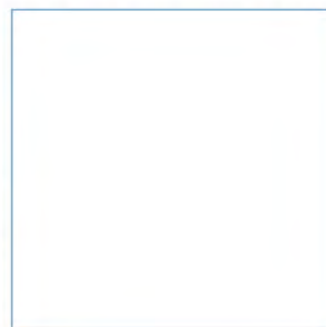
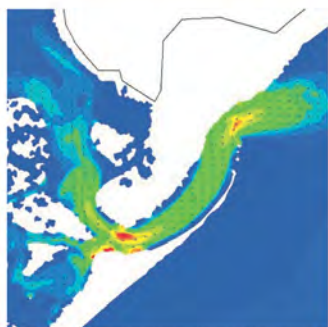
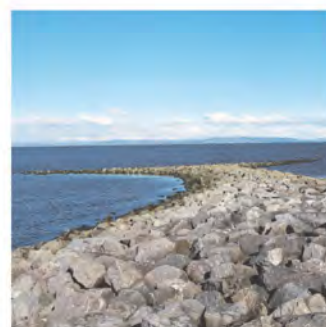


**Bourne Leisure Ltd**

# **Marine Ecological Surveys at Hafan y Môr, Gwynedd**

Baseline review to inform proposed breakwater development

February 2017



Innovative Thinking - Sustainable Solutions

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# Marine Ecological Surveys at Hafan y Môr, Gwynedd

Baseline review to inform proposed breakwater development

February 2017



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# Executive Summary

## Introduction

This report has been prepared for Bourne Leisure Ltd by ABPmer. It describes the ecological characteristics of the foreshore fronting the Bourne Leisure Holiday Park at Hafan y Môr (Gwynedd). This description is based on the findings from past survey work at this site and the results of two new bespoke ecological surveys of this area that were undertaken during 2016. The recent foreshore surveys were undertaken specifically to inform proposals for a breakwater and beach recharge project along this frontage.

The results presented in this report are therefore designed to provide the information needed to understand the biodiversity and nature conservation implications of this proposal. In particular, the information presented within this review is designed to help understand the implications for the internationally designated Pen Llŷn a'r Sarnau Special Area of Conservation (SAC) within which the proposed development and wider foreshore are located.

## Survey Approach

The marine ecology baseline survey work for this project was carried out in two phases (each undertaken by ABPmer). Initially, a broad scale survey was undertaken between 8 and 10 March 2016. This involved mapping key habitats across the shoreline in accordance with a standardised Phase 1 methodology. The results of this work were also used to confirm the presence of any designated interest features, rare species or nationally important biotopes in the area.

Then, from 19 to 21 September 2016, a more detailed ecological survey was conducted which focused more on the areas within and around the 'development footprint' of the two proposed breakwaters. This survey involved mapping key habitat features at a greater resolution. It also included extra sampling to provide quantitative information about the benthic invertebrates on the beach (i.e. those living within or on the sediment) and the characteristics of the sediment.

## Baseline Foreshore Characteristics

In general, the exposed upper-shore area at the top of the beach was characterised by a comparatively barren sand and shingle habitat (and also a bedrock habitat on the upper-shore around Porth Fechan beach). By contrast, the lower shore area had a much more diverse and species-rich gravel and boulder habitat. Between these two zones, the middle shore had a mix of different habitat types which included large patches of boulder and cobble reef habitat with areas encrusted by the honeycomb worm (*Sabellaria alveolata*). Within this mid-shore zone there were several discrete patches of notable biogenic growth by *S. alveolata* that were mapped as distinct reef features. These habitats are sub features of the Pen Llŷn a'r Sarnau Special Area of Conservation (SAC), as well as being Biodiversity Action Plan (BAP) Priority Habitat and listed as Habitats of Principal Importance in Wales.

Between the honeycomb worm reef patches on the middle shore, there were expanses of sandflat habitat that had a typically impoverished polychaete-dominated community. However, several eelgrass *Zostera marina* beds (which is a sub feature of the SAC as well as a BAP Priority Habitat and Habitat of Principal Importance in Wales) and notable razorshell/sea potato communities were recorded on the sandy lower shore of Porth Fechan beach.

The proposed breakwater project would involve installing two structures that would extend into the upper shore area. The footprint of the larger of the two structures would primarily overlap with sand and barren shingle habitat. Its toe would overlap with boulder habitat that includes patches of encrusting *S. alveolata*. The nearest large area of discrete biogenic reef structure through is located approximately 50 m away. The footprint of the smaller breakwater structure would cover sand and upper shore boulder habitat. *S. alveolata* was not recorded in this footprint and the nearest area of biogenic reef was located approximately 30 m away. Notable under-boulder communities were present on the lower shore below the breakwater footprint in this area.

## Conclusions

The marine ecology surveys have described the range of habitats that are present on the foreshore within and around the area where the proposed breakwaters could be placed. These habitats include extensive reef and sandbank features (qualifying features of the Pen Llŷn a'r Sarnau SAC and European Marine Site (EMS)). They also describe habitats of particular conservation importance including honeycomb worm *S. alveolata* reef, under boulder rock communities and eelgrass *Z. marina* beds.

Given the environmental value of the foreshore and the fact that it lies within the Pen Llŷn a'r Sarnau SAC/EMS, it is expected that the proposed project will need to be accompanied by an Environmental Impact Assessment (EIA) and an Appropriate Assessment<sup>1</sup> (y) under the Habitat Regulations as well as a marine licence and other relevant consents. When developing the proposed breakwater design therefore these requirements should be considered.

It is also recommended that potential opportunities are identified for enhancing the ecological value of the breakwater structures themselves. This could involve introducing objects, excavating pits or changing the roughness of surfaces to maximise the structural complexity of the breakwaters. Such measures can enhance diversity by introducing multiple niches and refuges against predators and environmental stresses and they have been undertaken elsewhere in the UK and North Wales either as good practice or to minimise/mitigate ecological effects as well as to enhance biodiversity. This report has described some previous enhancement measures.

As a next step in the process, it is recommended that a meeting is held on site to consider issues relating specifically to the design of the work, the potential for mitigation and the implications for the planning application as well as any other outstanding issues. It will also be important to engage with Natural Resources Wales (NRW) in a pre-application process and begin the process of licencing/consenting.

---

<sup>1</sup> Also termed a Habitats Regulations Assessment/Appraisal (HRA)) as undertaken to determine whether the ecological changes arising from the project could have an adverse effect on the integrity of the designated Pen Llŷn a'r Sarnau SAC site.



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# 1 Introduction

## 1.1 Report background

This report has been prepared for Bourne Leisure Ltd by ABPmer. It reviews the baseline ecological characteristics of the foreshore fronting the Bourne Leisure Holiday Park at Hafan y Môr (Gwynedd) (see Figure 1 for the location and Image 1 for a view of the foreshore). The report summarises information collected from two ecological surveys that were undertaken in March and September 2016. The results of the March survey were initially presented within a brief summary report (ABPmer, 2016a) however the integrated results from both surveys are now presented within this report.

These foreshore characterisation surveys were undertaken to inform the design and implementation of a proposed breakwater and beach recharge project along this frontage. In particular, the information presented within this review is designed to help understand the implications for the internationally designated Pen Llŷn a'r Sarnau Special Area of Conservation (SAC) within which the proposed development and wider foreshore are located.



Source: ABPmer March 2016

**Image 1.** View of the Hafan y Môr foreshore from below the Hafan y Môr Sewage Works

The March 2016 survey involved a broad-scale foreshore habitat mapping exercise. The September 2016 survey then involved mapping key habitat features at a greater resolution (particularly within/near the breakwater development footprint) as well as providing more detailed quantitative baseline information on the infaunal sedimentary community. Further information on the approach and methods used for the surveys are provided in Section 2.

In light of the findings from these baseline surveys, this report highlights key environmental features and potential issues associated with the breakwater proposal which will need to be considered further as part of the consenting process. In addition, some initial thoughts are presented about the potential for ecological enhancements within the breakwater design based on past projects and research in this field. Finally, recommendations on the scope of the next stages of the pre-application process are identified.

## 1.2 Background to breakwater project

The current design for the proposed breakwater development at Hafan y Môr consists of two breakwater structures (one approximately 185 m and the other 100 m in length). The potential locations of these structures are shown on Figure 1. The project could also involve beach recharge between the structures. In addition, the design of the structure includes boating facilities in the form of a small quay and slipway to enhance site access and the amenity value of the foreshore.

The ecological effects of this proposal will be a key issue for the planning application and marine licence consenting elements of this proposal. Particular consideration will need to be given to the fact that, as noted above, the Hafan y Môr foreshore is of high conservation importance and lies within the boundaries of the on Pen Llŷn a'r Sarnau SAC/European Marine Site (EMS).

The impacts of the project will, therefore, need to be evaluated within the context on the Habitat Regulations and with reference to the relevant conservation objectives for this SAC. These conservation objectives are set out in the CCW 2009 Regulation 33 guidelines which impose commitments to maintain the 'range' (i.e. distribution and extent), 'structure and functioning' and 'typical species' associated with relevant features which for Hafan y Môr include especially:

- Sandbanks which are slightly covered by sea water all the time;
- Large shallow inlets and bays;
- Reefs; and
- Mudflats and sandflats not covered by seawater at low tide.

The proposed development is also located within the Glanllynau A Glannau Pen-Ychain I Gricieth Site of Special Scientific Interest (SSSI) and near to the Morfa Abererch SSSI (see Figure 1).

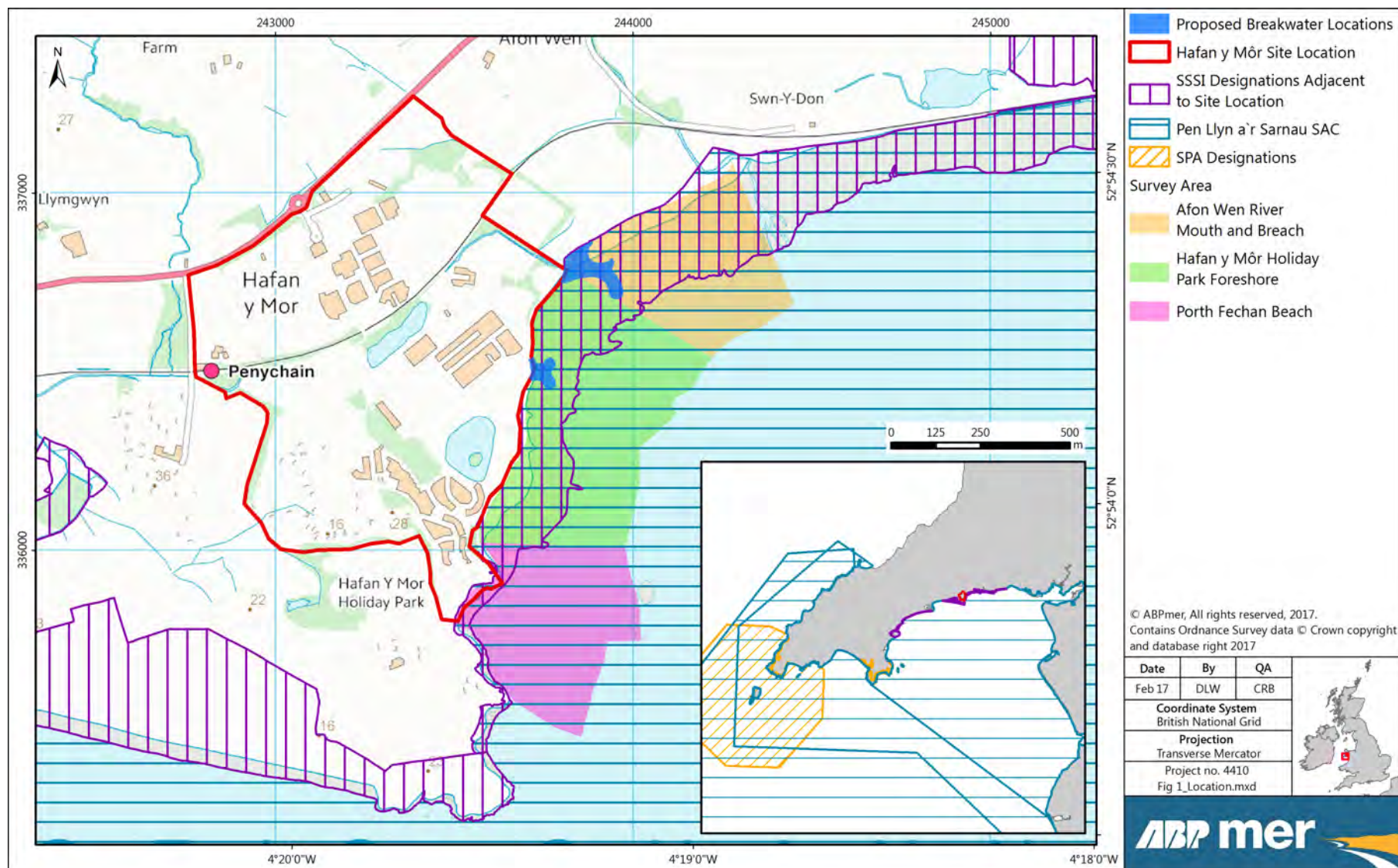


Figure 1. Location of the Hafan y Môr showing the extent of international and national designated areas

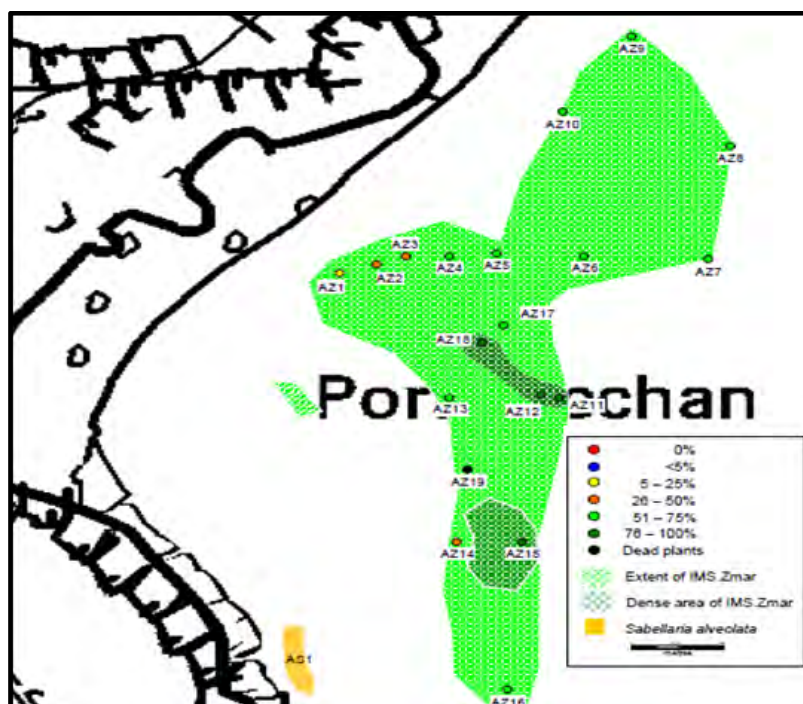
## 2 Survey Aims and Approach

The surveys of the Hafan y Môr shoreline were carried out to obtain an up-to-date baseline description of the habitats and species present within and around the area where the new breakwaters could be positioned. This information was required to provide a foundation for the impact assessment work that will be needed to accompany this breakwater proposal. The survey results are also expected to provide a foundation of any post-implementation monitoring work that may be needed in the future. Further information on the objectives and approach taken for each of the surveys is presented below. The results of the surveys are then presented in Section 3.

### 2.1 Previous surveys and data

Prior to conducting the surveys, available habitat maps and aerial images from past surveys were obtained and reviewed. The main source of such information was the mapping work conducted by CCW. This was undertaken as part of their programme to map all the coastal habitats in Wales from 1996 to 2004 (Brazier *et al.*, 2007). This survey recorded a range of notable features in the study area including honeycomb worm *Sabellaria alveolata* biogenic reef and eelgrass *Zostera marina* beds. The mapping results from this survey are shown in Figure 2.

In a separate survey in 2004/05, the *Z. marina* beds were also mapped as part of a CCW-commissioned survey of intertidal eelgrass beds in the Pen Llŷn a'r Sarnau SAC (Boyes *et al.*, 2008). This study recorded eelgrass beds in the south of the study area on the lower Porth Fechan beach (see Image 2). In addition recent online aerial images of the area were obtained. These maps and aerial images were then used to inform the surveys that were undertaken in March and September 2016. The 2016 surveys are designed to provide extra and up-to-date detail on the habitats in addition to these earlier surveys.



Source: Boyes *et al.*, 2008

Image 2. Extent of eelgrass recorded at Porth Fechan beach in 2004/05



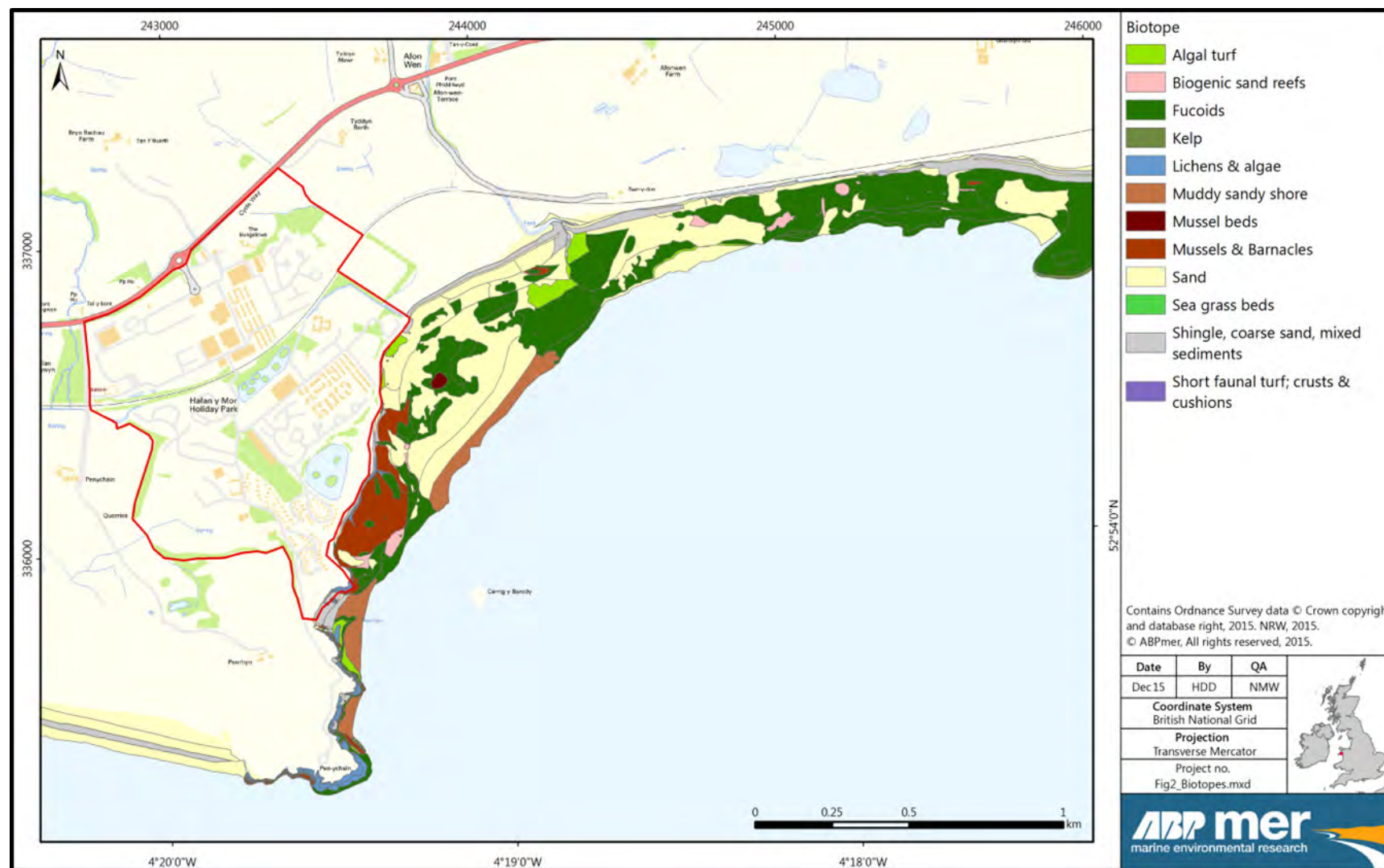
Source: Brazier *et al.*, 2007

Figure 2. Distribution of habitats on the Hafan y Môr foreshore based on CCW biotope data

## 2.2 March survey

### 2.2.1 Survey objectives

The main aims of the March 2016 survey were to achieve the following:

- Produce a broad-scale map the foreshore habitats covering the area of the proposed breakwater development and the adjacent shoreline (which could be directly or indirectly affected by the scheme); and
- Confirm the presence and distribution of any designated SAC interest features, rare species or nationally important biotopes under the footprint of the works or within its future influence.

Details about the methods employed for this survey are presented below.

### 2.2.2 Survey approach

The intertidal habitat mapping survey was undertaken between the 8 and 10 March 2016 and was scheduled to coincide with an equinoctial Spring tidal period. The survey approach was based on the standardised Phase 1 mapping methodology as detailed in the Marine Monitoring Handbook, Procedural Guidance No 3-1 (Wyn and Brazier, 2001) and CCW Handbook for Marine Intertidal Phase 1 Survey and Mapping (Wyn *et al.*, 2000). The landward boundary of this survey was Mean High Water Springs (MHWS). The seaward boundary was the lowest part of the shore which could be accessed safely at the time of low water using waders.

The habitat survey was undertaken on foot. Aerial photography and satellite images were taken into the field to create sketch maps. Habitats in the area were mapped using a Garmin Global Positioning System (GPS) (average accuracy  $\pm 5$  m) as polygons using the European Nature Information System (EUNIS) habitat classes to level 4 or 5. Biotopes, or other notable features, covering less than 5 m<sup>2</sup> were recorded using referenced target notes.

To describe the distribution of soft sediment biotopes, *in situ* sieving of sediment was undertaken from the representative habitat or where observations suggested a habitat change. The species present and their abundance were recorded. Observations of surface features from infauna (e.g. *Arenicola* casts, surface siphon holes etc.) were also recorded.

## 2.3 September survey

### 2.3.1 Survey objectives

The main aims of the follow-up September 2016 survey were to achieve the following:

- Produce a more detailed map of notable habitats (using differential GPS positioning) than was possible during the March survey;
- Record the density and coverage of *Sabellaria* reefs areas using a quadrat based methodology;
- Collect core samples for laboratory-based invertebrate analysis to describe the infaunal assemblages in areas of sandier sediment; and
- Observe any seasonal changes to may have occurred since the March survey.

Details about the methods employed for this survey are presented below.



### 2.3.2 Survey approach

The survey was undertaken on the foreshore in the vicinity of the proposed scheme between the 19 and 21 September 2016 and was scheduled to coincide with an equinoctial Autumn tidal period. The boundaries of notable features within the vicinity of the proposed footprint were mapped using a Real-Time Kinematic (RTK) Hemisphere S320 Global Navigation Satellite System (GNSS) Survey Receiver system (Image 3). The GPS rover was directly connected to the OSnet giving positions correct to British National Grid (OSGB36) and elevations to mODN.



Source: ABPmer September 2016

**Image 3. ABPmer Ecologist using the Hemisphere S320 Global Navigation Satellite System**

Within the main patches of *Sabellaria* growth, fixed point stations were sampled using a 0.25 m<sup>2</sup> quadrat at representative locations. In total there were 23 separate quadrat survey locations (labelled Q1 to Q23) that are shown in Figure 3. At each location the density and coverage of *Sabellaria* was recorded based on the standardised approach developed by the Wildlife Trusts for the North Western Inshore Fisheries and Conservation Authority (NWIFCA) (Egerton, 2014). This approach uses a classification system to record the type of colony formation (sheet, hummock, patchy, reef) as well as an indication of the development/health of the colony (newly settled worms, those with crisp apertures, those with worn apertures and dead worms). The photographic guide to the classification of *S. alveolata* presented in Egerton (2014) is shown as Image 4. For the purposes of mapping habitat boundaries, continuous areas of *Sabellaria* growth >1 m<sup>2</sup> were mapped as biogenic reef under the (EUNIS) habitat classification.

Invertebrate samples were also collected from five representative stations (Sites B1 to B5) to help characterise the infaunal assemblage across the study area. Two of these stations were located within upper shore sand habitat which overlapped with the footprint of the two proposed breakwater structures (Sites B1 and B3). The other stations were located within the mid-shore (Site B4) and lower shore areas (Sites B2 and B5). The locations of these stations are shown in Figure 3.

At four of these locations (Sites B1 to B4), two replicate cores (using a 0.007 m<sup>2</sup> hand core) were taken, one for particle size analysis (PSA) and one for quantitative analysis of macrofauna (invertebrate) abundance and biomass. The other location (Site B5) was positioned within the low water infralittoral fringe gravel habitat and could not be quantitatively sampled with a corer because the ground was too hard/coarse. At this site a semi-quantitative sample was taken by using a spade to collect a volume of sediment which was equivalent to that collected with a hand core. Field notes and photographs were also made at each of the sampling stations to record details such as the sediment type, the specific characteristics of the habitat at the precise point where the samples were retrieved (e.g. within the trough or crest of sand ripples), the depth of the sediment core and the presence of visible invertebrate fauna.

| <b>Formation Type</b>                                                                           |                                                                                                                                     |                                                                                                                                                |                                                                                                              |
|-------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|
| <b>Patchy</b>                                                                                   | <b>Sheet</b>                                                                                                                        | <b>Hummock</b>                                                                                                                                 | <b>Reef</b>                                                                                                  |
|                |                                                   |                                                             |                           |
| Small crusts or mounds which are less than 30 cm <sup>2</sup>                                   | Flat crust which are greater than 30 cm <sup>2</sup>                                                                                | Raised mound which are greater than 30 cm <sup>2</sup>                                                                                         | Large mounds which are greater than 1 m <sup>2</sup>                                                         |
| <b>Health Categories</b>                                                                        |                                                                                                                                     |                                                                                                                                                |                                                                                                              |
| <b>Dead</b>                                                                                     | <b>Worn Apertures</b>                                                                                                               | <b>Crisp Apertures</b>                                                                                                                         | <b>Newly Settled</b>                                                                                         |
|               |                                                  |                                                            |                          |
| Tubes have merged into a block of sediment. If a piece of reef is detached from the substratum. | There has been no clear new growth/ tube building. The apertures can still be seen. The tubes are still attached to the substratum. | New growth of tubes can be seen, the apertures are crisp and will have a fine wall. Tend to be a lighter sandy colour compared with worn reef. | Very small apertures between 1 mm and 4 mm. Usually found around the larger, older apertures as shown above. |

Source: Egerton. 2014

Image 4. *Sabellaria alveolata* classification guide



After the survey, the benthic core samples were transported to the laboratory for processing within 24 hours of collection. The processing was conducted according to the methods set out in Davies *et al.*, (2001) and involved washing the sediment through a 500 µm mesh sieve and then temporarily preserving the sample in 5 % formosaline solution. The fauna were then sorted from the sieve residue using a low power binocular microscope. All of the macroinfaunal specimens were then identified to species level (where practicable) and enumerated. This work was undertaken by Precision Marine Survey Ltd (PMSL) and the resulting species abundance and biomass matrix forwarded to ABPmer for analysis. PMSL adhere to BSI ISO 16665 standards and the National Marine Biological Analytical Quality Control (NMBAQC) Scheme Guidelines.

The PSA sample analysis was also undertaken by PMSL using an established methodology for determination of particle size of marine and estuarine sediments. The analysis was carried out using a Mastersizer laser diffractor which produces detailed sedimentary profiles for fine sediments (clay, sand and silts). An individual analysis report with graphic sedimentary profiles was produced after each analysis.

In addition, a static time-lapse camera was also set up on the shoreline over a 12 h period to help understand tidal movement within the area and record observations of shoreline usage by birds and visitors. The camera took photos of the foreshore every 10 seconds throughout daylight hours (Image 5).



Source: ABPmer, September 2016

**Image 5.** The static time-lapse camera in position at Hafan y Môr

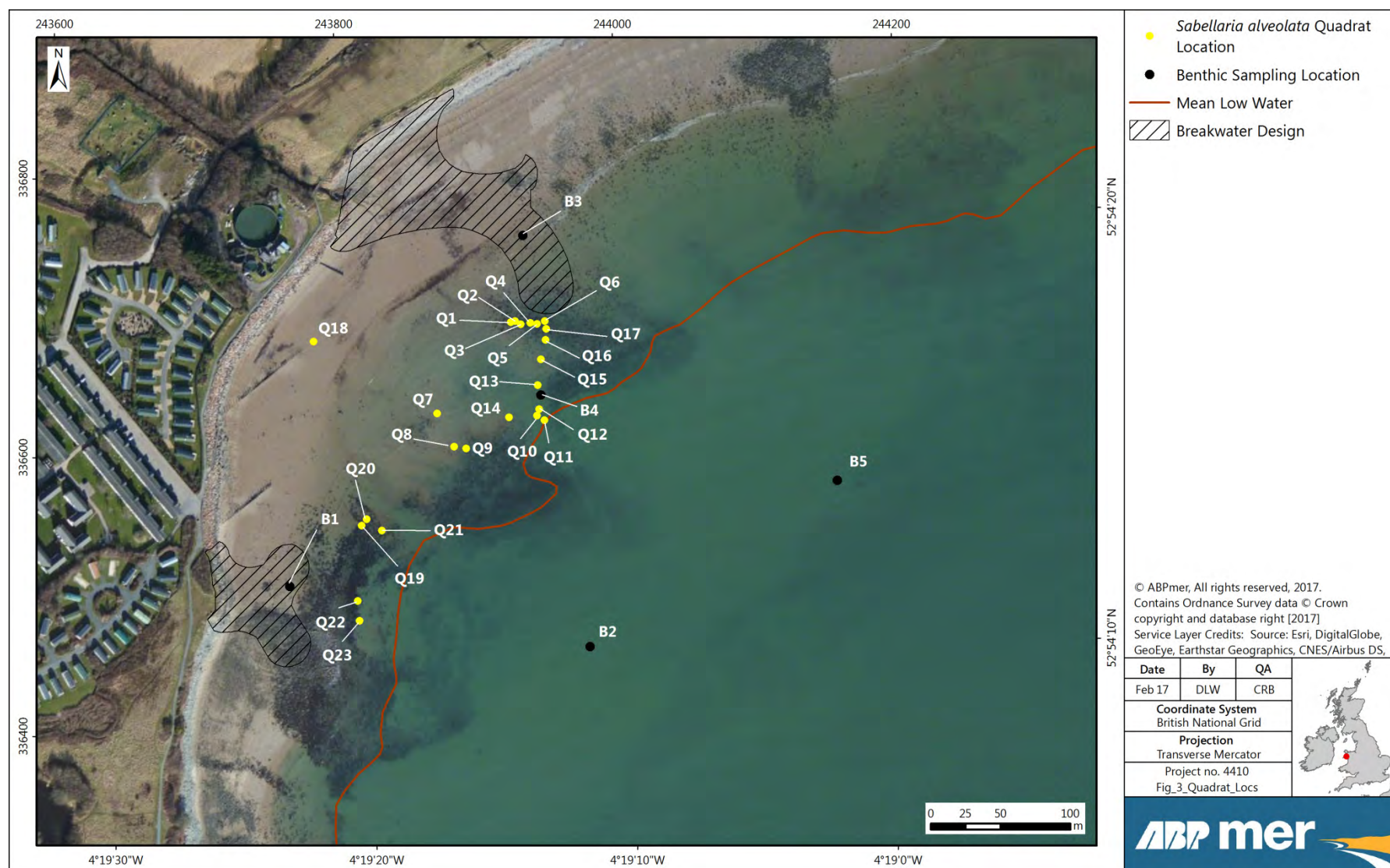


Figure 3. Location of the benthic sampling sites (Sites B1 to B5) and *Sabellaria* quadrat stations (Sites Q1 to Q23)

## 3 Baseline Habitats Review

### 3.1 Survey results

Following the completion of the surveys, the biotope extents across the area were mapped into Geographical Information System (GIS) layers using ArcGIS and using positional information derived from the GPS readings. The resulting habitat boundaries are shown in Figures 4a and 4b. These mapped areas were then also converted to 'Keyhole Markup Language Zipped (KMZ) files' to allow for easy visualisation and dissemination within 'Google Earth' software (see Image 6). These files allow users to interrogate the data from multiple viewpoints and to access indicative photographs of the individual biotopes (as taken during the surveys). The other results from the surveys are provided within a series of appendices. The details presented in each appendix are as follows:

- Appendix A: Photographic record of the species recorded in the surveys;
- Appendix B: The results from the quadrats to characterise density and coverage of *Sabellaria*;
- Appendix C: The invertebrate faunal analysis abundance matrices; and
- Appendix D: The sedimentary (PSA) results.



Source: Google Earth with ABPmer Biotope Map

**Image 6. Aerial view of foreshore showing biotope map**

To summarise the key findings from this work, the survey area was divided into three broad areas as shown on Image 6. These areas are as follows:

- **Afon Wen River Mouth and Beach:** The shoreline located between the Afon Wen river mouth and Hafan y Môr Sewage Works;
- **Hafan y Môr Holiday Park Foreshore:** The foreshore directly below Hafan y Môr Holiday Park located between the Sewage Works and Porth Fechan beach; and
- **Porth Fechan Beach:** The foreshore at Porth Fechan beach extending out to Cerrig y Barcdu Island.

The habitats observed in each area are described in the following sections with each section structured so that habitats recorded on the lower shore are described first, followed by mid-shore habitats and finally those habitats observed on the upper shore.





Figure 4a. Habitats on the Hafan y Môr recorded during the March and September 2016 surveys (Afon Wen river mouth to the holiday park)



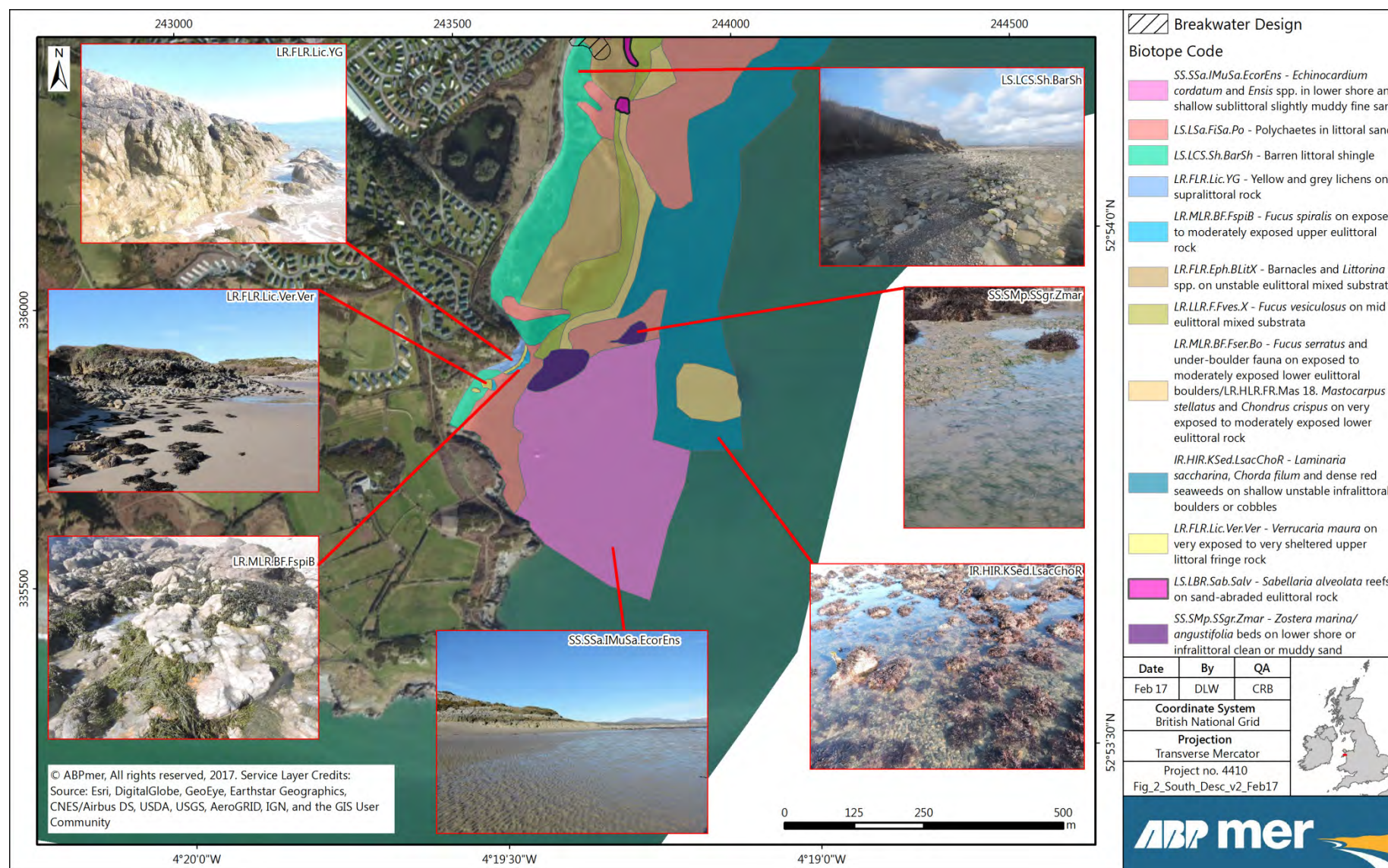


Figure 4b. Habitats on the Hafan y Môr recorded during the March and September 2016 surveys (the holiday park to Porth Fechan beach)

## 3.2 Afon Wen river mouth and beach

### 3.2.1 Lower shore habitats

The shallow sublittoral zone (as the lowest accessible point on the shoreline) consisted of a mixture of sand, gravel, cobbles and small boulders characterised by red seaweeds (particularly carrageen moss *Chondrus crispus* and calcareous algae *Corallina officinalis*) (Image 7). The sugar kelp *Saccharina latissima* (*Laminaria saccharina*) was also frequently recorded. This biotope is most appropriately assigned to IR.HIR.KSed.LsacChoR (*Laminaria saccharina*, *Chorda filum* and dense red seaweeds on shallow unstable infralittoral boulders or cobbles) and also extends into the intertidal along the infralittoral fringe (lowest part of the shore).

Epifaunal species recorded in this habitat included the marine hermit crab *Pagurus bernhardus*, the tube building polychaete *Pomatoceros* spp., the sea spider *Anoplodactylus pygmaeus*, the brittle starfish *Amphiura chiajei*, calcareous sponge *Sycon ciliatum*, sea squirt *Ascidiella aspersa*, the juvenile common starfish *Asteria rubens* and the snakelocks anemone *Anemonia viridis*.

The benthic sample collected from this area (Site B5) was characterised by a diverse number of taxa (30) and moderate abundance of individuals (16,279 m<sup>2</sup>). This included polychaetes (particularly *Nereis zonata* and *Polyophtalmus pictus*), bivalves *Rissoa* spp. and gammarid shrimps (such as *Dexamine spinosa*). Higher up the shoreline, the lower shore consisted of clean sand habitat with evidence of occasional sand mason worms *Lanice conchilega* and lugworm (*Arenicola* spp.) casts (LS.LSa.FiSa.Po: Polychaetes in littoral fine sand).



Source: ABPmer, March 2016

**Image 7.** View of carrageen moss *C. crispus* and other red seaweeds on mixed boulders, cobbles and gravel on the lower shore

### 3.2.2 Middle shore habitats

The middle shore area was characterised predominantly by fine sand with occasional lugworm *Arenicola* spp. casts (LS.LSa.FiSa.Po: Polychaetes in littoral fine sand). The infaunal sample collected in this area (Site B3) was characterised by a low species diversity (4 taxa) and organism abundance (571 individuals/m<sup>2</sup>). The species recorded in the sample (the errant polychaete *Nephtys cirrosa*, mobile crustaceans *Bodotria pulchella* and *Bathyporeia pilosa* and the bivalve *Fabulina fabula*) are typical of clean sand beach habitat.

Large cobble and boulder fields were also present in this mid-eulittoral zone. The upper sections of the boulder fields were sparse in terms of algae species with the bladder wrack *Fucus vesiculosus* and



spiral wrack *F. spiralis* occasionally recorded. Barnacles were abundant and the periwinkle *Littorina littorea* was also frequently recorded. Gammarids were present underneath the pebbles and cobbles. This habitat is most appropriately assigned to LR.FLR.Eph.BLitX (Barnacles and *Littorina* spp. on unstable eulittoral mixed substrata).

The lower sections of the boulder fields were characterised by abundant bladder wrack *F. vesiculosus* (LR.LLR.F.Fves.X: *Fucus vesiculosus* on mid eulittoral mixed substrata) (Image 8). The honeycomb worm *S. alveolata* was also recorded encrusting the boulders in varying densities. The area was rich in gastropod species including the netted dog whelk *Nassarius reticulatus*, flat periwinkle *Littorina obtusata*, dog whelk *Nucella lapillus*, common periwinkle *L. littorea*, the common limpet *Patella vulgata* and top shells (*Osilinus lineatus*, *Gibbula cineraria* and *G. umbilicalis*). The beadlet anemone *Actinia equina* was also occasionally recorded.



Source: ABPmer, September 2016

Image 8. Bladder wrack *Fucus vesiculosus* on the mid-shore

### 3.2.3 Upper shore habitats

The top of the upper foreshore below the high water mark consists of barren shingle, pebbles and cobble (LS.LCS.Sh.BarSh Barren littoral shingle) as shown in Image 9.



Source: ABPmer, September 2016

Image 9. View of the upper shore habitats looking towards Hafan y Môr holiday park



Within this zone there were several strandline areas characterised by sand hoppers (talitrid amphipods) on decomposing seaweed (LS.LSa.St.Tal: Talitrids on the upper shore and strandline). One area of large boulders on the upper shore was also recorded that was characterised by channelled wrack *Pelvetia canaliculata* (LR.MLR.BF.PelB: *Pelvetia canaliculata* and barnacles on moderately exposed littoral fringe rock).

Sand habitat was present below this area that extended into the middle shore. Barren upper shore boulder and pebble habitat was also present. This habitat was larger in extent in September 2016 than had been present in March 2016.

### 3.3 Hafan y Môr Holiday Park foreshore

#### 3.3.1 Lower shore habitats

The cobble and gravel habitat recorded along the shallow sublittoral and infralittoral fringe in this area was a continuation of the same habitat as recorded in Section 3.2.1 (IR.HIR.KSed.LsacChoR: *Laminaria saccharina*, *Chorda filum* and dense red seaweeds on shallow unstable infralittoral boulders or cobbles). Notable species recorded in this habitat within this area included several bloody Henry starfish *Henricia oculata* as well as a small spotted cat shark *Scyliorhinus canicula* foraging within a shallow pool.

'Clean' sand habitat with evidence of occasional sand mason worms *Lanice conchilega* and lugworm (*Arenicola* spp.) casts (LS.LSa.FiSa.Po: Polychaetes in littoral fine sand) was recorded above the gravel habitat. The benthic sample from the habitat in this area (Site B2) consisted of an impoverished community with only three *Nephtys cirrosa* and a single bivalve *Donax vittatus* recorded in the sample.

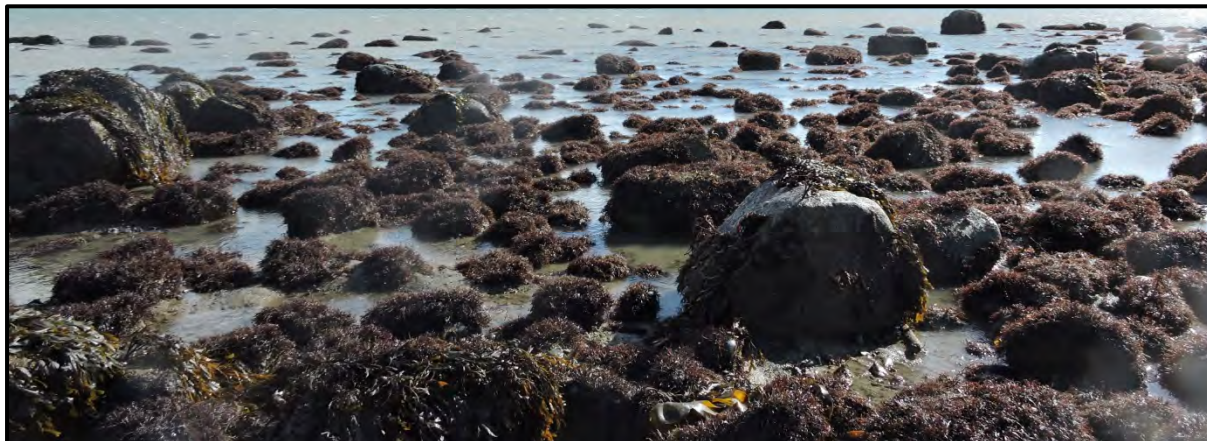
In the southern section of this area, large and medium sized boulders overlying sand and gravel were recorded (Image 10). The boulders were covered in carrageen moss *C. crispus* and serrated wrack *Fucus serratus*. Other alga species included the red seaweed *gracilaria verrucosa*, the false Irish moss *Mastocarpus stellatus* and kelp *laminaria digitata*. Snakelocks anemones *Anemonia viridis* and breadcrumb sponge *Halichondria* spp. were present attached to the boulders.

The under-boulder community recorded was rich with a range of mobile epifaunal species including broad-clawed porcelain crab *Porcellana platycheles*, long clawed porcelain crab *Pisidia longicornis*, sea spider *Nymphon* spp., juvenile common starfish *A. rubens* and chitons commonly observed. Other mobile crustacean species recorded more infrequently in this under boulder habitat included juveniles edible crabs *Cancer pagurus*, Risso's Crab *Xantho pilipes* and toad crab *Hyas coarctatus*.

Common prawn *Palaemon serratus* and chameleon prawn *Hippolyte varians* were present in shallow pools. Several fish species including the greater pipefish *Syngnathus acus*, worm pipefish *Nerophis lumbriciformis*, shore clingfish *Lepadogaster lepadogasta* and butterflyfish *Pholis gunnellus* were also observed. The habitat is considered to be a combination of LR.MLR.BF.Fser.Bo (*Fucus serratus* and under-boulder fauna on exposed to moderately exposed lower eulittoral boulders) and LR.HLR.FR.Mas (*Mastocarpus stellatus* and *Chondrus crispus* on very exposed to moderately exposed lower eulittoral rock). Sessile species such as sponges, sea squirts and bryozoans were also common under the boulders.

The habitat recorded under the boulders in this area is characteristic of the UK Biodiversity Action Plan (BAP) Priority Habitat 'Intertidal Under boulder Communities' (UK Biodiversity Action Plan, 2008a). This habitat is also listed as a Habitat of Principal Importance in Wales under the Natural Environment and Rural Communities (NERC) Act 2006 Section 42. Several sandy hummocks with eelgrass

(SS.SMp.SSgr.Zmar: *Zostera marina/angustifolia* beds on lower shore or infralittoral clean or muddy sand) were recorded within the wider LR.MLR.BF.Fser.Bo/LR.HLR.FR.Mas habitat.



Source: ABPmer, March 2016

**Image 10.** View of boulders covered in carrageen moss *C. crispus* and serrated wrack *F. serratus* on the lower shore

### 3.3.2 Mid-shore habitats

The mid-shore habitat was found to predominantly consist of boulder and cobble fields with a zone of LR.FLR.Eph.BLitX (Barnacles and *Littorina* spp. on unstable eulittoral mixed substrata) on the upper section of the boulder field and a zone of LR.LLR.F.Fves.X (*Fucus vesiculosus* on mid eulittoral mixed substrata) on the lower section. The habitat and species recorded was similar to that recorded on the mid-shore further east nearer the Afon Wen River Mouth (Section 3.2.2). The honeycomb worm *S. alveolata* was commonly recorded encrusting the boulders in this area (Figure 4). The *S. alveolata* structures generally consisted of flat (sheet) crusts or patchy mounds (Appendix A).

Several patches were also observed in which more notable biogenic growth had occurred (Image 11 and Appendix B).



Source: ABPmer, September 2016

**Image 11.** View of honeycomb worm *Sabellaria alveolata* reef on the mid-shore

These more distinct areas were mapped separately as LS.LBR.Sab.Salv (*Sabellaria alveolata* reefs on sand-abraded eulittoral rock) (see Section 2.3 and Figure 4). Honeycomb worm *S. alveolata* reef is a BAP Priority Habitat (UK Biodiversity Action Plan, 2008b) and also listed as a Habitat of Principal Importance in Wales under the NERC Act 2006 Section 42. The habitat is included in the OSPAR List

of Threatened and/or Declining Habitats and Species (OSPAR, 2008). Gravelly sand habitat between the *S. alveolata* reef consisted of a sparse assemblage with only the polychaete *Polyophthalmus pictus* (three individuals) and isopod *Sphaeromatidae* spp. recorded in the infaunal samples collected from this area (Station 4).

### 3.3.3 Upper shore habitats

The upper foreshore in this area consisted either of boulder seawall or large cobbles, boulders and shingle (LS.LCS.Sh.BarSh: Barren littoral shingle). Clean sand habitat with frequent *Arenicola* sp casts (LS.LSa.FiSa.Po: Polychaetes in littoral fine sand) was present below this zone in the northern section of this area (Image 12). The only species recorded in infaunal samples collected from this area was the polychaete *Nephtys cirrosa* (3 individuals) (Site B1).



Source: ABPmer, March 2016

Image 12. View of lugworm *Arenicola* sp on the upper shore sampled through sieving

## 3.4 Porth Fechan beach

### 3.4.1 Lower shore habitats

The infralittoral fringe and shallow sublittoral on Porth Fechan beach consisted of fine sand habitat. Razorshell (*Ensis* spp.) were recorded relatively abundantly with several living sea potato *Echinocardium cordatum* also recorded. Tests (shells) of dead sea potato were also abundantly recorded partially buried in the sediments. This habitat is most appropriately assigned to SS.SSa.IMuSa.EcorEns (*Echinocardium cordatum* and *Ensis* spp. in lower shore and shallow sublittoral slightly muddy fine sand).

The habitat around Cerrig y Barcdy Island consisted of gravel, boulders and cobbles with dense red seaweeds (particularly carrageen moss *C. crispus* and the calcareous red seaweed *C. officinalis*). The upper part of the island is best described as a combination of LR.MLR.BF.Fser.Bo (*Fucus serratus* and under-boulder fauna on exposed to moderately exposed lower eulittoral boulders) and LR.HLR.FR.Mas (*Mastocarpus stellatus* and *Chondrus crispus* on very exposed to moderately exposed lower eulittoral rock). The epifaunal invertebrate assemblage recorded was comparable to that observed on similar habitat on the lower Hafan y Môr Holiday Park foreshore (Section 3.3.1).

This mixed substratum sediment extended into the shallow sublittoral around Cerrig y Barcdy Island, where the biotope recorded in this zone was IR.HIR.KSed.LsacChoR (*Laminaria saccharina*, *Chorda filum* and dense red seaweeds on shallow unstable infralittoral boulders or cobbles). Asteroid echinoderms, in particular, juvenile common starfish *A. rubens* as well as several large spiny starfish



*Marthasterias glacialis* and the bloody Henry starfish *H. oculata* were recorded in this habitat (Image 13).

Several large patches of eelgrass *Z. marina* bed were also present on the lower shore on Porth Fechan Beach with small patches also recorded around Cerrig y Barcdy Island (SS.SMp.SSgr.Zmar *Zostera marina/angustifolia* beds on lower shore or infralittoral clean or muddy sand). The eelgrass beds were mapped in a broadly similar area to those beds recorded in 2004/05 as part of a CCW commissioned study of intertidal eelgrass beds in the Pen Llŷn a'r Sarnau SAC (Section 1.3). As well as being an interest feature of the Pen Llŷn a'r Sarnau SAC/EMS, this habitat is a UK BAP Priority Habitat (UK Biodiversity Action Plan, 2008c) also listed as a NERC Habitat of Principal Importance Section 42. Eelgrass beds are also included in the OSPAR List of Threatened and/or Declining Habitats and Species (OSPAR, 2008).



Source: ABPmer, September 2016

Image 13. Bloody Henry starfish *H. oculata* in gravel and boulder habitat on the lower shore

### 3.4.2 Mid-shore habitats

The mid-shore habitat along the rocky headlands and outcrops of Porth Fechan beach was characterised by a zone of spiral wrack *F. spiralis* (LR.LLR.F.Fspi: *Fucus spiralis* on sheltered upper eulittoral rock) with clumps of knotted wrack *Ascophyllum nodosum* also observed (Image 14). Fauna recorded included the common limpet *P. vulgata*, the beadlet anemone *A. equina* and periwinkle species (such as the common periwinkle *L. littorea*). The mid-shore section of the beach consisted of fine clean sand with evidence of polychaetes (LS.LSa.FiSa.Po: Polychaetes in littoral fine sand).



Source: ABPmer, March 2016

Image 14. Spiral wrack *F. spiralis* and knotted wrack *A. nodosum* on the mid-shore

### 3.4.3 Upper shore habitats

The upper foreshore of Porth Fechan beach consisted of barren shingle (LS.LCS.Sh.BarSh: Barren littoral shingle) (Image 15). Lichen zonation was observed along the rocky headlands (LR.FLR.Lic.YG: Yellow and grey lichens on supralittoral rock and LR.FLR.Lic.Ver.Ver: *Verrucaria maura* on very exposed to very sheltered upper littoral fringe rock). Below this zone, *Pelvetia canaliculata* and barnacles on moderately exposed littoral fringe rock (LR.MLR.BF.PelB) were present.



Source: ABPmer, March 2016

Image 15. Upper shore habitat on Porth Fechan beach

### 3.4.4 Other species recorded

During the surveys observations were made of a range of other species. This included several individual Little Egret *Egretta garzetta* and Grey Heron *Ardea cinerea*. These piscivorous (fish eating) waterbirds were recorded foraging around rockpools. Wading birds foraging on the shoreline (primarily in rocky areas) included several small flocks of Oystercatcher *Haematopus ostralegus* and Turnstone *Arenaria interpres*.

European herring gull *Larus argentatus* were recorded both on the shore and also further offshore on the times lapse video. Several flocks of auks (Razorbills *Alca torda* and Guillemot *Uria aalge*) were also recorded foraging offshore. In addition, during the September survey, there were sightings of a grey seal *Halichoerus grypus* either foraging or resting (floating) in the water column (Appendix A).



## 4 Conclusions

### 4.1 Key features

The marine ecology survey has been used to map the presence of a range of marine habitats including extensive reef and sandbank features (qualifying features of the Pen Llŷn a'r Sarnau SAC/EMS) within the study area. Habitats of particular conservation importance recorded included *S. alveolata* reef, under boulder rock communities and eelgrass beds. As well as being notable sub features of the SAC, these habitats are also BAP Priority Habitat and also listed as Habitats of Principal Importance in Wales under the NERC Act 2006 Section 42.

The footprint of the larger proposed breakwater structure primarily overlaps with littoral sand and barren shingle habitat. These habitats are generally impoverished and of low biodiversity (Image 16). The toe of the breakwater overlaps with boulder habitat with patches of encrusting *S. alveolata* attached to the rocks. The nearest large area of distinct biogenic reef structure is located approximately 50 m away.



Source: ABPmer, September 2016

**Image 16.** Habitat looking seaward from the toe of the larger proposed breakwater structure

The footprint of the smaller breakwater structure overlaps with sand and upper shore boulder habitat. *S. alveolata* was not recorded in the footprint with nearest area of biogenic reef located approximately 30 m away (Image 17). Notable under boulder communities were present on the lower shore below the breakwater in this area.



Source: ABPmer, September 2016

**Image 17.** Habitat looking landward from toe of smaller proposed breakwater structure



The results from these surveys will be important for informing the Marine Ecological Impact Assessment work, and other consenting and assessment requirements, that are likely to be needed for the breakwater proposal. This assessment work is likely to include a range of tasks including;

- The collation and review of any additional environmental data;
- Providing technical environmental assessment information (see below), including feedback on design and construction as part of an iterative process;
- Developing a mitigation and monitoring (and if required compensation) package; and
- Assistance with the Marine Licence.

The proposed development could require an Environmental Impact Assessment (EIA). The fact that the Pen Llŷn a'r Sarnau SAC/EMS extends over the foreshore area where the work will be carried out means that there is likely to be a requirement for an Appropriate Assessment (AA) to be produced under the Habitat Regulations. The AA will need to determine whether the ecological changes arising from the project will have an adverse effect on the integrity of this designated site.

At this stage and in the absence of a full scheme description we anticipate that the key marine ecological impacts that could potentially arise are:

- Changes in water quality during construction;
- The indirect consequences to mobile marine species through noise and visual disturbance during construction;
- The direct effects to intertidal habitats and species under the 'development footprint' from the installation of the breakwater and the placement of the recharge sediment;
- The indirect consequences for the adjacent intertidal and shallow subtidal habitats from changes to the physical environment (i.e. waves, tidal patterns and sediment movement causing accretion or erosion);
- The indirect consequences for the adjacent habitats and species from any significant changes to boating and other activities as a result of the operation of the new structure; and
- The spread of non-native species through the presence of the structure.

## 4.2 Scheme enhancement options

In developing the proposed breakwater design, it is recommended that potential opportunities are identified for enhancing the ecological value of the structure itself. Such measures could be valuable for improving the structure's integration with the environment; for minimising/mitigating any ecological effects and perhaps even providing benefits for certain species (e.g. *S. alveolata*).

The extent to which such measures can be included in the scheme design will be a relevant consideration under the 'mitigation hierarchy'<sup>2</sup> and may be particularly relevant in the context of the reviews of alternative options that will need to be undertaken as part of the EIA and Habitats Regulations Assessment/Appraisal (HRA) processes. In this context it will also be important to consider the implications of the relatively recent case law judgement (Briels Case, Netherlands<sup>3</sup>) from May 2014 which provides direction as to the nature of the mitigation measures within internationally designated sites.

<sup>2</sup> Set of prioritised steps to alleviate environmental harm as far as possible through avoidance, minimisation (or reduction) and restoration of detrimental impacts to biodiversity.

<sup>3</sup> The Court of Justice of the European Union (CJEU) judgment in Case C-521/12 T.C. Briels and Others v Minister van Infrastructuur en Milieu <http://curia.europa.eu/juris/liste.jsf?num=C-521/12>

It should firstly be recognised that a great deal of work has been done in the past to enhance the ecological value of coastal structures, with much largely having been done on a small-scale as part of general ecological enhancement trials and for the purposes of general research and/or to demonstrate good practice. There are however also examples of such measures being undertaken as a legal requirement of a development to offset predicted environmental effects. Further descriptions of this work and some brief summaries of these projects are presented below as a guide to the considerations that might be relevant at Hafan y Môr.

With respect to the general research/trial projects, there are many examples of which have been undertaken to enhance breakwaters or sea walls at locations through the UK such as at Tywyn, Colwyn Bay, Plymouth, Bouldnor (Isle of Wight), Shaldon (Devon) and Bournemouth<sup>4</sup>. Further details of these research projects are provided below:

- **Core-drilled rock armouring (Tywyn, Gwynedd):** When rock armour breakwaters were put in place at Tywyn in October 2011 artificial pools were created in the rock using core drills. These were monitored over the course of the project and were found to support greater species richness than adjacent rock surfaces on the breakwater and similar species richness to natural rock pools nearby. The artificial pools were also found to provide habitat for several species that were otherwise absent at mid-shore height on the breakwater. The breakwater also supported several sessile species of conservation importance (*S. alveolata*, and *M. Edulis*) in higher abundance than nearby natural rock (Evans *et al.*, 2016).
- **Core-drilled protective blocks (Plymouth, Devon):** Sacrificial concrete blocks placed to protect a large 19<sup>th</sup> century stone breakwater at Plymouth Sound were historically, cast with a depression where an iron fastening hook was embedded. These depressions have created artificial rock pool habitat. Based on this observation, further pits were core-drilled in protective blocks with differing diameters and distances from each other. The diversity and community structure of colonising epibiota was examined. In total, 33 species were observed in drilled holes and in control areas without drills (functional groups included algae, anemones, hydroids, ascidians, bryozoans, annelids, bivalves, sponges, gastropods and barnacles). Six of the 10 functional groups were found to be unique to the drilled pits (anemones, annelids, ascidians, bivalves, hydroids and sponges) (Firth *et al.*, 2014).
- **Pre-cast 'Bioblock' (Colwyn Bay, Conwy):** Following a principle similar to the Plymouth work, a 6 tonne pre-cast concrete cube (or 'Bioblock') with dimensions of 1.5x1.5x1.1 m was introduced to the rock armouring at Colwyn Bay in February 2012 (see Image 18). During the casting process a variety of micro-habitat features were introduced including rock pools and crevices varying diameters, depths and alignments. Monitoring of the 'Bioblocks' found they consistently supported greater species richness than adjacent boulders. Functional groups represented on the feature included algae, barnacles, shrimps, annelids, crabs, ctenophores and gastropods whilst those represented on the adjacent boulders included algae, barnacles and crabs (Firth *et al.*, 2014).
- **Drilled sea wall (Shaldon, Devon):** For the construction of new sea walls, features were introduced to enhance the surface roughness and to create pits and water-retaining features. These have resulted in a greater diversity of organisms occupying the engineered habitats when compared with the adjacent seawall<sup>5</sup>;

<sup>4</sup> Many of these have been undertaken under the umbrella of the 'Urbane' (Urban Research on Biodiversity on Artificial and Natural coastal Environments) project (<http://urbaneproject.org/project>) while others have been carried out as part of separate research and development initiatives. There are also further international examples such as in Australia (Browne and Chapman, 2014).

<sup>5</sup> <http://urbaneproject.org/project>

- **Attaching rock pools onto vertical sea walls** Bouldnor (Isle of Wight). To enhance the structural complexity and biodiversity of sea wall, a series of fluted 'sculptures' were attached to the wall in 2013<sup>6</sup>. These collected and retained water and became tidal pools.

These enhancement initiatives typically involve introducing objects or excavating pits to maximise the structural complexity of coastal structures and/or the roughness of their surfaces. This is based on the ecological premise that heterogeneity of the environment is essential for species co-existence, with structurally complex habitats offering a great variety of different microhabitats and niches (Firth *et al.*, 2012). In other words, these enhancements are designed to increase diversity on the basis that biodiversity is inherently greater where an environment includes multiple niches and refuges against predators and environmental stresses (Perkins *et al.*, 2015; Martins *et al.*, 2015).

Based on these considerations, Firth *et al.*, (2012) suggested that eco-engineering niches to enhance biodiversity should be undertaken at a variety of spatial scales. This should include roughness on a microscale (< 1 cm), surface heterogeneity such as pits and depressions on a small scale (< 5 cm) and refuges (such as crevices) and water retaining features (such as rock pools) on a medium scale (< 5 m). Granite blocks have been shown to support the greatest micro-scale colonization in comparison to concrete and limestone blocks (Coombes *et al.*, 2011).



Source: D. Roberts Urbane Website

**Image 18.** Bioblock positioned within rock armouring at Colwyn Bay

These projects are often undertaken for demonstration and not usually as a mitigation commitment to a specific development. However there are examples of work undertaken as legally-required mitigation and two such examples are:

- **Translocation of rocky 'skear' habitat (Morecambe, Lancashire):** for the rock armour breakwater and recharge project along the Morecambe frontage mitigation involved the restoration of an internationally-designated rocky shoreline habitat that would otherwise have been lost under the breakwater footprint (ABPmer 2008). In this case the rocky habitat which would have been lost was excavated, translocated and repositioned in front of the breakwater (see Image 19). This project successfully created a new stable skear habitat that became colonised by a typical assemblage of high shore epifaunal species (mussel and periwinkles) and was also used as mid-tide roost by waterbirds such as oystercatcher.

<sup>6</sup>

<http://www.ecclestonegeorge.co.uk/apps/blog/show/34140314-shelving-the-coast>



- **Creation of rock pools on the berth walls (Fishbourne, Isle of Wight):** For the implementation of a ferry access ramp at Fishbourne on the Isle of Wight (ABPmer 2016b) there is a planning requirement to install rock pool structures (similar to those used at Bouldner as described above) into the face of the berths concrete caissons. This is as mitigation for the loss of undesignated mudflat habitat. This work has not yet been implemented but will be undertaken in Spring 2017.



Image Source:: Lancaster City Council, March 2008

**Image 19. Breakwater at Morecambe with innovative rocky habitat mitigation area in front**

Overall, these projects have demonstrated that the geology of an artificial substratum can have a significant influence on the diversity and abundance of the colonizing community. In addition to these projects there will also be a range of other examples of mitigation being undertaken through a range of other methods which are less likely to be applicable at the Hafan y Môr. These include infilling of creek systems or the removal of intertidal structures to create new coastal habitat. However, further research is being undertaken into the feasibility of targeting the growth of particular desirable species on coastal defence structures. The results of this work may well be relevant in this case.

These projects and the wider research conducted in this field have demonstrated that introducing structural complexity into design can be valuable for enhancing biodiversity. For the work at Hafan y Môr it will be important to understand the value and effectiveness of these precedents and it will be necessary to consider further the extent to which they are required and the role that they might need to play in providing any required impact reduction.

## 4.3 Recommendations

This report has summarised the ecological characteristics of the area as well as identifying potential issues and scheme enhancement options. It is recommended as a next step that a meeting is held on site to consider issues relating specifically to the design of the work, the potential for mitigation and the implications for the planning application as well as any other key issues. It will also be important to engage with NRW in a pre-application process and begin the process of licencing/consenting.

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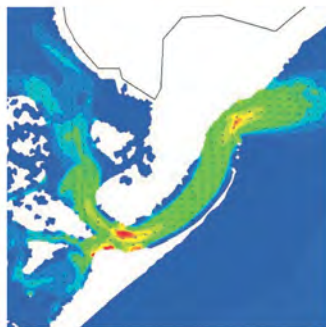
## 6 Abbreviations/Acronyms

|        |                                                                                        |
|--------|----------------------------------------------------------------------------------------|
| AA     | Appropriate Assessment                                                                 |
| BAP    | Biodiversity Action Plan                                                               |
| BSI    | British Standards Institution                                                          |
| CCW    | Countryside Council for Wales                                                          |
| EIA    | Environmental Impact Assessment                                                        |
| EMS    | European Marine Site                                                                   |
| ES     | Environmental Statement                                                                |
| EUNIS  | European Nature Information System                                                     |
| GIS    | Geographical Information System                                                        |
| GNSS   | Global Navigation Satellite System                                                     |
| GPS    | Global Positioning System                                                              |
| HRA    | Habitat Regulations Assessment                                                         |
| ISO    | International Organization for Standardization                                         |
| KMZ    | Keyhole Markup Language Zipped                                                         |
| MHWS   | Mean High Water Springs                                                                |
| NERC   | Natural Environment and Rural Communities                                              |
| NMBAQC | National Marine Biological Analytical Quality Control                                  |
| NRW    | Natural Resources Wales                                                                |
| NWIFCA | North Western Inshore Fisheries and Conservation Authority                             |
| ODN    | Ordnance Datum Newlyn                                                                  |
| OSGB   | Ordnance Survey Great Britain                                                          |
| OSnet  | Ordnance Survey - network of GNSS base stations covering Great Britain                 |
| OSPAR  | The Convention for the Protection of the Marine Environment of the North-East Atlantic |
| PMSL   | Precision Marine Survey Ltd                                                            |
| PSA    | Particle Size Analysis                                                                 |
| RTK    | Real-Time Kinematic                                                                    |
| SAC    | Special Area of Conservation                                                           |
| sp.    | Species                                                                                |
| SPA    | Special Protection Area                                                                |
| spp.   | Species (plural)                                                                       |
| SSSI   | Site of Special Scientific Interest                                                    |
| UK     | United Kingdom                                                                         |

Cardinal points/directions are used unless otherwise stated.

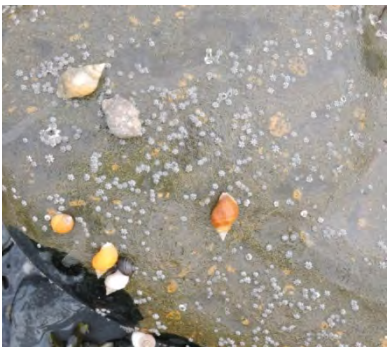
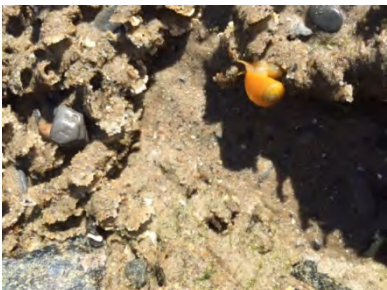
SI units are used unless otherwise stated.

# Appendices



Innovative Thinking - Sustainable Solutions

## A Species Recorded in the Surveys

| Image                                                                              | Species Name                                     | Image                                                                                | Species Name                                   | Image                                                                                 | Species Name                                                                                  |
|------------------------------------------------------------------------------------|--------------------------------------------------|--------------------------------------------------------------------------------------|------------------------------------------------|---------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|
|    | Snakelock anemone<br><i>Anemonia viridis</i>     |    | Dog whelk<br><i>Nucella lapillus</i>           |    | Honeycomb worm<br><i>Sabellaria alveolata</i><br>with serrated wrack<br><i>Fucus serratus</i> |
|   | Netted dog whelk<br><i>Nassarius reticulatus</i> |   | Common periwinkle<br><i>Littorina littorea</i> |   | Sand mason<br><i>Lanice conchilega</i>                                                        |
|  | Flat periwinkle<br><i>Littorina obtusata</i>     |  | Snakelock anemone<br><i>Anemonia viridis</i>   |  | Lugworm<br><i>Arenicola marina</i>                                                            |



| Image                                                                              | Species Name                                                           | Image                                                                                | Species Name                                                                                     | Image                                                                                 | Species Name                               |
|------------------------------------------------------------------------------------|------------------------------------------------------------------------|--------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|--------------------------------------------|
|    | Great scallop<br><i>Pecten maximus</i><br>(found alive in nearby pool) |    | <i>Sabellaria alveolata</i> encrusting rock with patches of serrated wrack <i>Fucus serratus</i> |    | Toad crab<br><i>Hyas coarctatus</i>        |
|    | Beadlet anemone<br><i>Actinia equina</i>                               |    | Sea potato<br><i>Echinocardium cordatum</i>                                                      |    | Greater pipefish<br><i>Syngnathus acus</i> |
|  | Common limpet<br><i>Patella vulgata</i><br>and top shells              |  | Kelp<br><i>Laminaria digitata</i><br>and Irish moss<br><i>Chondrus crispus</i>                   |  | Eelgrass<br><i>Zostera marina</i>          |

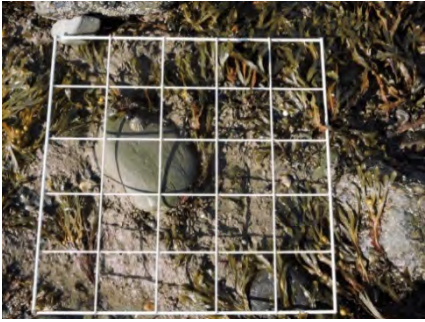
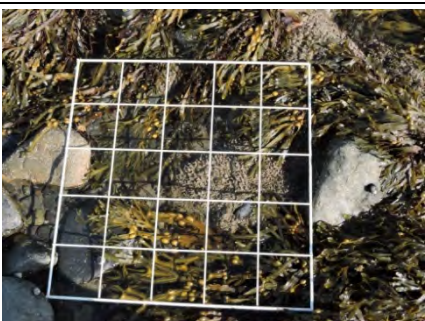
| Image                                                                             | Species Name                                     | Image                                                                                | Species Name                                                              | Image                                                                                 | Species Name                                  |
|-----------------------------------------------------------------------------------|--------------------------------------------------|--------------------------------------------------------------------------------------|---------------------------------------------------------------------------|---------------------------------------------------------------------------------------|-----------------------------------------------|
|   | Common starfish<br><i>Asteria rubens</i>         |    | Small spotted cat shark<br><i>Scyliorhinus canicula</i>                   |    | Breadcrumb sponge<br><i>Halichondria</i> spp. |
|   | Bloody Henry starfish<br><i>Henricia oculata</i> |    | Lichen zonation on rock<br>and patches of<br><i>Pelvetia canaliculata</i> |    | Risso's Crab<br><i>Xantho pilipes</i>         |
|  | Sand mason worm<br><i>Lanice conchilega</i>      |  | Knotted wrack<br><i>Ascophyllum nodosum</i>                               |  | Butterfish<br><i>Pholis gunnellus</i>         |

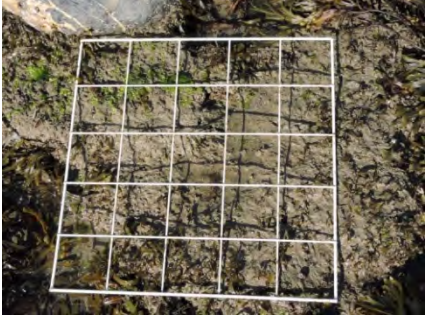
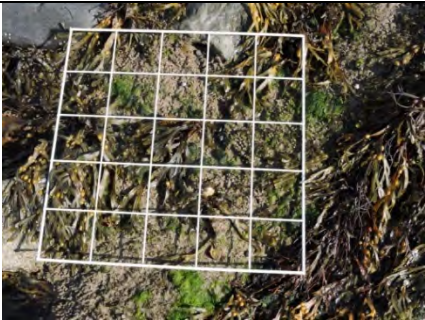
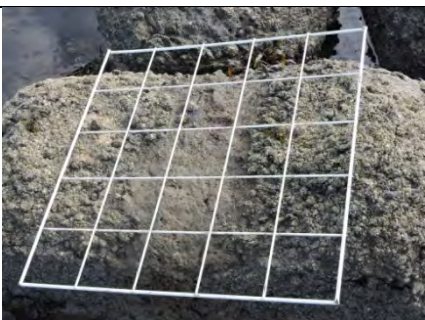
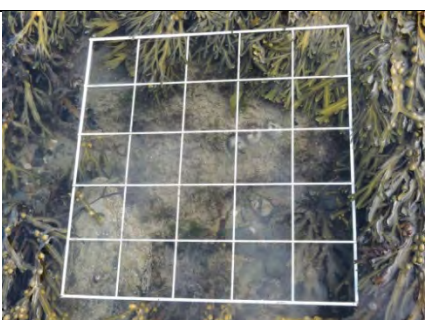


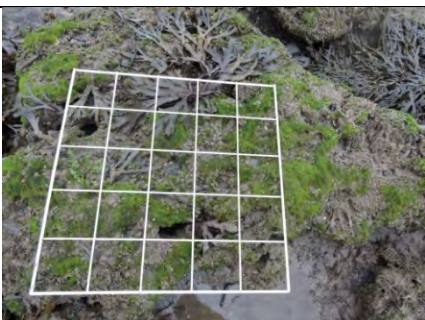
| Image                                                                              | Species Name                                     | Image                                                                                | Species Name                                                                                                              | Image                                                                                 | Species Name                            |
|------------------------------------------------------------------------------------|--------------------------------------------------|--------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|-----------------------------------------|
|    | Sea spider<br><i>Nymphon</i> sp                  |    | Long clawed<br>porcelain crab<br><i>Pisidia longicornis</i><br>with edible crab<br><i>Cancer pagurus</i><br>in background |    | Razorshell<br><i>Ensis</i> sp           |
|    | Spiny starfish<br><i>Marthasterias glacialis</i> |    | Bladder wrack<br><i>Fucus vesiculosus</i>                                                                                 |    | Juvenile Razorbill<br><i>Alca torda</i> |
|  | European Herring Gull<br><i>Larus argentatus</i> |  | Turnstone<br><i>Arenaria interpres</i>                                                                                    |  | Grey seal<br><i>Halichoerus grypus</i>  |



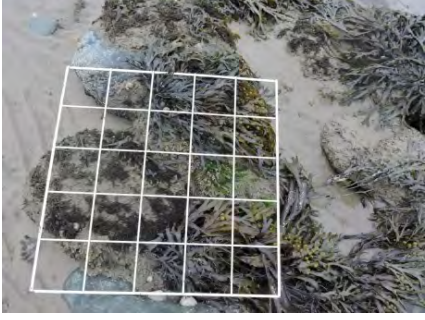
## B *Sabellaria aleveota* Quadrat Survey Results

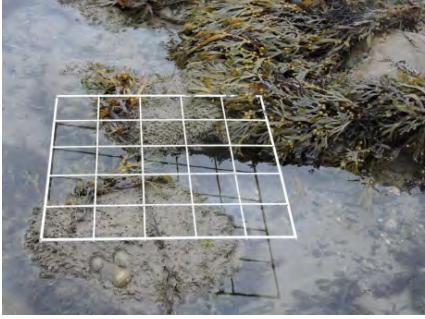
| Quadrat Number | Quadrat Image                                                                       | Total <i>Sabellaria</i> (%) | Formation (%) |       |         |      | Development/Health (%) |       |      |      |
|----------------|-------------------------------------------------------------------------------------|-----------------------------|---------------|-------|---------|------|------------------------|-------|------|------|
|                |                                                                                     |                             | Patchy        | Sheet | Hummock | Reef | New                    | Crisp | Worn | Dead |
| Q1             |    | 85                          |               | 100   |         |      |                        | 10    | 70   | 20   |
| Q2             |   | 30                          | 100           |       |         |      |                        | 30    | 70   |      |
| Q3             |  | 65                          |               | 100   |         |      |                        | 20    | 80   |      |
| Q4             |  | 20                          | 100           |       |         |      |                        | 80    | 20   |      |

| Quadrat Number | Quadrat Image                                                                       | Total <i>Sabellaria</i> (%) | Formation (%) |       |         |      | Development/Health (%) |       |      |      |
|----------------|-------------------------------------------------------------------------------------|-----------------------------|---------------|-------|---------|------|------------------------|-------|------|------|
|                |                                                                                     |                             | Patchy        | Sheet | Hummock | Reef | New                    | Crisp | Worn | Dead |
| Q5             |    | 100                         |               | 100   |         |      |                        |       | 30   | 70   |
| Q6             |   | 95                          |               | 100   |         |      |                        | 20    | 40   | 40   |
| Q7             |  | 25                          |               | 100   |         |      |                        |       | 100  |      |
| Q8             |  | 65                          | 100           |       |         |      |                        | 30    | 70   |      |
| Q9             |  | 90                          |               | 100   |         |      |                        |       | 60   | 40   |

| Quadrat Number | Quadrat Image                                                                       | Total <i>Sabellaria</i> (%) | Formation (%) |       |         |      | Development/Health (%) |       |      |      |
|----------------|-------------------------------------------------------------------------------------|-----------------------------|---------------|-------|---------|------|------------------------|-------|------|------|
|                |                                                                                     |                             | Patchy        | Sheet | Hummock | Reef | New                    | Crisp | Worn | Dead |
| Q10            |    | 65                          |               |       |         | 100  |                        | 60    | 40   |      |
| Q11            |   | 95                          |               |       |         | 100  |                        | 60    | 40   |      |
| Q12            |  | 100                         |               |       |         | 100  |                        | 20    | 80   |      |
| Q13            |  | 95                          |               |       |         | 100  |                        | 70    | 30   |      |
| Q14            |  | 50                          | 100           |       |         |      | 20                     | 80    |      |      |



| Quadrat Number | Quadrat Image                                                                       | Total <i>Sabellaria</i> (%) | Formation (%) |       |         |      | Development/Health (%) |       |      |      |
|----------------|-------------------------------------------------------------------------------------|-----------------------------|---------------|-------|---------|------|------------------------|-------|------|------|
|                |                                                                                     |                             | Patchy        | Sheet | Hummock | Reef | New                    | Crisp | Worn | Dead |
| Q15            |    | 50                          | 100           |       |         |      |                        |       | 100  |      |
| Q16            |   | 60                          |               | 100   |         |      | 5                      | 20    | 50   | 25   |
| Q17            |  | 65                          |               | 100   |         |      |                        | 50    | 50   |      |
| Q18            |  | 90                          |               | 100   |         |      |                        |       | 100  |      |
| Q19            |  | 85                          |               | 100   |         |      |                        | 10    | 90   |      |

| Quadrat Number | Quadrat Image                                                                       | Total <i>Sabellaria</i> (%) | Formation (%) |       |         |      | Development/Health (%) |       |      |      |
|----------------|-------------------------------------------------------------------------------------|-----------------------------|---------------|-------|---------|------|------------------------|-------|------|------|
|                |                                                                                     |                             | Patchy        | Sheet | Hummock | Reef | New                    | Crisp | Worn | Dead |
| Q20            |    | 50                          | 100           |       |         |      |                        | 20    | 50   | 30   |
| Q21            |   | 95                          |               | 100   |         |      |                        |       | 100  |      |
| Q22            |  | 90                          | 100           |       |         |      |                        | 30    | 70   |      |
| Q23            |  | 100                         |               |       |         | 100  | 10                     | 75    | 15   |      |

## C Benthic Invertebrate Laboratory Results

| Taxonomic Group                   | Taxa                            | Site B1 | Site B2 | Site B3 | Site B4 | Site B5 |
|-----------------------------------|---------------------------------|---------|---------|---------|---------|---------|
| Oligochaete worms                 | <i>Tubificoides benedii</i>     |         |         |         |         | 2       |
| Polychaete worms                  | <i>Glycera capitata</i>         |         |         |         |         | 1       |
|                                   | <i>Nephtys cirrosa</i>          | 3       | 3       | 1       |         |         |
|                                   | Nephtyidae                      |         |         |         |         | 1       |
|                                   | Nephtyidae                      |         |         |         |         | p       |
|                                   | <i>Nereis zonata</i>            |         |         |         |         | 13      |
|                                   | <i>Pholoe inornata</i>          |         |         |         |         | 3       |
|                                   | <i>Eteone</i>                   |         |         |         |         | 1       |
|                                   | <i>Mysta picta</i>              |         |         |         |         | 1       |
|                                   | <i>Phyllodoce mucosa</i>        |         |         |         |         | 1       |
|                                   | Harmothoe                       |         |         |         |         | 1       |
|                                   | <i>Owenia fusiformis</i>        |         |         |         |         | 1       |
|                                   | <i>Spirobranchus lamarcki</i>   |         |         |         |         | 1       |
|                                   | <i>Magelona johnstoni</i>       |         |         |         |         | 2       |
|                                   | <i>Euclymene oerstedii</i>      |         |         |         |         | p       |
|                                   | <i>Polyopthalmus pictus</i>     |         |         |         | 3       | 23      |
| Crustacea                         | <i>Bathyporeia pilosa</i>       |         |         | 1       |         |         |
|                                   | <i>Crassikorophium bonellii</i> |         |         |         |         | 1       |
|                                   | <i>Dexamine spinosa</i>         |         |         |         |         | 3       |
|                                   | <i>Hyale stebbingi</i>          |         |         |         |         | 3       |
|                                   | Isaeidae                        |         |         |         |         | 1       |
|                                   | <i>Bodotria pulchella</i>       |         |         | 1       |         |         |
|                                   | <i>Idotea pelagica</i>          |         |         |         |         | 1       |
|                                   | Sphaeromatidae                  |         |         |         | p       |         |
| Arthropoda                        | <i>Anoplodactylus pygmaeus</i>  |         |         |         |         | 2       |
| Tunicata                          | <i>Asciidiella aspersa</i>      |         |         |         |         | 2       |
| Ophiuroidea                       | <i>Amphiura chiajei</i>         |         |         |         |         | 2       |
|                                   | Ophiuroidea                     |         |         |         |         | 1       |
| Bivalves                          | <i>Parvicardium pinnulatum</i>  |         |         |         |         | 1       |
|                                   | <i>Donax vittatus</i>           |         | 1       |         |         |         |
|                                   | <i>Fabulina fabula</i>          |         |         | 1       |         | 1       |
|                                   | <i>Spisula elliptica</i>        |         |         |         |         | 1       |
| Gastropods                        | <i>Bittium reticulatum</i>      |         |         |         |         | 1       |
|                                   | <i>Rissoa lilacina</i>          |         |         |         |         | 8       |
|                                   | <i>Rissoa parva</i>             |         |         |         |         | 31      |
|                                   | <i>Leptochiton asellus</i>      |         |         |         |         | 1       |
|                                   | Nematoda                        |         |         |         |         | 3       |
|                                   | <i>Sycon ciliatum</i>           |         |         |         |         | p       |
| Porifera                          | <i>Ceramium</i>                 |         |         |         |         | p       |
| Red algae                         | <i>Nemalion elminthoides</i>    |         |         |         |         | p       |
|                                   | Total number of taxa            | 1       | 2       | 4       | 2       | 30      |
| Total abundance                   |                                 | 3       | 4       | 4       | 3       | 114     |
| Total abundance (m <sup>2</sup> ) |                                 | 428     | 571     | 571     | 428     | 16279   |
| P = Present                       |                                 |         |         |         |         |         |



## D PSA Laboratory Results

| Sample                                       | Parameter                                    | Site B1                  | Site B2                                | Site B3                                     | Site B4                             | Site B5                           |
|----------------------------------------------|----------------------------------------------|--------------------------|----------------------------------------|---------------------------------------------|-------------------------------------|-----------------------------------|
| Sample Type:                                 |                                              | Unimodal,<br>Well Sorted | Unimodal,<br>Moderately<br>Well Sorted | Unimodal,<br>Well Sorted                    | Polymodal,<br>Very Poorly<br>Sorted | Bimodal,<br>Very Poorly<br>Sorted |
| Textural Group                               |                                              | Sand                     | Slightly<br>Gravelly<br>Sand           | Slightly<br>Gravelly<br>Sand                | Sandy<br>Gravel                     | Gravelly<br>Sand                  |
| Sediment<br>Name                             |                                              | Well Sorted<br>Fine Sand | Slightly Fine<br>Gravelly Fine<br>Sand | Slightly Very<br>Fine Gravelly<br>Fine Sand | Sandy<br>Coarse<br>Gravel           | Coarse<br>Gravelly Fine<br>Sand   |
| Folk and Ward<br>method<br>( $\mu\text{m}$ ) | Median Grain Size $D_{50}$ ( $\mu\text{m}$ ) | 209.8                    | 138.73                                 | 151.96                                      | 561.0                               | 163.0                             |
|                                              | Mean Grain Size ( $\mu\text{m}$ )            | 209.2                    | 138.76                                 | 152.6                                       | 1112.3                              | 756.7                             |
|                                              | Sorting                                      | 1.371                    | 1.419                                  | 1.34                                        | 8.373                               | 9.640                             |
|                                              | Skewness                                     | -0.007                   | -0.004                                 | 0.006                                       | 0.369                               | 0.803                             |
|                                              | Kurtosis                                     | 0.941                    | 1.011                                  | 1.067                                       | 0.647                               | 0.459                             |
| Folk and Ward<br>method<br>( $\phi$ )        | Median Grain Size $D_{50}$ ( $\phi$ ):       | 2.253                    | 2.850                                  | 2.718                                       | 0.834                               | 2.617                             |
|                                              | Mean Grain Size ( $\phi$ ):                  | 2.257                    | 2.849                                  | 2.712                                       | -0.154                              | 0.402                             |
|                                              | Sorting                                      | 0.455                    | 0.505                                  | 0.422                                       | 3.066                               | 3.269                             |
|                                              | Skewness                                     | 0.007                    | 0.004                                  | -0.006                                      | -0.369                              | -0.803                            |
|                                              | Kurtosis                                     | 0.941                    | 1.011                                  | 1.067                                       | 0.647                               | 0.459                             |
| Folk and Ward<br>method<br>(Description)     | Mean                                         | Fine Sand                | Fine Sand                              | Fine Sand                                   | Very Coarse<br>Sand                 | Coarse Sand                       |
|                                              | Sorting                                      | Well Sorted              | Moderately<br>Well Sorted              | Well Sorted                                 | Very Poorly<br>Sorted               | Very Poorly<br>Sorted             |
|                                              | Skewness                                     | Symmetrical              | Symmetrical                            | Symmetrical                                 | Very Coarse<br>Skewed               | Very Coarse<br>Skewed             |
|                                              | Kurtosis                                     | Mesokurtic               | Mesokurtic                             | Mesokurtic                                  | Very<br>Platykurtic                 | Very<br>Platykurtic               |
| Bulk Grain Size                              | % Gravel                                     | 0.000                    | 1.864                                  | 0.008                                       | 38.054                              | 28.310                            |
|                                              | % Sand                                       | 100.000                  | 97.927                                 | 99.992                                      | 58.396                              | 71.377                            |
|                                              | % Mud                                        | 0.000                    | 0.209                                  | 0.000                                       | 3.550                               | 0.312                             |
|                                              | % Very Coarse Gravel                         | 0.000                    | 0.000                                  | 0.000                                       | 0.000                               | 0.000                             |
|                                              | % Coarse Gravel                              | 0.000                    | 0.000                                  | 0.000                                       | 17.720                              | 25.923                            |
|                                              | % Medium Gravel                              | 0.000                    | 0.641                                  | 0.000                                       | 6.222                               | 0.055                             |
|                                              | % Fine Gravel                                | 0.000                    | 0.851                                  | 0.000                                       | 9.345                               | 1.601                             |
|                                              | % Very Fine Gravel                           | 0.000                    | 0.372                                  | 0.008                                       | 4.767                               | 0.732                             |
|                                              | % Very Coarse Sand                           | 0.048                    | 0.492                                  | 0.175                                       | 2.700                               | 0.382                             |
|                                              | % Coarse Sand                                | 0.011                    | 0.000                                  | 0.000                                       | 11.507                              | 0.000                             |
|                                              | % Medium Sand                                | 27.084                   | 1.875                                  | 2.313                                       | 13.413                              | 0.962                             |
|                                              | % Fine Sand                                  | 70.034                   | 57.590                                 | 75.135                                      | 20.529                              | 42.404                            |
|                                              | % Very Fine Sand                             | 2.823                    | 37.970                                 | 22.369                                      | 10.247                              | 27.629                            |
|                                              | % Very Coarse Silt                           | 0.000                    | 0.209                                  | 0.000                                       | 0.390                               | 0.183                             |
|                                              | % Coarse Silt                                | 0.000                    | 0.000                                  | 0.000                                       | 1.340                               | 0.009                             |
|                                              | % Medium Silt                                | 0.000                    | 0.000                                  | 0.000                                       | 0.947                               | 0.080                             |
|                                              | % Fine Silt                                  | 0.000                    | 0.000                                  | 0.000                                       | 0.720                               | 0.040                             |
|                                              | % Very Fine Silt                             | 0.000                    | 0.000                                  | 0.000                                       | 0.154                               | 0.000                             |
|                                              | % Clay                                       | 0.000                    | 0.000                                  | 0.000                                       | 0.000                               | 0.000                             |

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