mg/kg (see Hobbs and Morgan, 2000). It should be noted that studies on sediment total hydrocarbon concentrations since 1996 suggest that the elevated levels were not due to the Sea Empress oil spill, but rather constitute a chronic source (a continuous and low volume) of contamination from anthropogenic sources 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. (Hobbs and Morgan 1992; Level et al., 1994 and 1997).

Sediment contaminants in the vicinity of Pembroke Dock

As described in Section 2.2 an assessment of the physico-chemical quality of the sediment was undertaken on samples collected in the vicinity of the Pembroke Port in 2018. All chemical and PSA data can be found in Section 7 (Appendix A).

Heavy Metal Contamination

Heavy metals are readily adsorbed by sediments, this can lead to metals accumulating to concentrations far higher than the surrounding environment. These sediments can become re-suspended through bioturbation or through physical processes/disturbances. Metals will tend to accumulate in these fine-grained sediments and can become bioavailable to marine organisms through ingestion. The uptake of heavy metals by marine organism can lead to bioaccumulation through tropic levels leading to apex organisms accumulating metals to adverse and toxic levels. This could result in significant adverse effects including mortality, impaired reproduction, reduced growth, alterations in metabolism as a result of oxidative stress and disruption to the food chain.

The RPS 2018 sediment survey concluded that the contaminant levels in the study area exceeded the CEFAS AL1, AL2 and Canadian TELs, with contaminant concentration remaining homogenous to a depth of 1.5 m at sites 3 and 4. Metals which were observed at elevated levels include arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc. The primary site for contamination was at site 1.

Arsenic concentrations exceeded the CEFAS AL1 at site 1 with all other sites exceeding the Canadian TEL. Cadmium concentrations were found to exceed the CEFAS LA1 at only site 1 with the other sites all below adopted guideline criteria. Chromium was found to be marginally exceeding the CEFAS AL1 at all sites except site 3 at a depth of 1.5 m. Copper was found to be considerably in excess of the CEFAS AL1 at site 1 with all other sites exceeding the Canadian TEL. Lead was recorded in excess of the CEFAS AL1 at site 1 and 2 and at a depth of 1.5 m at site 4 with all other sites exceeding the Canadian TEL. Mercury concentrations were found to exceed the CEFAS AL1 at site 1 and 2 and exceed the Canadian TEL at all sites. Nickel concentrations were in excess of the CEFAS AL1 at all sites and depths. Zinc concentrations exceeded CEFAS AL2 criteria from a surface sample collected site 1. All other sites displayed concentrations in excess of the CEFAS AL1 for cadmium.

In summary, site 1, closest to Carrs Rock and within the proposed slipway footprint, recorded all metal concentrations exceeding the CEFAS AL1 with zinc concentrations above CEFAS AL2 criteria. No other sites displayed contaminant concentrations in excess of respective CEFAS AL2 criteria.

Organotins

Concentrations of dibutyltin (DBT) and tributyltin (TBT) for one out of four samples collected exceeded the CEFAS AL1 for DBT and CEFAS AL2 for TBT. Site 1 displayed concentrations of 0.249 mg/kg for DBT, exceeding the CEFAS AL1 limit of 0.1 mg/kg dry weight (DW), and 2.56 mg/kg DW for TBT (CEFAS AL2 1mg/kg DW). All other sites DBT and TBT concentrations were below adopted guideline criteria.

Polychlorinated Biphenyls (PCBs)

The RPS 2018 PCB concentrations below the CEFAS AL1 of 0.02 mg/kg returned samples collected. This value is also below the Canadian TEL and PEL guideline criteria.

Total Hydrocarbons (THCs)

The highest THC concentrations were recorded at site 1 and 2, within the slipway footprint. Site 1 and site 2 returned THC concentrations of 34.3 mg/kg and 42.3 mg/kg respectively. At sites 3 and 4 THC concentrations were <15 mg/kg. Recorded concentrations within Pembroke Port are therefore considered to be comparable to background THC concentrations within MHW.

PAHs

PAH concentrations returned for surface sediment samples did not exceed the CEFAS AL1 threshold for any of the PAHs. The Canadian TEL was, however, exceeded for naphthalene, acenaphthene and fluorene. Often as a precursor to other chemicals, naphtalene is derived from coal tar, and has been used in the production of many different commercial products, including pesticides, lead-acid battery plates, tanning agents, and plasticizers (dispersants) used to produce concrete and plasterboard. Acenaphthene is a derivative of naphthalene and is commonly used as a precursor to commercial pigments and dyes. Fluorene is also produced from coal tar and its derivatives have electroluminescent properties that have been investigated for the production of light-emitting diodes. Coal tar is a thick dark liquid produced as a by-product from coke and coal gas from coal. Milford haven has a rich history in coal, oil and gas, and as such levels are expected to be high for the area. Heavy spillages and oil tank fires during WW2 are other likely PAH sources, followed by post war spillages of refinery long-chain product.

Summary of Physico-Chemical Properties in Sediments near Pembroke Dock

Sand and mud are the predominant sediment types in the vicinity of Pembroke Port with particle size remaining homogenous with depth. Sediment contaminant data for Pembroke Port indicated elevated above Cefas AL1 criteria for heavy metals with one recorded instance of Zinc exceeding the CEFAS AL2 at site 1. In addition, DBT and TBT concentrations were found to be elevated above AL1 and AL2 respectively at site 1. However, PCBs and PAHs were all found to be at concentrations below guidance. THCs were found to be highest at site 1 and 2 with lower THCs at site 3 and 4 (No threshold guidance is given for THCs).

4.5 Intertidal Benthic Habitats

MHW

Several studies have been undertaken of the shoreline environment in MHW including Petpiroon and Dicks (1982), and Moore (1997), which describe the floral and faunal assemblages as typical of moderately exposed rocky shores.

As part of NRW's statutory obligations for feature condition monitoring in Pembrokeshire Marine SAC, a series of seven rocky shore monitoring sites have been established in MHW. South Hook Point is one of these monitoring sites and has been studied annually since 2005 (Bunker, 2010a).

Intertidal surveys of the rocky northern shore of MHW, undertaken in October 2012 by RPS (2013) in support of the applications for consent for the South Hook CHP project, determined that the most widespread biotopes were middle shore bedrock or boulders dominated by the acorn barnacles *Semibalanus balanoides* and *Austrominius modestus*. These communities were classified as the LR.HLR.MusB.Sem.Sem, LR.HLR.MusB.Sem.LitX or LR.HLR.MusB.Sem biotopes. On more scoured boulders and cobbles the LR.HLR.MusB.Sem.LitX biotope dominated and was characterised by large patches of green *Verrucaria* species.

During the South Hook CHP project's intertidal survey, the jetty pilings were seen to provide wave sheltered and current swept artificial substratum, and habitat for animals, not commonly found elsewhere in MHW or the Pembrokeshire Marine SAC. The dominant species (frilled anemone *Metridium senile*, sea squirt *Ascidiella aspersa*, rosy feather star *Antedon bifida*, sponge *Mycale macilenta*, pink-hearted hydroid *Tubularia larynx* and mermaid's glove sponge *Haliclona oculate*) are not considered to be rare, but it is only on artificial substrata (e.g. jetty pilings and ship wrecks) that these species thrive together in abundance.

A number of introduced or 'alien' species were encountered during a previous RPS study in the MHW, including the seaweeds *Anotrichium furcellatum* and *Antithamnionella ternifolia* and the sea squirt *Styela clava*. Of scientific interest was the presence of the alien red seaweed *Dasysiphonia sp.* on one of the jetty piles (RPS, 2003).

Intertidal mapping of biotopes and core sampling was conducted in the vicinity of the (then) proposed Pembroke Power Station in October 2006 (RWE npower, 2007). The intertidal mudflats at Pwllcrochan Flats were identified as predominantly sandy muddy shores (LSD.LMU.SMu) and *Hediste diversicolor* and *Streblospio shrubsolii* in littoral sandy mud or soft mud shore biotopes (LS.LMU.Mu.HedStr) and, on the lower shore, a mosaic of shingle and algal species (LS.LGS/LR.Rkp.SwSed). The intertidal mudflats within Pembroke River were predominantly characterised by *Hediste diversicolor* and *Macoma balthica* in littoral sandy mud (LS.LMU.SMu.HedMac) biotope on the fringes and either sides of the channel, and *Zostera noltei* beds in upper to mid shore muddy sand (LS.LMS.ZOS.Znol).

In 2017, MHWESG commissioned Swansea University to carry out an assessment of the long-term change and health of *Zostera spp*, in the MHW using historical data and to determine the ecosystem's value (Unsworth *et al.*, 2017). There are two scientifically recognised species of seagrass in MHW; eelgrass *Zostera marina* and dwarf eelgrass *Z. noltei*. The report found that an estimated total area currently covered by seagrass was 181 ha, with the majority (158 ha) being made up of intertidal *Z. noltei* and 23 ha of subtidal *Z. marina*.

Pembroke Port

A survey of rocky intertidal shores within the MHW was carried out by The Marine Biological Association (MBA) for the MHWESG in 2010 (Miesskowska, 2011). A total of six sites were selected throughout the MHW with one site based at Llanreath, approximately 1 km south west of Pembroke Port. The site is in the lee of Carrs Rock, with a very sheltered, flat shore with long, narrow old Sandstone bedrock ridges running down the shore. The results of the study indicated an abundance of channel wrack *Pelvetia canaliculata*, Montagu's stellate barnacle *Chthamalus montagui*, and the acorn barnacles *A. modestus* and *S. balanoides*, on the high shore. The high shore mobile community also included several gastropods including, the rough periwinkle *Littorina saxatilis,* common periwinkle *Littorina littorea,* common limpet *Patella vulgata* and thick top shell *Osilinus lineatus*. Limpets and barnacles dominated the bedrock sections of the mid shore, with mussels *Mytilus* spp. and limpets most abundant on the cobble/shingle mid-shore habitat. The low shore cobble and shingle area had a similar range of biodiversity and abundances of species as the mid shore. A low number of macroalgal species were identified within the intertidal zone, which reflects the exposed nature of the environment.

In 2014, Morell (2014) conducted a rocky shore assessment throughout the MHW estuary, from Dale Point to Cosheston Folly. The closest site to Pembroke Port that was surveyed was Llanreath. The survey found that the upper shore was dominated by *P. canaliculata*, with flat wrack *Fucus spiralis* and red algae *Catenella caespitosa* present. The dominant barnacle species, *A. modestus,* with *C. montagui* occurred on the upper shore and low densities of *S. balanoides* were recorded on the lower shore. The only limpet species recorded was *P. vulgata*. Based on this information, the communities can be classified as *P. canaliculata* and barnacles on moderately exposed littoral fringe rock (LR.MLR.BF.PelB). The results of the Morrell (2014) were consistent with the previous study conducted by Miesskowska (2011).

Following a review of the EMODnet seabed habitats map at fine scale, EUNIS classification for Pembroke Port within the site boundary have returned several different classifications (Figure 4-6). *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). Classification returned in the Graving Dock identified *Hediste diversicolor* and *Macoma balthica* in littoral sandy mud (LS.LMu.MEst.HedMac). Species associated with these biotopes can be found in Annex B, Table B1.

Whilst no ecological site-specific surveys have been conducted in the immediate area of Pembroke Dock, sediment grab samples have been carried out to determine the PSA. The results of the grab samples indicate the that the sediment is composed of 26.09% (±7.09) and representing 73.94% (±6.22) sand and mud respective (see Figure 4-4). Therefore, it is highly likely that the dominant biotope classification for Pembroke Dock is littoral mud (LS.LMu). Due to the cohesive sediments, little oxygen is able to penetrate and as a result an anoxic layer is often present within a few millimetres of sediment surface. As such, the sediment may support communities of polychaetes, bivalves and oligochaetes.

The distribution of intertidal dwarf seagrass *Z. noltei* in Pembroke Port, specifically the most eastern extent (Hobbs Point) occurs across a total area of 3.49 ha. In 2010, the seagrass meadow at Hobbs Point underwent a rapid decline and completely disappeared, however this has now recovered to its 2016 extent. The report also looks at the abundance of seagrass (shoot density or

% cover) which can be used as an indicator of seagrass health and condition; seagrass shoot abundance at Hobbs point was found to be consistently high, indicating a healthy population.

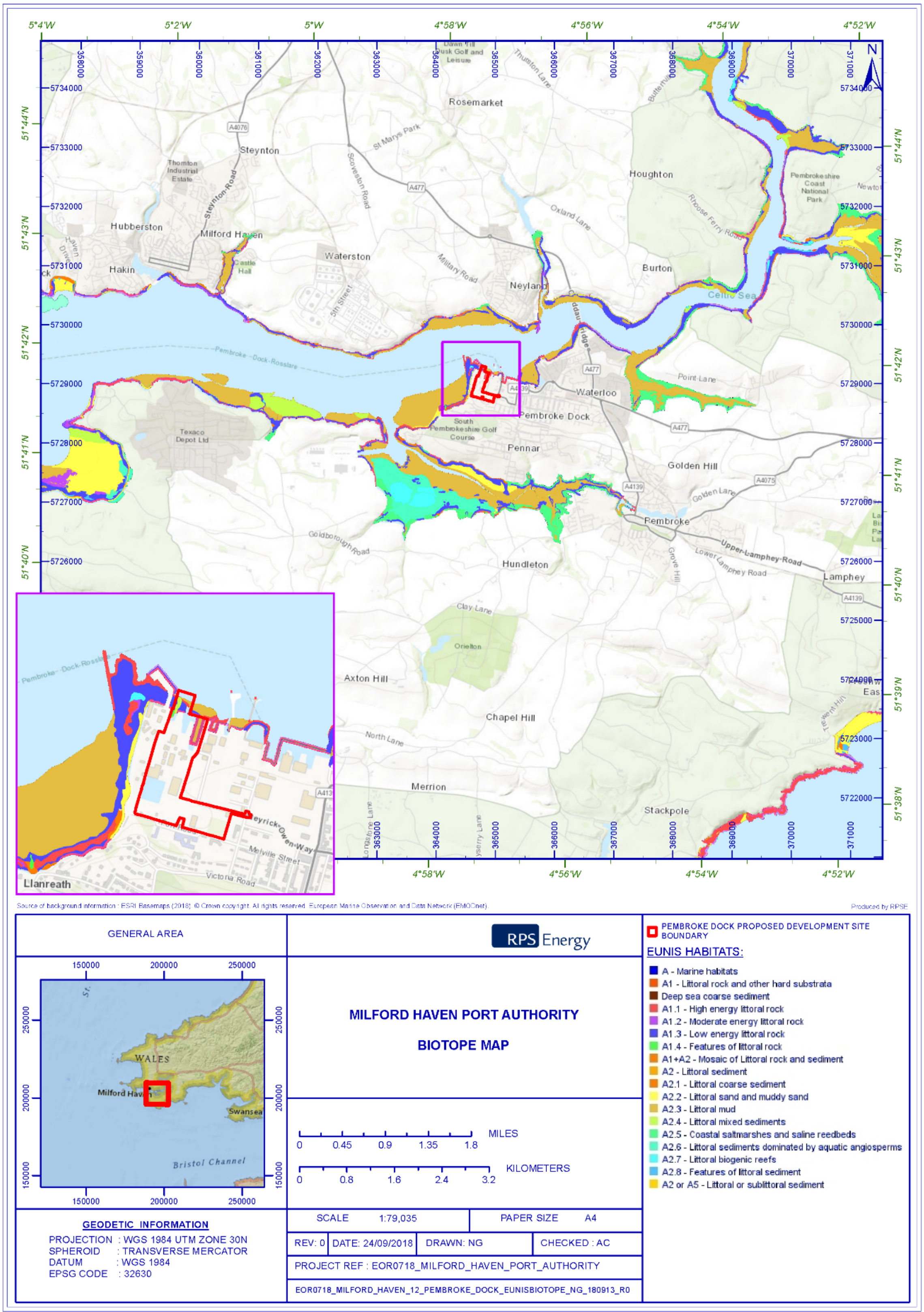

Figure 4-6: Benthic intertidal biotope map of the study area

4.6 Subtidal Benthic Habitats

MHW

The MHW is one of the most intensively studied coastal regions of the UK with respect to subtidal benthic habitats. These studies have largely been motivated by concern for the environmental effects of the oil industry. The diversity and composition of the macrobenthos have become one of the mainstays of marine biological effects monitoring with several large-scale studies of subtidal sediment benthos of the MHW system undertaken since the 1970s (Warwick, 2006). Seagrass and maerl have been intensely surveyed since the 1950s to monitor health and recovery.

Hobbs and Smith (1998) took a series of samples from the MHW in February 1996, following the Sea Empress oil spill, to monitor changes in the benthic fauna resulting from the oil spill. Hobbs and Smith (1998) found that the fauna of the survey area could be divided into three relatively distinct regions arranged along the length of the waterway, relating primarily to the balance between estuarine and marine conditions. Annelids were found to be the most abundant organisms in all three areas making up 75% of individuals, followed bymolluscs and crustaceans which contributed 6 to 11% of individuals. The stations upriver of the Cleddau Bridge were numerically dominated by tubificid oligochaetes and the polychaete *Paradoneis lyra,* with *Pholoe synophthamica*, *Sphaerosyllis* spp. The immigrant amphipod *Corophium sextonae* was also abundant, suggesting a polychaete/oligochaete-dominated upper estuarine mud shores (LS.LMu.UEst). The middle stations were dominated by the cirratulid group, consisting of *Chaetozone gibber* and *Caulleriella zetlandica* which made up over 50 % of the individuals at some stations. A third group of species, characterised by other cirratulids (*Aphelochaeta* spp., *Tharyx* spp. and *Caulleriella* spp.) and the bivalve *Abra alba* became more prominent toward the mouth of the MHW.

During benthic surveys conducted in 2002 to 2005 at the Texaco and Petroplus jetties, Hebog (2006) noted a dominance of opportunistic taxa including cirratulid and capitellid worms, as well as small crustaceans such as amphipods *Ampelisca* spp. There was also evidence of slower growing, equilibrium species, such as molluscs *Venerupis* spp. and *Gari* spp., as well as the reef building polychaete *Sabellaria spinulosa* although no reefs were classified at the time of the survey.

RPS undertook a study of the subtidal benthic ecology for the then proposed Pembroke Power Station (RPS, 2007d), to assess the potential effects arising from activities associated with this development. The site lies approximately 2,400 m south west of Pembroke Dock. Previous data collected by Hebog (2006) for Milford Haven Port Authority (MHPA) in April 2005 and by Enviromuir for RWE in July 2006 were collated as part of the baseline. This was supplemented by additional data gathered by RPS in October 2006 to provide sufficient coverage of the area. The surveys found that the most dominant fauna present in the subtidal communities were infaunal polychaetes. The top ten taxa, ranked by abundance over the study area were (in decreasing order): cirratulid species *C. gibber*, polychaete worm *Melinna palmata,* polychaete worm *Pholoe inornata,* cirratulid species *Monticellina dorsobranchialis,* seed shrimp *Ostracoda spp.,* bristle worm *Notomastus latericeus,* common slipper shell *Crepidula fornicata* (invasive molluscan species), polychaete worm *Hilbigneris gracilis,* polychaete worm *Ampharete lindstroemi* and catworms *Nephyts spp* (juveniles). These species were identified as characteristic of the marine biotope *Melinna palmata* with *Magelona* species and *Thyasira* species in infralittoral sandy mud (SS.SMu.ISaMu.MelMagThy).

A recent review of sediment and macrobenthos data, taken in 2008, 2010 and 2015, in the MHW was undertaken by Warwick in 2017. The purpose of the review was to determine the effects of the oil industry on the diversity and composition of the macrobenthos. The study found that there was a sequential change in community composition from the first sampling station at the mouth of the MHW into the Daugleddau at the final sampling station at Blacktar point. This change can be attributed to the salinity and sediment granulometry. Species abundance gradients can be associated with the salinity gradient. Those species identified with higher abundance in the intermediate station, at Pembroke River confluence, may favour the higher silt/clay content.

A review of EMODnet, can be found to be in line with the Warwick (2017) study. The mouth of the MHW up to the Milford Haven Port is represented by *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment (SS.SSa.CMuSa.AalbNuc). South of the Dragon LNG Terminal, the biotope changes to a *Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment (SS.SMx.CMx.MysThyMx) and continues into a mosaic of biotopes (described below) in the vicinity of Pembroke Port. To the north west of Pembroke Port, approximately 1,350 m away, subtidal kelp beds have been recorded directly under the Cleddau Bridge. This kelp bed represents an area of approximately 48,000 m^2. Beyond the Cleddau bridge, the biotope is classified as red seaweeds and kelps on tide-swept mobile infralittoral cobbles and pebbles (SS.SMp.KSwSS.LsacR.CbPb) up to Lawrenny Quay where the biotope is predominately classified as *Crepidula fornicata* and *Mediomastus fragilis* in variable salinity infralittoral mixed sediment (SS.SMx.SMxVS.CreMed). At Blacktar Point the area has been classified as *Hesionura elongata* and *Protodorvillea kefersteini* in offshore coarse sand (SS.SCS.CCS.MedLumVen).

There are two populations of the subtidal seagrass *Zostera marina* within MHW. The largest of which lies to the west of Pembroke Dock, located in Littlewick Bay on the north side of the MHW. The smaller population of *Zostera* lies approximately 3 km to the north west of the Littlewick Bay population, near Great Castle Head in Longoar Bay. The mudflats to the south east of the development, support an extensive bed of nationally scarce dwarf eelgrass *Z. noltei*.

A well-established maerl bed lies to the west of Pembroke Dock, in the vicinity of Littlewick Bay to Stack Rock. 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 the EC Habitats Directive(92/43/EEC) as amended 2010 on the Conservation of Natural Habitats and of Wild Fauna and Flora, the UK Biodiversity Action Plan (BAP) for the diversity of flora and fauna (1994), and the Welsh Government's Habitats and Species of Principal Importance for Wales list. The maerl bed constitutes as an Annex I Habitat important feature of Pembrokeshire Marine SAC.

Pembroke Dock

A detailed map and dataset of sedimentary habitats of the MHW was commissioned for the MHWESG from images of the sea floor collected in May 2012 (Carey 2015). The study compiled data from over 559 stations covering an area of over 40 km^2 creating an interpretive framework of classifications at each station. The results of this study, with information taken from the vicinity of Pembroke Port, found channel sediment types including: silt/clay, very fine/fine sand and very coarse sand. Shells, algae, cobbles were also found associated with the sediment types. Macrofauna and macroflora found throughout the channel included; lugworm *Arenicola marina,* common slipper shell*,* sand mason worm *Lanice conchilega,* anemones *Cerianthus sp.,* eelgrass *Zostera sp.,* sea lettuce *Ulva lactuca,* Montagu shell *Mysella (syn. Kurtiella*) *bidentata* and clams *Thyasira sp. Crepidula* and brown seaweeds were in highest abundance in the channel adjacent to Pembroke Port.

MHWESG commissioned a report in 2017 to review sediment macrobenthos data from 2008 to 2015 throughout MHW estuary (Warwick, 2017). A total of eight survey stations were reviewed and one particular survey station is located off Pembroke Port. Samples returned found that the most abundant species were polychaete worm *M. palmata,* seed shrimp*,* amphipod *Ampelisca diadema,* cirratulid species *C. gibber,* and amphipod *Photis longicaudata.* From 2008-2010, records showed a gradual increase in the number of species; the report does, however, suggest that there has been no improvement relating to the diversity indices from 2010-2015. An abundance/ biomass comparison of the years has indicated a lack of disturbance to the area and as a result a limited change in benthic community.

Pembrokeshire Marine/ Sir Benfro Forol SAC features include Annex I habitats of estuaries, large shallow inlets and bays and reefs (described in Section 3.1). Whilst Pembroke Dock lies outside of the SAC, these habitats require consideration. A review of EMODnet, in the vicinity of Pembroke Dock, indicates a subtidal habitat of Atlantic and Mediterranean low energy circalittoral rock (A4.3); supporting a biotope matrix of filamentous red seaweeds, sponges and *Balanus crenatus* on tide-swept variable-salinity infralittoral rock (IR.MIR.KT.FilRVS), polychaete/oligochaete-dominated upper estuarine mud shores (LS.LMu.UEst), kelp and red seaweeds (moderate energy infralittoral rock) (IR.MIR.KR), *Hesionura elongata* and *Protodorvillea kefersteini* in offshore coarse sand (SS.SCS.CCS.MedLumVen) and *Hediste diversicolor* and *Streblospio shrubsolii* in littoral sandy mud (LS.LMu.UEst.Hed.Str).

4.7 Fish and Shellfish Ecology

The MHW provides a varied habitat of hard and soft substrates to support a wide variety of fish species, which is further enhanced by the presence of artificial structures such as jetty piles, docks and localised beds of *Zostera* spp. and other macrophytes. Species found are described to be typical of species expected for a deep water harbour of this type. In general, a major increase in fish abundance in estuaries around South Wales has been recorded since the early 1980s, although this dramatic increase is likely at the expense of cold water fish, suggesting that global warming and increases in sea level temperature is responsible (Henderson and Seaby, 2001).

Data has been sourced from historic studies, baseline studies by RPS for the South Hook LNG (SHLNG) development (RPS, 2003) and for the (then) proposed Pembroke Power Station development (RPS, 2007c). This data has been supplemented with data obtained from WFD seine, otter, beam and fyke trawl surveys undertaken by the EAW in the MHW transitional and coastal waterbodies since 2004.

Fish Assemblage

MHW

Of the 112 fish species which have been recorded within the Pembrokeshire Marine SAC, 82 of which were recorded by Crothers (1966) in the MHW. The fish and shellfish species commonly occurring in the MHW, together with species of conservation importance (i.e., Annex II species and species listed by OSPAR as threatened or declining) are listed in Table 4.1.

Table 4.1: Fish species commonly occurring or of conservation interest within MHW

Common name	Scientific name	Common name	Scientific name
Herring	*Clupea harengus*	Pollack	*Pollachius pollachus*
Sole	*Solea solea*	Saithe	*Pollachius virens*
Plaice	*Pleuronectes platessa*	Bib	*Trisoptreus luscus*
Cod[4]	*Gadus morhua*	Thornback ray[4]	*Raja clavata*
Whiting	*Merlangius merlangus*	Greater pipefish	*Syngnathus acus*
Snake pipefish	*Entelurus aequoreus*	Sand gobies	*Pomatoschistus spp.*
Dragonet	*Callionymus sp.*	Sand smelt	*Atherina presbyter*
Red mullet	*Mullus surmuletus*	Wrasse	*Crenilabrus melops*
Sprat	*Sprattus sprattus*	Bass	*Dicentrachus labrax*
Haddock	*Melanogrammus aeglefinus*	Atlantic salmon[24]	*Salmo salmar*
European eel[234]	*Anguilla anguilla*	Sea trout[2]	*Salmo trutta*
Allis shad[234]	*Alosa alosa*	Twaite shad[234]	*Alosa fallax*
River lamprey[234]	*Lampetra fluviatilis*	Sea lamprey[234]	*Petromyzon marinus*

[2] Diadromous fish passing through Milford Haven.

[3] Annex II of the Habitats Directive (species whose conservation requires the designation of SACs).

[4] OSPAR threatened or declining species.

Seine and fyke net surveys undertaken by the EAW in the Milford Haven Waterway Inner WFD transitional waterbody (i.e. upriver of the Cleddau Bridge) since 2004 have predominantly recorded gobies *Pomatoschistus spp*, sand smelt *A. presbyter* and sea bass *D. labrax*, with lower numbers of clupeids including sprat *S. spattus* and herring. Three species of mullet, thick lipped *Chelon labrosus*, thin lipped *Liza ramada* and golden grey *Liza aurata* were regularly recorded, albeit in low numbers. Ballan wrasse *Labrus bergylta* and 15-spined stickleback *Spinachia spinachia* have also been occasionally recorded. Species of conservation interest which have been recorded in the seine and fyke net surveys, albeit extremely rarely, include Atlantic salmon *S. salmar*, sea trout *S. trutta* and European eel *A. anguilla*.

The otter trawl surveys conducted by the EAW in the Milford Haven Waterway Outer WFD waterbody, as expected for a different trawl method in an area further towards the mouth of the MHW, have typically recorded a different assemblage of species to the seine and fyke net surveys, although all trawls appear to have been dominated by high abundances of gobies. The otter trawls also recorded demersal species including plaice, flounder *Platichthys flesus* and solenette *Buglossidium luteum*.

Pembroke Port

RPS undertook seasonal otter trawl and seine netting surveys for the (then) proposed Pembroke Power station, approximately 2.5 km from Pembroke Port, in 2006 and 2007 (RPS, 2007c; Figure 2-1). Of the 112 species recorded within the Pembrokeshire Marine SAC, 27 species (*Pomatoschistus* spp. not identified to species) were recorded during these surveys. No new species to the SAC were noted, and other than Atlantic salmon, found upstream, no species of conservation significance were recorded (RPS, 2007c). During the otter surveys, 19 species of fish, including two species of elasmobranchs, thornback ray *Raja clavata* and lesser-spotted dogfish *Scyliohinus caniculus*, were recorded. Consistent with the findings of the EAW trawl surveys, the most abundant fish species sampled were gobies *Pomatoschistus spp*. with 400 individuals recorded in one trawl, associated with *Zostera* spp. and muddy seabed in Pembroke River (RPS, 2007c). Commercial species recorded included sea bass, for which the area is designated as a nursery area; sprat spp.; pollack *Pollachinus pollachinus*; and plaice. Other species such as thornback ray, sand smelt *Atherina presbyter* and red mullet *Mullus surmuletus* were also identified (RPS, 2007c).

As with the otter trawls, the most abundant fish taxon sampled in the seine nets for the Pembroke Power Station surveys were gobies. The same three species of mullet as recorded in the EAW trawl surveys were also noted in the seine net surveys: thick lipped, thin lipped and golden grey mullet. The thick lipped mullet was well represented in the study area, with the thin lipped found in higher proportions in the lower and upper Cleddau (RPS, 2007c).

MHW is known to support several diadromous fish species, all of conservation importance. Diadromous fish move between the sea and freshwater and thus must migrate through the waters of MHW to complete their life cycle. Six of these; Atlantic salmon, twaite shad, allis shad, river lamprey, sea lamprey and sea trout are anadromous (i.e., they spawn in freshwater). The European eel is catadromous (i.e. they spawn in the sea). Migratory fish travelling through the MHW tend to utilise the fast currents to rapidly reach spawning sites but move to sheltered water out of the tidal stream as the tide turns to prevent exert excessive energy swimming against the tide.

As discussed in Section 3.2.2, all six of the diadromous fish species and European eel are UK BAP Priority Species and species of principal importance for the purpose of the conservation of biodiversity under the Natural Environment and Rural Communities (NERC) Act 2006 (NERC, 2006). The European eel is also listed as Critically Endangered on the IUCN Red List. The European Union adopted Council Regulation No. 1100/2007 establishing measures for the recovery of European eel stocks. The European Commission approved the UK’s Eel Management Plans (EMPs) in March 2010 and Member States are required to submit regular reports to the European Commission reviewing these EMPs.

Four of the species of diadromous fish (lampreys and shad) are qualifying features of the Pembrokeshire Marine SAC including sea lamprey, river lamprey, allis shad and twaite shad. River lamprey is a primary reason for selection for the Cleddau Rivers / Afonydd Cleddau SAC and sea lamprey is also qualifying feature of this SAC. See Section 3.1 for further details on the features of Internationally designated conservation sites.

Few records exist in relation to the numbers and behaviour of these diadromous species within the MHW or the UK as a whole, however, twaite shad have been observed in the MHW by Dale Fort Field Studies Centre. Sturgeon *Acipenser sturio*, another threatened species, has also occasionally been recorded in southwest Wales, however, such individuals are regarded as vagrants, based on there being no evidence of an established population of any of the above species in or around MHW. Sandeel *Ammodytes spp.*, smelt, herring, cod, whiting, sole, plaice, mackerel *Scomber scombrus* and tope are also UKBAP and species of principal importance, discussed below.

Although little is known about the presence and abundance of these fish species within the MHW, across the UK there has been a decline in many of these migratory fish due to over-fishing at sea, the construction of weirs in the 19th century and other influences such as pollution.

<u>*River and sea lamprey*</u>

Lamprey are primitive, jawless fish resembling an eel, currently designated under Annex II of the EU Habitats Directive (1992) and Appendix III of the Bern Convention (1979). Confined to Western Europe, they migrate from North Atlantic coastal waters to spawn in the silt beds of many rivers in the UK. Lamprey do not always return to their natal river to spawn and thus monitoring behaviour and abundance of this fish species is difficult (Waldman *et al.,* 2008). Spawning sites are in the upper and middle reaches of rivers and lamprey feed predominantly on flounder but also on herring and sprat. Sea lamprey are the largest of the lampreys found in the UK and feed primarily on bass (Bird *et al*., 1994), which are found in large numbers in the MHW.

Although there are few records of lampreys within the Pembrokeshire Marine SAC, there are known populations within the Eastern and Western Cleddau rivers (Hurford and Guest, 2010). The rivers provide suitable habitat of gravels and silts for spawning and are primary and qualifying features of the Afonydd Cleddau/ Cleddau Rivers SAC, therefore can be expected to pass through the MHW.

<u>*Allis and twaite shad*</u>

Allis and twaite shad have been identified by Potts and Swaby (1991) as threatened species within the UK. Both species are classified as rare and listed in Appendix III the Bern Convention, Annexes II and V of the EC Habitats Directive, and protected under Schedule 5 of the Wildlife and Countryside Act (1981). Twaite shad spawning stocks are known to occur in only a few rivers in Wales and England and can constitute as Annex II species that are a primary reason for SAC selection. There is only one confirmed spawning population of allis shad in the UK, located in the Tamar estuary (in Devon, south west England). As such, this species is not currently listed as a primary reason for site selection at any other UK SAC.

Allis shad feed on crustaceans such as copepods, decapods, euphausiids and small fish. They enter estuaries in late spring and travel upstream to spawn. The species has declined in most rivers in northern Europe as a result of overfishing, habitat destruction in the upper reaches of rivers and the construction of weirs (Henderson, 2001; Jolly *et al.,* 2012). Research has shown there to be no evidence of spawning stocks for the allis shad in UK rivers at present and it may only spawn in a few French rivers (UK Biodiversity, 2001; Henderson 2001). Allis shad may be occasional visitors to the estuary, however likely favour the MHW to other estuaries such as the Severn Estuary as they are particularly sensitive to energetic, turbulent flows.

The twaite shad has also declined in many parts of Europe (Limburg and Waldman 2009) and there is now only evidence of spawning stocks in a few UK rivers, notably the Severn, Wye, Tywi, Usk and Solway (Wildlife Trust, 2001; UK Biodiversity, 2001; Henderson, 2001). Twaite shad were reported by Day in 1890 to be in decline due to the loss of spawning sites and although present in the first half of the 20th century, were not common due to the construction of weirs (Lloyd, 1941). In the MHW, twaite shad move into freshwater around April/May to spawn in gravelled areas in rivers and downstream migration occurs in late summer and autumn when temperatures decrease (Claridge and Gardner, 1978; Maitland and Hatton-Ellis, 2003). Peak migratory activity occurs between 10.6 and 12.3 °C and passage is aided by tides (Apprahamian, 1988; Maitland and Hatton-Ellis, 2003). Adult twaite shad do not feed in the estuary. The upper estuarine habitat is, however, a particularly important feeding ground for juveniles as there are high densities of planktonic crustaceans and greater shelter available (Apprahamian, 1988).

Atlantic salmon and sea trout

The Atlantic salmon is the largest of the UK's migratory fish. Populations in the UK have declined in recent years due to overfishing at sea, pollution and barriers to migration in its spawning rivers (Chaput, 2012; Krkosek, 2013). As a result, a long-term decline in line with North Atlantic and world salmon catches has been reported (DEFRA, 2000).

Adult salmon migration through estuaries typically takes a period of a few tides. Smolts and adults tend to use the faster currents to aid migration. Sea trout are generally stated to behave in the same manner as salmon in estuaries although sea trout smolt remain in estuarine waters longer and many fish return to their rivers within four months of leaving.

The National Rivers Authority (1991), now the Environment Agency estimated that the annual spawning run of salmon and sea trout in the MHW numbered some 13,250 fish, the majority being trout (Hobbs and Morgan, 1992). Since the assessment is based on angling returns only (assuming an exploitation rate of 10%), these findings can only be taken as a very general indication of the numbers of these fish which use the waterway. Natural Resources Wales (NRW) have carried out a salmon and trout monitoring project based on declared number of catches from the eastern and western Cleddau rivers. This information is then used to inform the stock status, which is then assessed using 'Conservations Limits'. Salmon 'Conservation Limits' is currently set at 1.55 million eggs; egg deposition between 2006 to 2015 has shown a gradual decline, putting the stock class as 'at risk'. The assessment for trout is under development with the current trend in stock decreasing (NRW, 2016).

The capture and patterns of salmon and sea trout in net and rod fisheries largely reflect the availability of fish moving into the river and can therefore be used to infer migration times (Fawley Laboratories, 1995). Sea trout tend to run earlier than salmon, with catches peaking in June for the former and September/October for salmon. In the Cleddau (East and West) rivers, in 2017 peak catches for sea trout occurred in July, and for salmon occurred in September (Environment Agency, 2019). Over the last 60 years, salmon have shown a change in run timing, the majority currently entering the river between August and October compared with prior to June (Aprahamian *et al.,* 2008). Adults continue to enter the river after the close of the fishing season (mid-October) and the late spawning 'blue back' salmon will run as late as February or March. Young seaward migrating salmonids leave the rivers and pass through the MHW from late winter to early summer (February to June), with peak migrations in the spring.

European eel

European eel are widely distributed throughout European estuarine and inland waters. In their adult phase eel spawn in the western central Atlantic Ocean, with the larval eel recruiting to European estuaries (Kettle and Haines, 2011).

The life-history of the European eel depends strongly on oceanic conditions; maturation, migration, spawning, larval transport and recruitment dynamics are completed in open ocean (Tesch, 2003). Partially mature adults leave rivers at different times, strongly dependent on lunar phase and atmospheric conditions (Van Ginneken *et al.,* 2005). Adults arrive in UK waters as glass eels, carried by the Gulf Stream from their spawning grounds in the Sargasso Sea (Bonhommeau *et al.,* 2008). They then enter estuaries during the spring and migrate upstream into freshwater, becoming elvers in the process. Mainly tidal currents govern the timing of their arrival (Bonhommeau *et al.,* 2009; Arribas *et al.,* 2012). The European eel pass through MHW at least twice during their complete life cycle.

Management of the European eel stock is a community-wide issue because the fish form a single stock (for reproduction) that is distributed across the European continent (Hanel *et al.,* 2019).

Recent recruitments of eel have been as low as 1% of historic levels, and adult eel that are migrating to the sea to spawn suffer high mortality rates (Bonhommeau *et al.,* 2008).

MWH Spawning and nursery grounds

The MHW provides a suitable spawning and nursery habitat for sandeel, sole, herring, mackerel, whiting, sprat and spotted ray.

Although sandeel have not been commonly recorded in EAW trawl surveys, or during recent fisheries surveys in the MHW (undertaken for other developments), they are demersal spawners and MHW has been identified as a high intensity spawning area for sandeel (Ellis *et al.*, 2010) (Figure 4-8).

Sole spawn in the early summer (April to June) within the mouth of the Bristol Channel, off the coast of Cardigan and Fishguard, and north of Wales between Anglesey and the Isle of Man (Pawson and Robson, 1995; Ellis *et al.,* 2010). Larvae can drift for 100 miles or more from offshore spawning grounds to inshore nursery areas. MHW has been identified as a low intensity spawning area for this species (Ellis et al., 2010). MHW is also recognised as a minor nursery area for flatfish (NRA, 1992) (Figure 4-8).

Herring spawn within the Pembrokeshire Marine SAC along the coast outside the MHW from January to March (Coull *et al*., 1998; Ellis *et al.,* 2012). The local spring spawning race within MHW runs from February to April, with spawning peaking in March. Herring spawn at gravel sites in the Daugleddau (Hobbs and Morgan, 1992) although positions vary from year to year according to gravel availability. Two spawning grounds were investigated by Clarke and King (1985), one at Burton Point and one further upstream at Castle Reach. Pembroke Port is situated at the southern extent of the spawning grounds (Figure 4-8).

Mackerel is a widespread and abundant pelagic fish species that spawns pelagically. It is fished both recreationally and commercially in MHW. Although this species has not been commonly recorded in trawl surveys in MHW, nursery areas for this species have been identified throughout the western half of the MHW (Figure 4-8) (Ellis *et al.,* 2010).

Whiting breed between January and July, but mostly in spring. There are whiting spawning areas in Cardigan Bay and off North Wales (Pawson and Robson, 1995). MHW is known to be a nursery area for whiting (Coull *et al*., 1998; Ellis *et al.,* 2012) (Figure 4-7).

Sprat is a coastal pelagic species, often found in shallow water close to shore, and sometimes tolerant of very low salinities (to 4%) (Whitehead, 1985). Sprat are a schooling species, with strong migrations between winter-feeding and spring and summer spawning grounds. Spawning occurs almost throughout the year, either near to coast or up to 100 km out to sea, mainly in April to August (Atlantic and Baltic) or as early as January in English Channel. The eggs of sprat are pelagic and float either at the surface or in mid-water at a depth of 25 to 50 m. Spawning takes place in the open sea, although some small populations may spawn close to the coasts. The eggs hatch in three to four days, and the larvae drift inshore. The young of the year live close inshore in shallow water, often in schools with first-year herring. Nursery areas have been identified throughout MHW, with Pembroke Port on the boundary of the spawning area (Figure 4-7).

European Plaice is a common flatfish occurring within muddy and sandy sediments, usually at depths of 10 m to 50 m. Ovary development occurs from late August to September with spawning occurring in December through to May. Females will then release eggs in ‘batches’ every three to five days for approximately a month. The larvae enter a planktonic stage and drift within the water column until metamorphosis after approximately eight to ten weeks and then settle in intertidal zones (Figure 4-7).

Thornback ray have been recorded in the waters of MHW, together with other species of ray and tope shark, are of some commercial importance. Low intensity nursery areas exist for these species in the area throughout MHW. Tope shark as listed as vulnerable on the IUCN Red List of Threatened Species (Walker *et al.,* 2006) (Figure 4-9).

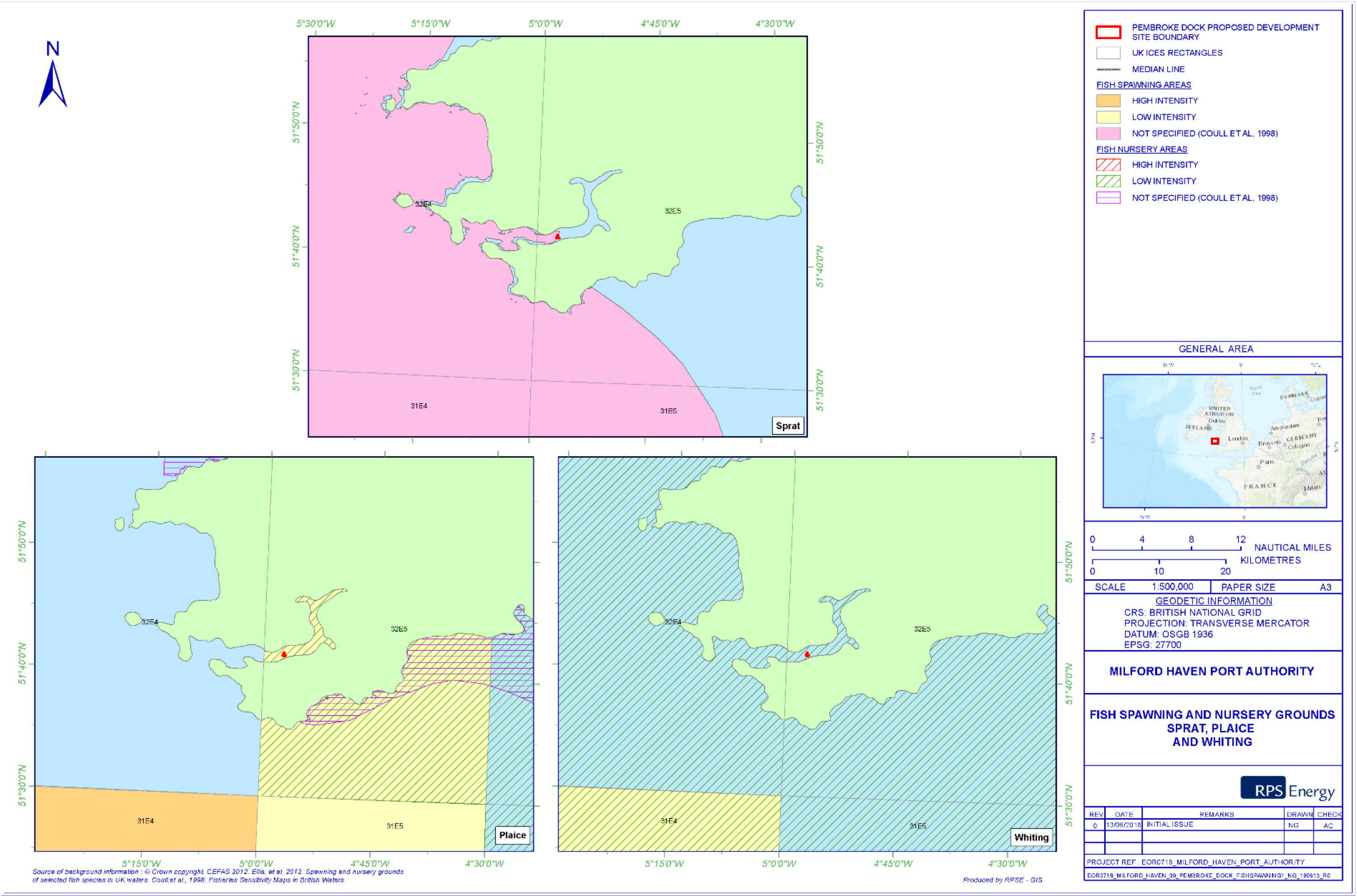

Figure 4-7: Spawning and nursery areas for Sprat, Plaice and Whiting.

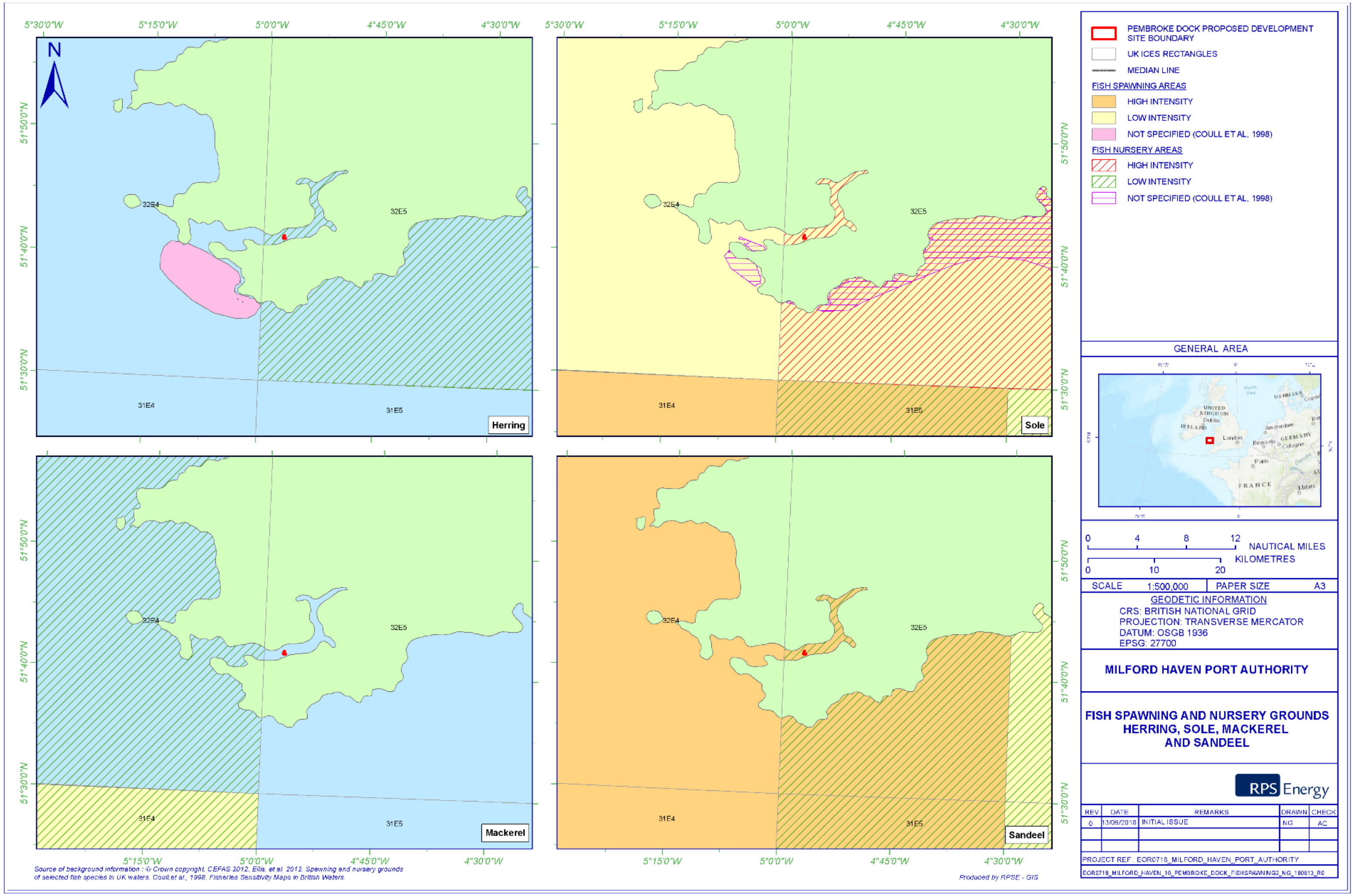

Figure 4-8: Spawning and nursery areas for Herring, Sole, Mackerel and Sandeel.

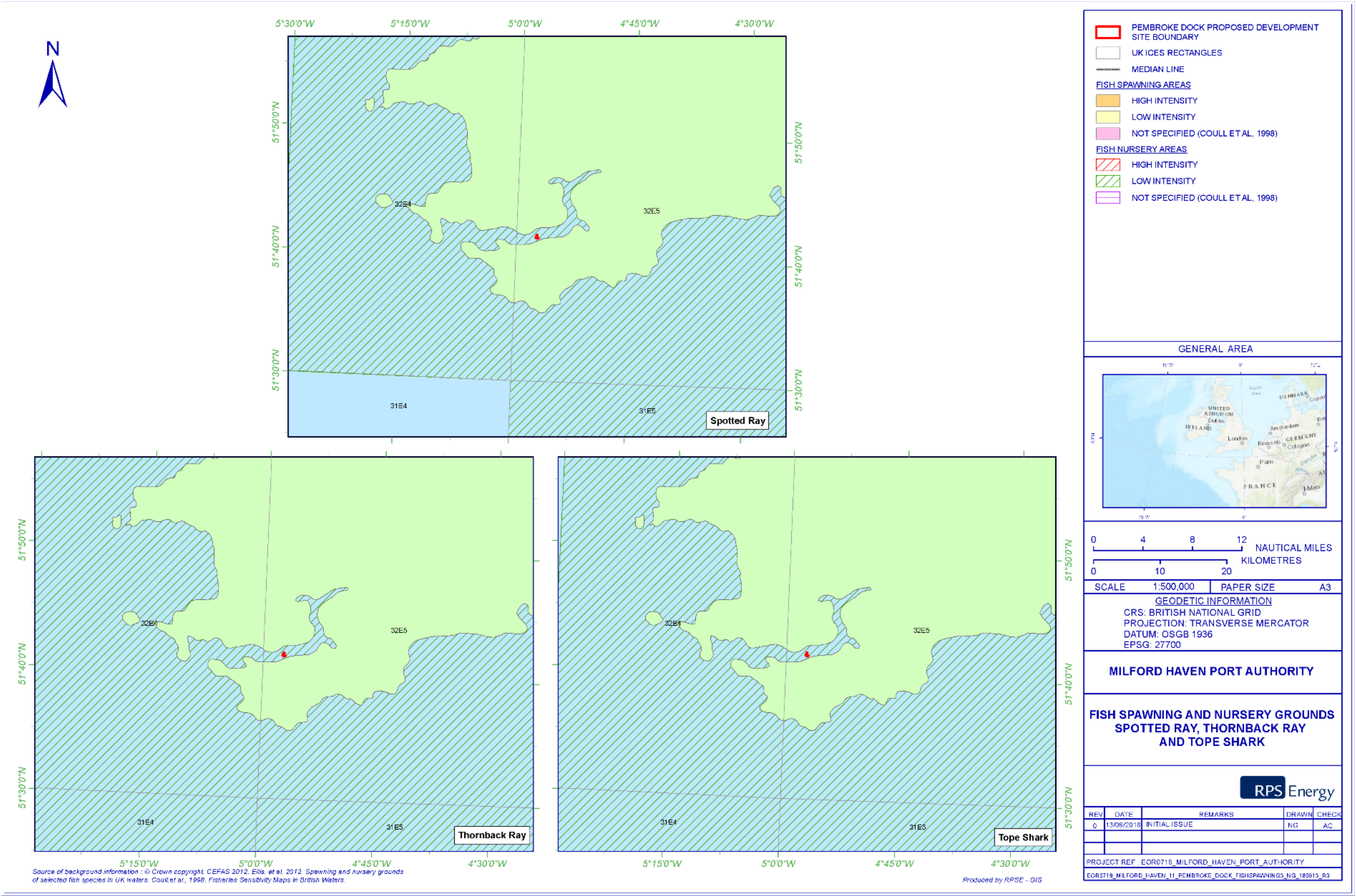

Figure 4-9: Spawning and nursery areas for Spotted Ray, Thornback Ray and Tope Shark.

Shellfish and Mollusc Assemblage

The EU Food Hygiene Regulations (852/2004, 853/2004 and 854/2004) are implemented in Wales through the Food Hygiene (Wales) Regulations 2006 (SI 2006/31) which came into force 11 January 2006. In accordance with the Regulations, bivalve production areas are classified according to the level of treatment they require prior to their sale. The competent authority for the purpose of the Food Hygiene (Wales) Regulations 2006 is the Agency except where it has delegated competencies. Local authorities collect this information and send it to the Centre for Environment, Fisheries and Aquaculture Science (CEFAS), who manage the program on behalf of the Food Standards Agency, who compile the data. Standards are set in terms of concentrations of coliform bacteria and Salmonella. Harvesting sites are classified from A to C; Grade A sites do not require pre-treatment and Grade C sites require intensive purification. A fourth category exists, from which harvesting is prohibited (Figure 4-10).

The EC Shellfish Waters Directive (79/923/EEC), adopted 30 October 1979, aims to protect or improve shellfish waters in order to support shellfish life and growth, therefore contributing to the high quality of shellfish products directly edible by man. There are two areas within MHW that have been designated as shellfish waters under this directive. The waters within the Carew River were designated as shellfish waters from 11 October 1999. The Milford Haven Cleddau (Eastern and Western) River was also designated in 1999, however, following a review of designations in 2003/2004, the area was extended in March 2004.

Historically, MHW has been harvested for wild cockles and Pacific oyster and in recent years the small scale market has grown to include permits for carpet shell clams (*Ruditapes decussatus)*, razor clams (*Pharidae* spp.) and designated oyster aquaculture sites.

The large area, diverse marine habitats and sediment types, results in a variety of shellfish species. These include the native oyster, mussels (*Mytilus edulis)*, lobsters (*Homarus gammrus)* and prawn (*Palaemon serratus)*, some of which have conservation and commercial interests.

MHW

<u>*Native oyster*</u>

Due to the specificity and sensitivity, the native oyster has been classified as a threatened species and is covered by a UK BAP. The species is of principal importance for the purpose of conservation of biodiversity under the Natural Environment and Rural Communities Act 2006 and is on the OSPAR list of threatened and/or declining species.

The native oyster is widely distributed around UK coasts, particularly in the south and west, with the main stocks found in the south-east, the Thames estuary, the Solent, the River Fal and MHW (MarLIN, 2019). Its wider European range extends from the Norwegian Sea to the Atlantic coast of Morocco, and into the Mediterranean and Black Sea.

The native oysters are widespread throughout the MHW with stocks present from Milford Haven town up to Picton Point. Historically, the native oyster beds upstream of the Cleddau Bridge from Burton to Llangwm were sufficiently productive to support a fishery (Hobbs and Morgan, 1992). However, the water quality within the MHW, vital to oyster recruitment, growth and reproduction, has decreased over time due to overfishing, increases in suspended sediment, pollution and the introduction of the invasive species, *Crepidula fornicata*. The resulting effect is a decrease in oyster fecundity, poor recruitment and a diminished oyster population unable to sustain a commercial fishery (Little *et al.*, 2016; Bohn *et al.*, 2015; Cefas, 2012).

MHW has a long history of oyster fishing including both the native oyster and the introduced pacific oyster, although the industry has now declined due to changing markets and disease. Current designated Bivalve Mollusc production areas within Milford Haven include the Cleddau River and all the beds above Cleddau Bridge (Cefas, 2012), which have been classified as Class B oyster beds, however, the fishery is currently not in operation within these classification areas (Jonathan Monk, Environment Manager, MHPA Pers. Comms.).

Breeding in the native oyster begins when the water temperature exceeds 15°C. Once the planktonic larva has been released into the water column, subsequent settlement depends on the hydrodynamic regime. Successful settlement and ontogenesis is dependent on the suitability of the seabed sediment conditions.

Pacific oyster (Crassostrea gigas)

The Pacific oyster is an invasive non-native species (INNS), which has been classified by the UK Technical Advisory group (UKTAG) on the WFD 'high impact list'. The Pacific oyster has been considered unlikely to be able to establish a self-sustaining population within the UK, and as a result is out-competed by local species (Shellfish Association, 2012). However, there is a known population within the MHW due to historical aquaculture (Robins *et al.,* 2017).

The Pacific oyster is cultivated throughout the UK primarily as a food resource, with distribution centred in the south and south-east of England. Around 1,200 tonnes of oyster are produced each year in the UK (Shellfish Association, 2012). Currently the MHW shellfisheries are not in operation for the production of Pacific oysters.

In the MHW, Pacific oysters have been recorded in small numbers (Robins *et al.,* 2017) occurring within the Cresswell/ Carew River, where there were former trestles for culturing, and in the main Cleddau channel up to Carron Pill.

Syvret *et al.* (2008), reported that the temperature regimes within the MHW are likely to result in spawning, although it was not thought to be sufficiently warm for consistent recruitment of this species. Recent predictive modelling data, however, suggests that an increase in sea temperatures could facilitate the reproduction and dispersal of the pacific oyster in the MHW, and therefore these Pacific oysters could act as a source population to support the spread of this non-native species (Robins *et al.,* 2016).

Mussel

Mussel beds are classed as a UK BAP Priority Habitat and currently on the OSPAR List of Threatened and/or Declining Species and Habitats. Blue mussel beds can also be key features of habitats listed in Annex I of the Habitats Directive.

Blue mussels are widespread on the shore and in shallow water around the coasts of the UK and Europe. Significant beds of blue mussels on soft sea beds are found in scattered locations within this broad range.

Wild stocks of mussels are present in patches throughout MHW, either present on rocky shores or raised beds acting as 'nursery' areas for larvae (Cefas, 2012). The main raised beds are found between the Cleddau Bridge and Picton Point at Lawrenny Quay, Coedcanlas and Sprinkle Pill. Jenkins Point, at the confluence of the Daugleddau the Carew and the Creswell Rivers, and Mount Pleasant are both Class B mussel beds.

Spawning occurs in partially in spring, following ripening of the male gonads. This stage is then followed by an additional gonad ripening for secondary spawning between late August and October (Seed, 1969a). Larvae spawned in spring can take advantage of plankton present in the water column, the secondary spawning in summer is generally more opportunistic and dependent on favourable conditions.

Common Cockle Cerastoderma edule

The species is found in coastal areas of the northern and eastern Atlantic Ocean, distributed throughout Europe and is one of the most abundant species of mollusc in tidal flats. Within Angle Bay and Pembroke River there are cockle shellfish beds, which has been classified as Class B. Historically, wild cockles have been classified for harvest, but cockle shellfisheries are currently not in operation (Cefas, 2012). In the event of renewed interest in this shellfishery, it is likely NRW will review and impose restrictions to access points to fishable areas in order to protect seagrass beds.

Cockles generally spawn between March and August followed by peak spat recruitment between May and September. Dates of spawning are highly temperature dependent with warming water in spring increasing to 13°C or above to induce spawning (Boyden, 1971) or a sudden temperature increase may be required (Ducrotoy and Elliot, 1991). Distribution, within the MHW, of larvae is determined by local hydrodynamics and settlement on favourable substrate to allow ontogenesis to occur (Cefas, 2012). Species have been found to spawn and settle within the MHW.

Carpet shell clam Venerupis corrugata

This species is found in shallow waters in the East Atlantic and the Mediterranean Sea. The clam's range extends from the coasts of Norway, south to West Africa.

Carpet shell clams have been found within the Milford Shelf, Pwilcrochan Flats and at Wear Point, all located to the west of Pembroke Dock. Distribution is wide within MHW as preferred habitat is sand, gravel or mud substrates.

Individual clams are either male or female, with breeding taking place throughout the summer months. Gametes are released into the water column with the resulting larvae eventually settling on favourable habitat after approximately two weeks. Recruitment is dependent on local currents, aiding dispersal outside the MHW or settling within substrate. Recruitment of the shell clam has been recorded within the MHW.

Common periwinkle Litorina Litorea

The periwinkle can be found throughout the north eastern coasts of the Atlantic Ocean, with a wide distribution throughout the UK. Periwinkles have been found in abundance throughout the whole of the MHW (Cefas, 2012).

Periwinkles are able to produce up to 100,000 eggs for a large female per year. These eggs are released throughout the year but are highly dependent on favourable conditions. Distribution is usually on rocky shores and in the higher and middle intertidal zones.

Important locations for periwinkle in the MHW with respect to spawning and nursery areas comprise those presently supporting adult populations, namely Angle Bay, Pwllcrochan shore lines and the Llanreath shores Collection of periwinkle takes place throughout the MHW and cockles are collected from the lower sandy flats of Angle Bay (QPI Global Ventures Ltd, 2013).

King scallop Pecten maximus & queen scallop Aequipecten opercularis

Both scallops are regionally abundant and have been found within the MHW, from Cosheston to the mouth of the MHW.

Spawning of the king scallop occurs from April to September, with the queen scallop spawning during the spring and autumn. Both species are similar with respect to ontogenesis, with eggs released into the water column and rapidly developing into pelagic larvae. These larvae soon settle to the seabed where they metamorphose into the young scallop (Pawson, 1995). Scallop spawning areas have been found to correspond with the adult distributions.

Decapod species

Pawson *et al.* (2002) describe the Pembrokeshire coast as a valuable potting ground. Potting for lobster, green shore crab, spider crab and velvet crab is common in the MHW. General statistics on the collection of these species is gathered by the Welsh Government however this data is confidential and unspecific to an area. Although specific information is not available, potting is chiefly seaward of Pembroke and sold into overseas markets.

As the common name indicates, the European lobster can be found throughout Europe and the UK. Within the MHW, the lobster can be found as high up Lawrenny Quay. Lobsters in MHW have been noted as breeding, with evidence of the populations extending as far as Lundy in the Bristol

Channel. They have been recorded to depths of around 60 m and are generally found on rocky substrata, with access to crevices, excavated tunnels or living in holes (Wilson, 2006).

Spider crabs are distributed throughout Europe and the UK. Spider crabs have been recorded within the MHW Estuary, from Angle Bay up to Milford Haven Dock, with sightings around the coast of Pembrokeshire. Spider crabs will generally feed on the algae present on rocky substrata (Cefas, 2012).

The velvet crab is a commonly occurring species whose distribution ranges from the lower intertidal/sublittoral fringe to depths of 80 m on rocky substrata (Clark, 1986). The species has an affinity for rocky substrata amongst both adults and juveniles, and the widespread occurrence around the UK coastline, therefore it is reasonable to assume that any area that meets the requirements for spawning and nursery that the species will occur in MHW.

Green (shore) crabs can be found on all types of shores, from high water to depths of 60 m in the sublittoral. Green crabs have been found throughout the year in the MHW (QPI Global Ventures Ltd, 2013) and are abundant intertidally during spring months. The shore crab feeds on invertebrates including worms, molluscs and small molluscs and barnacles are taken by young crabs. Breeding peaks in summer, and mating can only take place shortly after the female moults; the male finds a female before she is due to moult and carries her around underneath his body for a number of days. After the moult, copulation occurs. The female creates a cavity by burrowing in the sand; she lays the eggs whilst positioned over this cavity, attaches them to her walking legs and carries them around for several months. After hatching, the larvae are planktonic for 2-3 years. They then settle as young crabs and reach maturity after around a year (Cefas, 2012).

Prawns are found throughout the UK and within MHW, up to Lawrenny Quay (RPS, 2007). The common prawn is omnivorous. The sexes are separate, and breeding occurs between November and June. Fertilisation is external and occurs as the eggs leave the female's body. The female then carries the eggs around attached to hairs on her pleopods, up to 4000 eggs are carried for around 4 months. The planktonic larvae settle in July or August and begin to breed in February of the next year

Pembroke Port

Current shellfish water classification as of 2010 within the vicinity of Pembroke Port state that any shellfish collected from the area are unfit for consumption. The area from Pennar Point up to Cleddau Bridge have been classified as prohibited and therefore must not be harvested. Biological contaminant data is collected from shellfish populations and compared against a standard in terms of concentrations of coliform bacteria and *Salmonella*.

A review of the NBN gateway, in the near vicinity (<200 m) of Pembroke Port, species returned were grey top shell *Gibbous cineraria,* common slipper limpet, spotted cowrie *Trivia monacha*, common periwinkle, common limpet *P. vulgata*, chinaman's hat *Calyptraea chinensis*, painted top shell *Calliostoma zizyphinum*, common whelk *Buccinum undatum*, variegated scallop *Chlamys varia*, sea hare *Anaspidea* spp. and arctic cowrie *Trivia arctica*.

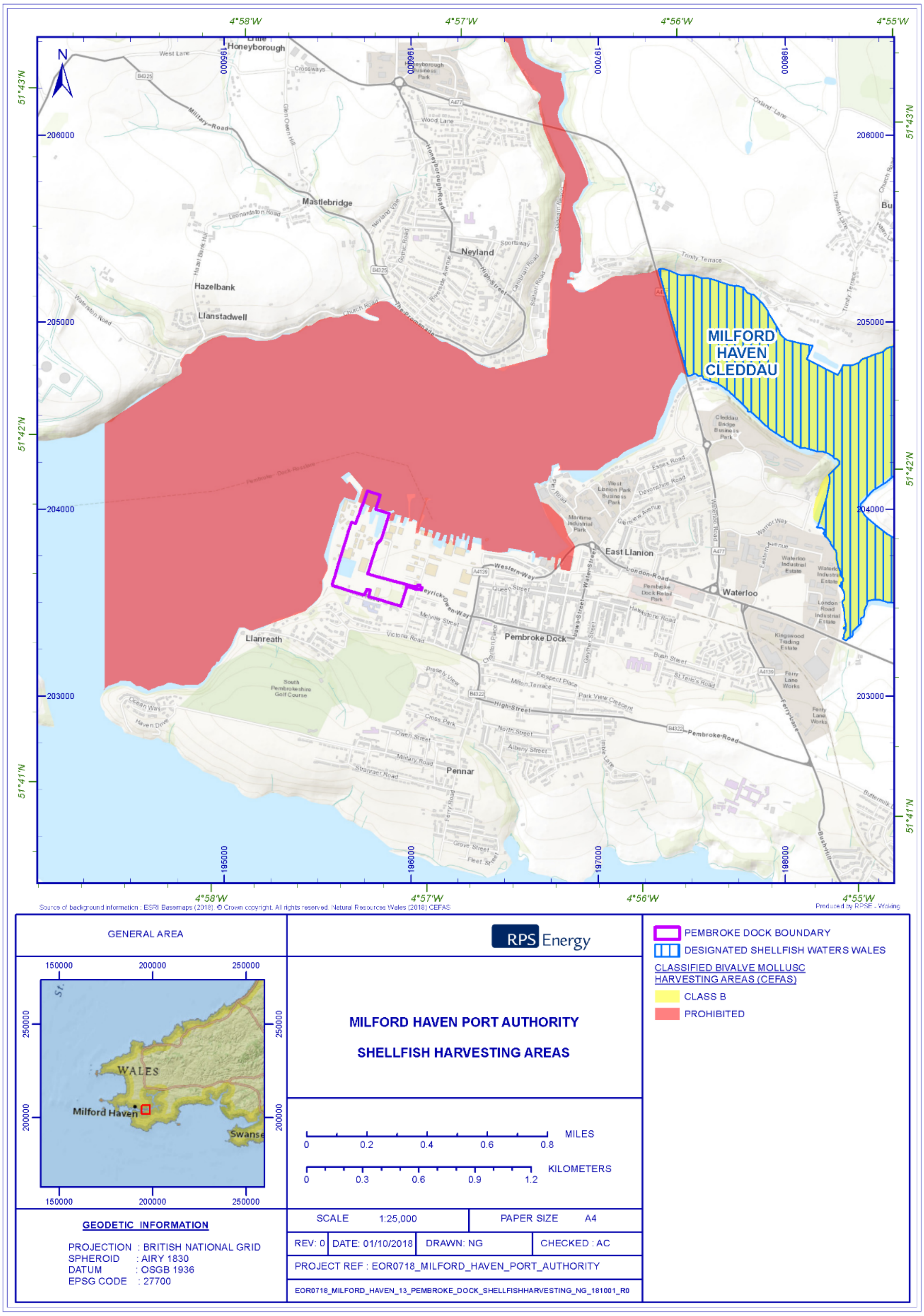

Figure 4-10: Shellfish harvesting areas in the immediate vicinity of Pembroke Dock

4.8 Marine Mammals

Welsh waters host a high level of marine mammal diversity, likely resulting from the influence of two major frontal systems in the Irish Sea, the Celtic Sea and Irish Sea Fronts (Baines and Evans, 2012). Eighteen species of cetacean have been recorded in Welsh waters since 1990, five of which are regularly sighted in the waters off Pembrokeshire; harbour porpoise (*Phocoena Phocoena*), bottlenose dolphin (*Tursiops truncatus*), short-beaked common dolphin (*Delphinus delphis*), Risso's dolphin (*Grampus griseus*) and minke whale (*Balaenoptera acutorostrata*). Grey seal (*Halichoerus grypus*) is the only pinniped species which breeds in Wales; whilst harbour seals (*Phoca vitulina*) are prevalent on the east coast of England and throughout the Scottish coast, there are no resident or breeding populations in Wales (IAMMWG, 2013). In addition, fin whale (*Balaenoptera physalus*), killer whale (*Orcinus orca*), and long-finned pilot whale (*Globicephala melas*) are recorded occasionally. Casual visitors to the region include, humpback whale (*Megaptera novaeangliae*), sei whale (*Balaenoptera borealis*), pygmy sperm whale (*Kogia breviceps*), northern bottlenose whale (*Hyperoodon ampullatus*), Cuvier's (*Ziphius cavirostris*), Sowerby's (*Mesoplodon bidens*) and Blainville's (*Mesoplodon densirostris*) beaked whales, striped dolphin (*Stenella coeruleoalba*), Atlantic white-sided dolphin (*Lagenorhynchus acutus*), and white-beaked dolphin (*Lagenorhynchus albirostris*) (Baines and Evans, 2012).

Cetaceans

South West Wales

The most frequently recorded cetacean in the MHW is harbour porpoise (Baines and Evans 2012), evidenced by the results of a hydroacoustic porpoise detector (POD) field study conducted by RPS for the South Hook dredging EIA (RPS, 2004c) which identified harbour porpoise as the most commonly recorded cetacean. These surveys also detected a reasonable abundance of bottlenose dolphin and short-beaked common dolphin in the area. Whilst Atlantic white sided dolphin and Risso's dolphin were also detected during the survey, detections were less frequent and further offshore, and as such these species have not been considered further for assessment.

Other species which are regularly recorded in the waters off Pembrokeshire include Risso's dolphin, short-beaked common dolphin, and minke whale, however these species are rarely sighted close to shore (Reid *et al.,* 2003; RPS, 2004c) and as such only harbour porpoise and bottlenose dolphin are considered further in this desktop review.

Harbour porpoise

The harbour porpoise has a widespread distribution throughout the north Atlantic, occurring in temperate waters, largely found over the North Atlantic continental shelf. The species is the most numerous marine mammal in north-western European shelf waters (Reid *at al.* 2003), and occurs throughout Welsh waters (Baines and Evans, 2012).

Harbour porpoise need to feed regularly due to a high metabolic rate (relative to dolphins), to meet their energy needs. They feed on a wide range of prey species including 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).

Harbour porpoise are found in water depths of 3 to 100 m but normally less than 50 m and are often associated with areas of fast tidal movement and areas of upwelling (Pierpoint, 2008). They are generally classed as an inshore marine mammal, particularly in the summer months. Harbour porpoise typically occur in small groups of (one to three) animals, with larger groups (one to ten) recorded in late summer and autumn.

Females can grow up to 1.6 m at sexual maturity at the age of three or four years, with males reaching 1.45 m on maturity at age three to four years (Lockyer, 2003*).* Most animals live to 12 years, though animals living up to 24 years have been recorded (Lockyer, 2003). Reproduction in harbour porpoise is strongly seasonal, with mating occurring between June and August (Lockyer, 2003). Gestation occurs over 10 to 11 months with an observed peak in birth rate during the months of June to July around the British Isles (Boyd et al., 1999).

Local to the study area high densities of harbour porpoise are found in coastal waters off southwest Wales (Reid et al., 2003), and are particularly abundant around the Pembrokeshire Islands (De Boer and Simmonds, 2003; Pierpoint, 2008; Stringell *et al.,* 2015). Large numbers of harbour porpoise have also been recorded year-round at St David's Head and Strumble Head (approximately 34 to 38 km to the northwest of the proposed development), highlighting the importance of the area for this species. Sightings are reported throughout the year around the islands of Skomer, Skokholm and Ramsey, and there is a locally important concentration in St. Brides Bay). Surveys carried out between March and November (2015) on Skomer Island (approximately 25 km west of the proposed development) show that harbour porpoise were sighted almost daily for much of this time, which is fairly typical of this species (noted to be 'abundant' in Skomer waters) (Büche and Stubbings, 2015). In coastal waters around Strumble Head, the Teifi Estuary and Cardigan Island and also off the series of headlands (Mwnt, Pen Peles, Aberporth, Yns Lochtyn) reaching up to New Quay, harbour porpoises are regularly seen throughout the year with increased sightings between July and September (Pierpoint, 2001; Heinänen and Skov, 2015). Whilst group sizes in these waters are typically less than 10, larger groups of several hundred have been recorded in late summer and autumn in Pembrokeshire (Carmarthenshire LBAP).

Marine Mammal Observers (MMO) during pile driving operations at the South Hook LNG jetty in 2005/2006 sighted two groups pf harbour porpoise over four days of observation. One of these groups (n = 3) remained at the site for approximately three hours (RPS, 2007). This data suggests that harbour porpoise occur regularly within MHW. A towed acoustic survey, employing an automated porpoise detection system, of harbour porpoise distribution showed clusters of harbour porpoise detections in close proximity to the mouth of MHW, namely south of Skokholm Island west of St. Annes Head and Skomer Island (Pierpoint, 2001).

Harbour porpoise in most of the eastern North Atlantic are generally considered to behave as a 'continuous' biological population that extends from the French coasts of the Bay of Biscay, northwards to the arctic waters of Norway and Iceland (IAMMWG, 2015). The IAMMWG, for practical management purposes however, has identified three Management Units (MU) as appropriate for harbour porpoise: North Sea (NS), West Scotland (WS) and Celtic and Irish Seas (CIS). The waters of MHW fall within the CIS MU which extends from the north west coast of France, to north west coast of the Republic of Ireland and east from South west coast of Scotland, including the entirety of Welsh waters. The total harbour porpoise abundance for the CIS MU was estimated as 104,695 animals (95% Confidence Interval (CI) 56,774 to 193,065) (IAMMWG, 2015). The waters of MHW coincide with the SCANS-III survey Block D; the estimated density of harbour porpoise in this block is 0.118 animals per km^2 (Hammond, 2017).

It is estimated (based on the SCANS-II survey which took place in July 2005) that the West Wales Marine SAC (designated for harbour porpoise) supports approximately 2506 individuals (95% CI: 1410 - 4455) for at least part of the year, as seasonal differences are likely to occur. This represents approximately 9% of the population within the UK part of the Celtic and Irish Sea MU (NRW & JNCC, 2015).

Bottlenose dolphin

The bottlenose dolphin has a worldwide distribution, occurring in tropical and temperate waters. The species occurs in a diverse range of habitats from shallow estuaries and bays, to the continental shelf and beyond into deeper waters. Bottlenose dolphins in the north east Atlantic have a predominantly coastal distribution (Baines and Evans, 2012).

Bottlenose dolphins, after harbour porpoise, are the next most frequently recorded cetacean species in Welsh waters. Identified hot spots are located in southern Cardigan Bay; Tremadog bay; and north and east of Anglesey (Baines and Evans, 2009).

The species is present throughout the year in Welsh waters, however animals are more likely to be found in small groups in coastal waters in summer (centred around Cardigan Bay), dispersing widely and generally north in winter, forming much larger groups (Baines and Evans, 2012). Bottlenose dolphin are the primary feature of Cardigan Bay SAC and a qualifying feature of Pen Llŷn a’r Sarnau SAC in northern Cardigan Bay. Any bottlenose dolphins sighted within the vicinity of the MHW are likely to have connectivity to one or both of these SACs.

Female bottlenose dolphins typically begin breeding at five to 13 years of age, with gestation lasting for 12 months. Bottlenose dolphins give birth to a single individual which will remain with its mother for several years. This species feeds on a wide variety of fish (including herring), cephalopods and occasionally shrimp and small rays and sharks. They pursue schooling prey and solitary prey throughout the water column as well as into the air above and into the sand below (Mann *et al.,* 2000). Bottlenose dolphin diet and hunting behaviour varies greatly as they adapt to the local prey availability and conditions and includes a variety of fish species, cephalopods (squid and octopus), krill and occasionally other crustaceans. Most fish prey species are bottom dwellers, but some surface dwellers or pelagic fish are also represented in the diet (Wells *et al*., 2002).

The MHW falls within the Offshore Channel, Celtic Sea and South West England (OCSW) MU, which occurs from the north coast of Pembrokeshire, to the east coast of the Republic of Ireland, and to the north coast of France. The total bottlenose dolphin abundance for the 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), which overlaps with the MHW), with an estimated density of 0.06 animals per km^2 (Hammond *et al*., 2017).

Pembroke Port

The NBN atlas showed that harbour porpoise and bottlenose dolphin have been sighted at the mouth the MHW, have been seen and recorded as far upriver as Llangwm though this was an exceptional occurrence (Pers comms Jonathan Monk, Environment Manager, MHPA). The probability of a cetacean venturing as far as Pembroke Port is therefore likely to be infrequent, however , a precautionary approach has been taken, with the assumption that individuals may occasionally be observed within the zone of influence of the Pembroke Dock Infrastructure project.

Pinnipeds

Milford Haven

Grey seal is the only pinniped species which breeds in Wales. Although there is some anecdotal data of individual animals that have remained around the Menai straits or on Ynys Enlli for some months at a time, there are no resident or breeding populations in Wales (IAMMWG, 2013). As such, harbour seal has not been considered for this assessment.

Grey seal

Grey seals are the larger of the two species of seal that occur in UK water, with males attaining up to 300 kg kilograms on maturity and females 150 to 200 kg kilograms (SCOS, 2017). Females can live for over 30 years and attain sexual maturity at approximately five years, with males living up to 20 years and attaining sexual maturity at approximately 10 years (SCOS, 2017).

Seals are highly mobile and feed mainly at the benthos in shelf seas (Thompson, 2012; Chen *et al.,* 2017). They forage widely and frequently travel up to 100 km between their haul-out sites and foraging areas, though they can travel further (SCOS, 2017). Telemetry studies of animals tagged on Welsh haul-out sites indicate that grey seals may make foraging trips to very localised areas, with animals from a particular locality tending to remain in that region (Strong *et al.,* 2006). Grey seals are generalist feeders, taking a wide range of prey items including whiting, cod, haddock, ling and various species of flatfish.

Based on the most recent pup production estimates, the Welsh ‘population’ forms around 2.6% of the UK population (SCOS, 2017). Grey seals are widely distributed in Welsh waters and moulting and resting haul-out sites are distributed throughout the Pembrokeshire Marine SAC, though only a small number of sites are regularly used as haul-outs by large numbers of seals (Baines *et al*., 1995). Breeding colonies in northwest Pembrokeshire, particularly on Ramsey Island, extend southwards to Skomer Island and northwards to southern Ceredigion (Baines and Evans, 2009).

Small concentrations occur around the Lleyn Peninsula and the coast of Anglesey. These breeding colonies act as haul-out sites in the non-breeding season. Approximately 5,000 grey seals use habitats on the Welsh coast, with colonies in north Pembrokeshire and Skomer Island being the most important breeding colony for grey seal in the south of the UK (SCOS, 2017). Approximately 5% of UK grey seal pups are born on the coasts of SW Wales and SW England each year (Duck, 1995; Baines *et al*., 1995; SCOS, 2017).

In 2015, 465 pups were born in North Pembrokeshire and 379 pups born on Skomer and adjacent mainland sites in 2015 (SCOS, 2017). In 2017, 383 pups were born within the Skomer Marine Conservation Zone (the highest number of seal births within the whole of the MCZ since records began) with 225 pups born on Skomer Island (the second highest total ever recorded) and 158 born on Marloes Peninsula (Büche and Stubbings, 2018). Pupping occurs between July and November, and in 2017 the highest number of pups were born in September (n = 146) and October (n = 57).

The Grey Seal Breeding Census Skomer Island 2017 (Büche and Stubbings, 2018) identified two seals hauled-out on North Haven beach, with tags which identified them as having originated at 105 km distance. Two seals which originated from the Skomer MCZ were identified in Cornwall, 147 km and 131 km away.

The development area falls within the Wales MU which extends from south of the Isle of Man, the length of the coast of Wales to the Severn Estuary. The total grey seal pup production estimate in 2014 for this MU was 1,650 (SCOS, 2017).

Pembroke Port

Four days of shore-based marine mammal observational surveys were conducted for the Pembroke Dock Power Station project in 2006. The surveys were undertaken from Pennar Cants, located to the west of Pembroke Port. A single grey seal was observed within the MHW on each of the four days of the survey. The seal was recorded close to shore between the entrance to Martins Haven and the Texaco jetty. During the survey, the shoreline in this area was also surveyed to identify potential haul-out areas. Whilst some small rocky outcrops were observed to occur at high tide, the intertidal area was generally mud and sand and therefore deemed unsuitable for hauling out (RPS, 2007). Two incidental sightings of grey seal were also recorded during pile driving operations at the South Hook LNG jetty in 2005/2006 (RPS, 2007).

A search on the NBN gateway, within 2 km of Pembroke Port, returned nine recorded events of grey seal. Sightings of grey seal have been predominantly to the north west of the Dock, near Llanstadwell with records dating from 1975 to 2017. The most recent records indicate grey seal usage during the summer months, which may coincide with opportunistic feeding behaviour on fish spawning to gain weight prior to breeding. The possibility of a winter haul out site being present near Pembroke Dock is highly unlikely.

European otter

Milford Haven

Otter are found across the UK and following a rapid decline in the 1950s (Mason and McDonald, 2004) has shown recovery in the last two decades across most of its western European distribution (Van Looy *et al.,* 2014). Populations can be found in Wales, southwest England and much of Scotland, where sea loch and coastal habitats now support one of the largest populations in Europe There is also a significant population of otter in Northern Ireland.

The otter is one of only a few European carnivores that has evolved the ability to actively forage both in water and on land (Oliveira *et al.,* 2008) and is highly capable of hunting in both freshwater (Carss *et al.,* 1990; Copp and Roche, 2003) and marine environments (Kruuk and Moorhouse, 1991; Heggberget, 1993; Parry *et al.,* 2010). The European otter is largely solitary and adult otters tend not to associate with other adults except for reproduction. Sexual maturity is attained at around 18 months in males and 24 months in females. They are non-seasonally polyoestrous, and gestation period is approximately 63-65 days, the litter size varies from one to five, and the life expectancy is around 17 years. Fish is the major prey of otters, sometimes exceeding more than 80% of their diet, which also consists of aquatic insects, reptiles, amphibians, birds, small mammals, and crustaceans (Roos *et al.,* 2015). Coastal otters will hunt as far as 100 m from shore in waters over 10 m deep, but most feeding occurs closer to shore in waters less than 3 m deep (Nolet *et al.,* 1994). The main hunting areas for otter on the coast are largely determined by the habitat preferences of prey species. Spraints collected from the open coast of Pembrokeshire and within the MHW were analysed and found to contain remains of the following species: blennies, bullhead, butterfish *Pholis gunnellus*, cod, crustaceans, dab, eel pout *Zoarces viviparus*, flatfish, gobies, lumpsucker *Cyclopterus lumpus*, minnow *Phoxinus phoxinus*, perch *Perca fluviatilis*, pike *Esox lucius*, pipefish, plaice, rockling, saithe *Pollachius virens*, sand eel, salmonids, sea stickleback (15-spined), stickleback (3-spined) *Gasterosteus aculeatus* and stone loach *Barbatula barbatula* (Liles, 2003a). In Britain, it is generally accepted that there is no birth peak, and that cub births are distributed evenly throughout the year. However, in Wales there may be a bias towards autumn and winter births (Liles, 2003a).

Coastal otter populations are not well defined in Wales and the prevalence of otter marine activity within this species' European range is currently also poorly defined. However, the coastline of South Wales provides a wealth of opportunities for otters, with large sections of remote or inaccessible coastline that provide potential foraging, resting and breeding sites (Parry *et al.,* 2010).

Otters are widely distributed in Pembrokeshire (Jones and Jones, 2004) and records indicate that otters utilise coastal areas for foraging and breeding at some locations (Liles, 2003a). Accordingly, Pembrokeshire may represent one of the most important areas for otters in Wales. The MHW SSSI supports nationally important numbers of otter (NRW – Marine character Areas MCA 21 Milford Haven). In 2004 the population estimate for otter in Wales was given as 762 (JNCC, 2007) and are considered to support a significant presence (JNCC, 2015).

Otter surveys were carried out within the Cleddau hydrometric area in 1977, 1984, 1991 and 2002. Distribution throughout this site and use of the site is known primarily through spraint records on foreshores, and foreshore access points from watercourses with suitable breeding and feeding habitat (CCW, 2005). A survey of otter activity and habitat availability on the Pembrokeshire Coast and MHW found signs of otters (spraints and tracks) at a number of survey sites (Liles, 2003a).

Effects of the Pembroke Dock Infrastructure Project on otters are assessed as part of Chapter 13 Biodiversity.

Pembroke Port

Otter sightings data within the MHW would suggest that use of Pembroke Dock and the adjacent area by otters is highly likely. However, due to high levels of anthropogenic activity surrounding the dock, otter behaviour is likely to be restricted to resting and territory marking, rather than feeding.

5 Conclusion

The waters bordering the proposed development are <50 m outside the boundary of the Pembrokeshire Marine SAC. The SAC includes the MHW Waterway SSSI which comprises eleven management sections. The River Cleddau SAC and West Wales Marine SAC have designated status but are not within the vicinity of the Pembroke Port.

The high tidal range in the MHW and in the vicinity of the site results in extensive water movements. The tidal excursion varies along the length of the estuary and is approximately twice as great for springs as for neaps. The mean tidal range for the MHW varies from 6.3 m at mean springs tide to 2.7 m at mean neap tide.

Water quality of MHW is typical of marine water given the low volumes of freshwater inputs. Salinity ranges from 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. dissolved oxygen is generally 100% saturation with variable nutrient and contaminant concentrations. Low concentrations of TSS have been recorded. Pembroke Port is situated within the lee of the Hobbs Point and Carrs Rock, both natural features that dissipate wave energy. As a result, suspended sediment particles at Pembroke Dock are low.

Coarse sediments are found within the main tidal flow areas of the MHW with fine sediments accumulating in low current and sheltered areas. Finer sediments are found within Pembroke Port as the area is sheltered, leading to energy abatement and settling of suspended sediments.

Sediment quality data suggests some low levels of contamination within proposed construction and dredge footprints. Sediment contaminant concentrations in the slipway footprint Graving Dock area were found above adopted guidelines for majority of metals and TBT. TPH and PCB concentrations were below adopted guideline levels.

Intertidal habitats found within Pembroke Port include polychaetes, bivalves and oligochaetes, associated with soft fine sediments. The intertidal dwarf seagrass *Z. noltei* has also been identified near Hobbs Point (~ 800 m west of the development footprint), covering a total area of 3.49 ha.

Subtidal benthic habitats near to Pembroke Port are mixed with varying proportions of silt/clay, fine sand, course sand and shells and cobble and rocky reef characterised by annelids, bivalves, and green and brown algae. Abundant subtidal benthic species within Pembroke Port include polychaetes *Melinna palmata* and *Chaetozone gibber*, seed shrimps O*stracoda* sp., and amphipods *Ampelisca diadema* and *Photis longicaudata*.

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. 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 were also regularly recorded within the MHW. Several species of diadromous fish migrate through the MHW between seawater and freshwater including sea lamprey *Petromyzon marinus*, river lamprey *Lampetra fluviatilis*, allis shad *Alosa alosa* and twaite shad *Alosa fallax*.

There are presently two areas within MHW that have been designated as shellfish waters under the EC Shellfish Waters Directive. There are a number of species collected on a non-commercial basis from the MHW and shellfish represent an important local resource for *ad hoc* harvesting and as food for other organisms, particularly birds. The area in the vicinity of Pembroke Port has been classified as prohibited (unfit for consumption) and therefore must not be harvested.

Several species of cetaceans have been recorded in the region, in particular the harbour porpoise and bottlenose dolphin, which has been sighted occasionally within the MHW although most records are along the coast, outside of the MHW. Grey seal is the only species of pinniped recorded in the MHW and individuals haul out in suitable locations throughout the Pembrokeshire marine SAC.

Otters have been found in high abundance with the MHW, suggesting regular use and possible despotic behaviour increasing their ecological range into the marine environment. It is assumed that otters may occur in the vicinity of Pembroke Dock, mainly using the riparian habitat for resting as there are no dens reported in this area.

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Appendices

Annex A – Sediment Quality Results

Table A1: Grab and core sample chemical parameters.

Description (DW,DBT, TBT)		dry solids (at 105°C)	total organic carbon	total hydrocarbon content by fluorescence	dibutyltin (DBT)	tributyltin (TBT)
Units		%	%	mg/kg	mg/kg DW	mg/kg DW
Cefas AL1 (mg/kg)					0.1	0.1
Cefas AL2(mg/kg)					1	1
Sample No.	Sample Type					
Site 1	**Grab Sample**	67.3	2.1	34.4	0.249	2.56
Site 2	**Grab Sample**	47.8	1.8	42.3	0.01045	0.013
Site 3	**Grab Sample**	47.1	2.1	12.1	0.01061	0.00895
Site 4	**Grab Sample**	48.1	2.2	4.97	0.0104	0.00996
Site 3	**Core Sample**	49.1			0.01018	0.00953
Site 4	**Core Sample**	50	2.5		0.005	0.0132

Description (Metals)		Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc
Units		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Detection Limit		0.5	0.1	0.5	0.5	0.5	0.01	0.5	3
Cefas AL1 (mg/kg)		20	0.4	40	40	50	0.3	20	130
Cefas AL2(mg/kg)		100	5	400	400	500	3	200	800
Canadian TEL(mg/kg)		7.2	0.7	52.3	18.7	30.2	0.13	15.9	124
Canadian PEL(mg/kg)		41.6	4.2	160	108	112	0.7		271
Sample No.	Sample Type								
Sample 1	**Grab Sample**	24.1	0.4	51.1	227	233	0.42	33.6	1170
Sample 2	**Grab Sample**	12.2	0.15	42.4	34.5	50	0.31	26.6	143
Sample 3	**Grab Sample**	13	0.13	40.4	23.6	41.8	0.13	29.6	142
Sample 4	**Grab Sample**	14.4	0.15	47.8	26.5	46.2	0.14	30.6	146
Core 3	**Core Sample**	13.1	0.16	35.4	25.2	45.7	0.17	27.4	138
Core 4	**Core Sample**	17.6	0.21	44.1	28.5	60.6	0.2	29.6	152

Description (PAH)	Units	Station:	Cefas AL1 (µg/kg)	Canadian TEL (µg/kg)	Sample No.	Sample 1	Sample 2	Sample 3	Sample 4
		Mass			Depth (m)	Grab Sample	Grab Sample	Grab Sample	Grab Sample
naphthalene	ug/kg	128	100	20.2		4.97	53.1	8.21	49.3
acenaphthylene	ug/kg	152	100	5.87		<2.0	4.54	<2.0	<2.0
acenaphthene	ug/kg	154	100	6.71		15.1	11.5	<1.7	8.07
fluorene	ug/kg	166	100	21.2		11.2	24.9	<1.7	20.1
phenanthrene	ug/kg	178	100	86.7		28.4	79.4	16.7	64.6
anthracene	ug/kg	184	100	46.9		9.74	15.1	3.93	13
fluoranthene	ug/kg	178	100	113		58.7	83.2	25.1	70.6
pyrene	ug/kg	202	100	153		47.9	70.2	19.9	55.2
benzo(a)anthracene	ug/kg	202	100	74		26.4	35.9	11.1	32.8
chrysene	ug/kg	228	100	108		23.7	40.8	11.7	36.6
benzo(b+j)fluoranthene	ug/kg	228	100	n/a		34.7	71.9	18.2	63

benzo(k)fluoranthene	ug/kg	252	100	n/a		13.5	22	7.34	20.3
benzo(a)pyrene	ug/kg	252	100	88.8		26.4	36.2	11.9	32.9
indeno(1,2,3-c,d)pyrene	ug/kg	252	100	n/a		14.8	29.5	9.04	27.6
dibenzo(a,h)anthracene	ug/kg	276	100	6.22		6.42	11.7	<1.6	12.5
benzo(g,h,i)perylene	ug/kg	278	100	n/a		15.9	33.2	9.48	30.4
Perylene	ug/kg	276	100	n/a		7.62	14.2	4.65	13.6

description (PCB congener)	Units	Cefas AL1 (mg/kg)	Cefas AL2(mg/kg)	Canadian TEL(mg/kg)	Canadian PEL(mg/kg)	Sample 1 Grab Sample	Sample 2 Grab Sample	Sample 3 Grab Sample	Sample 4 Grab Sample
18	mg/kg					0.000238	0.00155	0.00183	0
28	mg/kg					0	0	0	0
31	mg/kg					0	0	0	0
44	mg/kg					0	0	0	0
47	mg/kg					0	0	0	0
49	mg/kg					0	0	0	0
52	mg/kg					0.00206	0	0	0
66	mg/kg					0.000549	0	0	0
101	mg/kg					0	0	0	0
105	mg/kg					0	0	0	0
110	mg/kg					0	0	0	0
118	mg/kg					0	0	0	0
128	mg/kg					0.000995	0.000753	0	0
138	mg/kg					0.00512	0.00372	0.0032	0.00295
141	mg/kg					0.000579	0.00046	0	0
149	mg/kg					0.00181	0.00144	0.00151	0.000811

151	mg/kg					0.000386	0.000355	0	0
153	mg/kg					0.00347	0.00299	0.00278	0.00266
156	mg/kg					0	0	0	0
158	mg/kg					0.000505	0	0	0
170	mg/kg					0	0.000732	0	0
180	mg/kg					0.0019	0	0	0.00156
183	mg/kg					0.000297	0.000564	0.00053	0
187	mg/kg					0	0	0	0
194	mg/kg					0	0	0	0
Sum of 25 PCBs	mg/kg	0.02	0.2	21.5	189	0.017909	0.012564	0.00985	0.007981

			Sample No.	Site 1	Site 2	Site 3	Site 4	Site 3	Site 4
			Sample Type	Grab Sample	Grab Sample	Grab Sample	Grab Sample	Core Sample	Core Sample
Sediment	**mm**	**phi**	**Units**						
Very coarse gravel	>32<64	<-5>-6	%	0.00	0.00	0.00	0.00	0.00	0.00
Coarse gravel	>16<32	<-4>-5	%	0.00	0.00	0.00	0.00	0.00	0.00
Medium gravel	>8<16	<-3>-4	%	0.00	0.00	0.00	0.00	0.00	0.00
Fine gravel	>4<8	<-2>-3	%	0.00	0.00	0.00	0.00	0.00	0.00
Very fine gravel	>2<4	<-1>-2	%	0.00	0.00	0.00	0.00	0.00	0.00
Very coarse sand	>1<2	<0>-1	%	23.00	0.00	0.00	0.00	0.00	0.00
Coarse sand	>0.5<1	<1>0	%	19.40	0.00	0.00	0.00	0.00	0.00
Medium sand	>0.25<0.5	<2>1	%	18.80	0.15	0.33	0.52	0.00	2.44
Fine sand	>0.125<0.25	<3>2	%	8.61	5.01	4.17	5.50	1.36	4.37
Very fine sand	>0.0625<0.125	<4>3	%	4.18	6.62	4.61	3.45	6.13	4.98
Very coarse silt	>0.03125<0.0625	<5>4	%	5.57	15.80	12.10	14.90	10.10	11.00
Coarse silt	>0.015625<0.03125	<6>5	%	4.72	16.80	16.30	17.80	16.40	16.70
Medium silt	>0.007813<0.015625	<7>6	%	5.14	20.50	20.90	21.80	22.80	21.90
Fine silt	>0.003906<0.007813	<8>7	%	5.01	17.40	20.30	18.70	20.60	19.30
Very fine silt	>0.001953<0.003906	<9>8	%	2.65	8.81	10.70	8.98	11.50	10.10
Clay	<0.001953	>9	%	2.94	9.01	10.50	8.41	11.10	9.22

Annex B Intertidal Biotopes

Table B1: Intertidal species within the Pembroke Dock area

LR.LLR.F.Asc.X	LS.LMx.Mx.CirCer	LR.HLR.FT.FserTX	LS.LMu.MEst.HedMac
Spirorbidae	*Exogone naidina*	*Halichondria panicea*	*Eteone longa*
Semibalanus balanoides	*Sphaerosyllis taylori*	*Hymeniacidon perleve*	*Hediste diversicolor*
Gammaridae	*Pygospio elegans*	*Lanice conchilega*	*Nephtys hombergii*
Carcinus maenas	*Aphelochaeta marioni*	*Sabella pavonina*	*Pygospio elegans*
Littorina obtusata/mariae	*Chaetozone gibber*	*Pomatoceros triqueter*	*Streblospio shrubsolii*
Patella vulgata	*Cirriformia tentaculata*	*Elminius modestus*	*Aphelochaeta marioni*
Littorina littorea	*Capitella capitata*	*Semibalanus balanoides*	*Tharyx killariensis*
Nucella lapillus	*Mediomastus fragilis*	*Balanus crenatus*	*Capitella capitata*
Mytilus edulis	*Melinna palmata*	*Carcinus maenas*	*Manayunkia aestuarina*
Polysiphonia	*Tubificoides benedii*	*Gibbula cineraria*	*Heterochaeta costata*
Polysiphonia lanosa	*Tubificoides pseudogaster*	*Littorina littorea*	*Tubificoides benedii*
Ascophyllum nodosum	*Elminius modestus*	*Crepidula fornicata*	*Tubificoides pseudogaster*
Fucus vesiculosus	*Cerastoderma edule*	*Nucella lapillus*	*Corophium volutator*
Fucus vesiculosus		*Mytilus edulis*	*Hydrobia ulvae*
Enteromorpha intestinalis		*Ascidiella scabra*	*Cerastoderma edule*
		Styela clava	*Macoma balthica*
		Botryllus schlosseri	*Abra tenuis*
		Corallinaceae	*Mya arenaria*
		Lithothamnion	
		Chondrus crispus	
		Mastocarpus stellatus	
		Gracilaria gracilis	
		Ceramium	
		Polysiphonia fucoides	
		Fucus serratus	
		Enteromorpha intestinalis	
		Ulva lactuca	