ACA Pen Llŷn a'r Sarnau SAC

Prosiect Morwellt Porthdinllaen Seagrass Project

Samplu Gwaddodion Craidd Hydref 2012, dadansoddi data

Sediment Core Sampling October 2012, data analysis

2012

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Adroddiad wedi darparu ar gyfer ACA Pen Llŷn a'r Sarnau / A report prepared for the Pen Llŷn a'r Sarnau SAC

Publication date: October 2012

Contract number: AS 410187 / NWS2486

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Title: **Porthdinllaen seagrass project (Pen Llŷn a'r Sarnau SAC) - Sediment Core Sampling October 2012, summary report**

Author(s): **T. Stamp**

Restrictions: Unrestricted

Cover photograph: Burrowing shrimp (probably *Upogebia* sp.) collected in the cores at some locations

Recommended citation for this volume:

Stamp (2012). **Porthdinllaen seagrass project (Pen Llŷn a'r Sarnau SAC) - Sediment Core Sampling October 2012, data analysis.** A report to Gwynedd Council.

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Ar 10fed Hydref 2012, aeth plymwyr i gymryd samplau craidd o'r gwaddod a'r isfilod yn y môr ym Mhorthdinllaen, gogledd Cymru. Diben hyn oedd cynorthwyo i reoli'r gwely o forwellt (*Zostera marina)* sydd yno, ac sydd wedi'i restru fel nodwedd pwysig o dan Reoliad 35 Ardal Cadwraeth Arbennig Pen Llŷn a'r Sarnau. Cafodd y samplau eu cymryd o dyllau yng ngwely'r morwellt lle nad oedd lystyfiant ac o fewn y 'creithiau' sydd wedi'u ffurfio gan yr angorfeydd yn yr harbwr allanol. Cafwydd cyfanswm o 24 o samplau isfilodaidd ac wyth sampl i ddadansoddi maint gronynnau'r gwaddod eu casglu o wyth fan samplo mewn gwahanol fannau yn yr harbwr, tri o wely'r morwellt, tri o fewn y 'creithiau' angori a dau o'r gwaddodion heb lystyfiant o'i amgylch. Prif nod yr arolwg oedd asesu a oes unrhyw wahaniaeth arwyddocaol rhwng y cymunedau isfilodaidd a nodweddion gwaddodion y tri math o gynefinoedd.

Canfuwyd fod yn sylweddol llai o isfilod, biomas ac amrywiaeth o rywogaethau yn y cynefinoedd a ffurfiwyd yng nghreithiau'r angorfeydd nac yn y mathau eraill o gynefin. Yng nghynefiin y morwellt yr oedd y mwyaf o isfilod a biomas ac yr oedd yno gymaint o amrywiaeth o rywogaethau isfilod ag yn y cynefin gwaddodion. Canfuwyd mai nifer fechan o 'taxa' (grŵp neu grwpiau o boblogaethau o organebau) oedd fwyaf cyffredin ym mhob un o'r gwahanol fathau o gynefinoedd ac felly nad oedd yna wahaniaeth yn yr amrywiaeth cymesurol rhwng y gwahanol fathau o gynefinoedd, ond, fel y nodir uchod, roedd y gymuned isfilodaidd gryn dipyn yn helaethach yng nghynefin y morwellt ac roedd yno ragor o fiomas yn gyffredinol nag y y mathau eraill o gynefinoedd.

Er na ellid canfod unrhyw wahaniaeth arwyddocaol yn nodweddion y gwaddodion rhwng y gwahanol fathau o gynefin, roedd y gwaddodion yng nghynefinoedd creithiau'r angorfeydd a'r cynefinoedd gwaddodion yn frasach yn gyffredinol nag yng nghynefin y morwellt, sylw a wnaed gan awduron eraill. Ymhellach, gwelwyd mai'r mwyaf o waddodion bras, megis gro oedd yno y lleiaf o isfilod oedd yn bresennol. Cofnododd adroddiadau blaenorol o harbwr allanol Porthdinlaen fod hyd at 45 o angorfeydd yn yr harbwr allanol. Dywedir fod angorfeydd yr harbwr allanol yn cael eu symud bob tymor ac yn cael eu hail osod mewn mannau gwahanol yn yr harbwr allanol, ac efallai fod rhagor o angorfeydd yn cael eu gosod yno erbyn hyn. Mae'r angorfeydd fel pe baen nhw'n sgwrio neu'n creithio gwely'r môr ac mae'r creithiau yn yr harbwr allanol yn fwy tebygol o gynnwys cyfran helaethach o waddodion brasach. Gallai hynny arwain at gyfran lai o isfilod, yn ogystal ag at lai o fiomas ac amrywiaeth. Gallai'r fath golled o fioamrywiaeth yn yr ardal arwain at gynnydd yn y maetholion a gallai hynny effeithio ar allu gwely'r morwellt i gynnal rhywogaethau masnachol bwysig megis crancod a chimychiaid a physgod esgyll.

Er bod canlyniadau'r adroddiad hwn wedi dangos fod y gwely *Z marina* ym Mhortdinllaen yn cynnal cymuned isfilodaidd llawer cyfoethocach nag sydd yn y gwaddodion o'i amgylch nac yn y creithiau angorfeydd ar y gwely, mae'n amlwg efallai nad yw'r gwaith samplo yn yr astudiaeth hon wedi gallu darganfod perthynas uniongyrchol rhwng nodweddion y gwaddodion ac amrywiaeth y rhywogaethau, na chwaith berthynasau penodol rhwng mathau o gynefinoedd. Os bydd unrhyw arolygon o'r fath yn cael eu cynnal yn y dyfodol, dylid defnyddio dyluniad samplo llawer mwy trwyadl.

1 SUMMARY

On the 10th October 2012, diver deployed sediment and infaunal core sampling was undertaken within Porthdinllaen, North Wales. These were conducted to aid in the management of the seagrass bed (*Zostera marina*) present, listed as an important feature under Regulation 35 for the Pen Llŷn a'r Sarnau Special Area of Conservation. Cores were extracted from within the seagrass bed, adjacent unvegetated sediment and within "scars" created by the moorings present within the outer harbour. A total of 24 infaunal cores and eight cores for particle size analysis were collected at eight sampling stations across the harbour; three within the seagrass bed, three within mooring "scars", and two within the surrounding unvegetated sediment. The principal aim of this survey was to assess any significant difference between the infaunal communities and sediment characteristics of these three habitat types.

The mooring scar habitat was found to have a significantly lower infaunal abundance, biomass and diversity (S) than any of the other habitat types. The seagrass habitat was found to have the highest infaunal abundance and biomass, however the infaunal diversity (S) of the seagrass bed was found to be equal to that of the sediment habitat. All habitat types were found to be dominated by a small number of taxa and as such the proportional diversity was not found to between the habitat types however, as mentioned above, the infaunal community within the seagrass habitat was significantly more abundant and had a higher overall biomass than any of the other habitat types.

Although no significant difference could be detected in the sediment characteristics between the habitat types, the mooring scar and sediment habitat types were typically dominated by coarser sediments than the seagrass, an observation made by other authors. Furthermore the presence of coarse sediments, such as gravel, was found to have a negative correlation with the infauna abundance. Previous reports within Porthdinllaen outer harbour have recorded a maximum of 45 moorings within the outer harbour. The outer harbour moorings are also reportedly removed seasonally and replaced in different locations within the outer harbour, and the total number of moorings may be increasing over time. Moorings have a scouring effect on the seabed that is likely to result in an increase the proportion of coarser sediments within mooring scars in the outer harbour and which may subsequently result in a decreased infaunal abundance, as well as decrease the biomass and diversity. Such a loss of biodiversity within the area could feed into the higher trophic levels and may have impacts on the seagrass bed's ability to support commercially important crustacean and fin fish species.

Although the results of this report have highlighted that the *Z.marina* bed within Porthdinllaen supports a much richer infaunal community than the surrounding sediments and the mooring scars within the bed, it is apparent that the sampling effort used within this study may not have been adequate to detect relationships between the sediment characteristics and species diversity, plus species specific relationships between habitat types. If any future survey work of this type were to be conducted within the future a more rigorous sampling design should be employed.

2 INTRODUCTION

As part of the management of the Pen Llŷn a'r Sarnau Special Area of Conservation (SAC), the SAC Officer has been working with the National Trust, local fishermen, boat owners and others to look at options to reduce the impact of moorings on the seagrass (*Zostera marina*) bed at Porthdinllaen, North Wales. In October 2012 Marine Ecological Solutions Ltd. (Marine EcoSol) was contracted by the Countryside Council for Wales (CCW) to undertake sediment coring at 9 stations within Porthdinllaen outer harbour (Project Officer Lucy Kay, contract NWS2486). The coring was a component of a broader programme of studies being undertaken as part of the overall seagrass project to improve understanding of the biology and ecology of the seagrass bed at Porthdinllaen.

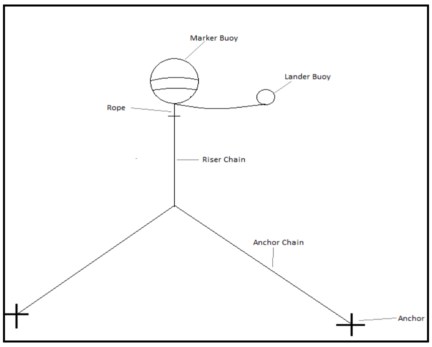


Figure 1: Two Anchor Mooring Design within Porthdinllaen Outer Harbour.

In peak season of 2012 45 moorings were recorded within the outer harbour at Porthdinllaen. The mooring designs are largely based on that illustrated within Figure 1: two anchor chains are linked to a central rising chain which is attached to a marker & landing buoys on the water's surface. The lengths of both the rising and anchor chains are dependent on the weight of the resident vessel and the depth in which the mooring is deployed. Due to the use of Porthdinllaen by both a variety of pleasure craft and commercial fishing vessels, the size of each mooring, and hence the degree of scarring surrounding each mooring is variable across Porthdinllaen outer harbour.

Traditional mooring designs, such as those at Porthdinllaen, are known to interact with the surrounding benthic (seabed) habitats through the sweeping action of the rising chain (Egerton 2011), as the surface marker buoy rises and falls during each tidal cycle and are moved by the prevailing tidal currents. This sweeping action scours the surrounding seabed habitats, creating distinct "scars" within the seagrass bed and altering the species composition of the seabed habitat (Egerton 2011). The presence of seagrass supports many marine epifauna and floral species (Connolly 1994, Milazzo *et al.* 2004, URL[1]: Marlin 2012), and there is also strong evidence to suggest that the presence of seagrass influences the community within the seabed sediment (infaunal community) (Webster *et al.* 1998) due to the presence of the seagrass rhizomes which act to stabilize, add structural complexity to, and increase oxygen transport within marine sediments (Webster *et al.* 1998, Milazzo *et al.* 2004).

Within the mooring scars at Porthdinllaen rhizome density may be reduced (Milazzo *et al.* 2004) and therefore the influence of the seagrass on the sediments would be reduced or removed. Supporting the comments from the scientific literature are diver observations from Porthdinllaen which indicate that the lack of seagrass and rhizomes, in combination with the scarring action of the chain, potentially result in a lack of fine sediments in the area immediately surrounding moorings (Morris, *pers. comm*., 2012). As a result the infaunal community within mooring scar zones may be more similar to that of surrounding unvegetated sediments, than that of adjacent areas of dense seagrass despite a small spatial scale.

Aims and Objectives

The 2012 diver sediment coring was conducted at Porthdinllaen to investigate the influence of the mooring scars and seagrass on the sediment infauna and sediment characteristics. Cores were collected from within mooring scars, from dense areas of seagrass beds, and also from nearby areas of sediment where neither mooring scars nor seagrass were present (Stamp 2012).

The current report is an analysis of the infauna and particle size composition found in cores following laboratory analysis by Thomson Ecology Ltd. Statistical analyses were performed to better understand the habitats of Porthdinllaen and determine the following:

1. Characterise the sediment and infauna of the mooring scar areas, the seagrass bed (where there is good seagrass cover), and the sediment away from the seagrass bed and scar areas;
2. Determine whether there are any discernible differences between the infauna and sediment composition of the different habitats where the samples were collected, and
3. Determine whether the differences can be attributed to specific environmental parameters.

3 PRACTICAL METHODS

The location of representative sampling stations for the sediment cores was determined using the results of previous seagrass surveys undertaken by Marine EcoSol, CCW and volunteers (2008, 2009, 2010 and 2012) (Morris *et al.* 2008a & 2008b, Morris *et al*. 2009, Egerton 2011) (Figure 4). The 3 target habitat types for the sediment cores were:

1- Mooring scar (M),
2- Dense seagrass bed (SS),
3- Sediment with no seagrass shoots, outside of the moorings (S).

As previous data did not indicate suitable sediment sites where no seagrass was present, ad hoc searching for appropriate sample sites for this habitat type was adopted, at depths appropriate to seagrass. All sampling was conducted by divers.

All diving activity was conducted by a fully qualified and endorsed HSE professional scuba team operating under the Diving at Work regulations 1997 and following advice of the Scientific and Archaeological Approved Code of Practise. Marine Ecological Solutions was the appointed diving contractor. All diving was undertaken from a Maritime & Coastguard Agency (MCA) coded diving support vessel. Diving project plans were submitted to CCW, Gwynedd Council and the HSE prior to the day of diving. Each diver was equipped with through water voice communications, carried a surface marker buoy and alerted the surface team when and where sampling was conducted. Sampling sites were marked with a hand-held Garmin Map60 GPS (using WGS 84 as the datum).

At each sampling station descriptive notes were made on the depth, sediment characteristics and dominant epifauna/flora present within an approximate 3m radius around the core sampling area (Brazier 2001, Marine Monitoring Handbook Procedural Guideline No 3-8). In adaptation of the guidelines and with CCW's advice the following cores were taken within an area of $1m^2$ at each sampling station:

* Three infauna sub-sample cores ($0.0014\ m^3$), see Figure 2.
* One sediment core ($0.00057\ m^3$) for Particle Size Analysis (PSA), see Figure 3.

All cores were individually sealed in zip lock plastic bags and transported to the surface. The infauna samples were treated and stored separately by sieving each sample through a 0.5mm mesh on deck of the support vessel, and transferring the remaining material in the sieve to an appropriately marked container and preserving it with 4% formalin. A previous infauna sample from the Porthdinllaen seagrass bed indicated that there may be a number of fragile infauna species present in the sediment so care was taken when sieving the infauna samples to try and reduce damage to the species in the sample. PSA sediment cores were sealed within zip-lock bags, transported to the surface and transferred to a container.

Figure 2: Infaunal core used for collection of sediment cores at Porthdinllaen on 10/10/2012. Core Diameter: 11cm, Core Penetrating Depth: 15cm, Core Volume: 0.0014 m3

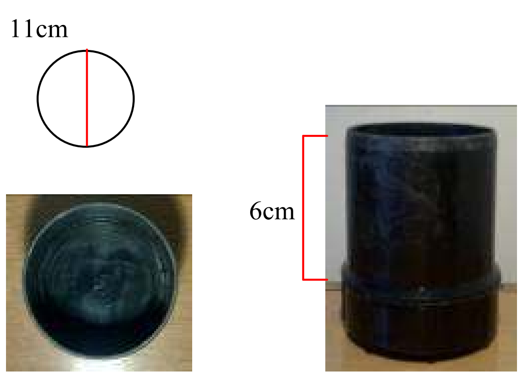


Figure 3: Sediment core used for collection of PSA samples at Porthdinllaen on 10/10/2012. Core Diameter:11cm, Core Penetrating Depth: 6cm, Core Volume: 0.00057 m3

Sampling effort

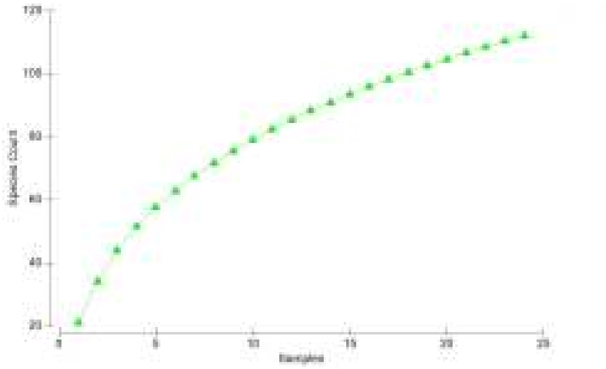


Figure 4: Species accumulation plot relating the number of species to the number of samples collected within the current project.

A species accumulation plot was used to estimate whether the sampling effort used within the current project was adequate to sample diversity of Porthdinllaen outer harbour. Within a species accumulation plot the mean number of species of the smallest sampling size (1 sample) are plotted. Then all combinations of the next sample size are randomized and the mean cumulative number of species is calculated for the progressive sample sizes, until the maximum number of samples (Ugland *et al.* 2003). The output can be used to indicate an increase in species (y axis) will be detected with an increase in sampling effort (x axis). The curve begins steep as the dominant/common taxa are sampled within the initial samples, as the number of samples increases the number of new species will decrease per sample, and the species accumulation curve plateaus. Species accumulation plots can indicate whether the sampling effort employed within a survey was adequate based on the shape of the curve, however they can only be conducted post survey work or pre-existing data sets. As neither had been conducted within Porthdinllaen prior to this project Figure 4 can only be used to help aid future projects within the area.

The species accumulation plot for the Porthdinllaen infaunal data set (Figure 4) indicates that between 20-25 samples an additional 1 species will have been identified within each new sample. As a result of this observation it is deemed that the biodiversity of Porthdinllaen was not fully sampled within the current project and that more samples would be required to make a true assessment of the infauna communities present.

Analytical Methods

All infauna core samples were sieved over a 0.5mm sieve in situ, and immediately preserved within a 4% formalin solution. The infauna and sediment samples were then sent to Thompson Ecology Ltd for analysis. All Species/ Taxa were identified to the lowest taxonomic resolution possible, enumerated and wet weighed. Sediment characteristics were quantified using a laser diffraction technique which measured the percentage contribution of differing sediment grain size classifications to the total sediment sample at each sampling station.

Statistical methods

All sub-sample data were pooled at each of the sampling stations. Univariate statistical analyses were then conducted within the IBM SPSS statistical package to assess any differences in the infauna abundance, biomass and diversity between habitat types. All multivariate statistics were conducted within the Plymouth Routines in Multivariate Ecological Research (PRIMER) statistical package V5, to assess infauna community differences between the 3 habitat types;

1. Mooring Scar,
2. Sediment,
3. Seagrass

Infauna species were also collapsed to functional feeding groups, information regarding each species function feeding group was sourced from the Biological Traits Catalogue (BIOTIC, MarLIN 2006) of the Marine Life Information Network of Britain and Ireland, please refer to appendix 4 for a list of the criteria of each functional feeding group. If taxa were identified to too coarse a taxonomic resolution then they were placed within the "indet." functional feeding category.

Assessing substrate and habitat type

An Analysis of Similarity (ANOSIM) test was conducted on the available environmental data for each station (substrate composition from Particle Size Analysis). This aimed to test for statistically significant relationships between the proportional sediment grain size classifications between the sampling stations without the biological community data in order to characterise the habitats around moorings, in sediments without seagrass and in the Porthdinllaen seagrass bed itself. All data was normalised and condensed into a similarity matrix, defined by Euclidean distance. Data from each of the sampling stations were then assigned a "factor" (label) which was the name of the habitat within which the sample originated. This data was then displayed using a Multi Dimensional Scaling (MDS) Plot, and an ANOSIM testing was conducted. The ANOSIM test statistic "R" is scaled from 0-1. A value of 0 indicates there is no statistical difference between the habitats, a value of 1 indicates there is strongly significant difference between the habitats. ANOSIM is a permutation test, and outputs a percentage of how many times the R statistics is likely to have occurred due to chance, a high percentage output indicates the R statistic is not a valid output. The average sample grain size within each of the habitat was then compared using An Analysis of Variance (ANOVA). To test for a significant difference in average sediment grain size between habitat types an Analysis of Variance (ANOVA) and further Post Hoc Tukey testing were used on the data from each of the sampling stations. To test the data conformed to the assumptions of ANOVA, it was first tested for homogeneity of variance using a Levene's test. If the variation was found to be significantly variable between samples, the data were transformed to minimize the variation. If the data would still not conform to homogeneity of variance a non-parametric equivalent to ANOVA was used to test for a statistically significant difference between the habitat types, Kruskal-Wallis & Mann-Whitney U.

Describing the infaunal community and functional diversity.

The pooled infaunal abundance and biomass at each of the sampling stations were averaged for each of the habitat types.

The infaunal and functional feeding diversity at each of the sampling stations were calculated using the DIVERSE function within PRIMER, these values were also averaged for each habitat.

In order to assess the infaunal community and functional feeding diversity three measures of diversity were selected;

1. Species Richness (S); the number of species within each habitat.

2. Shannon Weiner (H'(loge))

3. Simpson's Index of Dominance ((1-Lambda')).

Shannon Weiner and Simpsons Index are proportional measures of diversity, relating the total number of species to the total number of individuals within each sample. Shannon Wiener is weighted to rare taxa whereas Simpson's Index is related to dominant taxa, as a result using both diversity indices will display differing information about the infaunal community of each habitat type

Environmental data from each sample, i.e. percentage sediment components for each sample and depth within which they were collected, were also averaged for each habitat. To test for a significant difference in both the infaunal and environmental variables between habitat types an Analysis of Variance (ANOVA) and further Post Hoc Tukey testing were used on the data from each of the sampling stations. To test the data conformed to the assumptions of ANOVA, it was first tested for homogeneity of variance using a Levene's test. If the variation was found to be significantly variable between samples, the data were transformed to minimize the variation. If the data would still not conform to homogeneity of variance a non-parametric equivalent to ANOVA was used to test for a statistically significant difference between the habitat types, Kruskal-Wallis & Mann-Whitney U.

Assessing the infaunal community and functional diversity.

Both the infaunal abundance and biomass data from each of the sampling stations were imported into PRIMER. Each sampling station was then assigned a "factor" (label), which was the name of the habitat within which the sample originated. In order to down weight the influence of low values within both the abundance and biomass data sets a square root transformation was applied to all data (Clarke & Gorley 2006).

The data sets were then analysed according to the protocol used by Field *et al.* (1982) and Clark & Ainsworth (1993), where by the data is distilled into similarity coefficients and biologically significant relationships are inferred from such coefficients. A Bray Curtis similarity matrix was created for both the infaunal abundance and biomass in order to compare (dis)similarity of the infaunal abundance and biomass between the three habitats. This variation was then visually displayed using Multi Dimensional Scaling (MDS) plots. MDS plots relate the variation between the samples spatially on a 2 dimensional space (Figure 7). Each MDS plot is displayed with a stress value, which is representation of the validity of the displayed data. Based on the stress value with each MDS plots and the spatial ordination of each sampling location in relation to those of the same habitat type, the variation within each habitat could be qualitatively described.

If ANOSIM testing highlighted a significant difference between the habitat types in terms of the infauna abundance or biomass a SIMPER analysis was then used to quantify which species contributed to the percentage dissimilarity between those habitat types. For the purposes of this report any species found to create greater than 5% dissimilarity between the habitats was highlighted and used as a distinguishing species for that habitat.

Determining whether community differences can be attributed to environmental parameters measured.

Using a BEST analysis environmental and biological data were correlated to highlight which of the environmental variables (such as depth or substrate type), best correlated to the infaunal community within the samples. A BEST analysis highlights which of the environmental variables/ combination of variables "BEST explains" the infaunal community. BEST analysis outputs a spearman's rank correlation *P* significance value for each variable/combination of, which indicates the degree of relatedness between the environmental and biological variables. If *P=0* there is no relatedness between the variables, if *P=1* there is a high relatedness (Clark & Gorley 2006). In order to validate the results the results of the best analysis further regression testing was used to test if any of outputs from the best analysis correlated to the abundance or biomass of those species found by SIMPER analysis to create a high difference between habitat types.

4 RESULTS

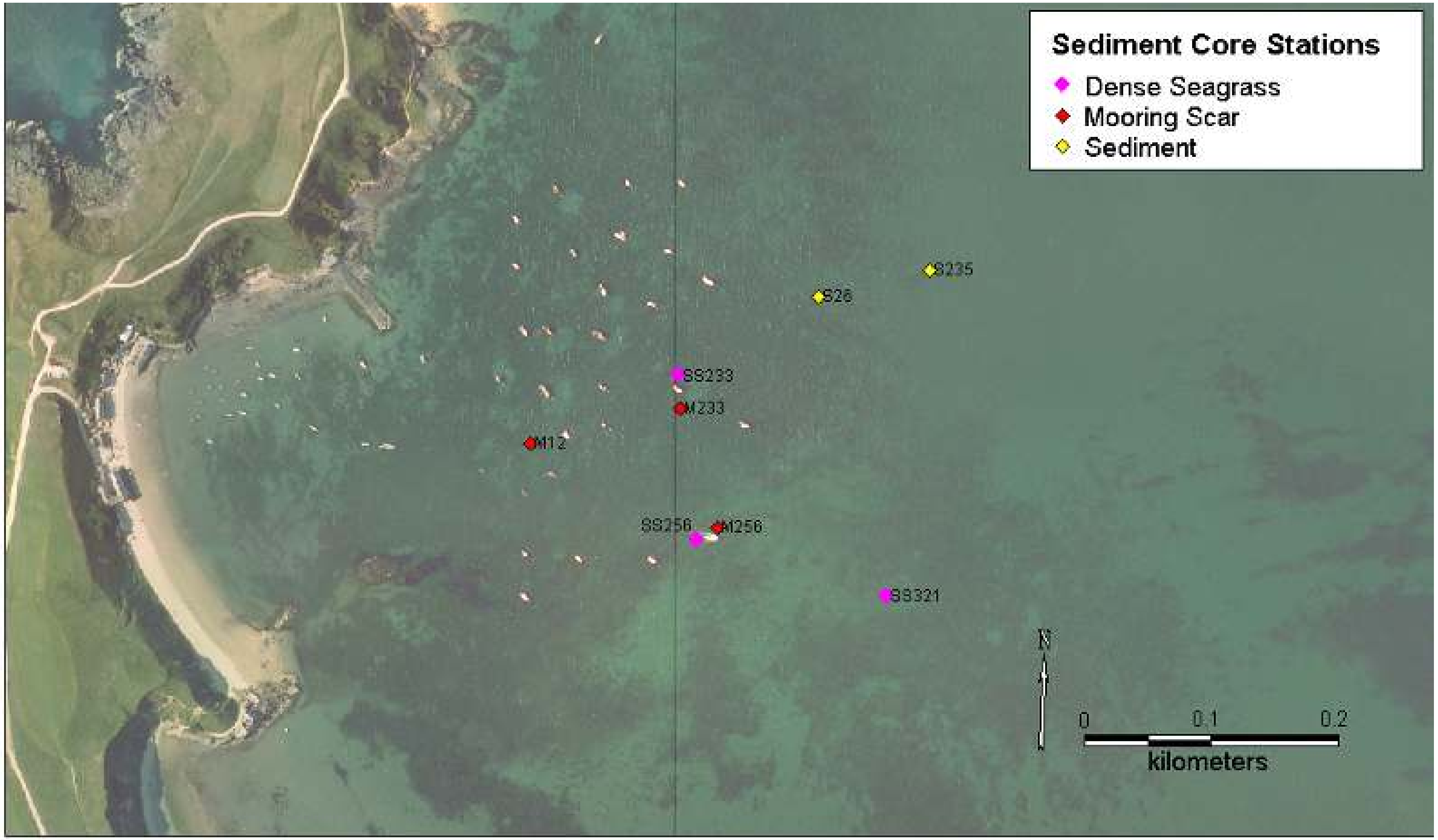


Figure 5: Map displaying sampling locations for Porthdinllaen sediment coring operations (10/10/2012). © This orthophotography has been produced by COWI A/S from digital photography captured by them in 2006. Licensed by the Welsh Government's Department for Environment to the Countryside Council for Wales.

24 infauna sub-sample and 8 sediment cores were collected by divers at Porthdinllaen on 10th October 2012. Station codes are displayed on the map in Figure 5. Samples were taken by scientific divers Harry Goudge, Jamie Ramday and Thomas Stamp, following Marine EcoSol Dive rules and under topside supervision of Liz Morris who was also responsible for sieving, storing and preserving the samples. Detail of diving operations is provided in Appendix 1.

Only two suitable sampling stations were located for sediment sites outside of mooring scars and without seagrass (labeled as sediment in Figure 5). Divers swam for long distances between SS321 and M256, and S26 in an attempt to locate sediments at suitable depths for seagrass to grow but without the presence of seagrass shoots or the impact of mooring. Seagrass was found to be patchy but extensive between SS321 and M256 and any sediment patches located in this area were too small for a rhizome free sampling station. For all other targeted habitats (dense seagrass & mooring scars) three separate stations were easily identified. Table 1 provides the GPS position and summary information for all sampling stations.

Table 1: Summary table of the sampling stations sampled within the Porthdinllaen sediment coring works of 10/10/2012.

Mooring ID	Habitat Type	Sediment description	JNCC Biotope Classification	Time	Latitude	Longitude	Depth BCD (m)
M12	Mooring Scar	Gravelly muddy sand	*SS.SMx.IMx**	17:45	52.9434	-4.5629	1.74
M233	Mooring Scar	Sandy gravel	*SS.SCS.ICS**	12:39	52.94368	-4.56115	3.1
M256	Mooring Scar	Sandy gravel	*SS.SCS.ICS**	14:40	52.94285	-4.56067	2.76
S26	Sediment	Sandy gravel	*SS.SCS.ICS.MoeVen*[/] *(U,W)*	10:10	52.94452	-4.55957	4.14
S235	Sediment	Sandy gravel	*SS.SCS.ICS.MoeVen*[/] *(U,W)*	11:10	52.94473	-4.55828	4.94
SS233	Seagrass Bed	Sandy gravel	*SS.SMp.SSgr.Zmar* + *SS.SCS.ICS.MoeVen*[/]	12:51	52.94392	-4.56118	3.07
SS256	Seagrass Bed	Gravelly sand	*SS.SMp.SSgr.Zmar* + *SS.SCS.ICS.MoeVen*[/]	15:38	52.94275	-4.5609	2.62
SS321	Seagrass Bed	Gravelly sand	*SS.SMp.SSgr.Zmar* + *SS.SCS.ICS.MoeVen*[/]	16:30	52.9424	-4.55865	3.29

During both sampling and statistical analyses it was noted that one large *Arctica islandica* was within station M233, the biomass of this individual (154.781g) accounted for 99.91% of the total biomass at that station. Due to the large skewing effect this was likely to have on both the Univariate and multivariate statistics, and the fact that only a single specimen of this species was found, not contributing greatly to the overall infauna community, it was removed from all the data sets.

A number of species were recorded as present within the abundance dataset. Excluding *Zostera marina*, the collective weight of these species accounted for 0.83% of the total biomass across all the samples, For the reason and due to a lack of quantifiable comparison between these and other species that were enumerated, they were omitted from the analysis within this report. For a list of these species please refer to data files associated with this report.

Sediment Characteristics between Habitat Types

Table 2: Sediment characteristics of 8 sampling stations within mooring scar, sediment and seagrass habitats, in Porthdinllaen Outer Harbour. Results taken from Particle Size Analyses of each station by Thomson Ecology, 2012. Sediment characteristics are displayed as the percentage contribution of each sediment size class to the total sediment sample. Descriptive statistics are also displayed for the mean grain size, Sorting, Skewness, Kurtosis, % Silt/Clay, plus a description of the over sediment type within each sample.

			Mooring Scar			**Sediment**		**Seagrass**		
Sediment*	**mm**	**phi**	**M12**	**M233**	**M256**	**S235**	**S26**	**SS233**	**SS256**	**SS321**
V. coarse gravel	>32<64	<-5>-6	0.00	8.76	6.25	0.00	12.42	3.51	7.53	0.00
Coarse gravel	>16<32	<-4>-5	0.00	20.90	16.54	1.05	14.34	8.24	1.02	0.82
Medium gravel	>8<16	<-3>-4	5.84	3.07	15.45	10.68	9.02	10.47	6.90	2.38
Fine gravel	>4<8	<-2>-3	8.68	3.57	11.67	11.95	6.04	13.97	3.26	1.47
V. fine gravel	>2<4	<-1>-2	5.84	1.93	4.54	11.41	2.63	5.44	0.93	0.98
V. coarse sand	>1<2	<0>-1	4.92	1.36	2.31	7.86	1.33	2.61	0.30	0.95
Coarse sand	>0.5<1	<1>0	10.00	8.36	5.10	17.90	7.68	9.37	4.06	2.60
Medium sand	>0.25<0.5	<2>1	26.97	35.68	21.83	26.03	26.90	27.97	31.41	13.00
Fine sand	>0.125<0.25	<3>2	18.88	16.25	15.25	10.88	18.07	15.85	35.92	48.48
V. fine sand	>0.0625<0.125	<4>3	5.77	0.12	1.05	0.95	1.58	1.36	8.19	28.81
V. coarse silt	>0.03125<0.0625	<5>4	3.47	0.00	0.00	0.37	0.00	0.75	0.11	0.51
Coarse silt	>0.015625<0.03125	<6>5	2.74	0.00	0.00	0.19	0.00	0.22	0.36	0.00
Medium silt	>0.007813<0.015625	<7>6	2.72	0.00	0.00	0.27	0.00	0.07	0.00	0.00
Fine silt	>0.003906<0.007813	<8>7	2.43	0.00	0.00	0.33	0.00	0.12	0.00	0.00
V. fine silt	>0.001953<0.003906	<9>8	1.37	0.00	0.00	0.14	0.00	0.04	0.00	0.00
Clay	<0.001953	>9	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Statistics	Mean (phi)		1.09	-0.54	-1.52	-0.06	-0.64	-0.23	0.59	2.56
	Sorting		2.80	2.84	2.82	2.04	2.95	2.54	2.76	1.24
	Skewness		-0.12	-0.68	0.20	-0.36	-0.54	-0.49	-0.68	-0.34
	Kurtosis		1.54	0.52	0.57	0.73	0.55	0.66	2.58	2.10
	% Silt/Clay		13.09	0.00	0.00	1.30	0.00	1.21	0.47	0.51
	Textural Group		*Gravelly Muddy Sand*	*Sandy Gravel*	*Sandy Gravel*	*Sandy Gravel*	*Sandy Gravel*	*Sandy Gravel*	*Gravelly Sand*	*Gravelly Sand*

* GRADISTAT classification system (Blott, S. J. & Pye, K., 2001). ** Folk & Ward

With each sediment sample a wide range of differing grain size categories were found, furthermore the proportion of each sediment grain size classification to 100% of the sediment sample differed between sampling stations (Figure 6). All sediment samples from the mooring scar, sediment habitats plus one seagrass sampling station, SS233, were dominated by the "medium sand" grain size classification. The remaining two sampling stations within seagrass habitat, SS256 & SS321, were dominated by the smaller "fine sand" grain size classification. SS256 & SS321 also had a higher proportion of the "very fine sand" grain size classification than any of the other sampling stations. In general the sampling stations within the mooring scar and sediment habitats had a higher proportion of coarser sediment than those of the seagrass habitat. An exception to this rule was sampling station M12, Mooring Scar habitat, which although dominated by "medium sand" had a larger proportion of finer sediment then any of other mooring scar and sediment habitats, which is displayed within Table 2, textural group section showing M12 to be typified by Gravelly Muddy Sand.

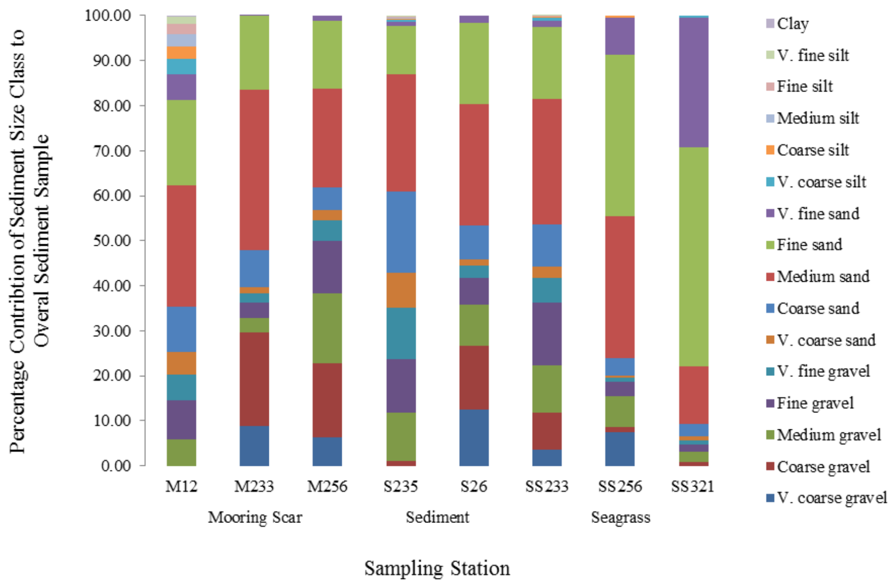


Figure 6: The percentage contribution of different sediment grain size classifications to each of the sediment samples of 8 sampling stations within mooring scar, sediment and seagrass habitats sampled in Porthdinllaen Outer Harbour.

No statistically significant difference could be detected between the sediment characteristics of each habitat type (ANOSIM, R=-0.156, P=86.8%), nor could any significant difference be detected for the mean grain size between habitat types (ANOVA, d,f=2,7, F= 0946, P= 0.448). Visual assessment of sampling station similarity (Figure 7), in terms of the proportional sediment composition at each, shows that as mentioned above the finer particles within sampling station M12 have distinguished M12 from all others sampling stations, including those of the same habitat type (Mooring Scar). Furthermore the SS233, mentioned above to have similar proportion of medium sand to those of the sediment habitat, is found to have a high similarity to the sediment habitat sampling stations, whereas SS256 and SS321 are more distinct from the sediment habitat. Despite these comments there is no clear distinction between any of the habitat types in terms of the sediment characteristics.

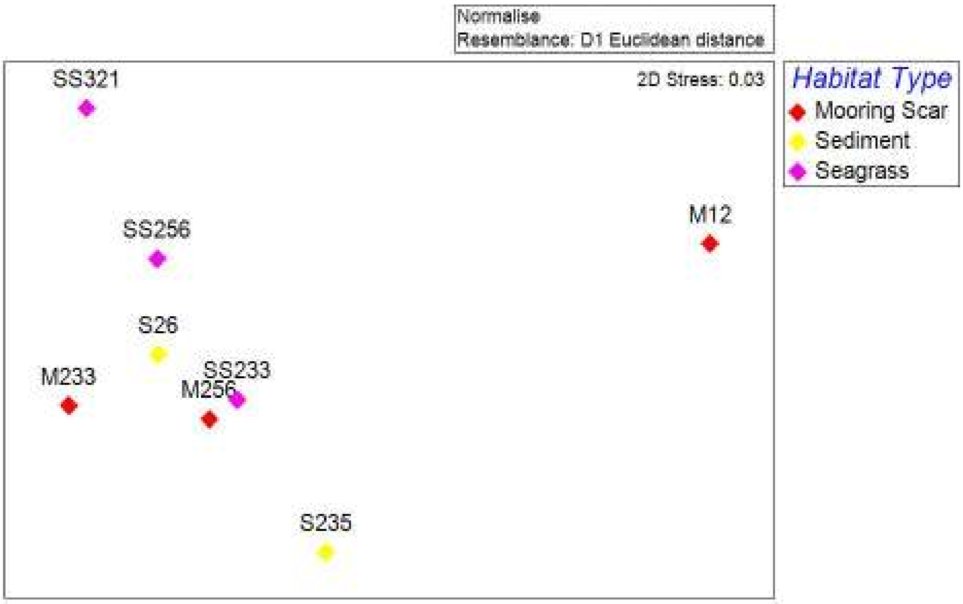


Figure 7: MDS plot displaying the similarity of each sampling station in relation to the sediment characteristics at 8 sampling stations within mooring scar, sediment and seagrass habitats sampled in Porthdinllaen Outer Harbour. M=Mooring Scar, S= Sediment, SS= Seagrass

Infauna Community

A total of 1322 individual organisms were sampled, within which 112 species (including *Z.marina*) were identified by Thompson Ecology from the infauna cores samples. Within the samples two species were markedly more abundant than the majority of identified taxa; the most common species was *Rissoa parva*, a small (5mm long, URL[1] MARLIN) herbivorous gastropod, which was the most dominant species in sampling station M12 (mooring Scar), SS233 & SS321 (seagrass). The second most common species was *Galathowenia oculata*, a deposit feeding polychaete worm, this was the most dominant species within both the sediment habitat types and sampling station SS256 (seagrass).

Infauna Abundance and Biomass

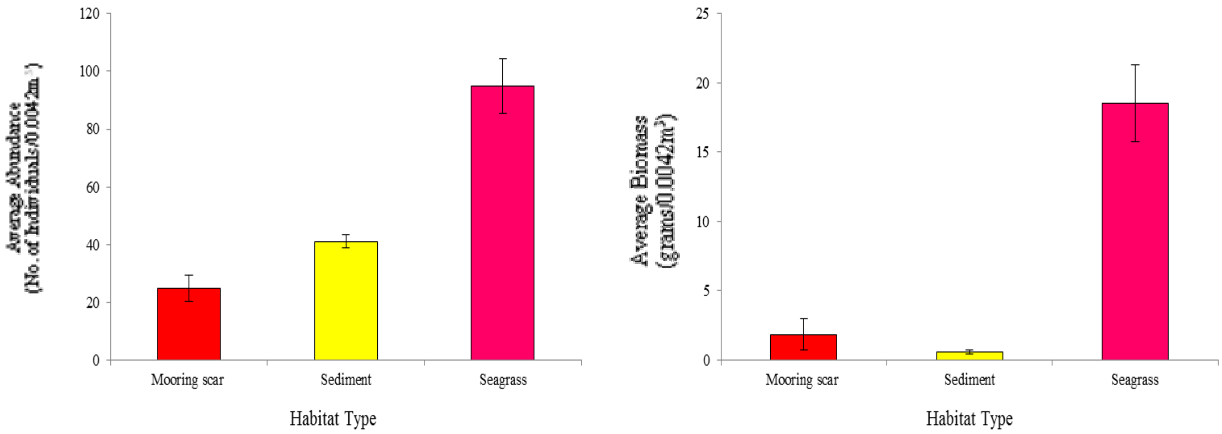


Figure 8:(left) Average infauna abundance (No. of individuals/0.0042m3) & (Right) average infauna biomass within each of the habitat types (±SE) sampled within the Porthdinllaen seagrass project 2012.

The average infauna abundance and biomass was found to be significantly higher within the seagrass habitat than in both the moorings scar and sediment habitats (Figure 8, Table 3). Further post-hoc Tukey testing confirmed a significantly higher infaunal abundance and biomass was found within the seagrass habitat than in both the mooring scar and sediment habitats, between the sediment and mooring scar habitat no significant difference could be detected.

Table 3: Statistical comparison of infauna abundance and biomass between mooring scar, sediment and seagrass habitat types within Porthdinllaen Seagrass Project 2012. * indicates Square root transformation.

Dependant Factor	Degrees of freedom	F	P
Infauna Abundance	2,7	19.902	0.004
Tukey Test			
Mooring Scar – Seagrass			0.004
Sediment – Seagrass			0.02
Sediment – Mooring Scar			0.472
Infauna Biomass*	2,7	10.864	0.015
Tukey Test			
Mooring Scar – Seagrass			0.023
Sediment - Seagrass			0.026
Sediment – Mooring Scar			0.959

Infaunal Diversity

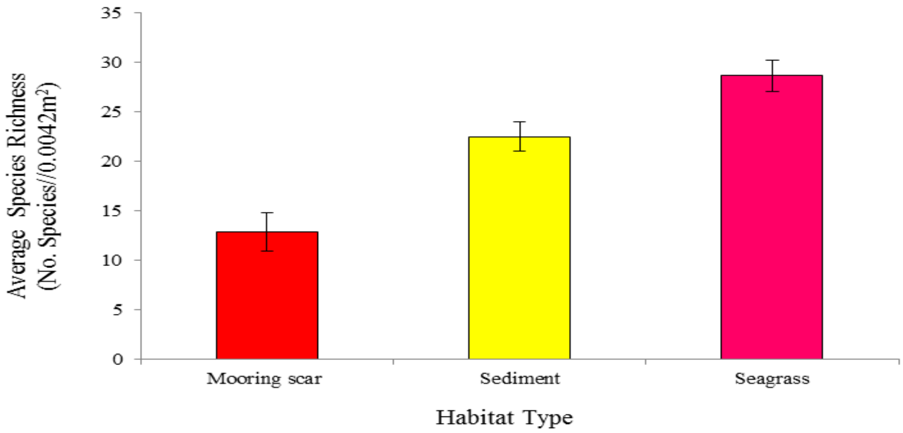
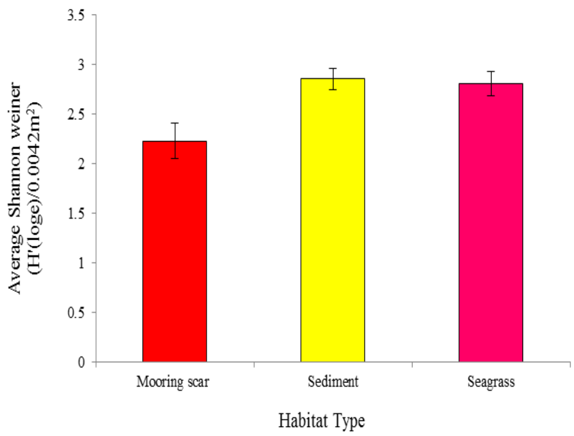


Figure 9: Average infauna species count (No. of species/0.0042m3) within each of the habitat types (±SE) sampled within the Porthdinllaen seagrass project 2012.

The infauna species count (S) was found to be on average highest within the seagrass and lowest within the moorings scar habitat (Figure 9). ANOVA and further Post Hoc tukey tesing showd a higly significant difference between the habitat types in relation to S (Table 4), the mooring scar habiat was found significantly lower species count than the both the sediment and seagrass habit, however no significant difference could be detected between the sediment and seagrass habitats (Table 4). The proportional diversity as measured with, Shannon Wiener and Simpson's index of dominance, was not found to be significantly different between any of the habitat types (Figure 10, Table 4).



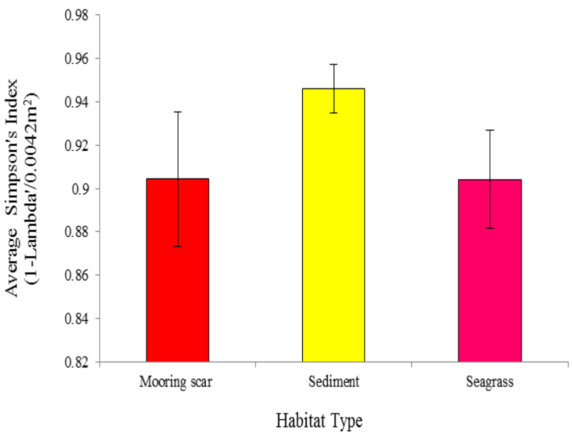


Figure 10: Average Shannon Weiner (H'(loge)/0.0042m2) (left) and Simpson's Index (1-lambda'/0.0042m2)(Right) within each of the habitat types (±SE) sampled within the Porthdinllaen seagrass project 2012.

Table 4: ANOVA table displaying a statistical difference in diversity (Shannon Weiner) between the mooring scar, sediment and Seagrass habitat types, sampled within the Porthdinllaen seagrass project 2012.

Dependant Factor	**Degrees of freedom**	**F**	**P**
S	2,7	7.235	0.033
Tukey Test			
Mooring Scar – Seagrass			0.035
Sediment – Seagrass			0.881
Sediment – Mooring Scar			0.089
Shannon Weiner	2,7	1.036	0.420
Simpson's Index of Dominance	2,7	0.265	0.777

Functional Feeding Diversity

A total of 10 functional feeding groups were identified from the species list, for information on the functional feeding group classification please refer to Appendix 4. Sub-surface deposit feeders were the most dominant functional feeding group within both the mooring scar and seagrass habitats, superseded by surface deposit feeders within the sediment habitat. Surface deposit feeders were the second most abundant feeding group within the mooring scar, and herbivores were the second most abundant group within the seagrass habitat (Figure 11). Herbivores were also relatively abundant within the mooring scar habitat and less abundant within the sediment habitat.

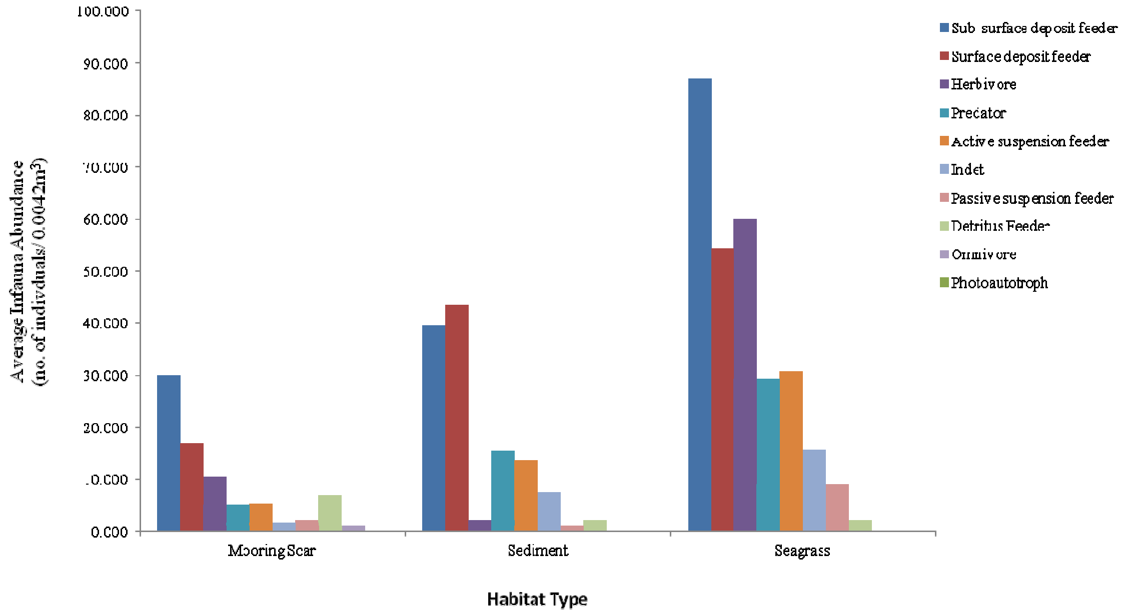


Figure 11:Average abundance of the functional feeding groups within the mooring scar, sediment and seagrass habitat types.

Every habitat type was found to contain all the recorded functional feeding groups, and as such the functional feeding diversity (S) did not differ between habitats. The proportional diversity proportional functional diversity (Shannon wiener and Simpson's index) was also not found to differ significantly between the three habitat types (Table 5)

Table 5: ANOVA table displaying a statistical comparisons in functional diversity between the mooring scar, sediment and Seagrass habitat types, sampled within the Porthdinllaen seagrass project 2012.

Dependant Factor	Degrees of freedom	F	P
S	2,7	0.112	0.897
Shannon Weiner	2,7	2.359	0.190
Simpson's Index	2,7	2.197	0.207

Sampling Station and Habitat Variability

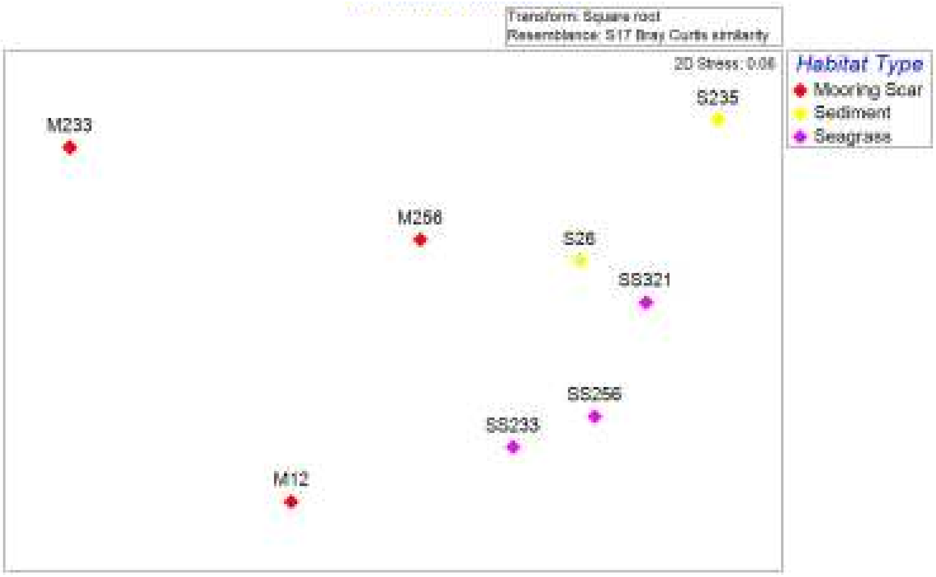


Figure 12: MDS plot displaying the similarity of each sampling station in relation to the infauna abundance (no. individuals/ 0.0042m^2) at each sampling station.

In terms of the infauna community abundance (Figure 12) the mooring scar habitat had the highest inner habitat variation of all the habitat types. All three sampling stations within the mooring scar habitat are displayed as highly distinct from each other comparative to those of the sediment and seagrass habitats, which indicates the proportional abundance and diversity of the infauna species at each of the mooring scar sampling stations was found to be highly variable. The sediment habitats were found to be similarly variable, however as only two sampling stations were established for this habitat type the scope for analysis is limited. The proportional infauna abundance within the sampling stations of the seagrass habitat had the highest similarity, displayed within Figure 12 with a high clustering of sampling stations SS233, SS256 and SS321. The low stress value within Figure 12 (0.06) indicates the output and hence observations on the spatial ordination of plots can be viewed with confidence.

ANOSIM testing between habitat types show there is a statistical significant difference between the habitat types in terms of the proportional abundance of the infaunal community (ANOSIM, R=0.442,*P*=1.4%). Pair-wise comparisons show each habitat type is distinct from each other (Table 6).

Table 6: ANOSIM pair wise comparisons indicating the statistical difference between habitat types and sampling station similarity as found by Bray Curtis similarity matrix, for Infauna abundance.

Groups	R	%
Mooring Scar-Sediment	0.5	20
Mooring Scar – Seagrass	0.444	10
Sediment - Seagrass	0.583	10

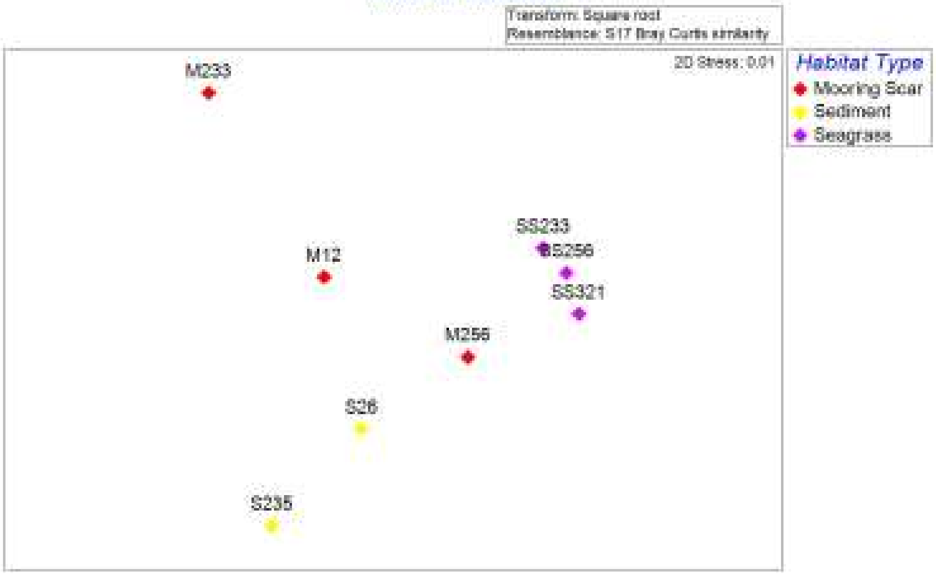


Figure 13: MDS plot displaying the similarity of each sampling station in relation to the infauna biomass (grams/ 0.0042m2) at each sampling station.

In terms of the infaunal biomass (Figure 13) the mooring scar has the highest inner habitat variation of all the habitat types, with all three sampling stations spatially separated. Similar to Figure 13 the sediment habitat types are also highly variable. The sampling stations within the seagrass habitat however were highly clustered, indicating the proportional infauna biomass within sampling stations SS233, SS256 and SS321 are relatively similar. The low stress value within Figure 13 (0.01) indicates the output and hence observations on the spatial ordination of plots can be viewed with confidence.

ANOSIM results (ANOSIM, R=0.619, *P*=0.007) show there is a statistical difference between the habitats in terms of the proportional infauna biomass, Pair-wise comparisons (Table 7) indicates the sediment and seagrass habitats are highly distinct, whereas the sediment and seagrass habitats are less so.

Table 7: ANOSIM pair wise comparisons indicating the statistical difference between habitat types and sampling station similarity as found by Bray Curtis similarity matrix, for infauna biomass.

Groups	R	%
Mooring Scar-Sediment	0.33	20
Mooring Scar – Seagrass	0.519	10
Sediment - Seagrass	1	10

Species Contributions to Community Differences between Habitat Types

SIMPER analysis indicated the abundance of two species was causing ≥5% dissimilarity between the habitat types, *Galathowenia oculata* (polychaete) and *Rissoa parva* (herbivorous gastropod). The abundance of *G.oculata* was not found to be significantly different between any of the habitat types (Figure 15 & Table 8). *R.parva* was found to have a significantly higher abundance within the seagrass than both the mooring scar and sediment habitats (Figure 15 & Table 8).

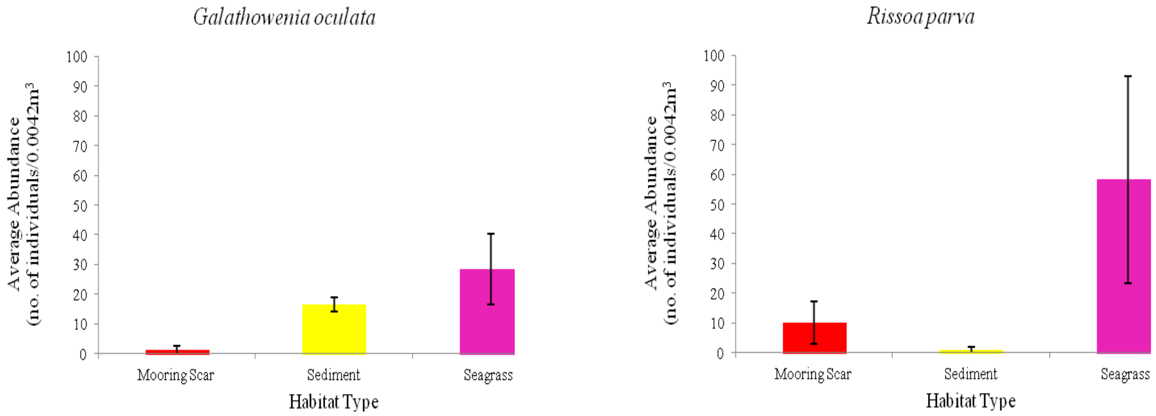


Figure 14: The average abundance of 2 species highlighted within SIMPER to create ≥5% dissimilarity between the mooring scar, sediment and seagrass habitats within Porthdinllaen outer harbour.

Table 8: Statistical comparison of the abundance of *Galathowenia oculata* & *Rissoa parva* between mooring scar, sediment and seagrass habitat types within Porthdinllaen Seagrass Project 2012. * indicates a Kruskal-Wallis test was performed to test for significant differences.

Dependant Factor	Degrees of freedom	F	P
Galathowenia oculata	2,7	6.229	0.130
**Rissoa parva*	2,7	6.175	0.046
Man-Whitney U			
Mooring Scar – Sediment			0.248
Mooring Scar – Seagrass			0.1847
Sediment - Seagrass			0.083

SIMPER analysis also highlighted the biomass of 4 species that created ≥5% dissimilarity between the habitat types; *Notomastus spp, Spisula subtruncata, Lucinoma borealis* & *Actiniaria spp.* Visual observations of the average biomass of each of these species within each of the three habitat types indicates that both *Notomastus spp.* and *Spisula subtruncata* had higher biomass within the sediment habitat. *Lucinoma borealis* and *Actiniaria spp* were both found to have higher biomass within the Seagrass habitat. High variation in the biomass of *Notomastus, Spisula subtruncata* and *Actiniaria* inhibited any statistical relationship to be found between the habitat types i.e. no significant difference could be found in the biomass of any of these species between any of the habitat types. *Lucinoma borealis* was however found to have a significantly higher biomass within the Seagrass habitat (Figure 16, Table 9).

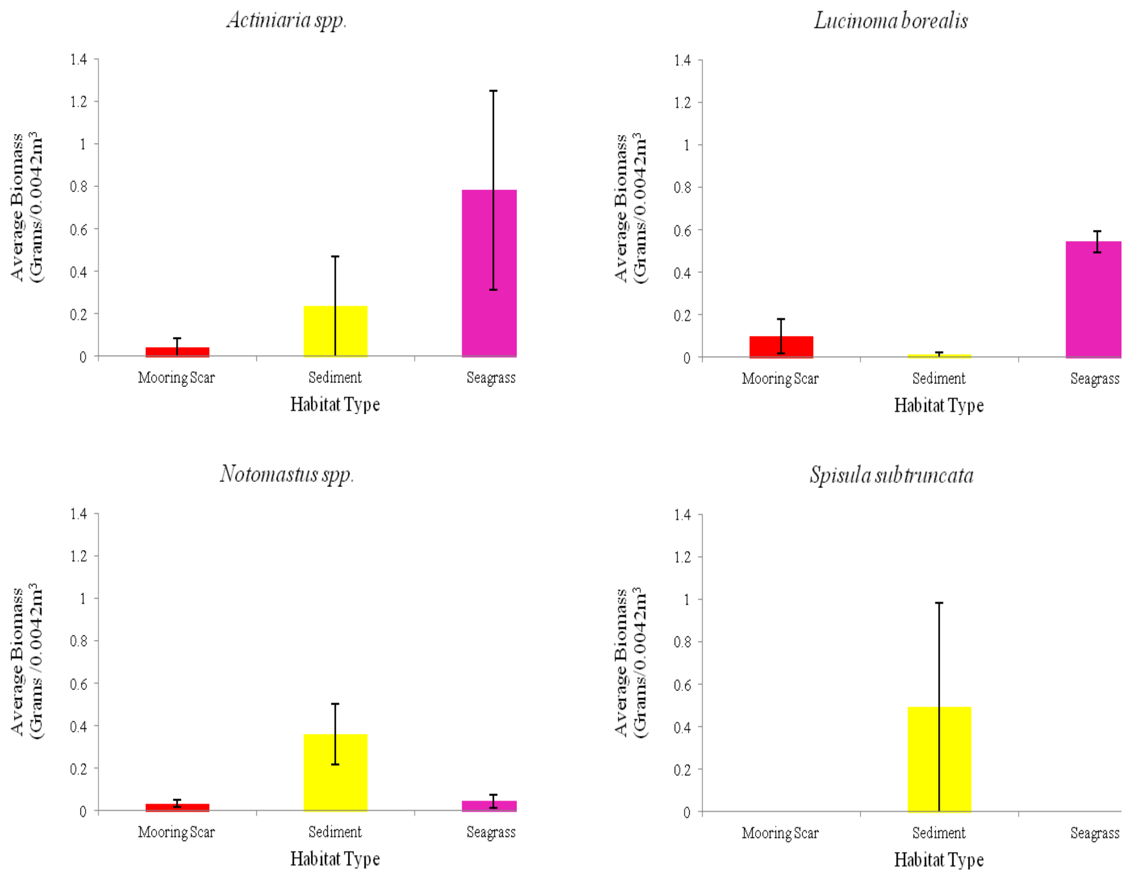


Figure 15: The average biomass of 4 species highlighted within SIMPER to create ≥5% dissimilarity between the mooring scar, sediment and seagrass habitats with Porthdinllaen outer harbour.

Table 9: Comparisons to test for statistically significant difference in the biomass of *Notomastus*, *Spisula subtruncata*, *Lucinoma borealis* & Actiniaria between the mooring scar, sediment and seagrass habitat types. All taxa except Actiniaria were tested using non-parametric Kruskal-Wallis, Actiniaria was found to have homogenous variation across the habitat types and was tested using ANOVA

Dependant Factor	Degrees of freedom	F	P
*Actiniaria	2,7	1.331	0.286
Lucinoma borealis	2,7		0.01
Man Whitney U			
Mooring Scar – Sediment			0.197
Mooring Scar – Seagrass			0.76
Sediment - Seagrass			0.050
Notomastus	2,7		0.234
Spisula subtruncata	2,7		0.223

Linking Biological and Abiotic variables

BEST analysis did not indicate any singular sediment characteristic/component that defined the infaunal community abundance or biomass. The output highlighted that a combination of the degree of coarse gravel, medium gravel and clay within the sediment samples best explained the infaunal abundance. In terms of the infaunal biomass coarse gravel, very coarse sand and coarse sand was found to be the highest correlating sediment component combination (Table 10). The percentage of coarse gravel within sediment samples, in all combinations of variables, highlighted to BEST match the infaunal abundance and biomass, and as such coarse gravel was used to validate the BEST analysis outputs.

Table 10: A list of the sediment grain size classifications, and their corresponding variable no. designations, used to relate biological and Abiotic variables BEST analysis within Porthdinllaen Seagrass Project 2012.

Variable no.	Sediment Grain Classification
1	V Coarse Gravel (>32<64mm)
2	Coarse Gravel (>16<32mm)
3	Medium Gravel (>8<16mm)
4	Fine Gravel (>4<8mm)
5	Very Fine Gravel (>2<4mm)
6	Very Coarse Sand (>1<2mm)
7	Coarse Sand (>0.5<1mm)
8	Medium Sand (>0.25<0.5mm)
9	Fine Sand (>0.125<0.25mm)
10	Very Fine Sand (>0.0625<0.125mm)
11	Very Coarse Silt (0.03125<0.0625mm)
12	Coarse Silt (>0.015625<0.03125mm)
13	Medium Silt (>0.007813<0.015625mm)
14	Fine Silt (0.003906<0.007813mm)
15	Very Fine Silt (0.001953<0.003906mm)
16	Clay (<0.001953mm)

Table 11: BEST analysis outputs correlating environmental variable to the infauna abundance (left) and biomass (right) within the samples of the Porthdinllaen seagrass project 2012.

Abundance		**Biomass**	
Variable no.	*Correlation*	*Variable no.*	*Correlation*
2,5,16	*0.528*	*2,6,7*	*0.426*
2,5,13	*0.523*	*2,5,6*	*0.410*
2,5,15	*0.523*	*2,5-7*	*0.398*
2,5,12	*0.516*	*2,6*	*0.377*
2,5,6,13,16	*0.507*	*2,5,7*	*0.366*
2,5,6,15,16	*0.507*	*2,7*	*0.365*
2,5,11	*0.506*	*2,5*	*0.341*
2,5,14	*0.506*	*2,6-8,13*	*0.341*
2,5,6,12,16	*0.505*	*2,6-8,14*	*0.341*
2,5,6,14,16	*0.505*	*2,6-8,15*	*0.341*

Further regression analysis complimented the results from the BEST analysis, indicating there was a negative relationship between the total infaunal abundance plus that of *G.oculata* and *R.parva* (highlighted by SIMPER to contribute to high percentage difference between habitat types). (Figures 17 & 18, Table 12). Although a relationship is visually apparent between the percentage of coarse gravel present within the sediment at the sampling stations and the infauna abundance (Figure 17) this could not be statistically verified with regression analyses due to a high degrees of variation within the data. No relationships could be found between the infauna biomass, diversity and percentage of coarse gravel at each sampling station.

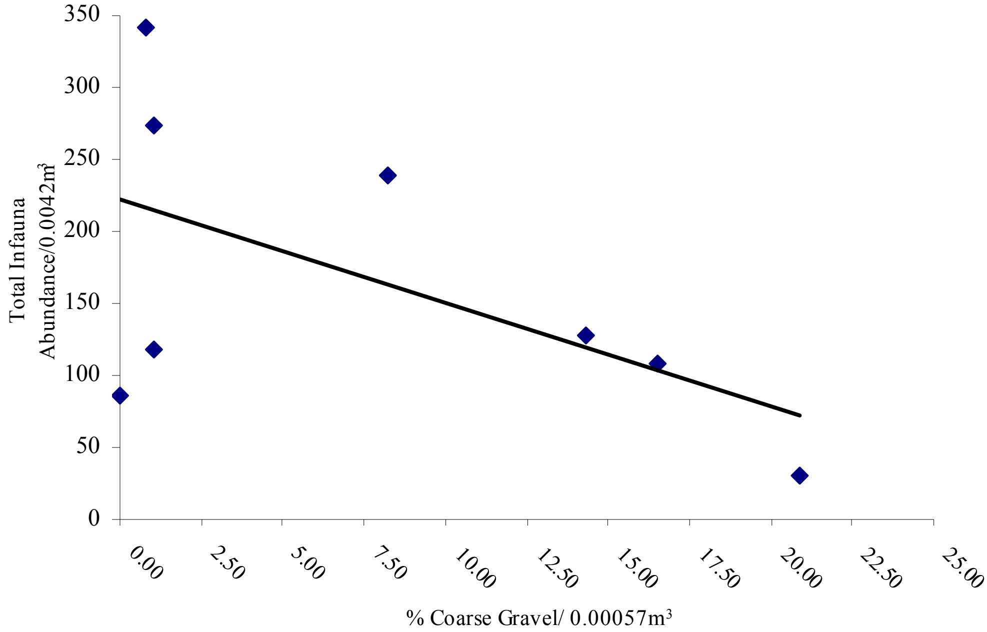


Figure 16: Scatter Plot, total infauna abundance compared to the percentage of coarse gravel at all sampling stations within the Porthdinllaen outer harbour

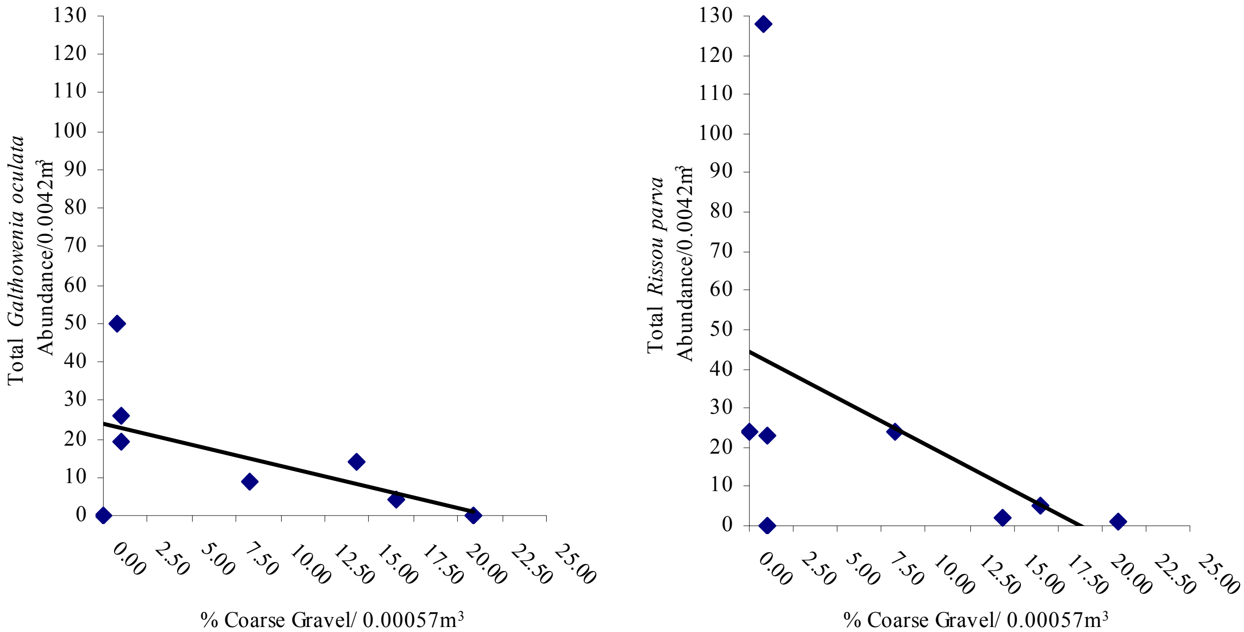


Figure 17: Scatter Plots, abundance of *G.oculata* and *R.parva* and percentage of coarse gravel at all sampling stations within the Porthdinllaen outer harbour.

Table 12: Linear relationship for the percentage of gravel within each sediment sample and the total infauna abundance and biomass, plus those of the species highlighted by SIMPER analysis.

Dependant Factor	***R^2***	***Linear relationship***	***Correlation***
Infauna Abundance	0.3139	Y=-7.1331x + 221.6	Negative
Galathowenia oculata Abundance	0.2907	Y = -1.0193x + 23.546	Negative
Rissoa parva Abundance	0.218	Y = -2.6808x + 45.518	Negative

5 DISCUSSION

Sediment Characteristics between Habitat Types

No statistically significant difference could be detected between the proportions of sediment grain size categories to the total sediment compositions, nor could any significant difference be detected in the average sediment grain size of the three habitat types. Sampling station M12 had an unusually high proportion of finer particles, and SS233 a high proportion of coarser sediments. Both of these sampling stations did not confer with the results from the other sampling station of the same habitat types. The variability within the sediment characteristics of the habitat and thus a lack of statistical difference in the sediment characteristics between the habitat types is likely to be attributed to a low sampling effort within each. Despite a lack of statistical significance, two of the three seagrass habitats were dominated by finer sand, all other sampling stations from within all the habitat types were dominated by coarser sediments. Previous comparative studies into the sediment profile of *Zostera marina* beds (Orth 1973, Boström & Bonsdorff 1997, Collins *et al.* 2010) found that *Z.marina* beds are typified by finer sediment. This relationship of finer sediments within *Z.marina* and indeed other species of seagrass, has been attributed to the presence of the seagrass shoots increasing friction in the water column, slowing water movement, and increasing the sedimentation of finer sediment grain in areas immediately adjacent to and within the seagrass beds. Furthermore the above sediment and below sediment structure of seagrass beds act to stabilize the sediments within beds i.e. finer particles that would normally become re-suspended are held within seagrass beds (Webster *et al.* 1998, Milazzo *et al.* 2004). Within the current study the sediments could not be statistically distinguished between the habitat types, possibly due to low sampling effort, but despite this result it is important to consider the qualitative evidence that suggests the sediment of two of the seagrass sampling stations (SS256 and SS321) were dominated by finer sediment grain size classifications.

Infaunal Communities - Trends Between Habitat Types

Deposit feeders overall were found to be the most dominant feeding type within all the habitat types. Sub-surface deposit feeders were dominant within the mooring scar and seagrass habitat, whereas surface deposit feeders were the most dominant within the sediment habitat type. Grazers were also a highly abundant functional feeding group within the seagrass habitat. The infaunal abundance and biomass were found to be higher within the seagrass habitat than both the mooring scar and sediment habitats. These results confer with results from other comparative studies of the infauna community of seagrass to those of surrounding seagrass habitats (Orth 1973, Boström & Bonsdorff 1997, Collins *et al.* 2010).

The number of species was also found to be higher within the seagrass habitat and sediment than in the mooring scar habitats. However the proportional diversity as measured by Shannon Weiner, and Simpson's index of dominance was not found to be significantly different between any of the habitat types, and this is most attributed to the presence of dominating taxa including *Rissoa parva*, a small herbivorous gastropod and *Galathowenia oculata*, a deposit feeding polychaete worm. The presence of a rhizome root structure beneath the sediment acts to stabilize the sediments and trap finer particles and organic material within Seagrass beds (Summerson & Peterson 1984). Benthic infauna utilise the increased stability of the sediments within seagrass beds, and deposit feeding organisms nutritionally exploit organic material. As such the presence of established beds can facilitate the increased abundance, biomass and diversity of benthic infauna species (Webster *et al.* 1998, Milazzo *et al.* 2004). Although the diversity within the Porthdinllaen *Z.marina* bed was not found to be any more diverse than the surrounding unvegetated sediments, it was found to have a significantly higher diversity than the mooring scar habitat. Furthermore the infauna abundance and biomass was found to be markedly increased within the seagrass than in any other habitat type. The mooring scar habitat was found to have the lowest infauna abundance and biomass. These results indicate that the mooring scar habitat to be impoverished when compared to that of the surrounding seagrass, despite a small spatial scale.

Similar comparative studies conducted within *Z.marina* beds within the UK (Collins *et al.* 2010), USA (Orth 1973) and Baltic sea (Boström & Bonsdorff 1997) found a similarly decreased infauna abundance and diversity (S) within mooring scars and surrounding unvegetated sediments to those of seagrass (*Z.marina*) habitats of the same area. An unusual result within the current report was that the total number of species (S) was not found to differ between the seagrass habitat and the surrounding unvegetated sediments, an observation not made by other authors. The rationale behind this relationship is unclear, however it may be related to an unmeasured high concentration of organic matter within the sediment habitat or, more likely, due to the low sampling effort within this habitat type. Only two sampling stations were found within the sediment habitat with variability in the infaunal diversity at one of the sampling stations is likely to have a large impact on the results quoted within this report. In the future it would be strong recommendation that the sampling effort within all the habitat types is increased. As shown when observing the inter habitat variation, the sampling stations within the sediment habitat types were found to be highly varied when compared to the seagrass and mooring scar. Furthering this point at the current level of sampling effort one new species/taxa will be identified within every new sample (Figure 4).

Proportional diversity, Shannon Wiener and Simpson's Index of Dominance, was not found to be differ between any of the habitat types. This indicates each of the habitats is dominated by a small number of taxa. SIMPER analysis indicated that two species, *Galathowenia oculata* and *Rissoa parva,* were contributing to a high amount of percentage dissimilarity between the habitat types. Both species were found to occur within all habitat types, and even dominate a number of the sampling stations. *R.parva* was found to have significantly higher abundance within the seagrass habitat. Variation in the abundance of *G.oculata* limited the detectability of any significant difference in the abundance of this species between the habitat types. The presence of both the species, dominating many of the sampling stations was therefore likely to contribute to the similar proportional diversity between the habitat types. The biomass of four other taxa (*Notomastus spp, Spisula subtruncata, Lucinoma borealis* & *Actiniaria spp)*, were also found to create high dissimilarity between the habitat types. High variation surrounding the average biomass values of three taxa (*Notomastus spp, Spisula subtruncata* & Actiniaria spp) negated any detectable difference in the average biomass of these species between the habitat types. *Lucinoma borealis* was found to have significantly higher biomass in the seagrass than in the sediment and mooring scar habitat. The high variation surrounding the average biomass of *Notomastus spp, Spisula subtruncata* & *Actiniaria spp* is likely to be attributed to the low sampling effort. To gather a more conclusive result displaying the true spatial distribution of these species across Porthdinllaen outer harbour it is likely the number of replicate samples within each of the habitat types would need to be increased.

Infaunal Communities - Characterising Taxa

Two species, one polychaete and one gastropod, were highlighted early on in data analyses to be common throughout the samples and typify the infaunal communities within all the habitat types:

1) Galathowenia oculata; A common deposit feeding, tube dwelling polychaete worm, which grows to a max length of 30mm. This species is found sublittoraly – 2800m within soft-sandy sediments of the north Atlantic Ocean. (Worms 2013).

2) *Rissoa parva*; A common herbivorous grazing gastropod which grows to a max length of 2mm. *R.parva* is found in a variety of marine habitats, often found feeding on micro-algal films growing on the surface of rock, macro-algae and other marine angiosperms (Worms 2013)

Both species are found commonly around the UK (Worms 2013), and their presence within Porthdinllaen outer harbour is not an indicator of any stressor or anthropogenic influence. Despite this if in successive studies the presence or abundance of such species is dramatically different to that found within the current study this should be noted and studied further, as this may represent a fundemantal change to the dominant ecology of Porthdinllaen Outer Harbour.

The biomass of four other taxa were also highlighted to create a high differences between the habitat types:

1) *Notomastus spp* high biomass within sediment habitat. *Notomastus spp,* A genus of deposit feeding polychaete worms. *Notomastus spp.* reside in burrows within sandy sediments within which they nutritionally exploit organic material. The genus typically reside within sandy-muddy habitats with a depth range of between the eulittoral to 7000m.

2) *Spisula subtruncata*, high biomass within the sediment habitat. *S.subtruncata* is a widespread suspension feeding bivalve, which burrows within sandy sediments (Marlin 2006)

3) *Actiniaria spp*., high biomass within the seagass habitat. Actinaria is an order within the phylum Cnidaria, which contains fauna commonly known as the sea anemones. Sea anemones are a widespread order of suspension feeding organisms which extract suspended organic particles from the water column via sweeping action of their feeding tentacles. Species within this order can be epiphytic, growing on the surface of other fauna/flora, attached to rocky substrata or burrowed within sediments.

4) *Lucinoma borealis*, high biomass within the seagrass habitat. *L.borealis* is a deposit feeding bivalve which resides burrowed with fine sediments from the intertidal – 200m (Worms 2013). *L.borealis* hosts symbiotic chemosynthetic bacterial species within gill structures known as bacteriocyctes, which oxidise reduced sulphur compounds such as H_2S (Johnson *et al.* 2002, Southward 1986). Reduced sulphur compounds accumulate within *Z.marina* beds due to the deposition of dead or decaying *Z.marina* leaves (Fisher & Hand 1984). Anaerobic bacterial decomposition of the leaf material increases the concentration of reduced compounds such as H_2S, NH_3 and H_2 within the sediments, which can be potentially toxic and limit the growth of the *Z.marina*. The presence of the chemosynthetic bacteria such as that housed within bivalve species *L.borealis* thus play a vital role in sulphur cycling within, and the maintenance and functionality of *Z.marina* beds (Johnson *et al.* 2002, Fisher & Hand 1984, Southward 1986).

The presence and abundance of the aforementioned taxa should also be monitored within future surveys of Porthdinllaen, as a change in the abundance of typify taxa such as these may indicate a fundemantal change to the ecology of the *Z.marina* bed. In particular the abundance of *L.borealis* should be observed and monitored within further studies due to its importance in the control of reduced sulphur compounds and it's implication on the *Z.marina* bed functionality.

Conclusions

To conclude the mooring scar habitat was found to have a significantly lower infaunal abundance, biomass and diversity (S) than any of the other habitat types. The seagrass habitat was found to have the highest infaunal abundance and biomass, however infaunal diversity (S) was found to be equal to that of the sediment habitat. All habitat types were found to be dominated by a small number of taxa and as such the proportional diversity was not found to be differ between the habitat types however, as mentioned, the community within the seagrass habitat was significantly more abundant and had a higher overall biomass than any of the other habitat types. Interestingly although no significant difference could be detected in the sediment characteristics between the habitat types, the mooring scar and sediment habitat types were typically dominated by coarser sediments than the seagrass, an observation made by other authors (Orth 1973, Boström & Bonsdorff 1997, Collins *et al.* 2010). Furthermore the presence of coarse sediments, such gravel, were found to have a significant negative correlation with the total infauna abundance, and the abundance of some species highlighted to differ between the habitat types. Previous reports within Porthdinllaen outer harbour (Morris *et al.* 2008 & 2009, & Egerton 2011, Stamp 2012), found a maximum of 45 moorings within the outer harbour. The moorings within the outer harbour are also reportedly removed seasonally and replaced in different locations within the outer harbour, and the total number of moorings may be increasing over time. Moorings have a scouring effect on the seabed that is likely to result in an increase the proportion of coarser sediments within mooring scars in the outer harbour and which may subsequently result in a decreased infaunal abundance, as well as decrease the biomass and diversity. Such a loss of biodiversity within the area could feed into the higher trophic levels and may have impacts on the seagrass bed's ability to support commercially important crustacean and fin fish species. Such a loss of biodiversity within the area could feed in the higher trophic levels and may have impacts on the seagrass bed's ability to support commercial important crustacean and fin fish species.

Although the results of this report have highlighted the *Z.marina* bed within Porthdinllaen supports a much richer infaunal community than the surrounding sediments and the mooring scars within the bed, it is apparent that the sampling effort used within this study may not have been adequate to detect relationships between the sediment characteristics and species diversity, plus species specific relationships between habitat types. As such if any future survey work of this type were to be conducted within the future a more rigorous sampling design should be employed. Another suggestion of this report is that the abundance and biomass of the species mentioned to contribute a high difference between the habitat types should be noted in future surveys. A change in the abundance of species such as *Galathowenia oculata* and *Rissoa parva* could indicate a dramatic change in the infauna ecology of the area. Special attention should also be given to the abundance and biomass of *Lucinoma borealis,* a species found within the current study to have a significantly higher biomass within the seagrass habitat, and through literature searches found to have a highly valuable sulphur cycling function within the *Z.marina* beds.

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APPENDIX 1: DETAILS OF DIVING OPERATIONS

Dive Details for Porthdinllaen Sediment Core Operations for 10/10/2012. Dive Site Abbreviations; M: Mooring Scar, S: Sediment with no Seagrass Present, SS: Dense Seagrass Bed

Dive Operation	Dive Site	Diver Name	Gas EAN (%)	Air In	Air Out	Dive Details Start	End	Duration (minutes)	Max Depth BCD (m)
1	S:26 + S:235	Harry Goudge	30	220	40	09:54	11:35	82	5.2
				200	80				
		Thomas Stamp	30	210	60	09:54	11:35	82	5.2
				210	60				
2	M:233 + SS:233	Gujameer (Jamie) Ramday	21	220	90	11:45	13:20	90	3.12
				220	90				
		Harry Goudge	30	40		Standby Diver			
				30					
3	M:256 + SS:256	Harry Goudge	30	220	90	14:37	16:10	93	3.08
				220	90				
		Thomas Stamp	25	210		Standby Diver			
				230					
4	SS:321	Thomas Stamp	25	200	80	16:24	17:32	66	3.52
				210	80				
		Gujameer (Jamie) Ramday	21	90		Standby Diver			
				90					
5	M:12	Gujameer (Jamie) Ramday	21	90	40	17:40	18:15	33	1.75
				90	40				
		Harry Goudge	25	90		Standby Diver			
				90					

APPENDIX 2: DIVER NOTES ON SEDIMENT COMPOSITION, FEATURES AND EPIFAUNA

Table a: Information on the position and sediment composition for each sampling station. Sediment composition section refers to the percentage contribution of each sediment component to the total sediment composition, please refer below for explanation.

Sampling Station Details					Sediment composition (%)								
							Gravel		Sand				
Mooring ID	**Time**	**Latitude**	**Longitude**	**Depth BCD (m)**	**Cobbles**	**Pebbles**	**Stone**	**Shell**	**Coarse**	**Medium**	**Fine**	**Mud**	**Live Shell**
M12	17:45	52.9434	-4.5629	1.74		75			25				
M233	12:39	52.94368	-4.56115	3.1		20			80				
M256	14:40	52.94285	-4.56067	2.76		30			60				10
S26	10:10	52.94452	-4.55957	4.14		12		3		75		5	5
S235	11:10	52.94473	-4.55828	4.94		8		8	77			2	5
SS233	12:51	52.94392	-4.56118	3.07		45		5	50				
SS256	15:38	52.94275	-4.5609	2.62		10			80				10
SS321	16:30	52.9424	-4.55865	3.29		5				70	20		5

Each sediment component is assigned a percentage to which it is of the total sediment composition, please find below a tabular key with a worked example from Table a.

Sediment Composition									
		Gravel		Sand					
Cobbles	**Pebbles**	**Stone**	**Shell**	**Coarse**	**Medium**	**Fine**	**Mud**	**Live Shell**	**Total**
	12		3		75		5	5	100%

Table b: Detailed information on the sediment characteristics, other sediment features and dominant epifauna and flora present at each sampling station. Please refer to Table c for a list of abbreviations and details on ranking system used within Table b.

Mooring ID	**Sediment Characteristics**				**Sediment Features: Present (P), Absent (blank)**											
	Surface Relief	**Firmness**	**Stability**	**Sorting**	**Tr**	**M/C**	**B/H**	**Tu**	**AM**	**W/d**	**R**	**SBL**	**SCL**	**Sc/M**	**SS/F**	**Dominant epifauna/ Flora**
S26	1	3	2	3		P	P	P						P		*Buccinum undatum, Callionymus spp, Cereus pedunculatus, Pomatoschistus spp*
S235	1	3	2	2	P	P	P	P						P		*Callionymus spp, Cereus pedunculatus, Pomatoschistus spp, Rhodophyta spp*
M233	2	3	3	3	P	P		P						P		*Callionymus spp, Cereus pedunculatus, Pomatoschistus spp, Sargassum muticum (*noted as present but not dominant*)*
SS233	1	3	3	2										P		*Anemonia viridis, Cereus pedunculatus, Pomatoschistus spp, Zostera marina, Sargassum muticum (*noted as present but not dominant*)*
M256	2	1	2	4	P		P							P		*Cereus pedunculatus, Pomatoschistus spp*
SS256	1	3	1	2			P	P				P		P		*Callionymus spp, Cereus pedunculatus, Pomatoschistus spp, Zostera marina*
SS321	2	2	2	2		P	P	P				P		P		*Anemonia viridis, Callionymus spp, Zostera marina*
M12	2	2	1	2	P			P						P		*Cereus pedunculatus, Chorda filum, Crenilabrus melops*

Tabular key explaining diver notes on ranking system for sediment characteristics and abbreviations used within sediment features of Table b

Sediment Characteristics				**Other Sediment Features (Present/ Absent)**										
Surface Relief	**Firmness**	**Stability**	**Sorting**	**Tr**	**M/C**	**B/H**	**Tu**	**AM**	**W/d**	**R**	**SBL**	**SCL**	**Sc/M**	**SS/F**
Even-Uneven	Firm-Soft	Stable-Mobile	Well-Poor	Tracks	Mounds/ Casts	Burrows/ Holes	Tubes	Algal Mat	Waves/ Dunes (>10cm High)	Ripples (<10cm High)	Subsurface Black Layer	Subsurface coarse layer	Subsurface clay/ mud	Surface silt/ Flocculent
Ranked on a Scale of 1-5 e.g. 1= Even or 5 = Uneven														

APPENDIX 3: PORTHDINLLAEN SAMPLE SUMMARY TABLE

Client	Site	Size of sample tub	Station	Sample	Size of core	Sieved	Preservation method	Habitat	Collector
CCW	Porth Dinllaen	5 litre	**S26**	**1 of 3**	0.0014 cubic metres (110mm diameter, 15cm deep)	0.5mm	~4% Formalin	Sublittoral Sediment. Fine sand and pebbles. No Seagrass	Marine EcoSol
CCW	Porth Dinllaen	5 litre	**S26**	**2 of 3**	0.0014 cubic metres (110mm diameter, 15cm deep)	0.5mm	~4% Formalin	Sublittoral Sediment. Fine sand and pebbles. No Seagrass	Marine EcoSol
CCW	Porth Dinllaen	5 litre	**S26**	**3 of 3**	0.0014 cubic metres (110mm diameter, 15cm deep)	0.5mm	~4% Formalin	Sublittoral Sediment. Fine sand and pebbles. No Seagrass	Marine EcoSol
CCW	Porth Dinllaen	5 litre	**S235**	**1 of 3**	0.0014 cubic metres (110mm diameter, 15cm deep)	0.5mm	~4% Formalin	Sublittoral Sediment. Coarse sediment, sand and pebbles. No Seagrass	Marine EcoSol
CCW	Porth Dinllaen	5 litre	**S235**	**2 of 3**	0.0014 cubic metres (110mm diameter, 15cm deep)	0.5mm	~4% Formalin	Sublittoral Sediment. Coarse sediment, sand and pebbles. No Seagrass	Marine EcoSol
CCW	Porth Dinllaen	5 litre	**S235**	**3 of 3**	0.0014 cubic metres (110mm diameter, 15cm deep)	0.5mm	~4% Formalin	Sublittoral Sediment. Coarse sediment, sand and pebbles. No Seagrass	Marine EcoSol
CCW	Porth Dinllaen	5 litre	**M233**	**1 of 3**	0.0014 cubic metres (110mm diameter, 15cm deep)	0.5mm	~4% Formalin	Mooring Scar. Coarse sediment of sand and pebbles. No seagrass	Marine EcoSol
CCW	Porth Dinllaen	5 litre	**M233**	**2 of 3**	0.0014 cubic metres (110mm diameter, 15cm deep)	0.5mm	~4% Formalin	Mooring Scar. Coarse sediment of sand and pebbles. No seagrass	Marine EcoSol
CCW	Porth Dinllaen	5 litre	**M233**	**3 of 3**	0.0014 cubic metres (110mm diameter, 15cm deep)	0.5mm	~4% Formalin	Mooring Scar. Coarse sediment of sand and pebbles. No seagrass	Marine EcoSol
CCW	Porth Dinllaen	5 litre	**M256**	**1 of 3**	0.0014 cubic metres (110mm diameter, 15cm deep)	0.5mm	~4% Formalin	Mooring Scar. Coarse sediment of sand and pebbles with some boulders. No seagrass	Marine EcoSol
CCW	Porth Dinllaen	5 litre	**M256**	**2 of 3**	0.0014 cubic metres (110mm diameter, 15cm deep)	0.5mm	~4% Formalin	Mooring Scar. Coarse sediment of sand and pebbles with some boulders. No seagrass	Marine EcoSol
CCW	Porth Dinllaen	5 litre	**M256**	**3 of 3**	0.0014 cubic metres (110mm diameter, 15cm deep)	0.5mm	~4% Formalin	Mooring Scar. Coarse sediment of sand and pebbles with some boulders. No seagrass	Marine EcoSol
CCW	Porth Dinllaen	5 litre	**M12**	**1 of 3**	0.0014 cubic metres (110mm diameter, 15cm deep)	0.5mm	~4% Formalin	Mooring Scar. Glacial clay? Sand and pebbles	Marine EcoSol
CCW	Porth Dinllaen	5 litre	**M12**	**2 of 3**	0.0014 cubic metres (110mm diameter, 15cm deep)	0.5mm	~4% Formalin	Mooring Scar. Glacial clay? Sand and pebbles	Marine EcoSol
CCW	Porth Dinllaen	5 litre	**M12**	**3 of 3**	0.0014 cubic metres (110mm diameter, 15cm deep)	0.5mm	~4% Formalin	Mooring Scar. Glacial clay? Sand and pebbles	Marine EcoSol
CCW	Porth Dinllaen	5 litre	**SS233**	**1 of 3**	0.0014 cubic metres (110mm diameter, 15cm deep)	0.5mm	~4% Formalin	Dense sublittoral seagrass in fine sediments	Marine EcoSol
CCW	Porth Dinllaen	5 litre	**SS233**	**2 of 3**	0.0014 cubic metres (110mm diameter, 15cm deep)	0.5mm	~4% Formalin	Dense sublittoral seagrass in fine sediments	Marine EcoSol
CCW	Porth Dinllaen	5 litre	**SS233**	**3 of 3**	0.0014 cubic metres (110mm diameter, 15cm deep)	0.5mm	~4% Formalin	Dense sublittoral seagrass in fine sediments	Marine EcoSol
CCW	Porth Dinllaen	5 litre	**SS256**	**1 of 3**	0.0014 cubic metres (110mm diameter, 15cm deep)	0.5mm	~4% Formalin	Dense sublittoral seagrass in fine sediments	Marine EcoSol
CCW	Porth Dinllaen	5 litre	**SS256**	**2 of 3**	0.0014 cubic metres (110mm diameter, 15cm deep)	0.5mm	~4% Formalin	Dense sublittoral seagrass in fine sediments	Marine EcoSol
CCW	Porth Dinllaen	5 litre	**SS256**	**3 of 3**	0.0014 cubic metres (110mm diameter, 15cm deep)	0.5mm	~4% Formalin	Dense sublittoral seagrass in fine sediments	Marine EcoSol
CCW	Porth Dinllaen	5 litre	**SS321**	**1 of 3**	0.0014 cubic metres (110mm diameter, 15cm deep)	0.5mm	~4% Formalin	Dense sublittoral seagrass in fine sediments	Marine EcoSol
CCW	Porth Dinllaen	5 litre	**SS321**	**2 of 3**	0.0014 cubic metres (110mm diameter, 15cm deep)	0.5mm	~4% Formalin	Dense sublittoral seagrass in fine sediments	Marine EcoSol
CCW	Porth Dinllaen	5 litre	**SS321**	**3 of 3**	0.0014 cubic metres (110mm diameter, 15cm deep)	0.5mm	~4% Formalin	Dense sublittoral seagrass in fine sediments	Marine EcoSol
CCW	Porth Dinllaen	1 litre	**S26**	**PSA**	0.00057cubic metres (110mm diameter, 6cm deep)	no	~4% Formalin	Dense sublittoral seagrass in fine sediments	Marine EcoSol
CCW	Porth Dinllaen	1 litre	**S235**	**PSA**	0.00057cubic metres (110mm diameter, 6cm deep)	no	~4% Formalin	Sublittoral Sediment. Fine sand and pebbles. No Seagrass	Marine EcoSol
CCW	Porth Dinllaen	1 litre	**M233**	**PSA**	0.00057cubic metres (110mm diameter, 6cm deep)	no	~4% Formalin	Mooring Scar. Coarse sediment of sand and pebbles. No seagrass	Marine EcoSol
CCW	Porth Dinllaen	1 litre	**M256**	**PSA**	0.00057cubic metres (110mm diameter, 6cm deep)	no	~4% Formalin	Mooring Scar. Coarse sediment of sand and pebbles with some boulders. No seagrass	Marine EcoSol
CCW	Porth Dinllaen	1 litre	**M12**	**PSA**	0.00057cubic metres (110mm diameter, 6cm deep)	no	~4% Formalin	Mooring Scar. Glacial clay? Sand and pebbles	Marine EcoSol
CCW	Porth Dinllaen	1 litre	**SS233**	**PSA**	0.00057cubic metres (110mm diameter, 6cm deep)	no	~4% Formalin	Dense sublittoral seagrass in fine sediments	Marine EcoSol
CCW	Porth Dinllaen	1 litre	**SS256**	**PSA**	0.00057cubic metres (110mm diameter, 6cm deep)	no	~4% Formalin	Dense sublittoral seagrass in fine sediments	Marine EcoSol
CCW	Porth Dinllaen	1 litre	**SS321**	**PSA**	0.00057cubic metres (110mm diameter, 6cm deep)	no	~4% Formalin	Dense sublittoral seagrass in fine sediments	Marine EcoSol

APPENDIX 4: MARINE LIFE NETWORK FUNCTIONAL FEEDING CLASSIFICATIONS

Functional Feeding Group		***Definition***
Photoautotroph		An organism that obtains metabolic energy from light by a photochemical process such as photosynthesis (e.g. seaweeds, phytoplankton).
Suspension feeder: Any organism which feeds on particulate organic matter, including plankton, suspended in the water column (Lincoln *et al.*, 1998).	Active	Catching food on a filter from water by actively sweeping (e.g. *Porcellana platychelyes*) or pumping (e.g. sea squirts, many bivalve molluscs).
	Passive	Catching food on a filter held into flowing water (e.g. hydroids, sea fans, sea pens), or collecting the 'rain' of detritus on sticky apparatus other than a filter (e.g. *Cucumaria frondosa*).
Deposit feeder: Any organism which feeds on fragmented particulate organic matter from the substratum; detritivores (Lincoln *et al.*, 1998).	Surface	Obtaining food from the surface of the substratum (e.g. *Corophium volutator*).
	Sub-surface	Obtaining food from within the substratum (e.g.*Echinocardium cordatum*).
Omnivore		Animal which feeds on a mixed diet including plant and animal material (from Lincoln et al., 1998).
Herbivore		An organism which feeds on plants, including phytoplankton.
Scavenger		Any organism that actively feeds on dead organic material (e.g. crabs, whelks).
Planktotroph		Feeding at least in part on materials captured from the plankton (Barnes et al., 1993).
Chemoautotroph		An organism that obtains metabolic energy from oxidation of inorganic substrates such as sulphur, nitrogen or iron (e.g. some microorganisms).
Predator		An organism that feeds by preying on other organisms, killing them for food (Lincoln et al., 1998).
Interface feeder		An organism that feeds at the interface between the water column and underlying substratum.
Grazer		Animals which rasp benthic algae (or sessile animals, such as bryozoan crusts).
Detritivore		An organism that feeds on fragmented particulate organic matter (detritus) (Lincoln et al., 1998).

APPENDIX 5: RAW DATA - SPECIES ABUNDANCE MATRIX

Taxon Name	M12	M233	M256	S235	S26	SS233	SS256	SS321
Corallinaceae			P					
Furcellaria lumbricalis						P		
Gigartina acicularis						P		
Phyllophora								
Gracilaria	P	P	P	P	P	P	P	
Plocamium cartilagineum						P	P	
Cordylecladia erecta						P		
Ceramium	P					P		
Apoglossum ruscifolium						P		
Cryptopleura ramosa						P		
Hypoglossum hypoglossoides	P							
Chondria						P		
Polysiphonia		P			P	P		
Pterosiphonia						P		
Heterosiphonia plumosa						P	P	
Dictyota dichotoma	P							
Sphacelaria	P	P			P	P		P
Laminaria (juv)						P		
Chaetomorpha		P						
Cladophora						P		
Zostera marina	P		P			P	P	P
PORIFERA								
FILIFERA								
Campanulariidae								
ACTINIARIA			2		1	16	2	
NEMERTEA	1			4	2	1	1	
NEMATODA	1	1		1	3	15	19	2
Harmothoe impar (agg)						1		
Malmgrenia arenicolae	1							
Subadyte pellucida						1		
Pholoe baltica (sensu Petersen)				1		2		
Pholoe inornata (sensu Petersen)						3		1

Taxon Name	M12	M233	M256	S235	S26	SS233	SS256	SS321
Sthenelais boa							1	
Eteone longa (agg)		1	3		1	1	7	1
Anaitides groenlandica				1				
Glycera fallax			1			2		
Glycera tridactyla		1	1					2
Streptosyllis websteri					1			
Exogone hebes	2		3	7	14	7	7	17
Exogone hebes (epitoke)	4	1	5	3	6	11	7	5
Nereididae (juv)							1	
Nephtys (juv)				2		2		3
Nephtys caeca			1		1			
Nephtys cirrosa		1						
Nephtys hombergii				1	3		1	2
Nephtys kersivalensis						3		
Lumbrineris gracilis						1		
Scoloplos armiger	1		1	2		6		
Aricidea minuta	5		3	1	7	1	9	5
Paradoneis lyra					1			
Poecilochaetus serpens				2	1		1	2
Atherospio guillei					1			
Malacoceros vulgaris							3	
Polydora ciliata (agg)					1			
Prionospio fallax						1		
Pseudopolydora pulchra				3	1			
Spio filicornis	2		2		4	4	1	11
Spio filicornis (Type A)							1	
Spiophanes bombyx			1	2	1		2	1
Streblospio			2					1
Magelona alleni					1			2
Magelona filiformis			6	1	4	1	7	4
Aphelochaeta marioni	5			1		2	1	
Caulleriella alata	3	5	1	1		3	1	

Taxon Name	M12	M233	M256	S235	S26	SS233	SS256	SS321
Caulleriella bioculata				1				
Chaetozone christiei		1	9	15	9	2	11	4
Chaetozone zetlandica	1				1	1	2	1
Cirriformia tentaculata	2	2				3		
Cirriformia (juv)						1		
Tharyx killariensis				1				3
Capitella		2	3		1	5	11	4
Mediomastus fragilis	1	1	2	2	2	7	6	2
Notomastus	13	2	6	8	5	14	1	
Clymenura			2	5				1
Euclymene oerstedii	7		11		4	12	13	2
Scalibregma celticum						2	2	
Galathowenia oculata			4	19	14	9	26	5
Owenia fusiformis				1				
Terebellides stroemi				1				
Lanice conchilega				2			1	
Spirobranchus lamarcki	1				1			
Tubificoides benedii	1			1				
Tubificoides pseudogaster (agg)	2	4	7		12	2	7	6
Anoplodactylus petiolatus						3		
COPEPODA				1	3	1		
MYODOCOPIDA					1		4	4
Schistomysis spiritus			1					
Perioculodes longimanus		3	9	1				1
Synchelidium maculatum			1		1			1
Urothoe elegans			1	1			1	
Harpinia antennaria			1	3	7	4	2	9
Dexamine spinosa			1				16	
Tritaeta gibbosa							1	
Ampelisca brevicornis				4	2			1
Ampelisca typica				1	1			
Bathyporeia elegans				1	1			

Taxon Name	M12	M233	M256	S235	S26	SS233	SS256	SS321
Bathyporeia tenuipes				1				
Abludomelita obtusata							1	
Abludomelita obtusata (Type A)							1	
Ampithoidae	1							
Ericthonius punctatus							1	
Siphonoecetes kroyeranus				1				1
Caprella (juv)							6	
Caprella acanthifera						2	1	
Pariambus typicus							1	
Tanaopsis graciloides				1		1		
Iphinoe trispinosa		2	6	1	1			1
Diastylis bradyi	1							
Philocheras trispinosus							1	
Crangon crangon			1					
Upogebia stellata						1		
Tectura virginea						1		
Tricolia pullus							2	
Lacuna vincta								2
Rissoa parva	24	1	5		2	24	23	128
Nuculidae (juv)							3	8
Nucula hanleyi				1				
Nucula nitidosa			1	2	2	1	1	4
Mytilus edulis (juv)	5		1			3	7	
Lucinoma borealis		1	3			7	7	5
Lucinoma borealis (juv)				1	1	2	9	4
Thyasira flexuosa					1	1	1	2
Kurtiella bidentata				1				1
Parvicardium exiguum				1				
Spisula subtruncata				2				
Fabulina fabula								1
Abra alba	1			3	1	13	11	19
Arctica islandica		1						

Taxon Name	M12	M233	M256	S235	S26	SS233	SS256	SS321
Venerupis senegalensis (juv)						3		
Chamelea striatula (juv)				1				
Thracia (juv)					1			
Crisia			P	P		P	P	
Flustrellidra hispida						P	P	
Amathia lendigera						P	P	
Bowerbankia						P	P	
Aetea						P		
Electra pilosa						P		
Bicellariella ciliata				P				
Beania mirabilis						P		
Scrupocellaria reptans			P	P		P	P	
Scrupocellaria scruposa							P	
Celleporella hyalina						P		P
Phaeostachys spinifera				P		P		
Phoronis			1					
Amphiuridae (juv)				1		2		
Acrocnida brachiata				P				
Amphipholis squamata						1	2	
ENTEROPNEUSTA						P		P
ASCIDIACEA						P	P	
ASCIDIACEA (juv)							1	P
Didemnidae							P	

APPENDIX 6: RAW DATA - SPECIES BIOMASS MATRIX

Taxon Name	M12	M233	M256	S235	S26	SS233	SS256	SS321
Sthenelais boa							0.0024	
Eteone longa (agg)		0.0007	0.0015		0.0004	0.0049	0.0059	0.0002
Anaitides groenlandica				0.0034				
Glycera fallax			0.3832			0.0031		
Glycera tridactyla		0.0001	0.003					0.0021
Streptosyllis websteri					0.0001			
Exogone hebes	0.0002		0.0002	0.0006	0.0021	0.0014	0.0001	0.0017
Exogone hebes (epitoke)	0.0014	0.0001	0.0003	0.0005	0.0011	0.0028	0.0003	0.0013
Nereididae (juv)							0.0001	
Nephtys (juv)				0.0017		0.0051		0.0012
Nephtys caeca			0.0034		0.0162			
Nephtys cirrosa		0.0035						
Nephtys hombergii				0.0106	0.018		0.1028	0.0348
Nephtys kersivalensis						0.0683		
Lumbrineris gracilis						0.0001		
Scoloplos armiger	0.0326		0.0017	0.0032		0.0075		
Aricidea minuta	0.001		0.0002	0.0001	0.0013	0.0011	0.0004	0.0015
Paradoneis lyra					0.0003			
Poecilochaetus serpens				0.0192	0.0023		0.0081	0.0151
Atherospio guillei					0.0024			
Malacoceros vulgaris							0.0157	
Polydora ciliata (agg)					0.0002			
Prionospio fallax						0.003		
Pseudopolydora pulchra				0.0018	0.0006			
Spio filicornis	0.0067		0.0031	0.0004	0.0058	0.0039	0.001	0.0113
Spio filicornis (Type A)							0.012	
Spiophanes bombyx			0.0005	0.0006	0.0002		0.001	0.0013
Streblospio			0.0001					0.0014
Magelona alleni			0.0148		0.0144			0.1206
Magelona filiformis			0.0104	0.002	0.0078	0.0035	0.0123	0.0102
Aphelochaeta marioni	0.0067			0.0001		0.0063	0.0001	
Caulleriella alata	0.0011	0.0054	0.0002	0.0001		0.0027	0.0027	
Caulleriella bioculata				0.0011				
Chaetozone christiei		0.0009	0.014	0.0181	0.0146	0.0029	0.0221	0.0023
Chaetozone zetlandica	0.0044				0.0003	0.0151	0.0093	0.0009
Cirriformia tentaculata	0.0358	0.1498				0.7452	0.1785	
Cirriformia (juv)						0.0001		
Tharyx killariensis				0.0028				0.0099
Capitella		0.0047	0.002		0.0001	0.0013	0.001	0.0003
Mediomastus fragilis	0.0018	0.0036	0.0099	0.0074	0.0017	0.004	0.0059	0.003
Notomastus	0.0283	0.0061	0.067	0.2166	0.5032	0.1089	0.0192	0.0034
Clymenura			0.0279	0.0286				0.0006
Euclymene oerstedii	0.0561	0.004	0.0687	0.0037	0.0658	0.1282	0.2103	0.2214
Scalibregma celticum						0.0198	0.0146	
Galathowenia oculata			0.0075	0.0167	0.0138	0.0051	0.013	0.0159
Owenia fusiformis				0.2162				

Taxon Name	M12	M233	M256	S235	S26	SS233	SS256	SS321
Terebellides stroemi				0.1146				
Lanice conchilega				0.0057			0.0235	
Spirobranchus lamarcki	0.0001				0.006			
Tubificoides benedii	0.0012		0.0001	0.0001				
Tubificoides pseudogaster (agg)	0.0003	0.0003	0.0003		0.0013	0.0014	0.0006	0.0009
Anoplodactylus petiolatus						0.002		
COPEPODA				0.0001	0.0001	0.0001		
MYODOCOPIDA					0.0001		0.0009	0.0012
Schistomysis spiritus			0.0003					
Perioculodes longimanus		0.0002	0.0016	0.0011				0.0002
Synchelidium maculatum			0.0002		0.0002			0.0001
Urothoe elegans			0.0007	0.0001			0.0001	
Harpinia antennaria			0.0001	0.0014	0.003	0.0047	0.0087	0.0022
Dexamine spinosa			0.0027				0.0031	
Tritaeta gibbosa							0.0001	
Ampelisca brevicornis				0.0315	0.0112			0.0016
Ampelisca typica				0.0013	0.0014			
Bathyporeia elegans				0.0001	0.0001			
Bathyporeia tenuipes				0.0007				
Abludomelita obtusata							0.0001	
Abludomelita obtusata (Type A)							0.0001	
Ampithoidae	0.0008							
Ericthonius punctatus							0.0001	
Siphonoecetes kroyeranus				0.0004				0.0001
Caprella (juv)							0.0005	
Caprella acanthifera						0.0002	0.0001	
Pariambus typicus							0.0001	
Tanaopsis graciloides				0.0001		0.0009		
Iphinoe trispinosa		0.0013	0.0017	0.0001	0.0001			0.0001
Diastylis bradyi	0.0066							
Philocheras trispinosus							0.0001	
Crangon crangon			0.0077					
Upogebia stellata						0.6627		
Tectura virginea						0.0006		
Tricolia pullus							0.0015	
Lacuna vincta								0.0273
Rissoa parva	0.0739	0.0004	0.0155		0.0059	0.0754	0.0288	0.3676
Nuculidae (juv)							0.0002	0.0039
Nucula hanleyi				0.0068				
Nucula nitidosa			0.0014	0.0021	0.0001	0.1783	0.0029	0.0102
Mytilus edulis (juv)	0.0002		0.0006			0.0014	0.0024	
Lucinoma borealis		0.0318	0.2628			0.6129	0.438	0.399
Lucinoma borealis (juv)				0.0002	0.0217	0.0045	0.124	0.0528
Thyasira flexuosa					0.0193	0.0022	0.1353	0.2793
Kurtiella bidentata				0.0016				0.0001
Parvicardium exiguum				0.0045				

Taxon Name	M12	M233	M256	S235	S26	SS233	SS256	SS321
Spisula subtruncata				0.9852				
Fabulina fabula								0.0059
Abra alba	0.0638			0.0186	0.013	0.5371	0.1909	0.3675
Arctica islandica		154.78						
Venerupis senegalensis (juv)						0.0142		
Chamelea striatula (juv)				0.0263				
Thracia (juv)					0.0047			
Crisia								
Flustrellidra hispida								
Amathia lendigera								
Bowerbankia								
Aetea								
Electra pilosa								
Bicellariella ciliata								
Beania mirabilis								
Scrupocellaria reptans								
Scrupocellaria scruposa								
Celleporella hyalina								
Phaeostachys spinifera								
Phoronis			0.0012					
Amphiuridae (juv)				0.0002		0.0001		
Acrocnida brachiata				0.3618				
Amphipholis squamata						0.0034	0.0003	
ENTEROPNEUSTA	0.0017					0.0035		0.0677
ASCIDIACEA								
ASCIDIACEA (juv)								
Didemnidae								

APPENDIX 7: DATA ARCHIVE

Data outputs associated with this project are archived as Project No. [386] and Media No. [1401] on server–based storage at Natural Resources Wales

The data archive contains:

[A] The final reports to Gwynedd Council in Adobe PDF formats:

Stamp. 2012. Porthdinllaen seagrass project (Pen Llŷn a'r Sarnau SAC) – Sediment core Sampling October 2012, summary report. A report to Gwynedd Council

Stamp. 2012. Porthdinllaen seagrass project (Pen Llŷn a'r Sarnau SAC) – Sediment core Sampling October 2012, data analysis. A report to Gwynedd Council

[B] Species and Sediment data in .xls format

[C] Species and Sediment data in Marine Recorder [MRCCW31700000008]

Metadata for this project is publicly accessible through The Natural Resources for Wales' Library Catalogue http://194.83.155.90/olibcgi/ by searching 'Dataset Titles'. The metadata is held as record no 115274.