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WYLFA NEWYDD

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Wylfa Newydd Project

Horizon Nuclear Power Wylfa Limited

Benthic Surveys Report

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Contents

Executive Summary

Jacobs UK Ltd (Jacobs) was commissioned by Horizon Nuclear Power Wylfa Ltd (Horizon) to undertake a full marine ecological survey programme within the vicinity of the proposed new Nuclear Power Station on Anglesey (the Wylfa Newydd Power Station).

This report details the findings of the intertidal ecological surveys (2010- 2014); the subtidal drop-down camera (DDC) surveys (2010 and 2011); and, subtidal grab surveys (2010, 2011 and 2015) carried out in the marine environment adjacent to the Wylfa Newydd Development Area and the surrounding Anglesey coastline. Results are also provided on the subtidal benthic survey work carried out within, and adjacent to, the Holyhead North licensed disposal site (the 'Disposal Site') during 2016. These studies represent two geographically distinct areas and are therefore discussed separately.

The benthic ecology results are supported by the physico-chemical data of sediments collected during these surveys and supplemented with a full literature review of the benthic environments of these regions including Cemlyn Lagoon; they are further discussed with reference to associated baseline survey programmes.

In 2010, the intertidal environment across the north Anglesey coastline was assessed and broad biotopes assigned. In subsequent years, biotopes were assigned to each site based on community quadrat data collected at each shore height (low, mid and upper). The intertidal habitats were characterised by exposed rocky substrata; these habitats supported a complex array of communities typical of their geographic location, which are clearly influenced by natural factors such as substratum, exposure and tidal height.

Across the north Anglesey coastline, high-resolution seabed images, using a remote DDC, were obtained at 68 and 54 subtidal sites, in 2010 and 2011, respectively. In 2010, 22 subtidal sites were sampled by Hamon grab, with material collected for biological and sediment physicochemical analyses; in May 2011, 26 subtidal sites were sampled. In 2015, 11 subtidal sites were re-sampled to provide further validation of the communities described in 2010 and 2011.

Subtidal sediment granulometry results from the north Anglesey coastline showed considerable variability, with muds and sands evident at most inshore sites, sheltered from strong tidal currents and associated scouring effects. At all offshore sites, and at some inshore sites subject to the scouring effects of strong tidal currents, sediments were characterised by coarser material, such as coarse sands and gravel. The subtidal sediment-bound concentrations of zinc and lead were elevated above empirically derived background levels, although levels of these and other metals were similar to data reported from other UK coastal sites. Concentrations of determinands were generally lower than the Cefas Action Level 1 (AL1); however, the notable exceptions were the exceedances of naphthalene concentrations at a number of subtidal sites in 2010. Yet the following year, at all the same sites the concentration of naphthalene was less than the minimum recording value (MRV).

Although metal levels were elevated at the subtidal sites, no concentrations exceeded the relevant Probable Effect Level (PEL) and most concentrations were below the Interim Sediment Quality Guidelines (ISQG) for the north Anglesey subtidal sites. Where ISQG were exceeded, concentrations were only slightly above the lower limits.

Two main community types were recorded from the Wylfa Newydd Development Area faunal grab survey: a bivalve mollusc-dominated community was generally recorded at inshore sites, while a more diverse, polychaete-dominated community was reported at offshore sites. Both the number of taxa and community abundances were appreciably higher at offshore sites compared to inshore sites.

On the rocky seabed along the north Anglesey coast, large colonial organisms such as the bryozoans *Alcyonidium diaphanum* and *Flustra foliacea*, as well as the cnidarian *Alcyonium digitatum*, were common at many of the subtidal sites. The DDC surveys in 2010 and 2011 recorded a total of 28 biotopes, these largely comprising of circalittoral faunal communities on rock, with a faunal composition characteristic of tide-swept environments.

Subtidal benthic surveys from within and adjacent to the Disposal Site recorded benthic communities representative of their dynamic environment, with tide-swept and scour-tolerant taxa commonly recorded.

Granulometric data indicated that the sedimentary substrata of the sites are dominated by gravels with a high proportion comprised of particles bigger than 2 mm. None of the chemical determinands analysed exceeded AL1, nor did any exceed ISQG and therefore PEL. The exception was arsenic, which marginally exceeded the ISQG at all sites sampled; however, concentrations were considerably lower than AL1.

Although none of the species recorded during the remote sampling of the benthos at the study areas have conservation designations, several features are on the Section 7 list of the *Environment (Wales) Act 2016* of priority habitats. These included mussel beds, fragile sponge and anthozoan communities, and subtidal sands and gravels.

Annex I habitats (rocky and biogenic reefs) were also recorded within both study areas, that of the Wylfa Newydd Development Area and the Disposal Site. Biogenic Sabellariidae reefs of 'low reefiness' were recorded in the vicinity of Church Bay, off the north-west coast of Anglesey, and two reef sites were recorded in the Disposal Site (one of 'low' and one of 'medium reefiness'). Elsewhere, distinct aggregations of Sabellariidae were commonly observed offshore, where they formed crusts and veneers on the seabed.

The findings detailed in this report describe the sediment and biological status of the intertidal and subtidal benthic environments in the vicinity of the Wylfa Newydd Development Area and the Disposal Site. Sediment chemistry indicated that contaminant levels are not of particular concern and are unlikely to be significantly influencing the faunal patterns observed. The subtidal and intertidal biological patterns appear typical of their location and are analogous with natural environmental factors. The results indicate that natural environmental influences are driving the community structure observed at these sites with sediment characteristics, tidal strength and habitat complexity the most important factors.

Historic survey work at Cemlyn Lagoon have recorded the presence of comparatively diverse lagoonal community including relatively uncommon plant species such as the brackish water-crowfoot *Ranunculus baudotii* and beaked tasselweed *Ruppia maritima*. The lagoonal benthic community of the lagoon has shown significant seasonal changes with faunadominated by the mud snail *Ecrobia ventrosa.* Lagoonal specialists such as the isopod *Idotea chelipes* and the cockle *Cerastoderma glaucum* have also been recorded in historical suveys at the lagoon.

1. Introduction

1.1 Overview

Horizon Nuclear Power Wylfa Limited (hereafter referred to as Horizon) is currently planning to develop a new Nuclear Power Station on Anglesey as identified in the *National Policy Statement for Nuclear Power Generation (EN-6)* (Department of Energy and Climate Change, 2011). The Wylfa Newydd Project (the Project) comprises the proposed new Nuclear Power Station, including the reactors, associated plant and Ancillary Structures and features, together with all of the development needed to support its delivery, such as highway improvements, worker accommodation and specialist training facilities. The Project will require a number of applications to be made under different legislation to different regulators; it will be consented under a Marine Licence from National Resources Wales (NRW) andas a Nationally Significant Infrastructure Project under the *Planning Act 2008*, the construction and operation must be authorised by a Development Consent Order.

Jacobs UK Limited (Jacobs) was commissioned by Horizon to undertake a full ecological survey programme within the vicinity of the proposed new Nuclear Power Station on Anglesey (the Wylfa Newydd Power Station). This work has included the gathering of baseline data to inform the various applications, assessments and permits that will be submitted for approval to construct and operate the Power Station and Associated Development[1].

This report details the findings of intertidal and subtidal benthic surveys carried out between 2010 and 2015 around the north Anglesey coast, within the vicinity of the Power Station Site (the indicative area of land and sea within which the majority of the permanent Power Station buildings, plant and structures would be situated). Detail is also provided on subtidal benthic survey work carried out within, and adjacent to, the newly licensed Holyhead North (IS043) disposal site during 2016.

A literature review covering previous work undertaken in Cemlyn Lagoon is provided. This details the findings of historic ecological studies of flora and fauna within the lagoon.

This report uses a number of technical terms and abbreviations. Key terms are capitalised and explained with their acronyms within the text. References to legislation are to the particular legislation in force at the time of writing this report.

1.2 The Wylfa Newydd Project

The Project includes the Wylfa Newydd Power Station and Associated Development. The Wylfa Newydd Power Station includes two UK Advanced Boiling Water Reactors to be supplied by Hitachi-GE Nuclear Energy Limited, associated plant and Ancillary Structures and features. In addition to the reactors, development on the Power Station Site would include steam turbines; control and service buildings; operational plant; radioactive waste storage buildings; Ancillary Structures; offices; and coastal developments. The coastal developments would include a Cooling Water System, a breakwater and a Marine Off-Loading Facility (MOLF).

1.3 Site Description

1.3.1 Wylfa Newydd Development Area

The Wylfa Newydd Development Area (the indicative areas of land and sea, including the Power Station Site, the Wylfa National Policy Statement Site[2] and the surrounding areas that would be used for the construction and operation of the Power Station) covers an area of approximately 409 ha (Figure 1-1). It is bounded to the north by the coast and the existing Magnox power station (the Existing Power Station). To the east, it is separated from Cemaes by a narrow corridor of agricultural land. The A5025 and residential properties define

[1] Development needed to support delivery of the Power Station is referred to as 'Associated Development'. This includes highway improvements along the A5025, Park and Ride Facilities for construction workers, Logistics Centre, Temporary Workers' Accommodation, specialist training facilities, Horizon's Visitor Centre and media briefing facilities.

[2] The site identified on Anglesey by the *National Policy Statement for Nuclear Power Generation (EN-6)* (Department of Energy and Climate Change, 2011) as potentially suitable for the deployment of a new Nuclear Power Station.

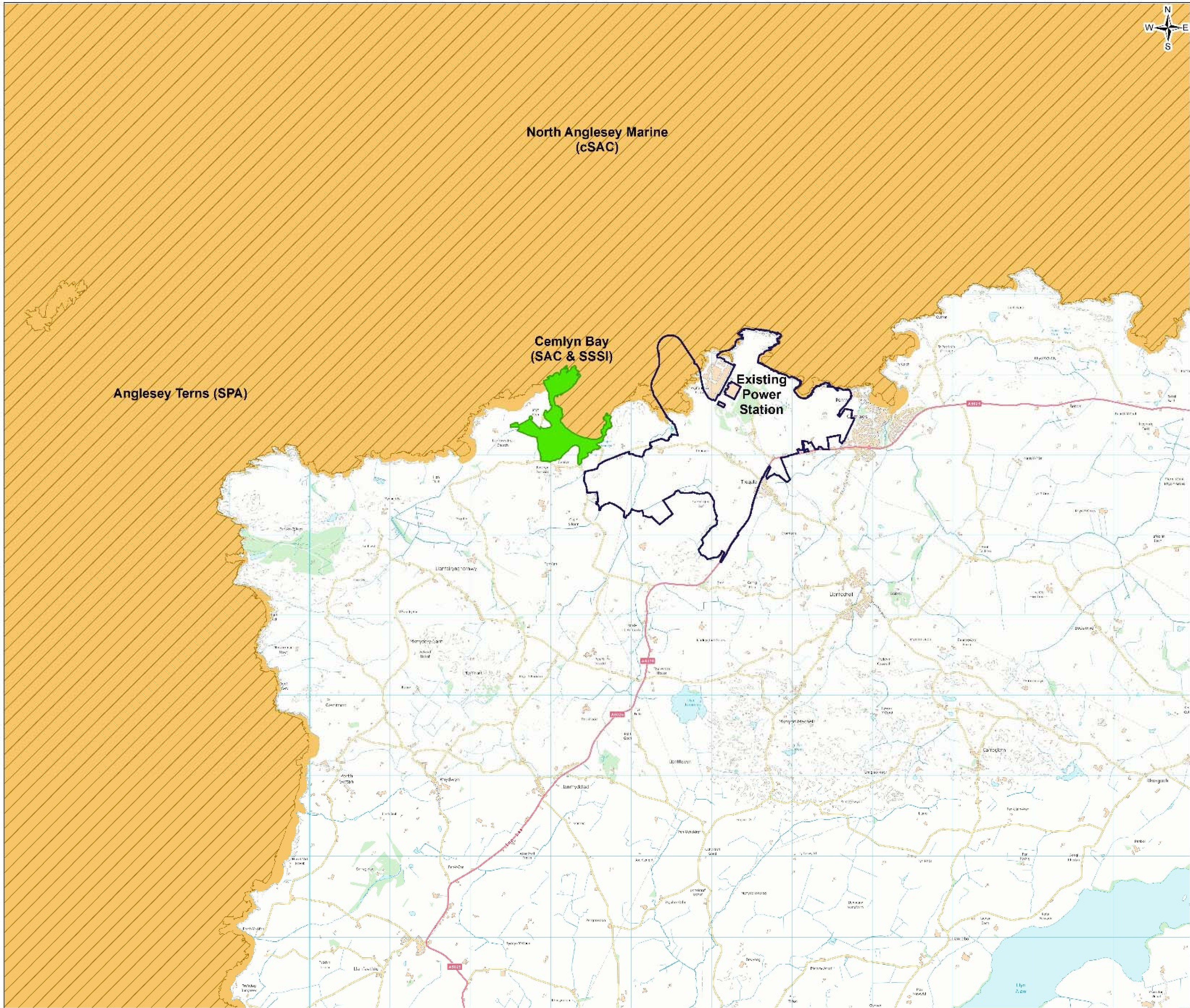
part of the south-east boundary, with a small parcel of land spanning the road to the north-east of Tregele. To the south and west, the Wylfa Newydd Development Area abuts agricultural land, and to the west it adjoins the coastal hinterland.

The Wylfa Newydd Development Area includes the headland south of Mynydd-y-Wylfa candidate local wildlife site. There are two designated sites for nature conservation within the Wylfa Newydd Development Area: the Tre’r Gof Site of Special Scientific Interest (SSSI) and the Anglesey Terns/Morwenoliaid Ynys Môn Special Protection Area. There is also a candidate Special Area of Conservation (cSAC) that has been submitted to the European Commission, but not formally adopted (North Anglesey Marine/Gogledd Môn Forol cSAC). The Wylfa Newydd Development Area is within 1 km of the Cae Gwyn SSSI, Cemlyn Bay Special Area of Conservation (SAC) and SSSI[3]. The Cemlyn Bay SAC and Anglesey Terns SPA both encompass the nearby Cemlyn lagoon.

The open-coast location of north Anglesey is characterised by strong tidal flows (>1.5 m s^{-1}) and a seabed that slopes steeply to a depth of approximately 25 m–30 m. The substrata comprise a mix of bedrock, boulders, cobbles and sediments, including gravel and sands in variable proportions. The infralittoral coastline around north Anglesey comprises a diverse habitat assemblage characteristic of a moderately exposed, western UK rocky coastline and is dominated by macrophytic algae.

[3] Note that the names of designated and conservation sites used throughout the report are consistent with JNCC guidance.

FIGURE 1-1



Legend
- Wylfa Newydd Development Area
- The North Anglesey Marine/Gogledd Môn Forol cSAC
- Bae Cemlyn/Cemlyn Bay SAC and SSSI
- Anglesey Terns/Morwenoliaid Ynys Môn SPA

Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	AUG 17	Initial Issue	HT	CT	EC	RB

Client
HORIZON NUCLEAR POWER

Project
WYLFA NEWYDD PROJECT
ENVIRONMENTAL STATEMENT

Drawing Title
WYLFA NEWYDD DEVELOPMENT AREA AND DESIGNATED MARINE AND COASTAL CONSERVATION SITES

Scale @ A3	1:46,000	DO NOT SCALE
Jacobs No.	60PO8077	
Client No.		

Drawing No.
60PO8077_DCO_D_13_01_01

This drawing is not to be used in whole or in part other than for the intended purpose and project as defined on this drawing. Refer to the contract for full terms and conditions.

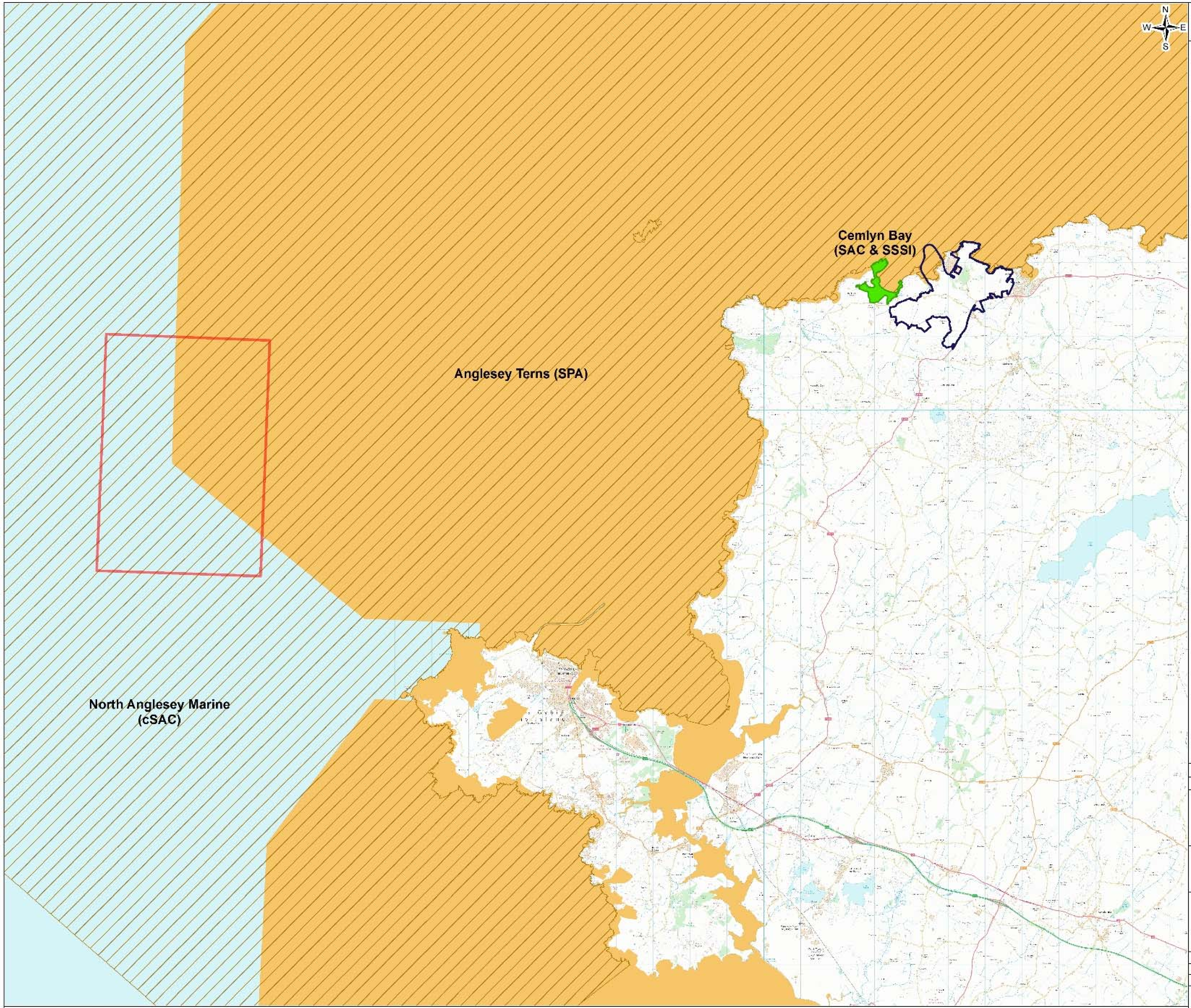
0 0.5 1 2 3 4 Kilometers

1.3.2 The Disposal Site

The newly licensed disposal site at Holyhead North (IS043) is situated approximately 4 km off the west coast of South Stack, Anglesey, at its closest point, within the Irish Sea. The Holyhead North disposal site (herein referred to as the 'Disposal Site') is rectangular in shape, measuring around 6.5 km in length and 4.45 km in width, oriented along a roughly north-south axis (Figure 1-2). The area of the site is approximately 28.8 km^2. The southern and northern sections of the Disposal Site's eastern boundary are approximately 9 km and 10 km, respectively, from the exit of Holyhead Harbour, whilst the north-west corner is approximately 15 km distant. At its nearest point, the Disposal Site is approximately 18 km from Porth-y-pistyll, on the north coast of Anglesey.

Before 2017, the Disposal Site represented the northern half of the Holyhead Deep (IS040) disposal site; however, in spring 2017 it was designated a disposal site in its own right. The site IS040 was heavily active for several decades, since 1983, receiving regular disposal events which in recent years have largely comprised maintenance dredgings from activity by Stena Line Ports.

FIGURE 1-2



0 1 2 4 6 8 Kilometers

Legend

- Wylfa Newydd Development Area
- Disposal Site
- The North Anglesey Marine/Gogledd Môn Forol cSAC
- Bae Cemlyn/Cemlyn Bay SAC and SSSI
- Anglesey Terns/Morwenoliaid Ynys Môn SPA

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Client

HORIZON NUCLEAR POWER

Project

WYLFA NEWYDD PROJECT
ENVIRONMENTAL STATEMENT

Drawing Title

DISPOSAL SITE

Scale @ A3	1:100,000	DO NOT SCALE
Jacobs No	60PO8077	
Client No.		

Drawing No.

60PO8077_DCO_D_13_01_02

1.4 Study Aims and Objectives

This study provides a detailed baseline description of the benthic environment along the north Anglesey coast and broadly characterises the benthic communities within and adjacent to the Disposal Site. The aim of the study is to inform the various applications, assessments and permits required to construct and operate the Wylfa Newydd Power Station and Associated Development.

The key objectives are:

- to provide a baseline description of the sedimentary environment in the vicinity of the Wylfa Newydd Development Area;
- to provide a baseline description of the intertidal and subtidal benthic marine communities in the vicinity of the Wylfa Newydd Development Area;
- to broadly characterise the sediment (physico-chemical) and subtidal benthic communities within the Disposal Site; and
- to detail the presence of any benthic features (habitats and species) of conservation interest.

Further to the key objectives stated above, additional 'rapid assessment' diver surveys were carried out in the vicinity of the Wylfa Newydd Development Area. The aim of these rapid assessment surveys was to determine the presence of any biogenic reef structures, specifically of the Ross worm (*Sabellaria spinulosa*)[4].

These objectives have been achieved through a combination of initial literature review followed by focused survey work, the results of which are presented in the following order within this report:

- Literature review (Chapter 2).
- Marine sediment – covering study areas in the vicinity of the Wylfa Newydd Development Area and Disposal Site (Chapter 3).
- Intertidal communities (Chapter 4).
- Subtidal communities – Wylfa Newydd Development Area (Chapter 5).
- Subtidal communities – Disposal Site (Chapter 6).

The report outlines the results of all the benthic survey work undertaken to date as well as relevant data from literature.

To inform the baseline description of Cemlyn Lagoon a detailed account of the community is provided within Chapter 2. The data presented is based on historic survey work, particularly work carried out by NRW.

A final overall discussion of baseline benthic environmental conditions is provided in Chapter 7, which includes consideration of any marine features of conservation importance located within the study areas. Where appropriate, reference is provided to corresponding technical appendices throughout this document.

1.5 Study Areas

The study areas for the benthic programme are geographically distinct, being broadly divided between that encompassing the marine environment adjacent to the Wylfa Newydd Development Area and an area encompassing the Disposal Site.

1.5.1 Wylfa Newydd Development Area

Data on all receptors have been collected in the marine environment out to 5 km from the Wylfa Newydd Development Area. Acknowledging connectivity between marine receptors, additional data were collected from beyond 5 km. This included collecting data on mobile receptors (marine mammals, seabirds and fish) and their

[4] *S. spinulosa* reef structures are listed as UK BAP habitats and under the Annex I feature 'reef'. *Sabellaria spinulosa* reef is also an OSPAR threatened and declining habitat. Although they are not specifically listed under the Section 7 list of the *Environment (Wales) Act 2016*, where the reefs are well developed, they are considered important marine features that contribute significantly to local biodiversity.

potential prey species and habitats, therefore allowing the wider effects on populations to be effectively assessed.

Hence, sampling for the benthic programme focused on the marine area extending 5 km from the Wylfa Newydd Development Area, although sites further afield (i.e. 12 km to the west and 15 km to the east) were also sampled to assess any potential effects on communities further afield. The benthic surveys that relate to this study area are referred to as the Wylfa Newydd Development Area within this report.

1.5.2 Disposal Site

The benthic sampling sites for the Disposal Site were situated within offshore waters within the immediate Disposal Site area and extend approximately 1.6 km from its boundary.

1.6 Surveys

The benthic survey programme used a multi-method approach to provide an accurate characterisation of the benthic environment. The programme design was agreed with Cefas and Countryside Council for Wales (CCW) in addition to consultation with Environment Agency Wales; the latter two organisations are now collectively known as Natural Resources Wales (NRW). A summary of the surveys is provided below; however, further detail is provided in each of the relevant chapters.

1.6.1 Intertidal Benthic Surveys

In 2010, species assemblage surveys were carried out at 10 sites along the north Anglesey coast allowing assignation of biotopes in the surrounding intertidal area. Trochid gastropod surveys following MarClim (2006) protocols were also carried out at five sites to record population abundance and structure of typical, southern, warm-water species and to identify temporal changes in populations. A number of species living on the coastline of the United Kingdom are either warm-water species with their northern limits in the UK or cold-water species with their southern limit in the UK and Northern Europe. Therefore, these species can be used as indicators of climate change by studying their distribution and abundance in response to changes in temperature (Mieszkowska *et al*., 2005).

In 2011, the species assemblage survey was expanded to include 12 sites, while trochid gastropods were studied at all sites in which they were present. This expanded programme was continued in 2012, 2013 and 2014, hence providing a robust understanding of the baseline intertidal environment.

1.6.2 Subtidal Drop-Down Camera Surveys

In June 2010 and 2011, drop-down camera (DDC) images were taken from a number of benthic sampling sites along the north Anglesey coast. Similarly, in late 2016, DDC images were taken from a number of benthic sampling sites within and adjacent to the Disposal Site.

High-resolution images were taken to provide information on substrata and the benthic communities. The data from these surveys also informed the selection of sampling sites for subsequent grab survey within both of the study areas.

1.6.3 Subtidal Grab Surveys

In 2010, quantitative benthic invertebrate sampling was carried out at 25 sites along the north Anglesey coast. Three replicate invertebrate samples were collected using a Hamon grab ($0.25m^2$) at each site. In 2011, the survey was repeated, using a mini-Hamon grab ($0.1m^2$), and three sampling sites added to the programme. Faunal data provided information on community patterns, biodiversity and ecological quality. Similarly, in late 2016, grab samples were collected from sampling sites within and adjacent to the Disposal Site using a mini-Hamon grab ($0.1m^2$).

At each grab site, sediment was collected for granulometric and chemical analyses. Sediments were analysed for a range of determinands including metals and organic compounds.

1.6.4 Rapid Assessment Surveys

In June 2016, Marine Ecological Solutions Limited was commissioned to carry out ‘rapid assessment’ diver surveys to search for the presence of Sabellariidae aggregations in the area around the cooling water outfall of the Existing Power Station, and the proposed breakwaters to the north of Porth-y-pistyll. Data obtained from these surveys have been considered in combination with data collected during grabbing and DDC surveys, and is discussed in Section 5.4.

2. Literature Review

A number of benthic studies have been carried out around the north Anglesey coast, including those by regulatory and conservation agencies, universities and local industries, and studies related to the Existing Power Station. The following sections summarise the key findings of studies pertinent to the subtidal and intertidal benthic components of this report, with particular recognition given to several recent subtidal studies.

For clarity, baseline information relating to Cemlyn Lagoon is provided in a separate section below, summarising previous ecological studies covering the lagoon's flora and fauna.

Reference is also provided to recent studies carried out as part of the baseline survey programme for the Wylfa Newydd Project.

2.1 Intertidal Environment

2.1.1 Intertidal Invertebrates

The hydrographic pattern caused by the meeting of the currents from Liverpool Bay with those of the Irish Sea has resulted in a biogeographical boundary whereby marine invertebrates with a southern distribution approaching their northern limits are found on the west coast of Anglesey (e.g. the gastropod *Phorcus lineatus* (syn. *Osilinus lineatus*) (Crisp and Knight-Jones, 1954; Lewis, 1964; Mieszkowska *et al.,* 2007)).

The intertidal habitats in the vicinity of Wylfa Head were described by Bamber (1989) as being predominantly rocky in nature, although Cemlyn Bay is characterised by a shingle beach, and a number of small sandy beaches are also situated within coves and inlets.

The shingle beaches, particularly at Cemlyn, were characterised by highly impoverished fauna while the sandy beaches supported more diverse and abundant communities. Where muddy sediments were present, the communities were dominated by taxa typical of organically enriched sediments, this being considered a result of organic debris in the sediments accumulating from adjacent algal beds (Bamber, 1989).

The rocky shore communities are dominated by the barnacle *Semibalanus balanoides*, while in less exposed areas the fauna is characterised by the macroalgal species *Fucus vesiculosus* and *Ascophyllum nodosum* with associated fauna such as limpets (*Patella vulgata*) and littorinid gastropods common. Similar habitats and communities have been recorded to the west of Wylfa Head, between Hen Borth and Carmel Head (Project Management Support Services (PMSS), 2011).

A study undertaken by Bamber (1989) in the vicinity of the cooling water discharge from the Existing Power Station found that the abundance of the dog whelk (*Nucella lapillus*) and barnacles were reduced in the immediate vicinity of the discharge but increased with distance from the cooling water outfall. However, no significant spatial pattern was evident in the distribution of limpets. In 2015 and 2016, this survey was repeated and similar patterns recorded in Appendix D13.05 Marine ecological baseline at the Cooling Water outfall of the Existing Power Station (Application Reference Number: 6.4.87).

2.1.2 Intertidal Communities

Approximately 40 biotopes were recorded from the area between Wylfa Head and Cerrig Brith by CCW during July and August 2003, of which five were considered specialist biotopes (NRW, unpublished data). The most common substratum recorded throughout the area was bedrock, with cobbles also common. The general area was described as cliff habitat supporting lichens and fucoids. To the east of the Existing Power Station, the rocks were barren below the lichen zone; whereas to the west, typical rocky shore communities were present, exhibiting the normal patterns of vertical-zonation characteristics of relatively exposed rocky shores. The area around Porth-y-pistyll was noted for its rich fucoid communities.

Moving westwards, the shoreline is more sheltered with the substrate characterised by rocky platforms interspersed with areas of mixed substrata. Rock pools, overhang and under-boulder communities were also present. A detailed biotope and species list were generated from these surveys. The macroalgae *Halurus equisetifolius* was present within the area; this is thought to represent the northerly limit of its distribution. Two non-native species were also recorded: the barnacle *Austrominius modestus* (orig. name *Elminius modestus*) and the macroalgae *Codium fragile* subsp. *fragile* (syn. *Codium fragile* subsp. *tomentosoides*).

Work commissioned by SeaGeneration (Wales) Ltd in 2008 and 2009 found that, at Carmel Head, approximately 4 km west of Wylfa Head, the majority of the intertidal area consisted of fucoid algae on the upper shore and in sheltered embayments on the mid shore. On exposed headlands, barnacles and mussels were the predominant biotope. Dense communities of kelp predominated along the entire lower shore. The splash zone typically supported lichen. At occasional steep-sided, narrow embayments, clean shingle was present on the upper shore and fucoid-covered boulders were present on the lower shore (PMSS, 2011).

At Hen Borth, approximately 2.5 km west of Wylfa Head, the north-east side of the shore consisted of shallow platforms and boulders of sedimentary rock, the centre of the bay consisted of medium sand, while to the south-west the substrate of the shore is steep rock. The upper shore consisted of barren shingle. The mid shore had a dense cover of fucoids (*Ascophyllum nodosum* and *Fucus serratus*) with a more diverse algal community closer to the low-water mark (species included *Corallina* spp., *Chondrus crispus*, *Palmaria palmata*, *Fucus serratus* and *Laminaria digitata*). Mixed sandy habitat with abundant red algae (*Chondrus crispus* and *Osmundea pinnatifida*) and snakelocks anemone (*Anemonia viridis*) covered an extensive area at the very lower shore (PMSS, 2011).

A recent report covering subtidal and intertidal biotope mapping of Porth-y-pistyll in Appendix D13.03 Porth-y-pistyll biotope surveys (Application Reference Number: 6.4.85), recorded a mosaic of rocky and sedimentary communities, with littoral fucoid communities, large swathes of kelp forest and park in the infralittoral zone, and a variety of mixed and soft sediment sublittoral communities. Comparison of the data with that collected in 2003 by NRW showed that the bay had experienced a fair degree of change, much of this considered a response to natural biological and physical impacts. Four non-native species, all algae, were recorded from the survey work in Appendix D13.03 Porth-y-pistyll biotope surveys (Application Reference Number: 6.4.85), including the invasive non-native species (INNS) of brown algae *Sargassum muticum*.

2.1.3 MarClim Data

The Marine Biodiversity and Climate Change (MarClim) study (MarClim, 2006) investigated the effects of climate change (increases in temperature) on changes in intertidal species' range.

Historical data showed that the northern limit of the trochid gastropod *Phorcus lineatus* was Point Lynas on the north-east coast of Anglesey (e.g. Lewis, 1964). However, populations of *P. lineatus* were reduced or wiped-out during the cold winter of 1962-63, with the subsequent northern extent of the population distribution being to the south of the Llyn Peninsula and colonies barely recovered during the following two decades. Subsequent studies indicated that recolonisation had occurred between the 1980s and 2004, with individuals recorded at Cemaes Bay and a breeding population discovered at Porth Swtan on the west coast of Anglesey near Holy Island (see Mieszkowska *et al*., 2007). On the north Anglesey coast, the abundances of *P. lineatus* in the 2000s were recorded as occasional (Mieszkowska *et al*., 2007).

2.2 Subtidal Environment

2.2.1 Subtidal Invertebrates

The subtidal communities in the eastern and central Irish Sea have been the subject of several studies. The area is described as being characterised by the bivalve mollusc *Venus* spp., with other species such as the burrowing urchin (*Spatangus purpureus*) and the bivalve mollusc (*Spisula* sp.) characterising deep and shallow communities, respectively. Offshore, to the west of Liverpool Bay, sand waves support a community that includes species characteristic of both deep and shallow *Venus* spp. communities (Mackie, 1990).

Sedimentary habitats to the west of Anglesey were described by Robinson *et al.* (2009a) as being a mixture of mud, sand and gravel; while to the north of Anglesey, Wilding *et al*. (2005) described substrates as consisting primarily of current-swept sand and gravel and shell fragments with areas of exposed, scoured, rocky outcrops.

Sublittoral substrates off the north Anglesey coast were found by Robinson *et al*. (2009b) to be a mix of exposed rocks and sandy sediments, while further offshore, mixed sediments were prevalent. The sublittoral, rocky fauna off the north coast of Anglesey was described as being characterised by dense beds of the brittle star *Ophiothrix fragilis* and the crinoid *Antedon bifida* with the sponges *Polymastia* spp. and *Suberites carnosus* (Hiscock, 1976 - cited in Wilding *et al*., 2005). Further offshore, due to the scoured nature of the environment, relatively sparse epifauna was recorded which was characterised by species such as sea urchins *Echinus esculentus* and *Echinus elegans* and the scallop *Aequipecten* sp. (Wilding *et al*., 2005).

SeaGeneration (Wales) Ltd commissioned visual surveys of the seabed north-west of Wylfa Head between the Skerries and Anglesey in 2008 (PMSS, 2011). Using remote camera stills and video, 15 biotopes were recorded in four main habitat types. Substrata were dominated by cobbles, pebbles and gravels with sponges, dahlia anemones (*Urticina felina*), ascidians, bryozoans (*Flustra foliacea* and *Crisia* spp.), serpulids, hydroids and barnacles (*Balanus crenatus*). In the south-eastern section of the survey area, between Carmel Head and Cemlyn Bay, large numbers of brittle stars such as *Ophiothrix fragilis* and *Ophiocomina nigra* were present along with encrusting bryozoans and anemones.

Small beds of the horse mussel *Modiolus modiolus* have been recorded in the past from the north and north-west of Anglesey and are an important feature now designated as a Section 7 Priority Habitat; although widespread as individuals, horse mussel beds are limited in their distribution (Rees, 2005).

2.2.2 Survey of North Wales and Pembrokeshire Tide Influenced Communities (2004)

A survey commissioned by NRW recorded 12 distinct subtidal biotopes from 15 sites off the coast of north-west Anglesey from which approximately 260 taxa were recorded (Moore, 2004).

Exposed sites supported kelp forests and dense algal carpets of *Phycodrys rubens, Cryptopleura ramosa, Membranoptera alata* and *Plocamium cartilagineum*. The barnacle *Balanus crenatus* was present in infralittoral areas, with hydroids and bryozoans, or encrusting species such as sponges and anemones, colonising the circalittoral bedrock. The more-sheltered sites were populated by foliose red algae and bryozoan turf. The area adjacent to Holyhead (inland sea) was characterised by infralittoral and sublittoral fringe habitats.

Although no UK Biodiversity Action Plan (BAP) species were recorded in these surveys, two nationally scarce species were present: the sea squirt *Pycnoclavella aurilucens* and the red alga *Gracilaria bursa-pastoris*.

Sites south-east of the Skerries were notable for high numbers of taxa and for the dense carpets of the hydroid *Tubularia indivisa*. Rich assemblages of ephemeral algae and uncommon species were recorded immediately to the west of Holyhead harbour.

2.2.3 North Anglesey Invasive Non-Native Species and *Sabellaria* spp. Video and Still Image Analysis (2017)

Work commissioned by NRW (Baldock and Goudge, 2017) used DDC and video imagery to discern benthic species composition and biotopes at 25 sampling sites near the north and west Anglesey coast. As part of the sampling programme, sites were selected that overlapped with the historical Holyhead Deep disposal site, of which, three sampling sites were within the Disposal Site.

Aims of the survey included the collection of data to establish the presence/absence of INNS, particularly in Holyhead Deep; verification of historical records of *S. spinulosa*; and the groundtruthing of sites to inform interpretation of multibeam data collected by the Maritime and Coastguard Agency.

A total of nine biotopes were recorded from this survey along with 190 taxa. The substrata predominantly comprised stable mixed and coarse sediments with extensive *S. spinulosa* reef recorded at nine of the survey sites, particularly in the vicinity of Church Bay along the north-west coast of Anglesey. No INNS were recorded during the survey programme.

The survey did not record any Section 7 species. The Section 7 habitats ‘blue mussel beds on sediment’ and ‘subtidal sands and gravels’ were recorded, along with the Annex I listed feature ‘biogenic reef’ due to the presence of *S. spinulosa* reefs and a blue mussel bed.

2.2.4 Deep Green Project Holyhead Deep Benthic Technical Report (2016)

To support the proposal by Minesto UK Limited for a tidal array, a benthic survey programme was carried out by CMACS (2016). The study included remote benthic sampling at 17 sites located within the southern half of Holyhead Deep.

Where grabs were taken, the sediments were dominated by muddy sandy gravel. Faunal communities were generally dominated by annelid worms and molluscs, followed by crustaceans. The most abundant species recorded was *S. spinulosa*. The study also recorded the congeneric *S. alveolata* from a number of sites and the horse mussel *M. modiolus*; although the latter was only recorded from sites outside the boundary of the Holyhead Deep disposal site.

The study recorded five dominant biotopes from the southern half of Holyhead Deep. The Annex I listed features *S. spinulosa* reef and rocky reef were recorded from the survey programme; however, no *S. spinulosa* reef was recorded within the boundary of Holyhead Deep disposal site. The Section 7 habitat ‘subtidal sands and gravels’ was recorded throughout the survey area. All fauna identified from this study have previously been recorded from the Irish Sea and there is no mention of any record of INNS (CMACS, 2016).

2.2.5 Geophysical Surveys and Habitat Mapping

Several geophysical and mapping studies have been carried out that encompass the north Anglesey coastal shelf and the Irish Sea. These studies have helped inform the subtidal benthic work detailed in this baseline report.

Marine geophysical surveys were carried out in 2009 and 2010 with the results presented in Appendix D12.01 Coastal Geomorphology Baseline for the Wylfa Newydd Project (Application Reference Number: 6.4.80). The seabed in the vicinity of the proposed Wylfa Newydd Power Station was found to consist of irregular undulating bedrock, in-part covered by a complex boulder clay sequence, which in turn is covered by a thin lag deposit. Across the wider survey area, the bed consisted of exposed rock amongst relatively smooth sands and gravels. West-facing shorelines consisted of irregular rock outcrops at the entrances to the small bays and coves and sandy sediment fans separated the rock headland areas. Below the cliff line, the rock exposure consists of a wave-cut platform sloping gently seaward.

The output of a SEACAMS project and, specifically, the work by Potter (2014), interpreted geophysical data covering the historical Holyhead Deep disposal site. Multibeam bathymetry indicated that the Holyhead Deep disposal site varies in depth from approximately 35 m to 95 m. The seabed in this area is a combination of coarse sediments, boulder and bedrock. In the Disposal Site the majority of rock and bedrock is predicted to occur along the south-eastern boundary of the site.

Particular acknowledgment has been given to the seabed habitats presented through the European Marine Observation and Data Network which provide broadscale predicted habitat maps that encompass the study areas.

The most up-to-date and comprehensive data source regarding seabed habitats and communities off the north Wales coast comes from the HABMAP project. Within the Disposal Site, the HABMAP work has predicted the presence of four biotopes, with the two most dominant being associated with the circalittoral mixed sediment habitat (SS.SMx.CMx).

2.3 Cemlyn Lagoon

Multiple surveys of Cemlyn lagoon have been carried out which provide baseline data on the lagoonal environment. Of specific relevance to this report are the long-term data gathered during NRW surveys.

2.3.1 Sediment

Under 'normal' conditions the main body of Cemlyn Lagoon will act as a sediment sink due to limited energy to rework the sediment. Tidal flux will cause a movement in and out of the lagoon at the north-western point whilst fine grain sediment will be delivered from up the catchment through fluvial flow from the main watercourse Nant Cemlyn. In storm conditions tidal flux and fluvial flow will still be influencing the sediment regime along with the potential for overtopping of the shingle ridge delivering a wide range of sediment grain sizes, this also could potentially provide enough energy to rework the sediment in the main body of the lagoon. Groundwater flow also will be at maximum under storm conditions increasing run-off and sediment input.

Water samples were taken in Cemlyn lagoon by Jacobs, on behalf of Horizon, during winter and spring 2016 to give an indication of the suspended solids, the results of this are detailed in the water quality report in Appendix D13.01 Water quality and plankton (Application Reference Number: 6.4.83).

2.3.2 Flora

Uncommon plant species historically recorded from the lagoon are the brackish water-crowfoot (*Ranunculus baudotii*) and beaked tasselweed (*Ruppia maritima*). *R. baudotii* is on the IUCN red list, but is classed as Least Concern as it is widespread with stable populations and does not face any major threats. *R. baudotii* is not a lagoonal specialist, it also occurs in ditches, ponds, machair lochs and dune slacks near the coast and occasionally grows inland in lakes and pools (Lansdown, 2011). *R. maritima* is also classed as Least Concern on the IUCN red list.

The spiral tasselweed (*Ruppia cirrhosa*) (IUCN red list species, Least Concern) has been recorded as present within Cemlyn lagoon by the Botanical Socirty of the British ISLES (BSBI) (Online Atlas of the British and Irish Flora) and is mentioned as a feature of the SSSI; however, a number of other databases do not list this species in the area. The plant forms part of the CCW conservation management plan (Lewis and Ratcliffe, 2008). Unfortunately, it is very difficult to distinguish *R. cirrhosa* from the conspecific beaked tasselweed (*R. maritima*) and hence may be under-recorded or even overlooked (Online Atlas of the British and Irish Flora). Surveys by Barnes (1987), Bamber *et al.* (2000) and Brazier *et al.* (unpublished c.f. Bamber *et al.,* 2001) have all recorded *R. maritima* but not *R. cirrhosa*; however, The Online Atlas of the British and Irish Flora lists the presence of *R. cirrhosa* at Cemlyn Lagoon and a pers. comm with Bill Sanderson (2012) confirmed that *R. cirrhosa* was present in the lagoon.

Several other marine flora were recorded in these surveys, these were the green alga *Ulva* sp., *Enteromorpha* sp., *Chaetomorpha melagonium*, *Cladophora* sp., the red alga *Polysiphonia* indet., *Phyllophora crispa* and *Polyides rotundus* (Barnes, 1987; Bamber *et al.,* 2000; Brazier *et al.,* unpublished c.f. Bamber *et al.,* 2001). Surveys by Bamber *et al.* (2001) and unpublished data from CCW in 2000 (cited within Bamber *et al.* (2001)) recorded 12 floral taxa, four of which were lichens, from the lagoon. Lichen species included *Caloplaca marina*, *Verrucaria maura, Xanthoria parietina* and an unidentified grey lichen.

No surveys have recorded the presence of any Schedule 5 species from Cemlyn Lagoon.

2.3.3 Benthic fauna

Cemlyn lagoon supports a diverse group of invertebrate species (Bamber *et al.,* 2001), of which several are specific to British lagoons such as the bryozoan *Conopeum seurati*, the lagoon cockle (*Cerastoderma glaucum*), the lagoonal mud-snail (*Ecrobia ventrosa*) and the lagoonal isopod (*Idotea chelipes*).

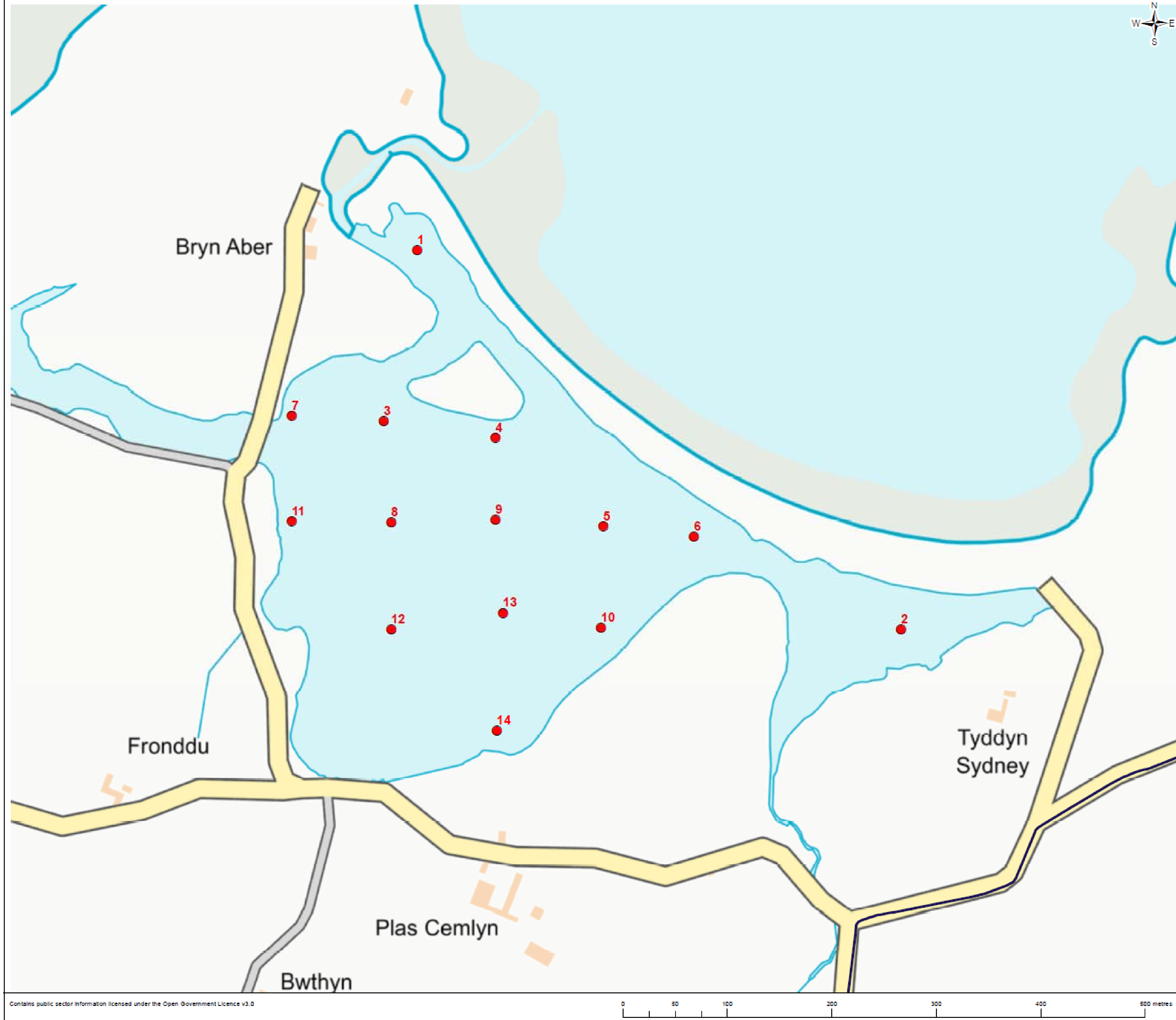
In recent years several studies have investigated the benthic fauna of the lagoon. Nikitik (2007) carried out a survey of the lagoon in 2006, recording benthic fauna from 14 sampling sites (Figure 2-1); stating that '…the benthic infaunal community was homogenous throughout the lagoon'. Three lagoonal specialists were present: *Ecrobia ventrosa*, *Monocorophium insidiosum*, *Idotea chelipes*; although the isopod *I. chelipes* was not present in the eastern part of the lagoon (site 2). Abundance of *M. insidiosum* was relatively low at site 2 compared to most of the western part of the lagoon but abundances were also low at sites in the central area of the lagoon. Abundance of *E. ventrosa* was similar at site 2 compared to sites in the central lagoon. Although the 2006 survey recorded fewer lagoonal specialists in the eastern area, the data are probably not robust enough to make a strong conclusion. The sites were typically dominated by the mud snail *E. ventrosa* but did not record the presence of the lagoonal cockle *Cerastoderma glaucum*.

Work by Stringell *et al.* (2013) looked at the spatial variability of communities at 14 separate locations in the lagoon during April 2006. A total of 17 species were identified including the lagoonal specialists *Idotea chelipes*, *Ecrobia ventrosa* and *Monocorophium insidiosum*. In contrast, a time-series sampling programme (three sites spanning 2006 to 2013) by NRW resulted in a total of 30 taxa (Green and Camplin, (2014)); however, the sample sites were all located in the deeper northernmost part of the lagoon, close to the shingle ridge (Figure 2-2). Inter-annual variability in diversity and abundance was recorded from the sites, with notably high abundances of the mud snail *E. ventrosa* at sites 2 and 3. The proximity to the ridge and the consequent saline input may allow more species to colonise this area of the lagoon.

Several of the taxa in the time-series sampling were only recorded on one occasion including fish and invertebrates such as Gobiidae, Spirorbidae, Nuculidae*, Magelona alleni* and *Idotea baltica*. Faunal abundances recorded by Nikitik (2007) and Green and Camplin (2014) showed similar results in terms of the more ubiquitous species, with high numbers of *Heterochaeta costata, Ecrobia ventrosa, Chironomid* indet. and *Monocorophium volutator* recorded throughout. Both surveys indicated a poorly developed population of *Cerastoderma glaucum*, with only two individuals found over the six-year period both of which were found in December 2007. It is thought that the periodic reduction of salinity during partial blocking of the weir in the summer months may be in part responsible for the low abundance and poor population structure of *Cerastoderma glaucum* at Cemlyn (Bamber *et al.,* 2001), whereas the species *Ecrobia ventrosa* and *M.insidiosum* may be more prevalent in this lagoon as a result of greater tolerance to low salinity levels and their shorter life histories (Green and Camplin 2014). Although older surveys recorded the presence of the bryozoan *Conopeum seurati* (Brazier *et al.,* unpublished; Sanderson *et al.,* unpublished c.f. Bamber *et al.,* 2001), more recent work has not identified this species in the lagoon since 2006 when a single specimen was recorded (Green and Camplin 2014).

The NRW time-series data demonstrated significant seasonal changes to the lagoon benthic communities and represent general declines in abundance during summer and autumn and recovery in winter and spring (Green and Camplin 2014).

FIGURE 2-1



Legend

- Wylfa Newydd Development Area
- NRW sampling site

Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	DEC 17	Initial issue	VG	CT	RW	RB

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Kenneth Dibben House, Enterprise Road, Southampton, SO16 7NS
Tel: +44(0)2380111250 Fax: +44(0)2380111251

Client: HORIZON NUCLEAR POWER

Project: WYLFA NEWYDD PROJECT
ENVIRONMENTAL STATEMENT
BENTHIC ECOLOGY REPORT

Drawing Title: NRW BENTHIC SAMPLING STATIONS

Drawing Status

Scale @ A3	1:3,500	DO NOT SCALE
Jacobs No.	60PO8077	
Client No.		

Drawing No. 60PO8007_AQE_REP_005_02_01

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0 50 100 200 300 400 500 metres

FIGURE 2-2

Legend

Wylfa Newydd Development Area

NRW sampling site between 2006 and 2013

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Project: WYLFA NEWYDD PROJECT
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Drawing Title: NRW BENTHIC SAMPLING STATIONS
BETWEEN 2006 AND 2013

Drawing Status

Scale @ A3	1:3,500	DO NOT SCALE
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3. Marine Sediment

3.1 Introduction

Bed sediments represent the ultimate sink for contaminants in marine environments, and they therefore give a good indication of both spatial and temporal patterns of contamination. As sediment contamination can result in the modification of sediment-dwelling communities, data describing contamination patterns are essential in order to interpret spatial and temporal community patterns. Physical sediment features influence both the uptake of contaminants and the characteristics of benthic communities, and therefore granulometric and textural information is required to support the interpretation of both chemical and biological data.

This section of the report presents the results of sediment physico-chemical data obtained from intertidal and subtidal sampling and subsequent analyses. Included within this chapter is reference to the results of the Detailed Offshore Ground Investigation (DOffGI) carried out in 2016 within the marine environment immediately adjacent to the Wylfa Newydd Development Area.

3.2 Methods

3.2.1 Site Selection

3.2.1.1 Intertidal Site Selection

Sediments were collected from two sites within Porth-y-pistyll bay between 2011 and 2014 in order to characterise baseline sedimentary conditions. The bay is adjacent to the proposed Wylfa Newydd Power Station and the proposed location of the Cooling Water intakes for the Project.

Much of the intertidal environment in Porth-y-pistyll bay is represented by bedrock; however, a couple of comparatively small areas of soft sediment exist, and from these areas two sediment sampling sites were established, these being adjacent to sites WI04 and WI12. Locations of the sites are provided in the results section of this chapter (see Figure 3-1).

FIGURE 3-1

Legend

- Wylfa Newydd Development Area
- Sediment sampling sites

Rev	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	JUN 17	Initial issue	HT	CT	EC	RB

Client: HORIZON NUCLEAR POWER

Project: WYLFA NEWYDD PROJECT
ENVIRONMENTAL STATEMENT
WYLFA SUBTIDAL BENTHIC REPORT

Drawing Title: WYLFA NEWYDD DEVELOPMENT AREA
INTERTIDAL SEDIMENT SITES, 2011-2014

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3.2.1.2 Subtidal Site Selection

The selection of suitable sediment sampling sites was initially based on a combination of predictive mapping where available (Section 2.2.5) and admiralty chart data. However, the results of DDC work, carried out as part of the benthic survey programme (see Chapter 5), was used to refine the selection.

Details of the site selection for each study area and the specific sampling methodology are provided below.

Wylfa Newydd Development Area

Twenty-five subtidal grab sites were initially selected in 2010 for biological and sediment sampling. Selection was made with reference to admiralty chart data, and particularly geophysical and seabed mapping studies, so that hard ground was actively avoided (Section 2.2.5). In 2011, a further three grab sampling sites (28 in total) were added to the programme. Further grab sampling was carried out as part of a validation survey in 2015, with a reduced number of sites being selected (11 sites) to validate data gathered in 2010 and 2011.

The sites selected covered a broad area along the north Anglesey coast, with sampling sites at varying depths and with substrata ranging from muddy to coarse sediment. Locations of the benthic grab sites sampled are provided in Figure 3-2.

As part of the DOffGI works, 12 boreholes were collected at sampling locations within Porth-y-pistyll and immediately to the north of the bay (see Fugro, 2016); these sampling locations corresponding with proposed areas for dredging as part of the Wylfa Newydd Project.

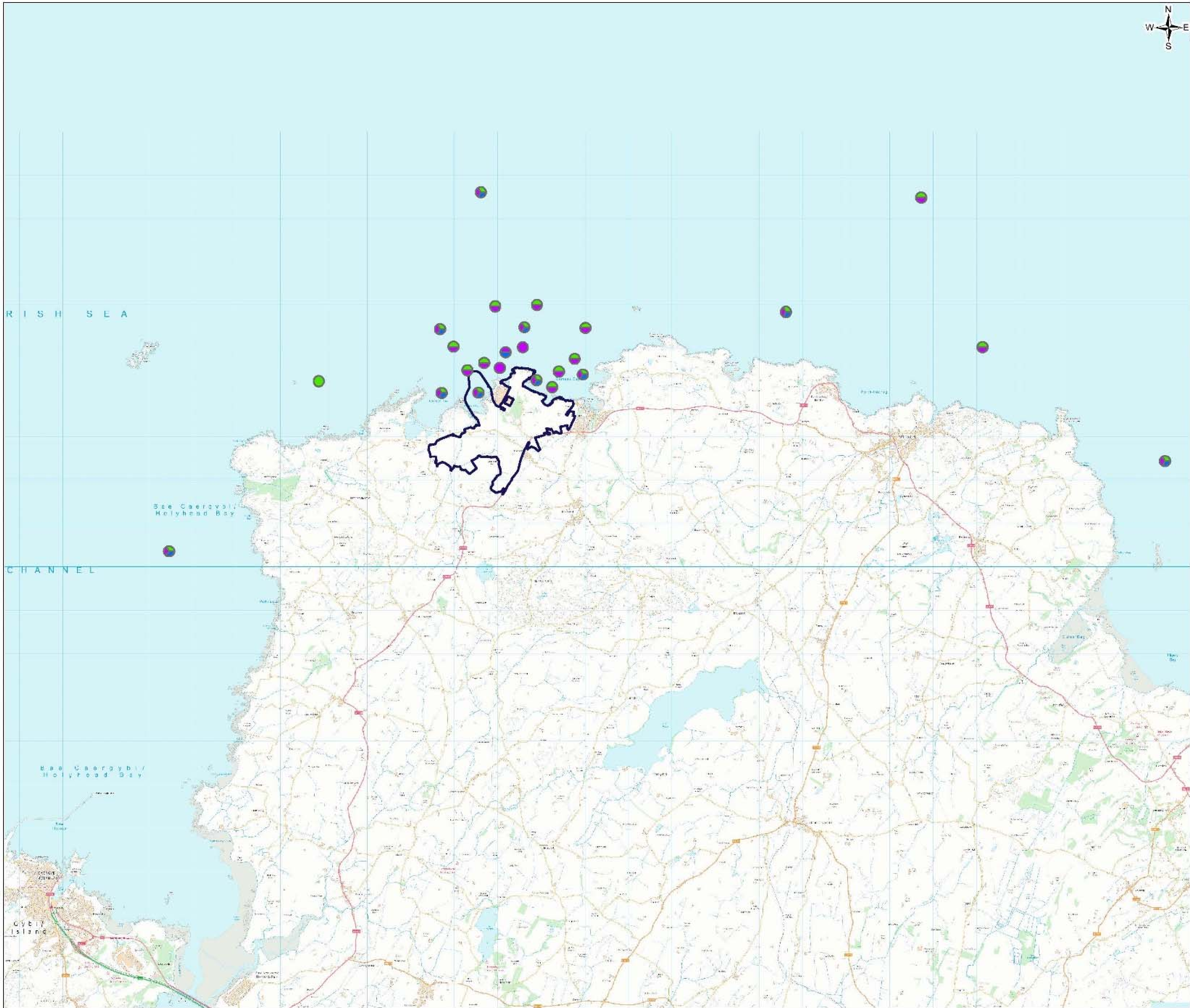

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FIGURE 3-2

Legend

Wylfa Newydd Development Area

Subtidal sediment sampling sites

Sampled in 2010

Sampled in 2011

Sampled in 2015

0	JUN 17	Initial issue	FT	CT	EC	RB
Rev	Date	Purpose of revision	Drawn	Check'd	Rev'd	App'd

Client

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WYLFA NEWYDD PROJECT
ENVIRONMENTAL STATEMENT
WYLFA SUBTIDAL BENTHIC REPORT

Drawing Title

WYLFA NEWYDD DEVELOPMENT AREA
SUBTIDAL SEDIMENT GRAB SITES 2010-2011 AND 2015

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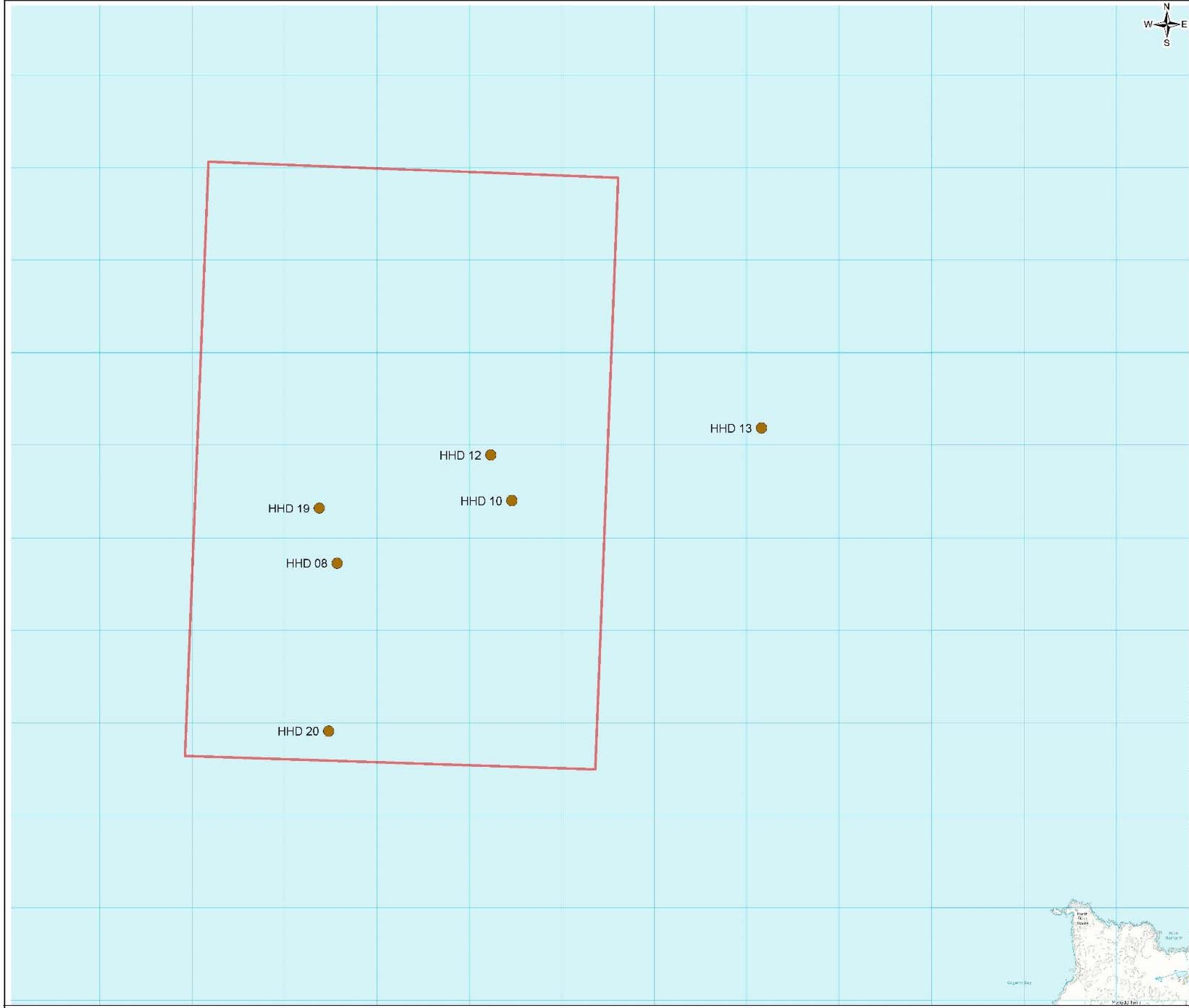
The Disposal Site

To broadly characterise the sedimentary environment, sites were selected to provide good spatial coverage at varying depths while acknowledging historical benthic data (Section 2.2.4 and 2.2.5). Recognition was also given to the location of ongoing and historical disposal activity (Potter, 2014) and the proximity of the sampling sites to commercial shipping routes.

Although 11 grab sites were initially proposed, following the results of the DDC survey in late October 2016, these were revised to account for the rocky substrata present at many of the sites and also the potential presence of *Sabellaria* spp. structures (see Section 5.3). Subsequently, eight grab sites were targeted (see Figure 3-3) within and adjacent to the Disposal Site.



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0 500 1,000 2,000 3,000 4,000 Metres

FIGURE 3-3

Legend

Disposal Site

Sediment grab locations

0	JUNE 17	Initial Issue	VG	CT	EC	RB
Rev	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd

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ENVIRONMENTAL STATEMENT
WYLFA SUBTIDAL BENTHIC REPORT

Drawing Title

DISPOSAL SITE
SUBTIDAL GRAB SITES 2016

Drawing Status

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3.2.2 Sampling Methodology

3.2.2.1 Intertidal Sampling Methodology

Samples were collected using a $0.01m^2$ hand-corer at the two intertidal sites, a single sample was collected at each site. Material was retrieved and placed in appropriate containers for physical and chemical analysis (see Section 3.2.3).

3.2.2.2 Subtidal Sampling Methodology

As much of the sedimentary material is characterised by coarse sediments, a Hamon grab was used to collect material. The Hamon grab consists of a rectangular frame forming a stable support for a sampling bucket attached to a pivoted arm. Sampling occursby the scoop being driven through the sediment and closing on a stop plate, thus sealing it completely. Samples are removed by opening the grab and washing material into a suitable receptacle.

To avoid contamination, material for metal analyses was retrieved with a plastic spatula while sediment for analysis of organics was collected using a metal spatula. Samples for particle size and radioisotope analyses were also taken. Sediments for granulometic and chemical analyses were refrigerated while materials for radioisotope analysis were frozen.

Samples were collected using a Hamon grab (0.25 m^2 in 2010; 0.1 m^2 in 2011, 2015 and 2016) with precision and accuracy attained by the use of GPS and, in the case of the 2016 Disposal Site survey, vessel dynamic positioning to ensure that the vessel remained within a few metres of its target location.

While the vessel held position, a single grab sample was collected for physical and chemical analysis, with the exception being 2015 when only physical analyses were carried out. A summary of the sediment analyses carried out in a given sampling year is provided in Table 3.1.

Table 3.1: Sediment analysis carried out each sampling year. 2010, 2011 and 2015 represent the benthic surveys specific to the Wylfa Newydd Development Area, while in 2016 sampling was carried out within the study area of the Disposal Site.

Sampling Year	Granulometry and Physical	Chemical	Biological (fauna)
2010	✓	✓	✓
2011	✓	✓	✓
2015	✓	X	✓
2016	✓	✓	✓

Twenty marine sediment samples were taken during the course of the DOffGI in 2016. The samples were analysed for heavy metals, organotins, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), particle size distribution and carbonate content.

All samples collected for sediment analysis were stored accordingly before and during transportation to the relevant UKAS-accredited laboratory.

3.2.3 Laboratory Analytical Methods

Samples for physical and particle size analyses, metals and organic compounds were sent to the National Laboratory Service. The samples collected as part of the DOffGI were sent to Cefas Lowestoft Laboratory.

All laboratories are UKAS accredited and the analytical methods used are accredited. A description of the analytical method can be found in Appendix A, Section A.1.

3.2.3.1 Limit of Detection (LoD) and Minimum Reporting Values (MRV)

Limit of detection (LoD; expressed as a concentration) is derived from the smallest concentration that can be detected with a reasonable level of confidence for the given analytical procedure (IUPAC, 1997).

Minimum Reporting Values (MRV) are minimum concentrations selected for reporting purposes which are often higher than the statistically derived method LoD and allow higher confidence that a sample is different from a blank sample containing no determinand of interest. MRVs are set by the analysing laboratory and are used to provide consistency of reporting as well as an allowance for sample variation.

The LoD and MRV are assigned values and are based upon ideal analysis conditions, although some factors such as matrix contamination or insufficient volume may result in a rise in MRV due to the need for dilution. In addition, some analytical techniques applied to saline water require substantial dilution (which may vary between samples) to reduce the chloride/saline interference. Dilution factors are incorporated in the MRV, which for some techniques can result in a high MRV.

3.2.4 Determinands Monitored

In addition to the particle size and granulometric parameters, sediments were analysed for a range of determinands known to be hazardous to aquatic life. The suite of substances included a number of metals and organic compounds (Table 3.2).

Table 3.2: Physical and chemical determinands reported by the laboratory. Organic compounds include polychlorinated biphenyls (PCBs); polycyclic aromatic hydrocarbons (PAHs) volatile organic compounds (VOCs) and Tributyltin.

Metals	Organic compounds			Granulometry and Physical
	(ICES-7) PCBs	PAHs	VOCs and Others	
Mercury	PCB - 28	Acenaphthene	Bromodichloromethane	Grain size fraction
Aluminium	PCB - 52	Acenaphthylene	Bromoform (tribromomethane)	Particle size report
Arsenic	PCB - 101	Anthracene	Chloroform (trichloromethane)	Sorting coefficient
Cadmium	PCB - 118	Benzo(a)anthracene	Dibromochloromethane	Kurtosis
Chromium	PCB - 138	Benzo(a)pyrene	Hydrocarbon screen (>C5-C44)	Organic carbon
Copper	PCB - 153	Chrysene	Tributyltin as cation	Dry solids at 30°C
Lead	PCB - 180	Dibenzo(ah)anthracene		
Nickel		Fluoranthene		
Zinc		Fluorene		
		Naphthalene		
		C2-Naphthalene		
		Phenanthrene		
		Pyrene		

3.2.4.1 Metals

Metals monitored were originally included in the (now repealed) European Dangerous Substances Directive (76/464/EEC) as List I and II substances. List I substances were those most toxic to aquatic life and are selected based on their persistence, toxicity and bioaccumulation potential. List II substances were other materials, which had a deleterious effect on aquatic life.

Of the original List I and II substances investigated in this study, cadmium, lead, mercury and nickel are designated as priority substances under the revised Priority Substances Directive, with cadmium and mercury also designated as priority hazardous substances. The Water Framework Directive (WFD) (2000/60/EC) aims to reduce the discharge of priority substances and to achieve the cessation of priority hazardous substances discharges. In addition, arsenic, chromium, copper and zinc are also designated as specific pollutants under the WFD; these are considered toxic substances when discharged into water in significant quantities for which WFD requires environmental standards to be set.

3.2.4.2 Polycyclic Aromatic Hydrocarbons (PAHs)

Polycyclic aromatic hydrocarbons (PAHs) are well-known chemical carcinogens: many are toxins, mutagens and teratogens and are known to be highly toxic to aquatic organisms. The greatest sources of PAHs are related to human activity, such as the refining of oil and the incomplete combustion of fossil fuels. However, natural sources for PAHs exist, such as forest fires and biogenic microbial production. The most immediate marine environmental risk from PAHs is from soluble compounds in the water column; however, as PAHs are hydrophobic, they readily adsorb onto suspended particulate matter which is then deposited and incorporated into bed sediments. This represents an important reservoir of PAHs, which can pose a risk to resident biota. The list of PAH compounds analysed includes the 13 most commonly occurring ones.

3.2.4.3 Polychlorinated Biphenyls (PCBs)

Polychlorinated biphenyls (PCBs) are organic compounds comprising a biphenyl group (i.e. composed of two benzene rings) with between one and 10 bonded chlorine atoms. PCBs have been used in a wide variety of applications such as coolants, flame-retardants, lubricating oils, hydraulic fluids, sealants and adhesives. However, as PCBs are highly toxic, persistent pollutants and readily bioaccumulated in animals, production in the UK ceased in the 1970s and sales of PCB formulations stopped in the mid-1980s. Moreover, PCBs are environmental contaminants regulated by the Stockholm Convention of Persistent Organic Pollutants (UNEP, 2009) and are included on the Oslo Paris Commission (OSPAR) list of chemicals for priority action due to their persistence, potential to bioaccumulate and toxicity (OSPAR, 2004).

Although theoretically 209 individual PCB congeners can be produced, the sediments in this study were examined for the seven ICES (International Council for the Exploration of the Sea) (ICES-7) PCBs congeners (CB28, 52, 101, 118, 138, 153 and 180) which are a mandatory requirement of the OSPAR Co-ordinated Environmental Monitoring Programme since 1998 (OSPAR, 2002).

3.2.5 Sediment Quality Standards

At present, there are no statutory Environmental Quality Standards for marine and estuarine sediments in the UK. However, where there is potential that the sediments analysed may be dredged and disposed at sea, Cefas have provided chemical Action Levels (sometimes known as sediment action levels) for the Disposal of Dredged Material (AL). Action Levels are not statutory contaminant concentrations for dredged material but are used as part of a weight of evidence approach to decision-making on the disposal of dredged material at sea. The Action Levels are therefore not ‘pass/fail’ criteria but triggers for further assessment. In general, contaminant levels in dredged material below AL1 are of no concern and are unlikely to influence the licensing decision. However, dredged material with contaminant levels above Action Level 2 (AL2) are generally considered unsuitable for sea disposal. Dredged material with contaminant levels between AL1 and AL2 requires further consideration and testing before a decision can be made.

Another approach often adopted to evaluate sediment quality is the *Canadian Sediment Quality Guidelines for the Protection of Aquatic Life*, developed and used by the Canadian Council of Ministers of the Environment (CCME) (2001). The CCME screening level guidelines were developed to assist in evaluating sediment quality based on an extensive database containing direct measurements of toxicity of contaminated sediments to a range of aquatic organisms exposed in laboratory tests and under field conditions. Whilst Canadian marine ecosystems may have inherent differences from UK marine ecosystems, it is considered that they can be used as authoritative assessment criteria for the assessment of ecological risk from sediments in the absence of any statutory UK guidance.

CCME standards have two guideline values, namely the Interim Sediment Quality Guidelines (ISQG) and Probable Effect Level (PEL). The ISQGs are more conservative while the PEL represents “*the lower limit of the range of chemical concentrations that are usually or always associated with adverse biological effects*” (CCME, 2001). An interpretation of the guideline values of the potential biological effect of the sediment on receiving flora and fauna is as follows:

- sediment concentrations < ISQG = rare biological effect;
- sediment concentrations > ISQG, < PEL = occasional biological effect; and
- sediment concentrations > PEL = frequent biological effect.

Table 3.3 presents all available chemical AL1 and AL2 provided by Cefas and ISQG and PEL currently used by CCME.

Table 3.3: Standards for analytes in sediment samples. Criteria are provided where available according to Cefas Action Levels and the CCME, ISQG and PEL.

Analyte	Assessment Criteria			
	AL1	AL2	ISQG	PEL
Acenaphthene (µg kg^{-1})	100	n/a	6.71	88.9
Acenaphthylene (µg kg^{-1})	100	n/a	5.87	128
Anthracene (µg kg^{-1})	100	n/a	46.9	245
Benzo(a)anthracene (µg kg^{-1})	100	n/a	74.8	693
Benzo(b)fluoranthene (µg kg^{-1})	100	n/a	n/a	n/a
Benzo(k)fluoranthene (µg kg^{-1})	100	n/a	n/a	n/a
Benzo(ghi)perylene (µg kg^{-1})	100	n/a	n/a	n/a
Benzo(a)pyrene (µg kg^{-1})	100	n/a	88.8	763
Chrysene (µg kg^{-1})	100	n/a	108	846
Dibenzo(ah)anthracene (µg kg^{-1})	100	n/a	6.22	135
Fluoranthene (µg kg^{-1})	100	n/a	113	1494
Fluorene (µg kg^{-1})	100	n/a	21.2	144
Indeno(1,2,3-c,d)pyrene (µg kg^{-1})	100	n/a	n/a	n/a
Naphthalene (µg kg^{-1})	100	n/a	34.6	391
Phenanthrene (µg kg^{-1})	100	n/a	86.7	544
Pyrene (µg kg^{-1})	100	n/a	153	1398
Arsenic (mg kg^{-1})	20	100	7.24	41.6
Cadmium (mg kg^{-1})	0.4	5	0.7	4.2
Chromium (mg kg^{-1})	40	400	52.3	160
Copper (mg kg^{-1})	40	400	18.7	108
Lead (mg kg^{-1})	50	500	30.2	112
Mercury (mg kg^{-1})	0.3	3	0.13	0.7
Nickel (mg kg^{-1})	20	200	n/a	n/a
Tributyltin (TBT) (µg kg^{-1})	100	1000	n/a	n/a
Zinc (mg kg^{-1})	130	800	124	271
Σ (ICES-7) PCBs (µg kg^{-1})	10	n/a	n/a	n/a
n/a – not available				

3.2.6 Data Analysis

Many metals are essential for life in low concentrations. However, even at moderately elevated levels they can become harmful or even lethal to aquatic life. Concentrations of metals were compared against the criteria mentioned above (Section 3.2.5).

Muds and silts tend to have naturally higher levels of metals compared to coarser sands due to the larger surface area and oxyhydroxide and organic coatings, which readily sequester metals. To allow for such variations, data need to be normalised using some factor, which is known to be subject to only naturally driven fluctuations. A common approach recommended by OSPAR (2000) is to normalise to aluminium and hence determine metal:aluminium ratios.

The level of enrichment of a metal within a sediment can be assessed by comparing the value of the metal:aluminium ratio to the Background Reference Concentration (BRC) for that metal. The BRC gives a range of values for the metal:aluminium ratio which would be expected in uncontaminated sediments as determined by OSPAR (2000). Concentrations are considered to be close to background if the metal:aluminium ratio is less than twice the upper limit of the BRC. As part of the analysis within this report, comparisons of a given metal:aluminium ratio have been compared with the BRC.

As for metals, the PAHs analysed were compared against the criteria mentioned above (Section 3.2.5). However, unlike metals and PAHs, there are no ISQG or PEL for the ICES-7 PCBs. Instead, CCME provides ISQG and PEL values for total PCBs (all 209 individual congeners) but not for the ICES-7 PCBs group. Cefas AL1 is provided for ICES-7 PCBs group, and this is used to review the results within the context of marine contamination thresholds.

3.3 Results

3.3.1 Intertidal Sediments

3.3.1.1 Granulometry

The sediments at the intertidal sampling sites within Porth-y-pistyll bay (WI04 and WI12) (Figure 3-1) showed clear spatial and temporal variation between years, although no particular pattern was observed.

At WI04, on the eastern side of the bay, sediments were classified in each sampling year as muddy sand or sand, except in 2013 when material was classified as sandy gravel with small shell fragments. At WI12, in the western corner of the bay, sediment was generally coarser than at WI04 being classified as either sand, sandy gravel or slightly muddy gravelly sand. Details of the particle size distribution can be found in Appendix A, Section A.2.

3.3.1.2 Metals

With the exception of zinc and lead in 2014 at site WI04, all other metal concentrations were reported below the relevant AL1 and ISQG. In 2014, zinc concentration reported at site WI04 (137 mg kg^{-1}) was found above the AL1 (130 mg kg^{-1}) and the relevant ISQG (124 mg kg^{-1}), while lead concentration (40.3 mg kg^{-1}) was the only other metal reported above the relevant ISQG (30.2 mg kg^{-1}). All metal concentrations reported can be found in Appendix A, Section A.3.

Metal:aluminium ratios for zinc, mercury, cadmium and lead were found to be greater than twice the relevant upper BRC, although some exceptions were reported for each metal ratio mentioned. In addition, the copper ratio was occasionally found marginally above twice the upper BRC. All calculated ratios can be found in Appendix A, Section A.3).

3.3.1.3 Organic Compounds

With the exceptions of naphthalene, in 2011 at site WI04, and all PAHs analysed in 2013 at site WI12, concentrations of PAHs were below the relevant ISQG and AL1 value (see Table 3.3) with many of the concentrations below the laboratory MRV.

Naphthalene concentration of 58.3 μgkg^{-1} was recorded at Porth y Felin in 2011, as compared to the ISQG of 34.6 $\mu g\ kg^{-1}$. All PAHs compounds analysed in 2013 at Porth-y-pistyll were reported above their ISQG value, and a number of them were also found above the AL1 (100 $\mu g\ kg^{-1}$). From this particular sample (WI12 in 2013), Acenaphthene was the only compound reported at a concentration (93.8 $\mu g\ kg^{-1}$) above the relevant PEL value (88.9 $\mu g\ kg^{-1}$). All concentrations recorded by the laboratory are provided in Appendix A, Section A.3.

In 2011, six out of seven PCB congeners analysed at Porth y Felin returned a positive result, although the combined concentration (<1.22 $\mu g\ kg^{-1}$) was less than AL1 (10 $\mu g\ kg^{-1}$). PCB concentrations recorded between 2012 and 2014, at Porth y Felin, were all below the MRV.

In Porth-y-pistyll, concentrations of PCB congeners in 2011 and 2012 were below MRV, while in 2013 five congeners returned a positive result and three in 2014; however, in both cases the combined concentrations were less than AL1 (<9.30 $\mu g\ kg^{-1}$ and <0.784 $\mu g\ kg^{-1}$, respectively). All concentrations recorded by the laboratory are provided in Appendix A, Section A.3.

Tributyltin (TBT), bromodichloromethane, tribromomethane (bromoform), trichloromethane (chloroform) and dibromochloromethane concentrations were consistently reported below the laboratory MRV at both sampling sites.

3.3.2 Subtidal Sediments

This section is broadly divided between the results for the Wylfa Newydd Development Area study and of the Disposal Site study. The Wylfa Newydd Development Area is then further divided between the grab sampling and DOffGI results.

3.3.2.1 Wylfa Newydd Development Area

Grab sampling sites are shown in Figure 3-2. The DOffGI sampling locations are provided in the Fugro (2017) report.

3.3.2.1.1 Granulometry

Sediments were composed of mud, sand and gravel in varying proportions and were divided between three broad sediment types. Within Cemaes Bay, predominantly muddy sediments were recorded at the three most inshore sites, while sandy sediments were present in the middle of Cemaes Bay, to the west of the Existing Power Station and in Cerrig Brith. At other sites, sediments were predominantly coarse, being characterised by gravels and coarse sands; this was particularly evident at the offshore sites.

Although sediments were broadly similar, some variability was evident between years. For example at WS03, there was a reduction in the proportions of fine and medium sands and an increase in the relative proportion of silt and clay. At WS14, the coarse sediments were dominated by particles >8 mm (e.g. large gravels, cobbles and boulders) in 2010 and 2011, but in 2015 the dominance in this size fraction was reduced and percentage distribution across the gravels and coarse sands size classes became more even. At WS16, the sediment was sandy gravels in 2010 and 2015 but notably coarser in 2011 when it was dominated by >8 mm particles.

Further detail on the sediment particle size distribution is provided in Appendix A, Section A.4.

From the DOffGI granulometric analysis of sediment, it was confirmed that across the sampling locations there is a thin veneer of soft sediment overlain on bedrock. At seven of the 12 sampling locations, only surface samples were obtained as there was insufficient depth of superficial sediment to collect a depth profile of samples. At the remaining sampling locations, both a surface sample and depth samples were obtained

The majority of samples were predominantly sandy gravel, or gravelly sand with very little silt content. The exceptions to this were BH1202 (1.0-1.5m) and BH1236 (1.5–1.7m), located to the north-east of Cerrig Brith and eastern region of Porth-y-pistyll, which both contained a high proportion of silt (51% and 76%, respectively); however, gravel and sand sized particles were also found in the samples.

Further detail on the sediment particle size distribution is provided in Appendix A, Section A.4

3.3.2.1.2 Metals

As detailed above (Section 3.2.2, Table 3.1), subtidal sediment metal concentrations were analysed in 2010 and 2011. Sediment-bound levels of copper, zinc, cadmium, mercury, lead and chromium were below the relevant ISQG at all sites in both years and hence below the PEL (Appendix A, Section A.5). Concentrations of arsenic slightly exceeded the relevant ISQG (7.24 mg kg^{-1}) at WS02 and WS06 in 2010 and at WS24 in 2011. At WS16, arsenic exceeded the ISQG in both sampling years. All concentrations of arsenic were well below the PEL at all sites in both years.

Concentrations of nickel slightly exceeded the AL1 at one site (WS02) in 2010 but were below the AL1 at all sites in 2011 (see Appendix A, Section A.5).

Most metal:aluminium ratios exceeded the upper range of the BRC in both years across the sampling sites, with many more than twice the upper range of the BRC. Geographically there were no obvious differences between the ratios, with values more than twice the upper range of the BRC across the study area. For example, the most offshore sites sampled (WS18 and WS19), recorded ratios in most metals more than twice the upper range of the BRC in both years.

For both zinc and lead, all values of the metal:aluminium ratios were more than twice the upper BRC in 2010, while in 2011, with the exception of site WS24, similar levels of elevation were recorded for both metals throughout the study area. For mercury, copper, cadmium and arsenic the ratios were more than twice the upper range of the BRC at the majority of sites in both years. Nickel ratios were greater than twice the upper range of the BRC at nine sites in 2010, although no values exceeded this limit for nickel in 2011. Similarly, the ratios for chromium were greater than twice the upper range of the BRC at three sites in 2010, but below the upper limit at all sites in 2011 (Appendix A, Section A.5).

From the DOffGI work analysis of the metal concentrations found exceedances of AL1 at six sampling locations. These exceedances were due to elevated levels of nickel (Ni) in BH1237, BH1236, BH1202, BH1210 and BH1234; elevated levels of zinc (Zn) at sampling locations BH1214 and BH1210; elevated levels of copper (Cu) at BH1210; and elevated levels of cadmium (Cd) at BH1202. All of the heavy metal exceedances were marginally above AL1 and well below AL2. Where heavy metal exceedances were recorded, these were as listed below:

- Cd was 0.43 mg kg^{-1}, 0.03 mg kg^{-1} over AL1 (0.40 mg kg^{-1}) and well below AL2 (5 mg kg^{-1}).
- Zn ranged from 153.6 mg kg^{-1} to 163.9 mg kg^{-1} which is respectively 23.6 mg kg^{-1} and 33.9 mg kg^{-1} over AL1 (130 mg kg^{-1}), but significantly below AL2 (800 mg kg^{-1}).
- Ni ranged between 20.2 mg $kg^{-1}$and 32.2 mg kg^{-1}, these were marginally over AL1 (20 mg kg^{-1}) and significantly below AL2 (200 mg kg^{-1}).
- Cu was 102.5 mg kg^{-1}, 62.5 mg kg^{-1} over AL1 (40 mg kg^{-1}) and well below the AL2 (400 mg kg^{-1})

At all sampling locations, none of the metal concentrations exceeded the relevant PEL values. Of the metal concentrations that exceeded the AL1, an exceedance of the ISQG was recorded with zinc, which marginally exceeded the relevant ISQG (124 mg kg^{-1}), and with copper, which exceeded the relevant ISQG (18.7 mg kg^{-1}).

Further detail on metal concentrations is provided in the DOffGI report (Fugro, 2017).

3.3.2.1.3 Organics Compounds

PAHs

In 2010 and 2011, the majority of PAHs concentrations were below MRV. PAH concentrations were generally higher in sediments from inshore sites, particularly at Cemaes Bay. Exceedances of the relevant ISQG for a particular compound were infrequent compared to all recorded concentrations and were only recorded in both years at WS20 with dibenzo(ah)anthracene and naphthalene (see Appendix A, Section A.5).

The only exceedances of the PEL for any of the compounds monitored was in 2010 when concentrations of naphthalene exceeded the PEL (391 µg kg^{-1}) at WS01 (420 µg kg^{-1}), WS02 (537 µg kg^{-1}) and WS25 (399 µg kg^{-1}). The following year (2011) concentrations of naphthalene at all these sites were below the MRV (30 µg kg^{-1}).

At site WS25, nine exceedances of the relevant ISQG were recorded in 2011; however, only one exceedance (naphthalene) was recorded at this site in 2010.

In 2010, concentrations of naphthalene exceeded AL1 at sites WS01, WS02, WS18, WS20, WS24 and WS25. The following year concentrations of naphthalene did not exceed the AL1 at any sites.

Benzo(a)anthracene, benzo(a)pyrene, chrysene, fluoranthene, phenanthrene, pyrene concentrations exceeded the relevant AL1 in 2011 at site WS25. In 2010, concentrations reported for all these compounds were well below the AL1 at WS25.

From the DOffGI work, analysis of the PAH concentrations found exceedances of AL1 at three sampling locations (BH1214, BH1238, BH1210) for methyl naphthalenes (2 samples), dimethyl naphthalenes (2 samples), trimethyl naphthalenes (1 sample), phenanthrene (2 samples), methyl phenanthrene (1 sample), fluoranthene (2 samples), pyrene (2 samples), benzo(b)fluoranthene (1 sample), benzo(a)pyrene (1 sample). The highest AL1 exceedance was 350µg/kg (trimethyl naphthalene at BH1238 in the south-eastern corner of Porth-y-pistyll), which is 250µg/kg over the AL1 threshold (100µg/kg). Site BH1238 also recorded the highest number of PAH exceedances (n=7). No AL1 exceedances were recorded at the other sampling locations during the DOffGI programme.

A number of the PAH concentrations exceeded the ISQG; these were all recorded at sites BH1214, BH1238 and BH1210.

At BH1238 an acenapthene concentration of 96.1 µg kg^{-1} was recorded, 8.1 µg kg^{-1} over the PEL (88.8 µg kg^{-1}). This was the only exceedance of PEL for PAHs across all samples, though this represents a lower value than the relevant AL1 (100 µg kg^{-1}) for this compound.

There was no exceedance of naphthalene for AL1 or PEL across the DOffGI sampling locations, nor were there any exceedances of AL1 for any sample for Total Hydrocarbon Content.

Further detail on PAH concentrations is provided in the DOffGI report (Fugro, 2017).

PCBs

The majority of individual PCB congeners were below the MRV in both sampling years. In 2010, the PCB congener 118 was above the MRV at WS02, WS20 and WS25, and the congener 153 above the MRV at WS20 and WS25. The only other PCB congener above MRV in 2010 was congener 138 at site WS20. In 2011, all PCB congeners tested at WS20 recorded concentrations above the MRV, while two congeners (118 and 153) were above the MRV at WS02.

The AL1 for the ICES-7 group of PCBs is 10 µg kg^{-1} for the sum of all concentrations recorded. In both years, the total PCB concentrations at all sites were below the AL1 (Appendix A, Section A.5).

From the DOffGI work, the sum of the ICES-7 PCBs congeners (CB28, 52, 101, 118, 138, 153 and 180) were below the AL1 at all sampling locations.

Other Organic Compounds

Tributyltin (TBT), bromodichloromethane, tribromomethane (bromoform), trichloromethane (chloroform) and dibromochloromethane concentrations were all reported below the laboratory MRV at all sites monitored.

From the DOffGI work, results showed that concentrations of organotins were all below AL1.

3.3.2.2 Disposal Site

Of the eight targeted grab sites, six were sampled for physico-chemical analyses (HHD_08, HHD_10, HHD_12, HHD_13, HHD_19 and HHD_20). At sites HHD_02 and HHD_16, prominent Sabellariidae tubes were recorded in the grab (Section 6.3); hence, further samples were not taken from these sites for sediment analysis.

3.3.2.2.1 Granulometry

All sites recorded similar substrata with sediment being classified as gravel. At all sites, a large proportion of the substrata were comprised of sediment with particle size above 2 mm, between 84% and 97.5%. Finer sediments were rare with muds and sands accumulating between 2% and 16%. The greatest proportion of sand was found at sites HHD_10 (9%) and HHD_20 (13%). Detail of the particle size distribution can be found in Appendix A, Section 0.

3.3.2.2.2 Metals

Arsenic was the only metal with concentrations reported above the relevant ISQG (7.24 mg kg^{-1}). The highest concentration reported was 12.4 mg kg^{-1}, well below the relevant PEL (41.6 mg kg^{-1}) and AL1 (20 mg kg^{-1}). All other metals were reported below the relevant ISQG and AL1 at all sites.

Cadmium was the only metal reported below MRV (0.04 mg kg^{-1}) in all sites sampled. Similarly, mercury was found below MRV (0.01 mg kg^{-1}) at four sites; the other two samples (HHD_13 and HHD_20) had concentrations marginally above the MRV (0.0135 mg kg^{-1} and 0.0155 mg kg^{-1}). Lead was the only metal with the metal:aluminium ratio greater than twice the upper BRC value in all sites sampled. Zinc, arsenic and nickel were also greater than twice the upper BRC value, but not at all sites, while the mercury ratio only exceeded this value at site HHD_20.

All metals concentrations reported and metal:aluminium ratios are provided in Appendix A, Section A.8.

3.3.2.2.3 Organics Compounds

PAHs compounds monitored were found to be at low concentrations. All compounds reported at sites HHD_08 and HHD_19 were found below MRV. Many of the concentrations reported at sites HHD_10 and HHD_12 were also found below MRV and some of them marginally about this value. None of the PAHs compounds monitored were reported above the relevant ISQG or AL.

Except the PCB-028 at site HHD_13 (0.154 μg kg^{-1}), all other PCB concentrations were reported below the MRV (0.1 μg kg^{-1}) at all sites.

PAH and PCB concentrations are provided in Appendix A, Section A.7.

Tributyltin (TBT), bromodichloromethane, tribromomethane (bromoform) and trichloromethane (chloroform) and dibromochloromethane concentrations were reported below the laboratory MRV at all sites.

3.4 Discussion

3.4.1 Intertidal Sediments

From the small areas of soft sedimentary shore within Porth-y-pistyll bay, the granulometric data indicates some variability between years and also between the two sites. Within the Porth y Felin site (WI12) (in the south-western margin of the bay) sediment was a mixture of sands and gravels, and are considered indicative of an environment that receives a moderate degree of exposure to tidal flows that circulate within the bay. To the south of WI12 is the Afon Cafnan; however, the results from the sediment sampling indicated that sedimentary material washed downstream is not accumulating in this area of the shore.

On the eastern side of the bay (WI04), the slightly muddier nature of the sediment suggests an area that allows some settlement of finer material, albeit limited. Although this area of the bay is not as sheltered from wave action as at Porth y Felin (WI12), the tidal flows here are less therefore allowing greater settlement of fine sediment to occur. Adjacent to the WI04 sampling site is a very small watercourse and it is likely that this contributes to the accumulation of finer material.

Metal concentrations reported in the intertidal area were considered elevated from BRC, with zinc, cadmium, mercury and lead reported as higher than twice the upper range of the BRC in most samples. However, zinc and lead were the only metals with concentrations reported above the relevant ISQG in Porth y Felin (WI04) in 2014 and only zinc was found above the relevant AL1. Closer to coastal inputs of anthropogenic or riverine origin, there is a general tendency for metal concentrations to be higher (OSPAR, 2000).

With the exceptions of naphthalene, in 2011 at site WI04, and all PAHs and PCBs compounds analysed in 2013 at site WI12, all organic compounds reported were below the relevant ISQG and AL1. Moreover, some of the concentrations were also below the laboratory MRV.

In 2013, all PAHs analysed at the Porth-y-pistyll site (WI04) were above the ISQG and several above the AL1. Acenaphthene was the only PAH which exceeded the PEL, although the concentration was below the AL1.

3.4.2 Subtidal Sediments

3.4.3 Wylfa Newydd Development Area

The substrata to the north of Anglesey were described by Wilding *et al.* (2005) as consisting primarily of current-swept sand and gravel and shell fragments with areas of exposed, scoured, rocky outcrops. Robinson *et al.* (2009a) indicated that sublittoral substrata in the vicinity of Wylfa Head were a mix of exposed rocks and sandy sediments, while further offshore, mixed sediments were prevalent. Granulometric data and field observations from both the 2010 and 2011 surveys indicated that on a spatial level the substrata varied considerably over the survey area, from muds to coarse gravel and cobbles, with a pattern clearly related to the scouring effects of the high energy currents.

Sampling sites from the sheltered inshore environments, such as the bays of Porth-y-pistyll, Cemlyn and particularly Cemaes, recorded muddy sands, consistent with coastal areas in the region that are less exposed to wave action and currents. By contrast, the exposed offshore sedimentary sites tended to be a combination of coarse and mixed sediments. However, as recorded by the DOffGI work in and adjacent to Porth-y-pistyll (Fugro, 2017), the sediment is a thin veneer overlying bedrock in this area. Although borehole samples north-east of Cerrig Brith and within the eastern region of Porth-y-pistyll contained a high proportion of silt, the majority of the borehole samples were sandy gravel or gravelly sand with very little silt content.

Comparisons between the grab sites sampled for two or three years showed some variation between the proportions of mud, sand and gravel at a few sites, with a shift from coarse gravel to a more mixed sediment substrata or vice versa. Although this may be in part due to physical influences on the sediment, such as the strong tidal flows in the region, it is more likely that the broad locations of these grab sites encompass transitional areas of sediment and, potentially, more than one type of benthic community. Consequently, sampling the bed just a short distance away from the exact location of a previous grab may result in these clearly identifiable shifts in the sediment composition.

From examination of the metal:aluminium ratios, it was found that across the study area as a whole, even several kilometres offshore, the ratios of the metals sampled were consistently higher than the upper range of the BRC, in many cases being more than twice the upper range. Therefore, metal concentrations were considered elevated from BRCs.

However, very few metal concentrations exceeded the relevant ISQG and only at WS16, with arsenic, did this occur in both sampling years. This site (WS16) represents the eastern most extent of the study area. At the relatively inshore site WS02 the concentration of nickel slightly exceeded the AL1 in 2010, this representing the only exceedance of AL1 across the sampling programme. From the results, it is therefore considered that metal concentrations, although elevated above background, are not generally at a level that could result in an occasional biological effect.

Similarly, the results of the DOffGI showed that very few metal concentrations exceeded the AL1 and, where they did, were well below the AL2. None of the borehole samples recorded an exceedance of the PEL for metals, though exceedances of ISQG were recorded for zinc at locations BH1210 and BH1214 and for copper at BH1210. These sites are located close inshore, immediately to the north and south of Porth y Gwartheg, adjacent to the mouth of Porth-y-pistyll.

Metal concentrations recorded within marine sediments can be attributed to both natural and anthropogenic sources. Metals occur naturally in the environment in varying concentrations and are present in rocks, soil and plants. The leaching of soils and the weathering of rocks are common natural sources of metal releases to the marine environment.

Metals can also be released to the marine environment from sources of human origin which, for metals such as chromium, nickel and zinc, can exceed the releases from natural sources. Sources of anthropogenic releases of metals to the environment include combustion processes, discharge of wastewater from industrial waste, sewage discharges and the use of fertilisers and wood preservatives.

The mean metal concentrations recorded in the subtidal sediments from the grab surveys were comparable to those recorded from other coastal sites and appreciably lower than those recorded from industrialised and known contaminated estuarine sites (Table 3.4). This is not unexpected, as estuaries such as the Mersey and Clyde have received chronic inputs of metals from anthropogenic sources, such as domestic and industrial discharge, for many years.

Table 3.4: Sediment-bound metal concentrations (mg kg^{-1}) from north Anglesey and other UK coastal (C) and estuary (E) sites.

Location	Cu	Zn	Cd	Hg	Pb	As	Cr	Ni	Reference
Moray Firth (C)	1.0	4.0	<0.01	<0.01	4.2	1.2	7.6	1.3	Talisman Energy (2006)
Southern North Sea (C)	8.0	31.0	<0.02	0.08	7.0	257	-	16.7	Strong (2011)
North Channel (C)	4.5	27.0	<0.06	<0.05	11.2	11.3	31.0	11.5	Breen *et al.* (1997)
Solway Firth (C)	10.1	60.0	0.09	0.02	31.7	5.8	65.2	17.6	Fisheries Research Services (FRS) / Scottish Environmental Protection Agency (SEPA) (1997)
Fal (E)	11170	1150	1.1	1.9	193	549	30.0	28.0	Bryan and Gibbs (1983)
Clyde (E)	31.4	187	0.15	0.3	107.4	39.9	141.8	30.5	FRS/SEPA (1997)
Severn Estuary (E)	43	215	71.0	0.4	84.0	38.0	15.0	0.24	EA unpublished data
Mersey (E)	84	379	1.2	3.0	124.0	-	-	29.0	Bryan and Langston (1992)
North Anglesey	5.3	35.1	0.03	0.01	11.4	5.7	12.8	7.9	Present study

Concentrations of PAHs were generally low across the study area with comparatively few exceedances of the ISQG or AL1. Where samples exceeded the AL1, they were generally minimal exceedances with the notable exception of naphthalene which exceeded the PEL at several sites in 2010 (WS01, WS02 and WS25). However, in the same year all other PAHs recorded from these sites were low in concentration, all being way below the ISQG threshold. Similarly all metal and PCB concentrations were low at these sites.

At these same sites (WS01, WS02 and WS25), in 2011, the concentrations of naphthalene were <30 μg kg^{-1} (below MRV) in all cases. Over the sampling programme this would result in a maximum arithmetic mean (assuming a value of 29.9 μg kg^{-1}) of 225 μg kg^{-1}, 283.5 μg kg^{-1} and 214.5 μg kg^{-1} at the sites WS01, WS02 and WS25 respectively; all of these values being considerably lower than the PEL (391 μg kg^{-1}).

Naphthalene is made from crude oil and coal tar and produced from the burning of fuel and thus exists in exhaust emissions, this being believed to be the main source of naphthalene in the environment (e.g. Gavin *et al*., 1996). In water volatilisation, adsorption, photolysis and aerobic biodegradation may be important fate processes, depending on local conditions. The half-lives for naphthalene in soil and water range from a few days to a few months (Bates *et al.,* 1997).

Contamination of the aquatic environment with naphthalene is most frequently associated with discharges from the chemical and petroleum industries and accidental spillages or leakages of petroleum products to land or water (UK Marine SAC, 2017). The minimal concentrations of naphthalene recorded in 2011 at these sites or elsewhere across the study area may indicate that the high concentrations of naphthalene found in the sediments in 2010 were from a spill, as all these sites are in the same area. Furthermore, the minimal naphthalene concentrations recorded the following year would suggest that the levels recorded in 2010 were the result of an event rather than an ongoing source.

Conversely, at the same site (WS25) nine PAHs were above the ISQG in 2011; however, in all cases the values were less than half of the PEL. Yet in 2010 values of the corresponding PAHs were well below the ISQG, indicating that these concentrations likely reflect an acute event (e.g. oil spill) rather than a chronic source. Calculation of the maximum arithmetic mean across both sampling years with these nine PAHs found that only three of the PAHs (acenaphthene, dibenzo(ah)anthracene and fluoranthene) exceeded the ISQG, and only fluoranthene the AL1.

Chemical analysis of the boreholes found that a number of PAH values exceeded the AL1; however, these were all constrained to three of the sampling locations: BH1210 and BH1214 (either side of Porth y Gwartheg) and BH1238 (in the sheltered embayment within the south-east of Porth-y-pistyll). The 2016 DOffGI did not record any AL1 exceedances of naphthalene, as found during the grab survey in 2010, although values of methyl-napthalene and dimethyl-napthalene exceeded the AL1 at BH1214 and 1238 and trimethyl-napthalene exceeded the AL1 at BH1238. Despite the PEL being marginally exceeded at BH1238 for acenapthene, it is also noted that this value was below the relevant AL1 threshold.

The grab site WS25 is closest to the borehole locations BH1210 and BH1214, all of these locations recording AL1 exceedances of metals and/or PAHs. As discussed above, it is possible that the exceedances may represent anthropogenic input such as a pollution event, particularly in the case of the PAHs.

The low levels of PCBs across the grab study area and from the boreholes (Fugro, 2017) indicate that this region has experienced minimal inputs from this environmentally persistent group of chemical compounds. At all sampling sites, in all years, the sum of PCB concentrations was considerably lower than the AL1 threshold (10 $\mu g\ kg^{-1}$).

3.4.4 Disposal Site

Offshore, to the north-west of Anglesey, the seabed is generally thought to comprise a platform of bedrock with some areas overlain with a coarse mix of boulders, cobbles and other lag deposits (Rees, 2005; Potter, 2014). At Holyhead North, rocky areas exist, particularly along the eastern margins (Potter, 2014). Results from the DDC survey (Section 6.3.5) confirmed that the seabed was rockier around the eastern margins of the Disposal Site; hence, grab sampling was not possible from much of the eastern region of the study area.

Sediment samples were collected at depths ranging from approximately 60 m to 85 m. Granulometry data indicated that the sedimentary substrata is dominated by gravel with a high proportion (more than 84%) of the substrata comprised of particles bigger than 2 mm at all sediment sampling sites analysed.

On account of the nature of the coarse substrata and the subsequent preclusion of grab sampling over much of the disposal site, the DDC survey provides useful supplementary data on the benthic substrata (Section 6.3). The DDC images confirmed that some areas were overlain with boulders and cobbles (Section 6.3.5), as per Rees (2005), while supporting the dominance of gravelly material, as recorded by the grab survey, within sedimentary areas.

With the exception of arsenic, metal concentrations recorded from the sampling sites were all below the ISQG and AL1. Arsenic was just above the ISQG (7.24 mg kg^{-1}) at all sites while, conversely, cadmium and mercury concentrations were below the MRV at most sites. Arsenic enters the marine environment from natural sources, such as volcanic action and low temperature volatization, and from anthropogenic point and diffuse sources. Mining, smelting of non-ferrous metals and burning of fossil fuels are the major industrial processes that contribute to anthropogenic arsenic contamination of air, water and sediment. The arsenic:aluminium concentration ratios for arsenic were all greater than twice the upper BRC range likely indicating an anthropogenic source; however, all arsenic values were well below the AL1 and PEL.

A range of marine organisms have been found to accumulate arsenic from sediments and the water column, including the bivalve molluscs *Scrobicularia plana*, *Cerastoderma* spp. and *Mytilus edulis*, the flatworm *Planaria* and the algae *Fucus vesiculosus*, *Ectocarpus siliculosus*, *Cladophora glomerata* and *Enteromorpha intestinalis* (UK Marine SAC, 2017). *S. plana* and *M. edulis* were considered to take up adsorbed arsenic from suspended or surficial sediments and *F. vesiculosus* from dissolved arsenic from the water column. Arsenic is bioconcentrated in organisms but is not biomagnified in food chains and so bioaccumulation is unlikely to be a problem in marine organisms.

All organic compounds monitored PAHs, PCBs, TBT and other volatiles were below the relevant ISQG and AL1 with many concentrations below MRV or only marginally above this value.

3.4.5 Overview

The results of the sediment study provide further confirmation of the strong influence of tidal flows, around both benthic study areas, even at depths of greater than 80 m in the case of the Disposal Site; with the offshore sites dominated by coarse sediments. It has also provided a greater understanding on the biological communities in the study areas (see Sections 5.3 and 6.3).

However, it should be realised that much of the seabed, intertidal and subtidal, along the north Anglesey coast and also to the north-west of Anglesey, is rocky in nature (bedrock, boulder and cobbles) and thus precluded sediment sampling.

The rocky substrata so prevalent in the area is clearly observable along the shore, while in the subtidal environment it is evidenced from a combination of geophysical surveys (D12.1), admiralty chart data and also the effective groundtruthing using DDC imagery (see Section 5.3.1). As part of the broader baseline marine ecology programme for the Project, the nature of the substrata has also been evidenced as part of other directed marine baseline surveys (e.g. appendices D13 (Application Reference Number: 6.4.85), D13 (Application Reference Number: 6.4.86) and D13 (Application Reference Number: 6.4.87).

Given the generally low concentrations of metals and organic compounds (PAHs and PCBs) recorded along the north Anglesey coast, it is considered that this coastline has experienced relatively low inputs from anthropogenic sources. Where exceedances of threshold sediment quality criteria have been recorded, it is thought that these are indicative of acute events such as spillage, rather than from a consistent source. The higher than background metal concentrations recorded throughout the area may be indicative of historical mining operations along the coast, such as the Parys Mountain copper mine near Amlwch. Aside from copper, this area is thought to contain extensive resources of zinc and lead.

In summary, it is considered that the determinand concentrations recorded in the sediments are unlikely to result in the realisation of an occasional effect on aquatic life. Especially given that, where exceedances of the ISQG were recorded in the first year of grab sampling, the concentrations in the subsequent sampling year were often way below the relevant threshold. Furthermore, the PEL exceedances recorded for the PAHs naphthalene and acenaphthene are considered the result of a pollution event rather than any chronic output.

4. Intertidal Benthic Ecology – Wylfa Newydd Development Area

4.1 Introduction

The intertidal habitats surrounding Wylfa Head are characterised by exposed rocky shores ranging from the gently shelving platforms found to the west of Cemlyn Bay to the steep cliffs around Wylfa Head. The area is interspersed by bays and small coves with shingle beaches present in some of these bays such as at Cemlyn Bay and, where there is a decrease in exposure, sandy beaches like that found within Cemaes Bay.

A programme of intertidal work was carried out to specifically characterise the intertidal environment in the vicinity of the Wylfa Newydd Development Area and to provide baseline information on the intertidal communities present. Surveys were carried out annually from 2010 to 2014 with all work taking place during July and August. Information on intertidal sediments is provided in the previous chapter (Chapter 3).

4.2 Methods

4.2.1 Site Selection

In 2010, 10 intertidal sampling sites were targeted within 2 km to the east and 2 km to the west of the Existing Power Station. These covered an area encompassing Cemlyn Bay, Porth-y-pistyll, Wylfa Head and Cemaes Bay (WI01 to WI10). Two additional sites were located farther afield, to the east of Wylfa Head. The first was at Point Lynas approximately 13 km away (for MarClim assessment study only, see below) and the second at Lligwy Bay (WI11), approximately 20 km away to increase coverage of the baseline study.

In 2011, two further sites were added to the intertidal benthic study, one at Porth-y-pistyll (WI12) and the other at Wylfa Head (WI13). These sites were also included in subsequent benthic surveys each year (2012-2014).

The location of the intertidal sampling sites is provided in Figure 4-1.

FIGURE 4-1

Legend

- Wylfa Newydd Development Area
- Intertidal benthic sites

D	JUN 17	Initial issue	HT	CT	EC	RB
Rev	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd

Client: HORIZON NUCLEAR POWER

Project: WYLFA NEWYDD PROJECT
ENVIRONMENTAL STATEMENT
WYLFA SUBTIDAL BENTHIC REPORT

Drawing Title: WYLFA NEWYDD DEVELOPMENT AREA
INTERTIDAL BENTHIC SITES 2010-2014

Scale @A3	1:15,000	DO NOT SCALE
Jacobs No.	60PO8077	
Client No.		

Drawing No.: 60PO8077_DCO_D_13_04_01

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4.2.2 Sampling Methodology

Initially, in 2010, a walkover survey was carried out from Trwyn Cemlyn to Cemaes Bay. The characterising intertidal habitats and biotopes were recorded and suitable sites selected for further intertidal survey work.

Subsequent to the walkover a species assemblage survey (sites WI01 to WI13) and a trochid gastropod survey (MarClim assessment) (sites WI01 to WI07; WI10 to WI12; Point Lynas) were carried out. These surveys are detailed separately.

4.2.3 Species Assemblage Survey

Sites WI01 to WI11 were surveyed in 2010, and WI01 to WI13 surveyed from 2011 to 2014. The exception was in 2014, when poor weather conditions precluded sampling of WI08.

In 2010, mid-shore intertidal habitats were assessed at each sampling site. Five 0.25 m^2 quadrats were placed semi-randomly on the mid shore, and the abundance of both fauna and flora was assessed and recorded as density or percentage coverage, as appropriate. Photos were taken of each quadrat for Quality Control and confirmation of species composition and coverage. Characterising taxa on the shore which were not present within the quadrats were recorded to assist with biotope assignation as appropriate.

During the intertidal survey programme, surveyors recorded the presence of any INNS, such as those species identified by the North Wales Wildlife Trust (2017) of concern in north Wales (see Appendix B, Section B.1).

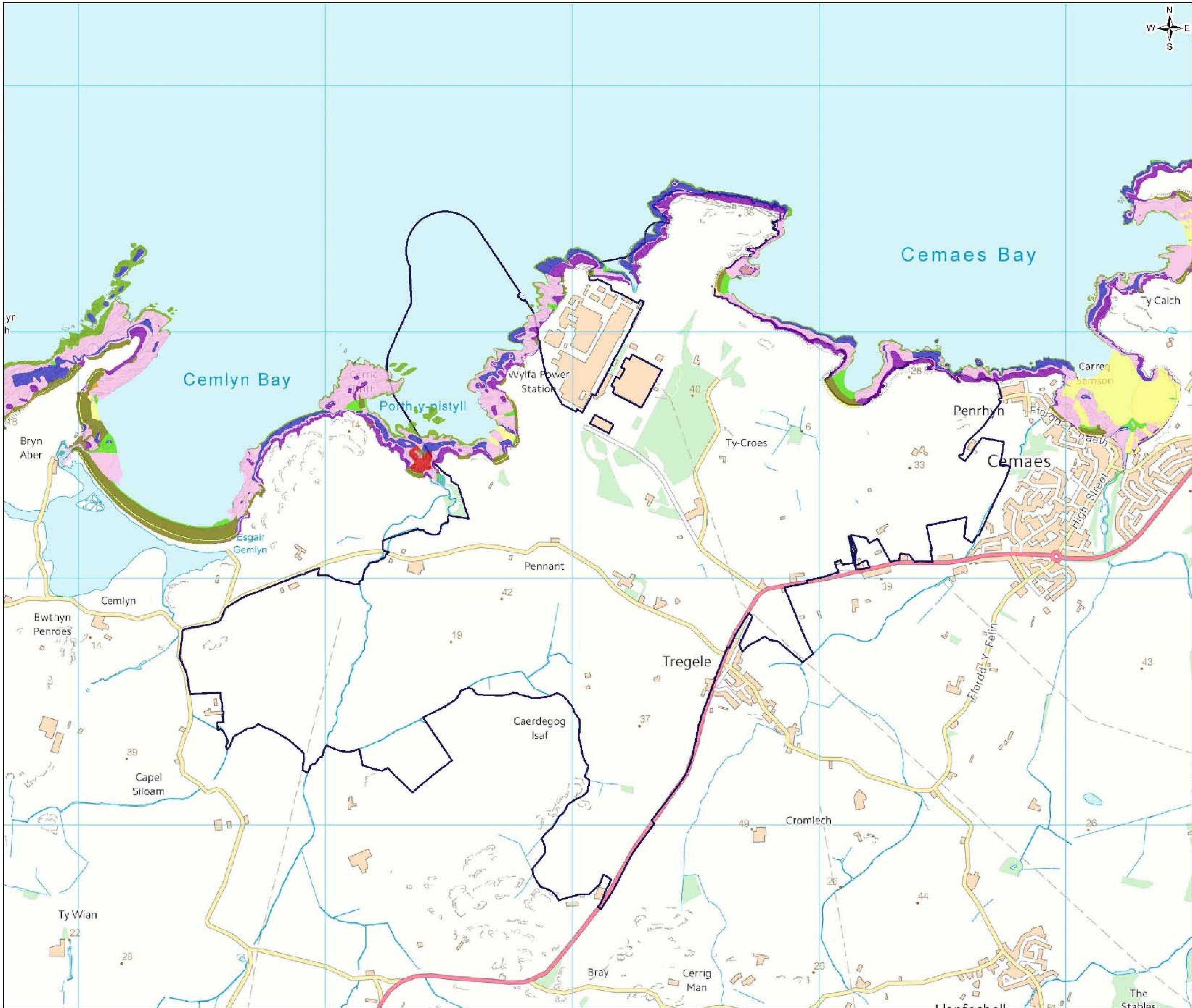
From 2011 to 2014, sampling effort increased with the addition of upper-shore and low-shore community assessments at each sampling site. Thus, the survey was carried out as outlined above at each shore height: upper, mid and lower.

Abundance data were converted to the SACFOR scale according to the Marine Nature Conservation Review SACFOR scale (Hiscock, 1996; see Appendix B, Table B.2) on which abundance is classed as Superabundant (S), Abundant (A), Common (C), Frequent (F), Occasional (O) and Rare (R).

The data collected were used to classify the habitats and assign or confirm biotope codes according to the Joint Nature Conservation Committee's (JNCC's) *The Marine Habitat Classification for Britain and Ireland* (JNCC, 2015). Broad habitat types and biotopes in the vicinity of Wylfa Head were mapped by NRW in 2003 (see Figure 4-2 and Figure 4-3); hence, providing a reference for those biotopes recorded during the intertidal study.

In July 2014, a detailed biotope assessment of Porth-y-pistyll was carried out along with an assessment of the rockpools found in the bay, the results of these surveys are reported separately in Appendix D13.03 Porth-y-pistyll biotope surveys (Application Reference Number: 6.4.85).

FIGURE 4-2



Legend

- Wylfa Newydd Development Area

Habitat Lifeforms

- Algal Turf
- Fucoids
- Kelp
- Lichens and Algae
- Muddy Sandy Shore
- Mussel Beds
- Mussels and Barnacles
- No Lifeform
- Saltmarsh
- Sand
- Shingle, Coarse Sand, Mixed Sediments
- Short Faunal Turf; Crusts and Cushions

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WYLFA NEWYDD PROJECT
ENVIRONMENTAL STATEMENT
WYLFA SUBTIDAL BENTHIC REPORT

Drawing Title

HABITAT LIFEFORMS
(FROM CCW, 2003)

Scale @ A3	1:15,000	DO NOT SCALE
Jacobs No.	60PO8077	
Client No.		

Drawing No.

60PO8077_DCO_D_13_04_02

FIGURE 4-3

Legend

Wylfa Newydd Development Area

Biotopes (2004 Code)

- IR.HIR.KFaR.Ala.Ldig
- IR.HIR.KFaR.Ala.Myt
- IR.MIR.KR.Ldig.Ldig
- LR.FLR.CvOv.AudCla
- LR.FLR.CvOv.SpR
- LR.FLR.CvOv.SpR.Den
- LR.FLR.Eph.Ent
- LR.FLR.Eph.EntPor
- LR.FLR.Eph.EphX
- LR.FLR.Lic.Pra
- LR.FLR.Lic.Ver.B
- LR.FLR.Lic.Ver.Ver
- LR.FLR.Lic.YG
- LR.FLR.Rkp.Cor
- LR.FLR.Rkp.FK
- LR.FLR.Rkp.G
- LR.FLR.Rkp.SwSed
- LR.HLR.FR
- LR.HLR.FR.Mas
- LR.HLR.FR.Pal
- LR.HLR.MusB
- LR.HLR.MusB.Cht
- LR.HLR.MusB.Cht.Cht
- LR.HLR.MusB.Cht.Lpyg
- LR.HLR.MusB.MytB
- LR.HLR.MusB.Sem.FvesR
- LR.HLR.MusB.Sem.LitX
- LR.HLR.MusB.Sem.Sem
- LR.LLR.F.Asc.FS
- LR.LLR.F.Asc.X
- LR.LLR.F.Fserr.X
- LR.LLR.F.Fspi.FS
- LR.LLR.F.Fves
- LR.LLR.F.Fves.X
- LR.LLR.F.Pel
- LR.LLR.FVS.AscVS
- LR.LLR.FVS.Fcer
- LR.LLR.FVS.FserVS
- LR.MLR.BF.Fser.Bo
- LR.MLR.BF.Fser.R
- LR.MLR.BF.FspiB
- LR.MLR.BF.FvesB
- LR.MLR.BF.PelB
- LR.MLR.BF.Rho
- LR.MLR.MusF.MytFR
- LS.LBR.LMus.Myt.Mx
- LS.LCS.Sh.BarSh
- LS.LMp.Sm
- LS.LMp.Sm.SM8
- LS.LSa.FiSa.Po
- LS.LSa.MoSa.AmSco.Eur
- LS.LSa.MuSa.Lan
- LS.LSa.MuSa.MacAre
- LS.LSa.St.Tal

Rev	Date	Purpose of revision	Drawn	Check'd	Rev'd	Apprd
0	JUN 17	Initial issue	HT	CT	EC	RB

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Project

WYLFA NEWYDD PROJECT
ENVIRONMENTAL STATEMENT
WYLFA SUBTIDAL BENTHIC REPORT

Drawing Title

WYLFA NEWYDD DEVLOPMENT AREA
INTERTIDAL BIOTOPES (CCW, 2003)

Scale @ A3	1:15,000	DO NOT SCALE
Jacobs No.	60PO8077	
Client No.		
Drawing No.	60PO8077_DCO_D_13_04_03	

0 0.125 0.25 0.5 0.75 1 Kilometers

4.2.4 Trochid Gastropod Survey

In 2010, trochid gastropod surveys were carried out at the five intertidal sites to the west of the cooling water outfall of the Existing Power Station and at Point Lynas, while between 2011 and 2014, populations were sampled at all intertidal sites where animals were present (see Section 4.2.2). The aim of the survey was to record population abundance and structure of typical, southern, warm-water species and to identify temporal changes in these populations.

The flat top shell (*Gibbula umbilicalis*) and thick top shell (*Phorcus lineatus* syn. *Osilinus lineatus*) were assessed in the region of the shore where they were most abundant with sampling methodology according to MarClim (2006) protocols. Five replicate searches were carried out for three minutes each, during which time, individuals were collected, including those on visible surfaces and in cracks and crevices or under stones. At each site, the abundance of each species collected during the searches was recorded and, depending on abundance, the basal width of all individuals collected or 100 randomly selected individuals were measured to the nearest millimetre.

4.3 Results

4.3.1 Biotope Classification

During the 2010 walkover of the shore between Trwyn Cemlyn and Cemaes Bay, an array of intertidal environments was identified with a wide variety of biological communities comprising eight broad habitats:

- Shingle (pebble) and gravel shores (LS.LCS.Sh);
- *Pelvetia canaliculata* and barnacles on moderately exposed littoral fringe rock (LR.MLR.BF.PelB);
- lichens or small green algae on supralittoral rock (LR.FLR.Lic);
- mussel and/or barnacle communities (LR.HLR.MusB);
- robust fucoid and/or red seaweed communities (LR.MLR.BF);
- fucoids in tide-swept conditions (LR.HLR.FT);
- polychaete/bivalve dominated muddy sand shores (LS.LSa.MuSa); and
- barren or amphipod dominated mobile sand shores (LS.LSa.MoSa).

4.3.1.1 Trwyn Cemlyn and Cemlyn Bay

Trwyn Cemlyn is the headland to the west of Cemlyn Bay. On the north-west-facing shore of the headland, the supralittoral was composed of shingle and boulders backed by a combination of rocky outcrops and coastal grassland. The mid and low shores were characterised primarily by fissured, shelving bedrock interspersed with small areas of boulders and cobbles. Similar substrata were present around the headland and into Cemlyn Bay, although, towards the channel between the bay and the saline lagoon, the shore was characterised by shingle and cobbles. Immediately to the west of the channel, further rocky outcrops were evident. To the east of the channel, the extensive ridge of shingle of Esgair Cemlyn extended throughout the north-east-facing inner shore of Cemlyn Bay forming the barrier between the bay and Cemlyn saline lagoon. The shingle ridge represents the Annex I habitat ‘perennial vegetation of stony banks’ and a qualifying feature of the Cemlyn Bay SAC.

The north-west-facing shore of the bay was characterised primarily by steep exposed rock which extended to the headland of Cerrig Brith where the rock substratum became less steep and was interspersed with fissures and boulders.

Throughout this area, the cobble shores were generally devoid of fauna and were classified as the biotope 'barren littoral shingle' (LS.LCS.Sh.BarSh). The upper- and mid-shore rocky platforms to the west of Trwyn Cemlyn supported communities typical of moderately exposed habitats with vertical successions from sparse growths of *Pelvetia canaliculata* and dwarf fucoids in the upper shore (LR.MLR.BF.PelB), abundant barnacles with limpets, littorinids and topshells in the mid shore (LR.HLR.MusB) and dense fucoids and kelp at low water (LR.HLR.FT). The rocky shore of Cemlyn Bay supported similar biotopes and included an area of dense fucoid algae and *Ascophyllum nodosum* towards the south-west corner of the bay in the mid-shore and low-shore zones.

4.3.1.2 Porth-y-pistyll Bay (includes Porth y Felin)

The intertidal areas of the bay were composed of a mosaic of habitats, ranging from muds and sands to exposed bedrock. Along the north-western shoreline of the bay, the upper shore was characterised by steep bedrock, while the mid- and lower-shore substrata were composed of bedrock and boulders; much of the eastern side of the bay was characterised by moderately exposed rocky platforms.

Throughout the bay, the rocky shore was characterised by communities typical of moderately exposed and sheltered habitats with vertical succession. This included lichens and *Pelvetia canaliculata* dominated communities in the upper shore (e.g. LR.FLR.Lic.YG and LR.MLR.BF.PelB), faunal and fucoid dominated communities on exposed and sheltered mid-shore zones respectively (e.g. LR.HLR.MusB.Sem.Sem and LR.MLR.BF.FvesB), and *Fucus serratus* and kelp communities along the low shore (e.g. LR.MLR.BF.Fser.R and IR.MIR.KR.Ldig.Ldig).

A freshwater stream drains at Porth y Felin, in the south-west corner of the bay. The substrata here contained a mix of gravelly, muddy sand covered in pebbles and shells, supporting, among other things, a mussel bed (LS.LBR.LMus.Myt.Mx) and also a *Fucus ceranoides* community (LR.LLR.FVS.Fcer), clearly showing the influence of the freshwater stream.

Other coves within the bay were characterised by shingle foreshores (LS.LCS.Sh.BarSh) and a mixture of muddy and mobile sands (e.g. LS.LSa.MoSa and LS.LSa.MuSa).

4.3.1.3 Porth y Gwartheg to Wylfa Head

From Porth y Gwartheg to Wylfa Head, the shore was very exposed and comprises a predominantly steep rocky cliff broken by steep-sided narrow inlets, particularly at Porth Wnal where the cooling water of the Existing Power Station discharges. Throughout this area, the upper shore supports yellow and grey lichens, the black lichen *Verrucaria maura* (LR.FLR.Lic) with *P. canaliculata* in less exposed areas (LR.MLR.BF.PelB). The mid shore was characterised by barnacles and limpets with very little macroalgal cover (LR.HLR.MusB), although the red algae *Porphyra umbilicalis* was present in places. At low water, dense swards of fucoids and kelp species dominated (LR.HLR.FT). The north-facing shore of Mynydd y Wylfa leading to Wylfa Head was particularly steep and exposed and was characterised by similar habitats in the vicinity of the Existing Power Station, although in places the rocks support little more than a few barnacles and limpets.

4.3.1.4 Wylfa Head to Trwyn y Parc

The coast to the east of Wylfa Head comprises a mosaic of steep rocky cliffs, rocky platforms and coves of shingle, sand and mud. Steep cliffs dominate the shore between Wylfa Head and Ynys Yr Ŵyn with the upper shore characterised by lichens (LR.FLR.Lic), with limpets and barnacles below (LR.HLR.MusB). Kelp and dense fucoids dominate in the low shore (LR.HLR.FT). At Ynys Yr Ŵyn, there was an area of rocks and boulders in the vicinity of the slipway which were covered by a dense growth of fucoids and the egg wrack *A. nodosum* (LR.HLR.FR) backed by a small shingle beach (LS.LCS.Sh). Eastwards to Porth y Wylfa, the shore was less steep with lichens (LR.FLR.Lic) at the top of the shore, below which a zone of *P. canaliculata* and dwarf fucoids with some *P. umbilicalis* was present (LR.MLR.BF.PelB). The mid shore was densely covered in barnacles with limpets and topshells present (LR.HLR.MusB), which gives way to dense fucoid and kelp (LR.HLR.FT) towards low water, and the cove at Porth y Wylfa was characterised by a shingle and cobble beach (LS.LCS.Sh). The shore to the east of the cove supports similar habitats as the west, although there are areas of broken rock where dense growths of fucoids and egg wrack occur (LR.HLR.FR). Cemaes Bay comprises primarily a large area of sand, which supports a community characterised by isopods, amphipods and polychaetes.

4.3.2 Species Assemblage Survey

4.3.2.1 Upper-Shore Community Assessment

Throughout the study area, the upper shore was characterised by bedrock with all sites being moderately to very exposed. The communities at all upper-shore sampling sites were assigned the biotope '*P. canaliculata* and barnacles on moderately exposed littoral fringe rock' (LR.MLR.BF.PelB).

From the 13 upper-shore sites, the number of taxa recorded ranged from 25 to 41 during the intertidal sampling programme. A list of all the taxa recorded from the upper shore is provided (Appendix B, Table B.3). The taxa were dominated by algae with molluscs and crustaceans sub-dominant. No INNS species were recorded on the upper shore during the programme.

In all years, the most commonly occurring and abundant taxa included the brown algae *P. canaliculata* and *Fucus spiralis*, the gastropod molluscs *Littorina saxatilis*, *L. littorea* and *P. vulgata*, and the lichen *Verrucaria maura*. Other taxa recorded during the programme included species of green algae and crustaceans.

4.3.2.2 Mid-Shore Community Assessment

From the 13 mid-shore sites, the number of taxa recorded ranged from 53 to 77 during the intertidal sampling programme. A list of all the taxa recorded from the mid shore is provided (Appendix B, Table B.4). The taxa were dominated by algae with molluscs and crustaceans sub-dominant. The INNS red algae *Asparagopsis armata* was recorded on the mid shore from site WI10 in 2013.

Other taxa recorded during the programme included species of sponges, cnidarians and bryozoans. Throughout the study period, the most commonly occurring taxa included the brown seaweeds *Fucus spiralis* and *F. serratus*, the red seaweeds *Lithophyllum* spp, *Corallina officinalis* and *Osmundea pinnatifida*, the gastropod molluscs *Patella vulgata*, *Gibbula umbilicalis* and *Nucella lapillus* and barnacles. In all years, the most abundant taxa throughout the mid-shore study area were *P. vulgata*, barnacles, *F. spiralis*, *G. umbilicalis* and *Lithophyllum* spp.

Two biotopes were identified at the mid-shore sampling sites:

- LR.MLR.BF.FspiB – *Fucus spiralis* on full salinity exposed to moderately exposed upper eulittoral rock. This biotope was recorded at six sites – site WI01 to the west of Trwyn Cemlyn; sites WI06, WI07 and WI13 on the west-facing shore of Wylfa Head; site WI09 at Trwyn y Penrhyn; and site WI10 at Trwyn y Parc. The communities at these sites were characterised by the brown seaweed *F. spiralis*, barnacles and the gastropod *P. vulgata*.

- LR.MLR.BF.Fser – *Fucus serratus* on moderately exposed lower eulittoral rock. This biotope was present at seven sites – sites WI02 and WI03 on the eastern side of Cemlyn Bay, site WI04 at Porth-y-pistyll, site WI05 south of the Existing Power Station jetty, site WI08 east of Porth yr Ogof, site WI11 at Lligwy Bay and site WI12 at Porth y Felin. The communities were characterised by relatively dense algal cover, particularly *F. serratus*, although *A. nodosum* and *F. spiralis* were also present. The most abundant fauna included the gastropods *P. vulgata* and *G. umbilicalis*.

The presence of *F. serratus* at a number of the quadrat stations over the survey period suggested that the mid-shore sites overlapped with the low-shore communities.

4.3.2.3 Low-Shore Community Assessment

From the 13 low-shore sites, the number of taxa recorded ranged from 52 to 100 during the intertidal sampling programme. A list of all the taxa recorded from the low shore is provided (Appendix B, Table B.5). The taxa were dominated by algae with molluscs and crustaceans sub-dominant. The INNS red algae *Asparagopsis armata* was recorded on the low shore from site WI09 in 2013.

Other taxa recorded during the programme included species of sponges, cnidarians, annelids, bryozoans and echinoderms. The most commonly occurring taxa included barnacles, the limpet *P. vulgata*, the brown algae *F. serratus* and the red algae *Lithophyllum* spp and *Mastocarpus stellatus*.

Two biotopes were identified at the low-shore sampling sites:

- LR.HLR.FR.Coff – *Corallina officinalis* on exposed to moderately exposed lower eulittoral rock. This biotope was recorded at seven sites – site WI01 to the west of Trwyn Cemlyn; sites WI06, WI07 and WI13 on the west-facing shore of Wylfa Head; site WI08 east of Porth yr Ogof; site WI09 at Trwyn y Penrhyn; and site WI10 at Trwyn y Parc. The communities at these sites were characterised by the red seaweeds *C. officinalis*, *M stellatus*, *Palmaria palmata* and *O. pinnatifida*, the encrusting algae *Lithophyllum* spp. and the limpet *P. vulgata*.

- LR.MLR.BF.Fser – *Fucus serratus* on moderately exposed, lower eulittoral rock. This biotope was present at six sites – sites WI02 and WI03 on the eastern side of Cemlyn Bay, site WI04 at Porth-y-pistyll, site WI05 south of the Existing Power Station jetty, site WI11 at Lligwy Bay and site WI12 at Porth y Felin. The communities were characterised by relatively dense algal cover, particularly *F. serratus*. The most abundant fauna included the gastropods *P. vulgata*, *Littorina obtusata* and *G. umbilicalis*.

4.3.3 Trochid Gastropod Survey

4.3.3.1 *Gibbula umbilicalis*

Considerable annual variability was evident in the mean numbers of *G. umbilicalis* recorded per search at each site, although in all years the number of animals at sites to the west of the Existing Power Station were appreciably higher than those recorded east of WI05 (see Figure 4-4). Between 2010 and 2014, the average number of *G. umbilicalis* recorded per search over the whole survey area varied between 35 (in 2011) and 54 (in 2012).

Throughout the study period, little spatial or temporal variation was evident in the mean width of *G. umbilicalis* (Figure 4-5). Between 2010 and 2014, the annual mean width of all animals collected varied between 14.7 mm (in 2010) and 15.6 mm (in 2012), while the mean widths recorded at each site ranged from 13.5 mm at WI01 and WI05 in 2010 to 17.2 mm at Point Lynas in 2012.

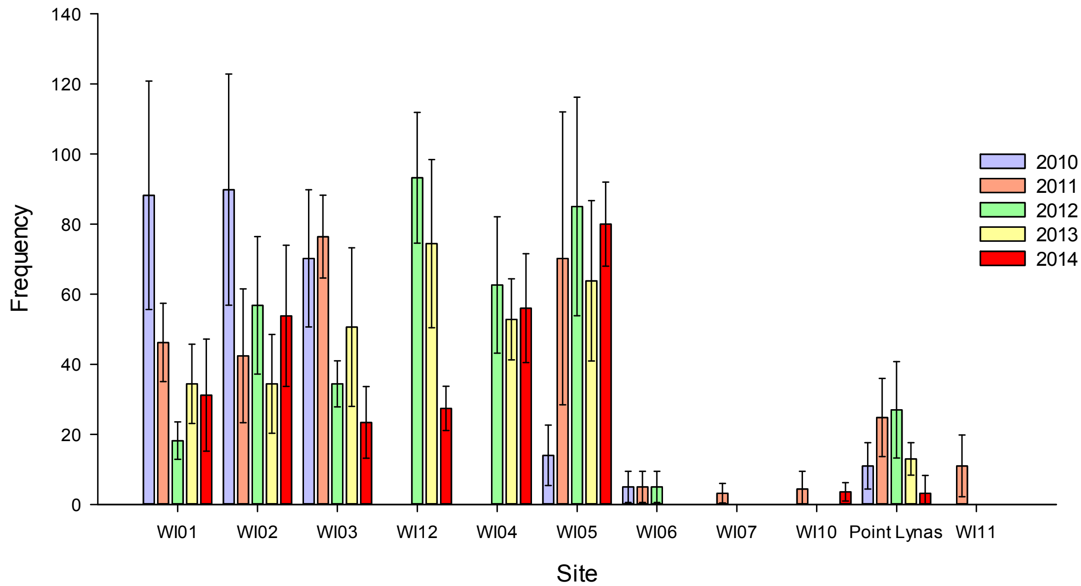

Figure 4-4: Mean number of *G. umbilicalis* recorded during timed searches between 2010 and 2014. Error bars represent the standard deviation. The sites are ordered from west to east.

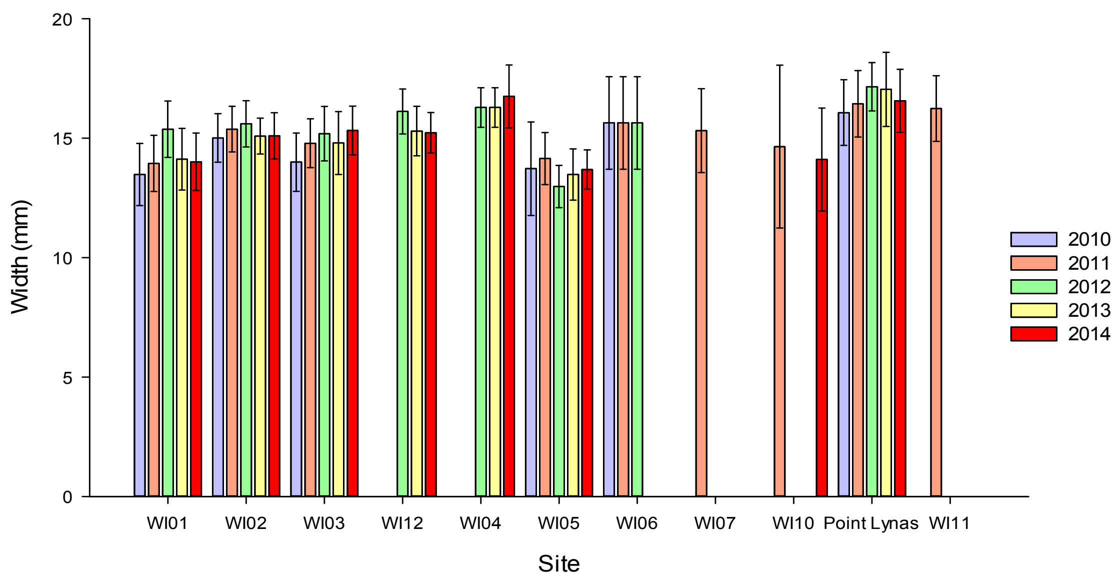

Figure 4-5: Mean width (mm) of *G. umbilicalis* recorded during timed searches between 2010 and 2014. Error bars represent the standard deviation. The sites are ordered from west to east.

The general population structure was similar between years and sites. However, low numbers of juveniles were recorded from WI03 and WI05, in 2010 and 2013 respectively. Likewise, the population structure at Point Lynas appeared to show two cohorts in 2010 and 2013, though these were not clearly discernible from the general population (Figure 4-6).

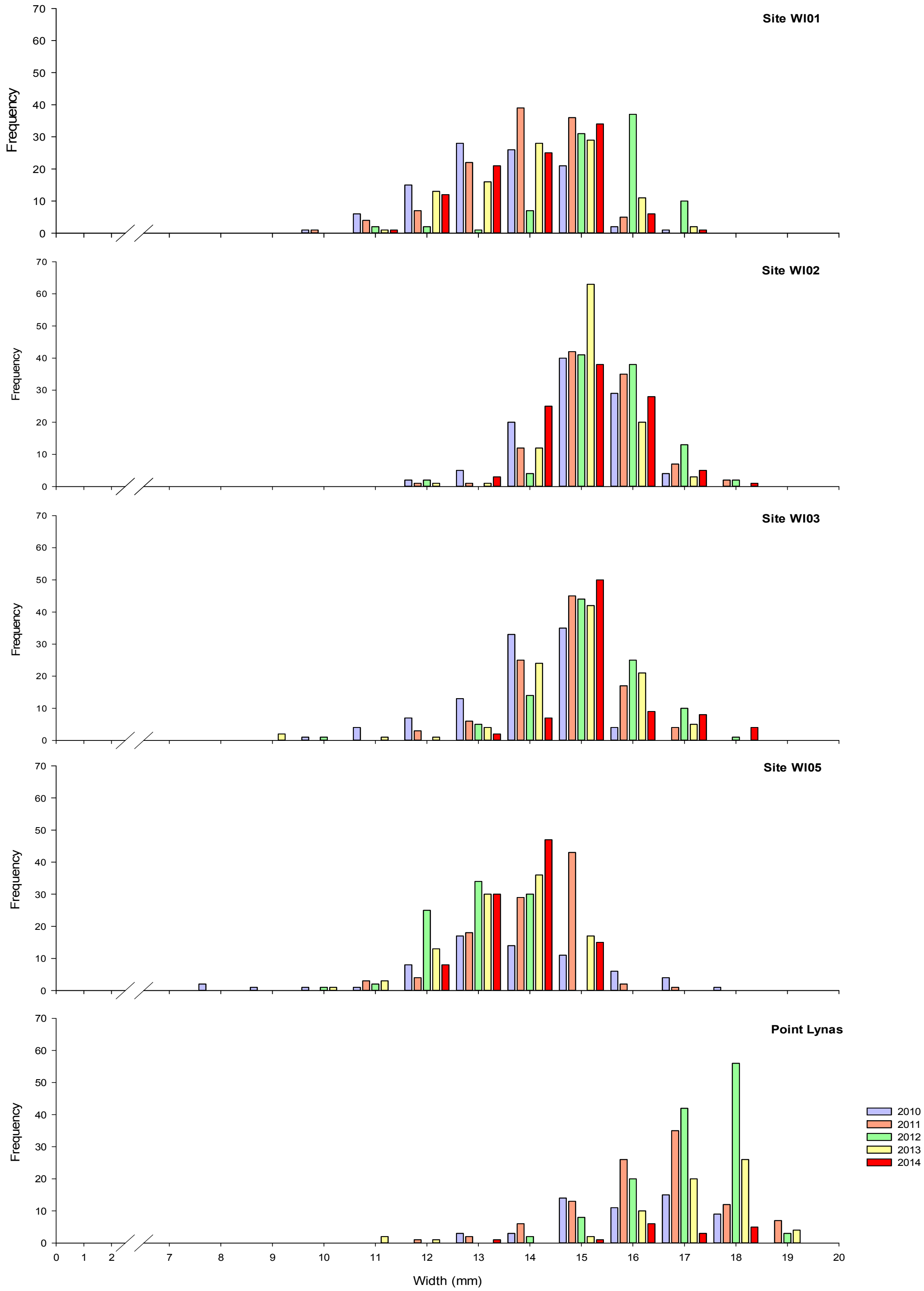

Figure 4-6: Size frequency of *G. umbilicalis* recorded at sampling sites along the north Anglesey coast from 2010 to 2014.

4.3.3.2 *Phorcus lineatus*

Throughout the study, *P. lineatus* was limited to the western most sampling sites, i.e. WI01 to WI05 and WI12. In 2010, individuals were only recorded at WI01 on the west-facing shore of Trwyn Cemlyn, while no individuals were recorded at any sites during the community quadrat assessments that year. In all subsequent years, *P. lineatus* were recorded at WI01 and WI02; however, their presence varied from year to year at the other sampling sites (Figure 4-7).

Where individuals were recorded at a site, the mean number recorded in a timed search was generally less than 20. A notable exception was at WI03 which recorded a mean number of >40 individuals in 2011; however, no individuals were recorded at WI03 in any other year.

Between 2010 and 2014, the mean number of individuals found per search at WI01 ranged between 7 (in 2011) and 20 (in 2013) and with a general pattern of increase at both WI01 and WI02 (Figure 4-7).

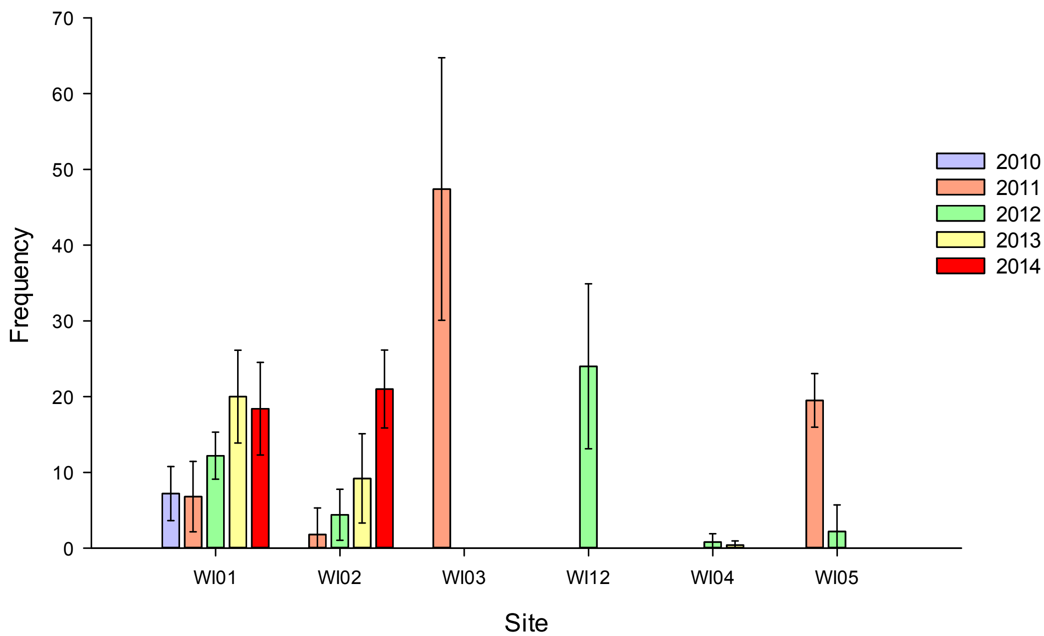

Figure 4-7: Mean number of *P. lineatus* recorded during timed searches between 2010 and 2014 at sampling sites along the north Anglesey coast. Error bars represent the standard deviation. The sites are ordered from west to east.

Between 2010 and 2014, the size of *P. lineatus* showed little spatial or temporal variation, with the annual mean width of all *P. lineatus* measured varying from 20.2 mm (2011 and 2013) to 21.1 mm (in 2010). The mean widths recorded at each site ranged from 17.5 mm (at WI04) to 21.7 mm (at WI02) (Figure 4-8). The mean width of *P. lineatus* at WI01 (the only site at which *P. lineatus* was recorded throughout the study) ranged from 20.1 mm (2011) to 21.3 mm (2012).

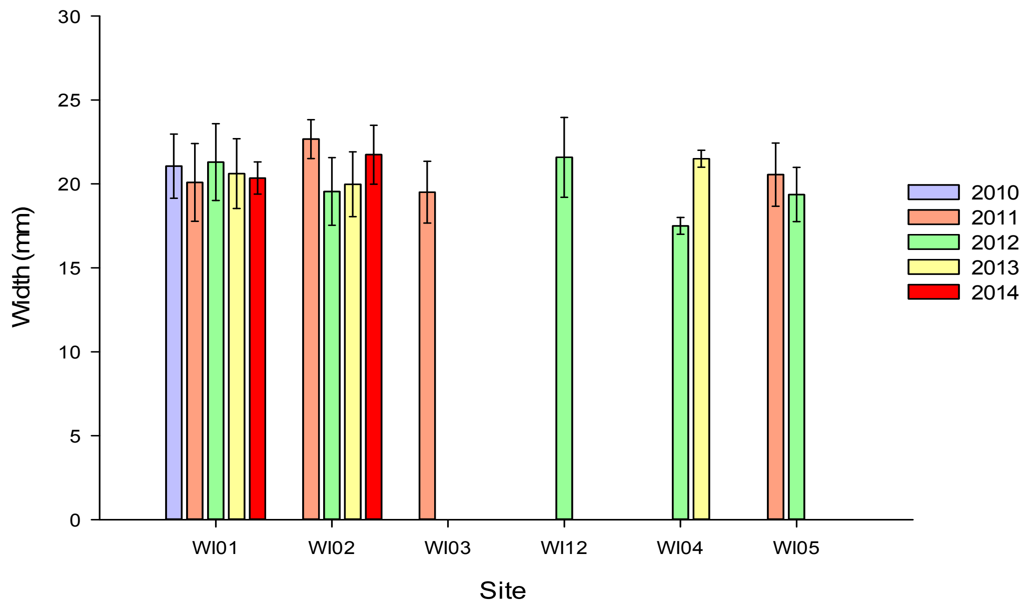

Figure 4-8: Mean width (mm) of *P. lineatus* recorded during timed searches between 2010 and 2014 at sampling sites along the north Anglesey coast. Error bars represent the standard deviation. The sites are ordered from west to east.

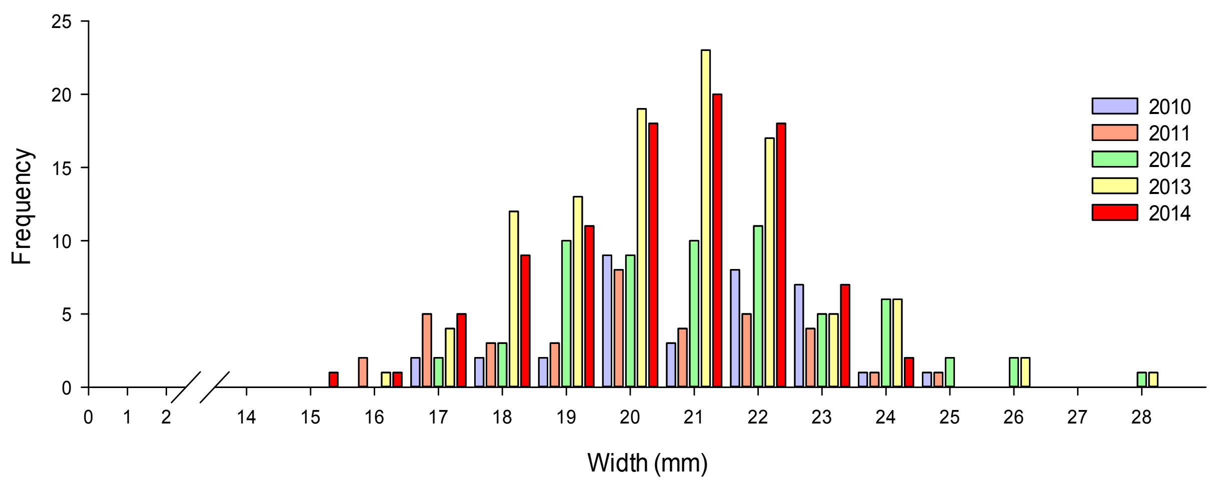

Figure 4-9: Size frequency of *P. lineatus* at WI01 recorded during timed searches between 2010 and 2014 at sampling sites along the north Anglesey coast.

Examination of the size frequency at WI01 showed a relatively similar population structure between years with no discrete cohorts identified and a generally similar size range. The majority of individuals recorded were represented by a width ranging from 19 mm to 21 mm (Figure 4-9).

4.4 Discussion

The walkover survey in 2010 confirmed that the distribution of the broad habitat types across the intertidal zone surveyed, from Trwyn Cemlyn to Cemaes Bay, reflected the distribution of habitat lifeforms identified during extensive biotope mapping carried out by NRW in 2003 (Figure 4-2). In subsequent years (2011 to 2014), the biotopes recorded at the intertidal sampling sites remained the same with the same characteristic species present, though the community composition varied.

The species complement and the communities recorded in the present study were typical of the habitats sampled and characteristic of the wider geographical area, with primary influences on their presence related to physical variables such as substratum, exposure and tidal height.

Of the biotopes recorded during the intertidal benthic study, several are listed within the habitats of principal importance for the purpose of maintaining and enhancing biodiversity in relation to Wales (Section 7 priority habitats). These were:

- blue mussel (*Mytilus edulis*) beds on littoral mixed substrata (LS.LBR.LMus.Myt.Mx);
- *Fucus ceranoides* on reduced salinity eulittoral rock (LR.LLR.FVS.Fcer); and
- coastal saltmarsh (LS.LMp.Sm).

All of the above biotopes were recorded from Porth-y-pistyll bay but are not considered particularly extensive in their coverage, cumulatively occupying approximately 1 ha in total. A focused biotope survey of Porth-y-pistyll bay provides further detail on these features in Appendix D13.03 Porth-y-pistyll biotope surveys (Application Reference Number: 6.4.85).

One of the qualifying features of the Cemlyn Bay SAC is the Annex I listed habitat ‘perennial vegetation of stony banks’ which comprises the shingle ridge that borders the saline lagoon at Cemlyn. Though not a marine feature in its own right, this feature occupies the area immediately inland of the upper shore where the shingle is reasonably stable.

Elsewhere, the majority of the intertidal area surveyed is fissured bedrock, this often forming a continuation with the sublittoral rocky habitats. Where the geogenic reef extends from the sublittoral uninterrupted into the intertidal (littoral) zone it is considered an example of ‘reef’ habitat as described under Annex I of the European Habitats Directive. This feature is present over considerable areas of the UK coastline, including extensive parts of the Anglesey coast.

Throughout the study period, the upper-shore communities at all sampling sites were assigned the biotope *P. canaliculata* and barnacles on moderately exposed littoral fringe rock (LR.MLR.BF.PelB). At the mid-shore sampling sites, the biotopes comprised fucoid communities of either *F. spiralis* or *F. serratus*. Although both communities are commonly recorded along the coastline, the recording of the characteristic *F. serratus* low-shore community, within the supposed mid-shore zone, highlights the blurring of the rocky shore zonation on the often heterogeneous topography of the rock forms in the study area. Rocky shore zonation is well studied, and though the archetypal zonation of rocky communities is understood, the transitional zones between one community and the next are often changing and not well delineated (e.g. Lewis, 1964). The north Anglesey coastline is typified by rugged, rocky intertidal areas, and hence, uniform sampling at defined intertidal zones is not always possible. For this reason, the frequent records of *F. serratus* within the expected mid-shore zone are not surprising within this study.

At the low-shore intertidal sampling sites, the biotopes recorded are characteristic of exposed to moderately exposed rocky shores inhabited by species typical of these environments. The records of the kelp *L. digitata* seaward of these low-shore communities indicate the proximity to the infralittoral fringe, the area defined by the shallowest point of the sublittoral zone. This zone, and thus the *L. digitata*, can potentially be immersed during large spring tides.

The intertidal sites WI06 and WI07, were the nearest to the location of the Existing Power Station outfall, lying to the west and east, respectively, from the mouth of the channel. The biotopes at these sites were the same at each upper, mid and low shore, being represented by *Pelvetia canaliculata* and barnacles on moderately exposed littoral fringe rock, *Fucus spiralis* on full salinity exposed to moderately exposed upper eulittoral rock, and *Corallina officinalis* on exposed to moderately exposed lower eulittoral rock, respectively.

Throughout the study the composition of the communities varied at WI06 and WI07, as at other sites, but the biotopes remained constant at each of the shore heights. In terms of total taxa, it was noted that slightly less than the mean low-shore taxa recorded during a given sampling year was recorded at WI06 and, conversely, slightly higher at site WI07. Cover of green algae, such as *Ulva lactuca* and *Ulva intestinalis* (syn. *Enteromorpha intestinalis*), was consistently higher at the low shore of WI06 when compared to the other sampling sites, and is considered indicative of disturbance such as greater wave action, this site being more exposed than many of the sampling sites. Green algae such as *U. lactuca* and *U. intestinalis* are rapid colonisers of bare rock and tolerant of freshwater runoff (e.g. Lewis, 1964).

Studies of the infralittoral communities within the outfall channel noted the absence of kelp within 100 m of the cooling water outfall in Appendix D13.05 Marine and ecological baseline at the Cooling Water outfall of the Existing Power Station (Application Reference Number: 6.4.87) and an increase in the green algae *Cladophora* sp., *Bryopsis* sp. and *Codium fragile.* Occasional records of *Cladophora* sp. were found at WI06 and WI07, though this species was found in greater abundances to the east of WI06. The alga *Codium fragile* is an INNS; however, there are no distinct records of this species from the present study. There is a single record of *Codium* spp. throughout the study, this being recorded at the low shore of WI06 in 2011. Yet this may constitute the native species of the *Codium* genus, though determination of the *Codium fragile* subsp. is notoriously difficult, often requiring DNA analysis.

The only confirmed records of INNS during the present study were at sites WI09 and WI10, in 2013, when the harpoon weed *Asparagopsis armata* was recorded. This was also recorded during the dive surveys in Appendix D13.05 Marine and ecological baseline at the Cooling Water outfall of the Existing Power Station (Application Reference Number: 6.4.87).

4.4.1 Trochid Gastropods

Results from the MarClim project have shown that the typically southern, warm water species of gastropods such as *P. lineatus* and *G. umbilicalis* have extended their range since the mid-1980s in Wales (MarClim, 2017). However, work by Crisp and Knight-Jones (c.f. Lewis, 1964) indicated that Wylfa Head represented the northern and eastern limit of *P. lineatus*, and a much more recent study by Mieszkowska *et al*. (2007) confirmed this limit. Therefore, the absence of any *P. lineatus* east of Porth-y-pistyll bay in this study aligns with these historical studies.

Being at the edge of its range it is not surprising that the western-most sampling site (WI01) recorded the greatest numbers of *P. lineatus*, with a clearly detectable drop in abundance heading eastwards until an absence of records is reached east of Porth-y-pistyll.

It has been suggested that the strong tidal flows present a natural barrier to the eastward spread of *P. lineatus* along the north Anglesey coast (Lewis, 1964). However, by contrast, *G. umbilicalis* was recorded much further to the east within the present study, with individuals recorded at Lligwy Bay (WI11), approximately 20 km to the east of Wylfa Head, albeit only in 2011.

Crisp and Knight-Jones (c.f. Lewis, 1964) did not record *G. umbilicalis* along the eastern side of Anglesey in the 1950s; however, there are now a number of records for this species along the same stretch of coastline (NBN Atlas, 2017). As with *P. lineatus*, the present study shows a clear decrease in abundance of *G. umbilicalis* east of Porth-y-pistyll bay, with records being infrequent except at Point Lynas where they were recorded in every sampling year.

Unlike *P. lineatus*, possible year classes were observed within the population structure of *G. umbilicalis*. Most notable were the low numbers of juveniles recorded at WI05, potentially indicating a self-supporting breeding population. At Point Lynas, abundances of *G. umbilicalis* were too low to discern the clear presence of year classes, though a few smaller individuals were recorded. However, the numbers and size of individuals recorded in the present study are reflective of established populations of *G. umbilicalis* populations on the north-western Anglesey coastline and, to a lesser extent in the east, at Point Lynas.

5. Subtidal Communities – Wylfa Newydd Development Area

5.1 Introduction

Many natural factors affect the distribution and structure of macrobenthic communities, such as substratum, salinity and currents. Similarly, anthropogenic inputs into marine systems can influence benthic communities. The coastal waters around Anglesey receive a variety of inputs from both domestic and industrial sources and chronic contamination of sediments and associated biota are known (Foster *et al*., 1978; Rainbow *et al*., 1999; Zhou *et al*., 2003). As benthic species represent a significant food resource to predators such as fish and birds, monitoring changes in the subtidal benthic macrofaunal communities can facilitate the assessment of effects on the wider ecosystem.

Remote methods of rapidly assessing the subtidal benthic environment can be achieved through DDC surveys. This provides a means of gathering data over a wide area and at numerous sites within a relatively short period, and also from areas where grabbing is not possible. Data generated from image analysis allow biotope codes to be generated, supplementing data obtained from the grab sampling and assisting with habitat mapping and characterisation.

As bed sediments act as the ultimate sink for contaminants in marine environments, the benthos of sedimentary habitats is ideal for characterising many aspects of environmental quality and for monitoring effects associated with anthropogenic influences. Sediment-dwelling macrofaunal communities are often used for marine environmental monitoring: they can be quantitatively sampled by grab sampling; are at most risk of exposure to contaminants; and, as they are short -lived, demonstrate comparatively rapid responses to deleterious effects at the community level.

This chapter first presents the findings of the DDC surveys carried out around north Anglesey and within the Wylfa Newydd Development Area in June 2010 and April 2011. This is followed by the interpretation of data gathered through faunal grab surveys undertaken in May 2010 and 2011, and in July 2015.

The purpose of this work is to assess and describe the subtidal benthic environment of the area and to identify any potential features of conservation importance (e.g. Annex I habitats and Section 7 priority species and habitats).

5.2 Methods

5.2.1 Site Selection

5.2.1.1 DDC Sites

The survey fieldwork was carried out by Aquatech, on behalf of Jacobs. In 2010, between the 4th and 7th of June, a total of 68 sites (prefixed by 'DDC') were surveyed (Figure 5-1). A large number of sites were selected to facilitate the characterisation of the seabed within the Wylfa Newydd Development Area, and the surrounding north Anglesey coast, particularly as large swathes are difficult or impossible to sample by other means.

Following the 2010 survey, a number of sites were dropped from the programme; the rationale for this is given in Table 5.1. Subsequently, further sites were added for the 2011 survey (sites 58-75) resulting in a total of 54 sites surveyed between the 27th and 28th April (Figure 5-1).

Table 5.1 : Rationale for omitting previous (2010) DDC sites in 2011.

DDC Survey sites	Selection criteria
4	The environment was not conducive with DDC; site also covered an area that is dive surveyed.
8	Same biotope as site 7 and almost at same location.
11	Site environment was not conducive to DDC methodology.
25-29; 32-33	All these sites had an environment that was not conducive with DDC methodology. In addition, sites 25-26 and 32-33, in Porth-y-pistyll, overlap the dive survey area.
38, 40	These sites were in a group of DDC sites all showing similar habitat. To further characterise the area, these were dropped and new sites allocated.
43, 44	Not conducive with DDC methodology. Grab samples used to characterise these habitats.
49	Rationalising sites, moved to grab site at 59.
54-57	Sites were purely to inform trawl surveys. Not required in 2011.

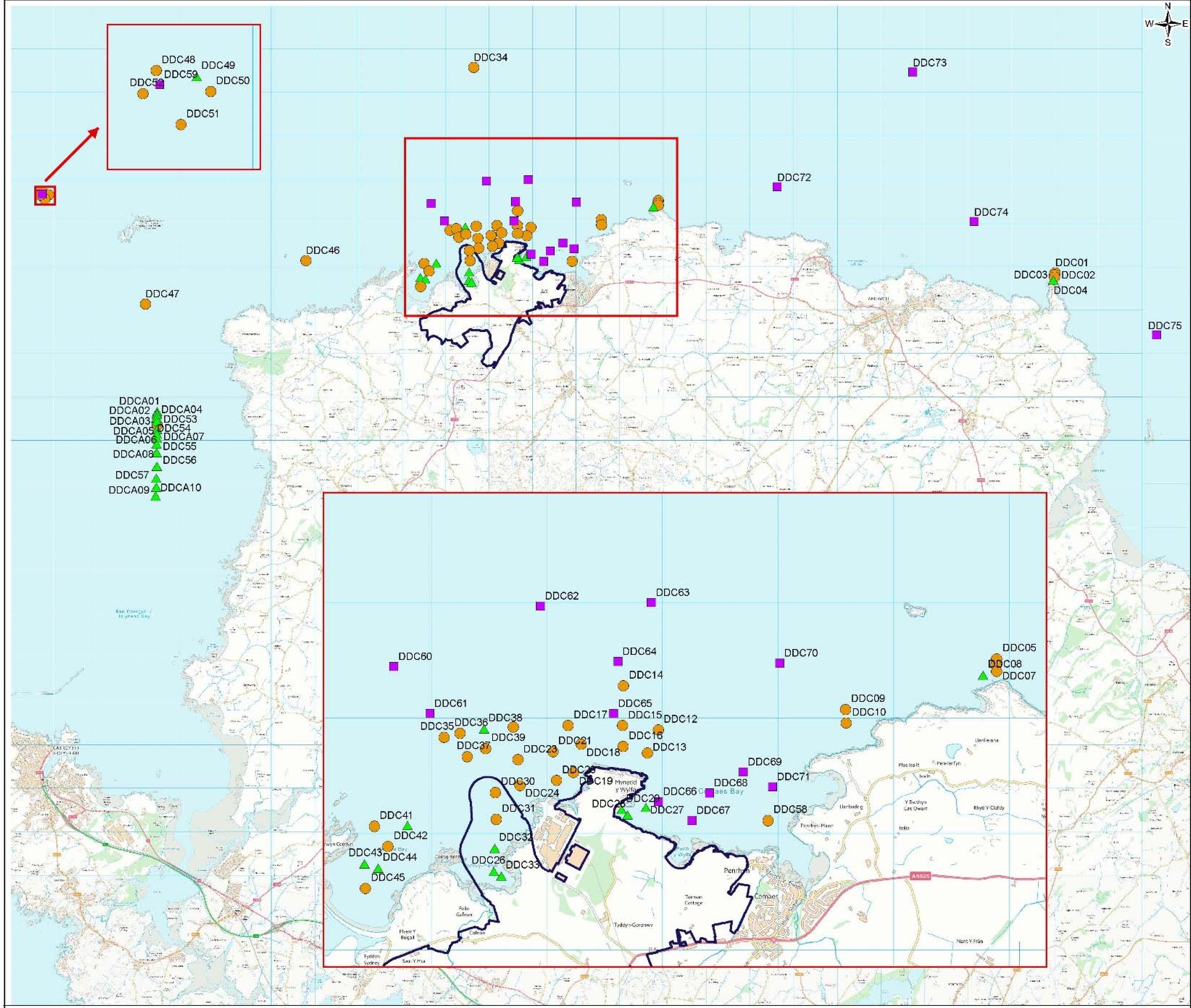

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FIGURE 5-1

Legend

Wylfa Newydd Development Area Boundary

Drop Down Camera Sites

- Sites monitored in 2010 and 2011
- Sites monitored in 2010 only
- Sites monitored in 2011 only

Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	JUNE 17	Initial Issue	VG	CT	EC	RB

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Churchill House, Churchill Way, Cardiff, CF10 2HH
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Client

HORIZON NUCLEAR POWER

Project

WYLFA NEWYDD PROJECT
ENVIRONMENTAL STATEMENT
WYLFA SUBTIDAL BENTHIC REPORT

Drawing Title

WYLFA NEWYDD DEVELOPMENT AREA
BENTHIC SURVEY
DROP DOWN CAMERA SITES 2010 AND 2011

Drawing Status

Scale @ A3	1:85,000	DO NOT SCALE
Jacobs No.	60PO8077	
Client No.		
Drawing No.	60PO8077_DCO_D_13_05_01	

5.2.1.2 Faunal Grab Sites

2010 and 2011

The results from the mid-shore geophysical survey undertaken during 2009 in Appendix D12.01 Coastal Geoorphology baeline for the Wylfa Newydd Project - 2014 (Application Reference Number: 6.4.80) were used to assist with site selection (allowed avoidance of known hard ground), along with admiralty chart data to provide information on water depths. Sampling sites (prefixed by 'WS') were selected to fall within varying proximity to the Existing Power Station and to provide suitable coverage of the Wylfa Newydd Development Area, and in 2010, 25 potential target sites had been identified.

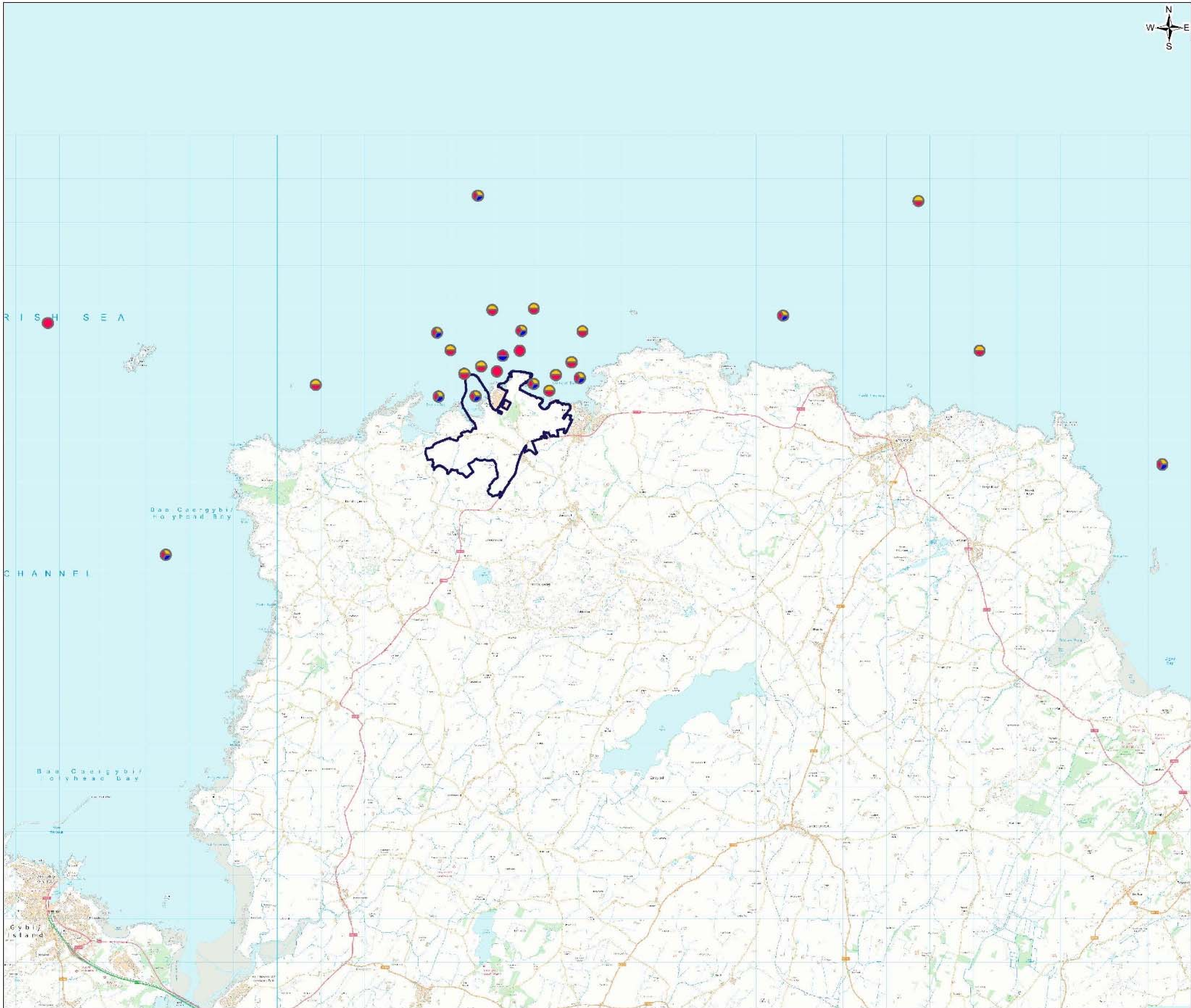
A total of 22 of the target sites were sampled in 2010. In 2011, 23 of the target sites were sampled, with three further locations added to the programme, to the north and west of Wylfa Head, within the vicinity of the proposed Cooling Water outfall of the Wylfa Newydd Power Station (WS26-WS28).

2015

Survey sites in 2015 were selected to represent those sampled in the baseline surveys undertaken in 2010 and 2011. The sampling sites fall within varying proximity in relation to the Existing Power Station to encompass suitable spatial coverage of the Wylfa Newydd Development Area. The 11 sites chosen for the 2015 survey were as follows: WS3, 5, 7, 13, 14, 16, 18, 20, 24, 25 and 27. These sites allowed a representative comparison with the 2010 and 2011 data without having to repeat sampling at all survey locations (see Figure 3-2).

Location of all sites sampled in 2010, 2011 and 2015 are illustrated in Figure 5-2 and positional data are available upon request.

FIGURE 5-2



Legend

Wylfa Newydd Development Area

Subtidal faunal sites

Sampled in 2010

Sampled in 2011

Sampled in 2015

0	JUN 17	Initial Issue	FT	CT	EC	RB
Rev	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd

Client

HORIZON NUCLEAR POWER

Project

WYLFA NEWYDD PROJECT
ENVIRONMENTAL STATEMENT
WYLFA SUBTIDAL BENTHIC REPORT

Drawing Title

WYLFA NEWYDD DEVELOPMENT AREA
FAUNAL GRAB SITES 2010-2011 AND 2015

Scale @A3	1:85,000	DO NOT SCALE
Jacobs No.	60PO8077	
Client No.		

Drawing No.

60PO8077_DCO_D_13_05_02

5.2.2 Sampling

5.2.2.1 DDC

Site positional data were programmed into the navigation and survey computers. The research vessel then approached each station in a head-to-tide direction. A dynamic positioning system was used to ground-stabilise the vessel with the 'A' frame pulley and camera directly over the site.

Once stable, dynamic positioning was achieved, the DDC cage was deployed and lowered to a few metres above the bottom before being slowly lowered the remaining distance to the seabed, thus reducing disturbance of bed sediments which may reduce visibility. Once the cage touched the seabed and a photographic image taken, the position was fixed.

Following the initial photographic image being taken, the cage was lifted a few metres above the bed for a short period, before being lowered again and a further image captured; at the majority of sites, three photographic images were taken. As the vessel had dynamic positioning engaged, subsequent images were very close to the original reference co-ordinates (within a radius of 2 m to 5 m); consequently, only a single position fix was recorded at each site. This methodology was employed for both the 2010 and 2011 surveys.

A number of high-resolution, digitally enhanced still images were obtained at each site using an Olympus SP350 camera. Generally, a minimum of three images (or replicates) were taken per site; however, at a number of sites where poor conditions were prevalent, fewer images were captured. At sites with interesting features, or when image quality was poor, additional images were taken. All images are available upon request.

All images were taken with the same settings and camera height so depicted objects could be scaled from the images if required. On a flat seabed, the image dimensions were 600 mm wide by 450 mm high, and the image size was 3264 x 2448 pixels. Images were tagged with full Exif data and overlaid with an image and site number.

5.2.2.2 Faunal Grab sampling

Quantitative subtidal benthic samples from sedimentary habitats have, as standard, been collected by grabs. Sampling was undertaken using a Hamon grab, which has proved to be reliable in collecting material from coarse sediments, such as gravel and cobbles, which are common throughout the study area (see Section 3.2.2 for a description of the Hamon grab). In 2010, a 0.25 m^2 Hamon grab was deployed from the Research Vessel (RV) *Prince Madog*. However, in 2011, the smaller vessel RV *Coastal Guardian* was used, which necessitated the use of a smaller sampling device and consequently a 0.1 m^2 mini Hamon grab was employed[5] .

Samples were collected within 50 m of each WS site with precision and accuracy attained by the use of GPS (Global Positioning System). Three replicate grabs were collected at each site for biological analysis with a further sample collected from which sediment was taken for physicochemical analyses (see Section 3 for methods and results). Biological samples were washed over a 1 mm (BS410) sieve, with all material retained on the sieve fixed in a 4 % formaldehyde solution.

[5] In 2010, sampling was undertaken from the RV *Prince Madog* using a 0.25 m^2 Hamon grab. Due to vessel availability in 2011, sampling was undertaken using the Environment Agency coastal survey vessel RV *Coastal Guardian*. Due to its much smaller size, RV *Coastal Guardian* was unable to operate the large Hamon grab due to inadequate clearance over the stern and limited deck space. Consequently, a 0.1 m^2 Hamon grab was utilised for the 2011 sampling programme, as this smaller device does not present the operational difficulties related to the larger grab associated with use on small vessels. A comparative study of 0.25 m^2 and 0.1 m^2 Hamon grabs was conducted by Cefas (Boyd *et al.,* 2006). Results showed that, although the larger grab collected a greater number of individuals per grab, the smaller device sampled a greater number of taxa per unit area. Although analysis of the data indicated that individual replicate samples from the two grabs were statistically different, when the data were scaled to the same area, any differences were insignificant. As replicate data are combined at each site to produce data for analysis, it was considered that use of the smaller grab in 2011 would not introduce a significant bias to the data.

5.2.3 Laboratory Analysis of Faunal Grabs

In the laboratory, samples were first drained over a 125 μm sieve to remove the formalin and to elutriate some of the fauna, thereby reducing damage to the organisms. Following this, the samples were washed over stacked sieves of 4, 2 and 1 mm to facilitate the removal of fauna from the residue. Subsequently, all fauna were picked from the residue fractions and specimens identified and enumerated. Fauna were identified to species level where possible using the most up-to-date keys and low- or high-powered microscopes where appropriate. The laboratory analysis was undertaken in accordance with the guidelines for processing marine macrobenthic invertebrate samples (see Worsfold *et al.,* 2010) and a minimum of 10 % of all samples were re-analysed for internal quality assurance for sample processing[6]; this was carried out for both the extraction of fauna and for identification. Nomenclature followed that of the World Register of Marine Species online database (WoRMS) (WoRMS Editorial Board, 2016). In addition to species abundance, biomass was also determined. Each taxon was blotted dry on absorbent paper and bulk weighed to 0.0001 g.

5.2.4 Data Analysis

5.2.4.1 DDC

The still images viewed at 1:1 provided the means to identify and measure seabed features and biota. All taxa were identified to the lowest possible taxonomic level using relevant keys and photographic guides (e.g. Hayward and Ryland, 1995) and internal Quality Control of images undertaken by an equally or more experienced marine ecologist. Taxa were semi-quantified using the SACFOR scale of abundance and biotope codes ascribed. See Appendix B, Section B.2 for SACFOR reference table. Prior to analysis, the taxa recorded across the DDC sites were checked for the most up-to-date nomenclature information using the WoRMs online database (WoRMS Editorial Board, 2016).

Analysis of the data allowed the designation of biotope codes and exploration of any spatial community patterns. The analysis is summarised in Table 5.2 below and detailed further in the corresponding appendices listed under the 'Reference' column. At those DDC sites where grab samples had also been taken, codes were finalised with consideration and inclusion of the faunal grab data in the assessments.

Table 5.2 : Summary of the range of statistical analysis undertaken on the DDC images, and to what purpose.

Data	'Test'	Software	Purpose	Reference
Raw counts and percentages per m^2 converted to SACFOR scale	n/a Biotope Classification	n/a	To classify habitats and assign biotope codes for each of the DDC sites sampled in 2010 and 2011 (after Conner *et al.,* 2004) and to visualise the different assignations spatially.	Appendix B, Section B.2 Appendix C, Section C.1.2
SACFOR scores converted to numerical values	CLUSTER and SIMPROF	PRIMER	To provide structural information on the DDC communities sampled and test if groups are not significantly different from each other based on converted SACFOR scores. Factors also analysed included exposure and depth.	Appendix C, Section C.1.3 Appendix C, Section C.3
As above	MDS	PRIMER	To provide a visual representation of any pattern of change in community composition spatially and between the two sampling years (where appropriate). Factors also analysed included exposure and depth.	Appendix C, Section C.1.3 Appendix C, Section C.3
As above	SIMPER	PRIMER	To identify those taxa that contributes to overall similarity and dissimilarity between groups (e.g. sites).	Appendix C, Section C.3

[6] Jacobs taxonomists participate in the North East Atlantic Marine Biological Analytical Quality Control Scheme

5.2.4.2 Grab Community Data

In order to analyse the subtidal grab communities, a suite of statistical analysis was undertaken to assess ecological quality and to explore community and biodiversity patterns. Table 5.3 summarises the analysis applied, and further details of data management can be found in the corresponding appendices cited in the 'Reference' column of the table.

Assessments of potential Annex I features (e.g. Sabellariidae aggregations) were undertaken, following appropriate assessment guidelines (see Section 'Annex I Habitat Assessment' listed below for further details).

For validation of the 2010 and 2011 data, the 11 sites sampled in 2015 that had also been sampled in 2010/2011 were analysed only. Ten of the sites had been sampled in all three years, but WS27 was sampled in 2011 and 2015 only.

Table 5.3 : Summary of the range of analyses undertaken on the faunal grab data, and to what purpose.

Analysis type	'Test'	Software	Purpose	Reference
Ecological quality	Infaunal Quality Index (IQI)	IQI Workbook UKTAG v01.	Multi-metric WFD tool from which 'ecological status' can be assigned to the sampled subtidal sedimentary community.	Appendix C, Section C.2.1
	Dominance Plot routine (DOMPLOT)	PRIMER	Investigation of abundance/biomass patterns to indicate possible stressed populations.	Appendix C, Section C.2.1 Appendix C, Section C.3
Population features	DIVERSE	PRIMER	Calculation of diversity indices for the sampled community.	Appendix C, Section C.2.2 Appendix C, Section C.3
Community patterns	CLUSTER and SIMPROF	PRIMER	To provide structural information on the communities sampled based on total abundances at each site for each year.	Appendix C, Section C.2.3 Appendix C, Section C.3
	MDS	PRIMER	To provide a visual representation of any pattern of change in community composition spatially and temporally across the WS communities.	Appendix C, Section C.2.3 Appendix C, Section C.3
	ANOSIM and SIMPER	PRIMER	To test for spatial and temporal differences in the communities sampled between 2010 and 2015, and to identify which taxa were important contributors to dissimilarities between communities.	Appendix C, Section C.2.3 Appendix C, Section C.3
Biotope classifications	n/a	n/a	To classify habitats and assign biotope codes for each of the grab sites sampled (after Conner *et al.,* 2004).	Appendix C, Section C.1.2
Biodiversity	TAXDTEST ('Expected distinctness test')	PRIMER	Calculation of AvTD and VarTD (taxonomic distinctness indices) plotted against those from expected 'master list' of the study area, and visualised with funnel plots.	Appendix C, Section C.2.4 Appendix C, Section C.3
Sabellariidae aggregations	DIVERSE	PRIMER n/a	Calculation of Shannon-Weiner (H') diversity indices to be used conjunction with assessment for Sabellariidae aggregations. Assess aggregations of Sabellariidae present for 'reefiness' according to Gubbay (2007).	Appendix C, Section C.2.2 Appendix C, Section C.3

Analysis type	'Test'	Software	Purpose	Reference
	Sabellariidae assessment			'Annex I Habitats' section in 5.2.4, below

5.2.4.3 Annex I Habitats

It was expected that aggregations of Sabellariidae worms may be recorded during the DDC and grab surveys. The Sabellariidae worm *Sabellaria spinulosa* and its congener *Sabellaria alveolata* can create biogenic reef structures that are recognised as an Annex I feature under 'Reefs'.

Assignment of Sabellariidae biotopes, specifically biogenic reef complexes, can be problematic (see Limpenny *et al*., 2010), as this polychaete genus and its associated structures characterise several biotopes, specifically subtidal biotopes with *Sabellaria spinulosa*. To assist with discrimination of these biotopes, the proposals put forward during an inter-agency workshop were considered (Gubbay, 2007) along with the specific definition as given within the *Interpretation Manual of European Union Habitats* (European Commission, 2007). The outputs of the inter-agency workshop and a Natural England report (Limpenny *et al.,* 2010) were then applied, where appropriate, to the grab sample and DDC data to help determine whether the Sabellariidae community sampled constituted a 'biogenic reef'.

The criteria of tube elevation along with extent and patchiness of the Sabellariidae aggregations are considered key elements for the assessment of biogenic reef according to the Habitats Directive definition (Table 5.4). Elevation was observed by retrieval of reef fabric in the grab samples, and assumptions made on the extent and patchiness (% cover); these latter attributes being derived from the number of grab replicates, at a specific sample site, that recorded Sabellariidae aggregations. Where DDC sites overlapped with the grab locations, a further review was carried out on the Sabellariidae aggregations. This enabled direct visual records of elevation, and helped with perception of aggregation patchiness and extent. Sabellariidae recorded in the DDC surveys are cited in Section 5.3.2 and detailed assessments outlined in Section 5.3.8.

Other reef attributes discussed during the Gubbay (2007) and Limpenny *et al.* (2010) reports, specifically for *S. spinulosa*, were considered in line with the data gathered on the faunal grab surveys. These included density (no. of individuals per m^2), associated biodiversity and, where repetitive annual sampling had been carried out, potential longevity of the feature.

Table 5.4 : Threshold ranges proposed by Joint Nature Conservation Committee (JNCC) workshop participants for the reef characteristics of elevation, spatial extent and patchiness, which could be used in combination to determine whether an area might qualify as a *S. spinulosa* reef. Note that the figures are presented as a starting point for wider discussion rather than accepted and fully agreed thresholds for *S. spinulosa* reef identification (Gubbay, 2007).

Characteristic	Not a reef	Reefiness Score		
		Low	Medium	High
Elevation (cm) Av. tube height	<2	2–5	5–10	>10
Extent (m^2)	<25	25–10.000	10.000–1,000,000	>1,000,000
Patchiness (% cover)	<10	10–20	20–30	>30

5.3 Results

By using a combination of DDC and grab methodologies, the Wylfa Newydd Development Area surveys recorded a range of benthic habitats across the north Anglesey coast, with a diverse range of species supported within these subtidal areas.

From the DDC surveys in 2010 and 2011, the key habitats and species are first described, with resulting biotopes listed and illustrated spatially with spatial and temporal community patterns explored. Modification to biotope ascriptions were then made following grab samples analysis, and records of any conservation features detailed.

The benthic faunal grab communities of 2010 and 2011 were assessed using the WFD IQI assessment tool and with reference to measures of potential community 'stress' as determined by abundance-biomass curves. Population and community features were explored and biodiversity patterns determined. The presence of any Sabellariidae in the grab samples was assessed for their 'reefiness' as a potential Annex I habitat feature, and the inclusion of the 2015 data here permits validation of all communities sampled in 2010 and 2011.

5.3.1 DDC – Key Habitats and Species

A total of 135 taxa were recorded between 2010 and 2011. A complete list of taxa identified across all the sites surveyed in 2010 and 2011 is provided (Appendix C, Table C.1). None of the taxa identified in 2010 and 2011 were classified as UK BAP priority species, or listed under Section 7.

The habitats encountered during the surveys fell into two broad categories. The first are habitats characterised by their exposed, tide-swept nature, and although the substratum may differ within this group, all sites are relatively free of silt and fine sediments. These habitats are typically from the exposed headland sites and offshore reference locations. The second category consists of habitats that are more sheltered and thus have a greater proportion of silt and fine sediments as there is less wave and tidal energy to disperse the finer particles. These habitats are typically from the sheltered bays and coves found close to Wylfa Head. Multivariate analysis, as shown in Section 5.3.3, further illustrates this high-level dichotomous split of communities with reference to exposure.

In both years, the most commonly recorded taxa were all characteristic of exposed, tide-swept locations. *Urticina* spp., *Flustra foliacea* and *Hydrallmania falcata* were widely common in both years and with *Alcyonidium diaphanum* and *Spirobranchus* sp. also commonly recorded in 2010 and 2011, respectively (Figure 5-3).

A large expanse of the seabed to the north-west of the cooling water outfall was dominated by the brittlestar *Ophiothrix fragilis* that forms extensive beds, with individuals at high densities of between 100 s m^{-2} to 1,000 s m^{-2} (Figure 5-4). Densities of *O. fragilis* were lower at sites DDC20, DDC24 and DDC30, and this area probably represented a transition from one habitat 'sheltered from tidal currents' to the other 'exposed to strong tidal streams'.

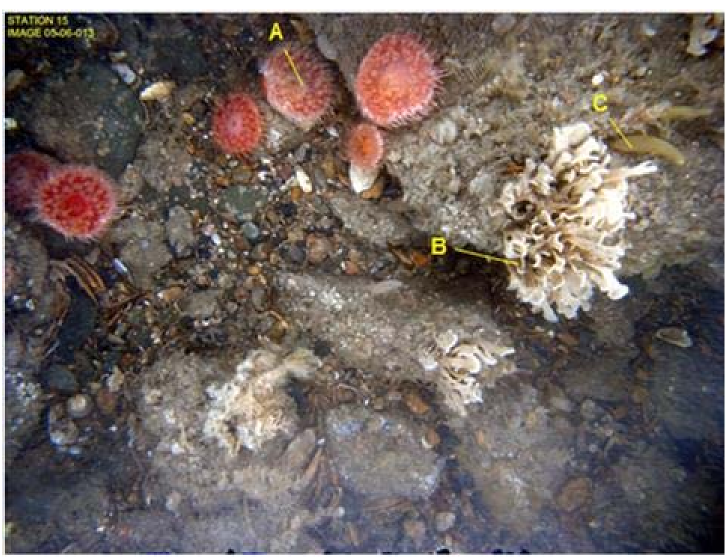


Figure 5-3 : An example of the seabed at Wylfa Head, where taxa such as *Urticina* spp. (A), *Flustra foliacea* (B) and *Alcyonidium diaphanum* (C) are common. Biotope code: SS.SMx.CMx.FluHyd.

Figure 5-4 : An example of a brittle star bed at Wylfa Head. High densities of *Ophiothrix fragilis* were recorded. Biotope code: SS.SMx.CMx.OphMx.

The omission of a number of the 2010 inshore rocky stations from the 2011 survey resulted in an overall reduction in recorded flora (Appendix C, Table C.1).

More sheltered sampling sites, e.g. in the Existing Power Station's cooling water outfall embayment, Cemaes Bay or Cemlyn Bay, were often heavily silted resulting in a sparser faunal community with a greater degree of algal growth (Figure 5-5). The grab samples obtained from these areas provide a much better indication of the habitat types as compared with the seabed image data. There were also a number of Sabellariidae aggregations at sites within Church Bay, to the west of the Wylfa Newydd Development Area (Figure 5-6).

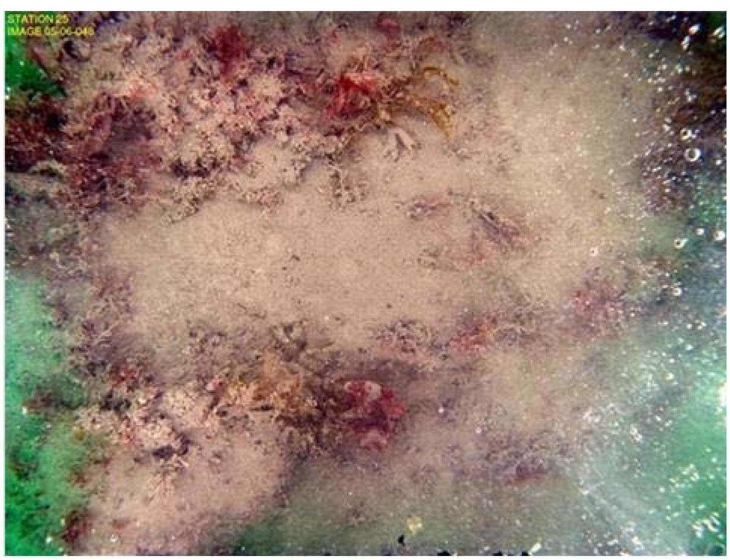


Figure 5-5 : An example of silted environment in bays sheltered from strong tidal currents (site DDC25, Porth-y-pistyll). No biotope code assigned.

Figure 5-6 : Example of Sabellariidae aggregations encountered in Church Bay.

5.3.2 DDC – Biotopes

Across the DDC sites, a total of 28 biotopes codes were recorded between 2010 and 2011. A list of the biotopes recorded and their descriptions are given in Table 5.5, and the distribution of the biotopes across the study area are shown in both Figure 5-7 and gure 5-8.

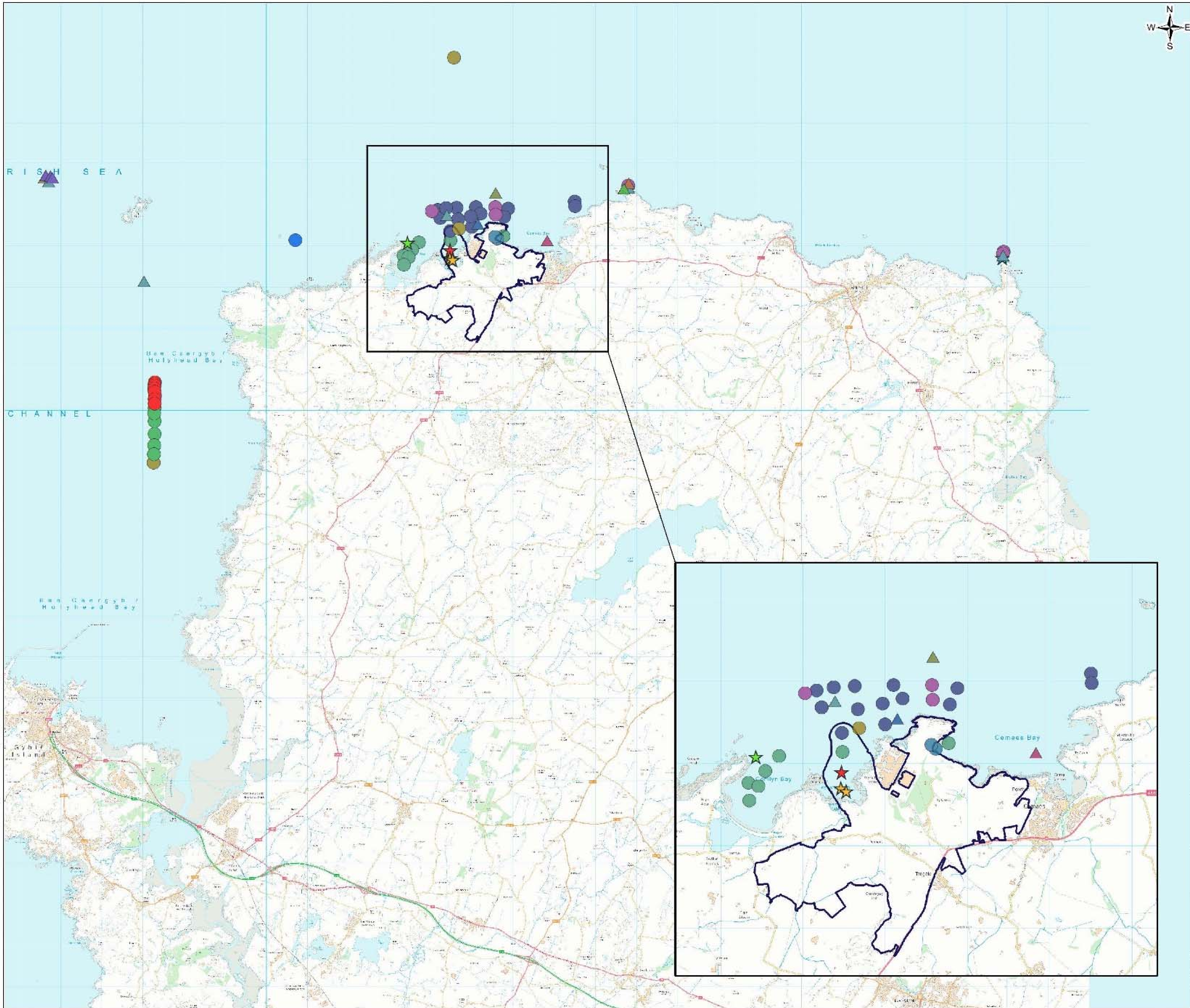
Table 5.5 : Biotope codes identified from the Wylfa Newydd Development Area DDC surveys in 2010 and 2011. (Following infaunal analysis of the grab samples, the biotopes SS.SSa.CMuSa.AalbNuc and SS.SSa.CMuSa were also recorded in 2011, see Table 5.6). Level Two habitat types are highlighted in bold for each code listed. Grey indicates presence of the habitat.

Habitat	Biotope code	Biotope description	2010	2011
High Energy Circalittoral Rock	**CR.HCR**.FaT.BalTub	*Balanus crenatus* and *Tubularia indivisa* on extremely tide-swept circalittoral rock	■	
	CR.HCR.FaT.Ctub.Adig	*Alcyonium digitatum* with dense *Tubularia indivisa* and anemones on strongly tide-swept, circalittoral rock		■
	CR.HCR.Xfa	Mixed faunal turf community with mixed ascidians, *Urticina* spp., *Alcynonium digitatum* and mixed hydroid and bryozoan turf		■
	CR.HCR.XFa.ByErSp. DysAct	Mixed turf of bryozoans and erect sponges with *Dysidia fragilis* and *Actinothoe sphyrodeta* on tide-swept, wave-exposed circalittoral rock	■	
	CR.HCR.XFa.FluCoAs	*Flustra foliacea* and colonial ascidians on tide-swept, moderately wave-exposed circalittoral rock	■	■
	CR.HCR.XFa.FluCoAs. SmAs	*Flustra foliacea*, small solitary and colonial ascidians on tide-swept circalittoral bedrock or boulders	■	■
	CR.HCR.XFa.FluCoAs.X	*Flustra foliacea* and colonial ascidians on tide-swept exposed circalittoral mixed substrata	■	
Moderate Energy Circalittoral Rock	**CR.MCR**	Moderate-energy, circalittoral rock		■
	CR.MCR.CMus.CMyt	*Mytilus edulis* beds with hydroids and ascidians on tide-swept, exposed to moderately wave-exposed circalittoral rock		■
	CR.MCR.CMus.Mdis	*Musculus discors* beds on moderately exposed circalittoral rock	■	■
	CR.MCR.CSab.Sspi	*Sabellaria spinulosa* encrusted circalittoral rock		■

Habitat	Biotope code	Biotope description	2010	2011
	CR.MCR.CSab.Sspi.As	*Sabellaria spinulosa*, didemnids and other small ascidians on tide-swept, moderately wave-exposed circalittoral rock		
	CR.MCR.EcCr	Echinoderms and crustose communities		
High Energy Infralittoral Rock	**IR.HIR**.KFaR.LhypR.Pk	*Laminaria hyperborea* park with dense foliose red seaweeds on exposed lower infralittoral rock		
Moderate Energy Infralittoral Rock	**IR.MIR**	Moderate energy infralittoral rock		
	IR.MIR.KR	Kelp and red seaweeds (moderate energy infralittoral rock)		
	IR.MIR.KR.XFoR	Dense foliose red seaweeds on silty moderately exposed infralittoral rock		
Sublittoral Coarse Sediments	**SS.SCS**	Sublittoral coarse sediment		
	SS.SCS.CCS	Circalittoral coarse sediment		
	SS.SCS.CCS.PomB	*Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles		
Sublittoral Sands and Muddy Sands	**SS.SSa**	Sublittoral sands and muddy sands		
Sublittoral Muds	**SS.SMu**[7]	Sublittoral cohesive mud and muddy sands		
	SS.SMu.CSaMu [8]	Circalittoral Sandy mud		
Sublittoral Mixed Sediments	**SS.SMx**.CMx	Mixed sublittoral sediment		
	SS.SMx.CMx.FluHyd	*Flustra foliacea* and *Hydrallmania falcata* on tide-swept, circalittoral mixed sediment		
	SS.SMx.CMx.OphMx	*Ophiothrix fragilis* and/or *Ophiocomina nigra* brittle star beds on sublittoral mixed sediments		
Sublittoral Macrophyte on Sediments	**SS.SMp**	Sublittoral macrophyte dominated communities on sediment		
Sublittoral Biogenic Reefs on Sediment	**SS.SBR**.PoR.SspiMx	*Sabellaria spinulosa* on stable circalittoral mixed sediment		

[7] Following infaunal analysis, this biotope (only recorded at DDC 31) was described as SS.SSa.CMuSa.AalbNuc
[8] All records of this biotope (SS.SMu.CSaMu) were changed to SS.SSa.CMuSa.AalbNuc following infaunal analysis.

FIGURE 5-7



Legend

Wylfa Newydd Development Area

Drop Down Camera Biotopes

Biotope Codes

- CR.HCR.FaT.BalTub
- CR.HCR.XFa.ByErSp.DysAct
- CR.HCR.XFa.FluCoAs
- CR.HCR.XFa.FluCoAs.SmAs
- CR.MCR.CMus.CMyt
- CR.MCR.CSab.Sspi.As
- CR.MCR.EcCr
- IR.HIR.KFaR.LhypR.Pk
- IR.MIR
- IR.MIR.KR
- IR.MIR.KR.XFoR
- SS.SBR.PoR.SspiMx
- SS.SCS.CCS
- SS.SCS.CCS.PomB
- SS.SMp
- SS.SMx.CMx
- SS.SMx.CMx.FluHyd
- SS.SMx.CMx.OphMx
- SS.SSa

Rev	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	JUN 17	Initial issue	HT	CT	EC	RB

Client

HORIZON NUCLEAR POWER

Project

WYLFA NEWYDD PROJECT
ENVIRONMENTAL STATEMENT
WYLFA SUBTIDAL BENTHIC REPORT

Drawing Title

WYLFA NEWYDD DEVELOPMENT AREA
DROP DOWN CAMERA BIOTOPES 2010

Scale @ A3	1:90,000	DO NOT SCALE
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Client No.		
Drawing No.	60PO8077_DCO_D_13_05_07	

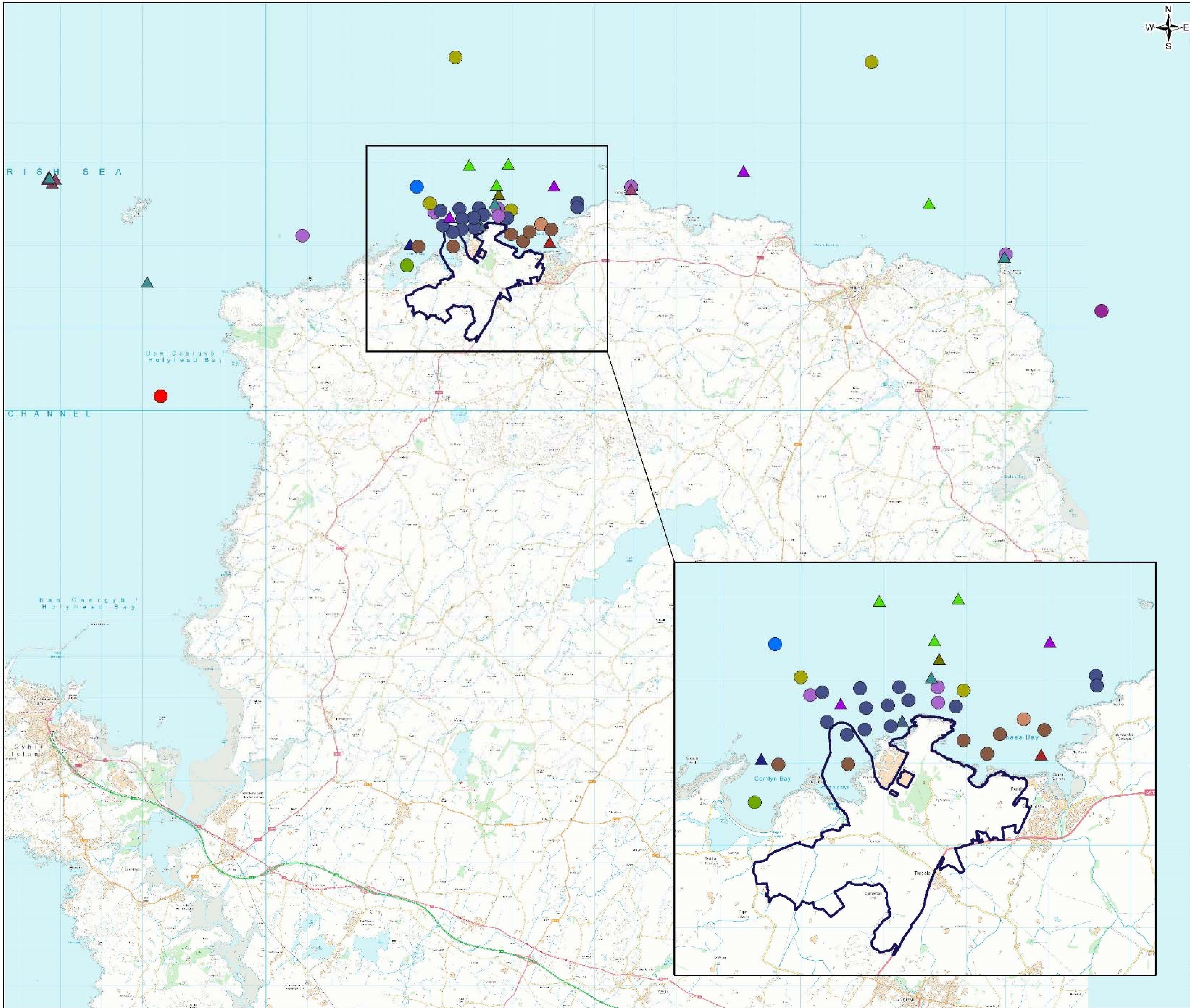


FIGURE 5-8

Legend

Wylfa Newydd Development Area

Drop down camera sites 2011

Biotope Codes

- CR.HCR.FaT.Ctub.Adig
- CR.HCR.XFa
- CR.HCR.XFa.FluCoAs
- CR.HCR.XFa.FluCoAs.SmAs
- CR.MCR
- CR.MCR.CMus.CMyt
- CR.MCR.CMus.Mdis
- CR.MCR.CSab.Sspi
- CR.MCR.CSab.Sspi.As
- CR.MCR.EcCr
- SS.SBR.PoR.SspiMx
- SS.SCS
- SS.SCS.CCS.PomB
- SS.SMx.CMx
- SS.SMx.CMx.FluHyd
- SS.SMx.CMx.OphMx
- SS.SSa
- SS.SSa.CMuSa
- SS.SSa.CMuSa.AalbNuc

0	JUN 17	Initial issue	HT	CT	EC	RB
Rev	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd

Client

HORIZON NUCLEAR POWER

Project

WYLFA NEWYDD PROJECT
ENVIRONMENTAL STATEMENT
WYLFA SUBTIDAL BENTHIC REPORT

Drawing Title

WYLFA NEWYDD DEVELOPMENT AREA
DROP DOWN CAMERA BIOTOPES 2011

Scale @ A3	1:90,000	DO NOT SCALE
Jacobs No.	60PO8077	
Client No.		

Drawing No.

60PO8077_DCO_D_13_05_08

This drawing is not to be used in whole or in part other than for the intended purpose and project as defined on this drawing. Refer to the contract for full terms and conditions.

0 0.5 1 2 3 4 5 Kilometers

The biotopes were not always classified to the same level due to the poor quality of some of the images, particularly as a result of disturbance of the soft sediment and general turbidity. Two sites (DDC11 and DDC25) did not have biotope codes assigned owing to poor image quality and neither being grab sampled. However, across the two years, of the 28 codes recorded, 16 comprised the same broad habitat type (Level 3 Habitat Type, e.g. 'CR.HCR.Fat; and 'SS.MCR.Csab') and 11 matching biotope codes were reported in total across both years.

A number of taxa were only recorded in either the 2010 or the 2011 surveys (Appendix C, Section C.4) and others showed changes in their abundance between the sampling periods, resulting in different biotopes being ascribed. Of these taxa, several displayed increases in their abundances at the recurring stations. Most notable were the bivalve *Mytilus edulis* where beds of the bivalves *Musculus discors* and *M. edulis* were found in 2011, the latter indicating a successful spatfall as no blue mussel beds were recorded the previous year, resulting in a biotope ascription change to CR.MCR.CMus.CMyt. Similarly, dense aggregations of the cnidarian *Tubularia indivisa* in 2011 changed the 2010 biotope ascriptions to CR.HCR.FaT.Ctub.Adig (Figure 5-9 and Figure 5-10).

In 2011, the following biotopes previously recorded in 2010 were not recorded: '*Flustra foliacea* and colonial ascidians on tide-swept exposed circalittoral mixed substrata' (CR.HCR.XFa.FluCoAs.X); 'Mixed turf of bryozoans and erect sponges with *Dysidia fragilis* and *Actinothoe sphyrodeta* on tide-swept wave-exposed circalittoral rock' (CR.HCR.XFa.ByErSp.DysAct); '*Balanus crenatus* and *Tubularia indivisa* on extremely tide-swept circalittoral rock' (CR.HCR.FaT.BalTub); and 'Circalittora coarse sediment' (SS.SCS.CCS). In addition, as no infralittoral rock habitats were surveyed in 2011, the four infralittoral biotopes belonging either to IR.HR ('High energy infralittoral rock') or IR.MCR ('Moderate energy infralittoral rock') were not recorded (Table 5.5).

Figure 5-9 : Dense aggregations of the blue mussel *Mytilus edulis*. Following a successful spatfall, a number of sites (DDC48-2a, DDC50a, DDC51a, DDC52a) had their biotope codes changed from those ascribed in 2010 to '*Mytilus edulis* beds with hydroids and ascidians on tide-swept exposed to moderately wave-exposed circalittoral rock'.

Figure 5-10 : The dense *Tubularia indivisa* (A) recorded at site DDC7a in 2011. The high densities of this animal resulted in a change of biotope code from that given in 2010. A number of dead man's fingers (*Alcyonium digitatum*) can be seen in the image (B).

In softer substrata, the results from the grab survey, where positions crossed over with the DDC sites, were used to give a higher resolution to the biotopes ascribed initially. Subsequent infaunal analysis of grab samples resulted in two additional biotopes as several sites designated as 'circalittoral sandy mud' (SS.SMu.CSaMu) from the DDC survey were changed to '*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand' (SS.SSa.CMuSa) or slightly mixed sediment' (SS.SSa.CMuSa.AalbNuc) (Table 5.6).

Similarly, retrieval of Sabellariidae structures in the grab samples provided greater confidence in ascription of these communities. The combination of these surveys confirmed the presence of the Sabellariidae biotope '*Sabellaria spinulosa* on stable circalittoral mixed sediment' ('SS.SBR.PoR.SspiMx) in Church Bay in 2010 and 2011(Figure 5-7 and gure 5-8) where the grab site WS13 overlapped with the DDC sites there (see Figure 3-2). In addition to this, the Sabellariidae communities seen at sites DDC63, DDC64 and DDC74 (which overlapped with WS09, WS05 and WS15, respectively) were found to be best described as '*Sabellaria spinulosa* encrusted circalittoral rock' (CR.MCR.CSab.Sspi) (see Figure 5-7 and gure 5-8). Full grab analysis is detailed in Sections 5.3.4 to 5.38 where assessment of 'reefiness' is also presented.

Table 5.6 : DDC biotopes changed following infaunal analysis of grab samples.

DDC Site	WS Grab Site	Initial DDC biotope	Final biotope following infaunal analysis
DDC31	WS25	SS.SMu	SS.SSa.CMuSa.AalbNuc
DDC42	WS03	SS.SSa	SS.SSa.CMuSa.AalbNuc
DDC63	WS09	SS.SMx.CMx	CR.MCR.CSab.Sspi
DDC64	WS05	SS.SMx.CMx	CR.MCR.CSab.Sspi
DDC66	WS20	SS.SMu.CSaMu	SS.SSa.CMuSa.AalbNuc
DDC67	WS23	SS.SMu.CSaMu	SS.SSa.CMuSa.AalbNuc
DDC68	WS22	SS.SMu.CSaMu	SS.SSa.CMuSa.AalbNuc
DDC69	WS06	SS.SSa	SS.SSa.CMuSa
DDC71	WS24	SS.SMu.CSaMu	SS.SSa.CMuSa.AalbNuc

5.3.3 DDC – Community Analysis

As described above in Section 5.3.1, there had been a distinction between the communities identified during the surveys, with exposure as an important influence for this partitioning. The assignment of DDC sites according to the environmental factors of exposure and depth, for multivariate analysis, are outlined in Appendix C, Section C.1.3

Multivariate analysis had confirmed the distinction between sites by showing a distinct grouping of them in relation to exposure for both years.

The main exposed clusters in 2010 (Figure 5-11) comprised samples from the following:

- Wylfa Head and Ogof Gynfor (35% similarity);
- Church Bay (45% similarity);
- Llanlleiana Head, Point Lynas and Wylfa Head (35% similarity); and
- Skerries and West Mouse (32% similarity).

In 2011, the clustering of the exposed stations (Figure 5-12), although less clearly defined than 2010, displayed several obvious clusters:

- Wylfa Head at a depth greater than 26 m (52% similarity);
- Wylfa Head and Ogof Gynfor (46% similarity); and
- Skerries (48% similarity).

The remaining exposed sites sampled in 2011 were largely made up of stations located to the north and east of Wylfa Head with a few exceptions. The sheltered sites were all within the depth range 1–15 m, and there was a degree of overlap present between the exposed north coast sites and those at Church Bay on the west coast.

MDS plots (Appendix C, Figure 8-1 and Figure 8-2) displayed similar visual patterns to those shown by cluster analysis, with grouping of the sheltered and shallow stations separate from the larger number of exposed stations that dominated the plots. When data were displayed according to depth (Appendix C, Figure 8-3 and Figure 8-4), they showed that similar communities were found in areas of similar depth range.

Some overlap was shown between the stations recorded in 2010 at a depth between 21–40 m, whilst the data from 16–20 m depth are situated around the periphery of these points, possibly indicative of the transition from the infralittoral to the circalittoral zones. The 2011 data showed a clear separation of sites in the depth ranges 6–10 m and 11–15 m, and an overlap between stations at depths of 16–25 m. There was an overlap between sites in the range 26–40 m, although the deepest DDC sites (62a and 73a) are displayed towards the edge of the plot.

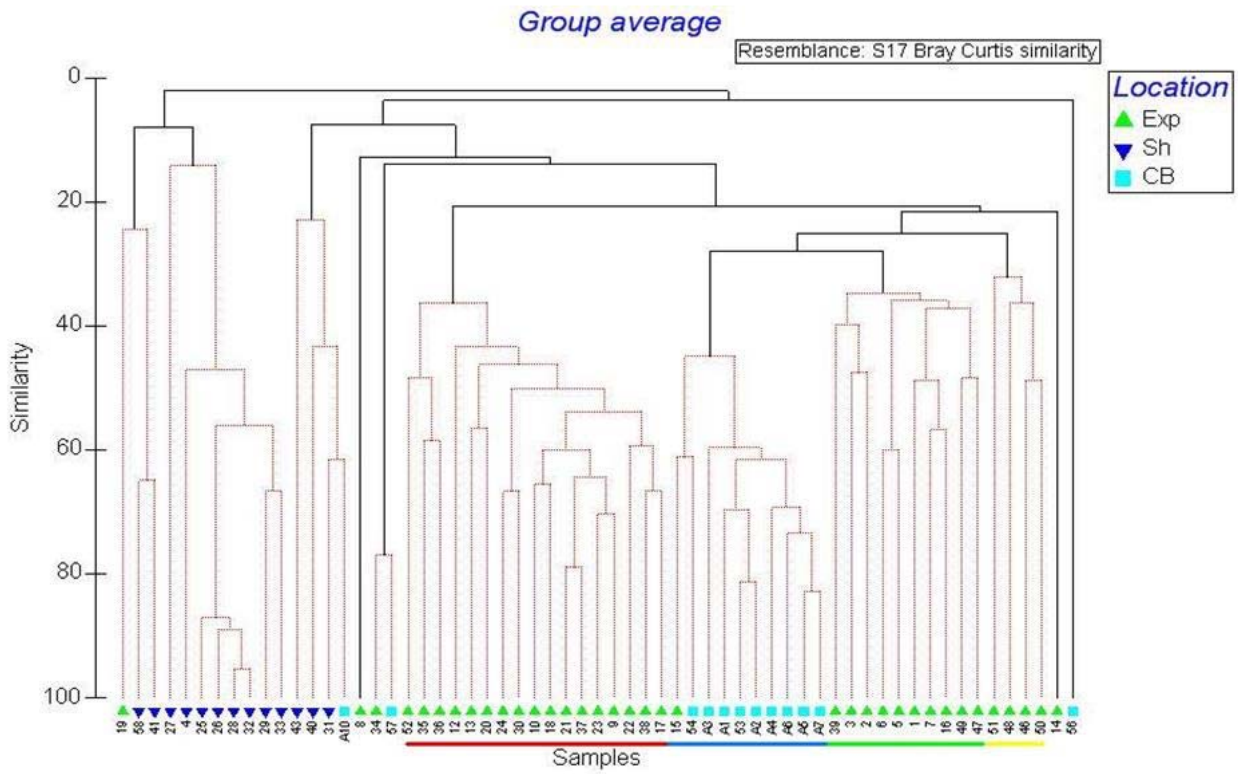


Figure 5-11 : Cluster diagram showing the % similarity between sampling sites along the north Anglesey coast based on DDC data obtained in June 2010. Sites are classed as either 'exposed' (Exp), 'sheltered' (Sh) or 'exposed in Church Bay' (CB). Clusters to the right of the plot form distinct groups from Wylfa Head and Ogof Gynfor (Llanbadrig Head) (red line), Church Bay (blue line), Llanlleiana Head, Point Lynas and Wylfa Head (green line), and the Skerries and West Mouse (yellow line).

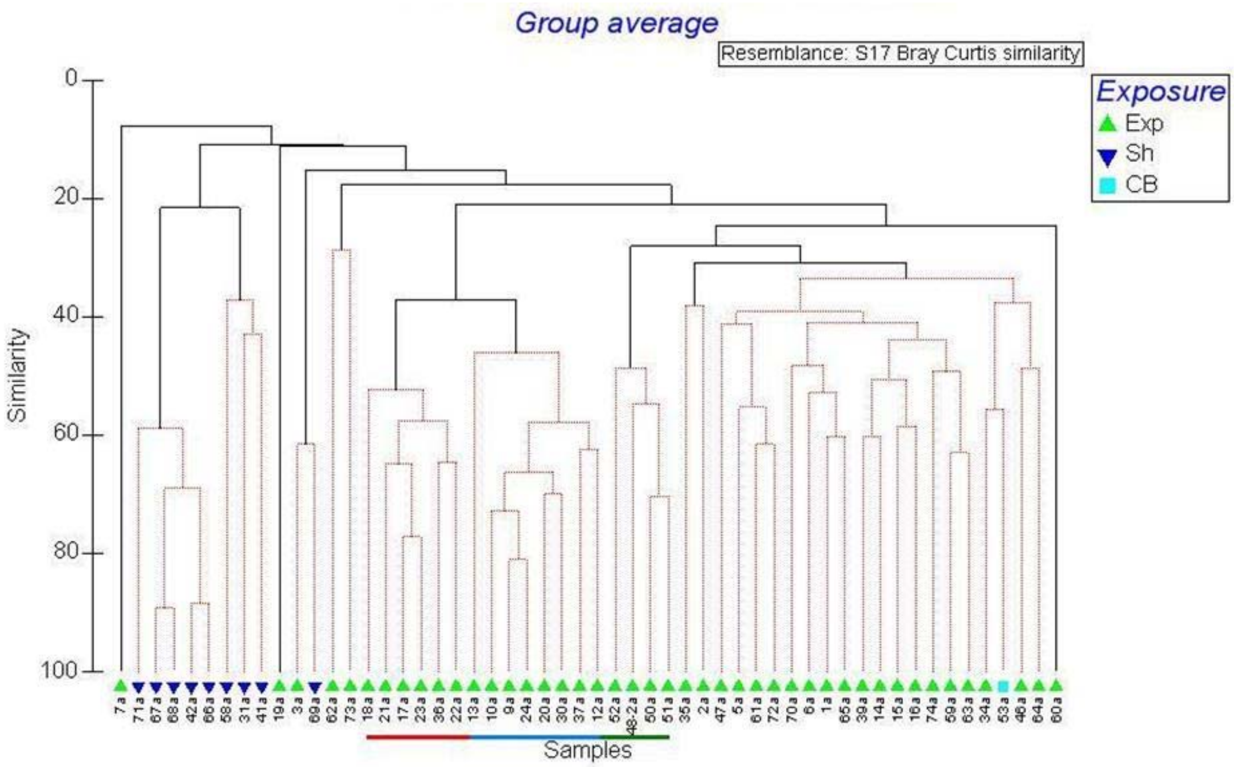


Figure 5-12 : Cluster diagram showing the % similarity between sampling sites along the north Anglesey coast based on DDC data, 2011. Sites are classed as either 'exposed' (Exp), 'sheltered' (Sh) or 'exposed in Church Bay' (CB). Clusters in the middle of the plot form distinct groups from Wylfa Head at a depth greater than 26 m (red line), Wylfa Head and Ogof Gynfor (blue line), and Skerries (green line).

When the sites sampled in both years were analysed together, the cluster diagram (Figure 5-13) and MDS plots (Appendix C, Section C.7) displayed a group of sheltered stations distinct from those that were exposed. There was also a clear distinction between groups highlighted (using SIMPROF) within the exposed locations. These were divided into:

- Wylfa Head and Ogof Gynfor (34% similarity);
- Skerries (23% similarity); and
- West Mouse, Port Lynas, Llanlleiana Head and due north of Wylfa Head (30% similarity).

The MDS plots displayed several DDC sites as outliers: DDC7a, DDC19, DDC31 and DDC58.

SIMPER analysis of the 2010 data showed that the differences between the north coast exposed sites and those in Church Bay were mainly attributable to the presence of Sabellariidae in Church Bay and the greater presence of *Urticina* spp., *Ophiura* sp. and *O. fragilis* along the north coast. The main contributors towards the dissimilarity between the sheltered and exposed stations were the presence of algae in the sheltered (shallow) sites and the presence of fauna synonymous with current-swept habitats, e.g. *O. fragilis*, *Alcyonidium diaphanum* and *Urticina* spp. in the exposed sites.

Following SIMPER analysis of 2011 data, it was found that the main contributors to dissimilarity between sites, at the sheltered and exposed locations, were the presence of *Ophiura albida* in the sheltered sites (12.8%) and *Urticina* spp. in the exposed (7.1%). The brittle star *O. albida* gave a significantly higher contribution than any other taxa to similarity between the sheltered sites in 2011 (84%), in comparison to *Urticina* spp. at the exposed locations (21%).

SIMPER analysis of the combined 2010 and 2011 data showed that a wide range of taxa contributed to the differences in the assemblages between years. Of the four taxa that individually contributed more than 4%

towards the dissimilarity between years, *O fragilis* was the largest contributor (7.8%). *O. albida* was not recorded in 2010 but was found at a number of sites in 2011 and in high abundances; however, there were a number of records for *Ophiura* sp. in 2010, which may have included this species.

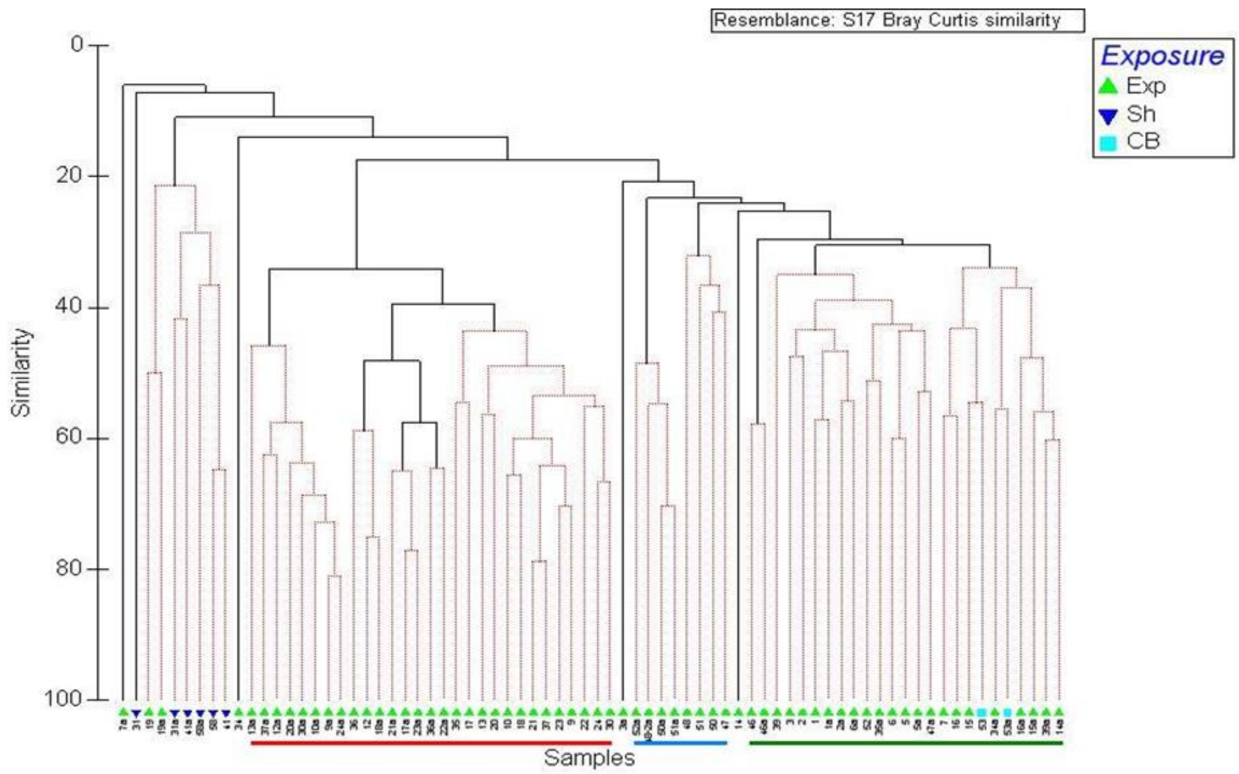


Figure 5-13 : Cluster diagram for all DDC sites sampled in 2010 and 2011 off the north coast of Anglesey. Sites are classed as either 'exposed' (Exp), 'sheltered' (Sh) or 'exposed in Church Bay' (CB). The cluster to the far left of the plot are sheltered sites. The exposed sites form a number of clusters which can be divided by locations with a distinct group shown from Wylfa Head and Ogof Gynfor (red line), a group from Skerries (blue line). Clusters in the middle of the plot form distinct groups from Wylfa Head at a depth greater than 26 m (red line), Wylfa Head and Ogof Gynfor (blue line), Skerries (green line) and sites from West Mouse, Port Lynas, Llanlleiana Head and due north of Wylfa Head.

5.3.4 Grabs – Ecological Quality

5.3.4.1 2010–2011

Results from the IQI analysis indicate that in 2010 the communities at all subtidal grab sites (WS) were assigned High ecological status. In 2011, the majority of sites were again assigned High status with the exception of four inshore sites between Cemaes Bay and Wylfa Head (sites WS20, WS22, WS23 and WS25) where the communities were assigned Good ecological status (Table 5.7).

In both 2010 and 2011, the communities at all sites returned a positive W statistic from the DOMPLOT routine, with the exception of a single site in Cemaes Bay (WS23) in 2011, which returned a value of -0.028: a factor related to the high numerical dominance of small juveniles of the bivalve *A. alba* (see Appendix C, Table C.2 for lists of dominant taxa at each site).

Table 5.7 : Subtidal infaunal quality status (IQI) and W statistic at each subtidal grab site in 2010 and 2011. Negative W statistic values listed in red.

	Quality Status (IQI)		W Statistic	
Site	2010	2011	2010	2011
WS01	HIGH	HIGH	0.134	0.124
WS02	HIGH	HIGH	0.174	0.151
WS03	HIGH	HIGH	0.149	0.008
WS04	HIGH	HIGH	0.183	0.236
WS05	HIGH	HIGH	0.214	0.179
WS06	HIGH	HIGH	0.246	0.183
WS07	HIGH	HIGH	0.205	0.418
WS08	HIGH	HIGH	0.266	0.462
WS09	HIGH	HIGH	0.178	0.119
WS10	HIGH	HIGH	0.248	0.203
WS11	HIGH	HIGH	0.107	0.151
WS13	HIGH	HIGH	0.185	0.286
WS14	HIGH	HIG	0.166	0.410
WS15	HIGH	HIGH	0.093	0.230
WS16	HIGH	HIGH	0.426	0.144
WS17	-	HIGH	-	0.074
WS18	HIGH	HIGH	0.157	0.308
WS19	HIGH	HIGH	0.287	0.447
WS20	HIGH	GOOD	0.168	0.035
WS22	HIGH	GOOD	0.313	0.070
WS23	HIGH	GOOD	0.088	-0.028
WS24	HIGH	HIGH	0.363	0.179
WS25	HIGH	GOOD	0.090	0.085
WS26	-	HIGH	-	0.130
WS27	-	HIGH	-	0.195
WS28	-	HIGH	-	0.449

5.3.4.2 2015 Validation

IQI results for 2015 recorded a range of ecological quality statuses from Moderate to High. Site WS20, a shallow site in Cemaes Bay, was assigned Moderate status; sites WS03 and WS25, shallow sites in Cemlyn Bay and to the west of Wylfa Head, were assigned Good statuses; all other sites were assigned High statuses (Table 5.8). There was no change in IQI status between 2011 and 2015 for all sites, except at WS03 and WS20, which had shifted into the lower range of Good and Moderate, respectively.

Table 5.8 : Subtidal infaunal quality status (IQI) at each subtidal grab site in 2015, with the statuses also listed for 2010 and 2011.

Site	IQI – 2010	IQI – 2011	IQI – 2015
WS03	HIGH	HIGH	GOOD
WS05	HIGH	HIGH	HIGH
WS07	HIGH	HIGH	HIGH
WS13	HIGH	HIGH	HIGH
WS14	HIGH	HIGH	HIGH
WS16	HIGH	HIGH	HIGH
WS18	HIGH	HIGH	HIGH
WS20	HIGH	GOOD	MODERATE
WS24	HIGH	HIGH	HIGH
WS25	HIGH	GOOD	GOOD
WS27	-	HIGH	HIGH

5.3.5 Grabs – Population Features

5.3.5.1 2010–2011

Between 2010 and 2011, there was relative consistency in the broad faunal features of the sampled population regarding the composition of key groups and total number of taxa at each site.

In 2010, a total of 403 taxa were identified of which 169 taxa were annelids, accounting for 41.9% of the total taxa. Crustaceans were represented by 94 taxa (23.3%), mollusca by 79 taxa (19.6%) and echinoderms by 22 taxa (5.5%), while poriferans, phoronids, nemerteans, cnidarians, sipunculids, pycnogonids, oligochaetes, tunicates, bryozoans, turbellarians, chaetognaths and entoproctans accounted for the remaining 10% of the total taxa identified. A total number of 13,967 individuals were enumerated, of which annelids represented 53.2%, molluscs 29.2%, echinoderms 5.8% and crustaceans 5.2%.

In 2011, a total of 407 taxa were identified of which 169 taxa were annelids, accounting for 41.5% of the total taxa. Crustaceans were represented by 92 taxa (22.6%), mollusca by 73 taxa (17.9%), echinoderms by 17 taxa (4.2%) and bryozoans by 15 (3.7%). Poriferans, phoronids, nemerteans, cnidarians, sipunculids, pycnogonids, oligochaetes, tunicates, bryozoans, turbellarians, chaetognaths and entoproctans accounted for the remaining taxa identified. A total number of 16,966 individuals were enumerated, of which molluscs represented 50.6%, annelids 37.6%, echinoderms 4.5% and crustaceans 3.7%.

In 2010, the number of taxa at each site varied between 23 and 143, while in 2011 the range was between 20 and 132 (Figure 5-14). In both years, lower numbers of taxa were evident at sites within Cemaes Bay and at shallow inshore sites, with higher numbers occurring at further offshore, deeper water sites. The number of individuals at each site varied between 101 and 3,152 individuals per 0.75 m^2 in 2010, while in 2011 the range was 178 to 5,260 individuals per 0.75 m^2 (Figure 5-15), although no spatial pattern was evident in either year.

In 2010, the most abundant taxon throughout the study area was the polychaete *Sabellaria spinulosa* which represented 14.5% of all individuals identified. The bivalve molluscs *Nucula sp*. and *Abra alba* were also important, representing 9.7% and 5.7% respectively of all individuals identified. In 2011, *A. alba* was the most abundant taxon, representing 27.6% of individuals, while *Nucula* sp. and *S. spinulosa* represented 10.6% and 6.1% of individuals respectively. Other abundant taxa in both years included the polychaetes *Jasmineira elegans*, *Mediomastus fragilis*, the brittle star *Ophiothrix fragilis* and juvenile mussels *Mytilus edulis*.

In 2010, the community biomass at WS01 and WS02 was 388 g and 335 g per 0.75 m^2 respectively, with the biomass dominants being brittle stars and nucleoid bivalve molluscs at both sites; elsewhere, biomass varied between 2.6 g and 89 g per 0.75 m^2. In 2011, similarly high biomass was again recorded at WS01 and WS02 with the same biomass dominants evident within the communities; comparable biomass was recorded at WS26 and WS27 where brittle stars and bivalve molluscs were dominant. However, a maximum biomass of 1,977 g per 0.75 m^2 was recorded at WS17 where mussels were the biomass dominant, representing 99% of the biomass. At other sites, biomass varied between 1.7 g and 158 g per 0.75 m^2.

In 2010, Shannon-Wiener diversity values (H') for the communities at each site ranged between 2.04 and 3.59, while values for evenness (J) varied between 0.56 and 0.84 (Appendix C, Table C.4). In 2011, H' values varied between 1.02 and 3.87 and J between 0.27 and 0.91. In both years, values for both indices indicate that throughout the survey area the communities were generally characterised by diverse and relatively evenly distributed fauna. However, lower relative values for H' and J were evident at sites WS03 and WS20 to WS25 in 2011, which reflects the relatively high dominance of *Abra alba* (see Appendix C, Table C.2 for list of dominant taxa at each site.

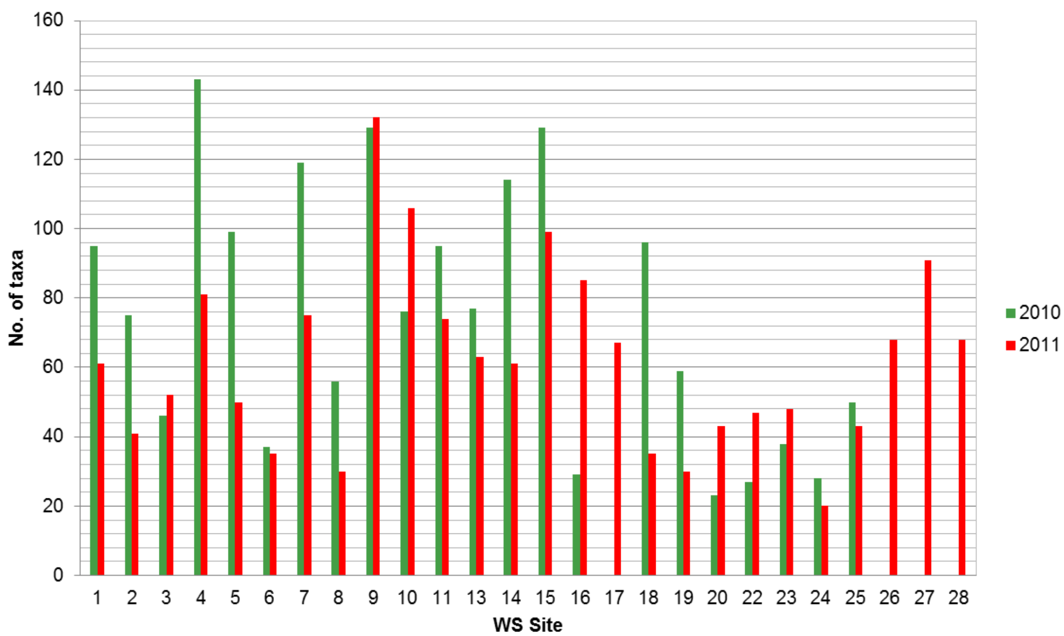


Figure 5-14 : Total number of taxa at subtidal sites in 2010 and 2011 (total pooled from all three replicate grabs).

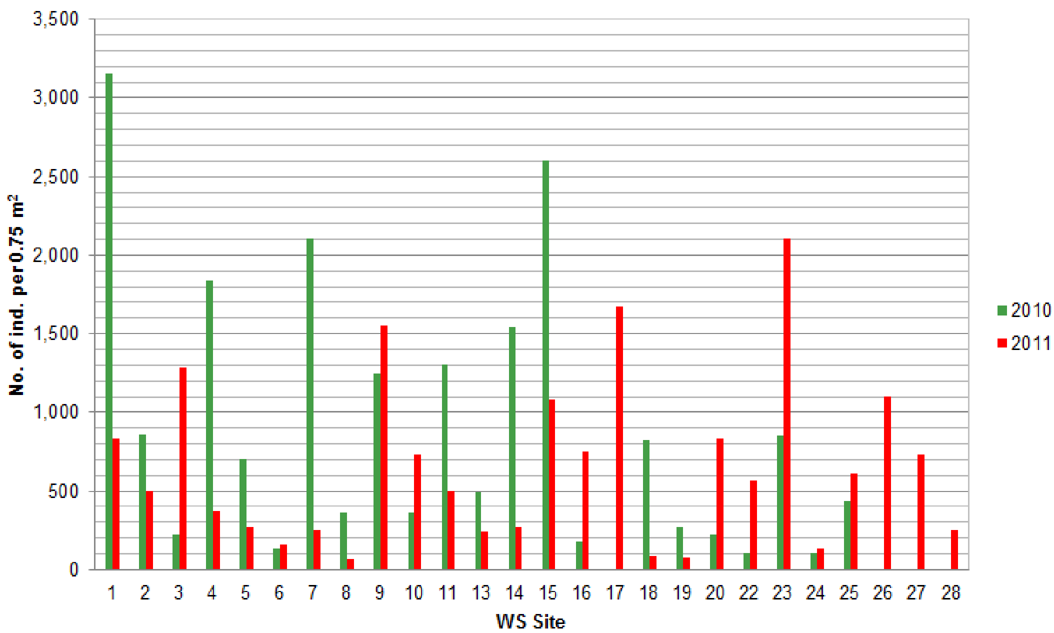


Figure 5-15 : Number of individuals at subtidal sites (per 0.75 m^2) in 2010 and 2011 (total pooled from all three replicate grabs).

5.3.5.2 2015 Validation

In 2015, 353 taxa were identified in total, of which 152 were annelids, accounting for 43.1% of the total. Molluscs were represented by 74 taxa (21.0%), crustaceans by 59 taxa (16.7%), echinoderms by 16 taxa (4.5%) while poriferans, phoronids, nemerteans, cnidarians, sipunculids, pycnogonids, tunicates, bryozoans, hydrozoans, turbellarians, chaetognaths and entoproctans accounted for the remaining 14.7% of the total taxa identified. In 2010 and 2011, totals of 403 and 407 taxa respectively were reported, and for both years annelids accounted for around 40% of the total taxa which is comparable with 2015. There was a notable increase in the total number of taxa recorded at WS18 in 2015 compared to 2010 and 2011. However, it is important to note that between 2010 and 2011, there was also variability in the species richness recorded at this site when comparing these two years alone (

Figure 5-16).

In 2015, a total of 8,440 individuals was enumerated, of which annelids represented 50.8%, molluscs 31.5%, crustaceans 7.4% and echinoderms 3.8% (colonial taxa such as bryozoans, hydrozoans and porifera were recorded only as present and were not included in subsequent analyses, as they were not quantified). Lower total abundances were recorded in 2015 compared to 2010 and 2011; an expected artefact of the reduced sampling programme. However, these communities sampled still reflect the faunal composition recorded in the two earlier years, with annelids dominant and representing approximately 50% of all individuals. In 2015, higher total abundances were recorded at a number of sites in comparison to the earlier sampling years, including WS25, WS05, WS27 and notably at site WS18 (Figure 5-17).

In 2015, the number of taxa at each site varied between 30 and 142 (

Figure 5-16). This is comparable with 2010 and 2011 where the minimum was between 20 and 23, and the maximum between 132 and 143 taxa. Lower numbers of taxa were evident at sites within Cemaes Bay, Cemlyn Bay and at shallow, inshore sites in 2015, with higher numbers occurring at offshore, deeper-water sites (see Figure 3-2 for site locations). This pattern of relatively lower species richness at these shallower sites (e.g.

WS03, WS20, WS23 and WS25) had also been observed in 2010 and 2011. The number of individuals at each site varied between 490 and 4,773 per 0.75 m^2 (Figure 5-17); no spatial pattern was evident in 2015.

In 2015, the two most abundant taxa throughout the study area were the bivalve mollusc *A. alba* and the polychaete *S. spinulosa*, which represented 14.8% and 13.9%, respectively, of all individuals identified. This compares with 2010 where *S. spinulosa* was dominant at 14.5%; however, *A. alba* represented only 5.7% of all individuals sampled that year. The polychaete *Lagis koreni* was also important in 2015, representing 6.7% of all individuals identified. Other abundant taxa included the bivalve molluscs *Nucula sulcata* and *Nucula nitidosa*, the polychaetes *J. elegans* and *M. fragilis*, the brittle star *O. fragilis* and the amphipod *Leptocheirus hirsutimanus*. In 2011, *A. alba* was the most abundant with *S. spinulosa* contributing 6.1% to overall abundances. See Appendix C, Table C.3, for list of dominant taxa at each site sampled in 2015.

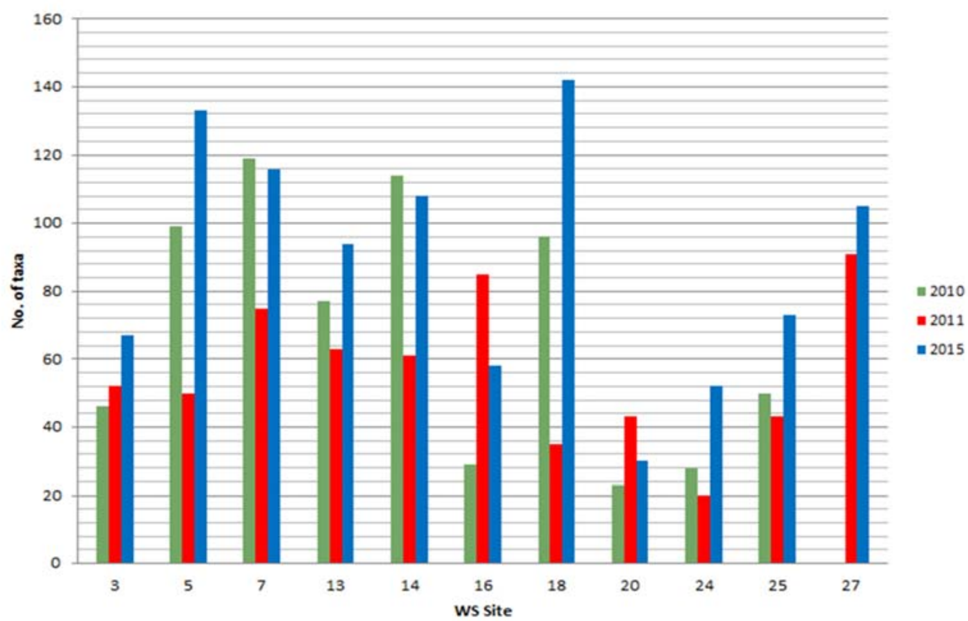


Figure 5-16 : Total number of taxa at subtidal WS sites in 2010, 2011 and 2015 (pooled from three replicate grabs).

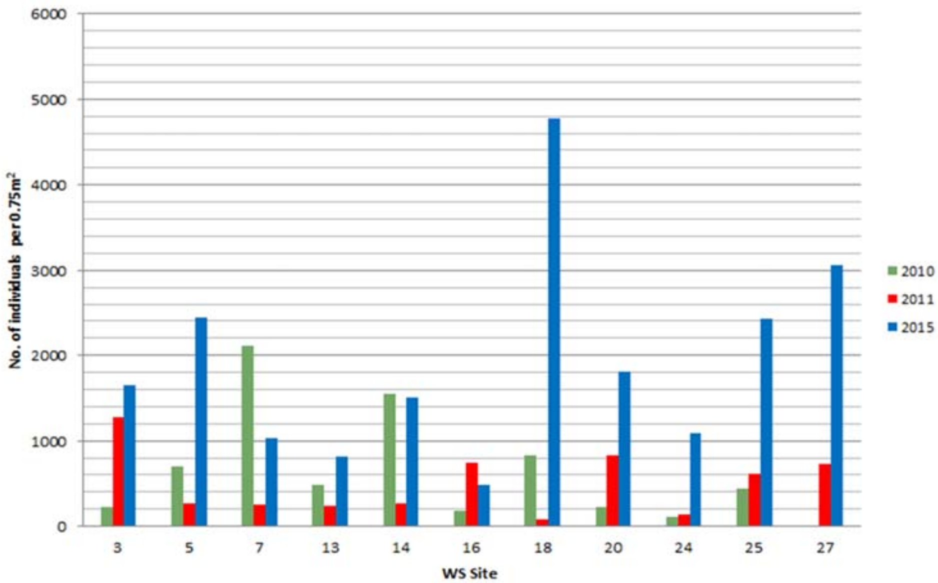


Figure 5-17 : Total number of individuals (per 0.75 m^2) at subtidal sites in 2010, 2011 and 2015 (pooled from three replicate grabs).

5.3.6 Grabs – Community Analysis and Biotopes

5.3.6.1 2010–2011

The dendrogram for the north Anglesey benthic community data sampled in 2010 and 2011 indicate a common similarity between all sites of 15%; above this level of similarity, two broad cluster of sites are evident (Figure 5-18). Group I comprised the communities recorded in both years at five sites in Cemaes Bay and two shallow inshore sites between Wylfa Head and Cemlyn Bay. The communities within this group show a common similarity of 32% and were characterised by moderate numbers of both taxa and individuals, the dominant species being the bivalve *A. alba* and the bivalve *N. nitidosa* subdominant (see Table 5.9). Group I sites were assigned the biotope SS.SSA.CMuSa.AalbNuc – '*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment' (see Connor *et al*., 2004). Sites in Group II showed a common similarity of 24% and were characterised by relatively high numbers of taxa with moderate abundance. The polychaete *S. spinulosa* and the bivalve *N. sulcata* were the most abundant taxa (Table 5.9). It is thought that the Group II sites were represented by several broad habitat types including CR.MCR.CSab and SS.SCS.CCS '*Sabellaria spinulosa* encrusted circalittoral rock' and 'circalittoral coarse sediment', respectively. A review of the Sabellariidae communities helped to determine the presence of biogenic reef (see Section 5.3.8).

Table 5.9 : Biological characteristics of faunal cluster groups (mean numbers per 0.75 m^2).

Group I		Group II	
Mean number of taxa	35	**Mean number of taxa**	72
Mean number of individuals	1,143	**Mean number of individuals**	1,359
Abra alba	712	*Sabellaria spinulosa*	149
Nucula nitidosa	159	*Nucula sulcata*	131
Spiophanes bombyx	23	*Mytilus edulis* juv.	96

Group I		Group II	
Thyasira flexuosa	22	*Jasmineira elegans*	77
Euclymene oerstedi	21	*Abra alba*	64
Nephtys hombergii	19	*Spirobranchus lamarcki*	56
Mediomastus fragilis	15	*Ophiothrix fragilis*	49

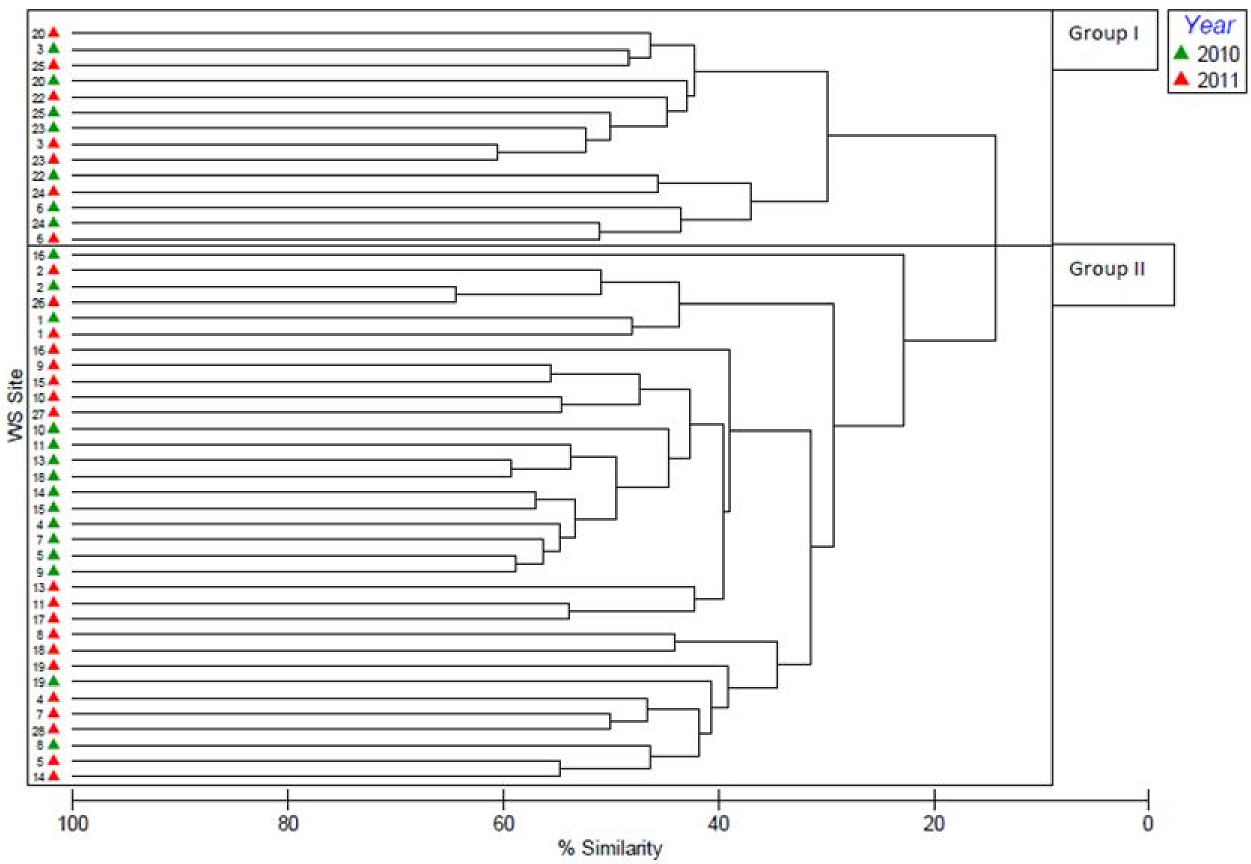


Figure 5-18 : Cluster dendrogram of the north Anglesey subtidal macrobenthic faunal community in 2010 and 2011 with broad cluster groups identified

5.3.6.2 2015 Validation

The dendrogram (Figure 5-19) and MDS plot (Figure 5-20) for the benthic community data collected in sites sampled in all three years is presented below. The cluster analysis indicates a common similarity between all sites of 12.38%. Above this level of similarity, two groups of sites are evident, of which one can be further split, with a common similarity of 23.73% (Group II).

Group I comprised the communities recorded in all three years (2010, 2011 and 2015) at the two most inshore sites in Cemlyn Bay (WS03 and WS25) and the shallow-water inshore sites in Cemaes Bay (WS20 and WS24). The communities within this group show a common similarity of 28.47% and were characterised by moderate numbers of both taxa and individuals; the dominant taxa were the bivalve *A. alba*, and the bivalve *N. nitidosa* was subdominant (see Table 5.10). Group I sites were assigned the biotopes SS.SSA.CMuSa.AalbNuc – ‘*Abra* *alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment' and SS.SMu.CSaMu.LkorPpel – '*Lagis koreni* and *Phaxas pellucidus* in circalittoral sandy mud' (JNCC, 2015).

Group IIa comprised just WS16 in 2010 and 2015; these sites showed a common similarity of 33.85% and were characterised by moderate numbers of taxa and low abundance. Group IIb was dominated by the small polychaete worm *Pisione remota* (Table 5.10) which is typically present in sediments with little or no silt and mud, and may be attributed to the biotope SS.SCS.CCS.Blan – '*Branchiostoma lanceolatum* in circalittoral coarse sand with shell gravel'. Sites in Group IIb showed a common similarity of 24.81% and were characterised by relatively high numbers of taxa and abundance. The polychaete *S. spinulosa* was the most dominant taxa, and the bivalve *Nucula sulcata* was subdominant (Table 5.9). It is likely that the Group IIb sites were represented by several broad habitat types, including SS.SBR.PoR.SspiMx – '*Sabellaria spinulosa* on stable circalittoral mixed sediment' and SS.SCS.CCS – 'circalittoral coarse sediment' respectively.

On examination of the ordination plot in Figure 5-20, there appears to be some clustering of 2015 sites but with a clearer separation based moreover on sample location, with the shallower sites clustered towards the left hand side of the plot. A two-way ANOSIM further supports this with a significant difference between sites ($R = 0.86$, $p = < 0.001$), but no significant difference detected between years ($R = 0.022$, $p = 0.39$). The bivalves *A. alba, Nucula nitidosa* and the polychaete *S. spinulosa* were the top ranking species contributing to overall percentage dissimilarities between these groups of sites. Analysing between-year groups, for all three comparisons the species *S. spinulosa*, *N. nitidosa* and *A. alba* were consistently the top three ranking taxa contributing to overall average percentage dissimilarity (SIMPER analysis).

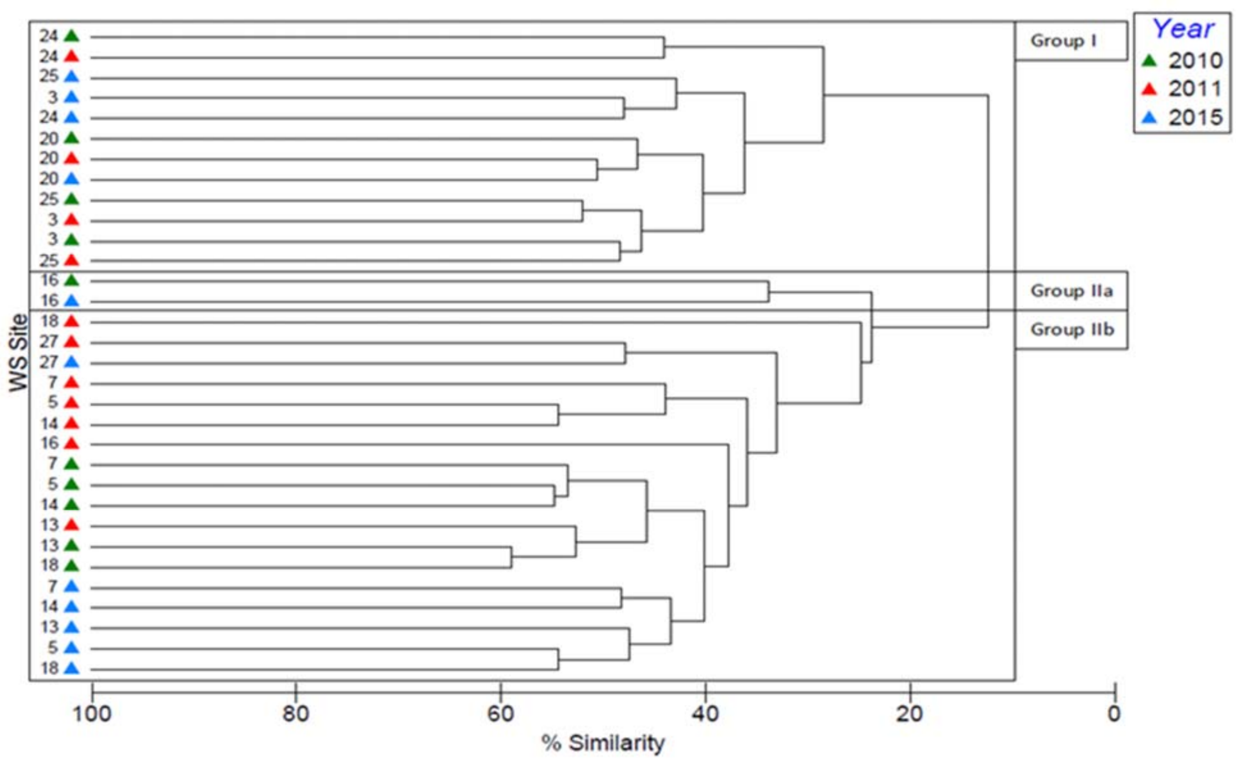


Figure 5-19 : Cluster dendrogram of the north Anglesey subtidal macrobenthic faunal community in 2010, 2011 and 2015 with broad cluster groups identified.

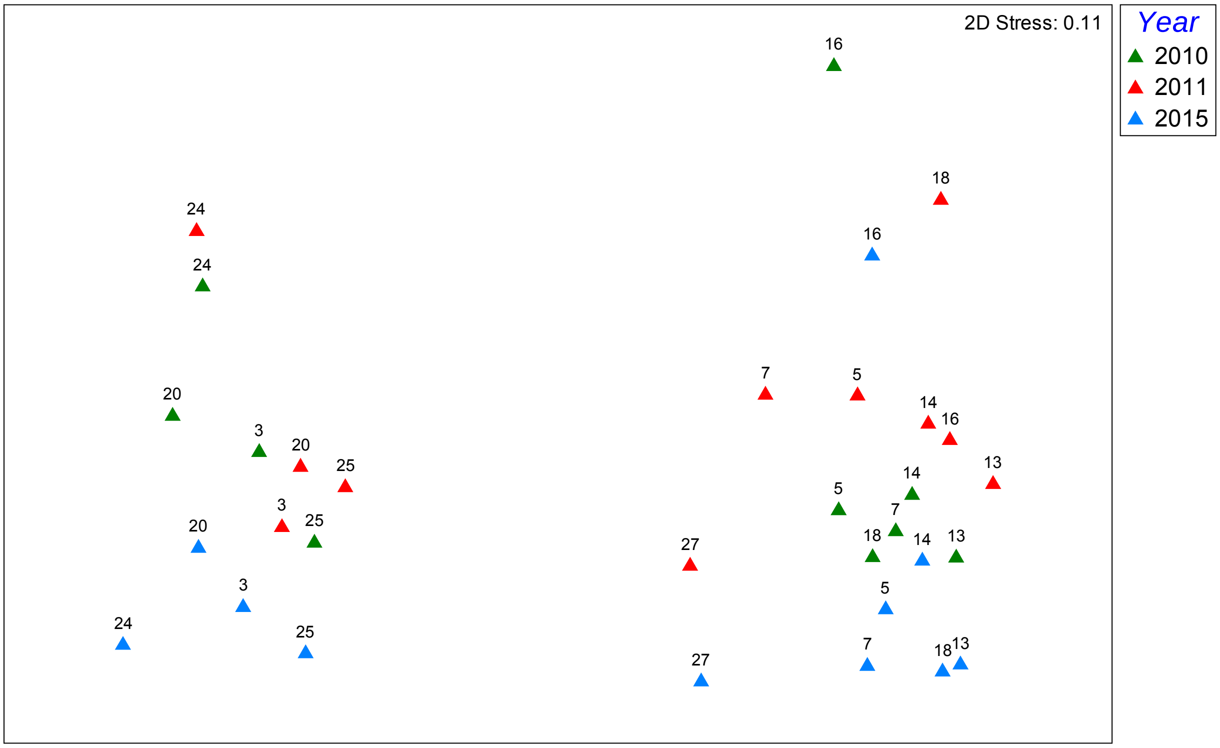


Figure 5-20 : Two-dimensional MDS plot of sites sampled in 2010/2011 and that were re-sampled in 2015 programme. Stress = 0.11

Table 5.10 : Biological characteristics of faunal cluster groups of communities sampled 2010, 2011 and 2015 (mean numbers per 0.75 m^2)

Group Ia		Goup IIa		Group IIb	
Mean number all individuals	553	**Mean number all individuals**	190	**Mean number all individuals**	758
Mean number taxa	41	**Mean number taxa**	37	**Mean number taxa**	79
Abra alba	276	*Pisione remota*	45	*Sabellaria spinulosa*	152
Nucula nitidosa	73	*Glycera lapidum*	16	Syllidae spp.	44
Lagis koreni	49	*Goniadella gracilis*	13	*Spirobranchus lamarcki*	41
Mediomastus fragilis	20	Aonides paucibranchiata	11	Sipuncula sp.	39
Scalibregma inflatum	10	Syllidae spp.	9	*Nucula sulcata*	36
Nephtys hombergii	8	*Spirobranchus lamarcki*	9	*Jasmineira elegans*	26
Spiophanes bombyx	7	Nemertea	7	*Sabellaria alveolata*	16.4

5.3.7 Grabs – Biodiversity

5.3.7.1 2010–2011

Funnel plots for the subtidal community data for 2010 and 2011 are given in Appendix C, Section C.10, from which it is evident that, at several sites in both years, values for AvTD are lower than expected (Appendix C, Figure 8-7) and several values of VarTD are higher than expected (Appendix C, Figure 8-8), with the inference that communities at these sites are experiencing some level of stress. There is no spatial pattern in the variation from the expected range for both statistics, with sites concerned dispersed throughout the survey area.

5.3.7.2 2015 Validation

Funnel plots for the subtidal community data for those sites sampled in all three years are given in Figure 5-21 and Figure 5-22. It is evident from the plots that, at several sites, values for AvTD are lower than expected and several values of VarTD are higher than expected. On initial interpretation of the funnel plots, the analysis has detected 'stress' at some of the sites sampled. However, there was no clear spatial pattern in the variation from the expected range for both statistics, with the sites concerned dispersed throughout the survey area; several sites varied from the norm in more than one year. Sites WS5, WS8, WS18 and WS19 all had decreased AvTD in 2010 and 2011, with increased VarTD in 2010 at sites WS8 and WS18. Sites WS13 and WS16 had decreased AvTD in 2010 and 2015 but only increased VarTD in 2015.

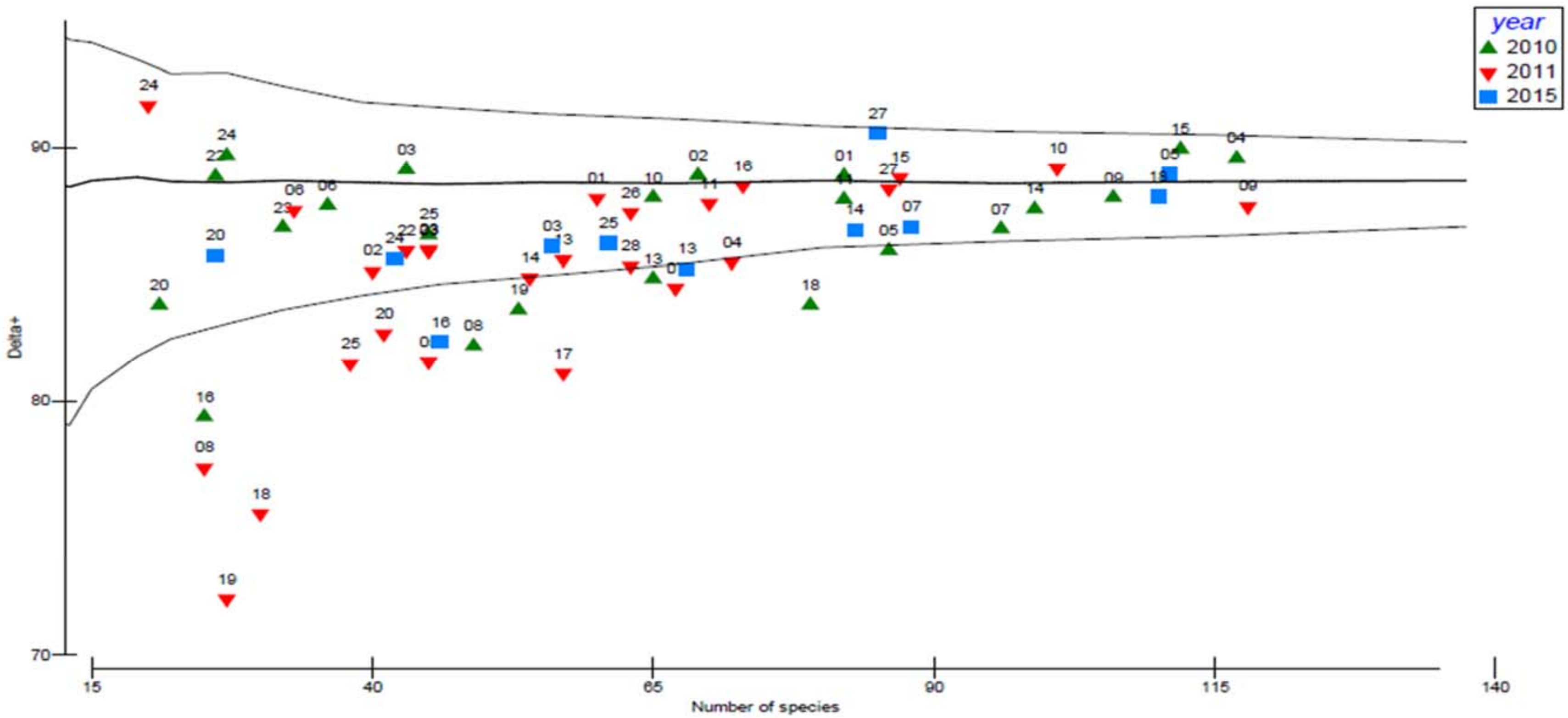


Figure 5-21 : Funnel plots for Average Taxonomic Distinctiveness (AvTD) for subtidal benthic communities, 2010, 2011 and 2015.

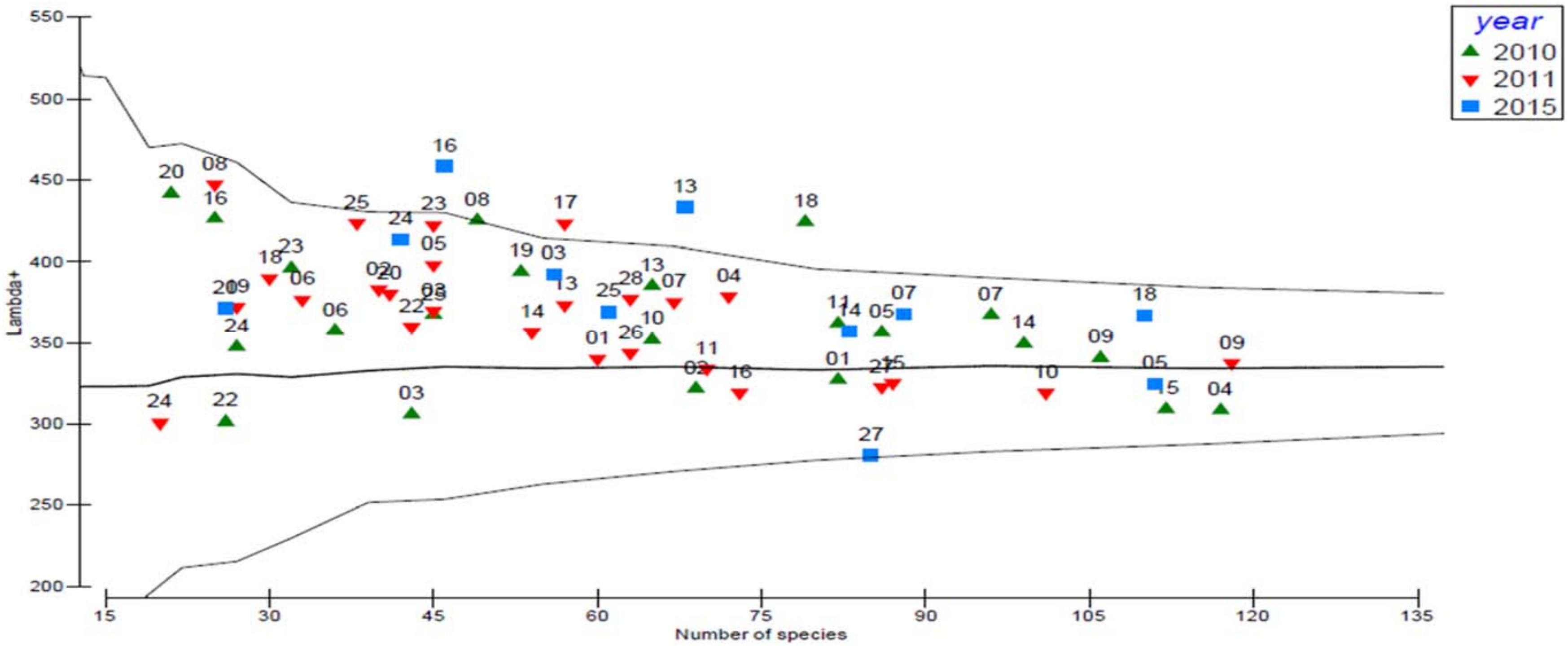


Figure 5-22 : Funnel plots for Variation in Taxonomic Distinctiveness (VarTD) for subtidal benthic communities, 2010, 2011 and 2015.

5.3.8 Grabs – Sabellariidae Aggregations

Assessment of Sabellariidae aggregations retrieved in the grab samples in terms of their potential 'reefiness' was made according to Gubbay (2007), with consideration of elevation, the densities of worms recorded and associated community diversity indices. The results of the grab observations were also used in conjunction with the DDC images, where appropriate, to help assign appropriate Sabellariidae biotopes to these sites (see Table 5.6 above for these and Figure 5-7 and gure 5-8 for distribution of these biotopes).

5.3.8.1 2010–2011

Visual observation from the subtidal grabs recorded the presence of Sabellariidae aggregations as either elevated structures (i.e. reef structures at >2 cm tube length) or thick/thin crusts (i.e. not reefs) (Figure 5-23). Between 2010 and 2011, a total of 11 sites sampled contained readily obvious Sabellariidae structures, with recordings from eight of these sites in 2010, and 10 in 2011 (Table 5.11). These 11 sites were distributed across the study area, but with none such structures observed from the inshore sampling site (refer to Figure 5-2 for distribution of grab sites).

a)

b)

Figure 5-23 : Elevated Sabellariidae aggregations (i.e. 'reef') observed from grab sample at WS13 (a), and crusts (e.g. 'not reef') of Sabellariidae aggregations observed from grab sample at WS11 (b), 2011.

Thick crusts (i.e. not reefs) were recorded at seven of the sites, but only in both years at sites WS08, WS11, WS13 and WS18. Three sites recorded elevated (i.e. >2 cm) structures (WS08, WS13 and WS18). Of those sites recorded with elevated structures, only WS13 in Church Bay was found to contain such fragments in both years and in the majority of the replicates. Site WS08 contained several small (2–5 cm), elevated fragments but only in a single replicate in 2011. Despite many fragments recorded from a single replicate at WS18 in 2010, the replicates in 2011 recorded small amounts of crusts with a single, small (2–5 cm) elevated fragment (Table 5.11).

Density values of *S. spinulosa* varied considerably, with the three highest values observed at sites with crusts (i.e. not reefs) recorded (WS05, WS09 and WS15) in 2011. Numbers of *S. spinulosa* did not necessarily reflect the presence of recorded structures in the grabs; for example, in 2010 the sites WS05 and WS15 did not record any structures from the grabs despite recording relatively high densities of *S. spinulosa*. The congener *Sabellaria alveolata* had also been recorded in the grab samples in 2010 and 2011, but in much lower abundances than *S. spinulosa* and as such are not considered here in this assessment.

Nine of those grab sites identified as having some form of Sabellariidae structure recorded a Shannon-Weiner diversity value (H') greater than 3 in at least one of the sampling years (Table 5.11). The highest H' value from all survey sites was recorded at site WS07 in 2011. However, at this site no *S. spinulosa* was recorded in 2011 and crusts had only been observed across three of the six replicate samples taken between 2010 and 2011.

Site WS13 in Church Bay was the only site identified as a potential biogenic reef site, in respect of all of the parameters considered. WS08 and WS18 (Wylfa Head – offshore) had recorded elevated tube structures (>2 cm) in the grab samples but are not considered representative of a 'reef' when also considering the low average patchiness of tubes observed across the DDC stills taken in 2010 and 2011 (<10%). No elevated tube structures (>2 cm) were recorded across the grab samples at WS09; however, very high densities of *S. spinulosa* had been recorded from these samples (1,033 m^{-2} in 2011) and a relatively high level of percentage patchiness observed from the DDC stills (20–30%). As a result of this, low confidence in assigning the site as 'not a reef' has been applied here.

Table 5.11 : Sabellariidae aggregations and their elevations recorded from the WS faunal grabs, 2010 and 2011. *S. spinulosa* densities (no. m^{-2}) and diversity values (H') are also listed. Note: three replicate grabs were carried out at each WS site in each year. The corresponding DDC sites listed against each WS site are also used as reference for interpretation and for determining average patchiness (% cover) of the sampling areas, but will not necessarily reflect a precise location match for the WS site. Resulting reefiness scores are assigned after Gubbay, 2007 and the confidence levels for each score denoted by [ ], low confidence, ( ), medium confidence, and no brackets for high confidence. *Sites surveyed in 2011 only.

Sites		Presence of Aggregations			Elevation			*S. spinulosa* no. m^{-2}		H'		Average Patchiness %	Reefiness Score
WS Grab Site	DDC Site	2010	2011	Total no. of reps	< 2cm Thin crust	< 2cm Thick crust	Elevated tubes > 2cm (cm)	2010	2011	2010	2011		
Church Bay – offshore													
WS13	DDC53	•	•	6		•	2-5, 5-10	295	233	2.64	3.10	20–30%	(Low)
West Mouse – offshore													
WS11	DDC46	•	•	5		•		453	390	2.59	2.91	<10%	Not a reef
Cemlyn Bay – offshore													
WS01	DDC37		•	2	•			11	33	2.48	2.05	<10%	Not a reef
WS07	DDC60*	•	•	3	•	•		285	0	3.22	3.87	0%	Not a reef
Wylfa Head – offshore													
WS05	DDC64*		•	2		•		164	353	3.50	2.70	< 10%	Not a reef
WS08	DDC62*	•	•	5	•	•	2 – 5	63	13	3.10	3.04	<10%	(Not a reef)
WS09	DDC63*	•	•	6		•		463	1,033	3.37	3.23	20–30%	[Not a reef]
WS18	DDC34	•	•	5	•	•	2- 5	393	3	2.93	3.15	<10%	(Not a reef)
Cemaes Bay – offshore													
WS10	DDC70*	•	•	2	•			87	317	3.56	3.58	<10%	Not a reef
West and East of Bull Bay – offshore													
WS14	DDC72*	•		1	•			44	37	3.26	3.53	<10%	Not a reef
WS15	DDC74*		•	3	•			319	720	3.59	3.44	20–30%	(Not a reef)

5.3.8.2 2015 Validation

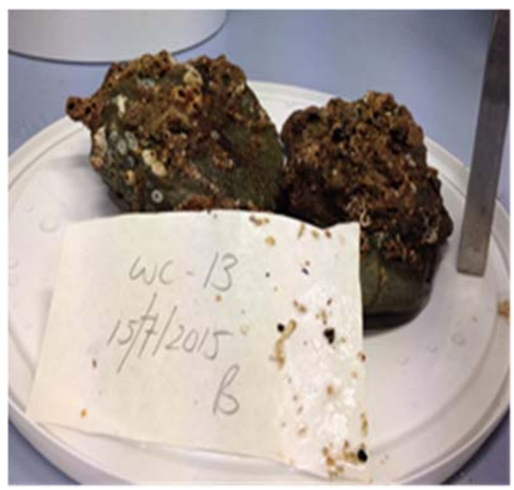
There was evidence of Sabellariidae aggregations in 2015 from observations of grab samples on the survey vessel, whilst being processed in the laboratory and by the presence of individuals recorded during taxonomic identification. These were recorded at WS13 (offshore of Church Bay); WS07 (offshore of Cemlyn Bay); WS05, WS08, WS18, WS27 (offshore of Wylfa Head); and in the far east at WS14 (offshore west of Bull Bay) and WS16 (offshore, west of Point Lynas).

Mixtures of thin and thick crusts (i.e. not reefs) were observed in the 2015 samples in the laboratory (WS13 and WS18,

Figure 5-24) and with some elevated structures (i.e. reefs) evidenced prior to sieving on the boat survey vessel at WS18 (Figure 5-25).

Density values of *S. spinulosa* at these sites varied greatly, with the three highest abundances recorded at sites WS05 (387 m^{-2}), WS14 (460 m^{-2}) and notably at WS18 (2,383 m^{-2}). These sites were typical of the sites where aggregations of Sabellariidae were also present in 2010 and 2011 (Table 5.11).

The reef-building organism *S. alveolata* (honeycomb worm) was also recorded in 2015 at the following sites: WS13 (two replicates), WS14 (two replicates), and with a notable presence at WS18 (all replicates, total densities at 444 m^{-2}); however, it was recorded at much lower densities than observed for *S. spinulosa. S. alveolata* had also been recorded in 2010 and 2011 and similarly as a sub-dominant to its congener *S. spinulosa.*



a) **b)**

Figure 5-24 : Crusts (i.e. not reefs) of Sabellariidae on small boulder from site WS18 (a) on small boulders from site WS13 (b), 2015.

Figure 5-25 : Elevated structures (i.e. reefs) (>2cm) observed in grab sample from site WS18, 2015.

5.4 Discussion

The aim of these assessments was to provide baseline information as to the spatial distribution of subtidal benthic habitats present, and to identify any important conservation features. The combination of the DDC operations alongside the faunal grab results has enabled biotope designation of the subtidal benthic communities within the vicinity of the proposed new Nuclear Power Station on Anglesey. These surveys allowed analysis of both the coarse and softer sediments present in the area, and through this, biotopes have been ascribed to the onshore and offshore areas, as well as being able to note any species of particular importance. Any conservation features, with particular reference to UK BAP species, Annex I habitats under the EC Habitats Directive and those listed under the Section 7 list of priority species, have been discussed.

5.4.1 DDC Communities

The rocky nature of the environment around north Anglesey means there is little in the way of mobile demersal fishing activity. This has resulted in relatively low levels of physical anthropogenic disturbance, especially when compared with many UK inshore, soft-sediment environments. The absence of such activities, along with the presence of suitable substrata and strong tidal currents, allows a diverse assemblage of organisms to colonise the seabed. Large, longer-lived, colonial organisms such as the bryozoan *F. foliacea* and the cnidarian *A. digitatum* were common at many of the sites surveyed with the DDC surveys in 2010 and 2011.

The results suggest that both depth and the degree of exposure to tidal currents drive the development of the communities encountered at each site. The more sheltered sites surveyed are exposed to lower tidal currents; thus, the deposition of fine sediments in these areas is greater when compared with sites that are further offshore and around the exposed headlands. Increased sediment deposition, at the sheltered sites, influences the composition of the epifaunal communities, with predominantly muddy sediments occurring in the most sheltered sites of Cemaes Bay (Section 3.3.2.1.1).

The shallower, more sheltered habitats along the north Anglesey coast showed considerable community heterogeneity in 2010, and this is possibly a consequence of the large spatial distribution of these sites and the highly varied nature of the seabed and degree of exposure. In contrast, the sheltered sites sampled in 2011 were within a more discrete region and showed considerable similarity in composition, as evidenced by the clustering seen in the MDS plot (Appendix C, Figure 8-2). The change in primary groups contributing towards the differences between the sheltered and exposed sites, from algae in 2010 to *Ophiura albida* in 2011, is not unexpected. None of the sites in the depth range 1–5 m were sampled in 2011, and furthermore, the substrata of most of the shallow sheltered 2011 sites were soft sediments as opposed to the rocky substrata sampled in 2010 which would favour sublittoral algal communities.

The subtidal, epifaunal communities at Wylfa Head (DDC15 and DDC16) were not significantly different when compared with those from further afield at sites such as Llanlleiana Head (DDC5 – DDC7) and Point Lynas (DDC1 – DDC3) to the east, and Carmel Head (DDC47) and Church Bay (DDC53) in the west. At all of these highly tide-swept sites, the epifauna were dominated by the hydroid *H. falcata*, the bryozoans *F. foliacea* and *A. diaphanum* and the dahlia anemones, *Urticina* spp. and many had been assigned the biotope code SS.SMx.CMx.FluHyd.

The presence of brittlestar beds north of Wylfa Head is expected as brittlestar beds are common around the coast of Anglesey and often accumulate in areas of moderate tidal flows. Invertebrate data collected during the subtidal fish trawling surveys (see Appendix D13.04 Fish and Fisheries (Application Reference Number: 6.4.86)) confirmed the presence of these brittlestar beds.

5.4.2 Faunal Grab Communities

The soft-sedimentary benthic communities showed considerable variability both in numbers of taxa and abundance and were spatially distinct between inshore and offshore sites. Sites within Cemaes Bay and at other inshore sites to the west of Wylfa Head were characterised by communities with moderate numbers of both taxa and individuals in the 2010 and 2011 surveys compared to offshore communities, and were similarly characterised in the 2015 validation study. The sediments at these sites were composed predominantly of finer material, particularly sands, and the communities were dominated by the bivalve molluscs *Nucula* spp. and *Abra alba*, both of which inhabit lower-energy sandy substrata.

The communities reported at the offshore sites in 2010 and 2011 were characterised by higher numbers of taxa than those observed at the inshore sites; community abundances were broadly similar throughout the survey area. The most abundant taxon in the offshore communities was the Ross worm *S. spinulosa*, which inhabits coarse sediments in high-energy areas: an environmental factor which typifies the offshore sites around north and west Anglesey. The community abundances and increased diversity of taxa were also reported in the 2015 validation study in the offshore sites, suggesting little temporal change.

5.4.3 Biotopes

At several DDC sites in 2011 (DDC23, 31, 34, 37, 42, 46 and 53), it was not possible to sample the same location as sampled in 2010; even so, many of these stations did not change from their 2010 biotope designations. The biotopes at sites DDC31 and DDC46 were changed, being respectively described as ‘sublittoral sands and muddy sands’ and ‘*Flustra foliacea* on tide-swept circalittoral mixed sediment’ in 2011. It is probable that these ascriptions are representative of the gradation to habitats with slightly different current regimes, as both biotopes are similar to those originally assigned to these stations in 2010. DDC46 and DDC46a (2011) at West Mouse were grouped together in the cluster plot and reasonably strong inter-annual similarities were also seen with DDC23, DDC37 and DDC53. In contrast, DDC31 and DDC34 are displayed on the periphery of both the cluster and MDS plots, DDC31 being particularly noticeable as an outlier. Analysis of the taxa showed this inshore site in 2010 to have a poor diversity (3 taxa recorded), whilst the community surveyed in 2011 (DDC31a) was comparatively rich (12 taxa). The change to a muddier substrata possibly gave rise to the richer community recorded.

Other outliers in the analyses included DDC7a (2011), DDC19 and DDC58. The most visually apparent outlier from the 2011 analyses was DDC7a at Llanlleiana Head. The DDC images at this site showed rocks festooned in the cnidarian *Tubularia indivisa* (Figure 5-10). Only very minor differences were recorded in location and depth between the 2010 and 2011 sample sites (DDC7 and DDC7a). Thus, it is considered that the difference seen between the associated community of this site (DDC7a) and the other survey sites is the result of good recruitment by this cnidarian. DDC19 and DDC19a north at Porth Wynal at Wylfa Head were the only stations given the biotope code ‘echinoderms and crustose communities’ (CR.MCR.EcCr) and recorded as having high densities of the feather star *Antedon bifida*. The particular assemblages identified at these sites separated them from the other stations. The silt-covered bedrock at DDC58 in Cemaes Bay in 2010 prevented accurate identification of the bivalve viewed, resulting in an incorrect record of *Mytilus* sp.; however, in 2011, the habitat was visible as a *Musculus discors* bed. Therefore, based on the clear images of the site provided during the 2011 survey, the initial biotope described in 2010 should instead be considered as ‘*Musculus discors* bed on moderately exposed circalittoral rock’.

Use of the grab data provided a better description of several of the DDC habitats, allowing a higher level of biotope assignation at a number of coincident sites. This was particularly useful at locations where few epibionts were visible. However, the tendency for the statistical outputs to force communities into a specific biotope means that the grab results should be used, where possible, in tandem with the images to produce the most accurate designations. The majority of the sites kept their initial biotope descriptions (as established by DDC images), a small number were changed according to those biotopes described from grab analyses (see Table 5.6), and a single station (DDC69/WS06) had its description changed to represent a biotope that sat between both the DDC and grab designations. The dominant taxa from the grab sample of WS06 north of Cemaes Bay did not represent SS.SSa.CMuSa.AalbNuc and instead was better described as SS.SSa.CMuSa (a level higher than that given by DDC analysis). It should also be noted that, in several instances, the slight offset of the grab from the position of the DDC has led to clearly different biotopes being recorded using each technique (e.g. DDC70, WS10). The complex mosaic of biotopes around this coastline increases the heterogeneity of the seabed communities, so it is entirely possible that quite discrete biotopes may be recorded within several metres of each other rather than always being a gradation of one biotope to another.

Sabellariidae biotope ascriptions are detailed below (Section 5.4.6).

5.4.4 Ecological Quality and Biodiversity

Assessment of the quality of the benthic environment throughout the survey area, as measured by the ecological quality status, indicates that the benthic communities are generally of High quality. This observation is supported by the derived W-statistic, which indicates that communities throughout the study area are undisturbed. Similarly, measures of biodiversity (AvTD and VarTD) indicate that the structure of the subtidal communities is as expected; with any deviation from the norm only present at offshore sites where it may be concluded that this is a typical deviation due to the high-energy, heterogeneous, sedimentary habitats characterising this area.

The ecological quality in 2010 was reported as High at all sites, Good to High at all sites in 2011 and Moderate to High in 2015. The sites which were not allocated High status in all years were inshore shallow sites WS03 (Cemlyn Bay), WS20 (Cemaes Bay) and WS25 (Porth-y-pistyll). The use of AMBI (AZTI's Marine Biotic Index) relies on species being categorised into one of five ecological groups (AMBI-EG) ranging from I to V; these thresholds are indicative of benthic community health, where AMBI-EG I represents 'very sensitive species' and AMBI-EG V 'first-order opportunistic' taxa' (Borja, 2005). The sites which were attributed Good status in 2011 had a relatively high abundance of *Abra alba* (AMBI-EG III 'species tolerant') compared to the previous year, which may have contributed to the decrease in ecological status between years. The sites in 2015 which were not reported as High quality had several dominant taxa assigned to AMBI-EG's of III and IV ('second-order opportunistic') , resulting in lower ecological quality scores, namely *A. alba* (AMBI-EG III), *Lagis koreni* (AMBI-EG IV) and *Mediomastus fragilis* (AMBI-EG III). The substrates at these sites were characterised by relatively homogenous, muddy sediments supporting communities of moderate numbers of taxa but high individual abundance. At WS25 and WS20, *A. alba* remained dominant in 2015, but at WS03 *L. koreni* was the most abundant taxa recorded (Appendix C, Table C.3). Indeed, it may be concluded that the high abundances of *A. alba* and *L. koreni* are an important causal factor in attributing the lower ecological statuses in 2011 and 2015. It is likely these changes are down to natural abundance fluctuations over time.

Any divergence from the expected values for the measures of diversity in 2010 and 2011 as determined by taxonomic distinctness (AvTD and VarTD) occurred exclusively at offshore sites. Examination of the species complement at these sites would indicate that this was likely to be related to grouping of closely related species, in this case syllid and phyllodocid polychaetes and mytiloid (mussel) bivalves, which are typical of high-energy, heterogeneous, sedimentary habitats. However, as the fauna concerned are not relative dominants or particular stress indicators, it is considered that the communities at these sites are typical with respect to biodiversity.

Taxonomic distinctness has advantages over univariate measures of biodiversity (evenness, species richness, etc.), but will be sensitive to differences in habitat characteristics. Any variability in sediment types within the sampling area will affect the species pool and can be detected in comparisons made between the sample list and the 'master list' (the 'norm'). Of the sites that might be assumed to be 'stressed' in 2015 because they have varied from the norm, several supported populations of *S. spinulosa* (WS5, WS13, WS16 and WS18). Diversity (species richness and evenness) may be higher at such sites where tubes of *S. spinulosa* are present, due to the increased habitat complexity afforded by such biogenic structures. Diversity will be increased across the range of all taxonomic lineages, as well as within particular groups, examples being species belonging to the phyllodocid family (paddle worms) and to the family Syllidae.

These results indicate that natural environmental influences are driving the community structure observed at these sites, with sediment type, tidal strength and habitat complexity the most important factors. All sites in 2015 which were removed from the norm were also not within the expected range in either 2010 or 2011, or both. Data from 2010 and 2011 remain representative of the biological communities prevailing in the area in 2015.

5.4.5 Temporal Changes

Although a few temporal changes were identified in the DDC surveys, multivariate analysis did not reveal large temporal differences between those sites in proximity of the Existing Power Station's cooling water outfall (DDC19a and DDC20a), or those directly north of Wylfa Head (DDC15a and DDC16a). Analyses of the combined 2010 and 2011 data showed these sites clustered together (Figure 5-13). The similarity shown between these sites (DDC15, DDC16, DDC19 and DDC20) demonstrates reliable baseline data are provided and any future work required should focus on these stations and the adjacent area. Though there were several examples of large temporal variations, these sites were a long distance from the Existing Power Station's cooling water outfall and are thought to represent natural variations as opposed to being the result of any thermal disturbance. As Wimpol (1985) noted, the rapid dispersal of the cooling water discharge at Wylfa Head suggests that there is minimal thermal influence on the seabed in this area.

General differences in the taxa lists from the DDC survey results (Appendix C, Table C.1) are largely attributable to the inclusion of taxa from sites only sampled in one year. Other contributing factors could be the resolution of the images, slight changes to the location and the decision not to sample infralittoral habitats in 2011. The variation in the annual timing of the surveys (June 2010 and April 2011) may have caused slight differences in the results as some fauna display seasonal patterns; however, in epibionts, these variations are most readily obvious in algae which made a noticeably greater contribution to the 2010 samples on account of the infralittoral stations sampled. Furthermore, the difference in timing between the annual sampling periods was just over one month and is thought unlikely to result in dramatically different faunal data at this time of year.

It is well known that soft-sediment benthic communities can undergo temporal changes due to a variety of factors, both natural and anthropogenic (see Gray and Mirza, 1979). The subtidal faunal grab data collected in all three years indicate some variability in the communities at all sites, although these changes are not considered to be ecologically significant during the sampling period. It is evident that the communities sampled across the study area have remained relatively stable with only natural inter-annual fluctuations in abundances. At the offshore site WS16 (west of Point Lynas), changes in communities across the three sampling periods were noted; it was shown to be outside of the expected range of taxonomic distinctness in both 2010 and 2015 and, in those years, was identified as distinct from the other, deeper, offshore sites (see Table 5.10 (Group IIa) and Figure 5-19). The biotope ascribed to WS16, SS.SCS.CC.Blan, was a higher level than the other broadly ascribed biotopes, SS.SCS.CCS, in this offshore area, and suggests a typical gradation of biotope in the vicinity of WS16 which is likely to shift over time due to the high-energy environment. Where there have been notable changes in community features, these can at present be related to the temporal change in physical habitat features (sediment types) which may support a different species assemblage. Consequently, it is considered that the data from 2010 and 2011 continue to provide an adequate baseline for future environmental assessments.

The lack of change in community composition and overall biotope classifications suggests the communities are persistent over time, at least in the medium term, and are unlikely to exhibit any sudden shifts under natural conditions.

5.4.6 Conservation Features

Several features were recorded that are designated Annex I habitats. These included 'Sandbanks which are slightly covered by sea water all the time', which covers muddy sand communities, and 'Reefs', which covers subtidal rocky communities and also where the intertidal rocky habitat extends into the rocky subtidal zone. On the east and south-east side of Anglesey is the Menai Strait and Conwy Bay SAC, which is specifically designated for the good examples of both sandbanks and reefs within the area. In addition to the Annex I habitats, subtidal sand and gravel habitats and those rocky communities characterised by sponge assemblages are designated features under the Welsh Section 7 list of priority habitats.

These Section 7 designations encompass a number of the biotopes recorded, such as SS.SCS.CCS (circalittoral coarse sediment), SS.SSa.CMuSa (circalittoral muddy sand) and SS.SSa.CMuSa.AalbNuc (*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment) as well as CR.HCR.XFa.ByErSp.DysAct (mixed turf of bryozoans and erect sponges with *Dysidea fragilis* and *Actinothoe sphyrodeta* on tide-swept wave-exposed circalittoral rock) and CR.MCR.CMus.Mdis (*Musculus discors* beds on moderately exposed circalittoral rock).

A further designated habitat was also recorded, SS.SBR.PoR.SspiMx (*Sabellaria spinulosa* on stable circalittoral mixed sediment). Although this feature is not on the Section 7 list, as a biogenic reef it is covered under the Annex I description for 'Reefs' and are also listed as a UK BAP priority habitat. These complex habitats are often inhabited by a rich and diverse associated community, and where grab samples revealed the presence of well developed Sabellariidae structures, a diverse community was recorded (Section 5.3.8). Inherent difficulties exist in the determination of this habitat; however, the combination of visual observations of elevated structures, from grab samples and DDC images, along with repeated records spatially (in same vicinity) and temporally, helped discern their presence. Further discussion of the assessment of these biogenic features is detailed below.

5.4.6.1 Annex I – Biogenic Reefs

Determining if an area of seabed covered in Sabellariidae qualifies as a biogenic reef has been the subject of several recent reports (e.g. Gubbay, 2007; Limpenny *et al*., 2010), and the *Interpretation Manual of European Union Habitats* (European Commission, 2007) does not quantify the 'elevation' of a structure to distinguish crust from reef. Application of quantitative parameters has been attempted to determine 'reefiness' (see Table 5.4; Gubbay, 2007), and a sensible starting approach is assigning a height of greater than 2 cm to represent an elevated structure (i.e. anything less than this was considered a crust) (Gubbay, 2007). Because structures of the Sabellariidae worm *S. spinulosa* can be found up to 30 cm in height within UK waters (Foster-Smith and White, 2001) and an elevation of 2–5 cm above the bed has been considered as low 'reefiness' (Gubbay, 2007), this suggests that the value of greater than 2 cm in the context of *S. spinulosa* biogenic reef designation is particularly conservative. Although several criteria have been suggested for the assessment of biogenic reef communities, including extent and patchiness, the overarching criterion is the elevated structure, and for this reason any *S. spinulosa* community without an observed elevated structure was not considered any further for review within this benthic programme.

Over the duration of the 2010-11 grab-sampling programme, three sites were identified with structures that represented elevations greater than 2 cm (WS08, WS13 and WS18). The results from visual observations of the grab material at WS13, along with the repetitive collection of fragments within the same vicinity and during both years, suggested the presence of Sabellariidae biogenic reef (of low reefiness); this was further evidenced by DDC surveys in the same locality at Church Bay.

Sabellariidae remained present in the form of crusts at all the sites re-sampled in 2015 (WS05, WS07, WS13, WS14 and WS18) and dense populations were present at the same localities recorded previously (WS05, WS14 and WS18). In addition, elevated Sabellariidae aggregations were photographically recorded in the grab sample at site WS18 (offshore of Wylfa Head) (Figure 5-25). At DDC34 (which overlapped with WS18), the presence of upright Sabellariidae tubes from a single replicate image with a patchiness of approximately 20% had been recorded in 2011. However, no Sabellariidae tubes were evident at DDC34 the year before in 2010 (surveyed approximately 50 m distant from DDC34, 2011). Densities of *S. spinulosa* varied at WS18, with high densities recorded in 2010 and 2015, but very low densities in 2011. The evidence suggests a rather ephemeral community at this site rather than a stable reef structure, leading to a biotope ascription based on the mixed sediments present (SS.SMx.CMx) rather than the presence of *S. spinulosa* reef.

Rapid assessment diver transect surveys were undertaken in 2016 around the Existing Power Station's cooling water outfall channel at Porth Wnal, and in the vicinity of the proposed breakwater structures in the north of Porth-y-pistyll. The aim of these surveys was to determine the presence of any biogenic Sabellariidae aggregations and if they constituted reefs. These assessments widened the overall spatial coverage for assessing Sabellariidae aggregations in the study area, as surveyed by DDC and faunal grabbing surveys of 2010-2011 and 2015. The results of the shallow transects at the outfall channel reported a SACFOR score of only 'Rare' or 'Present' and with a % patchiness score of 1–5%. To the east and west of the outfall channel, the deeper transects also revealed no reefs present with only sparsely distributed tubes, though with some patches of crusts recorded. Similarly, the breakwater footprint transects north of Porth-y-pistyll found no reef habitat and with only sparsely distributed individual tubes or isolated areas of crusts present.

Although *S. spinulosa* was the most abundant taxon in the offshore communities sampled, the presence of this Sabellariidae polychaete did not always result in any observable structure, and when the structures were recorded, the majority were as crusts overlying cobbles, i.e. not a reef according to Gubbay (2007). Several sites along the north coast recorded elevated fragments, but these were found to be patchy and/or ephemeral; hence, this led to a designation of CR.MCR.CSab.Sspi (*Sabellaria spinulosa* encrusted circalittoral rock) or even SS.SMx.CMx (circalittoral mixed sediment). Necessary caution was applied to the assignation of biotopes, particularly to biogenic reef. The ability of the DDC vessel to remain within 2–5 m of the sampling site means that an area of 5 m by 5 m may not be sampled. In contrast, the grabbing work drifted tens of metres from the target site owing to the strong tides. Hence, if multiple grabs detailing the same feature are retrieved, then more robust assumptions can be made on the habitat extent in the proximal area and greater confidence is gained that the extent requirement for a discrete biotope (an area ≥ 25 sq. metres) has been met.

From application of these criteria, the survey results suggest that in the vicinity of Church Bay there exists an area dominated by Sabellariidae biogenic reef of low reefiness for at least several hundred metres, and this is comparable with recent data from the area. Recent surveys by Baldock and Goudge (2017) confirmed the presence of extensive reefs >10 cm in height at five sampling sites in Church Bay. At sites approximately 1.5 km offshore from Wylfa Head, the surveyors had also reported diverse communities supported within a CR.MCR.CSab.Spi habitat but of only low aggregations over stony reef of cobbles and small boulders. Within this same area, a comparatively high number of taxa (> 125, Figure 5-14) were recorded from the grab site WS09, with no reef structures but thick crusts of Sabellariidae and high densities of *S. spinulosa* in 2010 and 2011 (Table 5.11). Analysis of images at DDC63 (coincident with WS09) led to the biotope CR.MCR.CSab.Spi being ascribed (gure 5-8).

The congener *Sabellaria alveolata* was recorded during the faunal grab surveys and recorded at the same sites in 2015 as they had been in 2010 and 2011, though at lower abundances than *S. spinulosa*. A recent report by Baldock and Goudge (2017) suggested that it was likely that the Sabellariidae reefs and crusts observed in their surveys of the north Anglesey area were comprised of tubes belonging to *S. spinulosa,* citing that, although specimens of subtidal *S. alveolata* had been recorded from other commercial surveys around north Anglesey, there is no evidence that the species forms reef in this area.

5.4.6.2 Section 7 Priority Species and INNS

No species with any conservation designations were recorded during the subtidal grab and DDC surveys; however, a single record of the UK BAP species *Palinurus elephas* was noted whilst carrying out the Existing Power Station cooling water outfall dive surveys in Appendix D13.05 Marine and ecological baseline at the Cooling Water outfall of the Existing Power Station (Application Reference Number: 6.4.87). *P. elephas* is also listed as a species of principal importance in Wales under Section 7.

No INNS were recorded during the subtidal benthic DDC and grab surveys. Similarly, a recent benthic survey by Baldock and Goudge (2017) of the offshore sublittoral communities between Church Bay in the west and Wylfa Head in the east did not report the presence of any INNS.

6. Subtidal Communities – Disposal Site

6.1 Introduction

As detailed in Chapter 1, specific consideration is given to Holyhead North, and in 2016, a benthic study was initiated to collect data from this area, herein referred to as 'the Disposal Site', and broadly characterise the seabed (Section 1.3.2).

This chapter uses the results of focused benthic surveys carried out in 2016 and also the findings from other relevant benthic studies, particularly those commissioned for the Minesto project (see Section 2.2.4), to generate an understanding of the physical and ecological nature of the Disposal Site and surrounding area. It should be acknowledged that the sediment characteristics (physical and chemical) are covered in Chapter 3.

6.1.1 The Disposal Site

A summary description of the Disposal Site is provided in Section 1.3.2. Following a literature review, this section provides further background detail on the Disposal Site. The description of the site is mainly supported by recent baseline data obtained using a combination of remote sensing, benthic grabs and DDC as part of a proposed development by Minesto in the area to the south of the Disposal Site (CMACS, 2016).

6.1.1.1 Physical

The Irish Sea is a high-energy shelf sea, with the site itself experiencing tidal velocities of 1.75 – 2 m sec^{-1} (depth averaged) and tidal ranges of around 4 m, resulting in well mixed unstratified waters with only a weak thermocline developing during times of fine weather. The Disposal Site falls into an area classified as 'offshore mixed waters' where waters are highly saline (>34 ‰) and exhibit moderate winter nutrient conditions (Potter, 2014; Kennington and Rowlands, 2004).

Multibeam bathymetry has indicated that the Disposal Site varies in depth from approximately 35 m to 95 m, though the majority of the site is deeper than 50m, with the seabed predominantly comprised of coarse sediments, boulder and bedrock. Work by the British Geological Survey and SEACAMS indicated that the majority of bedrock is found along the eastern and south-eastern boundary of the site, with estimates giving an area of 2.74 km^2 (~10% of the whole Disposal Site) for bedrock. Adjacent to the bedrock, covering approximately 9.59 km^2 is an area described as 'rock and sediment' with grab samples by SEACAMS recording 'sandy coarse gravel' to 'very coarse gravel' (Xodus, 2015). The areas of bedrock and rock tend to occupy the shallower waters (50 m to 60 m) with the coarse gravels found accumulated in the deeper plateaus. Due to the depths of Holyhead North, bed shear stress will be dominated by tidal processes and it is generally predicted to range between 6 Nm^{-2} to 10 Nm^{-2}, and with the bed shear stress threshold for bed transport of fine sediments at 0.18 Nm^{-2} (Potter, 2014).

6.1.1.2 Ecology

Mapping information, as provided by the HABMAP project (Robinson *et al.,* 2009a; 2009b; 2011), has predicted that the majority of the Disposal Site supports biotopes associated with the sedimentary SS.SMx.CMx ('Circalittoral mixed sediment') habitat in the west with other sedimentary areas supporting SS.SMx.CMx.MysThyMx ('*Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment'). The rocky areas of the eastern margins were predicted by HABMAP to be CR.MCR.EcCr.UrtScr ('Echinoderm and crustose communities') and CR.MCR.EcCr.FaAlCr ('Faunal and algal crusts on exposed to moderately wave-exposed circalittoral rock), with a mosaic of such rocky and sedimentary habitats across the Disposal Site. Infauna associated with the sedimentary habitats is predicted to include a wide range of taxa, including polychaetes, bivalves and brittlestars. Harder substrata may enable sessile epifaunal species to become established, particularly hydroids such as *Nemertesia* spp and *Hydrallmania falcata.* Scour-tolerant species such as the anemones *Urticina* spp. may be common within the CR.MCR.EcCr.UrtScr habitats. From interpretation of these biotope ascriptions, work by Xodus (2015) predicted that the dominant communities likely to be present will consist of taxa with very low to intermediate sensitivity and immediate to very high recoverability, in relation to potential stress from increased suspended sediment concentrations and smothering

(Xodus, 2015). CMACS (2016) undertook surveys to the south and south-east of IS043 as part of the Deep Green Project and had reported epifaunal communities of this area to be mainly sparse and often comprised of scour-tolerant taxa.

Annex I habitat ‘reefs’, as described within the *Interpretation Manual of European Union Habitats* (European Commission, 2007), were predicted to be present within the area, with rocky reefs extending along the central area of the Disposal Site, with biogenic reefs possibly present to the east (review by Xodus, 2015). Historical grab surveys indicated the presence of reef forming species in the area of the Disposal Site (Rees, 2005). Recent work has confirmed the presence of Sabellariidae worms to the south of IS043 (CMACS, 2016) and biotopes of Sabellariidae assigned at discrete sites within IS043 itself (Baldock and Goudge, 2017).

6.1.1.3 Use

Much of the material disposed at the Disposal Site is from maintenance dredging arisings, mainly consisting of fine dispersive material (Potter, 2014). However, there have been several capital dredging disposal operations carried out at Holyhead Deep since the mid 1980s, including a large-scale capital dredging disposal event in 1995 when approximately 450,000 tonnes of material was disposed at Holyhead Deep (Xodus, 2015). The Disposal Site has thus received both capital and maintenance dredged material, which suggests both consolidated and unconsolidated material have been disposed at the site. Although it is not known for certain whether rock material has previously been disposed at the site, anecdotal evidence suggests that it may previously have been permitted (Atkins, 2017).

The closer proximity of the eastern margin of the Disposal Site to Anglesey has resulted in the eastern region of Holyhead North (and the historical Holyhead Deep) receiving the majority of the disposal events. For example, data provided by Stena Line Ports since 2009 have shown that the eastern side, specifically towards the south-east of the Disposal Site, has experienced the most disposal events (source Stena Line Ports ltd., c.f. Xodus 2015).

6.2 Methods

The benthic ecology study encompassed two separate sampling surveys, DDC and grab, with the DDC informing final targeting of the grab sites. The results of sediment sampling work are provided and discussed in Chapter 3.

The DDC work was undertaken between the 28th and 30th October 2016. The grab survey was carried out on the 17th December 2016. All benthic survey work was undertaken from the RV *Aquadynamic*.

6.2.1 Site Selection

To broadly characterise the biological communities, sites were selected to provide good spatial coverage of the Disposal Site while acknowledging historical benthic data (Section 2.2). Recognition was given to the location of ongoing and historical disposal activity and the proximity to the closed southern half of the historical Holyhead Deep disposal site. Acknowledging the above, the sampling regime was focused on the eastern margin of the disposal site. However, the study also incorporates a number of sampling stations outwith this focal area, allowing representation of the wider benthic environment in and around the Disposal Site (Figure 6-1).

Across the Disposal Site, a total of 19 sites were targeted using a combination of DDC (17 sites) and grab (eight sites). Of the 17 DDC sites, six were initially selected as suitable for grab sampling, following assessment of the substratum. Following DDC analysis, many of the sites were confirmed as not being suitable for grab sampling, due to the amount of coarse particles of cobbles, boulders and bedrock present.

At a single DDC site (HHD_17), images of prominent tubes structures, belonging to the tube-building Sabellariidae worms, were captured, and as a precaution this site was deemed unsuitable for grab sampling to avoid potential damage to this feature. Two sites, 1 nm south of HHD_16 and HHD_08 (HHD_19 and HHD_20, respectively), were also targeted as potential grab sites to increase the spatial coverage of the western region of the Disposal Site. This resulted in a total of eight grab sites (Figure 6-1).

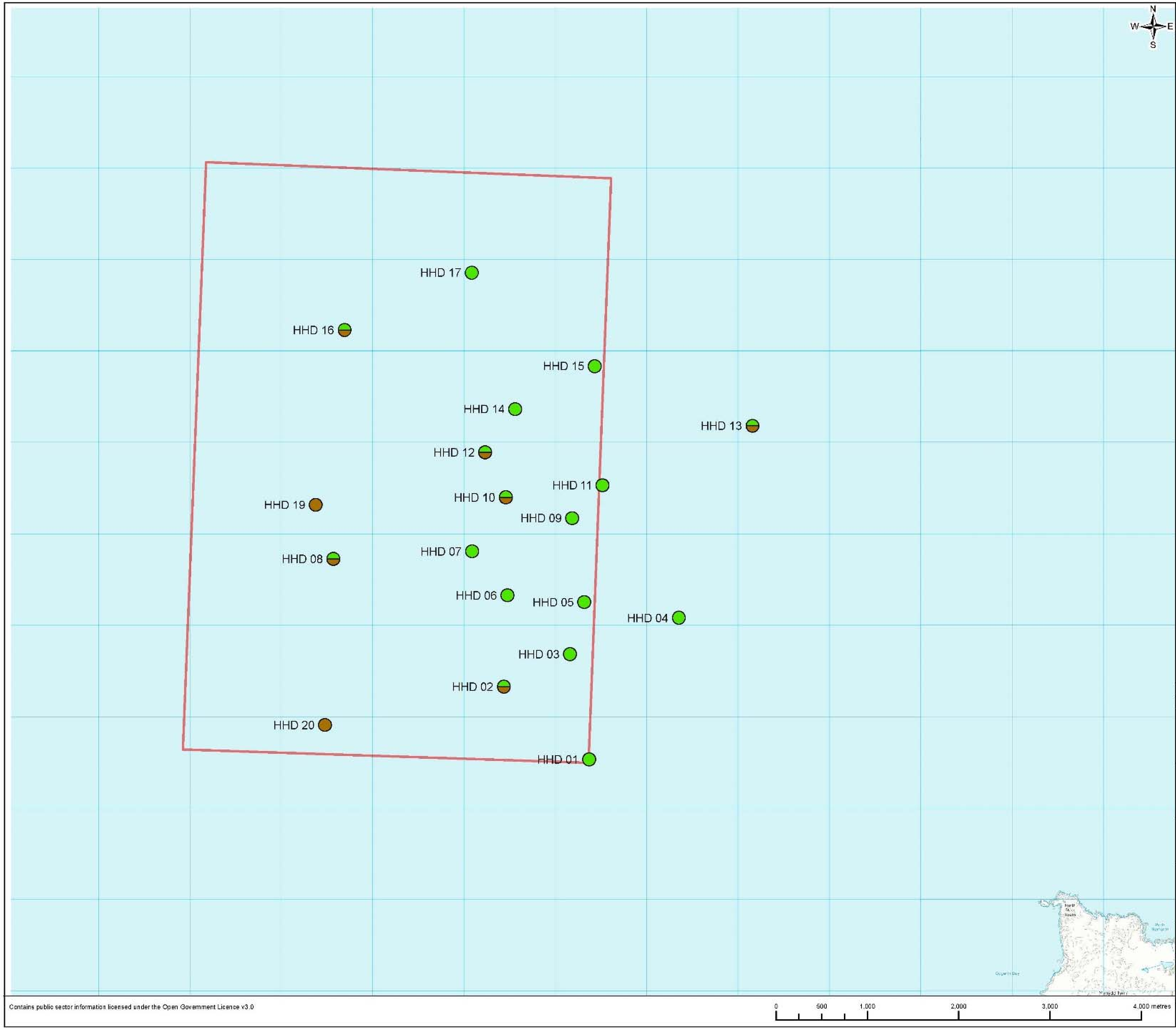


FIGURE 6-1

Legend

Disposal Site

Subtidal benthic survey sites

Drop down camera

Benthic fauna sampling

0	AUG 17	Initial Issue	VG	CT	EC	RB
Rev	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd

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Drawing No.

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6.2.2 Sampling Methodology

The aim of this programme was to broadly characterise the seabed of the Disposal Site, resulting in a taxa list and consideration of their relative abundances. Consideration of this DDC data thus allowed accurate discrimination of the benthic biotopes at each site and was used in conjunction with sediment and infaunal grab data if the remote sampling coincided.

All sampling was carried out using the RV *Aquadynamic* which used a dynamic positioning system to ensure that it remained within a few metres of its target location during deployment of the DDC and grab.

6.2.2.1 DDC

Underwater imagery was produced using the high resolution digital camera 'Weasel II' that has a frame size of 592 x 444 mm (~ 0.26 m^{-2}) (3264x2488 pixels) and a resolution of 53 million pixels per square metre, with live and recordable video outputs of each dive. A position fix was taken by the surveyors, once the camera reached the seabed, along with a record of depth, time, substratum and a brief description of the ecology. The camera was then raised off the seabed and re-deployed several times. Up to five still images were taken at each sampling site along with continuous video. Refer to Section 5.2.2.1 for detailed DDC methodology.

6.2.2.2 Faunal Grab Sampling

A 0.1 m^2 mini Hamon grab was deployed to collect faunal grab samples. At each site, a single biological sample was obtained, with a further one taken for physico-chemical analysis of sediment (see Sections 3.2.2 and 3.3 for methodology and results). All biological samples were washed over a 1 mm mesh sieve (BS410), with all material retained on the sieve fixed in a 4% formaldehyde solution. All biological samples collected were assessed for the presence of significant Sabellariidae tube structures, i.e. those that represented tubes >2 cm long. If these structures were present, then no further samples were taken for sediment analysis.

6.2.3 Laboratory Processing

All faunal grab samples were processed, as outlined in Section 5.2.3, implementing appropriate Quality Assurance/Quality Control (QA/QC) protocols (see Section 5.2.3). In addition to species abundances, biomass was also determined (blotted wet weight to 0.0001 g) and any encrusting epifaunal mats were recorded as present, but no weights obtained.

6.2.4 Data Analysis

6.2.4.1 DDC

All images were analysed and reviewed according to QA/QC protocols (Section 5.2.4). Specific consideration was given to the potential presence of biogenic reefs, including *Modiolus modiolus* (horse mussel). However, the only biogenic reef recorded during the surveys was that of Sabellariidae and the quality of these reefs recorded (as defined by its 'reefiness') was assessed using the criteria of Gubbay (2007) and Hendrick and Foster-Smith (2006). Rocky stony reefs were assessed using the criteria of Irving (2009) (see Section 6.2.4.3). At site HHD_11, no stills were taken due to a temporary cut in communication between the computer systems and the camera, so assessments were carried out using the video data.

6.2.4.2 Grab

Nomenclature followed that of the WoRMS online database (WoRMS Editorial Board, 2017). Any 'fragments' entries were deleted from the dataset, and all faunal abundances that had been recorded as present (e.g. hydroids and bryozoans) were converted to values of 1 prior to analysis.

For graphical interpretation of the faunal grab data, all total abundances and biomass were scaled up to values representing densities (individuals or g) per m^2 and the relative proportions of all major taxonomic groups were also calculated for each of these parameters at each site. Diversity indices (species richness, Pielou (J), Margalef (d) and Shannon-Weiner (H')) were calculated for each site, and abundance biomass patterns (ABC curves) evaluated via the DOMPLOT routine in PRIMER. Further multivariate analysis was undertaken in PRIMER, where appropriate, on square root transformed data to investigate patterns in the assemblages (CLUSTER, SIMPROF, ANOSIM) and, if detected, to identify which of those taxa contributed most to overall similarity within, and dissimilarity between, these communities (SIMPER) (see Appendix C, Section C.3 for full statistical glossary).

6.2.4.3 Annex I Habitats

The habitats surveyed were assessed for potential Annex I reef habitats (rocky and biogenic) and, where possible, subsequently classified into qualifying categories.

Areas that exhibited a high proportion of large particles were assessed for quality as a Rocky Reef with potential stony reefs being assessed according to Irving (2009) for 'reefiness' quality (Table 6.1). Both the physical nature of the habitat and biology (biota present) were taken into account. The characteristic 'extent' cannot be confidently assured in this study due to survey approach. There are currently no guidelines for determining the quality ('reefiness') of bedrock reef habitats, but the application of extent, patchiness and elevation, as outlined by Irving (2009), can be adopted to assess such features here.

Table 6.1 : Guidelines for assessing stony reef (Irving, 2009).

Measure of 'reefiness'	Not a 'stony reef'	Low 'reefiness'	Medium 'reefiness'	High 'reefiness'
Composition Boulders/cobbles (>64 mm)	<10%	10-40% (matrix supported)	40-95%	>95% (clast supported)
Elevation	Flat or undulating seabed	<64 mm	64 mm – 5 m	>5 m
Extent	<25 m^2	>25 m^2		
Biota	Infauna dominated			>80% epifauna
Patchiness (% cover)	10%	10-50%	50-75%	>75%

As aggregations of SabellarIldae worms were found to consist of both the Ross worm (*Sabellaria spinulosa*) and the honeycomb worm (*Sabellaria alveolata*), they have not been discriminated. However, work by Gubbay (2007) specific to assessing the quality of *S. spinulosa* biogenic reef has been adopted for these features and with additional reference to the earlier work by Hendrick and Foster-Smith (2006).

Where aggregations of Sabellariidae worms were detected, these were assessed for quality as a biogenic reef according to the guidelines of Gubbay (2007), as used for determination of *S. spinulosa* 'reefiness', and are summarised in Table 6.2 below. Elevation and patchiness were estimated from examination of the still and video images; however, as with stony reefs the measure of area had to be precluded from the assessment due to methods employed. Confidence levels for each score were applied (red = low, orange = medium and green = high confidence) to encompass any potential limitations in the assessment (after Hendrick and Foster-Smith, 2006).

Table 6.2 : Threshold ranges proposed for a measure of 'reefiness' for the biogenic reef of *Sabellaria spinulosa* (after Gubbay, 2007).

Measure of 'reefiness'	Not a reef	Low	Medium	High
Elevation (average tube height (cm))	<2	2-5	5-10	>10
Area (m^2)	<25	25-10,000	10,000-1,000,000	<1,000,000

Measure of 'reefiness'	Not a reef	Low	Medium	High
Patchiness (% cover)	<10	10-20	20-30	>30

6.2.4.4 Biotope Classification

Community data and physical features recorded from the DDC images were then used to classify habitats and assign biotope codes according to *The Marine Habitat Classification for Britain and Ireland* (Connor *et al*., 2004). Where grab samples were obtained, the data were used to supplement and refine that gathered by DDC, specifically for determination of the community.

If a site suggested a potential mosaic of biotopes (then these were assessed accordingly to see if it was merely a feature of the main habitat, a separate complex indicative of a discrete biotope or representative of a transitional zone between two biotopes (see Parry, 2015).

6.3 Results

Samples were obtained at depths ranging from approximately 60 m to 85 m. From the 19 sites surveyed, a mosaic of sedimentary and rocky habitats was identified, with subtidal features supporting, in general, a relatively impoverished tide-swept faunal community. However, some discrete features of conservation interest were recorded. Example images of the seabed from the 17 DDC sites are provided (Appendix D, Section D.1). No INNS were recorded during the study nor were any Section 7 priority species identified.

From the data gathered, the results are presented as follows:

- physical environment;
- rocky habitats;
- sedimentary habitats;
- Annex I features; and
- biotope classifications

6.3.1 Physical Environment

Most sampling sites were at depths between 60 m – 69 m. The shallowest sites (50 – 59 m) were recorded at sites HHD_04 and HHD_08, lying to the south-east and south-west, respectively, and the deepest sites (> 80 m) were recorded at HHD_07 and HHD_12 within the eastern area of the Disposal Site. The sites adjacent to these were also relatively deep at 70 m – 79 m depth (HHD_06 and HHD_10).

The majority of sites surveyed were dominated by rocky substrata, especially along the eastern margin of the Disposal Site, where a mixture of bedrock, boulders, cobbles and pebbles were found. Heading west across the Disposal Site, the substrata became gradually more dominated by sedimentary habitats. Some rocky sites had a proportion of finer sediments, gravel and sands, thus reflecting the mosaic of habitats across the area, and as such, some sites also represented transitional habitats between rocky and coarse substrata.

Further detail on the physical properties of the sediments is provided in Chapter 3.

6.3.2 Rocky Habitats

DDC images showed that the rocky habitats were characterised by tide-swept scour-resistant species and, overall, there was a low richness and density of epifaunal species observed. Taxa recorded across all the DDC images are given in Appendix D, Table D.2, with a total of 42 taxa recorded, ranging between three and 20 taxa at each site.

The most commonly observed erect species were the scour-tolerant *Flustra foliacea* (hornwrack bryozoan) and the large anemone *Urticina* spp. Other erect species included the hydroids Sertulariidae (e.g. *Hydrallmania falcata* and *Abietinaria abietina*) and *Nemertesia* sp. and sponges (Porifera). At only one of the sites (HHD_04) was a dense turf of sessile epifaunal species observed where a mixture of hydroids and bryozoans were visible and encrusting sponges also present.

Encrusting sessile biota were dominated by barnacles, visible across 15 of the 17 sites surveyed by DDC, and with calcareous worms (*Spirobranchus* sp.) also commonly recorded. At many sites, low crusts of Sabellariidae worm tubes were recorded on pebbles and cobbles, and these features are assessed in Section 6.3.4.

Commonly observed mobile fauna across almost all sites were restricted to the common starfish *Asterias rubens* and the prawn *Palaemon* sp. Also recorded were hermit crabs (Paguridae indet.), spider crabs (e.g. *Hyas coarctatus*), squat lobster (*Munida* sp.) and whelks (*Nucella lapillus*), and other various gastropods such as the necklace shell (*Euspira* sp.) and the painted top shell (*Calliostoma zizyphinum*).

6.3.3 Sedimentary Habitats

Infaunal analysis from grab samples was used to supplement the DDC data at sedimentary sites and thus provide a greater degree of information about the community.

The benthic community varied greatly between grab sampling sites. The epifaunal communities were relatively impoverished at all the sedimentary sites with sparse coverage of hydroids and bryozoans present. Although the infaunal populations were often recorded in low abundances, considerably higher abundances were recorded at sites HHD_02, HHD_16 and HHD_20, all of which were characterised by high numbers of the tube-building worms Sabellariidae. Figure 6-2 shows the abundances, biomass, number of taxa recorded and the representative proportions of each major faunal group. A full list of taxa and abundances (per 0.1 m^2 grab) are provided in Appendix D, Table D.3.

Higher densities (no. m^{-2}), biomass (g m^{-2}) and total number of taxa were recorded at sites HHD_02, HHD_16, and HHD_20. Maximum values for all these metrics were recorded at site HHD_20 (6,710 no. m^{-2}, 242.94 g m^{-2}, and 86 taxa). Conversely, the most impoverished community recorded was at site HHD_19 (60 no. m^{-2}, 0.02 g m^{-2} and 4 taxa).

In total, 135 taxa were recorded with communities generally dominated taxonomically by annelids, with crustaceans and echinoderms the least diverse groups. Annelids were also the most dominant faunal group numerically at all sites, except at HHD_10 where the arthropod crustacean *Balanus balanus* was dominant. The most abundant annelid taxa were the polychaetes *Sabellaria spinulosa, Sabellaria alveolata, Jasmineira elegans* and small syllids (*Syllis* spp.). The most abundant arthropod overall was the long-clawed porcelain crab *Pisidia longicornis*, and molluscs were dominated by juveniles of the bivalve *Mya truncata.*

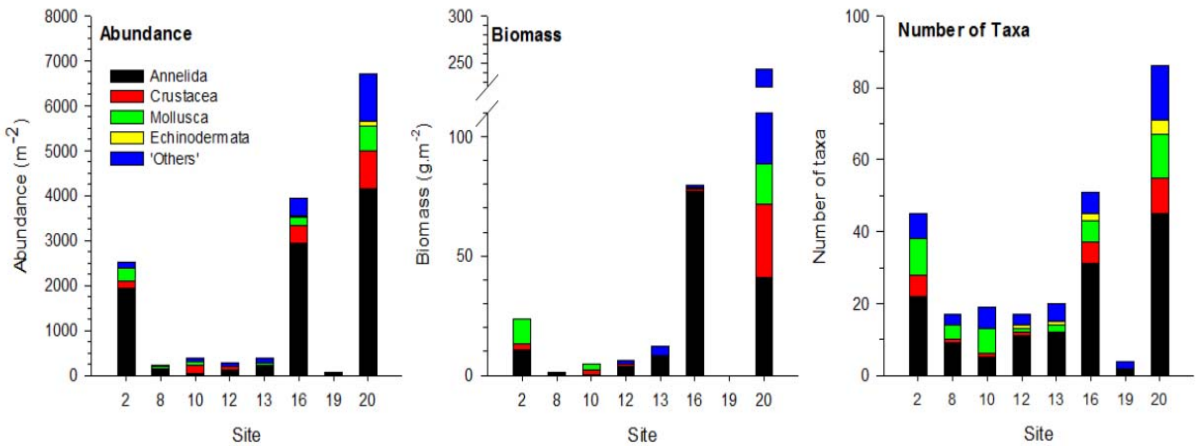


Figure 6-2 : Individual abundances (no. per m^2), biomass (g per m^2) and total number of taxa, recorded at each grab sampling site. For each site, the relative proportions of major taxa are shown for each parameter. 'Others' are a combination of the Hydrozoa, Anthozoa, Nemertea, Nemertoda, Sipunculida, Pycnogonida and Bryozoa groups.

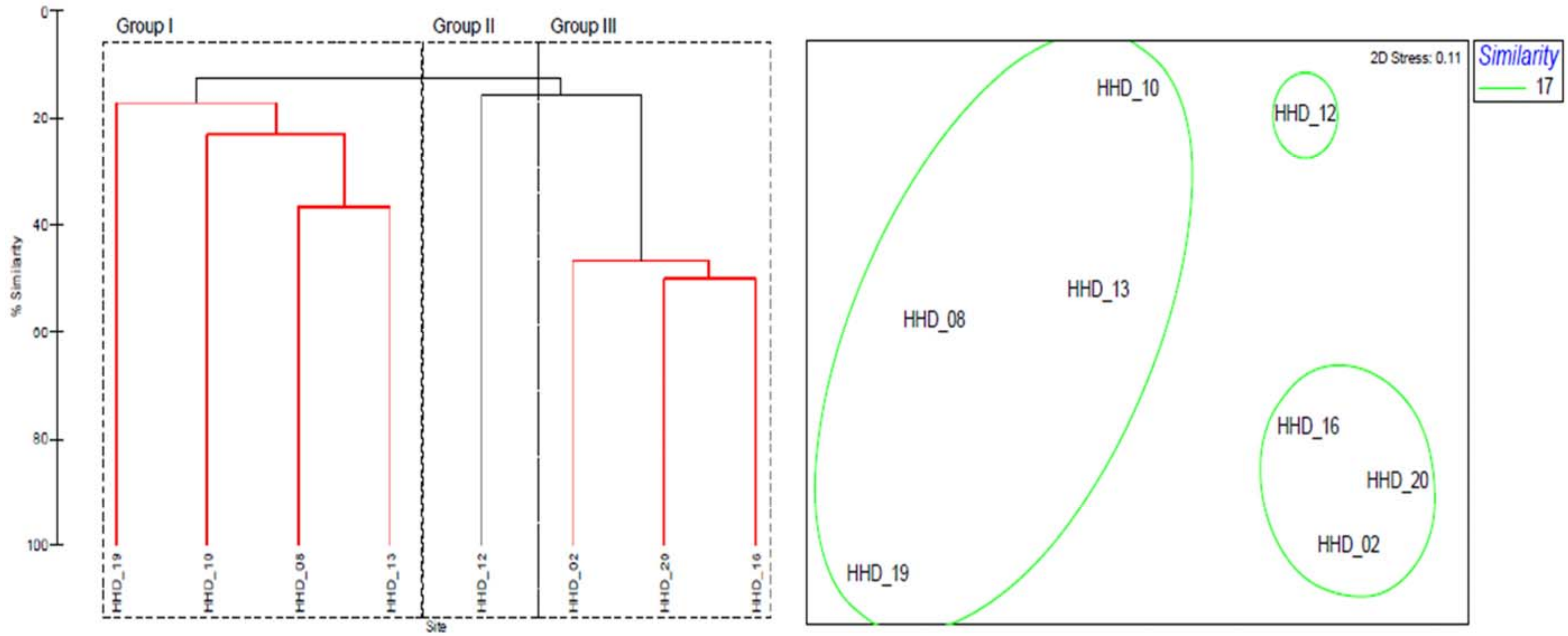
Analysis of ABC plots indicated non-stressed communities with associated W-statistic values all listed as positive. The lowest values were reported at HHD_02 (0.14) and the highest at HHD_13 (0.65) (Appendix D, Table D.4). At HHD_02, the abundance curve lay above the biomass curve for the top ranking species and then switched under as the data moved across the axis, indicating a moderately stressed community (Warwick and Clarke, 1991). The highest degree of community evenness (as determined by Pielou 'J' value) was recorded at HHD_13 (0.95) and HHD_08 (0.94), and the lowest at HHD_02 (0.68). Diversity values, as determined from Margalef (d) and Shannon-Weiner (H') indices, were the highest at HHD_20 (13.06 and 3.10 respectively), and the lowest at HHD_19 (1.67 and 1.24 respectively). Details on the diversity indices for all sites are provided in Appendix D, Table D.4).

Multivariate analysis indicated some grouping of these eight communities, but with no spatial pattern related to locality of the sites (Figure 6-3). SIMPROF reported that sites HHD_08, HHD_10, HHD_13 and HHD_19 were not significantly different from each other (cluster group I), as were sites HHD_02, HHD_16 and HHD_20 (cluster group III). Site HHD_12 was identified as an outlier to all these stations (cluster group II).

One-way ANOSIM identified a significant difference across these three groups of sites (Global R = 0.64, p = 0.014). Pairwise comparisons found a statistically significant difference between cluster I and III (R = 0.70, p = 0.029); however, there was no statistically significant difference between I and II (R = 0.33, p = 0.40). Despite a non-significant p value for comparisons between groups II and III (0.25), the associated R value was high at 1, thus indicating departure between these communities, and examination of the nMDS plot showed HHD_12 (group II) to be spatially separate to HHD_02, HHD_16 and HHD_20 (group III). Table 6.3 shows the biological characteristics of each cluster with average densities of the most abundant taxa for each group. Similar mean total abundances and number of taxa were calculated for groups I and II; these were markedly less than those recorded at group III.

SIMPER confirmed which taxa contributed most to the overall dissimilarities between groups I and III. The marked difference between these two groups was the high abundance of the polychaete species *S. spinulosa* and *J. elegans* in cluster group III, and their absence in group I. Group III (HHD_02, HHD_16 and HHD_20) were all characterised as having high total abundances, biomass and species richness, and at these sites they were characterised by Sabellariidae worms (*S. spinulosa* and *S. alveolata*) (cumulative contribution of 20.43%). Group I (sites HHD_08, HHD_10, HHD_13 and HHD_19) were characterised by a less diverse and abundant assemblages, with nematodes, nemerteans and the small Sylliidae polychaete *Syllis cornuta* contributing most to overall similarity (>10%). As group I comprised only a single sample (HHD_12), the raw data was examined in Table 6.3 and in Appendix D, Table D.3. At HHD_12, *B. balanus* was the most abundant taxa present (6 per 0.1 m^2), with juvenile sipunculids sub-dominant at 5 per 0.1 m^2.

SIMPER calculated that the higher relative abundances of *B. balanus*, sipunculids and the polychaete *Lysidice hebes* in group II compared to group I contributed most to overall dissimilarity, although with only a cumulative percent value of 18.41%. Differences between clusters II and III mirrored those ranked for comparisons between clusters I and III, with Sabellariidae worms, the polychaete *J. elegans* and the crustacean *P. longicornis* ranked as most important and abundant in group III.



a) b)

Figure 6-3 : (a) Cluster dendrogram of the Disposal Site communities (HHD), with those cluster connected by a red line not significantly different (*p* = >0.05, SIMPROF analysis) and (b) two-dimensional MDS ordination with Bray-Curtis similarities of the communities with 17% similarity cluster groups shown. Stress = 0.11.

Table 6.3 : Biological characteristics of faunal cluster groups, with abundances shown as mean densities per m^2 and number of taxa averaged across the sites within each cluster. The 10 most abundant taxa are listed, or those taxa with densities >10 individuals per m^2.

Cluster Group I		**Cluster Group II**		**Cluster Group III**	
HHD Sites: 08, 10, 13, 19		**HHD Site: 12**		**HHD Sites: 02, 16, 20**	
Balanus balanus	45	*Balanus balanus*	60	*Sabellaria spinulosa*	1,077
NEMATODA	20	SIPUNCULA indet.	50	*Sabellaria alveolata*	457
Syllis cornuta	20	*Syllis cornuta*	20	*Jasmineira elegans*	430
Gibbula tumida	15	*Lysidice hebes*	20	*Pisidia longicornis*	277
NEMERTEA	21			NEMATODA	213
				Syllis variegata	200
				Mya truncata juvenile	150
				Syllis cornuta	123
				SIPUNCULA indet.	100
				NEMERTEA	97
Mean number of individuals	**265**	**Mean number of individuals**	**280**	**Mean number of individuals**	**4,387**
Mean number of taxa	**15**	**Mean number of taxa**	**17**	**Mean number of taxa**	**61**

6.3.4 Annex I Reef Habitats

Potential Annex I 'reef' features were recorded during the DDC and grab surveys and have been assessed accordingly below.

6.3.4.1 Rocky Reefs

Of all the benthic sites surveyed by DDC, those identified as circalittoral rock were assessed for reefiness (Table 6.4). Hence, sites identified as sublittoral sediment habitats or biogenic reef were excluded from the rocky reef assessment. Although gravels can be considered for reefiness, this is only if there is evidence of elevation above the seabed (Irving, 2009).

The rocky reef sampling sites were assigned a score of stony reefiness as prescribed by Irving (2009) and with adoption of this method for consideration of those sites that exhibited potential bedrock features (see Table 6.1 above). Due to the nature of the deep water benthic sampling, it was not feasible to confidently assess the extent of the rocky reef, nor the degree of elevation. Confidence levels are applied to each score to take into account the aforementioned potential limitations to this assessment.

All the rocky sites assessed exhibited reef features, with all but one considered as a stony reef (HHD_01). Site HHD_01 was still assessed using the Irving approach (2009) and listed in the table, but is likely to be a potential bedrock not stony reef, as it was dominated by bedrock substrata. None of the sampling sites were considered to be of high reefiness. Of the 10 sites identified, four were of medium stony reefiness and the remaining six of low reefiness, with the lowest level of confidence applied to those sites described as medium. Where there was a combination of dense epifauna, this elevated the score, but not at the expense of any of the physical criterion (composition, elevation, etc.) (Table 6.4).

Table 6.4 : Site assessment for rocky reef habitat with scores listed as either low, medium or high. The confidence levels for 'reefiness' scores are denoted by [ ], low confidence, ( ), medium confidence, and no brackets for high confidence. Data shown are assessed from all replicate image stills (DDC) and then averaged (after Irving, 2009). * = Possible bedrock reef

Site	Survey Method	Composition	Elevation	Extent	Biota	Patchiness	Additional notes	Reefiness Score
HHD_01	DDC	80%	64 mm – 5 m	Not known	Likely dominated by epifauna	>80%	Predominantly bedrock but with some large cobbles. Low epifaunal coverage	**[Medium]***
HHD_04	DDC	60%	64 mm – 5 m		>80% epifauna	>75%	Dense epifauna, One image shows *Munida* sp. taking refuge under cobble.	**[Medium]**
HHD_05	DDC	20%	< 64 mm		Likely dominated by epifauna	60%	Epifauna predominantly barnacles and serpulids	**(Low)**
HHD_06	DDC	70%	64 mm – 5 m		>80% epifauna	>75%	Dense epifauna.	**[Medium]**
HHD_07	DDC	50%	64 mm – 5 m		Likely dominated by epifauna	60%	Epifauna predominantly barnacles and serpulids	**(Low)**
HHD_09	DDC	50%	64 mm – 5 m		Likely dominated by epifauna	50%	Dense epifauna on large particles. Transitional habitat, becoming more sedimentary.	**(Low)**
HHD_11	DDC	n/a	n/a		Likely dominated by epifauna	n/a	Video analysis only.	**(Low)**
HHD_13	DDC + Grab	25%	< 64 mm		Likely dominated by infauna	30%	Low epifaunal coverage, some gravels and finer sediment potentially supporting infaunal population.	**Low**
HHD_14	DDC	55%	64 mm – 5 m		Likely dominated by epifauna	60%	Encrusting barnacles and serpulids present.	**(Low)**
HHD_15	DDC	70%	64 mm – 5 m		Likely dominated by epifauna	70%	Large boulders. Encrusting barnacles and Sabellaridae crusts.	**[Medium]**

6.3.4.2 Biogenic Reefs

There was no evidence of *M. modiolus* (horse mussel) beds from the DDC work, with only a few empty *M. modiolus* valves recorded. From the grab samples, a single *M. modiolus* was recorded at site HHD_20, and single occurrences of juvenile mussels (Mytilidae indet.) recorded from sites HHD_08, HHD_10, HHD_13 and HHD_16.

Across 11 of the 19 benthic sites there was evidence of Sabellariidae tubes. Infaunal analysis recorded the presence of both biogenic reef forming worms: *S. spinulosa* and the congeneric *S. alveolata* but with *S. spinulosa* often the dominant of the two in terms of abundance. As with the assessment of stony reefs, the minimum area of these biogenic features could not be determined. The results of the assessments are presented in Table 6.5.

Of the 11 sites where Sabellariidae tube structures were recorded, nine were not considered to meet the criteria to be classified as a biogenic reef, as they were deemed to be not significant in terms of patchiness and/or elevation and with one (HHD_20) being of predicted low quality.

At these 11 sites, the tubes were mainly present as low crusts or veneers on pebbles with very few appearing to be elevated above the seabed (see Figure 6-4). However, at site HHD_17 erect structures >5 cm were consistently observed, with a high average patchiness percentage score of 75% across all stills taken, dominating the area of seabed photographed (Appendix E, Table D.1). Low epifaunal coverage was observed on all of these structures, although this may exclude smaller species and those more cryptic interstitial fauna that may exploit these features.

Using the scoring system of Gubbay (2007) in conjunction with Hendrick and Foster-Smith (2006), an overall score of medium reefiness was assigned to the Sabellariidae feature recorded at HHD_17. The average density of tubes across all the stills at HHD_17 was approximately 1,600 no. m^{-2}, with a maximum of >2,000 no. m^{-2}, hence scoring the feature as medium reefiness.

Table 6.5 : Sites assessment for biogenic Sabellariidae reef habitats with scores listed as either low, medium or high (after Hendrick and Foster-Smith, 2006; Gubbay, 2007). The confidence levels for 'reefiness' scores are denoted by [ ], low confidence, ( ), medium confidence, and no brackets for high confidence. S.spi = *S. spinulosa* and S.alv = *S. alveolata*.

Site	Survey Method	Elevation (cm)	Area	Patchiness	Density (no. m^{-2})	Notes	Reefiness score
HHD_01	DDC	<2 cm	Not known	10–20%	Not known	Thin crusts apparent on bedrock. Low density of tubes present.	**(Not a reef)**
HHD_02	DDC + Grab	2–5 cm		<10%	S.spi – 650 S.alv – 140	Relatively dense covering of tubes but not consistent in its coverage with low densities of worms recorded and tubes of low elevation above the seabed.	**(Not a reef)**
HHD_03	DDC	2–5 cm		20–30%	Not known	Transitional, variable coverage. Epifauna prominent.	**(Not a reef)**
HHD_04	DDC	<2 cm		<10%	Not known	Dense epifaunal cover on cobbles and amongst tubes.	**(Not a reef)**
HHD_06	DDC	<2 cm		<10%	Not known	Similar to HHD04. Relatively dense epifauna present, low crusts on substrata.	**(Not a reef)**
HHD_07	DDC	<2 cm		<10%	Not known	Discrete crusts present.	**(Not a reef)**
HHD_09	DDC	<2 cm		10–20%	Not known	Crusts apparent on large cobbles and boulders, also along pockets of sandy gravel but no erect formations.	**(Not a reef)**
HHD_15	DDC	<2 cm		10–20%	Not known	Similar to HHD09 with crusts apparent on large cobbles and boulders but no erect formations present.	**(Not a reef)**
HHD_16	DDC + Grab	<2 cm		<10%	S.spi – 540 S.alv – 1,070	Low crusts and low to medium densities of Sabellaridae worms, aggregations on	**(Not a reef)**

Site	Survey Method	Elevation (cm)	Area	Patchiness	Density (no. m^{-2})	Notes	Reefiness score
						pebbles and stones on non-consolidated sediments.	
HHD_17	DDC	5–10 cm		>30%	Not known	Erect formations of dense tube structures present across all image stills. Little epifauna apparent on these structures except *Flustra foliacea.*	**[Medium]**
HHD_20	Grab	2–5 cm		<10%	S.spi – 2,040 S.alv – 160	High densities of *S. spinulosa* and an associated rich infaunal community.	**[Low]**

a) **b)**

c)

Figure 6-4 : Images of samples showing Sabellariidae tubes and crusts from sites HHD_02 (a), HHD_16 (b) and HHD_20 (c). The site codes shown on the sample labels are survey codes and are not referred to in this document.

6.3.5 Biotope Classifications

Across the Disposal Site, a number of different habitats and species were identified, subsequently resulting in the ascription of nine separate rocky and sedimentary biotopes across the 19 benthic sites (Table 6.6).

Along the eastern margin of the Disposal Site, many of the sampling sites were ascribed the biotopes CR.MCR.EcCr.UrtScr (‘*Urticina felina* and sand-tolerant fauna on sand-scoured or covered circalittoral rock’) and CR.HCR (‘High energy circalittoral rock’). Relative abundances of characterising taxa were further examined in combination with the physical features of the habitats (e.g. higher relative abundances of *Urticina* spp. and the presence of sands and gravels as evidence of CR.MCR.EcCr.UrtScr).

At one of the rocky sites, sparse epifauna were recorded (HHD_11). At this site, the low density of epifauna such as hydroids, sponges and barnacles, encrusting the bedrock, boulders and cobbles, resulted in the assignation of CR.HCR.FaT (‘Very tide-swept faunal communities’). The barnacle *Balanus crenatus* is a characteristic feature of this biotope (CR.HCR.FaT), and where *B. crenatus* was clearly dominant and in high abundances (i.e. HHD_01, HHD_05, HHD_07 and HHD_15), the community was assigned as CR.HCR.FaT.BalTub (‘*Balanus crenatus* and *Tubularia indivisa* on extremely tide-swept circalittoral rock’).

At site HHD_04, the dense turf of epifauna on rock resulted in the biotope CR.HCR.XFa (‘Mixed faunal turf communities’) being ascribed (Appendix D, Section D.1). This site was also considered as a possible stony reef in consideration of its physical features and supported epifaunal coverage (Table 6.4, above).

The central and western stations of the Disposal Site were identified from the DDC work as circalittoral mixed sediments; comprising a mixture of coarse substrata. Codes were assigned following assessment of both DDC imagery and faunal grab community data, and so from this region biotopes were either assigned SS.SMx.CMx (‘Circalittoral mixed sediment’) or SS.SMx.CMx.FluHyd (‘*Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment’) where more conspicuous epifauna were present, at 10 of the sites.

At many of the grab sites, low abundances and species-poor assemblages were recorded from the sediments, and as a result, the code SS.SCS.CCS.Pkef (‘*Protodorvillea kefersteini* and other polychaetes in impoverished circalittoral mixed gravelly sand’) was assigned in combination with other biotopes codes (e.g. SS.SMxCMx or SS.SMX.CMx.FluHyd) at sites HHD_02, HHD_08, HHD_12 and HHD_19. Sabellariidae worms were recorded at HHD_02 but in low abundance; *S. spinulosa* is a characterising species for the SS.SCS.CCS.PKef biotope (Connor, 2004).

As described in Section 6.3.4, crusts of Sabellariidae tubes were common at a number of sites but only at HHD_16, HHD_17 and HHD_20 were these populations deemed significant enough to warrant consideration as a Sabellariidae biotope. Relative abundant populations of Sabellariidae worms, predominantly *S. spinulosa*, were recorded in the grab samples at HHD_02, HHD_16 and HHD_20. However, when considered in combination with assessment of additional parameters (biodiversity scores, associated fauna, tube height, patchiness, consolidation, etc.) it was only HHD_16 (in the north-west) and HHD_20 (in the south-west) that were ascribed the code SS.SBR.PoR.SspiMx.At both these locations (HHD_16 and HHD_20), this biotope was also in combination with the biotope code SS.SMx.CMx.FluHyd to reflect the patchiness and low heights of the tubes, and other features present.

HHD_17 in the northern area of the Disposal Site was assigned the code CR.MCR.CSab.Spi (‘*Sabellaria spinulosa* encrusted circalittoral rock’) with erect structures (5–10 cm) present in all DDC images (e.g. Appendix D, Section D.1).

Two sites were identified as transitional habitats, and were assigned the divergent codes SS and CR. Site HHD_06 was assigned SS.SMx.CMx as well as the rocky biotope CR.MCR.EcCr.UrtScr code; this site was adjacent to the rocky biotope sites in the eastern area. Site HHD_13, to the east of the Disposal Site, was assigned the codes CR.MCR.EcCr.UrtScr and SS.SCS.CCS.PKef to reflect the infauna present within the sediments.

Table 6.6 : Biotopes ascribed across the Disposal Site, with the depths listed and the survey method undertaken at each site. (* only video imagery was available.)

Site	Survey method	Depth (m)	Circalittoral rock biotope codes					Sublittoral sediment biotope codes			
			CR. HCR. Fat	CR. HCR.FaT.Bal Tub	CR. HCR. XFa	CR. MCR. EcCr. Urt Scr	CR. MCR. CSab Sspi	SS. SMx. CMx	SS. SMx. CMx. Flu Hyd	SS. SBR. PoR.SpiMx	SS. SCS. CCS. PKef
HHD_01	DDC	69		•		•					
HHD_02	DDC +Grab	68							•		•
HHD_03	DDC	67							•		
HHD_04	DDC	55			•						
HHD_05	DDC	65		•							
HHD_06	DDC	79				•		•			
HHD_07	DDC	85		•							
HHD_08	DDC + Grab	59						•			•
HHD_09	DDC	61				•					
HHD_10	DDC + Grab	79						•			
HHD_11	DDC*	73	•								
HHD_12	DDC + Grab	82						•			•
HHD_13	DDC + Grab	62				•					•
HHD_14	DDC	69						•			
HHD_15	DDC	67		•							
HHD_16	DDC + Grab	64							•	•	
HHD_17	DDC	67					•				
HHD_19	Grab	64						•			•
HHD_20	Grab	65							•	•	

6.4 Discussion

The aim of this study was to provide baseline information on the benthic habitats present, and to identify the presence of conservation features within the Disposal Site. These surveys have corroborated some of the existing data of the region (HABMAP, Robinson *et al.,* 2009a; 2009b; 2011), showing patterns in the features and communities of these tide-swept habitats. There was an overall spatial pattern of rocky substrata present along the eastern margins of the Disposal Site, with mixed sedimentary habitats becoming more dominant moving westwards. However, at many sampling sites mixed substrata were apparent, highlighting the spatial heterogeneity of the seabed where lag deposits of boulders, cobbles and gravels aggregate within the rocky sub-sea platform of hard pre-Cambrian rock (Rees, 2005).

6.4.1 Rocky Habitats

The sparse epifauna recorded across the site is evident of the physical environment where similar assemblages of these tide-swept and scoured rocky habitats have also been reported by CMACS (2016) within the southern half of Holyhead Deep. Strong tidal currents can have a profound influence on marine benthic communities with an increase in the number of taxa present resistant to scour and sand cover. Scour can occur in exposed situations where there is the temporary resuspension of relatively coarse (e.g. sand) material (Hartnell, 1998). The Irish Sea to the north-west of Anglesey has been described as a tidal scoured rough ground where sand acts as a source of abrasion as well as a possible sedimentary habitat (Rees, 2005). Across the study area, the bryozoan *F. foliacea* and the large anemone *Urticina* spp. were a common feature of the seabed, and these taxa are often representative of such regimes (Rees, 2005). Overall, across the Disposal Site epifauna were sparse, which is an indication of natural physical disturbances across the seafloor. The rocky biotope codes assigned reflected these assemblages with the '*Urticina felina* and sand-tolerant fauna on sand-scoured or covered circalittoral rock' (CR.MCR.EcCr.UrtScr) and 'High energy circalittoral rock' (CR.HCR) ascribed across these rocky areas. It is difficult to differentiate between different species of *Urticina* spp. (i.e. *Urticina felina* and *Urticina eques*). For the purpose of biotope assignation, it is the species *Urticina felina* that is the characterising species of the biotopes listed here; however, both species are themselves scour tolerant and found in tidal swept habitats.

Biota commonly observed can be a characteristic feature of more than one biotope, thus making it problematic to separate the habitats, based solely on the visible species complement. For example, the presence of *Urticina* spp. is common to high-energy environments, but also indicative of scoured environments, and the biological distinction between CR.HCR and CR.MCR.EcCR can include the relative dominance of scour-tolerant species such as *Urticina* spp., which is common to both CR.MCR.EcCr and CR.HCR.FaT (and CR.HCR.FaT.BalTub). Interpretation of the physical environment (high energy verses moderate) is also important between these biotopes. In the HABMAP extension project (Robinson *et al., 2*011), it was noted that predictions for the CR.HCR.FaT.BalTub and CR.MCR.EcCR.UrtCr biotopes are more widespread than would be realistically be expected, and inaccuracies in either the tidal and/or wave stress layers applied in the original project had led to inappropriate biotope associations.

The HAPMAP project predicted much of the eastern margin area of the disposal study site to comprise the biotope 'faunal and algal crusts on exposed to moderately wave-exposed circalittoral rock' (CR.MCR.EcCr.FaAlCr.). This habitat is characterised by coralline algal crusts with a grazed appearance due to the feeding activity of the urchin *Echinus esculentus* (Connor *et al.,* 2004). However, during the benthic surveys carried out by Jacobs, this biotope was not identified, and although CR.MCR.EcCr.FaAlCr will also support scour-tolerant species such as *Urticina felina* and *Flustra foliacea*, no coralline crusts or *E. esculentus* were recorded.

At a single site (HHD_17), the substratum was clearly dominated by erect forms of Sabellariidae tubes where the biotope code CR.MCR.CSabSpi (*Sabellaria spinulosa* encrusted circalittoral rock) was ascribed. This site was not selected for grabbing due to the sensitive features identified. Potential Annex I status of rocky and biogenic features is discussed further in Section 6.4.3.

6.4.2 Sedimentary Habitats

In comparison with the southern half of the historical Holyhead Deep disposal site, which was clearly dominated by sedimentary substrata (CMACS, 2016), many of the benthic sampling sites within the Disposal Site were comprised of cobbles and boulders and thus deemed unsuitable for grab sampling. The incursion of the rocky plateau along the eastern side of the Disposal Site, as depicted by HABMAP, was evidenced by the DDC images in this study.

However, within the Disposal Site, a number of the central and western sampling sites were identified as circalittoral mixed sediments (SS.SMx.CMx) habitats, complementing the HABMAP model which had predicted much of the western regions to belong to SS.SMx.CMx.FluHyd (*Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment) (Robinson *et al.,* 2011). With the additional community data gathered from the grabbing surveys, further resolution could be applied to these sedimentary habitats. Sediment particle size analysis recorded a predominance of gravelly sediments (medium to large pebbles) with relatively small proportions of finer sediments (see Chapter 3).

Multivariate statistical analysis revealed no significant geographical trend in the faunal assemblages of the Disposal Site surveys. Within the sediments of the Disposal Site, faunal communities were often impoverished, with low abundances and taxa richness, except at those sites where Sabellariidae worms were recorded in relatively high numbers. At those sites where low populations of infaunal communities were found, '*Protodorvillea kefersteini* and other polychaetes in impoverished circalittoral mixed gravelly sand' (SS.SCS.CCS.Pkef) was ascribed.

Within the central areas of the disposal study site and to the south, HABMAP predicted the sedimentary habitat SS.SMx.CMx.Mys.ThyMx (*Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment) to be present. This biotope had not been identified during any of DDC surveys, with none of the characterising bivalve species (*Kurtiella bidentata* (previously *M. bidentata*) or *Thyasira* spp.) being recorded from the grab samples. Furthermore, particle size analysis of the sediments described the predominance of coarse substrata, such as gravels, with proportions of finer particles comparatively low (see Section 3.3.2.2.1). Furthermore, studies to the south of the Disposal Site similarly did not record this biotope following grab faunal surveys (CMACS, 2016).

The CMACS study, which encompassed the southern half of the historical Holyhead Deep disposal site, often recorded the biotopes SS.SMX.OMx.PoVen (Polychaete-rich deep *Venus* community in offshore mixed sediments) and SS.SCS.CCS.MedLumVen (*Mediomastus fragilis, Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel). However, given the low numbers of venerid bivalves and absence of many of the characterising species, it was recognised that the former biotope ascription was not always a suitable fit (CMACS, 2016). The biotope SCS.CCS.MedLumVen comprises a more diverse community than SS.SCS.CCS.PKef, and it is considered that Pkef represents a disturbed or transient variant of the MedLumVen due to physical disturbances (see Connor *et al.,* 2004).

A total of 135 taxa were recorded from the eight grab sites within the Disposal Site, ranging from four to 86 taxa at each of the sampling sites. By comparison, the work by CMACS recorded a total of 318 taxa, from 23 sampling sites, over the southern half of the Disposal Site. Of the top 50 most abundant taxa recorded by CMACS (2016), 72% were also recorded from the Disposal Site, with *S. spinulosa* the most dominant taxa recorded in both studies.

Diversity indices were relatively high from the Disposal Site, for example all values of Pielou's evenness were >0.6, and at four sampling sites greater than 0.9. Similarly, with the exception of HHD_19, Shannon-Weiner diversity values were reasonably high, particularly at site HHD_12 (H' = 3.1).

Notably higher faunal abundances and taxa were recorded at those sites with reasonably high densities of Sabellaridae worms (i.e. HHD_02, HHD_16 and HHD_20). It is considered that the increased habitat complexity from these ecosystem engineers provides additional micro-habitats and niches for other species. For example, the long-clawed porcelain crab *P. longicornis* was found in very high abundances at the sites where these worms occurred, likely utilising the crevices available across these structures. High abundances of *P. longicornis* have also been recorded from other such biogenic habitats (Pearce *et al.,* 2014).

Relatively high densities of *S. alveolata* were reported from HHD_16 (1,070 m^{-2}); this number almost twice that recorded for *S. spinulosa* (540 m^{-2}) at the same site. *S. alveolata* is commonly recorded from intertidal habitats, but can also occur in the subtidal. CMACS (2016) reported similar densities of *S. alveolata* (1,540 m^{-2}) from a single sampling site off the north coast of Holy Island. The only sublittoral biotope code currently linked to *S. alveolata* is SS.SBR.PoR.SalvMx (*Sabellaria alveolata* on variable salinity sublittoral mixed sediment), but this was not deemed a suitable fit for the community at HHD_16. As such, the biotopes SS.SMx.CMx.FluHyd (*Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment) and SS.SBR.PoR.Sspi.Mx (*Sabellaria spinulosa* on stable circalittoral mixed sediment) were assigned. The SS.SBR.PoR.SalvMx biotope has mainly been identified within the Severn Estuary and is seen as supporting a reduced species complex, not reflected at HHD_16, as compared to SS.SBR.PoR.SpiMx.

At site HHD_20, SS.SBR.PoR.SpiMx and SS.SMx.CMx.FluHyd biotopes were assigned due to relatively high abundances of *S. spinulosa* and associated epifauna and infauna. The SS.SBR.PoR.SpiMx biotope can sometimes form part of a succession with other biotopes (e.g. PKef), where the biogenic features (crusts and reef) are destroyed by disturbance, but with re-colonisation occurring under the right conditions (Connor *et al*., 2004). As such, it is not surprising that features of PKef biotopes (SS.SCS.CCS.Pkef) were assigned to many sedimentary sites across the Disposal Site alongside the SS.SBR.PoR.SpiMX *S. spinulosa* biotope.

6.4.3 Annex I Habitats 1170 – Reefs

Stony reefs were identified across these rocky habitats; however, none were assessed as 'high' reefiness. Stony reefs recorded in this study were primarily defined by their physical characteristics as biota were often sparse at these sites, as was also found by CMACS (2016) across their study area. Site HHD_01 was identified as a medium quality stony reef, but the substratum suggests it could be a potential bedrock reef; however, there are currently no clear guidelines for assessing quality of such bedrock reef features.

Of the sites assessed for Sabellariidae reefiness, only two met the criteria for a Sabellariidae biogenic reef (HHD_20 and HHD_17), the other Sabellariidae features being best described as crusts. Work by Rees (2005) in this region also recorded many sites with biogenic Sabellariidae crusts, with an apparent 'reef' structure recorded at only a single site. More recently, work by CMACS (2016), to the south of the Disposal Site, recorded two sites of low reefiness and one of low to medium quality Sabellariidae reef.

At site HHD_17, situated in the north of the Disposal Site, distinct erect Sabellariidae structures with dense but clearly defined tubes were recorded and with an average cover of consolidated tubes of 75%. The numbers of tubes present are not necessarily an indication of the number of individuals, and as the spatial extent could not be determined, the degree of consistency in cover could not be determined across its spatial extent (area). This biogenic Sabellariidae feature was assessed as medium reefiness but with low confidence and, according to the assessment by Hendrick and Foster-Smith (2006), fits the biotope CR.MCR.CSab.Spi.

Baldock and Goudge's (2017) Sabellariidae assessments had recorded aggregations at three sites surveyed within IS043. At one site, erect tubes >10 cm had been observed, but over the entire transect elevation was highly variable, being between <5 cm and >10 cm. Both the biotope CR.MCR.CSab.Sspi and SS.SBR.PoR.SspiMx had been assigned, however with uncertainty for the latter due to a lack of significant proportions of mud within the seabed.

Acknowledging that biogenic Sabellariidae structures are often ephemeral features, especially in such high-energy environments, the stability and longevity of such structures is not predictable (Gibb *et al*., 2014), though it may be considered that those structures of a medium to high elevation could be indicative of a more stable feature.

Fine-scale monitoring methods of drop-down video and photography can provide a 'good' level of confidence for assessment of Sabellariidae reef characteristics based on elevation and consolidation. However, this strategy will only give a 'poor to moderate' confidence in assertion of the extent and density of such habitats (Hendrick and Foster-Smith, 2006). In recognition of the fragility of these features to potential impacts from surveying methodologies, DDC video and stills was considered the most appropriate for minimising damage to Sabellariidae reef formations, yet it is recognised that this limits the ability to confirm the extent of such features when present.

S. spinulosa is very common around all UK coasts (Jackson and Hiscock, 2008), and within the Irish Sea they are considered widespread across the lag gravels, where individuals encrust stones and shells (Rees, 2005). In most parts of its geographical range, *S. spinulosa* does not form reefs, but is solitary or in small groups encrusting pebbles, shell and bedrock. The crusts recorded from this study indicate the suitability of the environment for *S. spinulosa* colonisation; however, it is considered that the physical conditions such as scour and strong currents may largely preclude development of stable reef structures, instead resulting in a cyclical succession of communities (as described by Connor *et al*., 2004) of which the *S. spinulosa* crusts are just one.

6.4.4 Section 7 Priority Habitats and Species

Under Section 7 of the *Environment (Wales) Act 2016*, a list of those species and habitats of principal importance for the purpose of maintaining and enhancing biodiversity in relation to Wales has been produced.

Neither this study nor the CMACS (2016) study recorded Section 7 species within the Disposal Site. However, several biotopes were recorded that sit within the Section 7 broad habitat 'subtidal sands and gravels'. These were found in the central and western parts of the Disposal Site, yet the communities recorded at these sites tended to be impoverished. The Section 7 habitats 'tidal-swept channels' and 'fragile sponge and anthozoan communities' were not recorded during this study, nor were they found during the CMACS (2016) work.

7. General Discussion and Conclusion

7.1 Marine Sediments

The distribution of benthic fauna is closely related to the characteristics of the bed sediments they inhabit. Thus, it was important to investigate the spatial pattern of physical features (e.g. granulometry) and potential contamination of sediments from the benthic study areas in parallel to the ecological analyses. The results of the sediment study provided further confirmation of the strong influence of tidal flows around both study areas, even at depths of greater than 80 m in the case of the Disposal Site, with the offshore sampling sites dominated by coarse sediments. It should also be acknowledged that much of the seabed, intertidal and subtidal zones, along the north Anglesey coast and also to the north-west of Anglesey, is rocky and hence precludes sediment sampling.

The localised sampling of the intertidal sediments between 2011 and 2014 indicated some spatial and temporal variability within the area of Porth-y-pistyll bay, north Anglesey. In the south-western margins of the bay, there was a mixture of sands and gravels, whereas on the eastern side of the bay slightly muddier sediments were present. All metals were considered elevated from BRC; however, in 2014 in the south-west of the bay, zinc and lead were the only metals with concentrations reported to exceed the relevant ISQG. Overall, low concentrations of organic compounds (PAHs and PCBs) were found in these intertidal sediments during the sampling period with a few exceptions, most notably during 2013. Elevations in contaminants are not unexpected in coastal sampling areas situated close to potential sources of anthropogenic or riverine inputs.

The sublittoral soft-sediment areas sampled along the north Anglesey coast area were shown to consist of a mosaic of sediments ranging from muds to coarse gravel and cobbles, with a spatial distributional pattern likely to be related to the scouring effects of the high-energy currents. The sheltered inshore environments such as the bays of Porth-y-pistyll and Cemaes Bay were comprised of muddy sands, whereas in comparison, the exposed offshore sedimentary sites tended to be a combination of coarse and mixed sediments.

Metal concentrations of sediments from the north Anglesey coast (2010–2011) were considered elevated from BRCs. However, very few metals exceeded the relevant ISQG and, as such, were not at a level that may potentially result in a biological effect. Metal concentrations were comparable to those recorded from other coastal sites and appreciably lower than those from industrialised sites (see Table 3.1). Low concentrations of organic compounds were generally reported across the study area (2010–2011). A notable exception was for concentrations of the PAH determinand naphthalene, which had exceeded the PEL at several sites in 2010. The minimal concentration of naphthalene recorded in 2011 may have indicated that the level reported in 2010 was a result of a single event, such as an accidental petroleum spill, and not an ongoing source of contamination to the environment.

Chemical analysis of the borehole data also showed some exceedances of metals and, specifically, PAHs from the AL1 values. In the case of metals, these were generally demonstrated by minimal exceedances and all concentrations being well below the AL2 or even the PEL. Exceedances of the PAHs were limited to three of the borehole sampling locations. Despite the PEL being marginally exceeded in the south-eastern embayment of Porth-y-pistyll for acenapthene, it is also noted that this value (96.1 $\mu g\ kg^{-1}$) was below the relevant AL1 threshold (100 $\mu g\ kg^{-1}$). Similarly, in the south-western embayment of Porth-y-pistyll, at the intertidal sampling location WI12, the concentration of acenapthene (93.8 $\mu g\ kg^{-1}$) also marginally exceeded the PEL (88.9 $\mu g\ kg^{-1}$) but was less than the AL1 threshold.

Further offshore, to the north-west of Anglesey at the Disposal Site, the 2016 DDC surveys confirmed that the seabed was rockier around the eastern margins of the area; hence, grab sampling was not possible from much of the eastern margins. Utilising the data from the DDC surveys, it was determined that much of the rocky area was comprised of boulders and cobbles, whereas sediment samples indicated that the sedimentary substrata were dominated by gravel with a high proportion of particles bigger than 2 mm. Sediment contamination of these deeper sediments in the Disposal Site were low. With the exception of arsenic, all metal concentrations recorded from the Disposal Site were below the ISQG and AL1 thresholds; arsenic was reported at just above the ISQG at all sites. All organic compounds monitored were below the relevant ISQG and AL1 with many concentrations below MRV, or only marginally above this value.

7.2 Benthic Ecology – Wylfa Newydd Development Area

7.2.1 Intertidal Benthic Ecology

The annual intertidal benthic monitoring programme along the north Anglesey coast between 2010 and 2014 provided comprehensive data on key communities and habitats across the foreshore areas. Between Cemlyn Bay and Cemaes Bay, a range of broad habitats were observed, including rocky habitats exhibiting *Pelvetia canaliculata* and barnacles on moderately exposed littoral fringe rock; lichens or small green algae on supralittoral rock; mussel and/or barnacle communities; and robust fucoid and/or red seaweed communities. For the lower, sedimentary zones, shingle (pebble) and gravel shores; polychaete/bivalve dominated muddy sands; and barren or amphipod dominated mobile sandy shores were recorded. These exposed and predominantly rocky shores support abundant and diverse assemblages of flora and fauna exhibiting spatio-distributions driven by natural environmental factors (e.g. exposure and insolation), resulting in typical zonation patterns.

Throughout the study area, the upper shore was characterised by bedrock, with all sites being moderately to very exposed and communities assigned the biotope '*P. canaliculata* and barnacles on moderately exposed littoral fringe rock'. There was persistence in both occurrence and abundance of fucoids, gastropod molluscs (*Littorina* spp. and *Patella vulgata*) and lichens; all specialists adapted to the upper limits of the shore.

The most commonly occurring taxa of the more diverse mid shore included the brown seaweeds *Fucus spiralis* and *Fucus serratus*; the red seaweeds *Lithophyllum* spp., *Corallina officinalis* and *Osmundea pinnatifida*; the gastropod molluscs *P. vulgata* (limpets), *Gibbula umbilicalis* (top shells) and *Nucella lapillus* (whelks); and barnacles. Two biotopes were identified across the midshore sites: '*Fucus spiralis* on full salinity exposed to moderately exposed upper eulittoral rock' characterised by *F. spiralis,* barnacles and limpets; and '*Fucus serratus* on moderately exposed lower eulittoral rock' characterised by relatively dense algal cover and with the most abundant fauna comprising limpets and top shells.

The highest taxon richness was reported across the lower-shore communities, at which the main influence from abiotic stressors give way to biological drivers. A dominance of algae and sub-dominance of molluscs and crustaceans were observed; however, these were also supported by species of sponges, cnidarians, annelids, bryozoans and echinoderms. The most commonly occurring taxa included barnacles; limpets; the brown algae *F. serratus*; and the red algae *Lithophyllum* spp. and *Mastocarpus stellatus*. Two biotopes were identified at the low-shore sampling sites: '*Corallina officinalis* on exposed to moderately exposed lower eulittoral rock', which were characterised by a variety of erect and encrusting red seaweeds and limpets; and '*Fucus serratus* on moderately exposed, lower eulittoral rock' characterised by relatively dense algal cover and abundance of gastropods.

Gastropod survey results for *Phorcus lineatus* and *Gibbula umbilicalis* populations across the intertidal sites between 2010 and 2014 are in line with historical studies of the geographical range of these trochid gastropods. No *P. lineatus* was reported close to, and to the east of, Wylfa Head, although a general increase in populations at the most western sites (WI01 and WI02) was noted over the five-year monitoring period. In comparison, the relatively more widely distributed *G. umbilicalis* was recorded much further east than *P. lineatus* at Point Lynas, but with only small populations.

Intertidal features of conservation from this study are summarised in Section 7.4 below.

7.2.2 Subtidal Benthic Ecology

The aim of these subtidal assessments was to provide baseline information on the spatial distribution of subtidal benthic habitats and taxa, and to identify any important conservation features. The combination of the DDC operations (2010–2011) alongside the faunal grab results (2010–2011 and 2015) enabled biotope designation of both the coarse and softer sediment communities found within the study area.

Relative depth and degree of exposure to tidal currents was an important structuring influence on the distribution of subtidal benthic communities identified during the study. Under conditions of reduced tidal currents of the shallower, more sheltered areas (e.g. Cemaes Bay), these were subject to heavier siltation and naturally supported sparser faunal communities dominated by small bivalves.

Further offshore and around the exposed headlands, more diverse communities were recorded. At these highly tide-swept sites, the epifauna was dominated by a rich assemblage of hydroids, bryozoans and anemones; within the sediments a higher number of infaunal taxa were recorded, where the Ross worm (*Sabellaria spinulosa*), which inhabits coarse substrates in high-energy areas, was often numerically dominant (discussed further in Section 7.4.2 below). With relatively low levels of physical anthropogenic disturbances (e.g. from mobile demersal fishing gear) in combination with suitable substrata and strong tidal currents, diverse assemblages of large, longer-lived colonial organisms were often supported at these sites.

Assessment of the quality of the benthic environment throughout the survey area, as measured by the WFD IQI tool, indicated that the benthic communities were generally of High quality. This observation is supported by the derived W-statistic, which indicated that communities throughout the study area were undisturbed. Similarly, measures of biodiversity indicated that the structure of the subtidal communities is as expected, with any deviation from the norm only present at offshore sites where it may be concluded that this is a typical deviation due to the high-energy, heterogeneous, sedimentary habitats characterising this area.

Temporal changes in biotopes between the 2010 and 2011 DDC surveys were identified, in part, to be an artefact of the change in programme between the two years, e.g. the decision not to sample infralittoral habitats in 2011 and hence influencing the taxa identified in each year. Similarly, there were some inter-annual differences between the faunal grab communities sampled between 2010 and 2011: of population abundances and number of taxa recorded, and a change in ecological quality from High to Good or Moderate at a few sites. Those sites which were not allocated a High status in all years were inshore, shallow sites and had been numerically abundant in ‘species-tolerant’ or ‘second-order’ opportunistic taxa such as *Abra abra* and *Lagis koreni,* which are naturally abundant in these homogeneous finer sediments. However, overall, multivariate analysis did not reveal large temporal differences between the DDC communities, and similarly the validation of the grab faunal communities in 2015 showed that these temporal differences were not ecologically significant, with the separation of these communities typified by space (e.g. habitat type), rather than time.

Subtidal features of conservation from the study are summarised in Section 7.4 below.

7.2.3 Cemlyn Lagoon ecology

Cemlyn Lagoon is artificially controlled by way of the weir which varies the water level in the lagoon to prevent the ternery from flooding at high spring tides. The lagoon supports a relatively diverse set of species, several of which are specific to lagoons, including the bryozoan *Conopeum seurati*, the lagoon cockle *Cerastoderma glaucum* and the lagoonal mud-snail *Ecrobia ventrose,* these lagoonal specialists are considered tolerant of organic enrichment and other pollutants such as metals (Munari and Mistri, 2008). A number of uncommon plant species are found within the lagoon, including the brackish water-crowfoot *Ranunculus baudotii* and beaked tasselweed *Ruppia maritima*.

Comparison with other Welsh lagoons which were repeatedly monitored between 2006 and 2010 showed high variability in faunal abundances (Stringell *et al*., 2013). All saline lagoons show an inherent variability over ranges of scale and duration, both in space and in time, which are not experienced in other aquatic habitats. Work carried out by Stringell *et al.* (2013) at Cemlyn has highlighted the 'assumed' natural spatial (inter and intra) variability and temporal variability with this lagoon. This variability imparts comparatively severe environmental stresses, which themselves are responsible for the development of a specialist community in lagoons. Authors such as Stringell *et al.,* (2013), Bamber *et al.* (2001); and Bamber (2010) have expressed the difficulties in establishing monitoring programmes as unless the baseline was based on years or even decades of data it would not be possible to fully understand the natural variability and community structure in lagoons.

The majority of coastal saline lagoons are man-made and/or maintained, indeed under natural conditions most saline lagoons are considered temporary habitats. Therefore, removal of site management will result in the loss of lagoonal habitat at some sites (Bamber, 2010).

7.3 Benthic Ecology of the Disposal Site

The aim of the 2016 Disposal Site surveys was to broadly characterise the benthic environment and identify any features of conservation interest. The Disposal Site study has clearly evidenced the strong scouring and high-energy nature of the benthic environment across Holyhead North (IS043) and the surrounding environment of the Disposal Site. Spatial heterogeneity of the sea bed was evidenced by a broad pattern of rocky substrata present along the eastern margins of Holyhead North, with mixed sedimentary habitats becoming more dominant moving westwards, with some stations indicating transitional habitats.

The findings of this study align well with those by CMACS (2016) and Rees (2005), which found epifaunal benthic communities indicative of scoured environments, such as pebbles, cobbles and boulders encrusted with Sabellariidae and barnacles, and scour-tolerant species such as *Flustra foliacea* and *Urticina* spp. often present.

The benthic communities varied between the grab sampling sites with the infaunal populations often recorded in low abundances; however, considerably higher abundances were recorded at those sites characterised by the presence of the tube building worms Sabellariidae, notably *S. spinulosa*, in high numbers.

Features of conservation of the Disposal Site are summarised in Section 7.4 below.

7.4 Marine Conservation Features

7.4.1 Section 7 Habitats and Species

7.4.1.1 Wylfa Newydd Development Area

There were no Section 7 priority species identified during the intertidal and subtidal benthic surveys of this area. However, some of the biotopes recorded during these surveys are encompassed by Section 7 priority habitats.

Several Section 7 habitats within the intertidal zone at Porth-y-pistyll were recorded. These were 'blue mussel (*Mytilus edulis*) beds on littoral mixed substrata'; '*Fucus ceranoides* on reduced salinity eulittoral rock'; and 'coastal saltmarsh'. Although present within the bay, none of these habitats were particularly extensive in their coverage, see Appendix D13.03 Porth-y-pistyll biotope surveys (Application Reference Number: 6.4.85).

Similarly, the Section 7 listed mussel bed habiats ('Blue mussel beds' and '*Musculus discros* beds') were also recorded within the subtidal habitats with the biotopes '*Mytilus edulis* beds with hydroids and ascidians on tide-swept, exposed to moderately wave-exposed circalittoral rock' observed off Wylfa Head (2011) and '*Musculus discors* beds on moderately exposed circalittoral rock' in Cemaes Bay (2011). The Section 7 priority habitat 'fragile sponge and anthozoan communities on subtidal rocky habitats' was recorded during the DDC surveys as evidenced by the biotope '*Dysidea fragilis* and *Actinothoe sphyrodeta* on tide-swept wave-exposed circalittoral rock' recorded in 2010, approximately 3 km east of Wylfa head, inshore at Llanlleiana Head. Many of the sublittoral sediment sites were ascribed biotopes that encompassed the widely occurring Section 7 priority habitats 'subtidal sands and gravels' (SS.SCS.CCS – at Church Bay and West Mouse) and 'subtidal mixed muddy sediments' (SS.SSa.CMuSa and SS.SSa.CMuSa.AalbNuc in Cemlyn and Cemaes Bay). These two habitats can be found extensively around the Anglesey coastline.

No section 7 priority species or habitats have been recorded at Cemlyn Lagoon (e.g. Bamber *et al.,* 2001; Nikitik, 2007; Stringell *et al*., 2013).

7.4.1.2 The Disposal Site

There were no Section 7 priority species identified from the DDC surveys and faunal grab samples. Recent benthic surveys of the surrounding area to the south had also reported this (CMACS, 2016; Baldock and Goudge, 2017). Several biotopes were recorded from the Disposal Site surveys that fall under the Section 7 habitat 'subtidal sands and gravels'. These were found in the central and western parts of the Disposal Site; the infaunal communities recorded at these sites tended to be impoverished.

7.4.2 Annex I Habitat 1170 – Reefs

There were no biogenic reefs of the horse mussel *Modiolus modiolus* reported within 5km of the Wylfa Newydd Development Area or at the deeper Disposal Site to the west. Specimens were retrieved in the faunal grab samples, but only infrequently and then in very low abundances. Rocky (stony and bedrock) reefs and biogenic reefs of Sabellariidae polychaete worms had been observed across the two study areas, and it is these Annex I features that are summarised here.

Intertidal *M. edulis* beds were recorded in Porth-y-pistyll and were ascribed the biotope LS.LBR.LMus.Myt.Mx; however, they only encompassed a total area of 0.18 ha and did not represent large examples of this habitat. As such, they were not considered to constitute an Annex I 'reef' habitat.

7.4.2.1 Wylfa Newydd Development Area

The majority of the intertidal area surveyed across north Anglesey was fissured bedrock; this feature often forms a continuation with the sublittoral rocky habitats, and where the reef extends from the sublittoral uninterrupted into the intertidal zone, it is considered an example of a bedrock reef habitat. This feature is present over considerable areas of the UK coastline, including extensive parts of the Anglesey coast, particularly along the northern coastline of Anglesey.

Evidence of these rocky reefs, both subtidally and intertidally, were provided by this work and other baseline surveys of the region. Biotope surveys by NRW in 2003 (not published) and Jacobs in 2014, see Appendix D13.03 Porth-y-pistyll biotope surveys (Application Reference Number: 6.4.85) provide considerable evidence of the rocky reefs present in the intertidal and subtidal environments along the north Anglesey coast.

Specific recognition was given to the potential presence of Sabellariidae reefs in the area, and the baseline surveys of this and other studies recorded notable aggregations of Sabellariidae were observed. Using criteria put forward by Gubbay (2007) and Hendrick and Foster-Smith (2006), assessments were made of whether these aggregations could be considered as reef structures. The inshore DDC and grab sampling surveys did not record aggregations of Sabellariidae, and similarly, during the rapid assessment dive surveys within Porth Wnal and just to the north of Porth-y-pistyll, no reefs or significant aggregations were recorded. Crusts of Sabellariidae were commonly recorded in the DDC and grab surveys across the offshore sites, but with elevated (> 2 cm) structures observed across a limited number of these sites with reefs determined only within the Church Bay area (8 km from Wylfa Head) and of being of low reefiness. However, it is possible that larger reef structures (e.g. of medium reefiness) are also present offshore of Church Bay and approximately 1.5 km north of Cemlyn Bay, following recent surveys by Baldock and Goudge (2017) that recorded structures >10 cm in height.

7.4.2.2 The Disposal Site

Stony reefs were identified across all the rocky habitats surveyed in the Disposal Site surveys; however, none were assessed as 'high' reefiness. Stony reefs recorded in this study were primarily defined by their physical characteristics as biota were often sparse at these sites, as was also found by CMACS (2016) across their study area to the south. Site HHD_01 on the south-eastern corner of the study site was assessed as a medium quality stony reef, and on examination of the substratum it may be a more suitable fit as a bedrock reef; there are currently no clear guidelines for assessing quality of such bedrock reef features.

Crusts and veneers of Sabellariidae tubes were commonly reported across the survey sites and with abundances of both *S. spinulosa* and *S. alveolata* recorded in high densities in some of the grab samples. In consideration of all the measured parameters available, only two sites were identified as supporting biogenic reefs of Sabellariidae, with one of low quality reefiness (HHD_20) and one to the north of the licenced area of medium quality (HHD_17). Baldock and Goudge (2017) had also reported substantial reef structures within the northern area of the licenced area ('West Anglesey Reef 35'). However, historical work by Rees (2005) almost exclusively recorded crusts of Sabellariidae across this region, and extensive surveys in 2015 by CMACS (2016) to the south and south-east of the Disposal Site recorded just five sites qualifying for assessment, and with three of these meeting the criteria for a biogenic reef.

7.4.3 Invasive and Non-Native Species

The surveys undertaken in this study of the benthic environment of north Anglesey, only a small number of INNS were recorded. For reference, a full list of the INNS of concern in north Wales are listed in Appendix B, Section B.1.

7.4.3.1 Wylfa Newydd Development Area

No INNS were recorded from the subtidal faunal grab and DDC surveys within 5km of the Wylfa Newydd Development Area.

The only confirmed INNS from the intertidal benthic surveys was a recording of the red algae *Asparagopsis armata* identified from the mid shore at site WI10 in 2013, and low shore at site WI09 in 2013; these sites are both situated within Cemaes Bay. Although this alga had not been identified during the subtidal benthic grab and DDC surveys, it had been recorded in the subtidal from the biotope dive surveys in Porth-y-pistyll, which had also confirmed the presence of two other INNS red algal species: *Heterosiphonia japonica* and *Anotrichium furcellatum* in Appendix D13.03 Porth-y-pistyll biotope surveys (Application Reference Number: 6.4.85).

Intertidal biotope surveys across Porth-y-pistyll in 2014 recorded the INNS *Sargassum muticum* at five low-shore locations along the bay, including within a rockpool on Cerrig Brith in Appendix D13.03 Porth-y-pistyll biotope surveys (Application Reference Number: 6.4.85), however, this large brown alga was not recorded at any of the intertidal transect sites (WI03, WI04 and WI12) of Porth-y-pistyll over the duration of this study, or elsewhere within 5km of the Wylfa Newydd Development Area.

The alga *Codium fragile* subsp. is an INNS; however, there are no distinct records of this species from the present study. A single record of *Codium* sp. was reported in the vicinity of the Existing Power Station from the low shore in 2011, yet this may constitute a native congener to *C. fragile*, with identification of the subsp. difficult to determine and requiring DNA analysis.

No INNS were reported by Baldock and Goudge (2017) during subtidal DDC assessments between Church Bay and Point Lynas.

No INNS have been recorded at Cemlyn Lagoon (e.g. Bamber *et al.,* 2001; Nikitik, 2007; Stringell *et al*., 2013).

7.4.3.2 The Disposal Site

With the relative close proximity of the historical licensed disposal site Holyhead Deep (IS040) to Holyhead marina, where there are known records of INNS, there is the concern that *Didemnum vexillum* (the carpet sea squirt) may occur in the area following disposal of dredged material from Holyhead Port. Within or adjacent to the Disposal Site, no INNS were recorded from this study. This corroborates the work carried out by Baldock and Goudge (2017) and CMACS (2016), which also did not record the presence of INNS from the Disposal Site and adjacent area.

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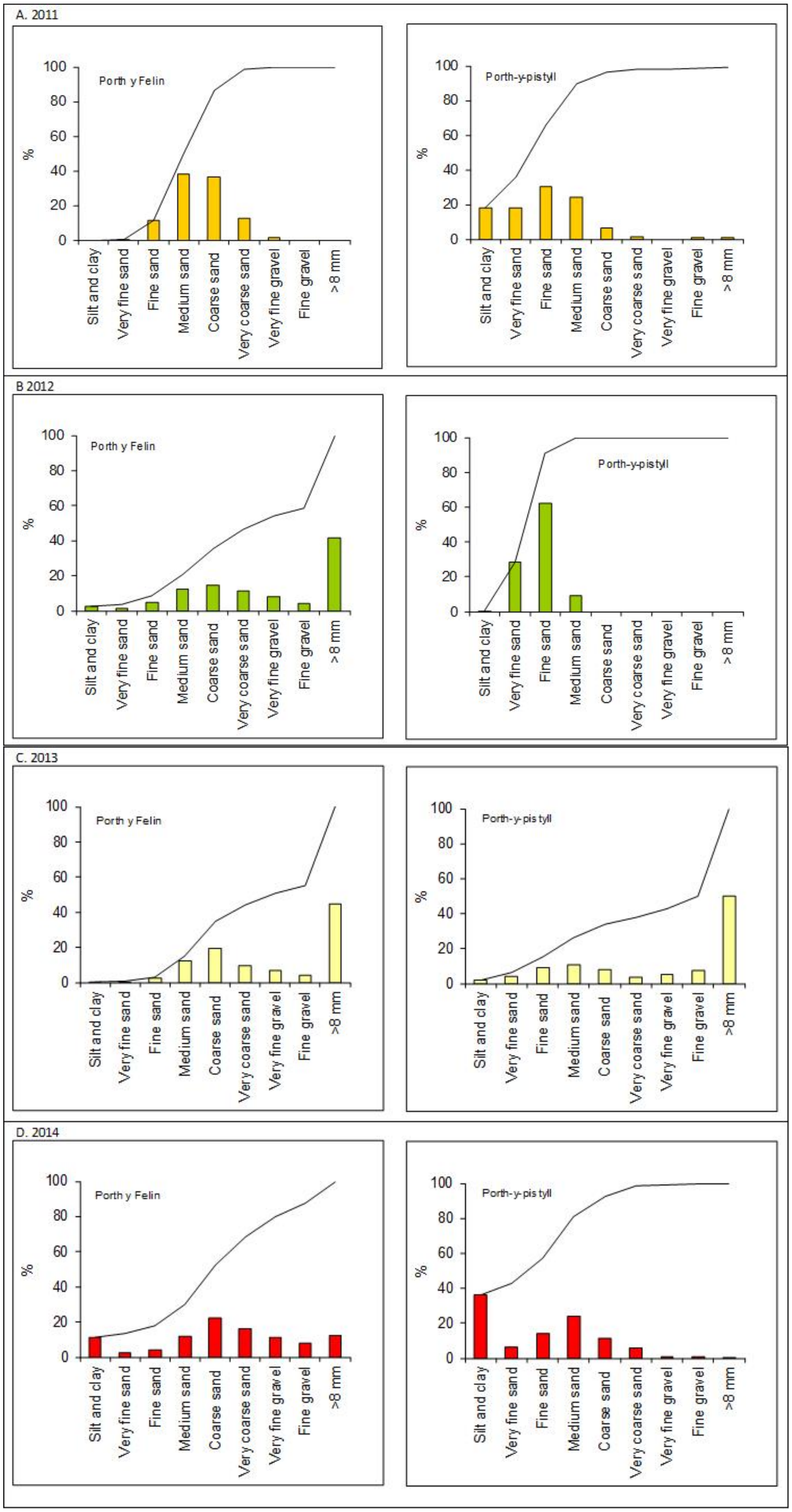
Appendix A. Marine Sediment - Additional Information

A.1 Laboratory Analytical Methods

One fraction of the sample was used for granulometry or particle size analysis (PSA). These were determined by sieving and laser diffraction using a Malvern Laser instrument. This method allows particle size to be reported from >63 mm to 1 mm by sieving and from 1 mm to <0.98 μm by laser diffraction, covering the full particle size spectrum.

A separated fraction of the samples submitted were homogenised, jaw crushed and sieved to <2 mm. The prepared sample was then digested in aqua regia to extract metals. The digested samples analysed by inductively coupled plasma optical emission spectrometry (ICP-OES). For the organic compounds analysis, a different fraction of the sample was air-dried and extracted in dichloromethane, after which a portion of the solvent layer was removed and exchanged into hexane. The resultant extract was analysed by Gas Chromatography Mass Spectrometry (GC-MS).

A.2 Sediment Particle Size Distribution from Intertidal Sediment Samples



A.3 Concentrations Reported by the Laboratory from Intertidal Sediment Samples

Table A.1: Sediment-bound metal concentrations (mg/kg dry weight) reported, AL, ISQG and PEL concentrations. Value highlighted in blue indicates metal concentration above AL1 while values in blue indicate concentrations above ISQG.

Analyte	AL1	AL2	ISQG	PEL	Porth y Felin (WI04)				Porth-y-pistyll (WI12)			
					2011	2012	2013	2014	2011	2012	2013	2014
Copper	40	400	18.7	108	11.9	7.96	4.75	10.2	4.73	3.57	10.2	11.4
Zinc	130	800	124	271	72.1	62.5	56.1	137	40.2	31.6	84.7	74.3
Cadmium	0.4	5	0.7	4.2	0.117	0.079	0.043	0.125	0.075	0.034	0.068	0.076
Mercury	0.3	3	0.13	0.7	0.0241	0.034	0.015	0.0246	0.0137	0.011	0.012	0.0324
Lead	50	500	30.2	112	13.3	10.1	8.75	40.3	4.84	4.12	8.92	13.8
Arsenic	20	100	7.24	41.6	3.84	1.98	1.57	4.32	0.8	2.19	2.02	5.19
Chromium	40	400	52.3	160	21	16.4	15	22.4	9.69	7.76	14.7	26.2
Nickel	20	200	-	-	13	11.3	10.8	15.2	6	5.09	11.4	15.2

Table A.2 : Metal:aluminium concentration ratios and Background Reference Concentrations (BRC). Values in red indicate ratios are greater than twice the upper BRC range.

Analyte	BRC range	Porth y Felin (WI04)				Porth-y-pistyll (WI12)			
		2011	2012	2013	2014	2011	2012	2013	2014
Copper	2.2–4.5	9.22	8.50	5.72	5.10	7.03	9.27	12.01	5.45
Zinc	8.8–18	55.89	66.70	67.51	68.50	59.73	82.08	99.76	35.55
Cadmium	0.007–0.03	0.09	0.08	0.05	0.06	0.11	0.09	0.08	0.04
Mercury	0.0034–0.0066	0.0187	0.0363	0.0181	0.0123	0.0204	0.0286	0.0141	0.0155
Lead	1.8–4.0	10.31	10.78	10.53	20.15	7.19	10.70	10.51	6.60
Arsenic	2.0–4.5	2.98	2.11	1.89	2.16	1.19	5.69	2.38	2.48
Chromium	9.0–20	16.28	17.50	18.05	11.20	14.40	20.16	17.31	12.54
Nickel	4.4–9.1	10.08	12.06	13.00	7.60	8.92	13.22	13.43	7.27

Table A.3 : PAHs concentrations (µg/kg dry weight), AL, ISQG and PEL values. Values highlighted in blue were found above AL1. Values in blue were found above the relevant ISQG, while the value in red was also found above the relevant PEL.

Analyte	AL1	AL2	ISQG	PEL	Porth y Felin (WI04)				Porth-y-pistyll (WI12)			
					2011	2012	2013	2014	2011	2012	2013	2014
Acenaphthene	100	n/a	6.71	88.9	5.2	<2	3	<1	5.6	<2	93.8	4.83
Acenaphthylene	100	n/a	5.87	128	<2	<2	<2	<1	<2	<2	13	1.29
Anthracene	100	n/a	46.9	245	9.2	<2	<2	2.88	<2	<2	51.4	9.5
Benzo(a)anthracene	100	n/a	74.8	693	14.8	3.3	3.4	3.94	<2	<2	207	15.2
Benzo(a)pyrene	100	n/a	88.8	763	12.7	3.4	4	5.04	<2	<2	218	13.5
Chrysene	100	n/a	108	846	15.0	4.6	4.4	3.18	<3	<3	206	15.1
Dibenzo(ah)anthracene	100	n/a	6.22	135	<5	<5	<5	1.92	11.2	<5	17.4	4.63
Fluoranthene	100	n/a	113	1494	25.5	5.8	5.2	6.87	3.52	<2	370	22

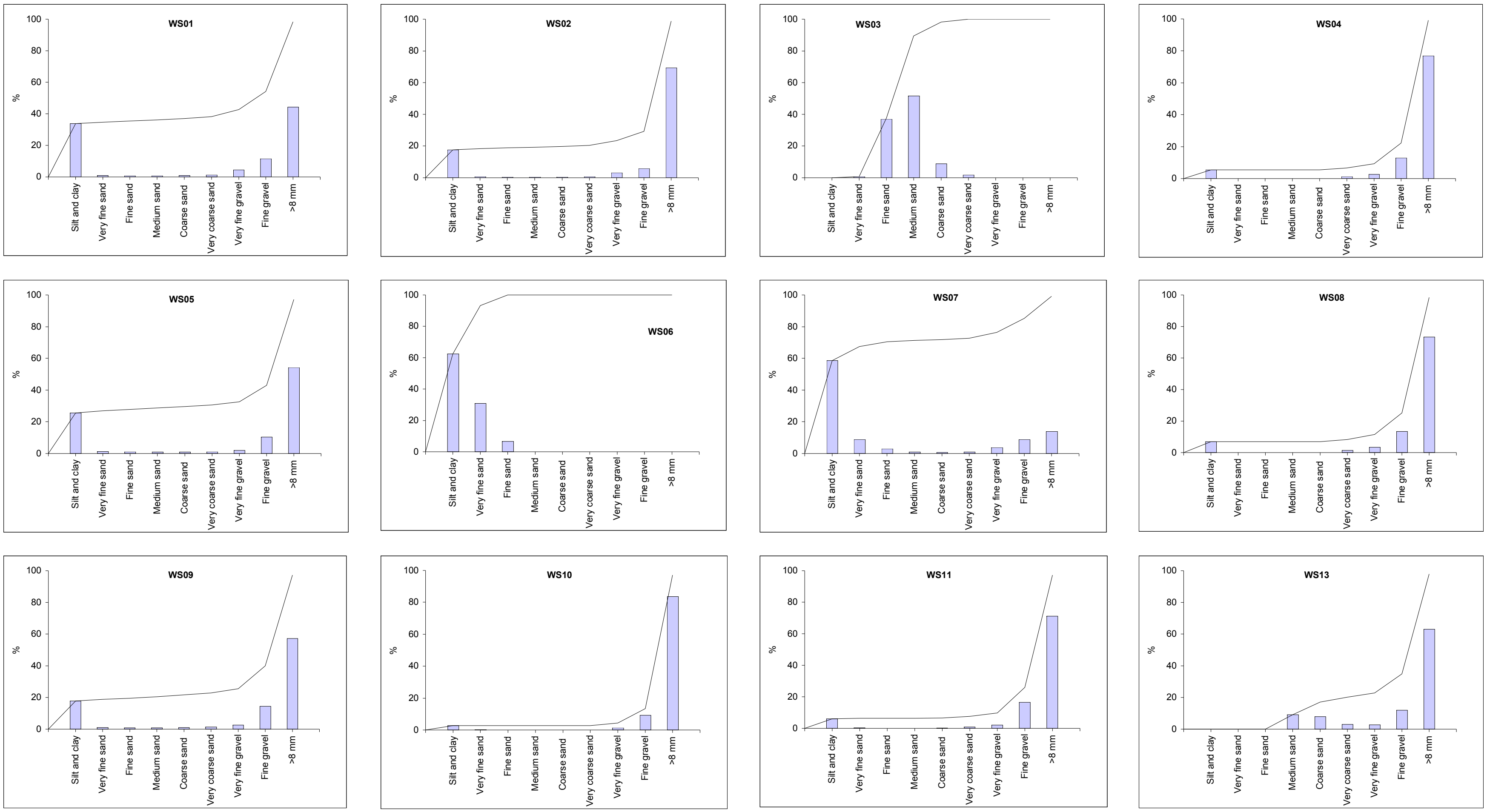
Analyte	AL1	AL2	ISQG	PEL	Porth y Felin (WI04)				Porth-y-pistyll (WI12)			
					2011	2012	2013	2014	2011	2012	2013	2014
Fluorene	100	n/a	21.2	144	15.2	<10	<10	<5	<10	<10	87.4	6.53
Naphthalene	100	n/a	34.6	391	58.3	<30	<30	6.14	<30	<30	80.2	31.5
Phenanthrene	100	n/a	86.7	544	53.4	<10	<10	12	<10	<10	375	36.5
Pyrene	100	n/a	153	1398	23.4	<3	4.5	5.13	<3	<3	316	17.2

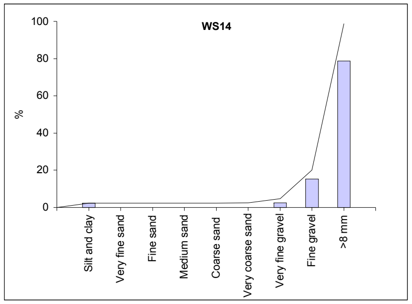
Table A.4 : PCBs concentrations (µg/kg dry weight) reported and AL values.

Analyte	AL1	Porth y Felin (WI04)				Porth-y-pistyll (WI12)			
		2011	2012	2013	2014	2011	2012	2013	2014
PCB-028	n/a	0.16	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.171
PCB-052	n/a	0.24	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	0.108
PCB-101	n/a	0.24	<0.1	<0.1	<0.1	<0.1	<0.1	1.2	<0.1
PCB-118	n/a	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	1.4	0.105
PCB-138	n/a	0.12	<0.1	<0.1	<0.1	<0.1	<0.1	2.28	<0.1
PCB-153	n/a	0.16	<0.1	<0.1	<0.1	<0.1	<0.1	2.64	<0.1
PCB-180	n/a	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.48	<0.1
∑ PCBs	10	<1.22	<0.7	<0.7	<0.7	<0.7	<0.7	<9.30	<0.784

A.4 Sediment Particle Size Distribution at Subtidal Sites at the Wylfa Newydd Development Area

A.4.1 2010

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%
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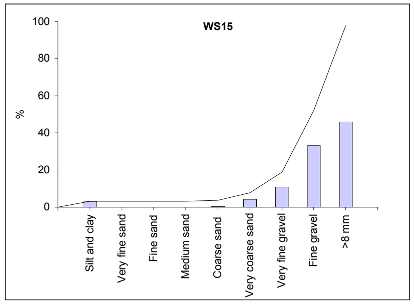
Very fine sand
Fine sand
Medium sand
Coarse sand
Very coarse sand
Very fine gravel
Fine gravel
>8 mm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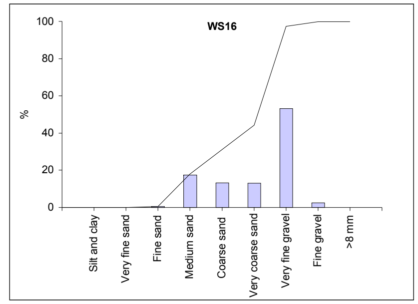
Fine sand
Medium sand
Coarse sand
Very coarse sand
Very fine gravel
Fine gravel
>8 mm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Coarse sand
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Fine gravel
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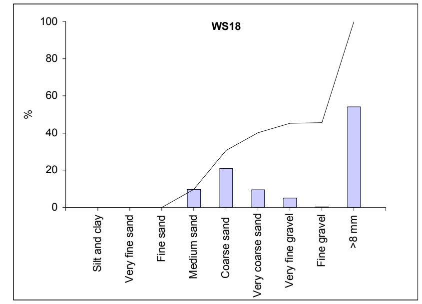
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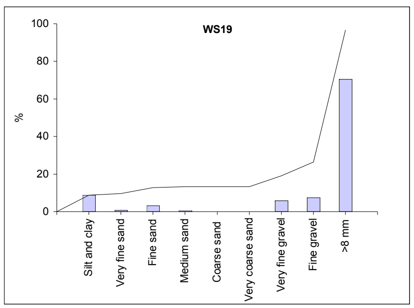
Fine gravel
>8 mm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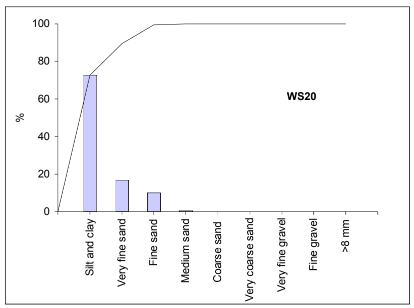
Medium sand
Coarse sand
Very coarse sand
Very fine gravel
Fine gravel
>8 mm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Coarse sand
Very coarse sand
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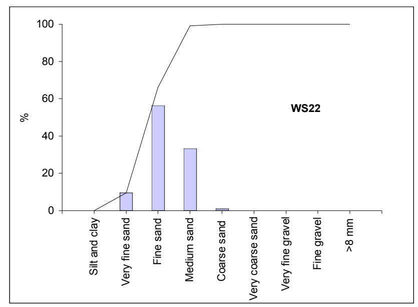
Fine gravel
>8 mm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Coarse sand
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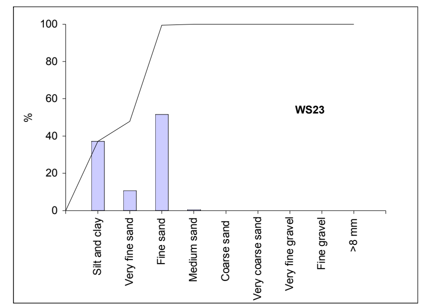
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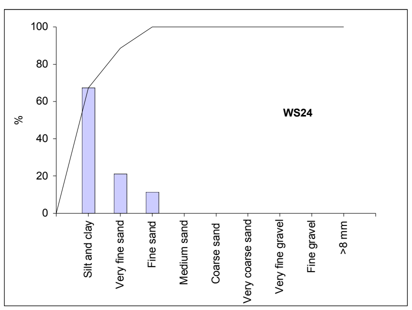
Coarse sand
Very coarse sand
Very fine gravel
Fine gravel
>8 mm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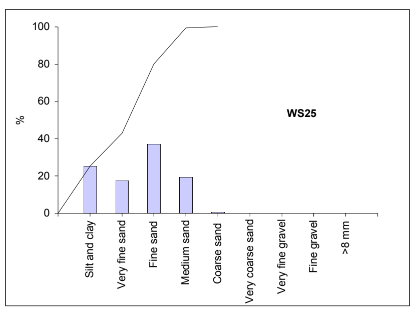
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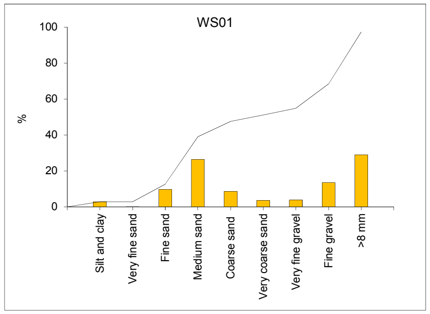
A.4.2 2011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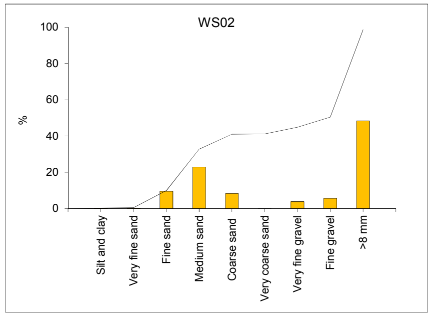
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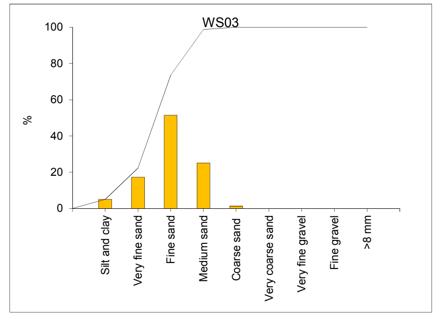
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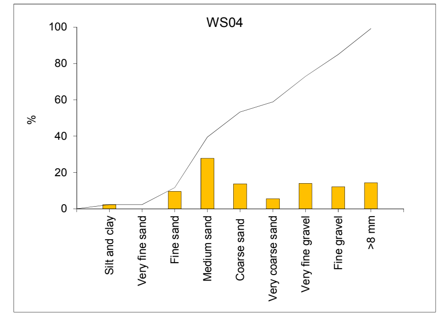
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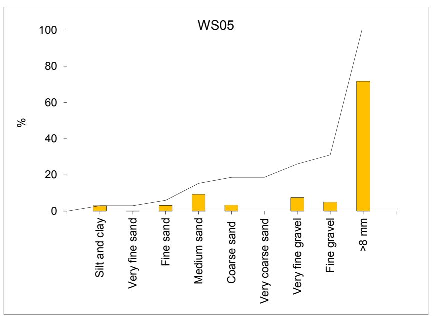
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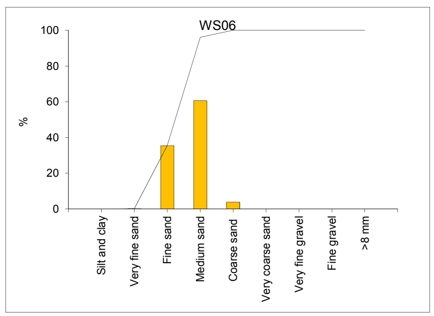
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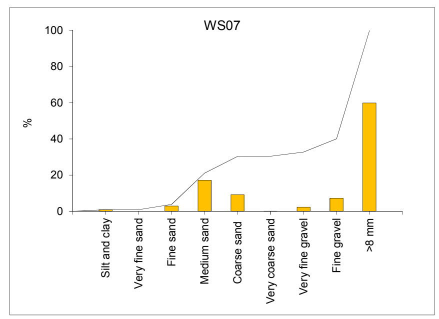
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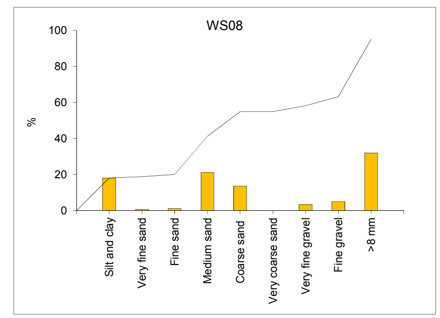
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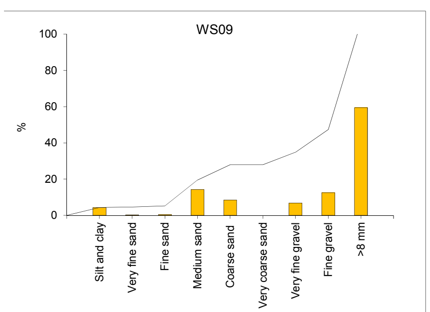
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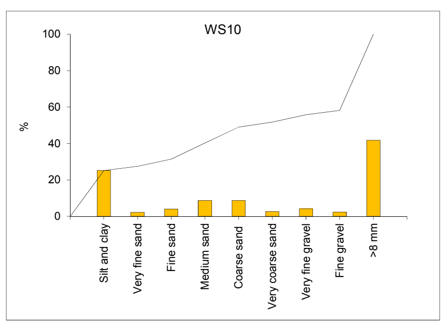
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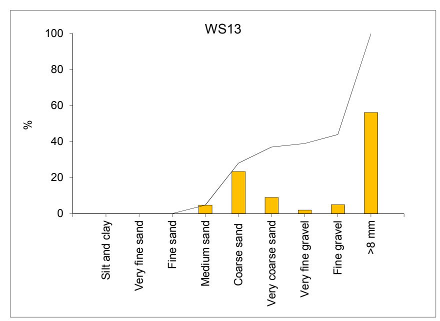
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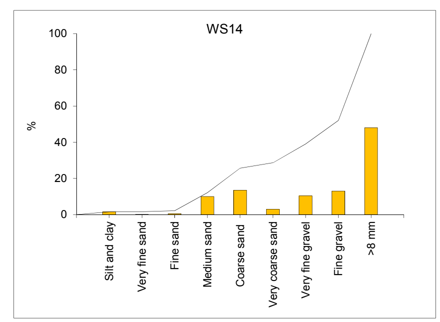
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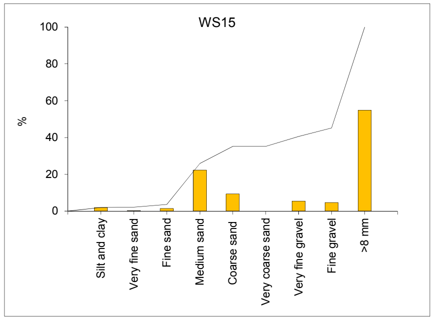
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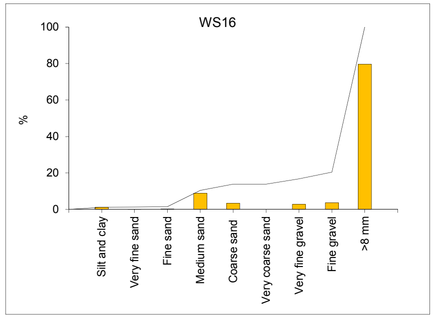
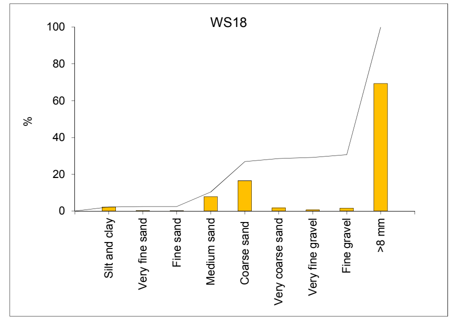
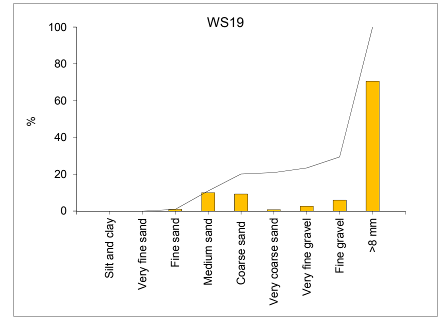
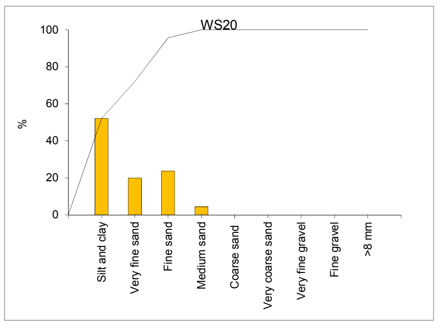
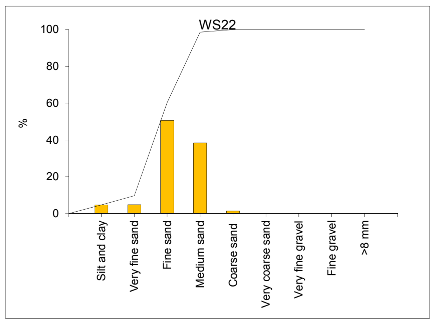
Fine gravel
>8 mm

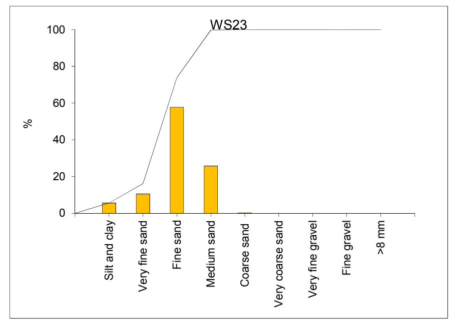

WS16
100
80
60
40
20
0
%
Silt and clay
Very fine sand
Fine sand
Medium sand
Coarse sand
Very coarse sand
Very fine gravel
Fine gravel
>8 mm

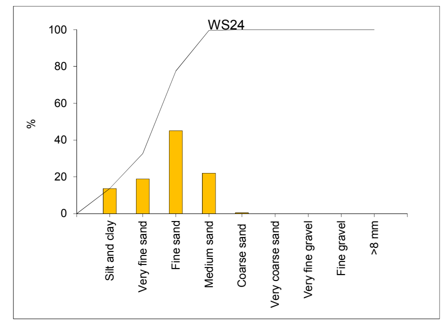

WS18
100
80
60
40
20
0
%
Silt and clay
Very fine sand
Fine sand
Medium sand
Coarse sand
Very coarse sand
Very fine gravel
Fine gravel
>8 mm

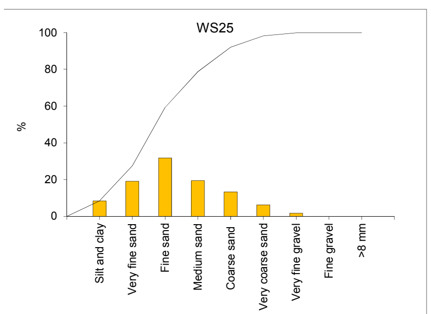

WS19
100
80
60
40
20
0
%
Silt and clay
Very fine sand
Fine sand
Medium sand
Coarse sand
Very coarse sand
Very fine gravel
Fine gravel
>8 mm

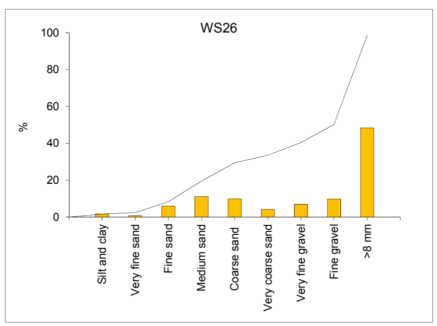

WS20
100
80
60
40
20
0
%
Silt and clay
Very fine sand
Fine sand
Medium sand
Coarse sand
Very coarse sand
Very fine gravel
Fine gravel
>8 mm

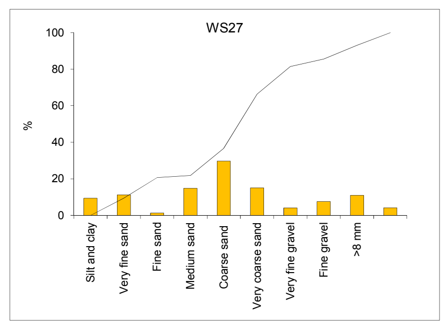

WS22
100
80
60
40
20
0
%
Silt and clay
Very fine sand
Fine sand
Medium sand
Coarse sand
Very coarse sand
Very fine gravel
Fine gravel
>8 mm

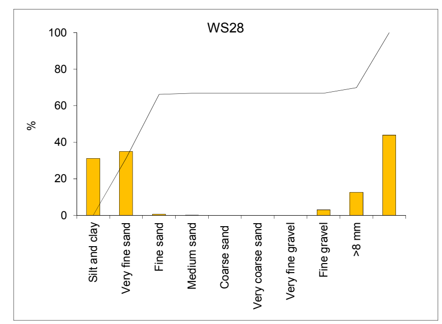

WS23
100
80
60
40
20
0
%
Silt and clay
Very fine sand
Fine sand
Medium sand
Coarse sand
Very coarse sand
Very fine gravel
Fine gravel
>8 mm


WS24
100
80
60
40
20
0
%
Silt and clay
Very fine sand
Fine sand
Medium sand
Coarse sand
Very coarse sand
Very fine gravel
Fine gravel
>8 mm


WS25
100
80
60
40
20
0
%
Silt and clay
Very fine sand
Fine sand
Medium sand
Coarse sand
Very coarse sand
Very fine gravel
Fine gravel
>8 mm


WS26
100
80
60
40
20
0
%
Silt and clay
Very fine sand
Fine sand
Medium sand
Coarse sand
Very coarse sand
Very fine gravel
Fine gravel
>8 mm


WS27
100
80
60
40
20
0
%
Silt and clay
Very fine sand
Fine sand
Medium sand
Coarse sand
Very coarse sand
Very fine gravel
Fine gravel
>8 mm


WS28
100
80
60
40
20
0
%
Silt and clay
Very fine sand
Fine sand
Medium sand
Coarse sand
Very coarse sand
Very fine gravel
Fine gravel
>8 mm

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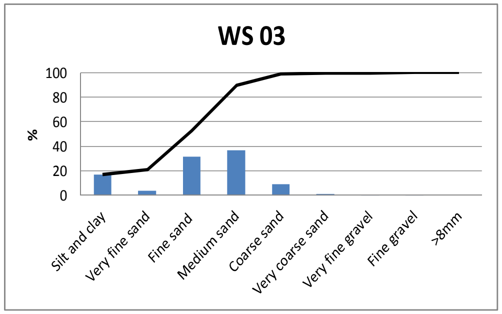
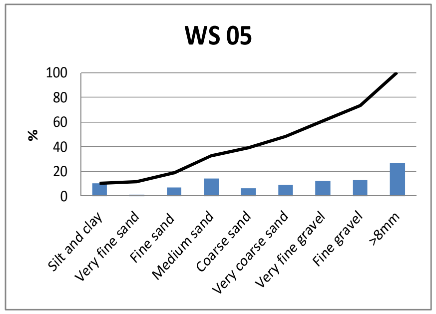
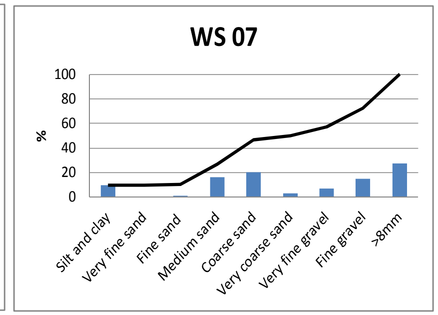
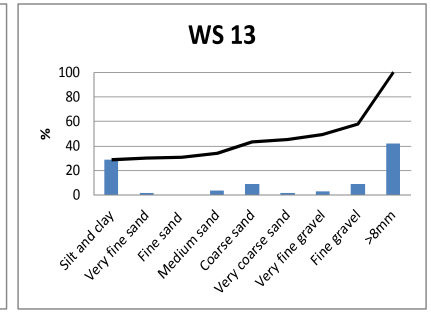
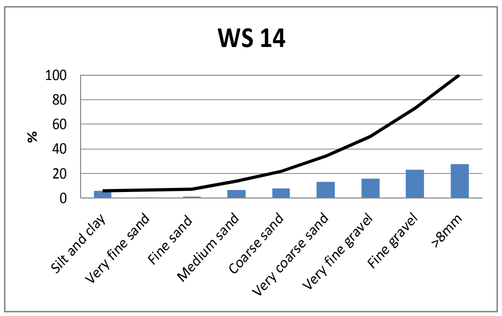
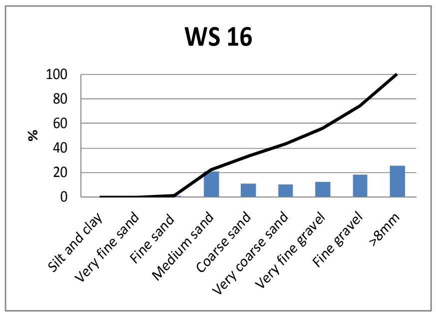

WS 03
100
80
60
40
20
0
%
Silt and clay
Very fine sand
Fine sand
Medium sand
Coarse sand
Very coarse sand
Very fine gravel
Fine gravel
>8mm

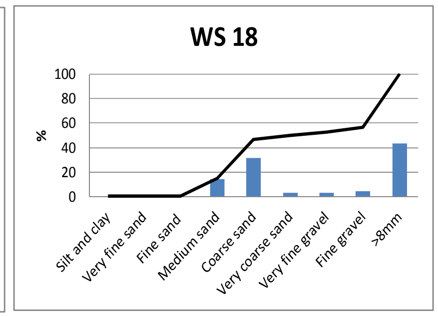

WS 05
100
80
60
40
20
0
%
Silt and clay
Very fine sand
Fine sand
Medium sand
Coarse sand
Very coarse sand
Very fine gravel
Fine gravel
>8mm

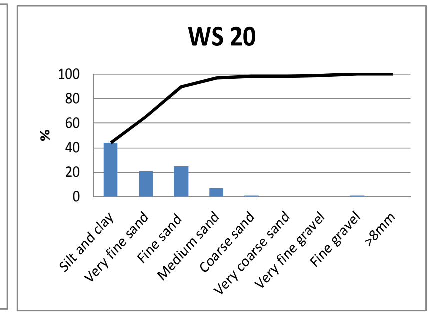

WS 07
100
80
60
40
20
0
%
Silt and clay
Very fine sand
Fine sand
Medium sand
Coarse sand
Very coarse sand
Very fine gravel
Fine gravel
>8mm

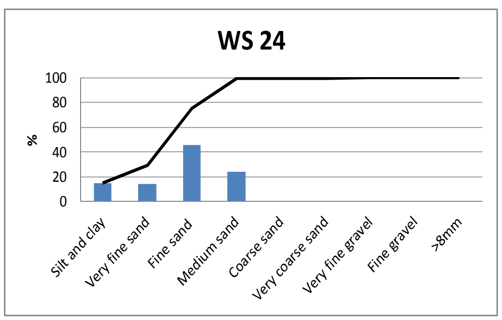

WS 13
100
80
60
40
20
0
%
Silt and clay
Very fine sand
Fine sand
Medium sand
Coarse sand
Very coarse sand
Very fine gravel
Fine gravel
>8mm

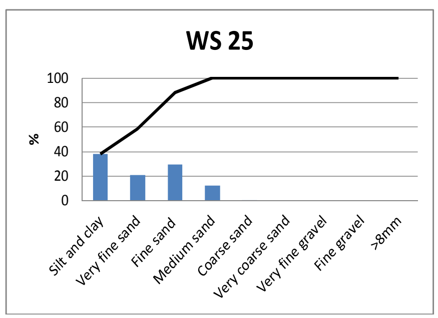

WS 14
100
80
60
40
20
0
%
Silt and clay
Very fine sand
Fine sand
Medium sand
Coarse sand
Very coarse sand
Very fine gravel
Fine gravel
>8mm

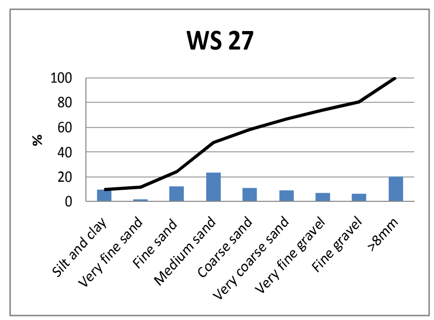

WS 16
100
80
60
40
20
0
%
Silt and clay
Very fine sand
Fine sand
Medium sand
Coarse sand
Very coarse sand
Very fine gravel
Fine gravel
>8mm


WS 18
100
80
60
40
20
0
%
Silt and clay
Very fine sand
Fine sand
Medium sand
Coarse sand
Very coarse sand
Very fine gravel
Fine gravel
>8mm


WS 20
100
80
60
40
20
0
%
Silt and clay
Very fine sand
Fine sand
Medium sand
Coarse sand
Very coarse sand
Very fine gravel
Fine gravel
>8mm


WS 24
100
80
60
40
20
0
%
Silt and clay
Very fine sand
Fine sand
Medium sand
Coarse sand
Very coarse sand
Very fine gravel
Fine gravel
>8mm


WS 25
100
80
60
40
20
0
%
Silt and clay
Very fine sand
Fine sand
Medium sand
Coarse sand
Very coarse sand
Very fine gravel
Fine gravel
>8mm


WS 27
100
80
60
40
20
0
%
Silt and clay
Very fine sand
Fine sand
Medium sand
Coarse sand
Very coarse sand
Very fine gravel
Fine gravel
>8mm

A.5 Sediment Particle Size Distribution at Subtidal Sites for the DOffGI (Fugro, 2017)

Table A.5: Physical properties of DOffGI sediment samples. Sample depth within each borehole is provided.

Sampling station	Sample depth (m)	Visual Description	Gravel % (> 2mm particle size)	Sand % (> 0.063mm to < 2mm particle size)	Silt/clay % (< 0.063mm particle size)
BH1237	0.00-0.30	Slightly muddy, sandy gravel	53	44	3
BH1236	0.00-0.40	Slightly muddy, gravelly, shelly sand.	9	83	8
BH1236	1.50-1.70	Thick, sticky, brown gravelly mud (clay?).	12	13	76
BH1202	0.00-0.50	Slightly muddy, shelly, sandy gravel.	74	25	1
BH1202	1.00-1.50	Sandy, gravelly mud containing broken shell fragments.	32	17	51
BH1202	2.00-2.40	Slightly muddy, sand/gravel.	46	49	6
BH1214	0.00-0.50	Slightly muddy, shelly, sandy gravel.	50	45	5
BH1229	0.00-0.50	Slightly muddy, slightly shelly, sandy gravel.	56	38	6
BH1228	0.00-0.32	Brown, slightly muddy, sandy gravel (grey shale?).	70	18	12
BH1215	0.00-0.70	Gravel (grey shale?)	No PSA - gravel.	0	0
BH1238	0.00-0.30	Slightly muddy, sandy gravel containing broken shell fragments.	62	34	4
BH1203	0.00-0.30	Sand containing some broken shell fragments.	0	96	4
BH1203	1.00-1.30	Gravelly sand.	37	62	1
BH1203	2.00-2.30	Gravel (grey shale?)	No PSA - gravel.	0	0
BH1234	0.00-0.50	Slightly muddy, gravelly sand containing broken shell fragments.	28	67	6

Sampling station	Sample depth (m)	Visual Description	Gravel % (> 2mm particle size)	Sand % (> 0.063mm to < 2mm particle size)	Silt/clay % (< 0.063mm particle size)
BH1234	1.00-1.50	Slightly muddy, sandy gravel containing broken shell fragments.	42	55	3
BH1234	2.00-2.50	Slightly muddy, gravelly sand containing broken shell fragments.	26	69	5
BH1235	0.00-0.40	Slightly muddy, sandy gravel containing broken shell fragments.	37	55	8
BH1235	1.20-1.40	Slightly muddy, sandy gravel containing broken shell fragments.	47	46	7
BH1210	0.00-0.50	Slightly sandy gravel.	93	7	0

A.6 Laboratory Concentrations Reported in Subtidal Sediments Collected at the Wylfa Newydd Development Area

Table A.6: Sediment-bound metal concentrations (mg/kg dry weight) reported in 2010 and 2011, AL, ISQG and TEL concentrations. Value highlighted in blue indicates metal concentration above AL1, while values in blue indicate concentrations above ISQG.

Analyte		Copper	Zinc	Cadmium	Mercury	Lead	Arsenic	Chromium	Nickel
AL1		40	130	0.4	0.3	50	20	40	20
AL2		400	800	5	3	500	100	400	200
ISQG		18.7	124	0.7	0.13	30.2	7.24	52.3	-
PEL		108	271	4.2	0.7	112	41.6	160	-
Site	Year								
WS01	2010	7.36	37.6	0.045	0.016	14.2	5.1	10.4	9.44
	2011	3.55	30.4	0.026	0.011	9.41	3.94	9.71	4.49
WS02	2010	11	65.1	0.062	0.03	25.5	7.39	21.4	22.2
	2011	5.18	41.8	0.042	0.021	15.3	4.05	16.3	6.29
WS03	2010	6.35	43.5	0.04	0.016	16.1	5.47	14.8	12.2
	2011	5	38.1	0.032	0.015	12.3	4.22	14.9	8.03
WS04	2011	5.37	32.1	0.029	0.014	10.7	3.92	16	7.01
WS05	2010	4.61	27.2	0.026	0.01	11.4	4.53	7.85	6.6
	2011	5.36	42.2	0.032	0.019	14.2	3.34	16	10.9
WS06	2010	3.41	29	0.021	0.005	9.73	7.87	9.85	8.71

Analyte		Copper	Zinc	Cadmium	Mercury	Lead	Arsenic	Chromium	Nickel
AL1		40	130	0.4	0.3	50	20	40	20
AL2		400	800	5	3	500	100	400	200
ISQG		18.7	124	0.7	0.13	30.2	7.24	52.3	-
PEL		108	271	4.2	0.7	112	41.6	160	-
Site	Year								
	2011	3.3	26.8	0.016	0.007	8.46	7.19	8.04	4.11
WS07	2010	3.77	16.2	0.019	0.005	6.01	3.79	6.93	5
	2011	2.11	20.1	0.014	0.006	7.1	5.08	10.2	4.25
WS08	2011	2.84	20.7	0.016	0.009	6.83	3.35	7.82	2.27
WS09	2011	4.84	32.3	0.032	0.015	10.5	4.47	13.2	6.67
WS13	2011	2.3	19.2	0.019	0.005	6.56	4.32	8.03	1.4
WS14	2010	8.69	41.2	0.042	0.014	16.2	5.78	14.9	10.5
	2011	4.17	27	0.019	0.01	8.59	4.91	12.5	5.17
WS15	2011	4.68	26	0.021	0.009	8.16	7.04	9.69	4.17
WS16	2010	3.48	29.4	0.024	0.002	6.27	17.1	9.56	9.8
	2011	2.54	23	0.029	0.006	5.75	13	11.6	5.79
WS18	2010	2.75	16.8	0.018	0.005	6.6	6.54	8.71	6.38
	2011	2.06	14.4	0.016	0.004	6.03	5.52	6.51	2.52
WS19	2010	5.52	16.6	0.017	0.004	6.07	5.52	7.75	6.14
	2011	1.65	15.2	0.014	0.004	4.98	3.53	5.13	0.69
WS20	2010	9.98	66.9	0.065	0.03	23.7	6.78	23.3	17.5
	2011	8.52	64	0.059	0.036	22	5.89	27.2	13.1
WS22	2010	7.3	41.4	0.036	0.008	11.8	5.4	11.3	10.8
	2011	4.73	37.2	0.032	0.013	11.5	4.72	15.6	7.43
WS23	2010	5.83	41.6	0.049	0.017	14.2	4.07	12.4	9.18
	2011	5.03	40.8	0.047	0.015	13.2	3.66	16.8	7.33
WS24	2010	7.1	64.4	0.03	0.003	8.15	6.51	10.6	11.3
	2011	7.49	37.9	0.036	0.005	7.99	11.3	23.5	15
WS25	2010	9.22	57.1	0.056	0.022	21.1	6.64	20.2	15
	2011	5.31	41	0.04	0.01	9.33	2.65	10.8	5.31
WS26	2011	6.95	45.9	0.032	0.022	13.8	3.82	14.4	7.91
WS27	2011	6.97	31	0.034	0.011	11.4	4.28	12.1	5.66
WS28	2011	4.67	30.9	0.021	0.012	10.9	5.01	10.3	4.71

Table A.7: Background Reference Concentrations (BRC) and metal:aluminium concentration ratios for subtidal sediments in 2010 and 2011. Values in red indicate ratios are greater than twice the upper BRC range.

Analytes		Copper	Zinc	Cadmium	Mercury	Lead	Arsenic	Chromium	Nickel
BRC range		2.2 - 4.5	8.8 - 18	0.007 - 0.03	0.0034 - 0.0066	1.8 - 4.0	2.0 - 4.5	9.0 - 20	4.4 - 9.1
Site	Year								
WS01	2010	14.84	75.81	0.091	0.0323	28.63	10.28	20.97	19.03
	2011	9.2	78.76	0.067	0.0285	24.38	10.21	25.16	11.63
WS02	2010	9.17	54.25	0.052	0.025	21.25	6.16	17.83	18.5
	2011	5.79	46.76	0.047	0.0235	17.11	4.53	18.23	7.04
WS03	2010	8.84	60.58	0.056	0.0223	22.42	7.62	20.61	16.99
	2011	8.45	64.36	0.054	0.0253	20.78	7.13	25.17	13.56
WS04	2011	7.03	42.02	0.038	0.0183	14.01	5.13	20.94	9.18
WS05	2010	12.6	74.32	0.071	0.0273	31.15	12.38	21.45	18.03
	2011	7.11	55.97	0.042	0.0252	18.83	4.43	21.22	14.46
WS06	2010	12.97	110.27	0.08	0.019	37	29.92	37.45	33.12
	2011	12.18	98.89	0.059	0.0258	31.22	26.53	29.67	15.17
WS07	2010	24.01	103.18	0.121	0.0318	38.28	24.14	44.14	31.85
	2011	8.02	76.43	0.053	0.0228	27	19.32	38.78	16.16
WS08	2011	7.7	56.1	0.043	0.0244	18.51	9.08	21.19	6.15
WS09	2011	6.86	45.75	0.045	0.0212	14.87	6.33	18.7	9.45
WS13	2011	9.62	80.33	0.079	0.0209	27.45	18.08	33.6	5.86
WS14	2010	8.69	41.2	0.042	0.014	16.2	5.78	14.9	10.5
	2011	6.46	41.8	0.029	0.0155	13.3	7.6	19.35	8
WS15	2011	11.28	62.65	0.051	0.0217	19.66	16.96	23.35	10.05
WS16	2010	8.85	74.81	0.061	0.0051	15.95	43.51	24.33	24.94
	2011	6.81	61.66	0.078	0.0161	15.42	34.85	31.1	15.52
WS18	2010	14.55	88.89	0.095	0.0265	34.92	34.6	46.08	33.76
	2011	9.16	64	0.071	0.0178	26.8	24.53	28.93	11.2
WS19	2010	29.21	87.83	0.09	0.0212	32.12	29.21	41.01	32.49
	2011	9.71	89.41	0.082	0.0235	29.29	20.76	30.18	4.06
WS20	2010	6.93	46.46	0.045	0.0208	16.46	4.71	16.18	12.15
	2011	5.23	39.26	0.036	0.0221	13.5	3.61	16.69	8.04
WS22	2010	17.59	99.76	0.087	0.0193	28.43	13.01	27.23	26.02
	2011	7.88	62	0.053	0.0217	19.17	7.87	26	12.38
WS23	2010	10.03	71.6	0.08	0.0293	24.44	7.01	21.34	15.8
	2011	6.2	50.31	0.058	0.0185	16.28	4.51	20.72	9.04
WS24	2010	19.45	176.44	0.08	0.0082	22.33	17.84	29.04	30.96
	2011	5.85	29.61	0.028	0.0039	6.24	8.83	18.36	11.72
WS25	2010	8.7	53.87	0.05	0.0208	19.91	6.26	19.06	14.15
	2011	12.58	97.16	0.095	0.0237	22.11	6.28	25.59	12.58
WS26	2011	7.72	51	0.036	0.0244	15.33	4.24	16	8.79

Analytes		Copper	Zinc	Cadmium	Mercury	Lead	Arsenic	Chromium	Nickel
BRC range		2.2 - 4.5	8.8 - 18	0.007 - 0.03	0.0034 - 0.0066	1.8 - 4.0	2.0 - 4.5	9.0 - 20	4.4 - 9.1
Site	Year								
WS27	2011	10.28	45.72	0.05	0.0162	16.81	6.31	17.85	8.35
WS28	2011	12.69	83.97	0.057	0.0326	29.62	13.61	27.99	12.8

Table A.8: Polycyclic aromatic hydrocarbons (PAHs) concentrations (µg/kg). AL, ISQG and TEL values. Values highlighted in yellow indicate concentration above AL1; values in blue indicate concentration above ISQG; and values in red indicate concentration above PEL.

Analytes		Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Chrysene	Dibenzo(ah)anthracene	Fluoranthene	Fluorene	Naphthalene	Phenanthrene	Pyrene
AL1		100	100	100	100	100	100	100	100	100	100	100	100
AL2		-	-	-	-	-	-	-	-	-	-	-	-
ISQG		6.71	5.87	46.9	74.8	88.8	108	6.22	113	21.2	34.6	86.7	153
PEL		88.9	128	245	693	763	846	135	1494	144	391	544	1398
Site	Year												
WS01	2010	3	<2	2.4	7.9	7.9	10.9	<5	11.5	<10	420	<10	10
	2011	<2	<2	<2	6.2	6.3	8.6	<5	10.2	<10	<30	<10	8
WS02	2010	3.5	2.2	5.9	20.8	23.4	31.9	5.7	33.6	10.4	537	30.8	26.7
	2011	<2	<2	2.5	9.1	9.2	12.6	<5	14.5	<10	<30	17.4	11.4
WS03	2010	<2	<2	<2	<2	<2	<10	<5	<2	<10	<60	<10	<2
	2011	<2	<2	3.7	11.1	11.4	17.3	<5	17.6	<10	<30	22	13.1
WS04	2011	<2	<2	<2	4.6	3.8	9.9	<5	8.8	<10	<30	16.2	7.3
WS05	2010	<2	<2	<2	4.2	4	<10	6.9	6.7	<10	86.8	<10	3.7
	2011	<2	<2	2.5	8.3	8.9	12.6	<5	14.8	<10	<30	15.6	11.7
WS06	2010	<2	<2	<2	<2	<2	<10	<5	<2	<10	46.8	<10	<2
	2011	<2	<2	<2	<2	<2	<2	<5	2.2	<10	<30	<10	<2
WS07	2010	<2	<2	<2	<2	<2	<10	<5	<2	<10	<43.9	<10	<2
	2011	<2	<2	<2	2	<2	3.7	<5	3	<10	<30	<10	2.6
WS08	2011	<2	<2	<2	4.6	4.6	7	<5	7.5	<10	<30	<10	5.7
WS09	2011	<2	<2	<2	7.5	7.4	11.9	<5	12.1	<10	<30	17	8.9
WS13	2011	<2	<2	<2	<2	<2	<2	<5	<2	<10	<30	<10	<2
WS14	2010	3.9	<2	<2	9.8	8.6	13	9.8	14.8	<10	<60	10.5	13.8
	2011	<2	<2	<2	5.1	4.4	7.1	<5	6.3	<10	<30	<10	5.7
WS15	2011	2.2	<2	<2	5.9	6.3	17.6	<5	9.8	<10	<30	31.2	8.9

Analytes		Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Chrysene	Dibenzo(ah)anthracene	Fluoranthene	Fluorene	Naphthalene	Phenanthrene	Pyrene
AL1		100	100	100	100	100	100	100	100	100	100	100	100
AL2		-	-	-	-	-	-	-	-	-	-	-	-
ISQG		6.71	5.87	46.9	74.8	88.8	108	6.22	113	21.2	34.6	86.7	153
PEL		88.9	128	245	693	763	846	135	1494	144	391	544	1398
Site	**Year**												
WS16	2010	<2	-	<2	<2	<2	<10	<5	<2	<10	-	<10	<2
	2011	<2	<2	<2	3.9	4	5.8	<5	6.6	<10	<30	<10	5.4
WS18	2010	<2	<2	<2	<2	<2	<10	<5	<2	<10	172	<10	<2
	2011	<2	<2	<2	3.8	3.5	5.4	<5	6.2	<10	<30	<10	5.1
WS19	2010	<2	<2	<2	<2	<2	<10	<5	<2	<10	<43.9	<10	<2
	2011	<2	<2	<2	2.3	<2	3.4	<5	4.8	<10	<30	<10	4.1
WS20	2010	5.3	7.2	15.6	37.9	40.3	48.6	54.1	64.8	19	123	67.1	55.1
	2011	3.1	3.1	9	32.2	35	45.4	8.3	52.2	21.3	60.6	64.4	39.4
WS22	2010	<2	<2	<2	2.1	<2	<10	<5	<2	<10	71	<10	<2
	2011	<2	<2	2	6.2	5.7	8.9	<5	10.3	<10	<30	<10	7.3
WS23	2010	2.1	3.7	6.5	20.1	23.4	27.2	29.9	34.4	<10	73.6	28.4	27.1
	2011	<2	<2	3.5	10.7	9.4	15.5	<5	17	<10	<30	20.9	12
WS24	2010	<2	<2	<2	<2	<2	<10	<5	<2	<10	115	<10	<2
	2011	<2	<2	<2	<2	<2	3.1	<5	2.1	<10	<30	<10	<2
WS25	2010	4.7	<2	5.6	18.3	19.5	29.8	6.2	30.1	<10	399	27.7	23.7
	2011	31.8	3.8	19.8	102	100	113	10.4	190	34.7	<30	157	155
WS26	2011	<2	<2	2.8	9.9	9.8	11.7	<5	15.2	<10	<30	15.2	12
WS27	2011	<2	<2	2.4	8.8	7.7	11.5	<5	13.1	<10	<30	14.9	10.4
WS28	2011	<2	<2	<2	4.4	3.9	6	<5	6.8	<10	<30	<10	5.5

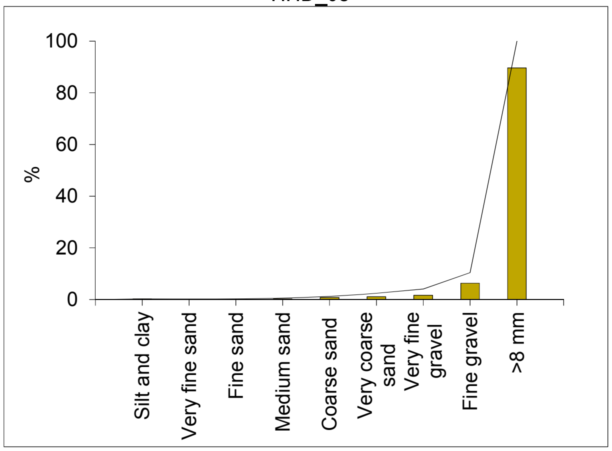
Table A.9: Polychlorinated biphenyls (PCBs) concentrations (µg/kg) and AL value.

Analyte		PCB 028	PCB 052	PCB 101	PCB 118	PCB 138	PCB 153	PCB 180	∑PCBs
AL1		-	-	-	-	-	-	-	**10**
Site	**Year**								
WS01	2010	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7
	2011	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7
WS02	2010	<0.1	<0.1	<0.1	0.12	<0.1	<0.1	<0.1	<0.72
	2011	<0.1	<0.1	<0.1	0.16	<0.1	0.12	<0.1	<0.78
WS03	2010	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7
	2011	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7

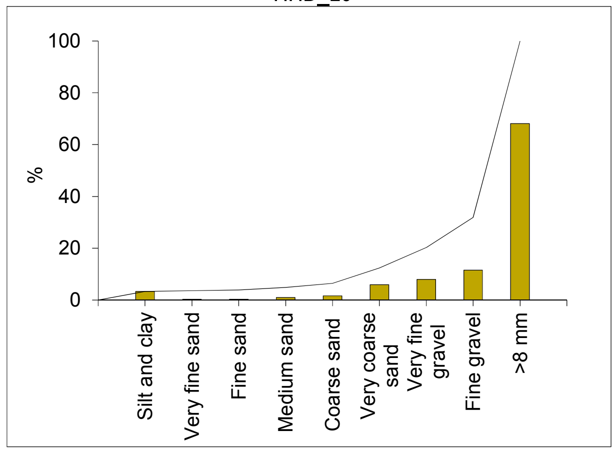
Analyte		PCB 028	PCB 052	PCB 101	PCB 118	PCB 138	PCB 153	PCB 180	∑PCBs
AL1		-	-	-	-	-	-	-	10
Site	Year								
WS04	2011	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7
WS05	2010	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7
	2011	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7
WS06	2010	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7
	2011	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7
WS07	2010	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7
	2011	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7
WS08	2011	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7
WS09	2011	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7
WS13	2011	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7
WS14	2010	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7
	2011	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7
WS15	2011	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7
WS16	2010	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7
	2011	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7
WS18	2010	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7
	2011	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7
WS19	2010	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7
	2011	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7
WS20	2010	<0.1	<0.1	<0.1	0.12	0.12	0.12	<0.1	<0.76
	2011	0.68	0.48	0.36	0.44	0.4	0.52	0.24	2.86
WS22	2010	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7
	2011	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7
WS23	2010	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7
	2011	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7
WS24	2010	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7
	2011	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7
WS25	2010	<0.1	<0.1	<0.1	0.16	<0.1	0.12	<0.1	<0.78
	2011	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7
WS26	2011	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7
WS27	2011	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7
WS28	2011	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7

A.7 Particle Size Distribution at Subtidal Sites within the Disposal Site

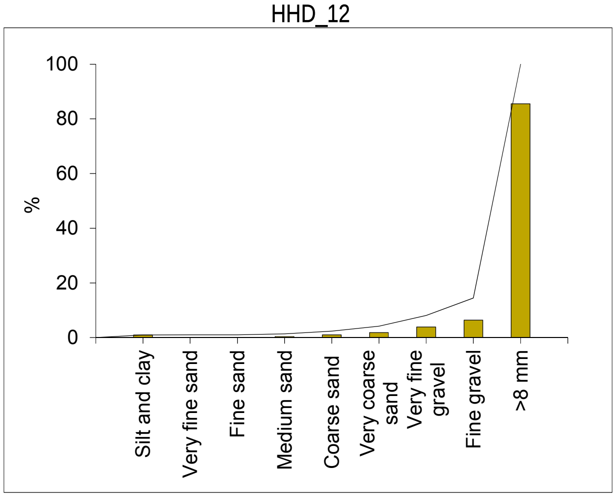
HHD_08



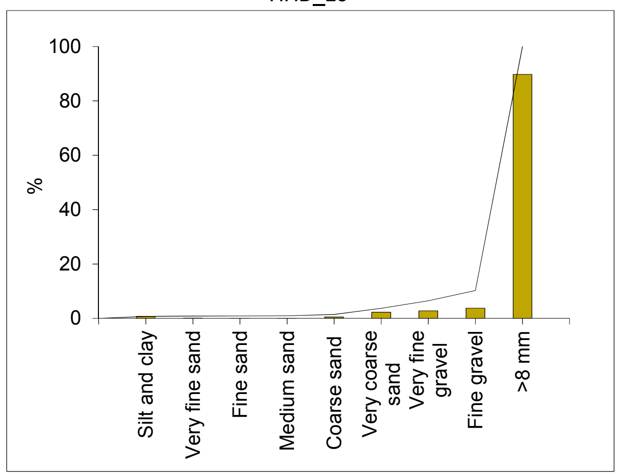
HHD_10



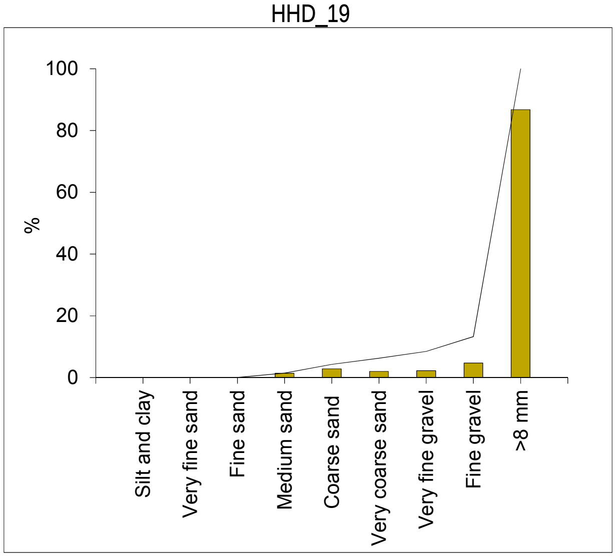
HHD_12



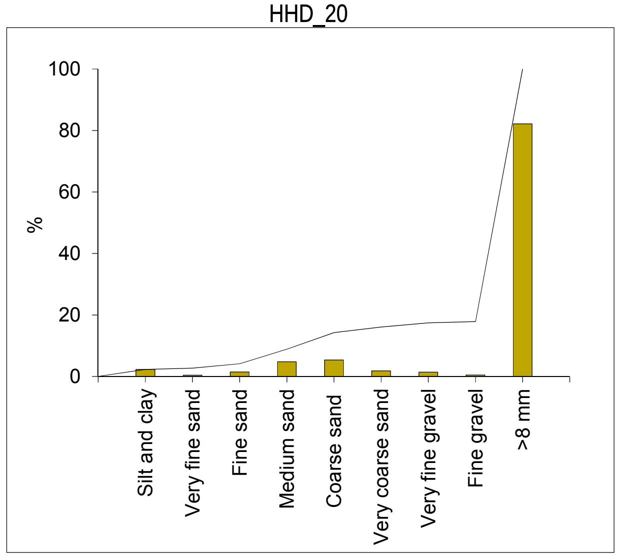
HHD_13



HHD_19



HHD_20



A.8 Laboratory Results Reported for Samples Collected at the Disposal Site

Table A.10: Sediment-bound metal concentrations (mg/kg dry weight) reported in 2016, AL, ISQG and TEL concentrations. Values highlighted in blue indicate metal concentration above ISQG.

Analyte	Copper	Zinc	Cadmium	Mercury	Lead	Arsenic	Chromium	Nickel
AL1	40	130	0.4	0.3	50	20	40	20
AL2	400	800	5	3	500	100	400	200
ISQG	18.7	124	0.7	0.13	30.2	7.24	52.3	-
PEL	108	271	4.2	0.7	112	41.6	160	-
HHD_08	1.69	20.3	<0.04	<0.01	6.64	7.28	5.8	5.8
HHD_10	4.22	30	<0.04	<0.01	9.39	9.57	15.2	12.9
HHD_12	3.14	36.3	<0.04	<0.01	8.16	12.4	9.9	13.9
HHD_13	6.31	55.3	<0.04	0.0135	16.3	7.7	23.6	18.8
HHD_19	2.06	23.3	<0.04	<0.01	7.4	9.4	8.7	7.7
HHD_20	3.89	30	<0.04	0.0155	10.7	8.12	14.3	8.6

Table A.11: Background Reference Concentrations (BRC) and metal:aluminium concentration ratios calculated in 2016. Values in red indicate ratios are greater than twice the upper BRC range. 'n/a' indicates metal concentration reported below the MRV.

Analyte	Copper	Zinc	Cadmium	Mercury	Lead	Arsenic	Chromium	Nickel
BRC range	2.2 - 4.5	8.8 - 18	0.007 - 0.03	0.0034 - 0.0066	1.8 - 4.0	2.0 - 4.5	9.0 - 20	4.4 - 9.1
HHD_08	7.32	87.88	n/a	n/a	28.74	31.52	25.11	25.11
HHD_10	6.08	43.23	n/a	n/a	13.53	13.79	21.90	18.59
HHD_12	5.89	68.11	n/a	n/a	15.31	23.26	18.57	26.08
HHD_13	4.07	35.68	n/a	0.0087	10.52	4.97	15.23	12.13
HHD_19	5.61	63.49	n/a	n/a	20.16	25.61	23.71	20.98
HHD_20	5.93	45.73	n/a	0.0236	16.31	12.38	21.80	13.11

Table A.12: Polycyclic aromatic hydrocarbons (PAHs) concentrations (µg/kg). AL, ISQG and TEL values.

Analytes	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Chrysene	Dibenzo(ah)anthracene	Fluoranthene	Fluorene	Naphthalene	Phenanthrene	Pyrene
AL1	100	100	100	100	100	100	100	100	100	100	100	100
AL2	-	-	-	-	-	-	-	-	-	-	-	-
ISQG	6.71	5.87	46.9	74.8	88.8	108	6.22	113	21.2	34.6	86.7	153
PEL	88.9	128	245	693	763	846	135	1494	144	391	544	1398
HHD_08	<1	<1	<1	<1	<1	<3	<1	<1	<5	**<5**	<5	<1
HHD_10	<1	<1	<1	<1	<1	<3	<1	1.57	<5	<5	<5	1.42

Analytes	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Chrysene	Dibenzo(ah)anthracene	Fluoranthene	Fluorene	Naphthalene	Phenanthrene	Pyrene
AL1	100	100	100	100	100	100	100	100	100	100	100	100
AL2	-	-	-	-	-	-	-	-	-	-	-	-
ISQG	6.71	5.87	46.9	74.8	88.8	108	6.22	113	21.2	34.6	86.7	153
PEL	88.9	128	245	693	763	846	135	1494	144	391	544	1398
HHD_12	<1	<1	<1	3.02	3.93	5.5	1.02	5.93	<5	**<5**	6.74	4.97
HHD_13	1.44	<1	2.75	10.4	12.4	17.2	3.14	20.9	5.16	12.7	23.5	15.8
HHD_19	<1	<1	<1	<1	<1	<3	<1	<1	<5	<5	<5	<1
HHD_20	<1	<1	1.15	4.3	5.36	8.21	1.41	9.23	<5	5.95	10.5	6.77

Table A.13: Polychlorinated biphenyls (PCBs) concentrations (µg/kg) and AL value.

Analyte	PCB 028	PCB 052	PCB 101	PCB 118	PCB 138	PCB 153	PCB 180	∑ PCBs
AL1	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**10**
HHD_08	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7
HHD_10	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7
HHD_12	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7
HHD_13	0.154	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.754
HHD_19	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7
HHD_20	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.7

Appendix B. Wylfa Newydd Development Area - Intertidal Benthic Ecology

B.1 Non-Native Marine Species (Subtidal and Intertidal) of Concern in North Wales (North Wales Wildlife Trust, 2017)

Scientific Name	Common Name	Status	Distribution in Wales
Didemnum vexillum	Carpet sea squirt	GB rapid response alert species	Established in Holyhead Harbour in north Wales.
Undaria pinnatifida	Japanese kelp / Wakame	High alert species	Recorded from Holyhead Harbour and Pembroke Dock (Wood *et al*., 2015).
Rapana venosa	Rapa whelk	High alert species	Not yet recorded in Wales; however, it is likely to arrive and will quickly spread.
Watersipora subtorquata	Red ripple bryozoan	High alert species	Not yet recorded in Wales; however, it is likely to arrive and will quickly spread.
Crepidula fornicata	American slipper limpet	Strategic priority species	Established in parts of South Wales.
Crassostrea gigas	Pacific oyster	Strategic priority species	Widely established in Wales.
Sargassum muticum	Wireweed	Strategic priority species	Established in parts of Wales, particularly along the Llŷn Peninsula and Anglesey.
Eriocheir sinesis	Chinese mitten crab	Strategic priority species	Established in the River Dee.
Grateloupia turuturu	Devil's tongue weed	Strategic priority species	Established in Milford Haven.
Tiostrea lutaria	New Zealand flat oysters	Strategic priority species	Established in the Menai Strait.
Corella eumyota	Orange-tipped sea squirt	Low alert species	Known to be present in north Wales.
Hemigrapsus sanguineus	Asian shore crab	None given	Several sightings in the UK, with one sighting in South Wales.
Codium fragile	Green sea- fingers	None given	Reported in waters off the Scilly Isles, the Channel Islands, areas of South Wales and the South coast of England and also as far as the west coast of Scotland and Argyll.
Caprella mutica	Japanese skeleton shrimp	None given	Limited reports of this species in Wales (includes Holyhead Harbour in 2014). Found in UK waters on the south coast of

Scientific Name	Common Name	Status	Distribution in Wales
			England, the west coast of Scotland and the Western Isles.
Styela clava	Leathery sea squirt	None given	Predominantly the south coast of England. Occurs on the west coast of Wales and Scotland. Recordings in Anglesey and the Llŷn, as well as other parts of north Wales.
Botrylloides violaceus	Orange cloak sea squirt	None given	Found in few areas of the UK, including Milford Haven and the south-west coast of England.
Asparagopsis armata	Harpoon weed	None given	Recorded on the Llŷn Peninsula and in areas of South Wales; however, it is more common in south-west England and has spread as far as the Shetland Isles.

B.2 MNCR SACFOR Abundance Scales

Code	Abundance
S	Superabundant
A	Abundant
C	Common
F	Frequent
O	Occasional
R	Rare

Growth Form	Size of Individuals/Colonies		Size of Individuals/Colonies					
Percentage cover (%)	Crust/ meadow	Massive/ Turf	<1 cm	1-3 cm	3-15 cm	>15 cm	Density	
>80%	S		S				>1/0.001m^2 (1x1cm)	>10,000/m^2
40-79%	A	S	A	S			1-9/0.001m^2	1000-9999/m^2
20-39%	C	A	C	A	S		1-9/0.01m^2 (10 x 10cm)	100-999/m^2
10-19%	F	C	F	C	A	S	1-9/0.1m^2	10-99/m^2
5-9%	O	F	O	F	C	A	1-9/1m^2	
1-5% or density	R	O	R	O	F	C	1-9/10m^2 (3.16 x 3.16m)	
<1% or density		R		R	O	F	1-9/100m^2 (10 x 10m)	
					R	O	1-9/1000m^2 (31.6 x 31.6m)	
						R	<1/1000m^2	

B.3 Upper-Shore Taxa List

Table B.1 : Upper-shore taxa recorded between 2011 and 2014 at the Wylfa Newydd Development Area. Taxa are listed alphabetically within their major taxonomic grouping * Lichens currently do not belong to one single phyla.

PORIFERA	CNIDARIA	ANNELIDA - Polychaeta	ARTHROPODA - Crustacea
Porifera	*Actinia equina*	Spirorbinae	*Carcinus maenas* Cirripedia Gammaridae *Idotea neglecta* Isopoda indet. *Ligia oceanica*
ARTHROPODA - INSECTA	**MOLLUSCA - Gastropoda**	**MOLLUSCA - Bivalvia**	**ALGAE - RHODOPHYTA**
Anurida maritima	*Gibbula cineraria* *Gibbula umbilicalis* *Littorina fabalis* *Littorina littorea* *Littorina obtusata* *Littorina saxatilis* *Littorina saxatilis var. neglecta* *Littorina* spp. # juv *Nucella lapillus* *Patella vulgata* *Phorcus lineatus*	*Mytilus edulis*	*Catenella caespitosa* *Ceramium* sp. *Chondrus crispus* *Corallina officinalis* *Dumontia contorta* *Hildenbrandia* Lithophyllum *Lithothamnion* *Lomentaria articulata* *Osmundea pinnatifida* *Polysiphonia* sp. *Porphyra umbilicalis* *Vertebrata lanosa*
ALGAE – PHAEOPHTYTA	**ALGAE - CHLOROPHYTA**	**LICHENS***	
Ascophyllum nodosum *Ectocarpus* sp. *Elachista* sp. *Fucus spiralis* *Fucus* spp. (sporlings) *Fucus vesiculosus* *Leathesia* *Pelvetia canaliculata*	*Cladophora* sp. *Prasiola* sp. *Spongomorpha* *Ulva intestinalis* *Ulva lactuca*	*Caloplaca marina* *Lecanora* *Lichina pygmaea* *Verrucaria maura* *Verrucaria mucosa*	

B.4 Mid-Shore Taxa List

Table B.2 : Mid-shore taxa recorded from between 2010 and 2014 at the Wylfa Newydd Development Area. Taxa are listed alphabetically within their major taxonomic grouping * Lichens currently do not belong to one single phyla.

PORIFERA	CNIDARIA - Hydrozoa	CNIDARIA - Anthozoa	ANNELIDA - Polychaeta
Halichondria sp. *Porifera*	Hydrozoa	*Actinia equina* *Anemonia viridis* Cnidaria indet. *Urticina felina*	Annelida Spirorbinae Terebellomorpha
ARTHROPODA - Crustacea	**ARTHROPODA - Insecta**	**MOLLUSCA - Polyplacophora**	**MOLLUSCA - Gastropoda**
Carcinus maenas *Carcinus maenas* # juv Cirripedia *Dynamena* sp. *Dynamene bidentata* Gammaridae *Idotea granulosa* *Idotea neglecta* *Idotea* sp. Isopoda indet. *Ligia oceanica* Paguridae Sphaeromatidae	*Anurida maritima*	*Acanthochitona crinita* Polyplacophora	*Gibbula cineraria* *Gibbula spp.* # juv *Gibbula umbilicalis* *Littorina fabalis* *Littorina littorea* *Littorina obtusata* *Littorina saxatilis* *Littorina saxatilis var. neglecta* *Littorina* spp. # juv *Nucella lapillus* *Patella pellucida* *Patella vulgata* *Phorcus lineatus* Rissoidae *Tritia reticulata*
MOLLUSCA - Bivalvia	**BRYOZOA**	**ECHINODERMATA - Ophuiroidea**	**ECHINODERMATA - Asteroidea**
Mytilus edulis	Bryozoa *Electra pilosa*	Ophiuroidea	*Asterina gibbosa*
CHORDATA - Tunicata	**CHORDATA – Osteichthyes**		
Dendrodoa sp.	*Lipophrys pholis*		

TABLE CONTINUES OVERLEAF

Table B.2 : Continued

ALGAE - Rhodophyta	**ALGAE - Phaeophyta**	**ALGAE - Chlorophyta**	**LICHENS***
Acrochaetium	*Ascophyllum nodosum*	*Chaetomorpha*	*Verrucaria maura*
Asparagopsis armata	*Cladostephus* sp.	*Cladophora* sp.	*Verrucaria mucosa*
Audouinella sp.	*Dictyota* sp.	*Prasiola* sp.	
Callophyllis laciniata	*Ectocarpus* sp.	*Spongomorpha*	
Catenella caespitosa	*Elachista* sp.	*Spongonema*	
Ceramium sp.	*Fucus serratus*	*Ulva intestinalis*	
Chondrus crispus	*Fucus spiralis*	*Ulva lactuca*	
Chylocladia verticillata	*Fucus* spp.	*Ulva spp.*	
Corallina officinalis	*Fucus* spp. (sporlings)		
Cryptopleura ramosa	*Fucus vesiculosus*		
Dumontia contorta	*Halopteris scoparia*		
Gelidium sp.	*Leathesia* sp.		
Grateloupia filicina	*Pelvetia canaliculata*		
Hildenbrandia	*Petalonia fascia*		
Jania rubens	*Ralfsia verrucosa*		
Laurencia obtusa			
Laurencia pinnatifida			
Lithophyllum sp.			
Lithothamnion			
Lomentaria articulata			
Lomentaria clavellosa			
Mastocarpus stellatus			
Membranoptera			
Membranoptera alata			
Osmundea pinnatifida			
Palmaria palmata			
Phyllophora			
Plocamium cartilagineum			
Plumaria plumosa			
Polysiphonia sp.			
Porphyra umbilicalis			
Pterocladiella capillacea			
Rhodophyta indet.			
Vertebrata lanosa			

B.5 Low-Shore Taxa List

Table B.3 : Low-shores taxa recorded from between 2011 and 2014 at the Wylfa Newydd Development Area. Taxa are listed alphabetically within their major taxonomic grouping * Lichen s currently do not belong to one single phyla.

PORIFERA	CNIDARIA - Hydrozoa	CNIDARIA - Anthozoa	PLATYHELMINTHES
Halichondria panicea *Halichondria* sp. Porifera	Hydrozoa	*Actinia equina* *Actinia fragacea* Actiniaria *Anemonia sulcata* *Anemonia viridis* Cnidaria indet. *Urticina felina*	Turbellaria
ANNELIDA - Polychaeta	**ARTHROPODA - Crustacea**	**ARTHROPODA - Insecta**	**MOLLUSCA - Polyplacophora**
Lanice conchilega Phyllodocidae Sabellidae Serpulidae *Spirobranchus* sp. Spirorbinae	*Cancer pagurus* juv. *Carcinus maenas* *Carcinus maenas* # juv Cirripedia Crangonidae *Dynamena* sp. *Eulalia* sp. Gammaridae *Idotea neglecta* Isopoda indet. *Necora puber* Paguridae *Sphaeroma sp.* Sphaeromatidae	*Anurida maritima*	Polyplacophora
MOLLUSCA - Gastropoda	**MOLLUSCA - Bivalvia**	**MOLLUSCA - Nudibranchia**	**BRYOZOA**
Calliostoma zizyphinum Gastropoda indet. *Gibbula cineraria* *Gibbula* sp. # juv *Gibbula umbilicalis* *Littorina fabalis* *Littorina littorea* *Littorina obtusata* *Littorina saxatilis* *Littorina* sp. # juv *Nucella lapillus* *Patella pellucida* *Patella vulgata* Rissoidae *Tricolia pullus*	*Mytilus edulis*	Nudibranchia *Pleurobranchus* sp.	Bryozoa *Electra pilosa* *Membranipora* sp.

TABLE CONTINUES OVERLEAF

Table B.3 : Continued

ECHINODERMATA - Ophuiroidea	**ECHINODERMATA - Asteroidea**	**CHORDATA - Tunicata**	**ALGAE - Rhodophyta**
Amphiuridae	*Anseropoda placenta*	Ascidia sp.	*Acrosorium ciliolatum*
	Asterias rubens	*Botryllus schlosseri*	*Asparagopsis armata*
	Asterina gibbosa	*Dendrodoa* sp.	*Audouinella* sp.
			Brongniartella byssoides
			Callophyllis sp.
			Ceramium sp.
			Chondrus crispus
			Chylocladia verticillata
			Corallina officinalis
			Cryptopleura ramosa
			Cystoclonium purpureum
			Delesseria sanguinea
			Dilsea carnosa
			Dumontia contorta
			Dumontia sp.
			Furcellaria sp.
			Gastroclonium ovatum
			Gelidium sp.
			Gracilaria gracilis
			Halidrys siliquosa
			Heterosiphonia plumosa
			Hildenbrandia sp.
			Hypoglossum hypoglossoides
			Laurencia obtusa
			Laurencia sp.
			Lithophyllum
			Lithothamnion
			Lomentaria articulata
			Lomentaria clavellosa
			Mastocarpus stellatus
			Membranoptera alata
			Nemalion elminthoides
			Osmundea pinnatifida
			Palmaria palmata
			Phycodrys rubens
			Phyllophora pseudoceranoides
			Plocamium cartilagineum
			Plumaria plumosa
			Polysiphonia sp.
			Porphyra umbilicalis

ECHINODERMATA - Ophuiroidea	ECHINODERMATA - Asteroidea	CHORDATA - Tunicata	ALGAE - Rhodophyta
			Pterocladiella sp. *Rhodomela sp.* Rhodophyta *indet.*

TABLE CONTINUES OVERLEAF

Table B.3 : Continued

ALGAE - Phaeophyta	ALGAE - Chlorophyta	LICHENS*
Alaria esculenta *Ascophyllum nodosum* *Dictyota sp.* *Ectocarpus* sp. *Elachista* sp. *Fucus serratus* *Fucus spiralis* *Fucus* spp. *Fucus* spp. *(*sporlings*)* *Fucus vesiculosus* *Laminaria digitata* *Laminaria hyperborea* *Laminaria* spp. *Laminaria spp.* (sporlings*)* *Leathesia* sp. *Ralfsia sp.* *Vertebrata lanosa*	Chlorophyta indet. *Cladophora* sp. *Prasiola* sp. *Spongomorpha* *Spongonema sp.* *Ulva intestinalis* *Ulva lactuca* *Ulva* spp.	*Verrucaria maura* *Verrucaria mucosa*

Appendix C. Wylfa Newydd Development Area – Subtidal Benthic Ecology

C.1 DDC Data Analysis

C.1.1 SACFOR

Taxa were semi-quantified using the SACFOR scale of abundance: Super-abundant (S), Abundant (A), Common (C), Frequent (F), Occasional (O), Rare (R) and Present (P) (JNCC, 2010, see Appendix B, Section B.2 for table). The abundance ratings were determined for each DDC site as opposed to each individual image (station). To determine the SACFOR score for each species or taxonomic group, the total number of useable images for each site was taken into account and the area of seabed they represented, e.g. where three images were present. These covered an area of 0.81 m^2 and this was scaled up to give densities or percentage cover per m^2.

C.1.2 Biotope Codes

Biotope codes were assigned to each habitat to the lowest possible level of the Marine Habitat Classification Hierarchy (Connor *et al*., 2004). The list of taxa, along with habitat descriptions, biotope codes and seabed images, is available upon request. The biotope codes were entered into GIS to provide a visual representation of the seabed habitats found in 2010 and 201. The metadata within each image taken were synchronised with the GPS track data from the three survey days and a Keyhole Markup Language (KML) file created using the 'GPicSync' software freely available on the internet (http://gpicsync.software.informer.com/1.3/). This makes the images useable with any 'geocode aware' computer application, allowing the images to be viewed *in situ* on a map.

C.1.3 Community Analysis

The SACFOR data were transformed to numerical values between six and one for the scores S to R, respectively (P for 'Present' was given a score of 0.3).

Temporal and spatial differences in the community compositions recorded at the stations were shown visually using the PRIMER™ software. A cluster analysis was used to detect groupings of samples, such that samples within a group are more similar to each other than samples between groups. The result of a hierarchical clustering is represented by a dendrogram. A Similarity Profile (SIMPROF) test was carried out to detect those sites/groups of sites that are not statistically different from each other. SIMPROF tests the statistical validity of the internal structure of each group at every node of the dendrogram. The MDS ordination provides a 2-dimensional or 3-dimensional representation of distances between samples, i.e. how samples are different in their community compositions.

Factors were assigned to each site based on depth range (1–5 m, 6–10 m, 11–15 m, 16–20 m, 21–25 m, 26–30 m, 31–40 m, 41–50 m) and general exposure (Sh = sheltered; Exp = exposed; CB = Church Bay). The term 'sheltered' was used to describe sites located in the shallow bays along the north coast whilst 'exposed' described those located further offshore and subject to strong tidal currents. The sites in Church Bay are also exposed to strong currents, but, being on a west-facing coast, the prevailing conditions were considered different enough to warrant assigning a separate factor.

To allow discrimination of the statistical data, the sites surveyed in 2011 had an 'a' added to their number (e.g. 35a). None of the stations in 2011 were below 6 m.

In 2010, stations 11, 42, 44, 55, A8 and A9 were not included in the cluster and MDS diagrams. These sites were either devoid of flora and fauna or were so sparse in bionts that they resulted in outliers from the main group. This distorted the MDS plots making the majority of the data unreadable. In 2011, the stations 45a, 48-1a and 75a were removed from the resemblance matrix for the same reasons as given above.

During analysis of the 2011 photographic data, it was found that site 48 had two distinct biotopes, ascribed as SS.SCS.CCS.PomB in the first two images and CR.MCR.CMus.CMyt in the second two images. Due to the clear differences in the biotopes, this station was sub-divided into 48-1a and 48-2a.

For the purposes of the analyses, the taxa entries *Tubularia* sp. and *Tubularia indivisa* were grouped to a single entry (*Tubularia* sp.). It was considered that this approach would give a more accurate representation of similarities in the assemblage composition. The difficulties of differentiating between *Tubularia indivisa* and *T. larynx* from photographic images can often result in the precautionary option of categorising under the *Tubularia* sp. entry, even though it is likely in this instance that the species recorded was *Tubularia indivisa*.

See Appendix C, Section C.3, for full statistical glossary.

C.2 Grab Data Analysis

C.2.1 Ecological Quality

The communities at each WS site were examined using the Infaunal Quality Index (IQI), developed for the classification of transitional and coastal water bodies for the WFD (WFD-UKTAG, 2008). The IQI is a multi-metric tool composed of the AZTI Marine Biotic Index, Simpson's Evenness and number of taxa from which ecological status can be assigned to a benthic community with status ranging from bad to high.

Subtidal abundance/biomass patterns were examined using the DOMPLOT routine of the PRIMER® multivariate environmental statistical package. From this, the W statistic is derived which describes the relationship between the cumulative abundance and biomass of a community. Values of the W statistic vary between 1 and -1, with values between 0 and 1 representing an undisturbed community, 0 and -0.5 moderately disturbed and -0.5 and -1 highly disturbed.

C.2.2 Population Features

The three replicate grabs from each WS site were pooled to provide total abundances, number of taxa and biomass (g). The abundance and biomass totals were standardised to allow the data from 2011 and 2015 that was obtained from 0.1 m^2 Hamon grabs comparable to the data obtained by the larger grab (0.25 m^2) in 2011.

Colonial taxa such as bryozoans, entoprocta and porifera were recorded only as present and were not included in subsequent analyses.

Diversity indices (Shannon Weiner (H') and Pielou's evenness (J) was also calculated for each site in all years on all pooled raw data as computed from the DIVERSE routine in PRIMER®. The Shannon-Wiener index (H') is widely used to analyse marine community data in relation to community diversity and the effect of stress. The index integrates the number of species and individual abundance to provide a summary value with resulting values falling with increasing stress. J is derived from the Shannon-Wiener Index, with values ranging between zero and one. Low values for *J* indicate high dominance and are indicative of stressful conditions, while higher values indicate a more even distribution of individuals between species and are representative of stress-free conditions

C.2.3 Community Patterns and Biotopes

To provide an overview of the broad community types present at the grab sampling sites, the results from the particle sediment analysis (see Section 3.3.2.1) were used in tandem with the faunal analyses. The presence of key characterising species allowed ascription of biotopes at varying resolution.

In order to detect patterns in the subtidal communities, cluster analysis was undertaken. To reduce the influence of highly dominant species, the data underwent fourth root transformation. The resulting similarity matrix is displayed as a dendrogram, which illustrates the progressive linking of sites. The level of similarity is indicated on the vertical axis, showing the greater similarity between groups linked towards the bottom of the diagram.

To further test for temporal and spatial differences between those communities sampled between 2010 and 2015, ANOSIM was used to test for significant statistical differences, and SIMPER ran to rank those taxa that were important in contributing to overall dissimilarities and similarities between the communities.

C.2.4 Biodiversity

In environmental assessments, it is useful to examine the biodiversity of a community. It is well understood that generally, as the stress experienced by a benthic community increases, the number of taxa reduces, and that the taxonomic spread of these taxa also reduces, which can result in heavily impacted communities consisting of a few closely related species, often of the same genus. How close any one taxon is to another can be indicated by taxonomic diversity and distinctness measures, which do not rely on the number of taxa present but rather on taxonomic differences through a classification tree between every pair of taxa which, for standard Linnaean classification, are discrete quantifiable distances. From this, the Average Taxonomic Distinctness

(AvTD) of a community can be calculated; AvTD is defined as the average taxonomic distance apart of all its pairs of species.

Within a community, particular genera may be represented by several species, while others may be represented by only one taxon. This is the variation of the taxonomic distances between each pair of taxa and can be measured by the Variation in Taxonomic Distinctness (VarTD). Unlike standard diversity indices, both AvTD and VarTD are independent of survey design, thus allowing direct comparison of historical data irrespective of sampling effort. A further advantage of these measures is that they can be used to determine how a community varies from the norm. This is achieved by comparing a community species list against a master inventory of taxa from the appropriate biogeographical area. The results of this analysis are given in the form of a funnel plot, which indicates the 95% confidence limits within the AvTD of a community of taxa; if observed values of AvTD fall out of this range, they are considered to have varied significantly from the norm. Similar comparisons can be made for VarTD. Generally, stressed communities are indicated by decreased AvTD and increased VarTD.

Prior treatment of the community data for the 2015 validation had included removal of ‘singletons’ (those taxa that had occurred only once in the entire survey programme) and the combination of taxa in the polychaete family Syllidae. Owing to recent changes in nomenclature for the Syllidae, species belonging to the genus *Syllis* were combined for all years to avoid an increase in the number of closely related taxa for this group in 2015, which would have been an artefact of changes in the literature and not necessarily due to a reduction in phylogenetic diversity.

See Appendix C, Section C.3, for full statistical glossary

C.3 Statistical Glossary

The following descriptions of the various tests used within this report are summarised below with full descriptions provided in the PRIMER® manual (Clarke & Gorley, 2006). The full manual should be consulted for detailed descriptions of each test undertaken. Plymouth Routines In Multivariate Ecological Research (PRIMER®) (www.primer-e.com) is a programme designed to analyse datasets where samples contain several variables.

ANOSIM

Analysis of Similarity (ANOSIM) tests are a form of hypothesis testing for differences between pre-defined groups, e.g. sites/times of sampling. ANOSIM tests can be applied to multivariate datasets and are not restricted to balanced designs, i.e. equal numbers of replicate samples within sites or treatments or both.

ANOSIM tests provide two results: R-values and *p*-values. Of these two values, R is often the most useful to use for interpreting the data as it is not affected by the number of replicates but by actual differences between the two or more groups of data. On the other hand, *p* is always influenced by the sample size and might mask confidence in the results obtained from smaller datasets.

R-values lie between -1 and 1. R = 1 only when all replicates within groups are more similar to one another than any replicates from different groups. R = 0 when similarities between all replicates regardless of groupings are the same on average. R-values well below zero suggest greater similarities between replicates from different groups than within groups and may indicate errors in labelling of samples.

Bray-Curtis Similarity

Before many of the analyses can be undertaken in PRIMER, a similarity matrix must be constructed. This creates a matrix containing a value for every pairwise (between species) comparison possible between the samples. The higher the value, the more similar the comparison is. This matrix is used for comparison of samples in subsequent statistical tests. PRIMER uses the Bray-Curtis coefficient (S), which is particularly common in ecological analyses.

Cluster Analysis

Cluster analysis is designed to find natural groups or ‘clusters’ of samples within the main dataset, again based on a Bray-Curtis similarity matrix. Each cluster is successively linked to the next most similar sample or cluster until a tree diagram (dendrogram) is completed with all samples finally forming a single cluster (the whole tree).

Cluster analysis is particularly useful for determining groups of sites with distinct ecological communities. This does not imply that the species themselves are necessarily different, since patterns of abundance may also play a role in determining similarities. Dendrograms can be used to complement MDS plots or, when stress values are too high in MDS plots, they might prove a useful substitute to show clusters of samples.

DOMPLOT

The Dominance Plot (DOMPLOT) routine ranks species for both the abundance and the biomass dataset, and plotted on the same graph with their relative abundance/biomass plotted against the increasing rank (Abundance Biomass Comparison (ABC) plots). For each ABC plot, a W statistic is computed which describes the relationship between the cumulative abundance and the biomass of a community. W statistic values measure the extent to which the biomass curve lies above the abundance curve, and values will vary between 1 and -1. Values between 0 and 1 represent an undisturbed community, 0 and -0.5 a moderately disturbed community and -0.5 and -1 a highly disturbed community

DIVERSE

DIVERSE is a routine in PRIMER calculates a range of diversity indices, including species richness (S), Shannon-Weiner (H') and Pielou's evenness (J)

Transformation of Data

Data transformation is used to remove the weighting of common or rare species within a sample when undertaking statistical analysis. The type of transformation used depends on the biological (not statistical) questions being asked of a dataset and whether a broad or specific approach is required. The more severe the transformation, the broader the answer, as all species become more equal, thus giving a greater weighting to species with low abundances.

Multi-dimensional Scaling

Multi-dimensional Scaling (MDS) plots provide a visual representation of the relationships between samples and can be useful for data interpretation. The Bray-Curtis similarity matrix described above can be used to create an MDS plot of the sample similarities. Samples with greater similarities are placed closer to one another, with more dissimilar samples placed further away.

The usefulness of the plots is indicated by a stress value. If stress values in a 2-D plot are too high, a 3-D plot can be generated, which might provide a better representation as there is more dimensional space in which to plot the samples and their relative distances to each other. Stress values should be considered as follows:

- <0.05 – excellent representation of the relationships between the data;
- <0.1 – good plot with little prospect of a misleading interpretation;
- <0.2 – potentially useful, although for values toward the upper end of this range too much emphasis should not be placed on the detail of the plot;
- 0.2 to 0.3 – treat these points with scepticism and consider plots at higher dimensions; and
- >0.3 – the points are close to random. Consider plots at higher dimensions.

SIMPER

When differences have been detected between groups of samples, Similarity Percentage (SIMPER) tests can be used to determine the individual species that contribute to the differences between groups of samples and the similarities between samples within a group. The SIMPER test identifies species that typify a group and/or potentially an environmental condition or effect.

SIMPROF

The Similarity Profile (SIMPROF) test searches for statistically significant evidence of genuine clusters in samples where no pre-defined sample structure exists. Tests are conducted at every link in the dendrogram to determine if each group has a significant structure. Significant clusters are displayed as a different colour on the dendrogram. SIMPROF clusters can then be overlaid onto the MDS plot to signify which groups of samples are statistically different to each other.

TAXDTEST

Calculate biodiversity indices based on the taxonomic (or phylogenetic/functional etc) relatedness between the species making up a species list or quantitative sample, indices which are robust to variations in sampling effort. These routines (TAXDTEST) permit hypothesis tests for biodiversity change and comparison over wide space and time scales.

C.4 DDC Survey Taxa

Table C.1 : Taxa recording during the 2010 and 2011 DDC survey of the Wylfa Newydd Development Area and surrounding areas of north Anglesey coast. Taxa are grouped by their broad taxonomic groups.

Phyla / Class	Common Group Name	Scientific Name	2010	2011
PORIFERA	Sponge	Porifera - encrusting/massive		
	Sponge	Porifera - branching		
	Sponge	*Clathrina coriacea*		
	Sponge	*Sycon ciliatum*		
	Sponge	*Raspailia (Clathriodendron) hispida*		
	Sponge	*Dysidea fragilis*		
	Sponge	*Tethya* sp.		
	Sponge	*Polymastia boletiformis*		
	Sponge	*Polymastia penicillus*		
	Sponge	*Cliona celata*		
	Sponge	*Axinella dissimilis*		
	Sponge	*Amphilectus fucorum*		
	Sponge	*Grantia compressa*		
	Sponge	*Guancha* sp.		
	Sponge	*Hemimycale columella*		
	Sponge	*Stelligera* sp.		
HYDROZOA	Hydroid	Hydrozoa		
	Hydroid	*Tubularia* sp.		
	Hydroid	*Tubularia indivisa*		
	Hydroid	Sertulariidae		
	Hydroid	*Abietinaria abietina*		
	Hydroid	*Diphasia* sp.		
	Hydroid	*Hydrallmania falcata*		
	Hydroid	*Sertularella gayi*		
	Hydroid	*Sertularia argentea*		
	Hydroid	*Nemertesia* spp.		
	Hydroid	*Nemertesia antennina*		
	Hydroid	*Nemertesia ramosa*		
	Hydroid	*Aglaophenia* sp.		
	Hydroid	Campanulariidae		
	Hydroid	*Obelia* sp.		
	Hydroid	*Sarcodictyon roseum*		
CNIDARIA – Anthozoa	Soft Coral	*Alcyonium digitatum*		
	Anemone	Actiniaria		
	Anemone	*Epizoanthus couchii*		

Phyla / Class	Common Group Name	Scientific Name	2010	2011
	Anemone	*Cerianthus lloydii*		
	Anemone	*Urticina* spp.		
	Anemone	Sagartiidae		
	Anemone	*Sagartia* sp.		
	Anemone	*Sagartia elegans*		
	Anemone	*Cereus pedunculatus*		
	Anemone	*Actinothoe sphyrodeta*		
	Anemone	*Adamsia palliata*		
PLATYHELMINTHES	Flat worm	*Prostheceraeus vittatus*		
ANNELIDA – Polychaeta	Polychaete worm indet.	Polychaeta indet.		
	Reef building tube worm	*Sabellaria* spp.		
	Reef building tube worm	*Sabellaria spinulosa*		
	Tube worm	*Lanice conchilega*		
	Tube fan worm	Sabellidae		
	Tube fan worm	*Sabella* sp.		
	Tube fan worm	*Sabella pavonina*		
	Tube fan worm	*Bispira volutacornis*		
	Calcareous tube worm	Serpulidae		
	Calcareous tube worm	*Spirobranchus* sp.		
	Calcareous tube worm	*Salmacina dysteri*		
CRUSTACEA (Lower)	Barnacle	*Balanus* sp.		
CRUSTACEA (Higher)	Amphipod	*Jassa* sp.		
	Shrimp	Caridea indet.		
	Shrimp	*Crangon crangon*		
	Hermit crab	Paguridae		
	Hermit crab	*Pagurus bernhardus*		
	Hermit Crab	*Pagurus prideaux*		
	Porcelain crab	*Pisidia longicornis*		
	Spider crab	Majidae		
	Spider crab	*Inachus* sp.		
	Spider crab	*Macropodia* sp.		
	Masked crab	*Corystes cassivelaunus*		
	Brown crab	*Cancer pagurus*		
MOLLUSCA – Polyplacophora	Chiton	Polyplacophora		
MOLLUSCA – Gastropoda	Topshell	*Gibbula cineraria*		

Phyla / Class	Common Group Name	Scientific Name	2010	2011
	Topshell	*Calliostoma zizyphinum*		
	Moon snail	*Euspira catena*		
	Whelk	*Nassarius reticulatus*		
	Whelk	Buccinidae		
MOLLUSCA – Opisthobranchia	Nudibranch	*Tritonia lineata*		
	Nudibranch	*Trapania pallida*		
	Nudibranch	*Polycera* sp.		
	Nudibranch	*Doris pseudoargus*		
	Nudibranch	*Flabellina* sp.		
	Nudibranch	*Flabellina pedata*		
MOLLUSCA – Bivalvia	Bivalve	Bivalvia		
	Mussel	*Mytilus* sp.		
	Mussel	*Musculus discors*		
	Scallop	*Aequipecten opercularis*		
MOLLUSCA – Cephalopoda	Octopus	*Eledone cirrhosa*		
BRYOZOA	Bryozoan	Bryozoa - encrusting		
	Byozoan	Bryozoa - bushy		
	Bryozoan	*Vesicularia spinosa*		
	Bryozoan	*Crisia* sp.		
	Bryozoan	*Membranipora membranacea*		
	Bryozoan	*Flustra foliacea*		
	Bryozoan	*Chartella* sp.		
	Bryozoan	*Bugula* spp.		
	Bryozoan	*Cellaria* sp.		
	Bryozoan	*Alcyonidium diaphanum*		
ECHINODERMATA – Crinoidea	Feather star	*Antedon bifida*		
ECHINODERMATA – Asteroidea	Sea star	*Crossaster papposus*		
	Sea star	*Henricia* sp.		
	Sea star	*Asterias rubens*		
	Sea star	*Leptasterias (Leptasterias) muelleri*		
	Sea Star	*Marthasterias glacialis*		
ECHINODERMATA – Ophiuroidea	Brittle star	*Ophiothrix fragilis*		
	Brittle star	*Amphiura filiformis*		
	Brittle star	*Ophiura* sp.		
	Brittle star	*Ophiura albida*		
	Sea squirt	Tunicata		
CHORDATA – Tunicata	Sea squirt	Tunicata - encrusting		
	Sea squirt	*Clavelina lepadiformis*		
	Sea squirt	*Pycnoclavella* sp.		

Phyla / Class	Common Group Name	Scientific Name	2010	2011
	Sea squirt	*Synoicum incrustatum*		
	Sea squirt	*Aplidium punctum*		
	Sea squirt	*Ciona intestinalis*		
	Sea squirt	*Ascidiella* spp.		
	Sea squirt	*Ascidia mentula*		
	Sea squirt	*Dendrodoa* sp.		
	Sea squirt	*Botryllus schlosseri*		
	Sea squirt	*Polyclinum* sp.		
	Sea squirt	*Molgula* sp.		
CHORDATA – Pisces	Poacher	*Agonus cataphractus*		
	Wrasse	*Labrus mixtus*		
	Goby	*Pomatoschistus* sp.		
RHODOPHYCOTA	Red algae	Rhodophyta		
	Red algae	*Calliblepharis* sp.		
	Red algae	*Delesseria sanguinea*		
	Red algae	*Furcellaria lumbricalis*		
	Red algae	*Meredithia microphylla*		
	Red algae	*Phyllophora crispa*		
	Red algae	*Schottera nicaeensis*		
PHAEOPHTA	Brown algae	Phaeophyceae		
	Brown algae	*Colpomenia peregrina*		
	Brown algae	*Dictyota dichotoma*		
	Brown algae	*Laminaria hyperborea*		
CHLOROPHYCOTA	Green algae	Chlorophyta		
	Green algae	*Ulva* sp.		
	Green algae	*Ulva lactuca*		

C.5 DDC – MDS Ordinations By Exposure

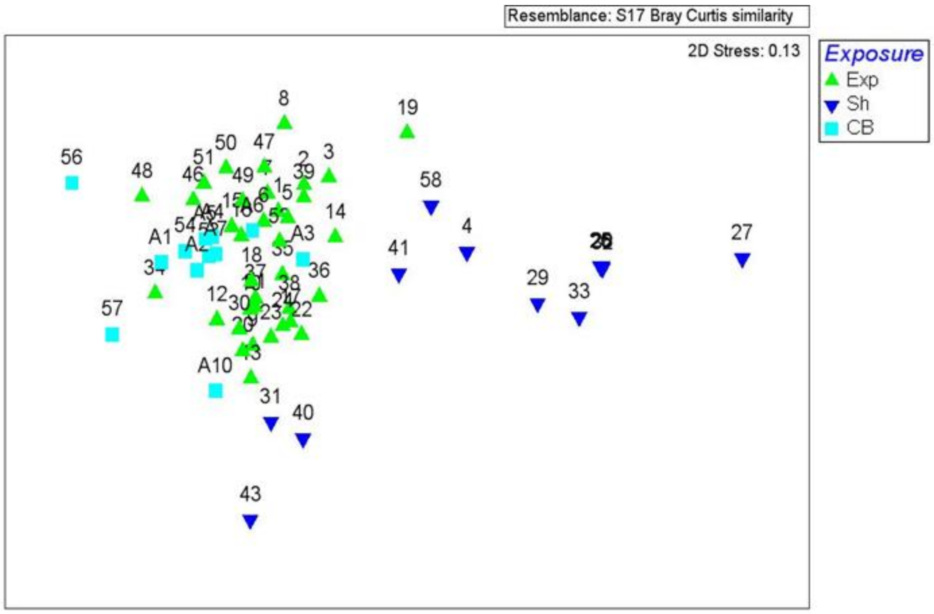


Figure 8-1 : MDS plot displaying the similarities of associated communities at sampling sites along the north Anglesey coast based on DDC data, 2010. Sites are classed as either ‘exposed’ (Exp), ‘sheltered’ (Sh) or ‘exposed in Church Bay’ (CB).

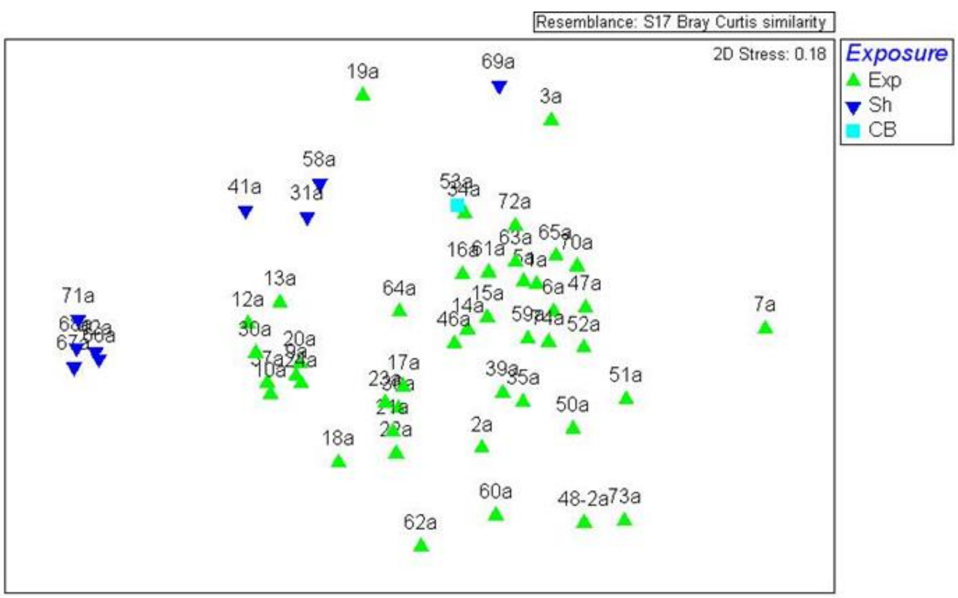


Figure 8-2 : MDS plot displaying the similarities of associated communities at sampling sites along the north Anglesey coast based on DDC data, 2011. Sites are classed as either ‘exposed’ (Exp), ‘sheltered’ (Sh) or ‘exposed in Church Bay’ (CB).

C.6 DDC – MDS Ordinations By Depth

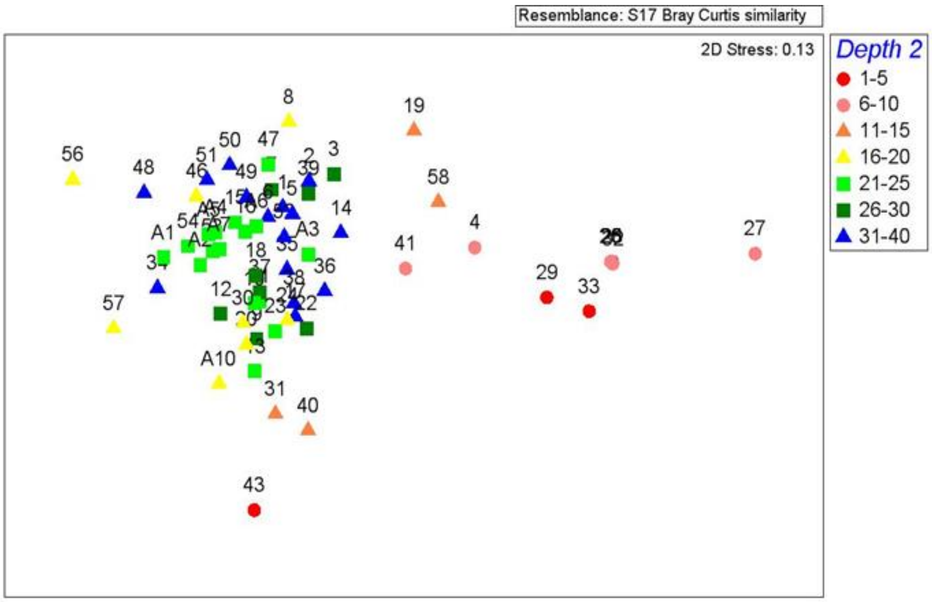


Figure 8-3 : MDS plot displaying the similarities of associated communities at sampling sites along the north Anglesey coast based on DDC data, 2010. Sites are classified by depth from the surface (m).

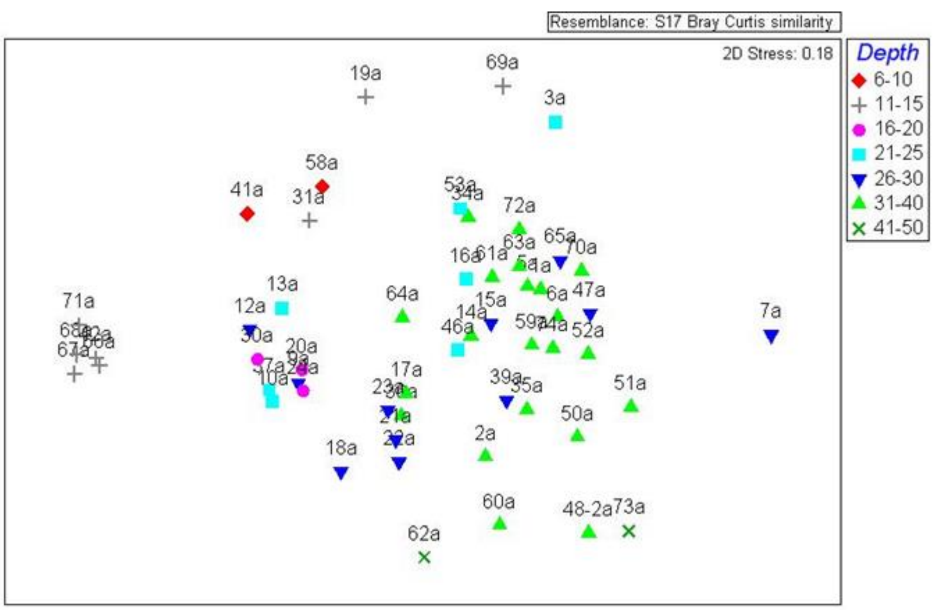


Figure 8-4 : MDS plot displaying the similarities of associated communities at sampling sites along the north Anglesey coast based on DDC data, 2011. Sites are classed by depth (metres) from the surface.

C.7 DDC – MDS Pooled 2010 and 2011 Data

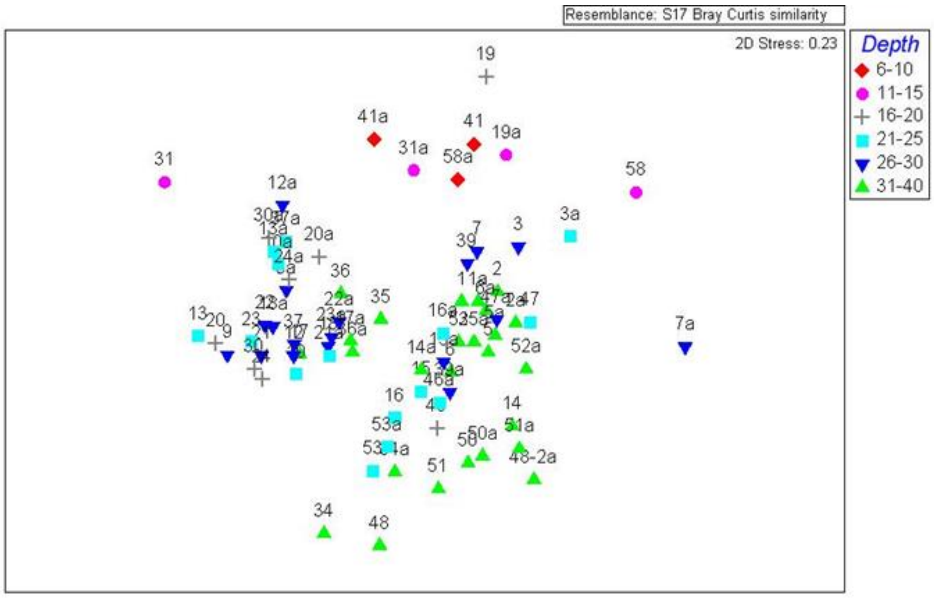


Figure 8-5 : MDS plot displaying the similarities of associated communities at repeated sampling sites along the north Anglesey coast based on DDC data, 2010 and 2011. Sites are classed by depth (metres) from the surface.

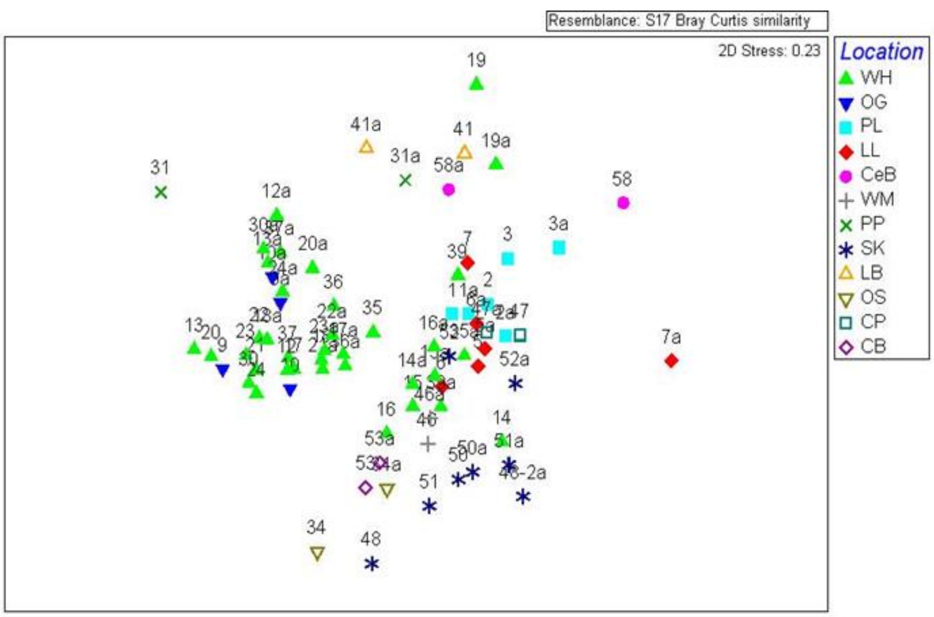


Figure 8-6 : MDS plot displaying the similarities of associated communities at repeated sampling sites along the north Anglesey coast based on DDC data, 2010 and 2011. Sites are classed by location (WH – Wylfa Head, OG – Ogof Gynfor, PL – Port Lynas, LL – Llanlleiana Head, CeB – Cemaes Bay, WM – West Mouse, PP – Porth-y-pistyll, SK – Skerries, LB – Llanbadrig Head, OS – Offshore, CP – Carmel Passage, CB – Church Bay).

C.8 Faunal Grabs – Dominant Taxa

Table C.2 : The dominant taxa and their abundance (numbers per 0.75m^2) at subtidal sites in 201 and 2011 (key for the different major taxonomic groups is listed at the bottom of the table.

2010		2011		2010		2011		2010		2011	
WS01				WS02				WS03			
Nucula sulcata	1374	*Nucula sulcata*	1053	*Ophiothrix fragilis*	216	*Nucula sulcata*	350	*Abra alba*	76	*Abra alba*	2105
Ophiothrix fragilis	332	*Abra alba*	360	*Aphelochaeta marioni*	174	*Ophiothrix fragilis*	318	*Nucula nitidosa*	26	*Nucula nitidosa*	720
Abra alba	306	*Euclymene oerstedi*	180	*Abra alba*	111	*Abra alba*	295	*Mediomastus fragilis*	16	*Nephtys* sp.	30
Ophiura albida	138	*Ophiura albida*	55	*Nucula sulcata*	78	*Mediomastus fragilis*	55	*Scoloplos armiger*	14	*Spiophanes bombyx*	30
Euclymene oerstedi	128	*Mediomastus fragilis*	38	*Mediomastus fragilis*	63	*Euclymene oerstedi*	25	*Ophiura albida*	11	*Ophiura albida*	25
2010		2011		2010		2011		2010		2011	
WS04				WS05				WS06			
Sphaerosyllis bulbosa	299	*Sphaerosyllis bulbosa*	180	*Sabellaria spinulosa*	123	*Sabellaria spinulosa*	265	*Magelona johnstoni*	22	*Abra alba*	108
Socarnes erythrophthalmus	268	*Mediomastus fragilis*	50	*Edwardsia claparedii*	63	*Golfingia elongata*	53	*Nephtys hombergii*	19	*Spiophanes bombyx*	53
Leptocheirus pectinatus	176	*Golfingia elongata*	40	*Mediomastus fragilis*	57	*Mediomastus fragilis*	40	*Travisia forbesii*	19	*Spio armata*	43
Gattyana cirrhosa	86	*Glycera lapidum*	38	*Gattyana cirrhosa*	29	*Syllis cornuta*	35	*Nephtys* sp.	10	*Magelona johnstoni*	38
Sabellaria spinulosa	78	*Syllis cornuta*	38	*Aonides paucibranchiata*	28	*Glycera lapidum*	23	Mactridae sp.	7	*Magelona wilsoni*	23
2010		2011		2010		2011		2010		2011	
WS07				WS08				WS09			
Sabellaria spinulosa	658	*Syllis cornuta*	38	*Spisula solida*	64	*Mediomastus fragilis*	18	*Sabellaria spinulosa*	347	*Jasmineira elegans*	873
Sipuncula sp.	98	*Aonides paucibranchiata*	35	*Sabellaria spinulosa*	47	*Syllis cornuta*	15	Sipuncula sp.	95	*Sabellaria spinulosa*	775

2010		2011		2010		2011		2010		2011	
WS01				WS02				WS03			
Golfingia vulgaris vulgaris	94	*Glycera lapidum*	30	*Socarnes erythrophthalmus*	40	*Aonides paucibranchiata*	15	Maldanidae sp.	63	*Nucula sulcata*	270
Syllis cornuta	74	Polycirrinae indet	30	*Syllis cornuta*	17	*Glycera lapidum*	15	*Musculus costulatus*	40	Sipuncula sp.	158
Syllis armillaris	74	*Spisula* sp.	28	Sipuncula sp.	15	Nemertea	13	Ascidiacea	36	*Chone* sp.	155
2010		2011		2010		2011		2010		2011	
WS10				WS11				WS13			
Sabellaria spinulosa	65	*Sabellaria spinulosa*	238	*Sabellaria spinulosa*	340	*Jasmineira elegans*	340	*Sabellaria spinulosa*	221	*Sabellaria spinulosa*	175
Hiatella arctica	19	*Musculus discors*	218	*Mytilus edulis juv*	339	*Sabellaria spinulosa*	293	Ascidiacea	30	*Sabellaria alveolata*	78
Gattyana cirrhosa	18	*Dendrodoa grossularia*	115	*Jasmineira elegans*	182	Sipuncula sp.	45	*Sabellaria alveolata*	25	*Jasmineira elegans*	38
Spirobranchus lamarcki	17	*Nucula sulcata*	108	*Hiatella arctica*	60	*Syllis variegata*	43	*Syllis variegata*	18	*Pisidia longicornis*	28
Jasmineira elegans	16	*Musculus costulatus*	95	*Musculus discors*	35	Polycirrinae indet	33	*Sphenia binghami*	16	*Amphipholis squamata*	15
2010		2011		2010		2011		2010		2011	
WS14				WS15				WS16			
Spirobranchus lamarcki	373	*Sphaerosyllis bulbosa*	58	*Spirobranchus lamarcki*	411	*Sabellaria spinulosa*	540	*Pisione remota*	32	*Spirobranchus lamarcki*	730
Sphaerosyllis bulbosa	169	*Glycera lapidum*	50	*Sabellaria spinulosa*	251	*Dipolydora coeca*	238	*Glycera lapidum*	30	Serpulidae sp.	243
Serpulidae sp.	78	Polycirrinae indet	50	Nemertea	176	*Spirobranchus lamarcki*	218	*Goniadella gracilis*	19	*Spirobranchus triqueter*	120
Syllis cornuta	72	*Spirobranchus lamarcki*	48	*Gattyana cirrhosa*	147	*Jasmineira elegans*	175	*Spirobranchus lamarcki*	13	*Sabellaria spinulosa*	80
Golfingia elongata	62	Nemertea	40	*Eumida sanguinea*	100	Polynoidae sp.	145	*Amaeana trilobata*	12	*Echinocyamus pusillus*	68

2010		2011		2010		2011		2010		2011	
WS17				WS18				WS19			
-	-	*Mytilus edulis* juv.	2905	*Sabellaria spinulosa*	295	*Urothoe marina*	28	*Syllis cornuta*	97	*Syllis cornuta*	35
-	-	*Jasmineira elegans*	620	*Sabellaria alveolata*	60	*Aonides paucibranchiata*	18	*Syllis* sp. H	20	*Mediomastus fragilis*	18
-	-	*Sabellaria spinulosa*	100	*Jasmineira elegans*	58	*Opisthodonta* sp. A	18	*Protodorvillea kefersteini*	19	*Pisione remota*	15
-	-	*Hiatella arctica*	93	*Syllis armillaris*	36	*Syllis cornuta*	15	*Aonides paucibranchiata*	11	Nemertea	13
-	-	Sipuncula sp.	45	*Pisidia longicornis*	34	*Glycera lapidum*	13	*Goniadella gracilis*	10	*Echinocyamus pusillus*	13
2010		2011		2010		2011		2010		2011	
WS20				WS22				WS23			
Abra alba	56	*Abra alba*	1713	*Nucula nitidosa*	22	*Abra alba*	880	*Nucula nitidosa*	292	*Abra alba*	3933
Nucula nitidosa	43	*Chaetozone gibber*	50	*Abra alba*	17	*Spiophanes bombyx*	135	*Abra alba*	271	*Nucula nitidosa*	418
Nephtys hombergii	27	*Nucula sulcata*	40	*Spiophanes bombyx*	13	*Nucula nitidosa*	125	*Thyasira flexuosa*	56	*Euclymene oerstedi*	200
Euclymene oerstedi	27	*Nucula nitidosa*	35	*Mediomastus fragilis*	6	*Paraspio decorata*	30	*Euclymene A*	38	*Kurtiella bidentata*	135
Thyasira flexuosa	23	*Euclymene oerstedi*	30	*Magelona filiformis*	6	*Magelona filiformis*	28	*Euclymene oerstedi*	30	*Thyasira flexuosa*	95
2010		2011		2010		2011		2010		2011	
WS24				WS25				WS26			
Nucula nitidosa	26	*Abra alba*	125	*Nucula nitidosa*	153	*Abra alba*	1095	-	-	*Abra alba*	890
Magelona filiformis	12	*Nucula nitidosa*	115	*Abra alba*	93	*Mediomastus fragilis*	108	-	-	*Ophiothrix fragilis*	498
Abra alba	9	*Magelona filiformis*	20	*Thyasira flexuosa*	28	*Spiophanes bombyx*	48	-	-	*Nucula sulcata*	348
Spiophanes bombyx	9	*Bathyporeia tenuipes*	13	*Lagis koreni*	21	*Ophiura albida*	28	-	-	*Aphelochaeta marioni*	263
Mediomastus fragilis	7	*Spiophanes bombyx*	10	*Notomastus* sp.	16	*Nucula nitidosa*	25	-	-	*Mediomastus fragilis*	173

2010		2011		2010		2011			
WS27				WS28					
-	-	*Nucula sulcata*	843	-	-	*Mediomastus fragilis*	50	**Annelida**	
-	-	*Ophiothrix fragilis*	208	-	-	*Glycera lapidum*	45	**Crustacea**	
-	-	*Abra alba*	98	-	-	*Abra alba*	35	**Mollusca**	
-	-	Polynoidae sp.	40	-	-	*Ophiura albida*	35	**Echinodermata**	
-	-	*Pholoe baltica*	38	-	-	*Ophiothrix fragilis*	28	**Others**	

Table C.3 : The dominant taxa and their abundance (numbers per 0.75m²) at subtidal sites in 2015. Key for each major taxonomic group is listed at the bottom of the table.

WS03		WS05		WS07	
Lagis koreni	715	*Leptocheirus hirsutimanus*	463	*Gnathia oxyuraea*	103
Nucula nitidosa	325	*Sabellaria spinulosa*	290	Balanoidea	68
Abra alba	153	*Edwardsia claparedii*	188	Polycirrinae	48
Spiophanes bombyx	50	Sipuncula	128	*Aonides paucibranchiata*	40
Kurtiella bidentata	33	Nemertea	100	*Sabellaria spinulosa*	38
WS13		**WS14**		**WS16**	
Sabellaria spinulosa	208	*Sabellaria spinulosa*	345	*Pisione remota*	145
Nemertea	35	*Spirobranchus lamarcki*	83	Nemertea	35
Syllis pulvinata	25	*Sphaerosyllis bulbosa*	75	*Aonides paucibranchiata*	33
Syllis variegata	25	*Syllis pulvinata*	60	*Gnathia oxyuraea*	28
Sipuncula	23	Balanoidea	60	*Goniadella gracilis*	18
WS18		**WS20**		**WS24**	
Sabellaria spinulosa	1788	*Abra alba*	1350	*Lagis koreni*	398
Jasmineira elegans	675	*Scalibregma inflatum*	133	*Nucula nitidosa*	228
Sabellaria alveolata	333	*Mediomastus fragilis*	60	*Abra alba*	98
Mya truncata # juv	195	*Nucula nitidosa*	53	Pectinariidae # juv	60
Sipuncula	140	*Pseudopolydora pulchra*	48	*Magelona johnstoni*	43
WS25		**WS27**		**Key**	
Abra alba	1065	*Nucula sulcata*	793	Annelida	
Mediomastus fragilis	288	*Ophiothrix fragilis*	473	Mollusca	
Lagis koreni	280	*Abra alba*	443	Crustacea	
Arenicola marina	85	*Sabellaria spinulosa*	248	Echinoderms	
Scalibregma inflatum	78	*Kurtiella bidentata*	185	Others	

C.9 Faunal Grabs – Diversity Indices

Table C.4 : Values for the Shannon-Wiener diversity index (H') and Pielou's evenness (J) for all subtidal benthic sites sampled 2010 and 2011.

Site	H'		J	
	2010	2011	2010	2011
WS01	2.482	2.045	0.557	0.499
WS02	2.642	2.115	0.622	0.569
WS03	2.744	1.254	0.725	0.324
WS04	3.527	3.475	0.721	0.800
WS05	3.496	2.696	0.781	0.696
WS06	2.810	2.724	0.773	0.772
WS07	3.220	3.873	0.696	0.906
WS08	3.104	3.035	0.790	0.911
WS09	3.366	3.233	0.711	0.666
WS10	3.558	3.577	0.840	0.772
WS11	2.589	2.914	0.580	0.683
WS13	2.642	3.095	0.626	0.759
WS14	3.258	3.526	0.703	0.872
WS15	3.589	3.441	0.748	0.759
WS16	2.757	2.744	0.836	0.623
WS17	-	1.351	-	0.329
WS18	2.929	3.154	0.658	0.902
WS19	2.738	2.935	0.686	0.881
WS20	2.251	1.016	0.739	0.272
WS22	2.676	1.683	0.821	0.440
WS23	2.045	1.209	0.575	0.316
WS24	2.800	1.806	0.832	0.603
WS25	2.451	1.435	0.633	0.387
WS26	-	2.353	-	0.566
WS27	-	2.628	-	0.587
WS28	-	3.723	-	0.892

C.10 TAXDTEST 2010

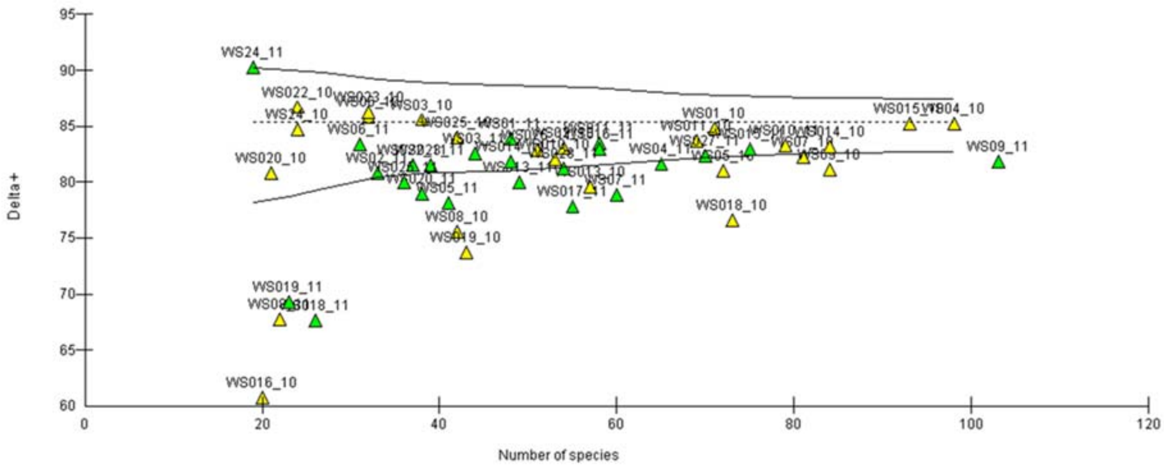


Figure 8-7 : Funnel plot for Average Taxonomic Distinctiveness (AvTD) for subtidal benthic communities, 2010-2011.

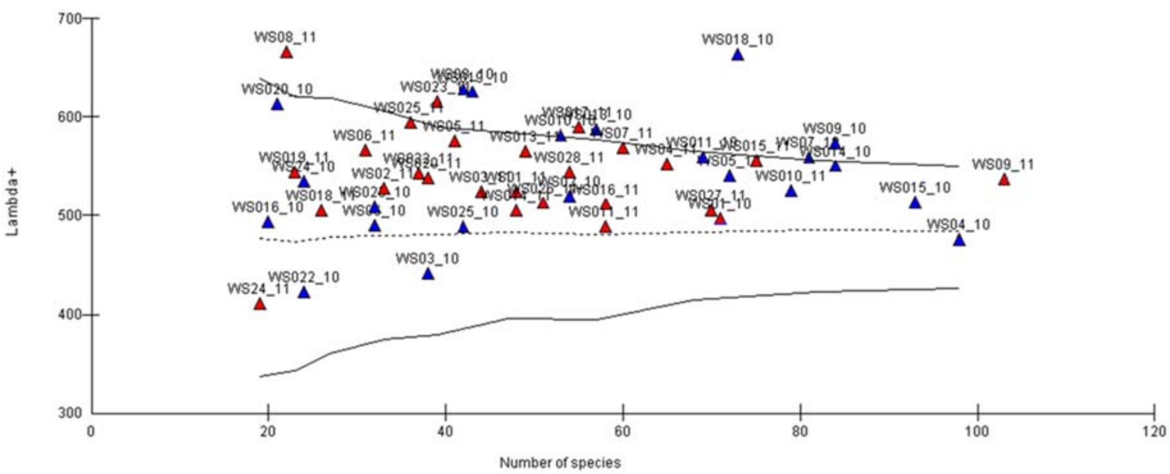
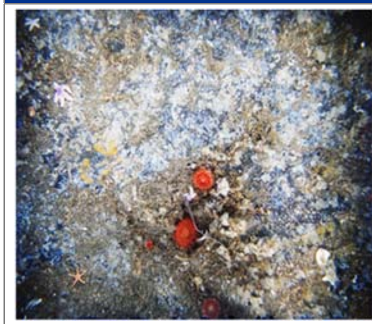
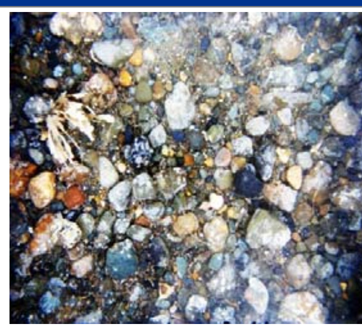
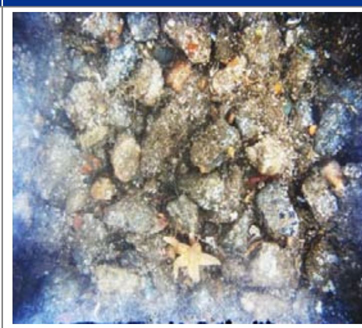
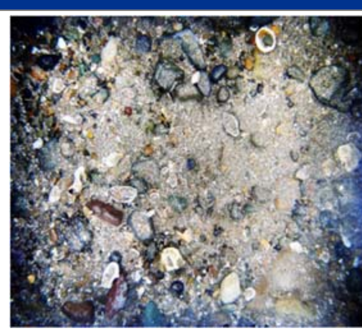


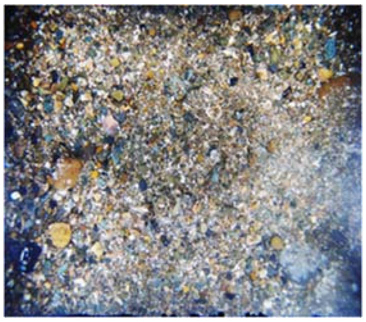
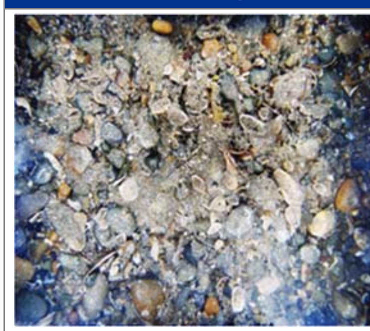
Figure 8-8 : Funnel plots for Variation in Taxonomic Distinctiveness (VarTD) for subtidal benthic communities, 2010-2011.

Appendix D. Disposal Site –Subtidal Benthic Ecology

D.1 DDC Images

Table D.1: Example DDC images from sampling sites of the Disposal Site survey. Assigned biotope code(s) are given. Sites where grab samples were taken are denoted by (*).

HHD_01: CR.HCR.FaT.BalTub / CR.MCR.EcCr.UrtScr	**HHD_02 *: SS.SMx.CMx.FluHyd / SS.SCS.CCS.Pkef**	**HHD_03: SS.SMx.CMx.FluHyd**
		
HHD_04: CR.HCR.XFa	**HHD_05: CR.HCR.FaT.BalTub**	**HHD_06: CR.MCR.ECCr.UrtScr / SS.SMx.CMx**
		
HHD_07: CR.HCR.FaT.BalTub	**HHD_08 *: SS.SMx.CMx / SS.SCS.CCS.PKef**	**HHD_09: CR.MCR.EcCr.UrtScr**
		

HHD_10 *: SS.SMx.CMx	HHD_11: CR.HCR.FaT	HHD_12 *: SS.SMx.CMx / SS.SCS.CCS.Pkef
	NO IMAGES AVAILABLE, VIDEO ONLY	
HHD_13 *: CR.MCR.EcCr.UrtScr / SS.SCS.CCS.Pkef	**HHD_14: SSS.SMx.CMx**	**HHD_15: CR.HCR.FaT.BalTub**
		
HHD_16 *: SS.SMx.CMx.FluHyd / SS.SBR.PoR.SpiMx	**HHD_17: CR.MCR.CSabSSpi**	
		

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D.2 Disposal Site – Taxa Recorded

Table D.2 : Epifauna recorded from the DDC images taken across the Disposal Site. X represents presence of a taxon.

Taxa	HHD_01	HHD_02	HHD_03	HHD_04	HHD_05	HHD_06	HHD_07	HHD_08	HHD_09	HHD_10	HHD_11	HHD_12	HHD_13	HHD_14	HHD_15	HHD_16	HHD_17	Frequency
PORIFERA	x		X	x	x	x												**5**
Stelligera stuposa				x														**1**
HYDROZOA			x	x	x													**3**
Tubularia sp.	x	x	x	x	x													**5**
Abietinaria abietina	x		x	x				x								x		**5**
Hydrallmania falcata		x		x	x		x		x							x		**6**
Sertularella gayi																x		**1**
Nemertesia spp.	x	x	x						x									**4**
Nemertesia ramosa		x																**1**
Alcyonium digitatum	x																	**1**
ACTINIARIA indet.															x			**1**
Urticina spp.	x			x		x			x	x	x	x	x		x			**9**
Sabellaria sp.	x	x	x												x	x	x	**6**
Sabella pavonina																	x	**1**
Spirobranchus	x				x		x		x			x	x		x	x		**8**
Filograna sp.			x						x									**2**
BALANOIDEA		x	x	x	x	x	x	x	x	x	x		x	x	x		x	**14**
Balanus balanus	x																	**1**
Jassa sp (tubes)				x														**1**
DECAPODA									x									**1**
Palaemon sp.	x	x	x	x	x	x									x		x	**8**
Pagurus sp.					x				x						X			**3**
Munida rugosa				x														**1**
Pisidia longicornis				x														**1**
Ebalia sp.			x						x									**2**
Majidae indet									x									**1**

Taxa	HHD_01	HHD_02	HHD_03	HHD_04	HHD_05	HHD_06	HHD_07	HHD_08	HHD_09	HHD_10	HHD_11	HHD_12	HHD_13	HHD_14	HHD_15	HHD_16	HHD_17	Frequency
Hyas coarctatus											x				x			**2**
Calliostoma zizyphinum	x																	**1**
Littorina sp															x			**1**
Euspira catena				x														**1**
Nucella lapillus									x						x			**2**
Polycera sp.									x									**1**
BRYOZOA indet		x		x	x				x		x	x	x	x	x	x		**10**
Eucratea sp.										x								**1**
Flustra foliacea		x	x		x	x	x	x	x	x						x	x	**10**
Bicellariella sp.									x									**1**
Cellaria sp.	x			x					x									**3**
Alcyonidium diaphanum									x									**1**
Crisidia sp.	x								x									**2**
Asterias rubens	x			x		x			x			x		x	x			**7**
Henricia sp.	x		x															**2**
ASCIDIACEA									x						x			**2**
Total Taxa	**15**	**9**	**12**	**16**	**10**	**6**	**4**	**3**	**20**	**4**	**4**	**4**	**4**	**3**	**13**	**7**	**5**	

Table D.3 : Abundances of all taxa recorded across the Disposal Site from the grab samples (numbers per 0.1 m^2 grab). P = Present, and all taxa are listed in taxonomic order.

Group	Taxa	HHD_02	HHD_08	HHD_10	HHD_12	HHD_13	HHD_16	HHD_19	HHD_20
PORIFERA	*Sycon ciliatum*								P
CNIDARIA	Sertulariidae			P	P				P
	Hydrallmania falcata						P		
	ACTINIARIA								2
	Edwardsia claparedii				1				
NEMERTEA	NEMERTEA	1	2			2	8	1	20
NEMATODA	NEMATODA	4	1	2		4	20	1	40
SIPUNCULIDA	Sipuncula indet	5		1	5		7		18
	Golfingia elongata					1			
ANNELIDA	*Golfingia vulgaris*	1							
	Polynoidae indet	5					6		10
	Gattyana cirrhosa								1
	Lepidonotus squamatus	6		1			4		6
	Polynoe scolopendrina	1							
	Pholoe inornata	2			1	1	2		9
	Pholoe baltica					2			
	Phyllodocidae indet								1
	Eteone indet		1						
	Eteone longa								1
	Hesionura elongata		1						
	Pseudomystides limbata	1							
	Phyllodoce mucosa						1		3
	Eulalia indet						1		2
	Eulalia bilineata	1							1
	Eumida sp.	2							
	Eumida bahusiensis								2
	Eumida sanguinea				1		1		2
	Glycera sp. juv						3		1
	Glycera lapidum # agg				1	1	4		3
	Goniadidae juv							1	
	Goniadella gracilis		1	1					
	Hesionidae # indet								4
	Psamathe fusca	3					3		1
	Syllidae # indet								2
	Syllis cornuta	2	5		2		28	3	7
	Syllis pulvinata						4		4

Group	Taxa	HHD_02	HHD_08	HHD_10	HHD_12	HHD_13	HHD_16	HHD_19	HHD_20
	Syllis c.f. armillaris						2		
	Syllis variegata	6					36		18
	Syllis vittata								1
	Eusyllis blomstrandi		1	1		2			1
	Exogoninae # indet						1		
	Sphaerosyllis bulbosa								1
	Sphaerosyllis taylori				1	3	5		
	Autolytinae	1		1			1		
	Nereididae juv		1			1	4		
	Eunereis longissima						1		1
	Nephtys kersivalensis								1
	Marphysa bellii								1
	Lysidice hebes				2		1		5
	Lumbrineridae #juv	1					1		15
	Lumbrineris aniara/cingulata					4			5
	Lumbrinereis coccinea					1			
	Arabella iricolor								1
	Protodorvillea kefersteini					2			1
	Schistomeringos neglecta								1
	Paradoneis lyra				1		1		3
	Laonice bahusiensis		1			2			2
	Dipolydora coeca	3		1					5
	Caulleriella alata				1				4
	Capitella						1		
	Heteromastus filiformis				1				
	Notomastus	1			1	1	7		
	Clymenura indet	2							
	Euclymene sp. A	2							
	Sclerocheilus minutus	1					5		4
	Sabellariidae #juv						2		5
	Sabellaria alveolata	14	1				107		16
	Sabellaria spinulosa	65					54		204
	Ampharetidae juv	1							1
	Melinna #juv								1
	Melinna palmata								2
	Terebellides stroemii #juv						1		
	Polycirrinae indet				1				
	Thelepus setosus	1							3

Group	Taxa	HHD_02	HHD_08	HHD_10	HHD_12	HHD_13	HHD_16	HHD_19	HHD_20
	Sabellidae indet								1
	Jasmineira elegans	73					3		53
	Serpulidae indet		1			2	1		
	Spirobranchus triqueter						2		
ARTHROPODA	PYCNOGONIDA								2
	Achelia echinata	1					1		4
	Anoplodactylus petiolatus								2
	Verrucaria stroemia								6
	Balanus balanus			18	6				
	Parapleustes assimilis	1							
	Tryphosella sarsi						1		1
	Liljeborgia pallida								1
	Ampelisca #indet	1							
	Ampelisca spinipes		1						
	Othomaera othonis						1		
	Gammaropsis maculata						1		
	Gammaropsis palmata								1
	Erithonius punctatus								8
	Unciola crenatipalma						25		
	Janira maculosa	1							2
	Tanaidae #indet								1
	Apseudes talpa	1							
	Pisidia longicornis # agg	10					12		61
	Eurynome sp.								1
	Monodaeus couchii	2					1		3
MOLLUSCA	Polyplacophora juv								3
	Leptochiton asellus			1					
	Gibbula tumida		1	1		4			
	Gibbula tumida #juv						1		3
	Crisilla semistriata	1							
	Euspira nitida	1							
	Buccinum undatum #juv	2							
	Onchidorididae			1					
	Nuculidae juv	1							
	Nucula nucleus	1							
	Mytilidae juv		1	1		1	1		1
	Modiolus modiolus								1
	Musculus subpictus	2							

Group	Taxa	HHD_02	HHD_08	HHD_10	HHD_12	HHD_13	HHD_16	HHD_19	HHD_20
	Pectinidae juv			1					
	Palliolum striatum	1							
	Anomiidae juv		1						2
	Anomia ephippium								1
	Timoclea ovata								1
	Timoclea ovata juv		2	1			1		1
	Tapes juv								1
	Mya truncata juv	13					10		22
	Sphenia binghami	3			1		3		3
	Hiatella arctica	3		3			1		16
BRYOZOA	*Crisidia cornuta*					P			P
	Crisia	P		P			P		P
	Alcyonidium diaphanum		P						
	Vesicularia spinosa								P
	Eucratea loricata								P
	Flustra foliacea								P
	Crisularia plumosa			P					
	Bicellariella ciliata	P				P			
ECHINODERMATA	*Ophiothrix fragilis*								1
	Ophiothrix fragilis juv								1
	Amphiuridae juv				1	2	1		7
	Amphipholis squamata						3		1
CHORDATA	Ascidiacea			1					10

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D.3 DOMPLOT and DIVERSE output

Table D.4 : DOMPLOT output (W-statistic) and diversity indices (d’, J’ and H’) for each grab site community sampled, December 2016.

Site	W-statistic	d’	J’	H’
HHD_02	0.141	7.96	0.68	2.57
HHD_08	0.494	5.10	0.94	2.67
HHD_10	0.392	4.91	0.75	2.21
HHD_12	0.540	4.80	0.90	2.56
HHD_13	0.646	5.22	0.95	2.86
HHD_16	0.238	8.37	0.71	2.80
HHD_19	0.200	1.67	0.90	1.24
HHD_20	0.184	13.06	0.70	3.10