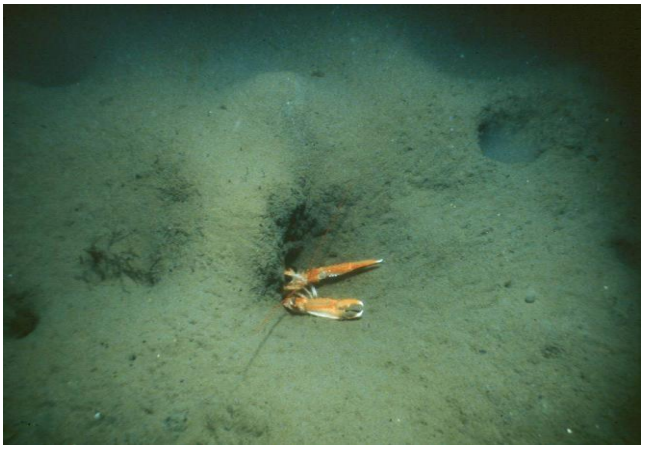
Alternative Marine Conservation Zones in Irish Sea mud habitat:

Assessment of habitat extent and condition at "Queenie corner" and assessment of fishing activity at potential MCZ sites.



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Executive Summary

27 Marine Conservation Zones (MCZs) in Secretary of State and English waters were designated by the UK government, acting through Defra, in a first tranche in 2013, followed by a second tranche of 23 MCZs designated in 2016. Consultation of a third tranche is planned for early 2017, including potentially a number of sites of particular concern to the Northern Ireland fishing industry (Slieve Na Griddle, South Rigg and Mud Hole). Defra previously identified that these three sites, which were originally suggested through the Irish Sea Conservation Zones project, require further consideration due to their location within important fishing grounds, and that their designation "could have a significant impact on the fishing sector, particularly within Northern Ireland". Defra has encouraged the fishing industry to develop alternative site proposals for protecting subtidal mud habitats in the Irish Sea region, and that all available options will be then be considered in the third tranche of designations (Defra, 2015). Alternative sites were proposed following stakeholder engagement in a report for Seafish by AFBI in 2015 (AFBI, 2015); this concluded that the "least worst" options in terms of potential fishery displacement, yet representing the key habitat of interest, subtidal mud, were West of Walney in the eastern Irish Sea and a new site, "Queenie Corner", in the western Irish Sea.

West of Walney was included in Tranche 2 of the MCZ designations, and this included a co-location zone with wind farms which had held up its submission in Tranche 1. It passed through consultation and was designated in January 2016. The site proposed as "Queenie Corner" in AFBI (2015) was formally proposed to Defra for consideration in October 2015, with support of both the Anglo-North Irish Fish Producers' Organisation Ltd. and Northern Ireland Fish Producers' Organisation Ltd. However, due to the introduction of the Welsh Fishery Zone, the site had to be re-drawn to avoid overlap with this zone, which reduced the original site area proposed. During 2014 and 2015 additional surveys were completed by AFBI aboard the RV *Corystes* to provide the habitat evidence required for full consideration of Queenie Corner by Defra. Seafish provided funding for processing of samples and work up of these data to evaluate the presence, extent and condition of the habitat at Queenie Corner, and compare this to similar evidence at the remaining potential sites of Slieve Na Griddle, South Rigg and Mud Hole. This work is reported here, along with a comparison of fishing effort between 2006 and 2014 over each of these sites, and also West of Walney, to provide an overview of how these sites compare in terms of potential fisheries displacement should designation occur and management measures require banning of mobile gear fisheries.

Queenie Corner has good evidence of the presence of subtidal mud habitat, with 145 km^2 of the site containing such habitat. Of this, some 19 km^2 is in waters deeper than 75m, which is a threshold now under consideration due to the ecological network guidance principles for MCZ designations having representation of broad-scale habitats at a variety of depth bands in each region (of which the Irish Sea is one). The mud habitat at Queenie Corner shows the same range of infauna communities as Slieve Na Griddle and South Rigg, albeit in differing proportions. There is a strong gradient in sediment particle size, carbon and nitrogen sediment content and fauna across the site, driven by bathymetry and oceanographic conditions. Individually, neither South Rigg nor Slieve Na Griddle harbour the same extent of subtidal mud habitat as Queenie Corner, but they do harbour a

greater extent of mud deeper than 75m due to the depth range at these sites. A summary of these considerations is provided in the table below.

Irish Sea	Site	Area (km2)	Approximate Depth range (m)	Features		Average Fishing Effort % of NI fleet total (2006-2014)
				Subtidal mud	Mud habitats in deep water	
West	South Rigg	146	50-150	96 km2	42 km2	1.77
West	Slieve Na Griddle	58	60-125	53 km2	58km2	1.23
West	Queenie Corner	147	55-100	145 km2	19 km2*	1
East	Mud Hole	73	20-50	73 km2	35 km2	1.19
East	*West of Walney*	*388*	*15-33*	*316 km2*	*135 km2*	*0.94*

* Note that "mud habitats in deep water" has been considered in Queenie Corner to be that habitat which is deeper than 75m. This is not the same definition as used in the other sites; instead this refers to habitat qualities. It has not been possible to define how much mud habitat at Slieve Na Griddle and South Rigg is deeper than 75m. There is no mud habitat in the eastern Irish Sea that is deeper than 75m.

[West of Walney details are in italics due to this site already having been designated as an MCZ]

All habitat evidence for Queenie Corner was supplied by AFBI to Defra and the Joint Nature Conservation Committee (JNCC), who provides scientific advice to Defra in support of MCZ designation Tranche 3, so that this site meets the data confidence thresholds for feature presence, extent and condition, and can be considered for inclusion in Tranche 3. It is hoped that this site could now be considered as a potential substitution for other western Irish Sea subtidal mud MCZ options. In the eastern Irish Sea, where different types of mud habitat seabed communities are found, it is noted that with the recent designation of West of Walney MCZ and the addition of subtidal mud habitat as a feature of Fylde MCZ that adding Mud Hole to the potential MCZ sites for inclusion in Tranche 3 will not bridge remaining ecological gaps in the subtidal mud habitat part of the MCZ network, as such gaps exist for communities found exclusively in the western Irish Sea.

Introduction

Background

This project was conceived as a follow-on to the work reported in AFBI (2015), which examined potential alternative sites for provision of Marine Conservation Zones (MCZs) in mud habitat within the Irish Sea. The Northern Ireland fishing industry registered dissatisfaction with the sites proposed by the Irish Sea Conservation Zones[1] project due to their potential impact to the industry should management measures for such sites involve closure to bottom-trawling. The original proposed sites fall in mud habitat that is fished for the Dublin Bay Prawn, *Nephrops norvegicus*, and these sites are therefore of significance to the industry (Cappell *et al*., 2010). The UK government, acting through Defra (Department of Environment, Food and Rural Affairs), who hold responsibility under the Marine Bill (Marine and Coastal Access Act, 2009) to designate areas of offshore UK waters as MCZs, gave the NI fishing industry an opportunity to suggest alternative sites and provide supporting habitat evidence, and held back the contentious sites from submission in Tranche 1 and Tranche 2 of the MCZ designation process. Alternative sites and supporting evidence was required in time for Tranche 3 of the Defra-led designation process, due to commence in early 2017.

In order to select alternative sites and provide supporting information to refine choices, it was suggested by the Department of Agriculture and Rural Development (DARD-NI) that AFBI facilitate stakeholder workshops, to allow the NI fishing industry to discuss and suggest options. Funding was provided by Seafish for AFBI to evaluate each of the potential alternative sites suggested by the first workshop through analysis of their potential for fisheries displacement and provide evidence of habitat type at each site (see AFBI, 2015[2]). This information was presented at a second stakeholder workshop with the "least worst" options for alternative sites selected. The two sites which emerged from this process were the extended "West of Walney" site in the eastern Irish Sea (including the original proposed co-location zone with the wind farms in the area), and a new site, "Queenie corner", in the western Irish Sea. It was intended that together these sites would contribute an appropriate proportion of "Subtidal Mud" habitat as per the published "Ecological Network Guidance" for MCZ design[3] to replace the contentious sites of "South Rigg", "Slieve Na Griddle" (both western Irish Sea) and "Mud Hole" (eastern Irish Sea) in Tranche 3 of the MCZ designation process.

The "West of Walney" site was already suggested by the Irish Sea Conservation Zones project, which has included provision of suitable habitat evidence, but the site had not been included in Tranche 1 of the MCZ designation process, in part due to potential issues due to partial co-location with wind farm developments. This site was latterly included in Tranche 2 of the MCZ designation, including the co-location areas, and in January 2016 was formally designated as an MCZ.

[1] http://www.irishseaconservation.org.uk/
[2] http://www.seafish.org/media/Publications/Seafish_2015_Alternative_MCZs_in_Irish_Seafinal.pdf
[3] http://jncc.DEFRA.gov.uk/pdf/100705_ENG_v10.pdf

The “Queenie Corner” site was a new site with habitat evidence chiefly confined to sparse grab samples (providing sediment grain size information and infaunal species abundance and biomass), and *Nephrops norvegicus* burrow density data from annual stock assessment underwater TV surveys (completed jointly between AFBI and the Marine Institute, Ireland). In order to meet data requirements to provide moderate or high confidence in the presence, extent and condition of a site’s feature (in this case ‘subtidal mud’), AFBI and Seafish funded further survey work, specifically involving additional grab samples and underwater video tows, which are reported here. These data were used together with the *Nephrops* burrow density data to refine the boundary of the “Queenie Corner” site and this information was then passed to Defra and the Joint Nature Conservation Committee (JNCC) for their consideration for inclusion in Tranche 3 of the MCZ designation process.

In order for industry to fully assess the potential for fisheries displacement from the designation of any “subtidal mud” sites in the Irish Sea, the VMS data from 2014 was examined in conjunction with previous datasets for each of the following sites:

- South Rigg
- Slieve Na Griddle
- Mud Hole
- Queenie Corner
- West of Walney

A summary of these sites in terms of the MCZ features for which they are considered is provided in Table 1 below, including the area of the mud habitats for each site. The location of these sites over predicted mud habitat distribution (from EU SeaMap) is shown in Figure 1 below. Table 1 also includes reference to Fylde MCZ (located in the eastern Irish Sea), which was designated in Tranche 1 but which has now had ‘subtidal mud’ habitat added as an MCZ feature (added in January 2016) and therefore may have a bearing on the total mud habitat being afforded protection as a Marine Protected Area in the Irish Sea regional area. Due to the lack of Northern Ireland fishing activity within Fylde (which, although mud habitat, doesn’t harbour notable *Nephrops* population), it is not discussed further within this report.

Table 1. Summary of Irish Sea "subtidal mud" potential MCZ sites of interest to NI Fishing Industry (NB. In January 2016 "West of Walney" was formally designated; all other sites are for consideration within this report).

Site	Area (km2)	Approximate Depth range (m)	Features for designation							
			Moderate energy circalittoral rock	Low energy circalittoral rock	Subtidal mud	Mud habitats in deep water	Subtidal sand	Subtidal mixed sediments	Sea-pen and burrowing megafauna	Arctica islandica
South Rigg	146	50-150	x	x	96 km2	42 km2	x	x	x	x
Slieve Na Griddle	58	60-125		x	53 km2	58km2			x	
Queenie Corner	147	55-100			145 km2	19 km2*	x		x	
Mud Hole	73	20-50			73 km2	35 km2			34 km2	
West of Walney	388	15-33			316 km2	135 km2	x		135 km2	
Fylde	260	5-18			*104 km2 approx*					

* In "Queenie Corner", 'Mud Habitats in Deep Water' are represented by the area of mud habitat that is deeper than 75m. This definition is potentially different to that used for other sites where the information was taken from Defra and JNCC documents (e.g. Defra, 2013).

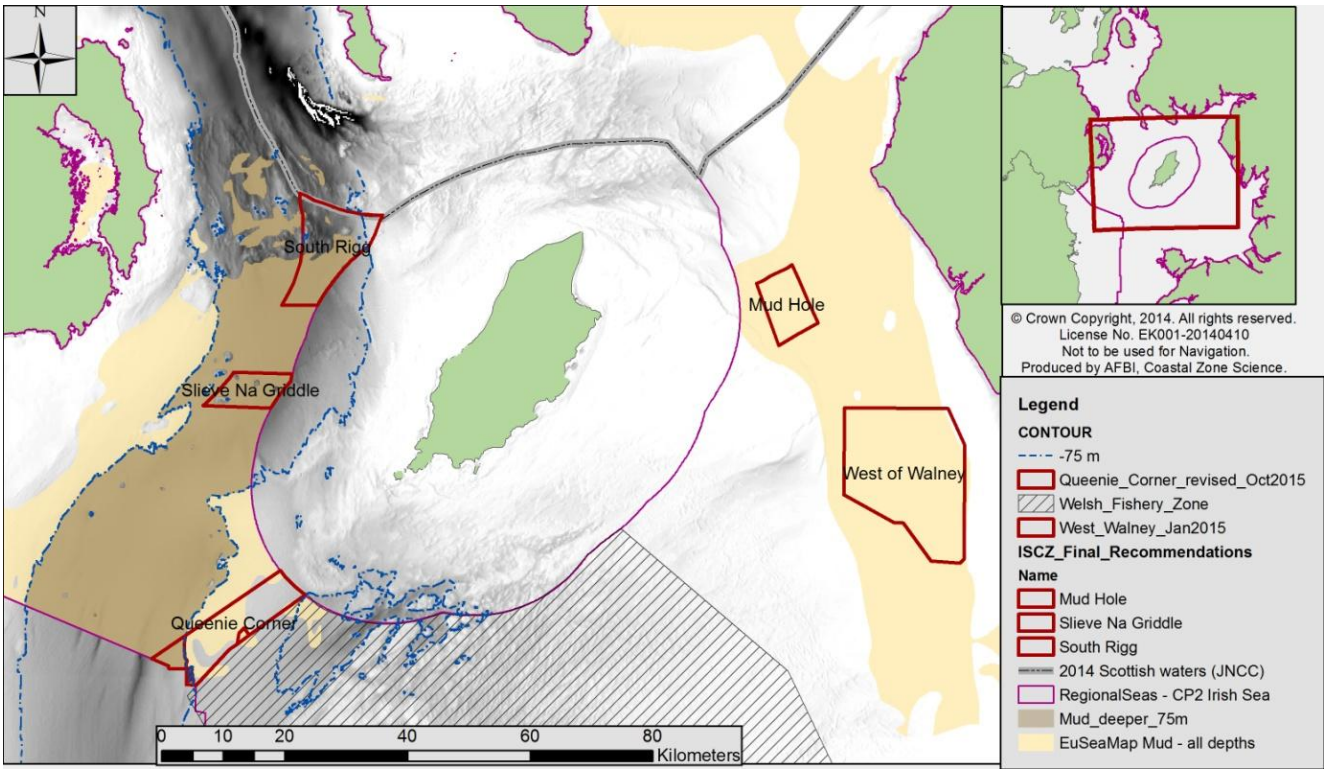

Figure 1. Subtidal mud habitat potential MCZ sites (& West of Walney designated MCZ).

In order to meet the set ecological network coherence objectives, within each Charting Progress[4] (CP, e.g. CP2) region, such as the Irish Sea offshore (>12nM from land) region, two examples of a broad-scale habitat such as subtidal mud within each energy category and depth zone should be included in the MCZ network. Depth zones are defined as follows:

- 0-10m
- 10-75m
- 75-200m
- 200m+

Within the Irish Sea CP2 region, excluding Scottish waters, there are no waters deeper than 200m which can be considered for designation, however appropriate representation of the 10-75m and 75-200m depth bands should be attempted. Figure 1 indicates the predicted subtidal mud habitat extent and demarks the area that exceeds 75m depth (indicated by the brown colour). The 75m contour was generated for this project from "OceanWise" Digital Elevation Model, which incorporates all UK Hydrographic Office approved bathymetric data correct at April 2015. This shows that within the Irish Sea CP2 region, approximately 1390 km^2 of mud is found deeper than 75m. The network guidance suggests that, as a minimum, 10% of this mud should be designated within MCZs in the region, equating to a guide amount of 139 km^2. Notably the 75 – 200m mud habitat is only found in the western Irish Sea, not the eastern Irish Sea.

Report content

This report is divided into two parts:

Part I addresses the fishing effort data patterns over each of the "Subtidal mud" potential MCZ sites (yet un-designated) and the West of Walney site (now designated as an MCZ).

Part II presents the habitat evidence available following data collation and additional surveys for the "Queenie Corner" site.

[4] Charting Progress 2 was a UK wide assessment of the state of the marine environment, published by Defra in 2010. UK waters were split into a number of reporting areas and the Irish Sea CP2 region has been used within the ongoing MCZ designation process to assess representivity of broad-scale habitats and habitats of conservation interest across the wider UK Marine Protected Area (MPA) network.

Part I:

1.1 Methodology

Vessel Monitoring System (VMS) data from 2006 to 2014 inclusive were used for these analyses. Data were sourced from the UK government for all vessels tagged by the "GBN" flag, which relates to the Northern Ireland fleet only ('Great Britain Northern Ireland'). For 2006 to 2012 this included all vessels 15m and over in length and for 2013 and 2014 this included all vessels 12m and over in length.

Effort hours were calculated using the following procedure:

All VMS records 'pings' from fishing vessels active within the area > 52°N & <56°N latitude, >8°W & <3°W longitude were extracted from national data records for all GBN flag vessels. All vessels within the dataset are anonymised, preventing identification of individual vessels, however only those vessels using otter-trawl gear were included in this analysis. Vessel speeds (knots) were derived from temporal and positional ping information to identify vessels likely to be involved in fishing activity. Vessels are assumed to be engaged in fishing activity within the speed bounds of 0.5kn - 4.5kn (WGSFD, 2013). Pings located within and around harbours are removed (VMS Tools R statistics package, 2013). Effort is calculated for individual pings as the time since the previous vessel ping on a given fishing trips. Effort for all vessels is aggregated at a grid resolution of 0.25km for each year within the study period.

VMS spatial summary data were available in a Geographical Information System (GIS) for 2006 to 2014. The effort hours in each of the aforementioned sites were calculated and the results are presented below.

Limitations:

As the under 15m vessels (and under 12m vessels from 2013 onwards) are not tracked via VMS, their activity could not be included in the analyses. It was not possible within the scope of this report to estimate their extent of activity so the lack of representation of smaller vessels should be kept in mind. This is likely to have a greater impact on describing potential fisheries displacement on sites close inshore and where smaller vessels are known to work the prawn grounds, particularly in the eastern Irish Sea.

From 2013 vessel monitoring systems (VMS) were required on all vessels 12m and above. The roll out of this to all 12m+ vessels was not yet complete at the end of 2014, therefore not all vessels 12m+ are included in 2013 and 2014 VMS datasets. However, from 2013 onwards the data presented in this report includes vessels between 12 and 15 metres that were not included in the analyses for the years 2006 – 2012. It was not possible within the scope of this study to separate out these new vessels or quantify their contribution to overall activity. It does not appear to skew the data but the reader should keep in mind that there are additional vessels reported from 2013 onwards.

1.2 Presentation of Results

Effort hours are the unit of measurement for fishing intensity in this study. The Irish Sea area is split into 0.25km^2 intensity grids; each grid cell has a unit of effort for each year. Each site is overlaid on these grids. Summaries are presented below of the extraction of effort hours for each site; the data extraction method allowed vessels using bottom otter trawls (typically of the *Nephrops* fleet) to be isolated for calculation of fishing effort totals. Figure 2 below provides a map of the fishing effort hours of the NI bottom trawl fleet in 2014 for the whole of the Irish Sea region.

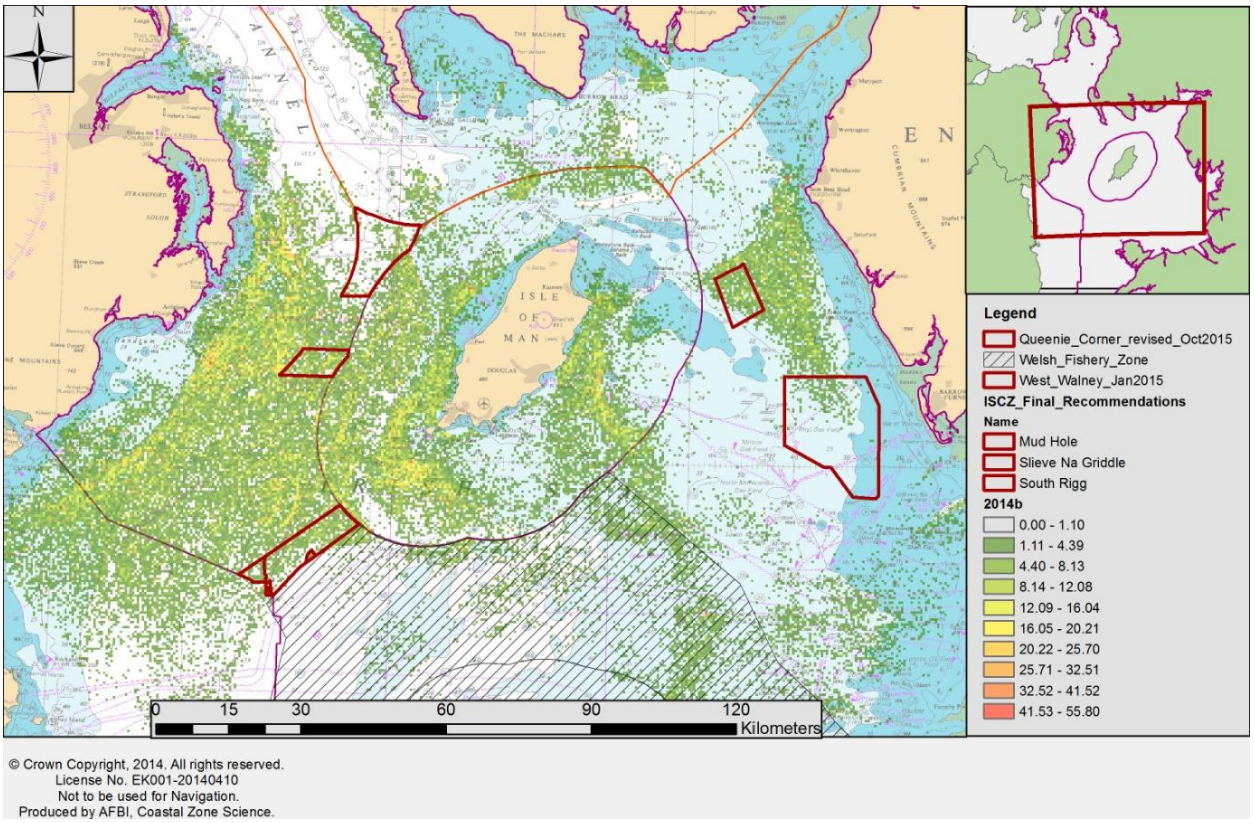

Figure 2. 2014 fishing effort hours for the NI bottom trawling fleet across the Irish Sea.

Table 2 illustrates the percentage of total annual effort hours of the total NI bottom trawl fleet at the sites over each year. For example, in 2007 if total NI bottom trawl fishing effort is 100%, only 1.09% of that effort is in Queenie Corner. These data are presented graphically in Figure 3 below.

Table 2. Seven year analysis - Percentage of total annual effort hours at each site:

	Queenie Corner	Slieve Na Griddle	South Rigg	West of Walney	Mud Hole
2006	0.84	1.21	2.66	1.37	2.52
2007	1.09	1.25	2.46	2.06	1.98
2008	0.53	1.29	1.87	0.51	1.08
2009	1.05	1.45	2.85	1.21	1.00
2010	0.82	1.19	2.15	0.61	1.33
2011	0.60	1.12	1.24	0.67	0.76
2012	1.02	1.18	0.96	0.43	0.67
2013	1.63	1.43	0.95	1.00	0.70
2014	1.38	0.97	0.82	0.56	0.71
Mean	*1.00*	*1.23*	*1.77*	*0.94*	*1.19*

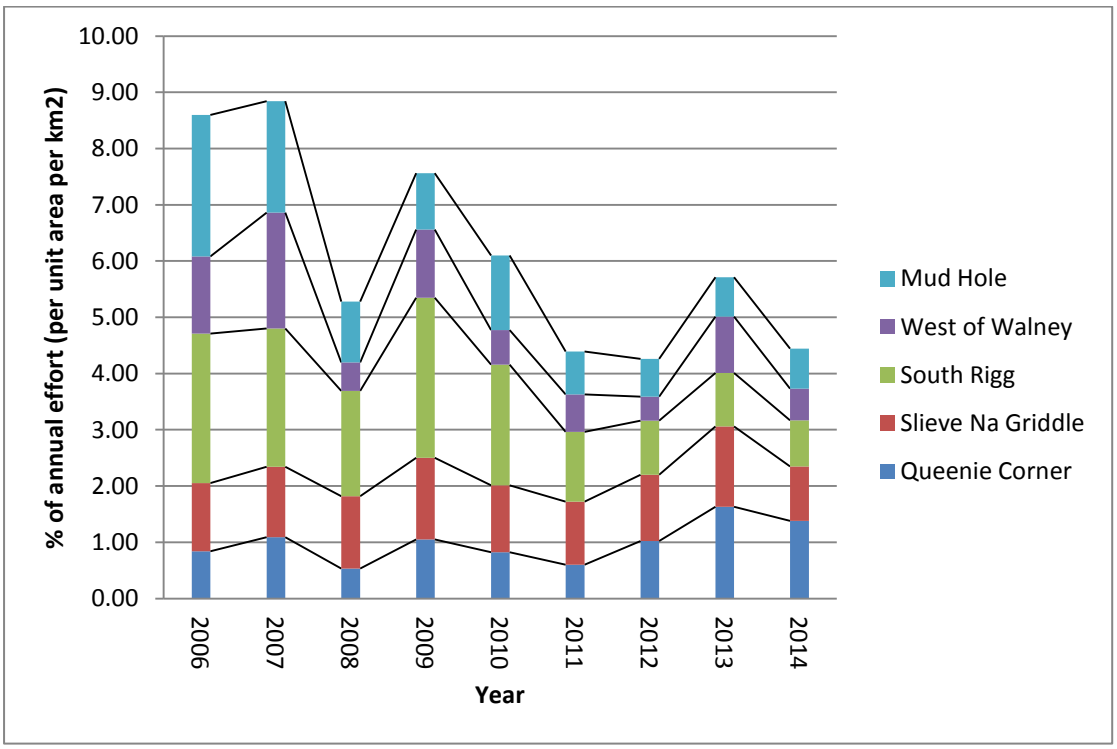

Figure 3. Nine year percentage of total effort hours at each site – Annual proportion of effort

Figure 3 demonstrates the annual variability in activity between these sites as percentage effort for each year. For example, South Rigg had a much greater percentage of activity in 2006 compared to 2014, while Queenie Corner has seen an increase in proportion of effort over this time period. Figure 4 below shows a fluctuating pattern of total fishing effort over these sites across the time period, with a general decline from the 2006 and 2007 levels. Together the sites in 2014 represent 4.44% of total NI Nephrops fleet effort.

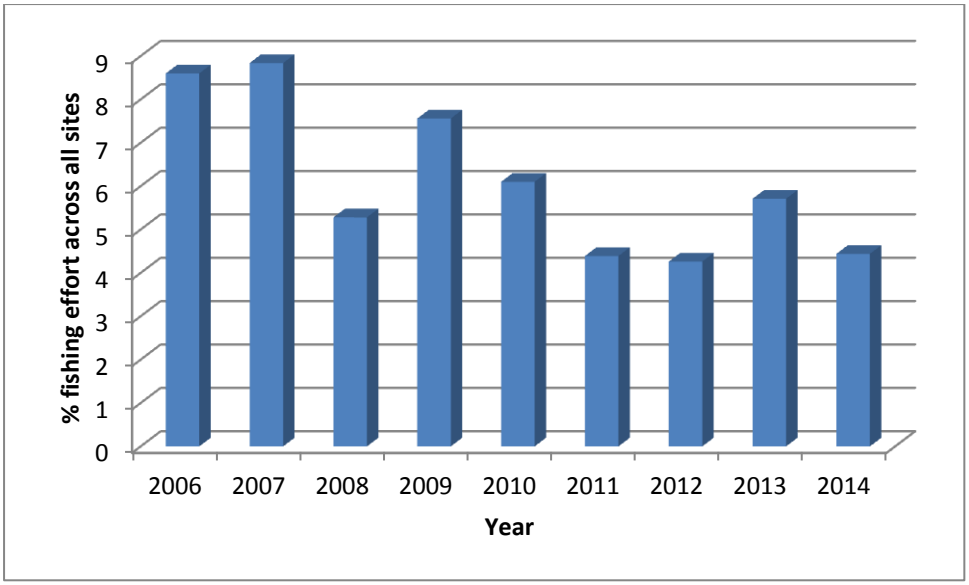

Figure 4. Nine year total percentage effort hours at all sites (NI bottom trawl fleet)

1.2.1 Site breakdown

To indicate the spatial pattern of bottom trawling fishing effort over each site and its variability between years, maps are provided below comparing effort at each site between 2006 and 2014. These maps should be compared with the summary figures provided in Table 2 above. Note that the spatial scale of each map differs due to the differences in site sizes; scale (in km) is shown on each figure.

South Rigg

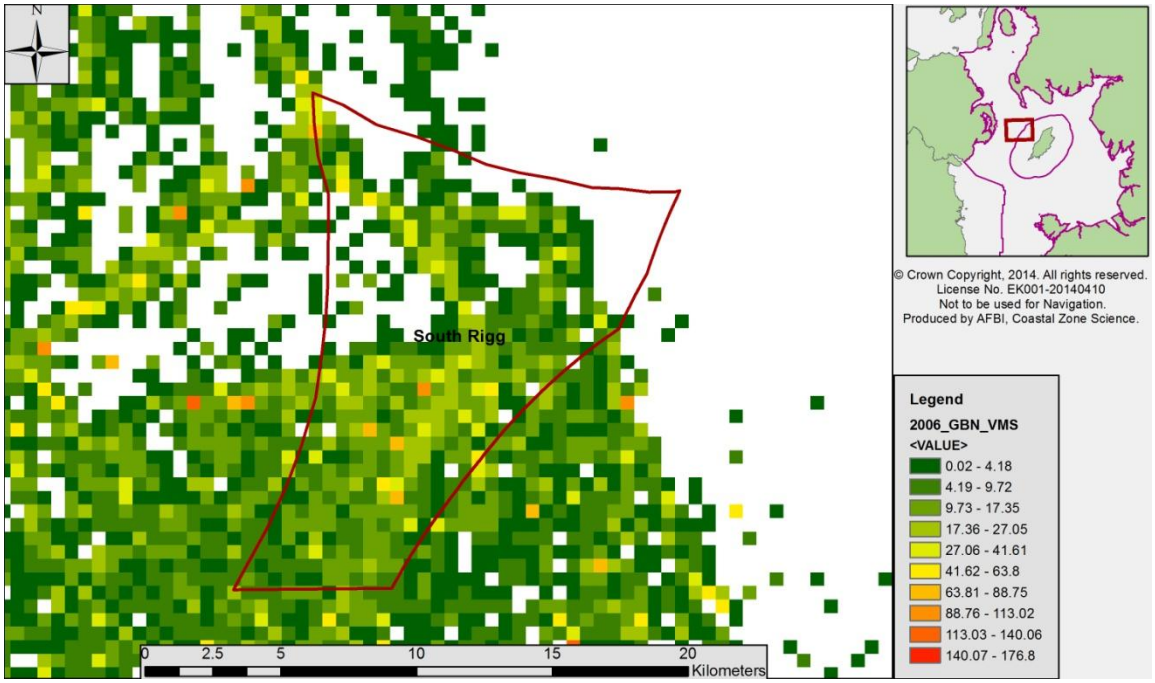

Figure 5. 2006 NI fleet VMS fishing effort hours per year per 0.25km^2

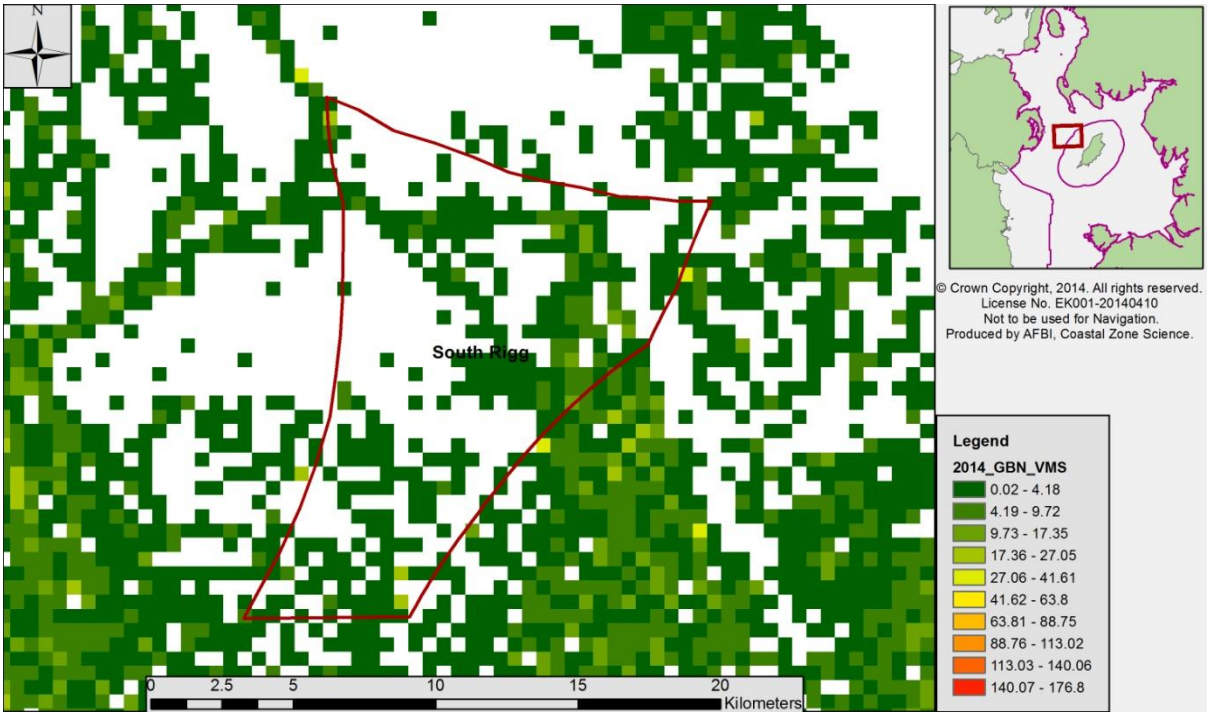

Figure 6. 2014 NI fleet VMS fishing effort hours per year per 0.25km²

Slieve Na Griddle

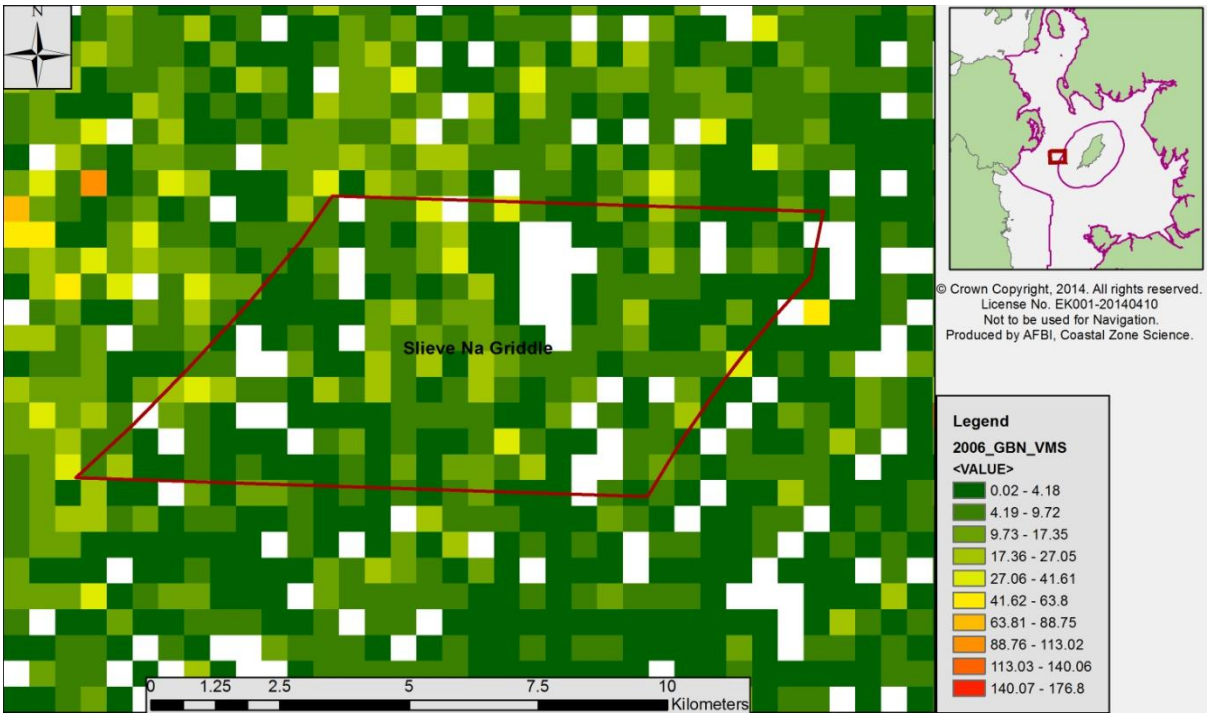

Figure 7. 2006 NI fleet VMS fishing effort hours per year per 0.25km²

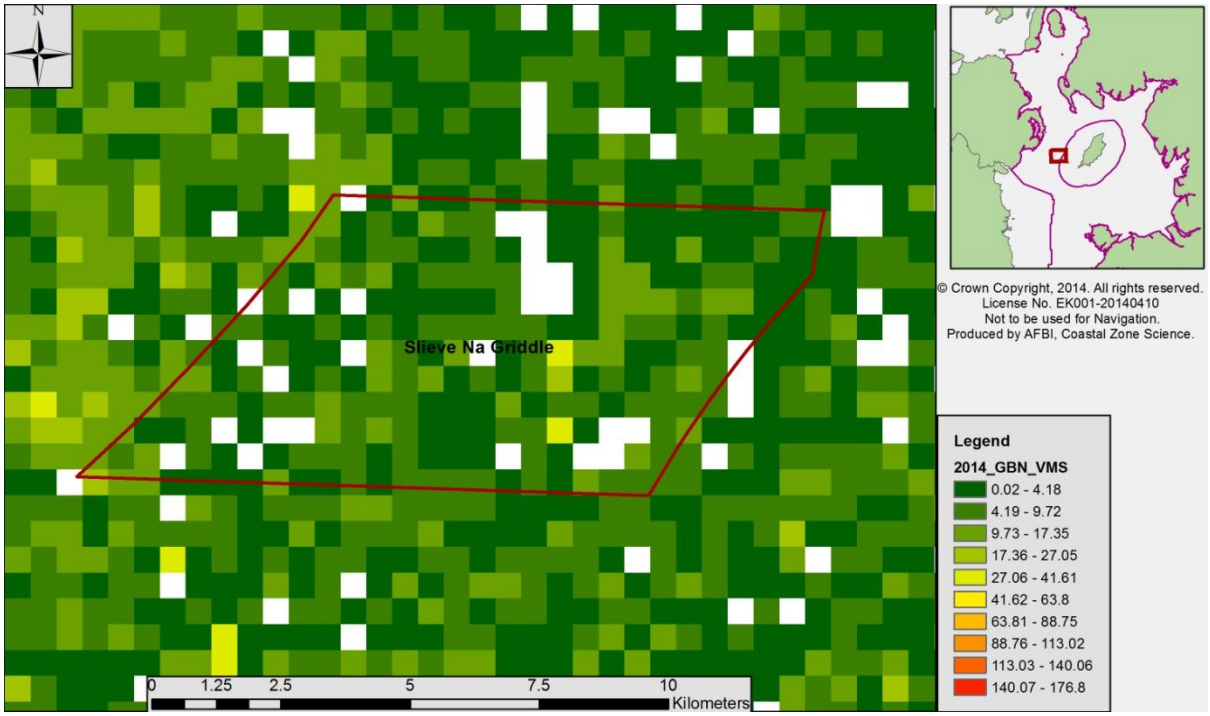

Figure 8. 2014 NI fleet VMS fishing effort hours per year per 0.25km^2

Queenie Corner

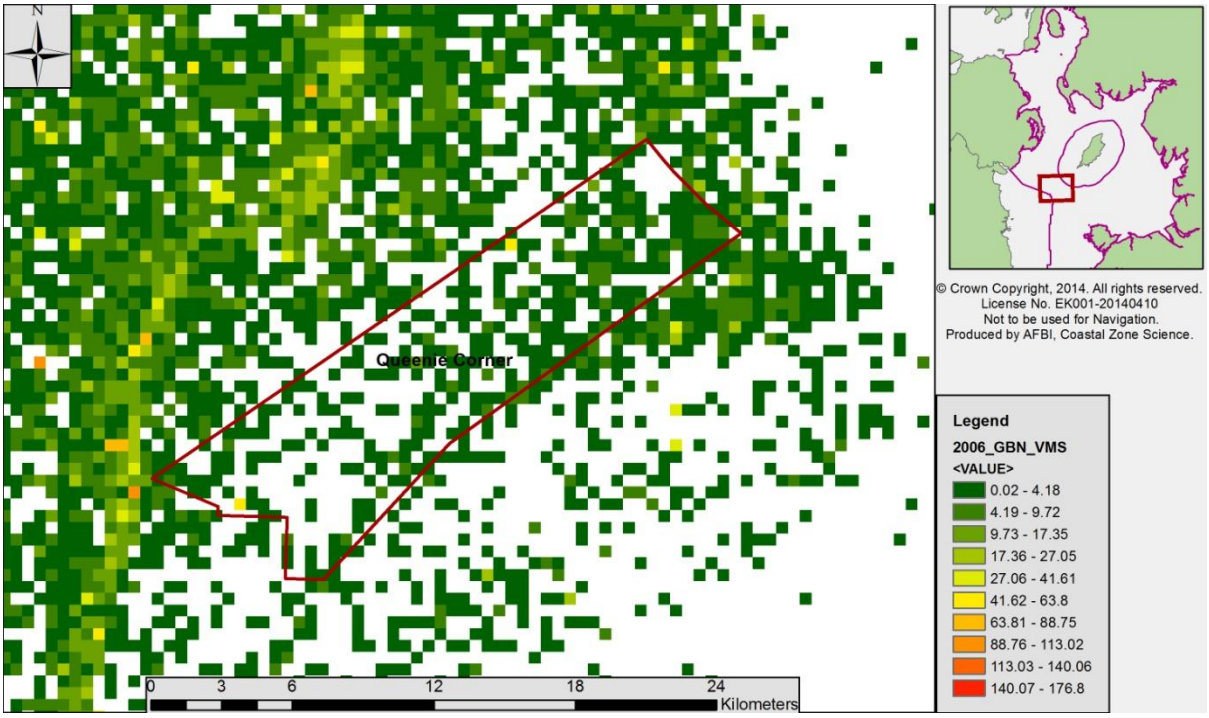

Figure 9. 2006 NI fleet VMS fishing effort hours per year per 0.25km^2

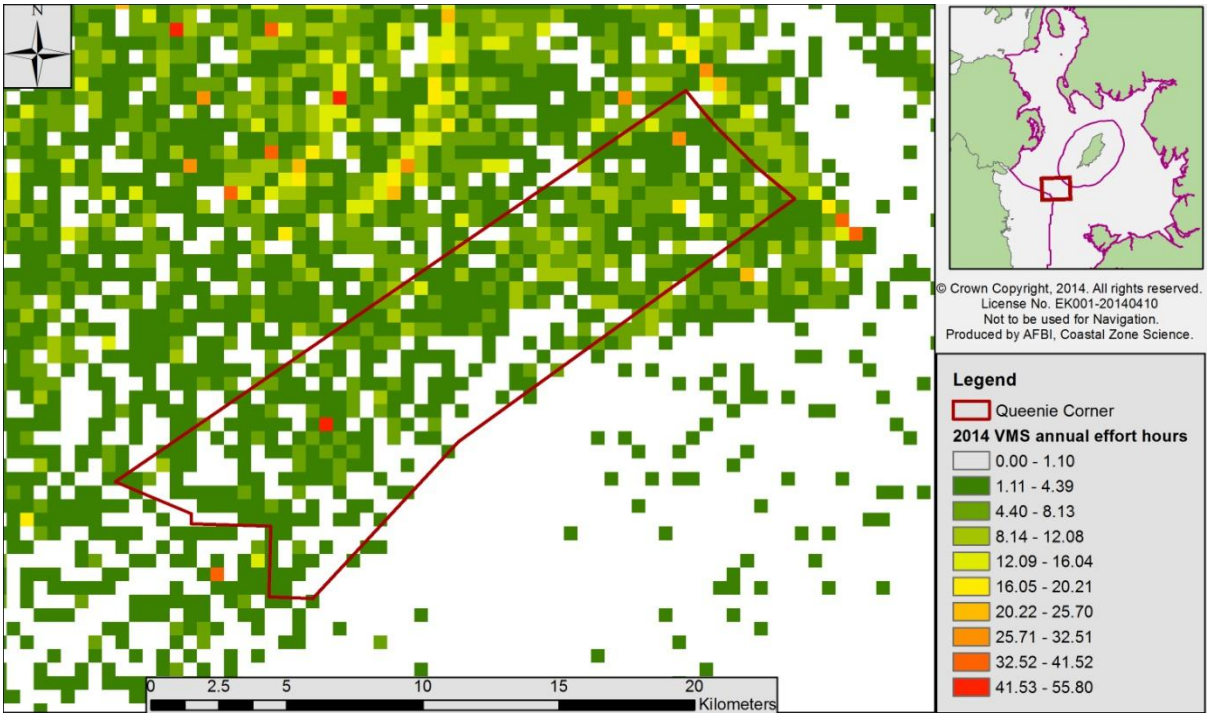

Figure 10. 2014 NI fleet VMS fishing effort hours per year per 0.25km^2

Mud Hole

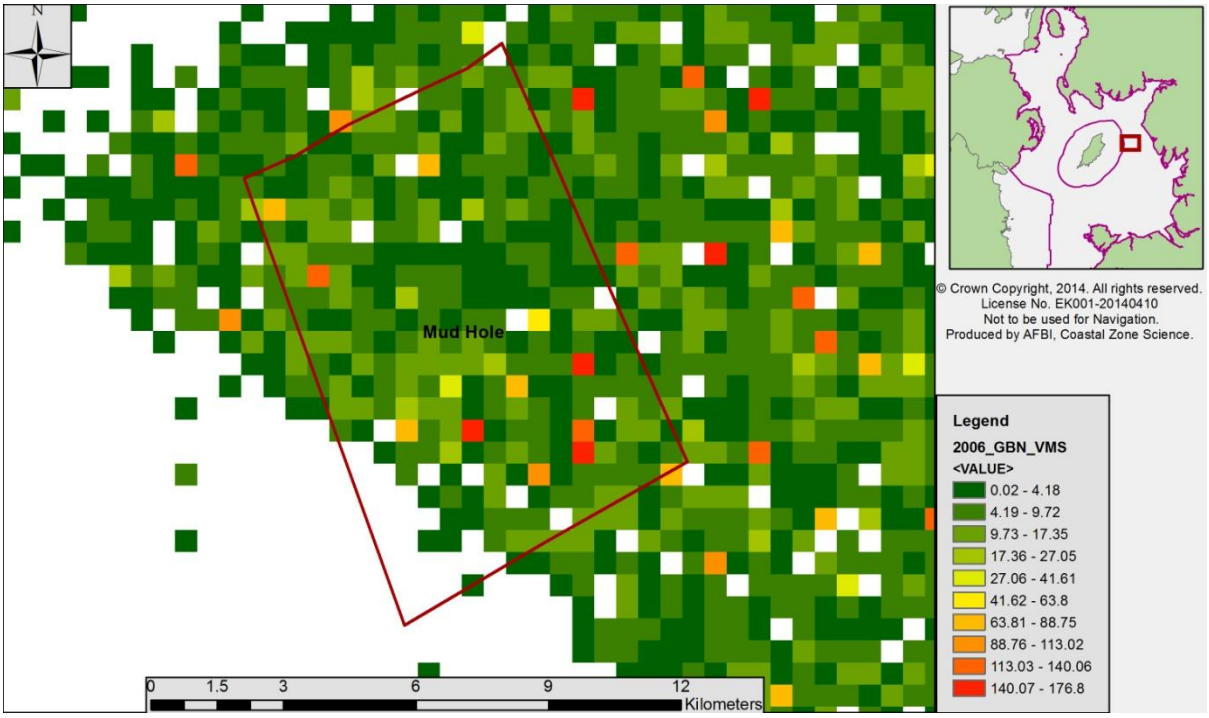

Figure 11. 2006 NI fleet VMS fishing effort hours per year per 0.25km^2

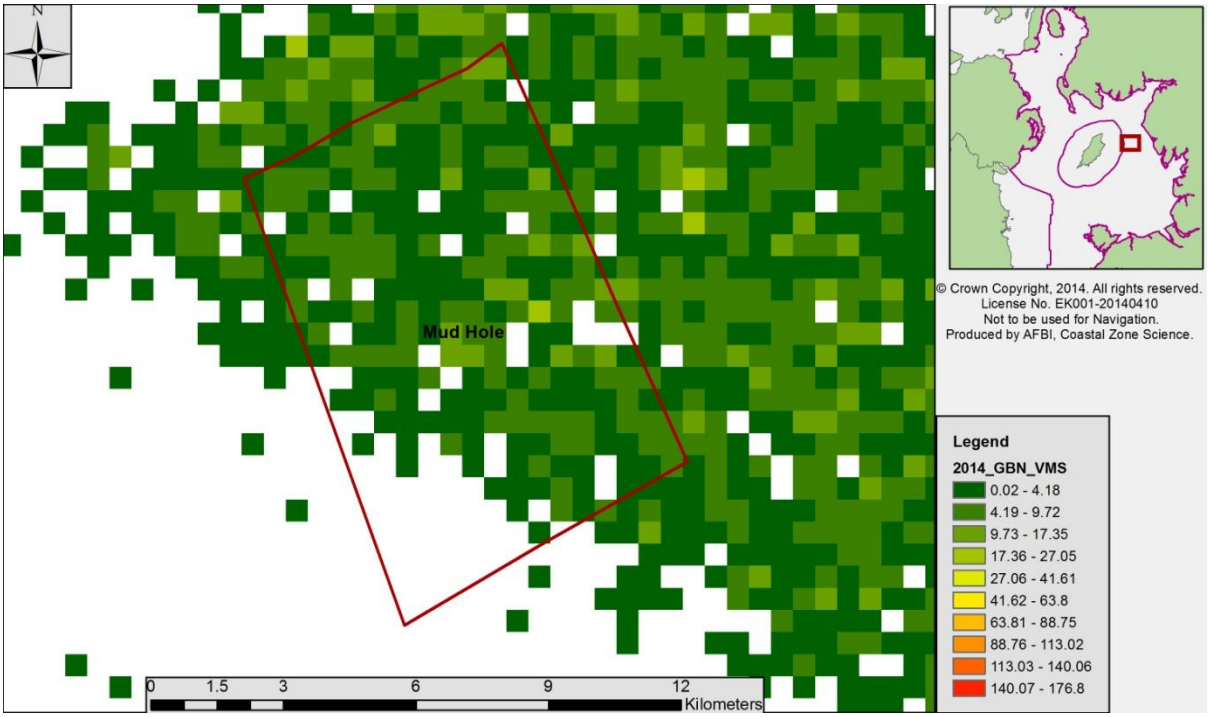

Figure 12. 2014 NI fleet VMS fishing effort hours per year per 0.25km^2

West of Walney

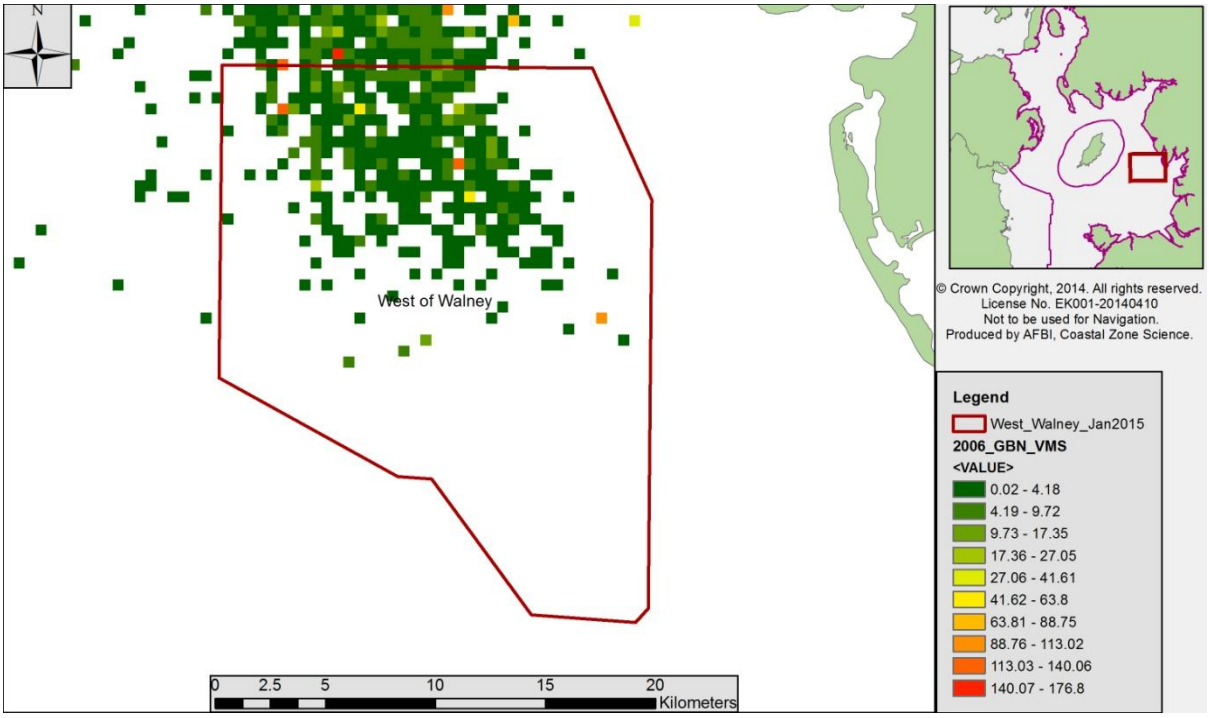

Figure 13. 2006 NI fleet VMS fishing effort hours per year per 0.25km²

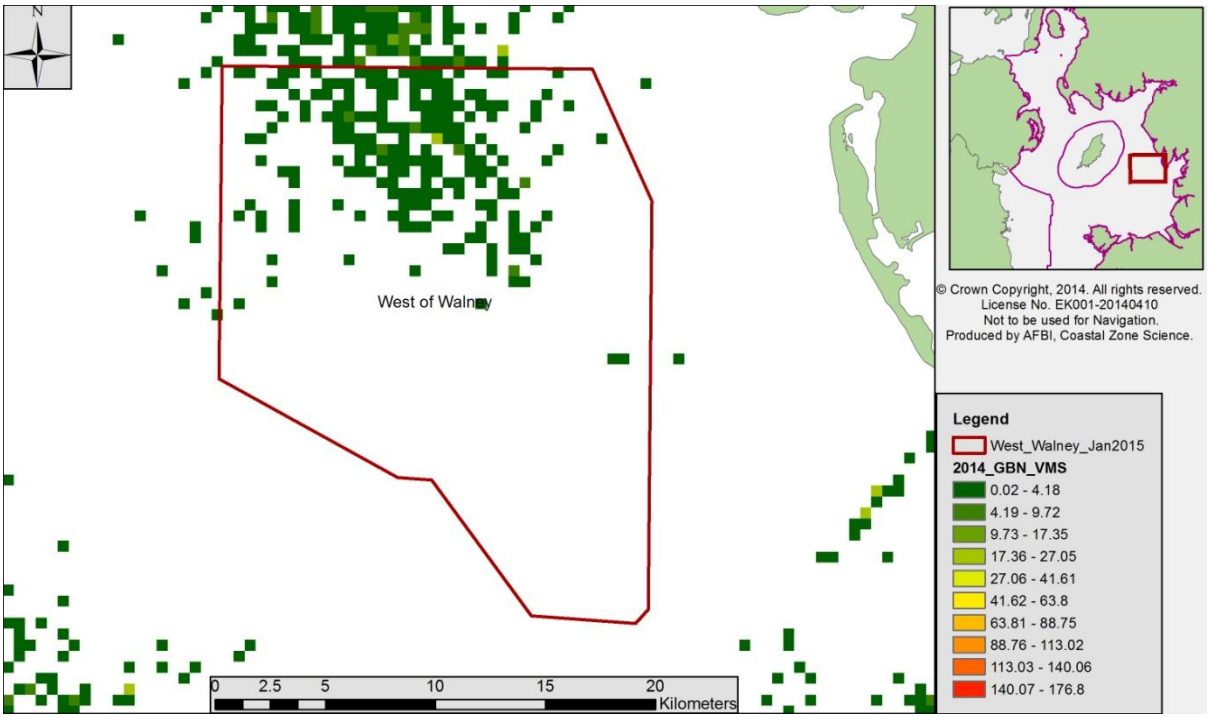

Figure 14. 2014 NI fleet VMS fishing effort hours per year per 0.25km²

Part II: Presentation of habitat evidence for "Queenie Corner" proposed site.

2.1 Definition of target habitat: "Subtidal mud"

The requirement to identify alternative "subtidal mud" predominant/broad-scale habitat potential MCZ sites necessitates that there is evidence of this feature presence, extent, and, where possible, condition at the alternative proposed sites. Further information regarding an operational definition of the target mud biotopes is provided following review of JNCC published information on habitat features of conservation interest, which refer to the Marine Nature Conservation Review classification biotopes (Connor *et al.,* 2004), biodiversity action plan priority habitat descriptions (BRIG (ed. Ant Maddock) 2008, updated 2011) and OSPAR definitions (e.g. OSPAR, 2008, 2010), with supplementary information provided by a separate JNCC document (JNCC, 2014):

- "Mud" biotopes must have minimum 20% silt-clay content (Connor *et al.,* 2004)
- In addition to broad-scale "subtidal mud", there are also two target '**habitats of conservation interest**' found often within the broad-scale habitat:
    - "**Mud habitats in deep water**": deeper than 20m, often (but not exclusively) characterised by "burrowing megafauna";
    - "**Seapen and burrowing megafauna communities**": usually deeper than 20m, but may be shallower in sea loughs. Must contain seapens- one or more of *Virgularia mirabilis, Pennatula phosphorea, Funiculina quadrangularis*.

These habitats of conservation interest have the following component biotopes and biotope complexes presented in Table 3, which have been identified in the Irish Sea as reported in AFBI (2015).

Table 3. Mud habitat biotopes identified within the Irish Sea (AFBI, 2015)

EUNIS code 2008	EUNIS level	EUNIS name 2008	JNCC 04.05 code	MCZ HOCI
A5.35	**4**	**Circalittoral sandy mud**	**SS.SMu.CSaMu**	Mud habitats in deep water / Sea-pen and burrowing megafauna communities
A5.351	5	[Amphiura filiformis], [Mysella bidentata] and [Abra nitida] in circalittoral sandy mud	SS.SMu.CSaMu.AfilMysAnit	Mud habitats in deep water
A5.36	**4**	**Circalittoral fine mud**	**SS.SMu.CFiMu**	Mud habitats in deep water / Sea-pen and burrowing megafauna communities
A5.361	5	Seapens and burrowing megafauna in circalittoral fine mud	SS.SMu.CFiMu.SpnMeg	Mud habitats in deep water / Sea-pen and burrowing megafauna communities
A5.362	5	Burrowing megafauna and [Maxmuelleria lankesteri] in circalittoral mud	SS.SMu.CFiMu.MegMax	Mud habitats in deep water / Sea-pen and burrowing megafauna communities
A5.363	5	[Brissopsis lyrifera] and [Amphiura chiajei] in circalittoral mud	SS.SMu.CFiMu.BlyrAchi	Mud habitats in deep water
A5.37	**4**	**Deep circalittoral mud**	**SS.SMu.OMu**	Mud habitats in deep water / Sea-pen and burrowing megafauna communities
A5.375	5	[Levinsenia gracilis] and [Heteromastus filifirmis] in offshore circalittoral mud and sandy mud	SS.SMu.OMu.LevHet	Mud habitats in deep water

The term “burrowing megafauna” is used in both seapen biotope (SS.SMu.CFiMu.SpnMeg) and also within the “mud habitats in deep water” definition. From the component biotopes in the EUNIS classification the following species may be considered to form part of burrowing megafauna (note that where specific densities of such species in a habitat are specified to aid classification into the habitats of conservation interest these are noted (JNCC, 2014)):

- *Nephrops norvegicus*, e.g. from *Nephrops* stock assessment underwater video surveys, burrow density must be >0.2/m^2
- *Brissopsis lyrifera*
- *Calocaris macandreae*
- *Goneplax rhomboides*
- *Jaxea nocturna*
- *Maxmuelleria lankesteri*
- *Callianassa subterranea*
- *Upogebia deltaura*

This is not an exhaustive list, but all these species are found in varying abundances in Irish Sea mud habitat, and the presence of these has been used to highlight habitat of interest.

There is some debate about what the varying abundances of these species may indicate in terms of "undisturbed habitat". For example, Queirós *et al*. (2006) suggested that burrowing Crustacea (*Jaxea nocturna* in their example) could dominate benthic communities in trawled areas, with filter-feeding species showing a marked decline. Trawling mobilises sediments which may affect filter-feeders disproportionately through smothering, whereas burrowing species avoid such impacts and are therefore less vulnerable. It has been suggested that *Nephrops* may dominate the "disturbed" areas subject to trawling in part due to trawling, as they are not sensitive to smothering through disturbance of sediment, and appear able to re-construct burrow entrance where these may have collapsed from physical disturbance, as deeper parts of the burrow system appear to withstand trawl passes.

2.2 New considerations in determining site boundary

In September 2015 AFBI was notified that following the Silk Review, the National Assembly for Wales would have extended authority over its waters beyond the 12nM limit, through creation of a "Welsh Fishery Zone". This new political boundary must be considered in addition to the Scottish boundary and Irish Sea CP2 region when proposing offshore MCZ sites (for Secretary of State waters). The initial Queenie Corner alternative MCZ site suggested in AFBI (2015) straddled what is now termed the Welsh Fishery Zone, and consequently resulted in the necessary trimming of this site by 132 km^2. The data reported in this document focus on the revised Queenie Corner site extent, but it should be noted that survey work was completed in 2014 and 2015 using the 'old' extent, prior to introduction of the Welsh Fishery Zone, and therefore data presented extend into this zone.

2.2 Methodology

To assess the presence, extent and condition of subtidal mud habitats in Queenie Corner, the following data sources were used:

- **Underwater video** – *Nephrops* stock assessment (ICES FU15), 2003-2015 annual surveys, and longer video tows completed from the RV *Corystes* in 2015 (cruise number CO2415).
- **Day grab data** (sediment descriptions and infaunal communities)
    - 85 samples were collected across two cruises in 2014 and 2015 aboard the RV *Corystes* (cruise numbers CO4814 and CO2415).

2.2.1. Underwater video analysis

The *Nephrops* underwater video burrow density data were presented geographically in GIS (Geographical Information System), symbolised according to average density following the approved stock assessment method (ICES, 2007), with densities associated with the mid-transect position of each video transect. Using the criteria outlined above, all burrow densities in excess of 0.2/m^2 were assumed indicative of burrowing megafauna.

The additional video tows were used to determine trends over larger spatial scales, as these tows were for a minimum of 30 minutes. These provided contextual information which can be useful when interpreting the grab sample data. A standard definition camera was deployed along with a GoPro camera recording high definition footage. Position of the camera sledge on the seabed was determined and recorded from an Ultra-Short Baseline (USBL) acoustic tracking device.

2.2.2. Grab samples data analysis

Each grab sample represented 0.1m^2 of seabed, with sub-samples taken for particle size analysis and nutrient analysis (nitrogen and organic carbon), and the remainder sieved gently using a 1mm sieve, with the residue preserved in buffered formalin and processed for species abundance by National Marine Biological Analytical Quality Control (NMBAQC) accredited laboratories.

The particle size data were analysed using the laser grain sizing method, following NMBAQC guidelines. The mean grain size, sorting and percentage of silt and clay (mud fraction), percentage of sand and percentage of gravel were extracted for further analysis.

The resulting species abundance data matrix was checked with the World Register of Marine Species ("WoRMS")[5] directory for species nomenclature, and colonial species removed. Notes of shell fragments were removed and juvenile species were removed. Datasets were merged into one species abundance matrix for further analysis. Two statistical analyses were completed, one using species level abundance data, and one using family level abundance data (aggregated). The latter was undertaken to help remove any artifacts that may arise due to two different laboratories having completed the infaunal species extraction and enumeration.

[5] http://www.marinespecies.org/

Univariate statistics were calculated for each sample, specifically species diversity, richness and even-ness/equitability (see Clarke, 1993, and Clarke and Warwick, 2001).

The sample data were subjected to multivariate statistical analysis within the software package PRIMER (Plymouth Routines in Multivariate Ecological Research - Clarke, 1993 and Clarke and Warwick, 2001) following fourth-root transformation. A cluster analysis was performed (90% cut-off) and Bray-Curtis similarity matrix computed to permit multi-dimensional ordination. An Analysis of Similarity was performed for the clusters to assess the significance of their differences. A Similarity of Percentages (SIMPER) routine was used to identify species contributing most to the similarity of each cluster. This information was then used to assist with the assignment of biotopes (EUNIS level 5) to each sample cluster.

An "environmental parameters" dataset was constructed to aid the analysis of the species data. This consisted of the sediment grain size data as noted above.

The "Bio-env" routine was used to examine the influence of percentage gravel, percentage sand, percentage mud (silt/clay), grain size sorting and mean grain size.

A method to assess the "natural-ness" or disturbance to a species assemblage was applied to the grab sample data. The AZTI Marine Biotic Index (AMBI) (AZTI-Tecnalia, www.azti.es), based on ecological succession in macroinvertebrate assemblages, was used to derive a measure of how disturbed each sample site is according to the species assemblages present. Species are assigned to groupings based on characteristics as noted below, and the ratio between the proportion of each group used as a measure of disturbance (Borja *et al.,* 2000).

- Group I: Species very sensitive to disturbance, present under unpolluted conditions (initial state): specialist carnivores, some deposit-feeding tubicolous polychaetes.
- Group II: Species indifferent to disturbance, present in low densities, non-significant variations with time (from initial state, to slight unbalance), suspension feeders, less selective carnivores, scavengers.
- Group III: Species tolerant to excess organic matter enrichment. They occur under normal conditions, but are stimulated by organic enrichment (slight unbalance situations), surface deposit-feeding species, as tubicolous spionids.
- Group IV: Second-order opportunistic species (slight to pronounced unbalanced situations). Mainly small sized polychaetes: subsurface deposit-feeders, such as cirratulids.
- Group V: First-order opportunistic species (pronounced unbalanced situations). These are deposit-feeders, which proliferate in reduced sediments.

Multivariate-AMBI (M-AMBI), also known as Ecological Quality Ratio, is a newer development which appears to be sensitive to disturbance induced by fishing pressure, whereas AMBI traditionally is most responsive to pollution (e.g. organic enrichment) and less sensitive to changes induced by physical impacts, as may be seen from some fishing activities (Borja *et al.,* 2009). The M-AMBI metric ranges from 0 to 1, with one being high/good benthic health, and 0 representing low/poor benthic health.

Finally, in order to facilitate understanding of the grab sample data in relation to the criteria for mud habitats of conservation importance, a decision tree was used to assign an arbitrary value to illustrate their fit to the criteria, from a scale of '0' (no fit) to '6' (full fit- all possible criteria of mud grain size, burrowing megafauna other than *Nephrops* and *Nephrops* burrow densities >0.2/m^2). This decision tree is illustrated in Figure 15 below.

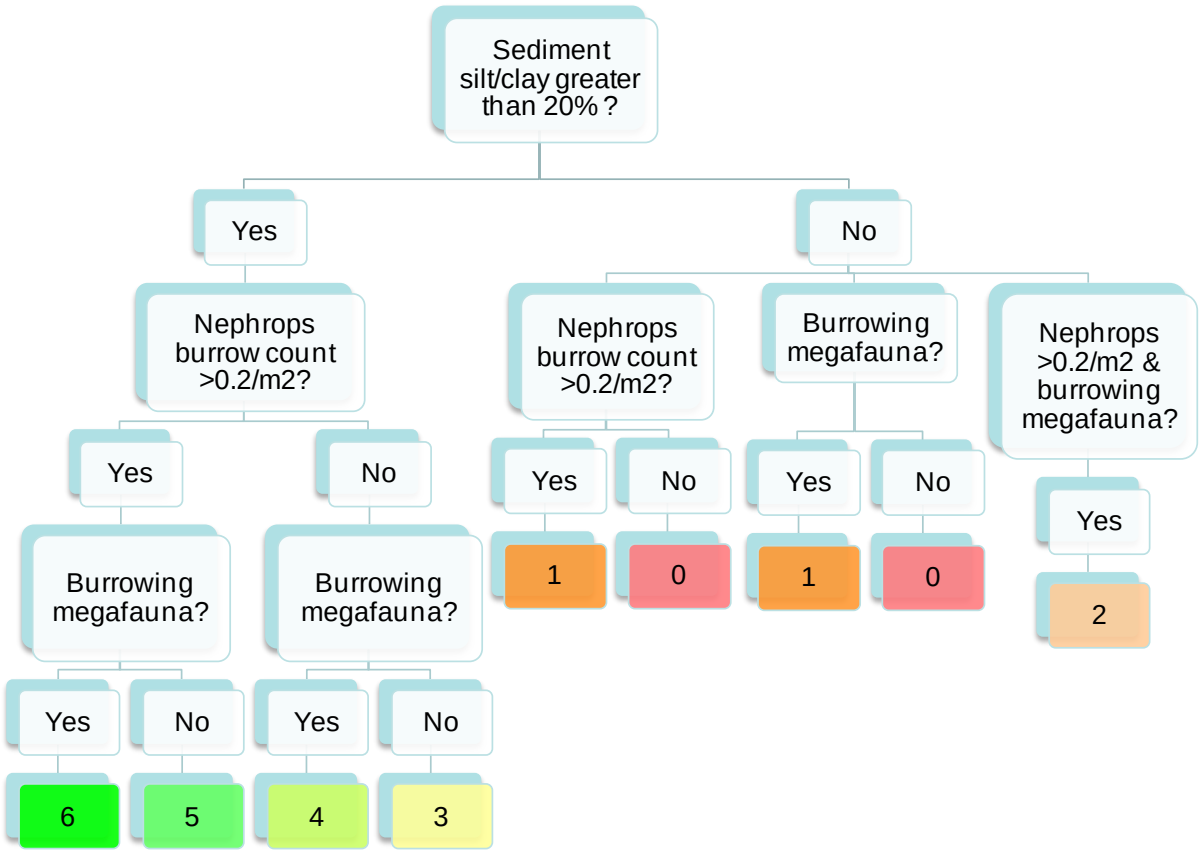

Figure 15. "Burrowed mud index" developed using decision tree

A GIS shapefile was created for the grab samples to allow spatial presentation of the data, attributing them by the following:

- Mean grain size
- Grain size sorting
- Percentage silt/clay content
- Nearest *Nephrops* burrow density
- Species diversity
- Species even-ness
- Cluster identifier
- Biotope
- Burrowed mud index
- Presence of burrowing megafauna species

- AMBI
- M-AMBI

The various habitat datasets were used in GIS to determine the proportion of the Queenie Corner site which could be considered as subtidal mud habitat (split by the 75m depth contour) and any other identified habitat.

2.3 Results

To provide context across the Irish Sea region, results are presented at this scale alongside the datasets reported in AFBI (2015), and also at the Queenie Corner site scale.

2.3.1. Underwater video data

FU15 (Western Irish Sea) burrow data are held by AFBI and data from 2003-2015 were available, providing a denser total coverage of sampling stations as station locations differ each year. Burrow densities in FU15 are highest of all ICES-managed grounds, often exceeding 3.0 burrows/m^2 in some areas. In spite of some variation in burrow densities over different years the main spatial distribution appears stable, with the edge of the *Nephrops* ground where burrow densities fall below 0.2 burrows per m^2 clearly defined. This boundary area occurs outside of the predicted mud habitat from EU SeaMap. Some areas which are not predicted to be mud habitat also show notable *Nephrops* burrow densities, particularly to the North-east and South-east of the predicted western Irish Sea mud area. It is well documented that *Nephrops* burrows may be found on sandy sediments in addition to muds, which may be the case in these areas (Afonso-Dias, 1997). Within Queenie Corner (Figure 16), burrow densities across the whole area with the exception of one small pocket exceed the 0.2/m^2 threshold.

The habitat context video tows revealed an east-west pattern, with more easterly tows showing sparser *Nephrops* burrows but many dead *Brissopsis lyrifera* testes and frequent seapens *Virgularia mirabilis.* The more westerly tows showed an increased in burrows, including those of *Calocaris macandreae*, and many *Turritella communis* shells (see Figure 17).

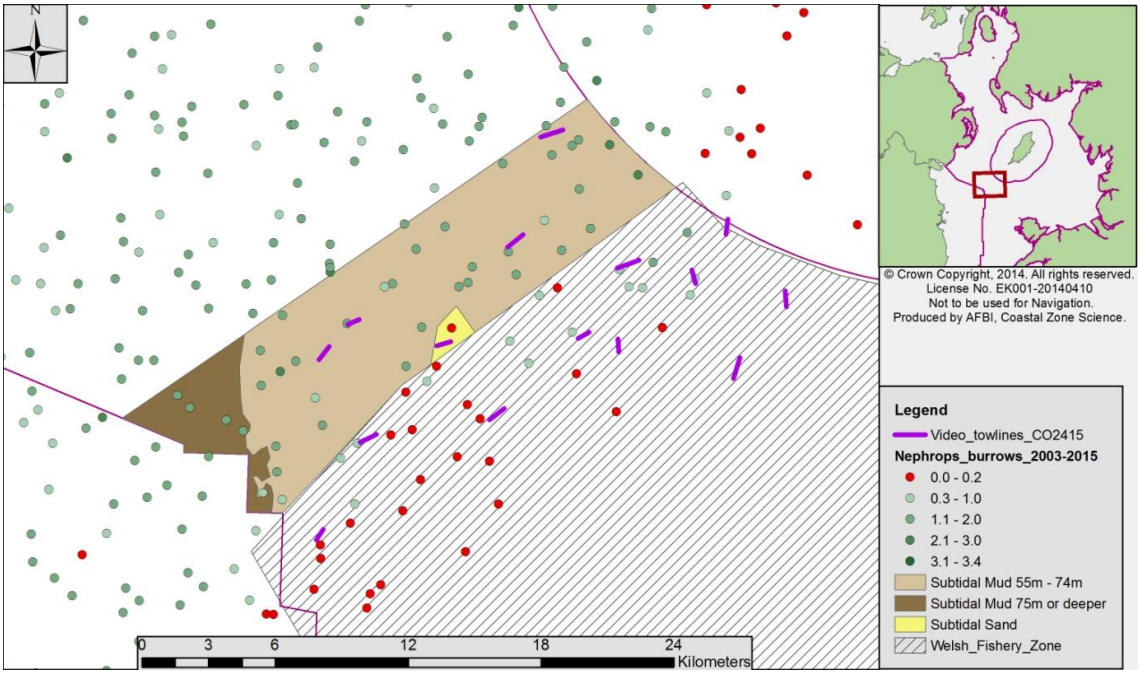

Figure 16. *Nephrops* underwater video data and location of habitat context video tows from CO2415 across Queenie Corner

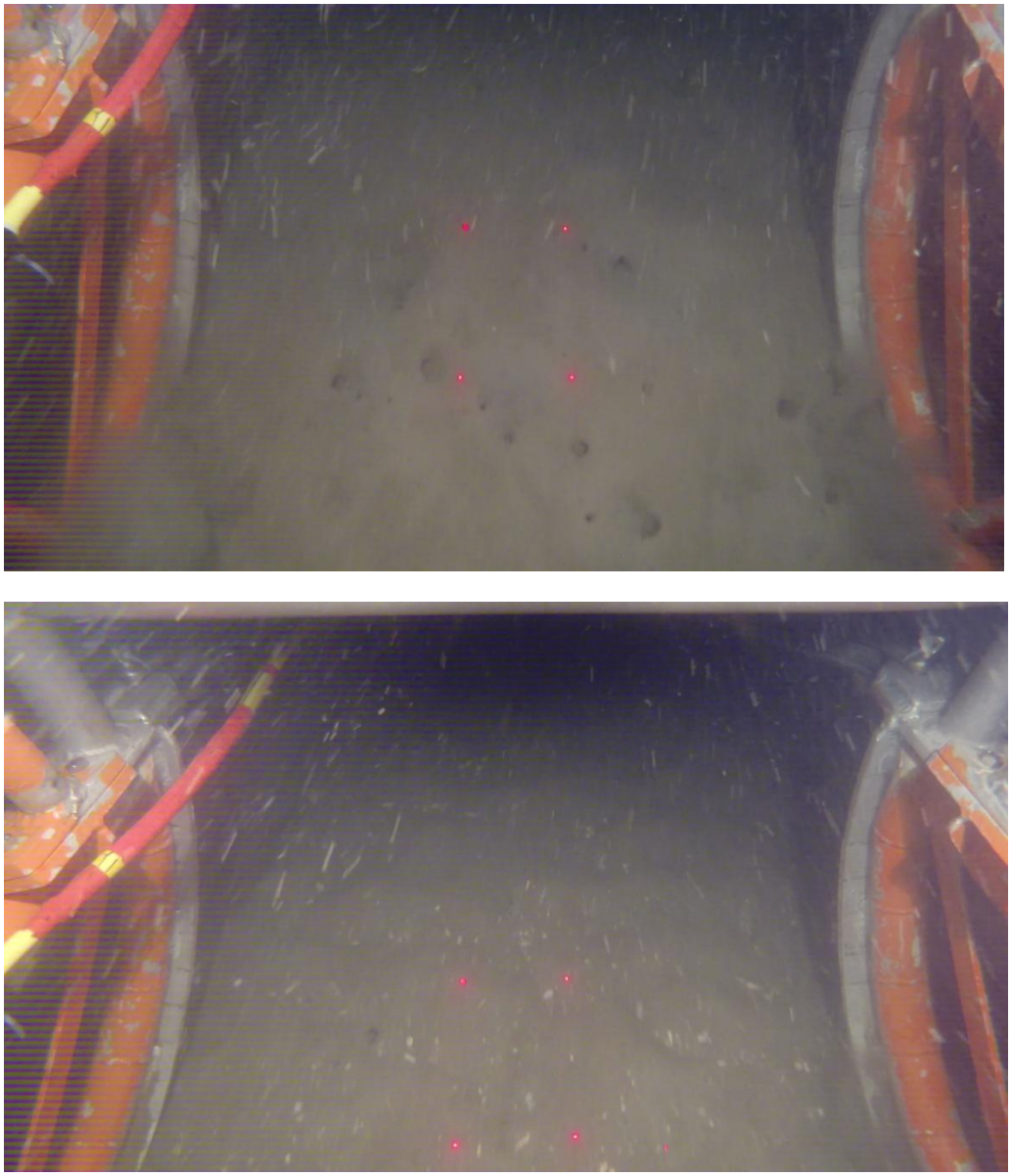

Figure 17. GoPro video stills demonstrating dense burrows (upper image) and dense *Turritella communis* shells (lower image). Lasers provide scale (17.5cm between each point).

2.3.2. Grab sample data

A total of 229 species were identified in the grab samples for the Queenie Corner area.

2.3.2.1 Univariate analysis

At an Irish Sea regional level, the species diversity indices (e.g. Shannon's diversity index in Figure 18) showed strong spatial trends across the eastern and western Irish Sea, with highest diversity found on the Walney area of eastern Irish Sea, and at South Rigg area and the eastern part of Queenie Corner. Lowest diversity was found in the more central areas of the western Irish Sea *Nephrops* ground, and the "Mud Hole" area of the eastern Irish Sea. However, within the western Irish Sea *Nephrops* ground there are localised higher diversity spots, some of which appear to be found closest to bedrock reef areas.

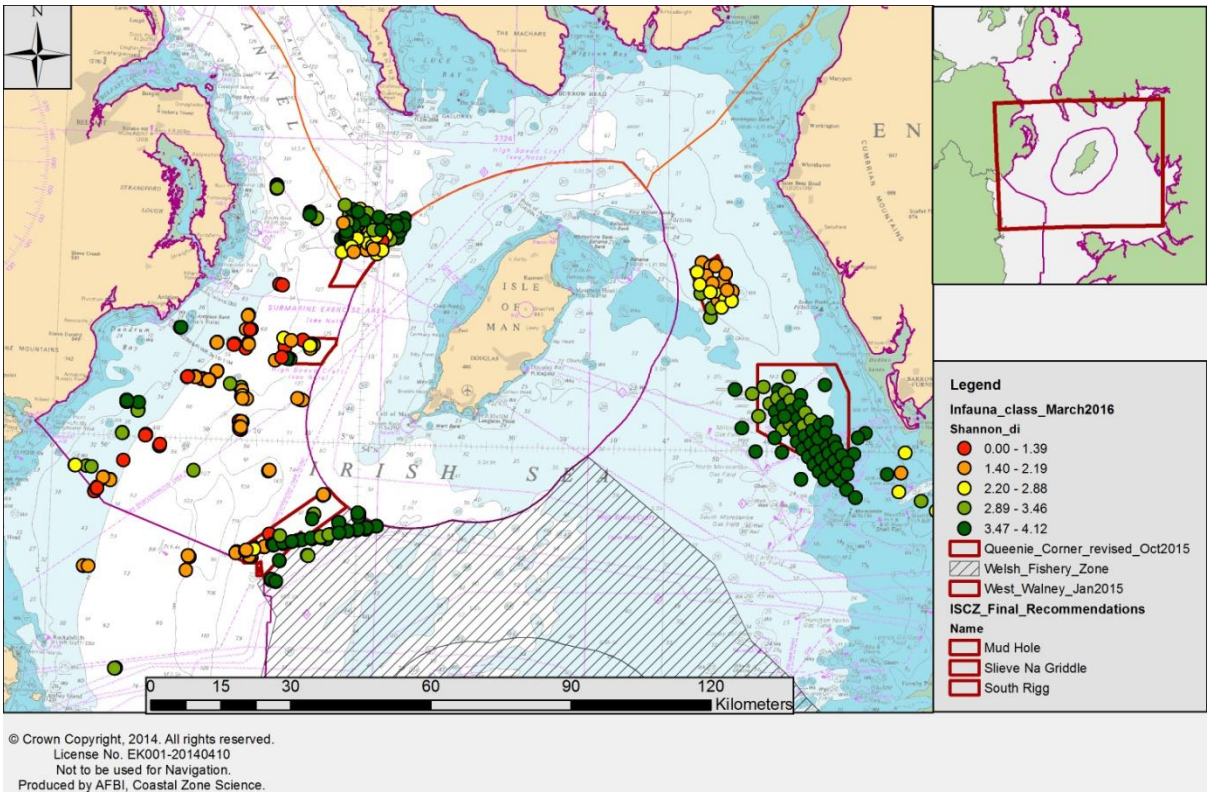

Figure 18. Shannon's diversity index for grab sample sites

Interpretation of these results with respect to potential influence of disturbance, e.g. fishing activity, must be treated with caution. A number of studies have suggested that where disturbance is minimal, species diversity can be reduced due to the influence of competitive exclusion between species, and that disturbance may act to reduce competition and therefore at intermediate disturbance diversity may be maximised (Connell, 1978; Huston, 1979). It is very difficult over such a large geographical area to make assumptions about whether diversity or even-ness has been impacted by disturbance, only that there are geographical differences and additional analyses are used in this study to further investigate such differences.

At a site level, there exists a strong correlation between infaunal species diversity and sediment parameters, specifically as shown below (Figure 19) the percentage mud (silt/clay) fraction.

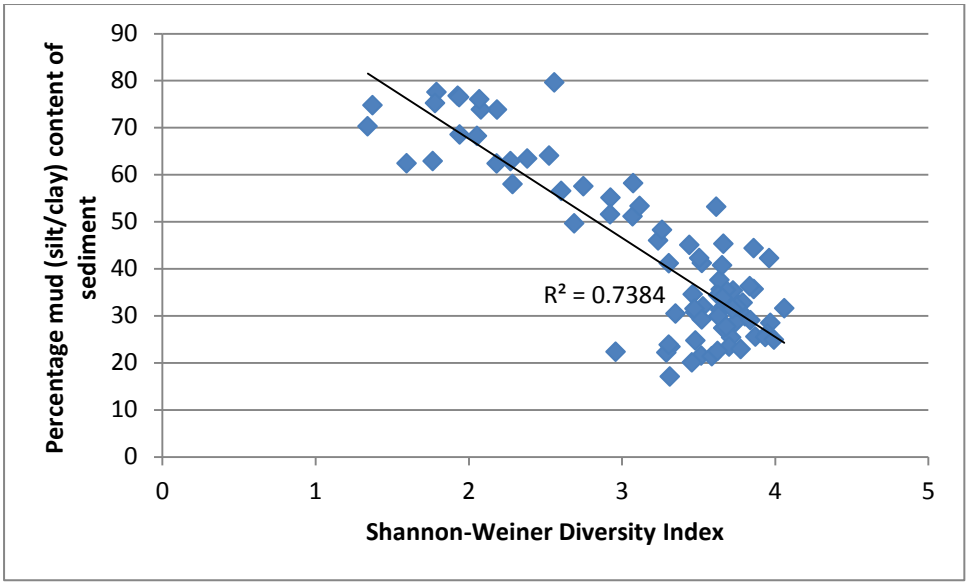

Figure 19. Queenie Corner infaunal diversity plotted against percentage mud fraction of sediments.

2.3.2.2. Multivariate analysis

Irish Sea

The cluster analysis used a 5% significance level and identified a total of 82 clusters from the 416 samples. A SIMPROF test was also performed which tested whether there is clear evidence of group structure within the samples: the global sample statistic (Pi) was 5.68, at a significance level of 0.1%, indicating that there is strong evidence of group structure.

There were three samples which contained no species, and therefore the MDS plot created from the entire dataset was sampled to exclude these, to allow a visual inspection of the remaining samples. Figure 20 below show the MDS plot symbolised by cluster, which shows how these group relative to each other in multidimensional space. The stress level is 0.19 in the two-dimensional plots, which indicates that these provide a potentially useful picture of how the samples relate to each other, but cross-checking with the clusters enables reassurance that similar patterns in differences between samples can be seen. Figure 21 presents the same MDS plot with the Folk sediment classification for each of the samples presented in the symbology.

When the clusters are plotted geographically, it is clear that there is a strong spatial pattern in cluster distribution (i.e. clusters are not spread evenly or randomly across all samples across the Irish Sea). This is shown when the sample labels of the MDS plots are examined (sample labels relate to surveys which were derived usually from single sites, before being aggregated for this study) but better examined within GIS, as shown in the map in Figure 22. For example, West of Walney

harbours clusters starting with ‘a’ only (yellows and orange colour code in Figure 22), whereas in the North part of South Rigg, and the eastern part of Queenie Corner, clusters starting with ‘b’ dominate. The deeper waters of southern South Rigg, western part of Queenie Corner, Slieve Na Griddle and some interspersed areas in the western Irish Sea exhibit similar clusters (‘i’s and ‘j’s), while the deepest parts of the western Irish Sea prawn ground and areas more to the west show mostly clusters ‘u’, which is also found in smaller parts of Queenie Corner, Slieve Na Griddle and South Rigg. In Mud Hole, none of the same clusters as those in the western Irish Sea are found.

This emphasises how the benthic communities of the western and eastern Irish Sea differ, but that within the western Irish Sea although there are pockets of one cluster dominating over another, all of South Rigg, Slieve Na Griddle and Queenie Corner contain the same range of clusters on mud habitat (with varying proportions only, perhaps related to depth of mud and location in relation to the seasonal western Irish Sea gyre).

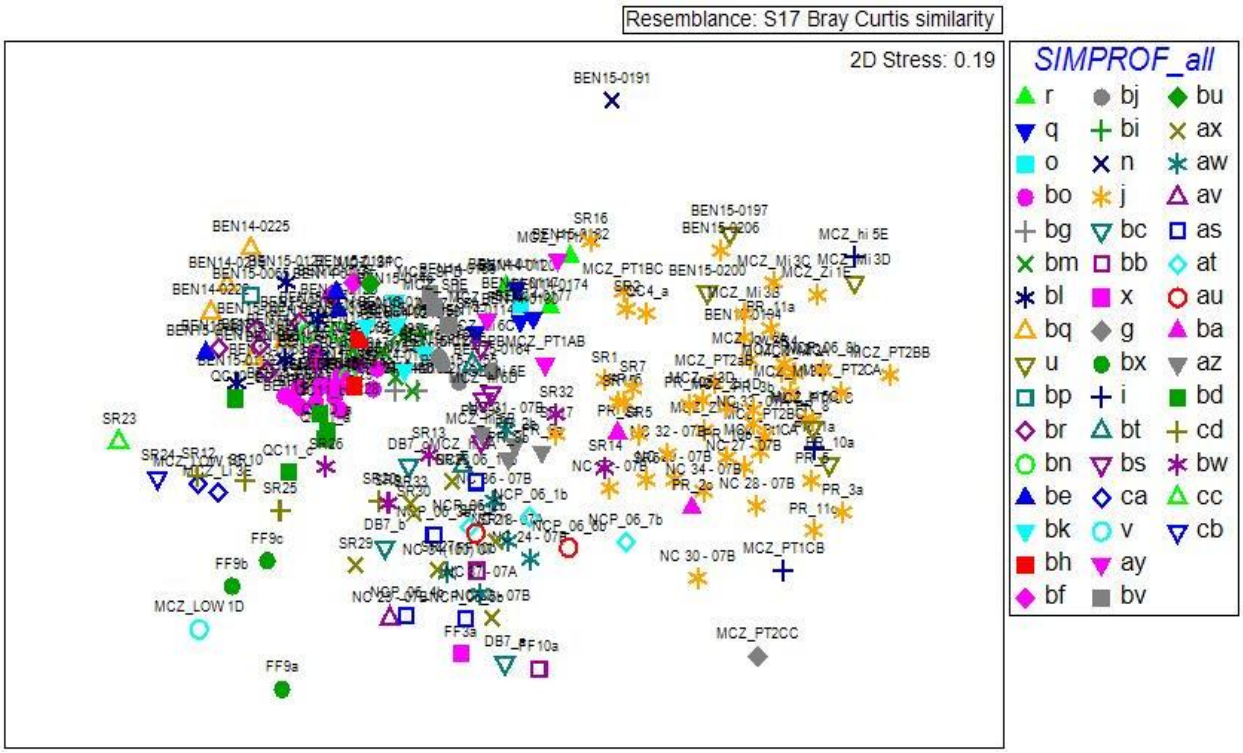

Figure 20. Irish Sea samples MDS plot coded by cluster (“SIMPROF”)

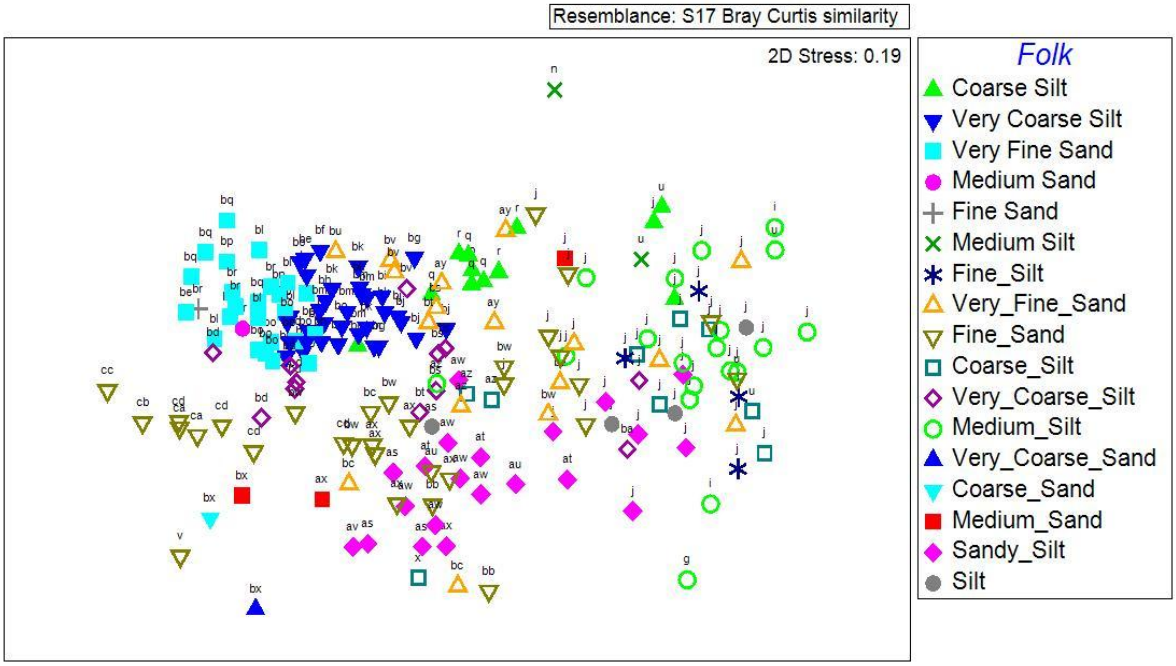

Figure 21. Irish Sea samples MDS plot coded by Folk sediment classification

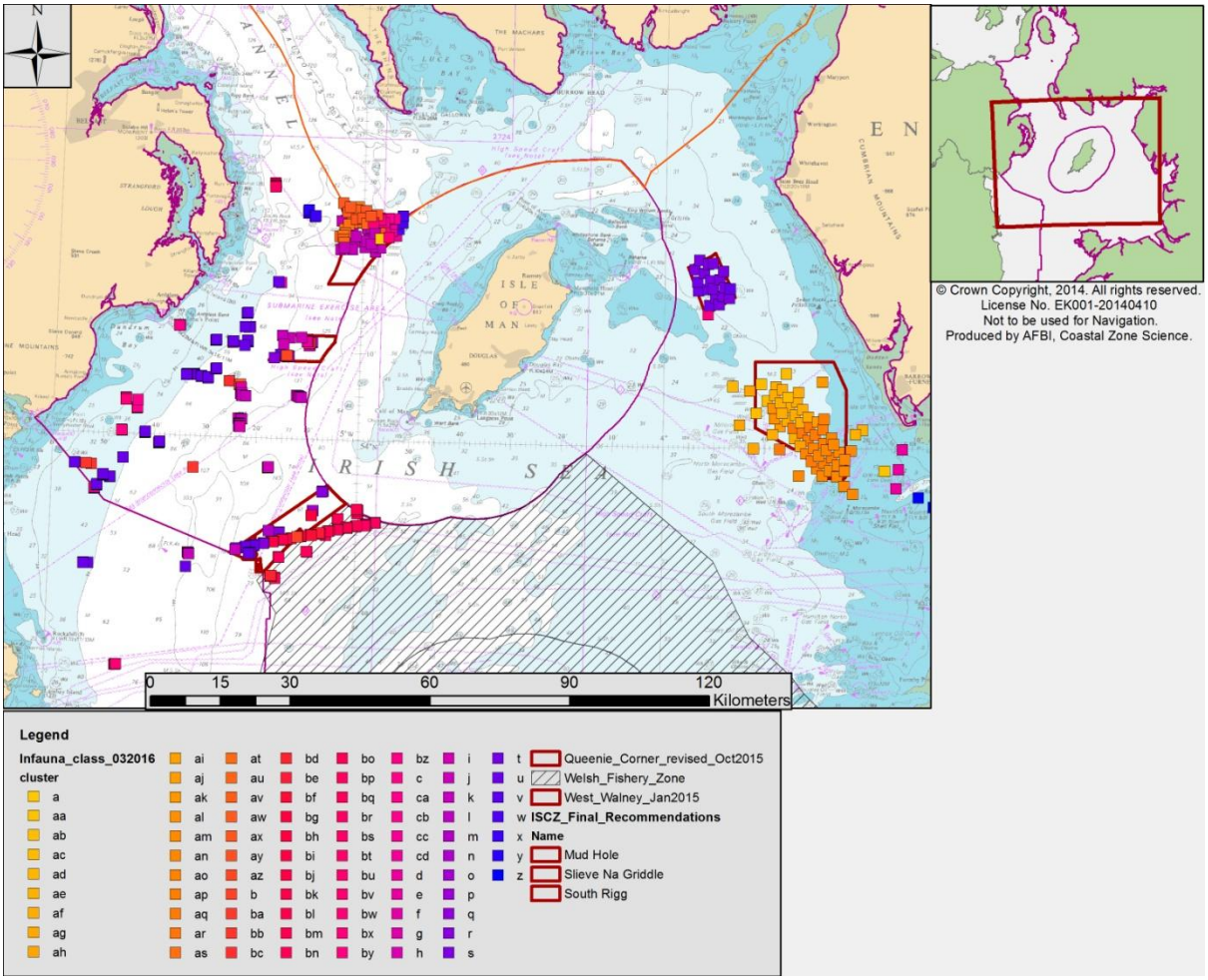

Figure 22. Grab samples coded by cluster

Queenie Corner

The cluster analysis used a 5% significance level and identified a total of 12 clusters from the 85 samples with species taxonomically aggregated to Families. A SIMPROF test was also performed which tested whether there is clear evidence of group structure within the samples: the global sample statistic (Pi) was 8.77, at a significance level of 0.1%, indicating that there is strong evidence of group structure.

Figure 23 and 24 below present the MDS plot of the 12 clusters and also symbolised by Folk sediment classification.

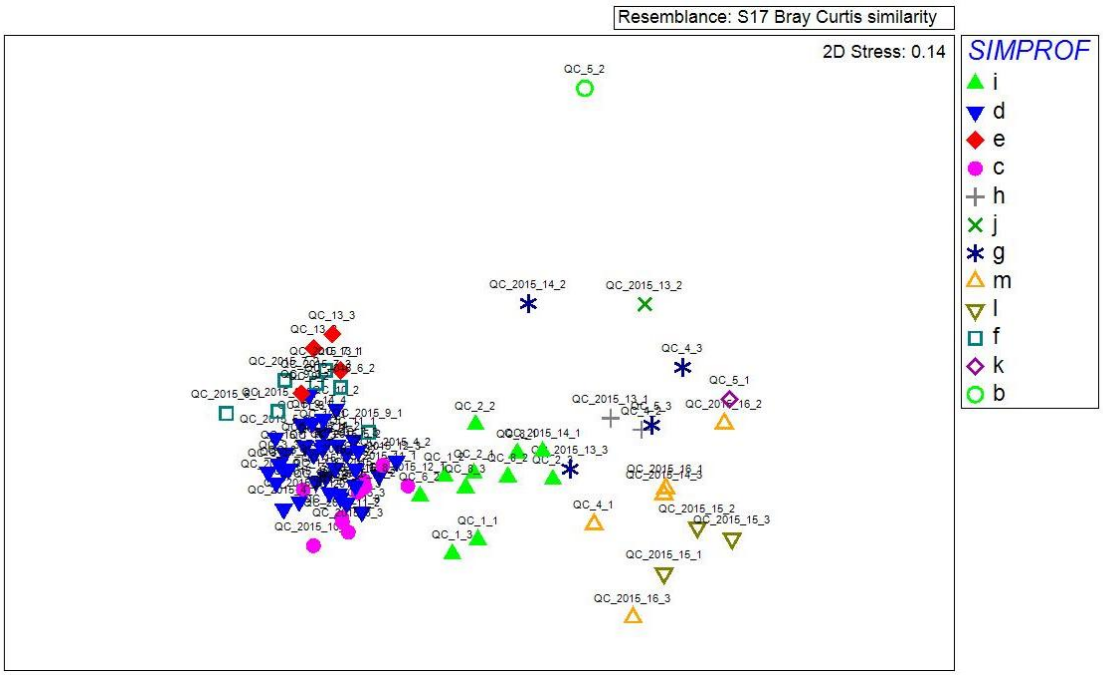

Figure 23. Queenie Corner samples MDS plot coded by cluster ("SIMPROF")

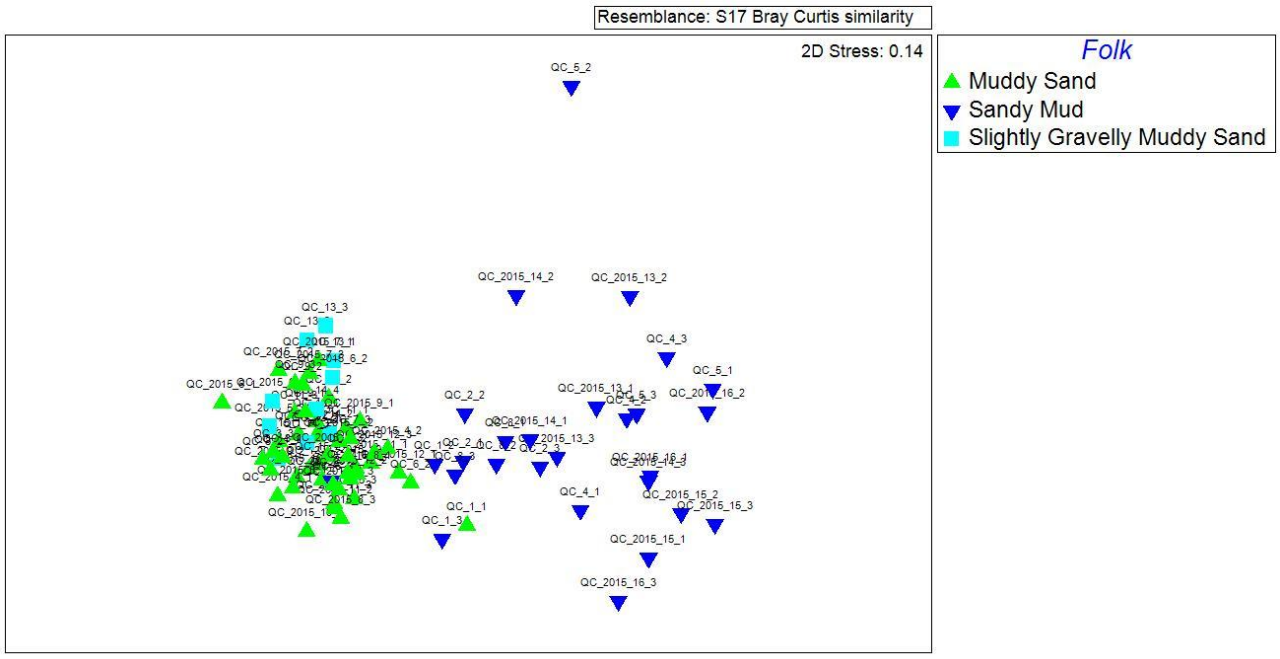

Figure 24. Queenie Corner samples MDS plot coded by Folk sediment classification

To further illustrate how these clusters and their distribution in multidimensional space relate to mud communities of interest, the distribution of key mud burrowing fauna which are readily sampled by Day grab were plotted on the MDS plots (Figures 25-27 below) and then also on maps (Figures 28-30).

It can be seen that there is a clear difference between the sample sites which harbour each characterising mud burrowing species. For example, *Brissopsis lyrifera* (Figures 25 and 28) appears to be found to the east of the Queenie Corner site (though is known to have high inter-annual variability in both abundance and spatial extent), while *Calocaris macandreae* is found in the deeper water with finer mud to the west of the site; *Goneplax rhomboides* is more patchily distributed across the site.

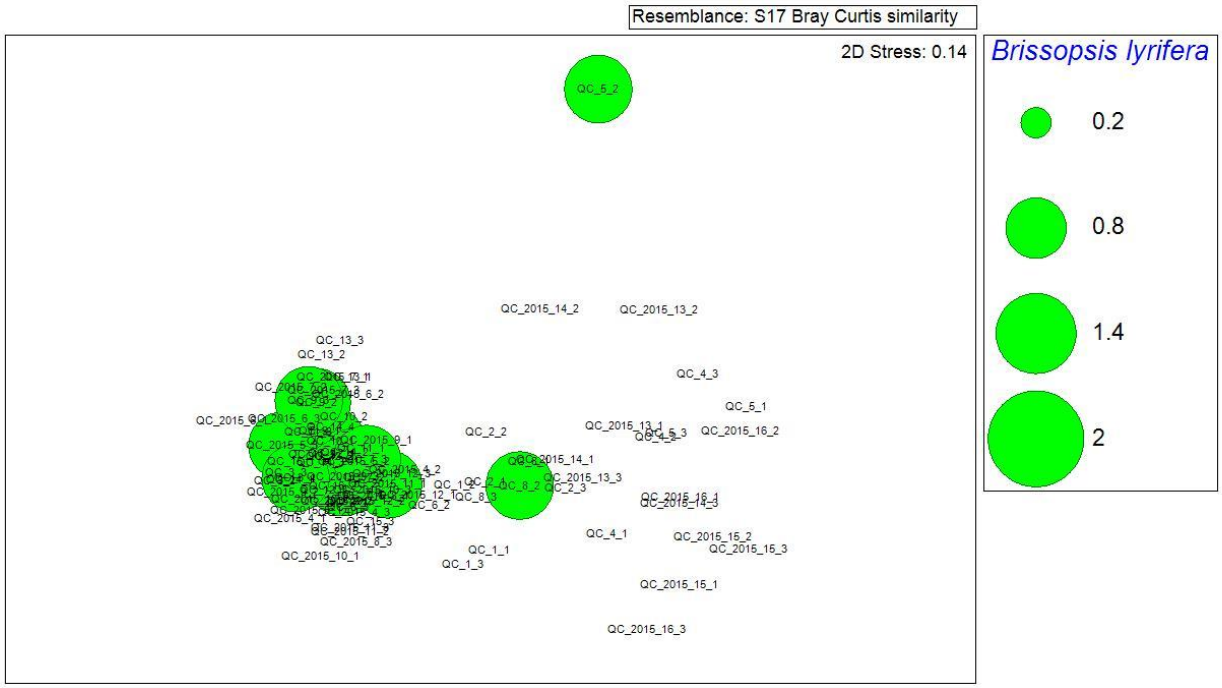

Figure 25. MDS plot with sample labels and *Brissopsis lyrifera* abundance (fourth root transformed) overlaid.

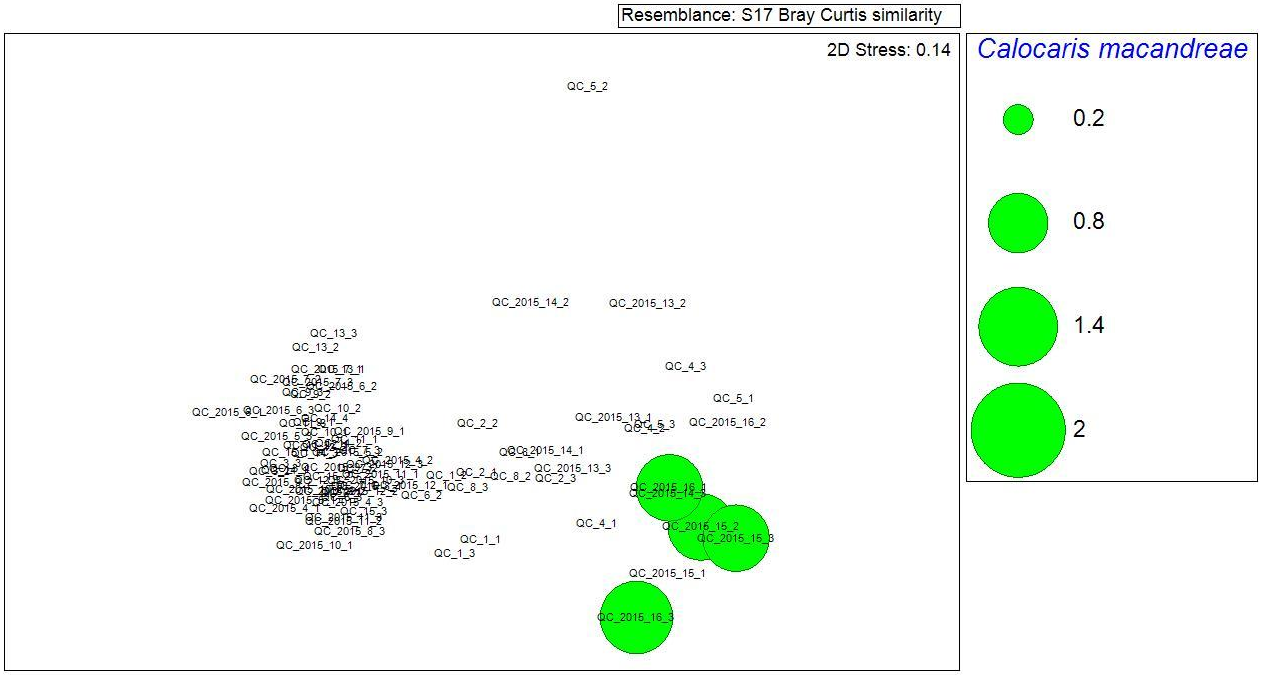

Figure 26. MDS plot with sample labels and *Calocaris macandreae* abundance (fourth root transformed) overlaid

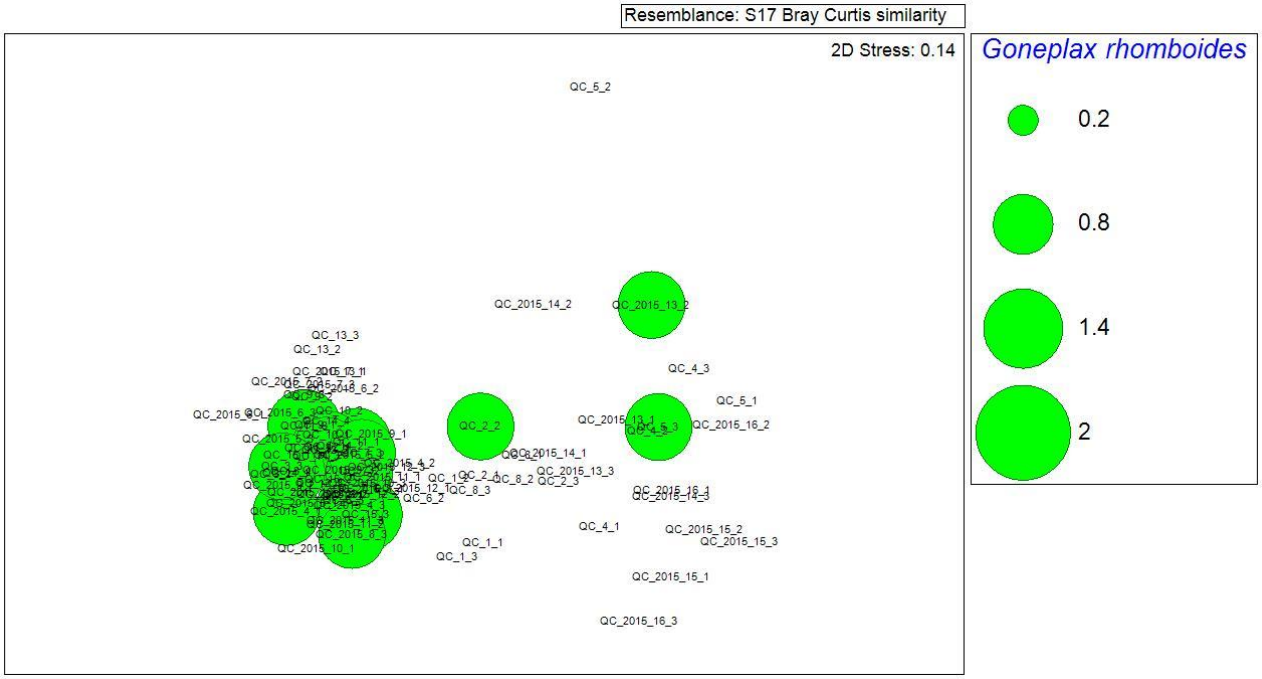

Figure 27. MDS plot with sample labels and *Goneplax rhomboides* abundance (fourth root transformed) overlaid

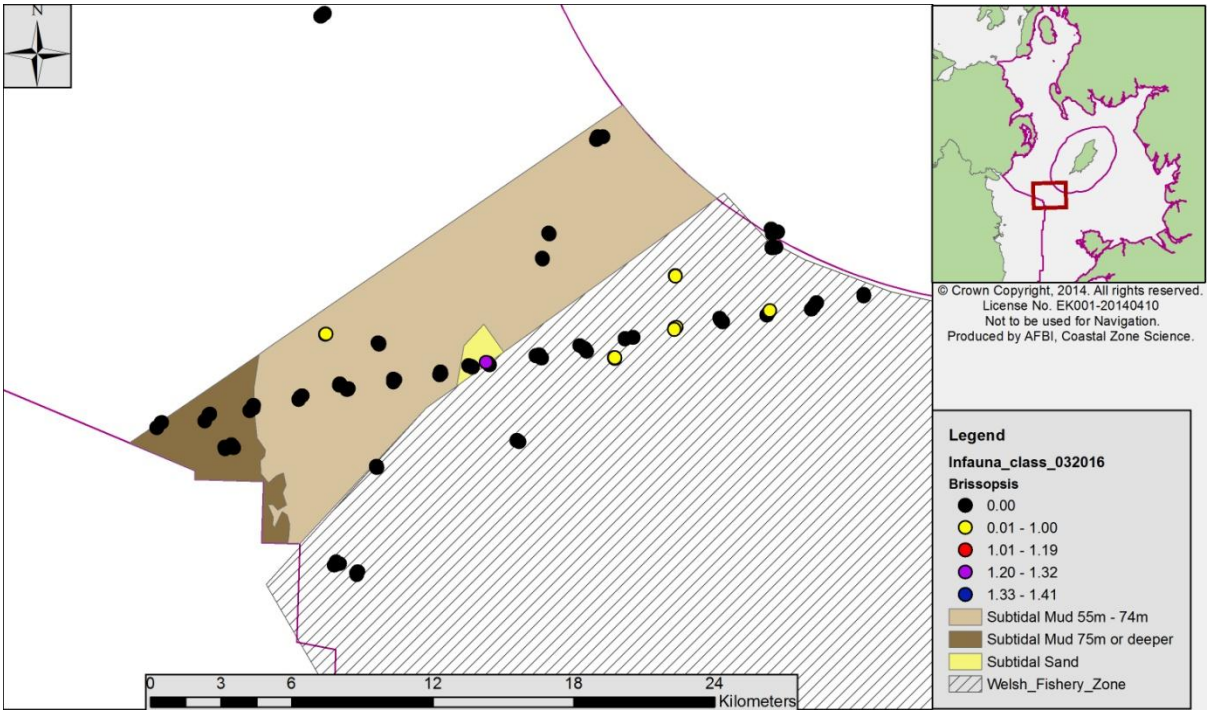

Figure 28. Map of grab sample sites with abundance (fourth root transformed) of *Brissopsis lyrifera* shown.

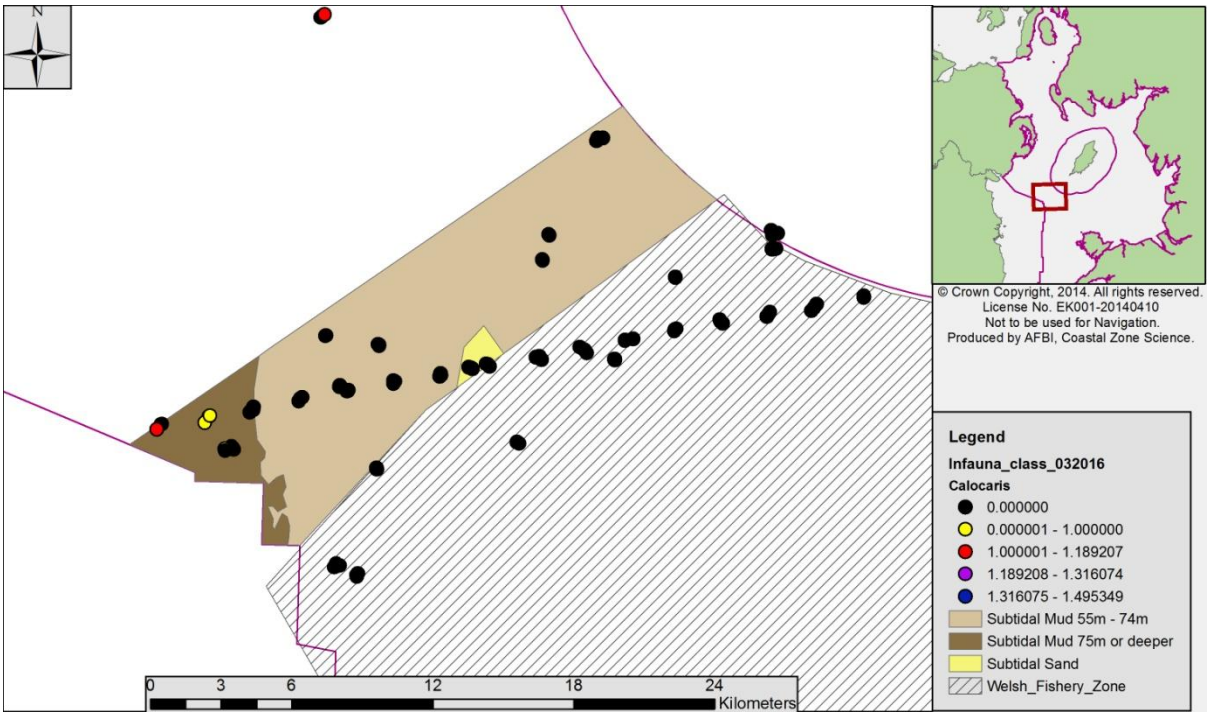

Figure 29. Map of grab sample sites with abundance (fourth root transformed) of *Calocaris macandreae* shown.

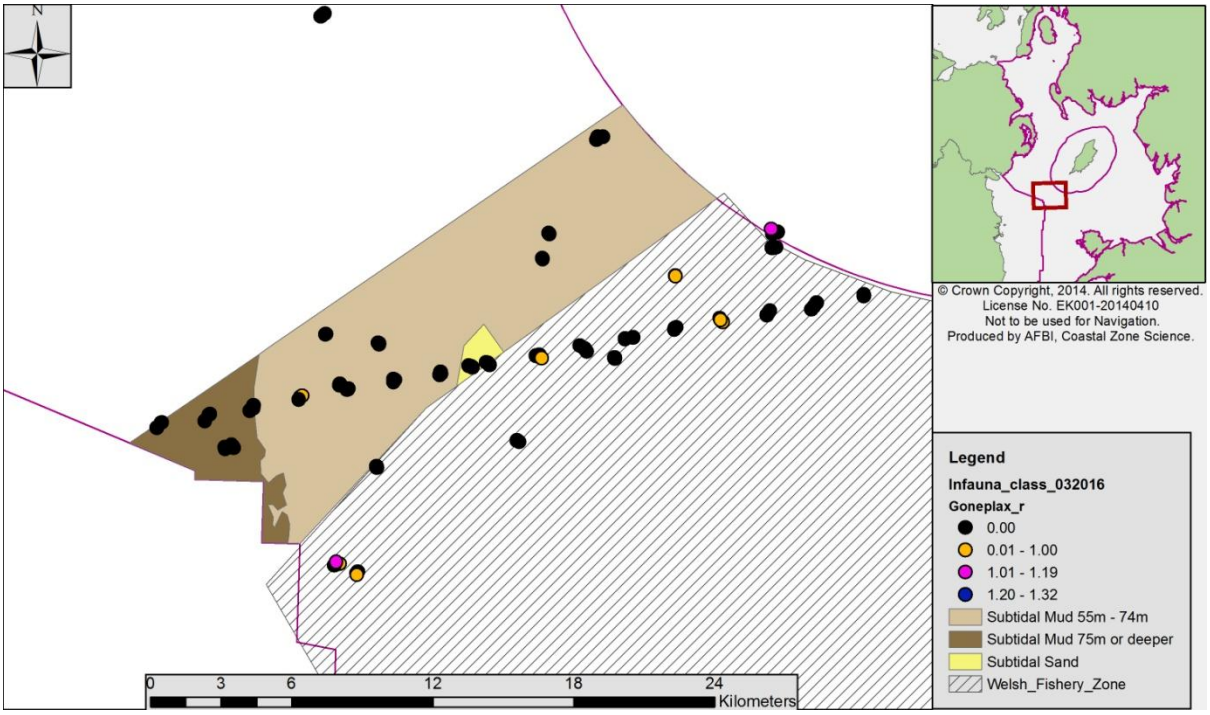

Figure 30. Map of grab sample sites with abundance (fourth root transformed) of *Goneplax rhomboides* shown.

The analysis of similarity test (ANOSIM) investigated whether there were differences between the assemblages between different sediment types, as classified by the Folk method based on mean grain size. This found a significant (p=<0.1%) difference between species assemblages, suggesting that sediment type has an important role in community structuring across the study area.

To further investigate this, the BIO-ENV routine was used to examine the correlation (Spearman's) between normalised environmental parameters, which were in this case sediment parameters (Nitrogen content, organic Carbon content, mean grain size, sorting and percentage mud, percentage sand and percentage gravel) and community assemblages found within the samples. The best correlation (sample statistic (Rho): 0.576, at a significance level of 1%) was with organic Carbon content, percentage of sand, percentage of mud (silt and clay fraction) and mean grain size.

Biotope classification for all samples (across the Irish Sea)

The SIMPER routine was used to identify the species contributing to the separation between sample groups, in this case the groups identified from the cluster analysis. These may be considered as the characterising species from each cluster. The SIMPER-derived characterising species were used to aid classification into EUNIS/MNCR biotopes, along with the accompanying sediment information from the samples.

The biotopes consisted of more than one cluster identified from the multivariate analysis, indicating that each biotope represents a range of assemblages, with potentially some spatial or other influence on composition.

The biotopes identified and their characterising species are provided in Table 4 and Figures 31 and 32 below.

A total of one biotope complex (SS.SSa.CMuSa) and five biotopes were identified. The biotope complex (EUNIS classification level 5) could not be further classified to biotope level (EUNIS level 4) as there were few samples and it was difficult to match the species lists with those published in the classification. Two of the biotopes were jointly assigned- SS.SMu.CSaMu.SpnMeg and SS.SMu.CSaMu.MegMax- as it was difficult to distinguish between the two especially as seapens are not well represented in grab samples. The UWTV footage permitted some nearby records of *Virgularia mirabilis* but this could not be positively assigned to the grab sample locations. It is also possible for the grab samples to under-sample the echiuran *Maxmuelleria lankesteri,* which was only identified in two samples. It is difficult without spatially coincident video footage to confirm whether *Maxmuelleria lankesteri* occurs at any significant density and whether this forms a separate biotope to the SS.SMu.CSaMu.SpnMeg biotope. Seapens can also be found in SS.SMu.CSaMu.MegMax, but at lower densities than in SS.SMu.CSaMu.SpnMeg. SS.SMu.CSaMu.MegMax also has reportedly higher diversity than in SS.SMu.CSaMu.SpnMeg, but again this is difficult to confirm here. Fishing activity likely acts as an important community modifier and this may suppress certain (e.g. erect filter-feeders) species from becoming abundance and alter competition and this community structure. As such, it is challenging to assign biotopes with great certainty.

It should also be noted that when the classification scheme was built, there were fairly few deeper water (>40m) records, and therefore deeper water areas may harbour modified mud community assemblages compared to their shallow water counterparts. It is also a recognised challenge to reconcile biotopes identified from epifauna on video and those identified from infauna from grab samples even when spatially conincident.

Table 4. Biotopes and biotope complexes identified from grab sample data and their characterising species

EUNIS code 2008	EUNIS level	EUNIS name 2008	JNCC 04.05 code	MCZ HOCI	Characterising species from SIMPER
A5.26	**4**	**Circalittoral muddy sand**	**SS.SSa.CMuSa**	Circalittoral muddy sand	*Amphiura sp., Astropecten irregularis, Glycera capitata, Ophiura sp., Pholoe inornata, Magelona sp., Nucula nitidosa*
A5.261	5	[Abra alba] and [Nucula nitidosa] in circalittoral muddy sand or slightly mixed sediment	SS.SSa.CMuSa.AalbNuc	Abra alba and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment	*Abra alba, Nucula nitidosa, Ophiura sp., Glycera unicornis, Magelona mirabilis*
A5.35	**4**	**Circalittoral sandy mud**	**SS.SMu.CSaMu**	Mud habitats in deep water / Sea-pen and burrowing megafauna communities	
A5.351	5	[Amphiura filiformis], [Mysella bidentata] and [Abra nitida] in circalittoral sandy mud	SS.SMu.CSaMu.AfilMysAnit	Mud habitats in deep water	*Amphiura filiformis, Nephtys incisa, Abra nitida, Phoronis, Pholoe baltica, Nucula nitidosa, Kurtiella*
A5.36	**4**	**Circalittoral fine mud**	**SS.SMu.CFiMu**	Mud habitats in deep water / Sea-pen and burrowing megafauna communities	
A5.361	5	Seapens and burrowing megafauna in circalittoral fine mud	SS.SMu.CFiMu.SpnMeg	Mud habitats in deep water / Sea-pen and burrowing megafauna communities	*Nephrops norvegicus, Virgularia mirabilis, Nephtys incisa, Phoronis muelleri, Callianassa sp., Calocaris macandreae, Goneplax rhomboides, Monticellina sp., Amphiura chiajei, Abra sp., Galathowenia oculata, Turritella communis*
A5.362	5	Burrowing megafauna and [Maxmuelleria lankesteri] in circalittoral mud	SS.SMu.CFiMu.MegMax	Mud habitats in deep water / Sea-pen and burrowing megafauna communities	
A5.363	5	[Brissopsis lyrifera] and [Amphiura chiajei] in circalittoral mud	SS.SMu.CFiMu.BlyrAchi	Mud habitats in deep water	*Brissopsis lyrifera, Nucula sulcata, Galathowenia oculata, Amphiura chiajei, Calocaris macandreae*
A5.37	**4**	**Deep circalittoral mud**	**SS.SMu.OMu**	Mud habitats in deep water / Sea-pen and burrowing megafauna communities	
A5.375	5	[Levinsenia gracilis] and [Heteromastus filifirmis] in offshore circalittoral mud and sandy mud	SS.SMu.OMu.LevHet	Mud habitats in deep water	*Levinsenia gracilis, Nephtys incisa, Nucula sulcata, Glycera unicornis, Monticellina sp.*

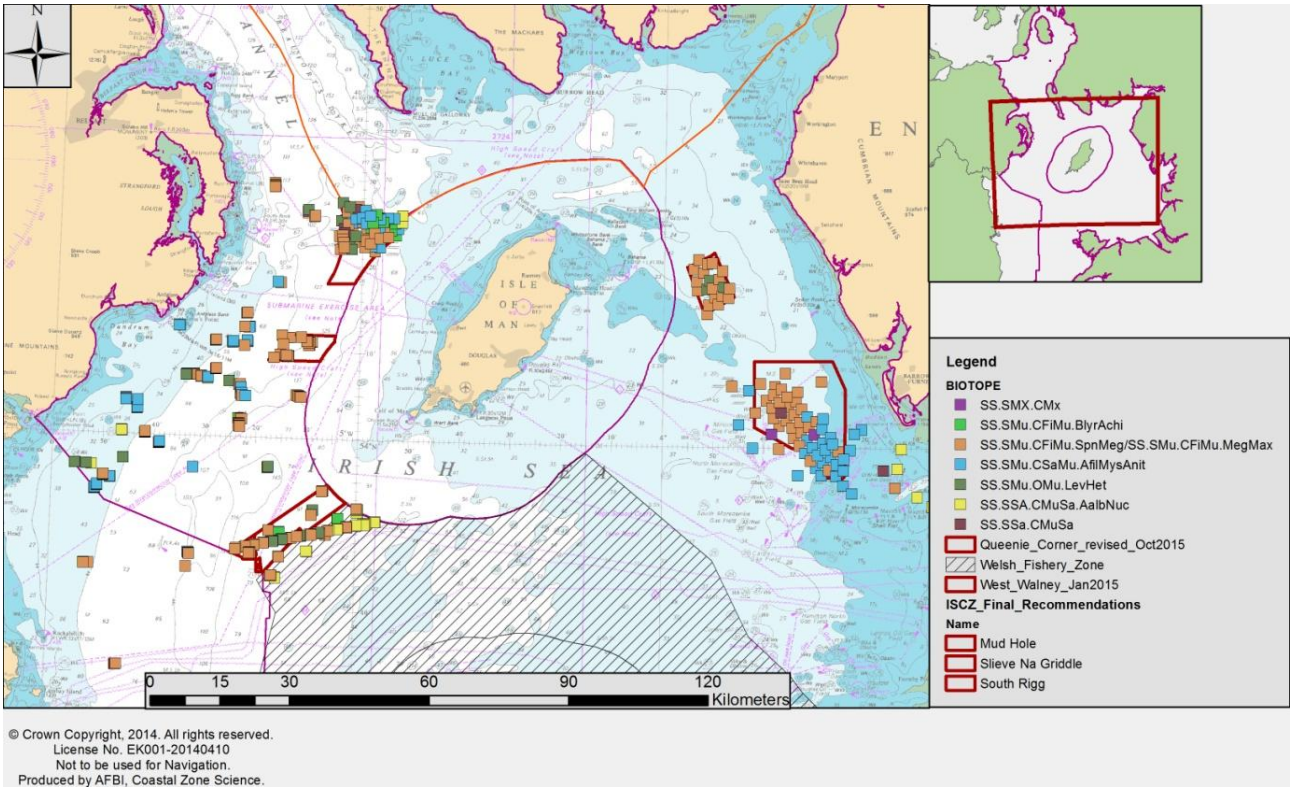

Figure 31. Map of Irish Sea grab sample sites coded by biotope

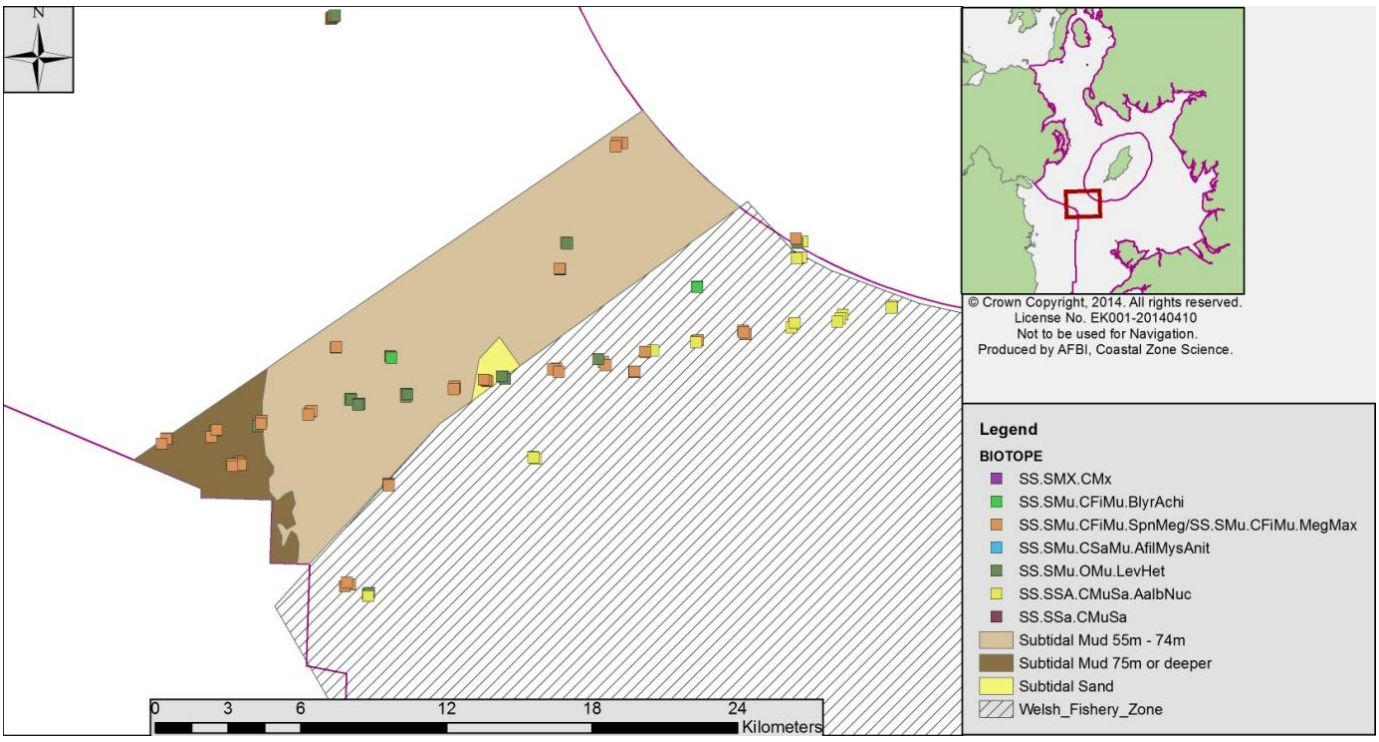

Figure 32. Map of Queenie Corner grab sample sites coded by biotope

Data compatibility with requirements for identification of 'subtidal mud' habitat

To improve the accessibility of the grab sample information for MCZ designation process, the community data and sediment characteristics (including nearby *Nephrops* burrow density data) were utilised to produce as "burrowed mud" index, with the results presented in Figures 33 and 34 below, with higher numbers representing the greater number of criteria met (e.g. <20% mud, *Nephrops* burrow density >0.2/m^2 and other burrowing megafauna represented). Most sites which fall on the predicted mud habitat are found to have a high burrowed mud index score, with some such sites extending east of the mud habitat predicted in the eastern Irish Sea.

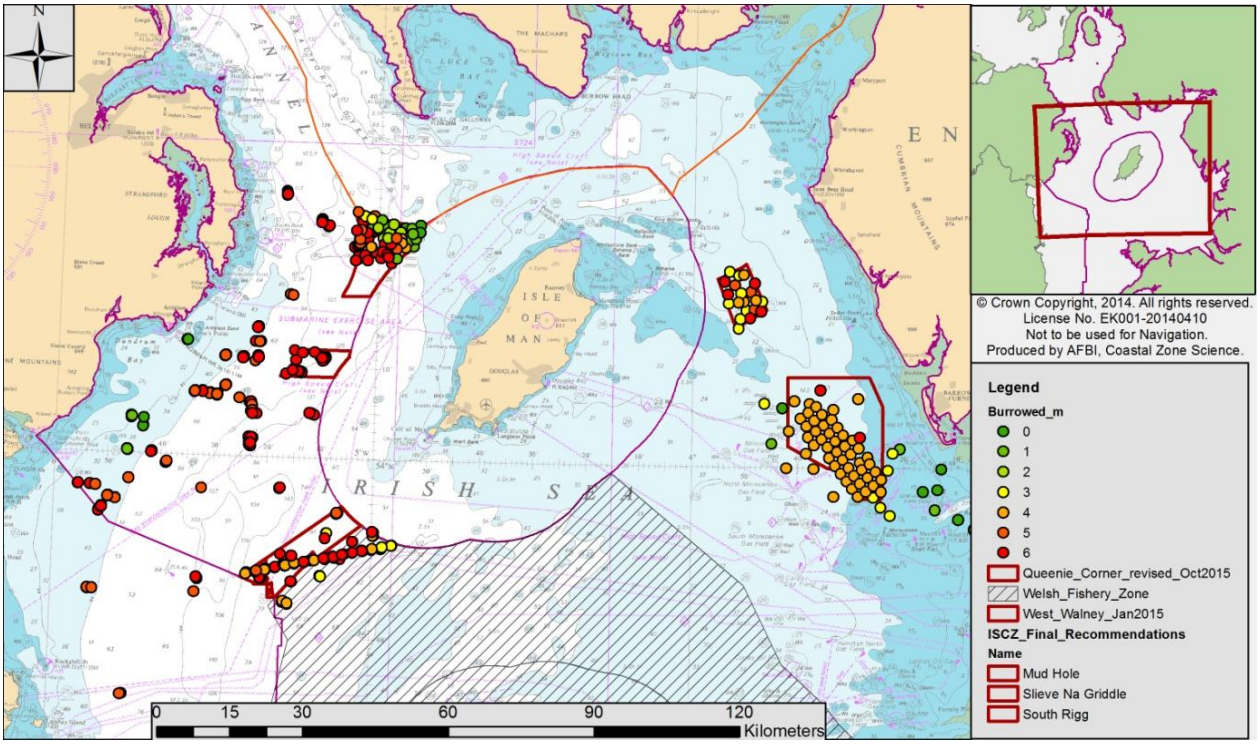

Figure 33. Map of Irish Sea grab sample sites coded by "burrowed mud index"

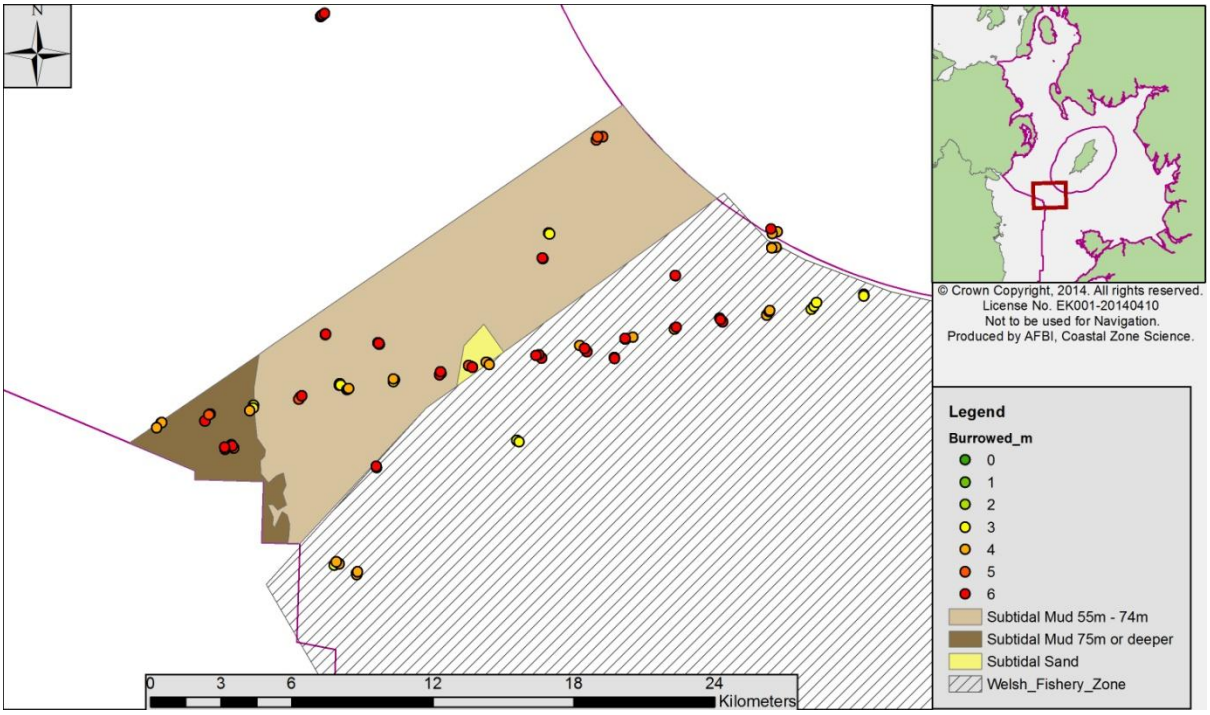

Figure 34. Map of Queenie Corner grab sample sites coded by "burrowed mud index"

Additional sedimentological data were also presented to guide delineation of potential habitats, namely the Folk classification (based on sediment grain size) (Figure 35) and sediment nutrients (Figures 36 and 37).

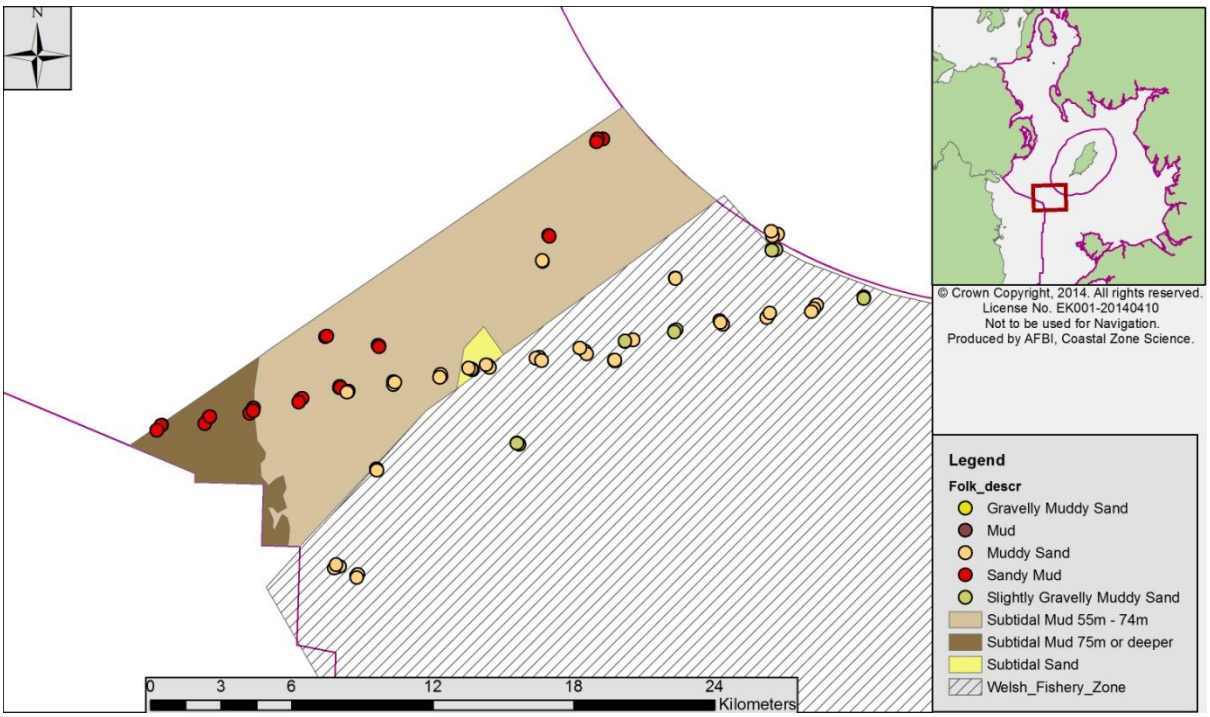

Figure 35. Map of Queenie Corner grab sample sites coded by Folk sediment description

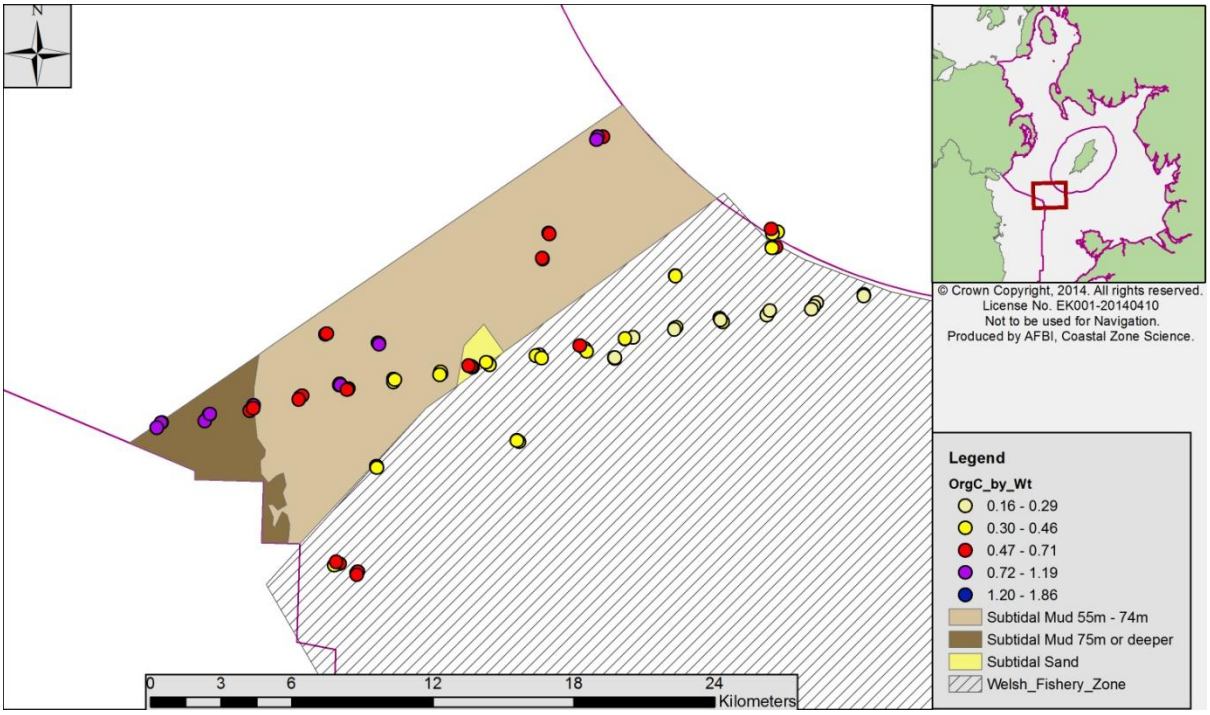

Figure 36. Map of Queenie Corner grab sample sites coded by sediment Organic Carbon content by weight

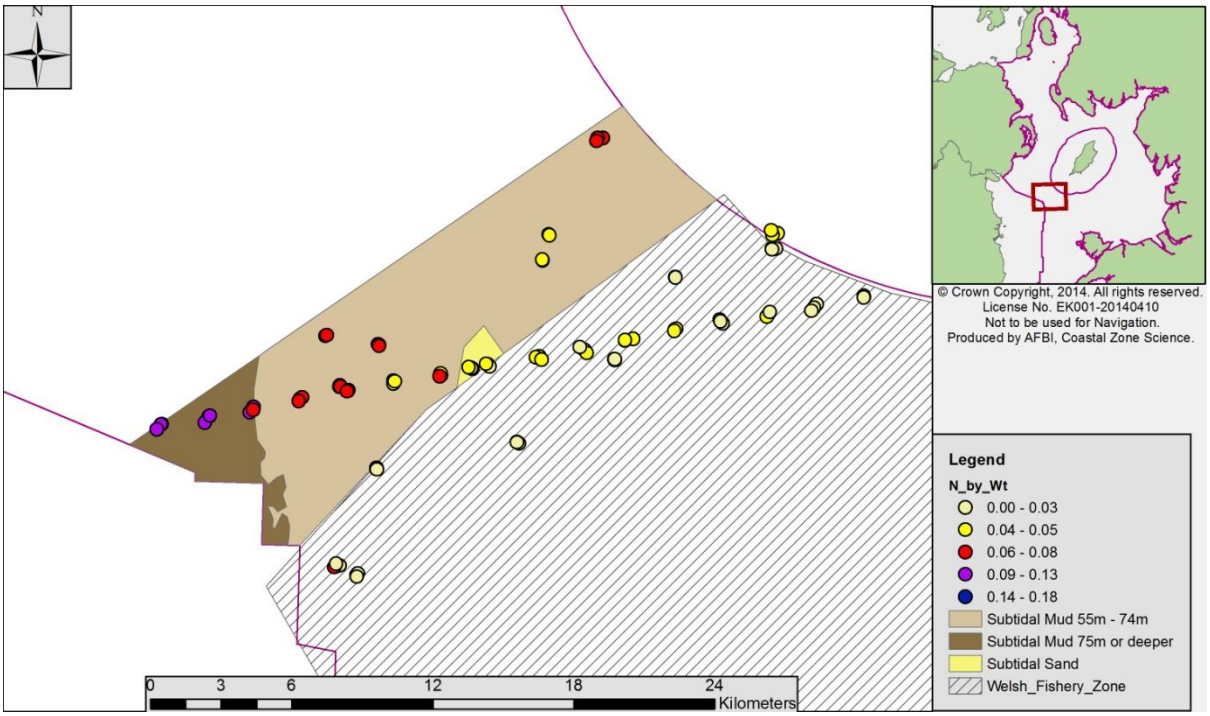

Figure 37. Map of Queenie Corner grab sample sites coded by sediment Nitrogen content by weight

To investigate the condition of the communities sampled by grabs, AMBI and M-AMBI was applied (Figure 38).

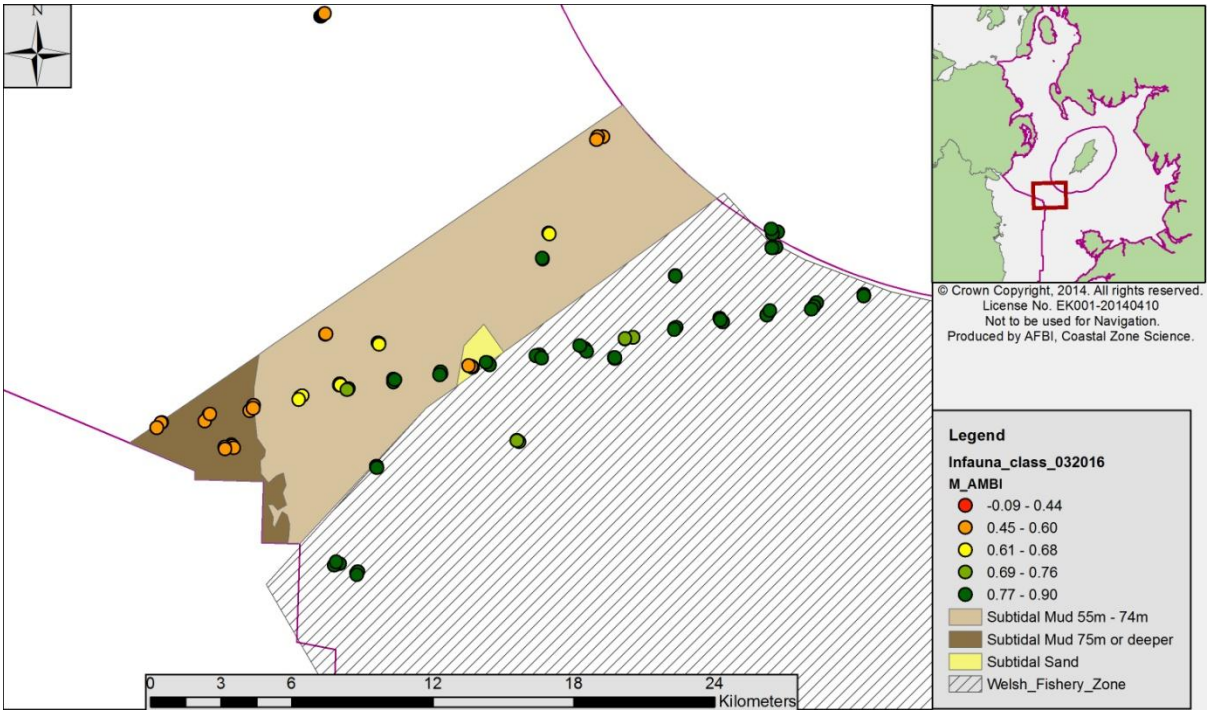

Figure 38. Map of Queenie Corner grab sample sites coded by M-AMBI index, with 0 representing declined benthic health, and 1 representing best benthic health.

The M-AMBI results show a strong east-west gradient across Queenie Corner, which is likely related to sediment type, and potentially also fishing effort. It is recommended that to tease apart the influence of fishing intensity versus sedimentological characteristics on benthic assemblages, specific studies could address how the macroinvertebrate assemblages differ at different levels of fishing intensity over the same mud habitat.

Figure 39 below provides the final predicted broad-scale habitats (equivalent to EUNIS classification level 3) for Queenie Corner (total area 147 km^2), indicating that the vast majority of the site is subtidal mud, with a deeper mud pocket (19 km^2) to the southwest of the site, and a tiny pocket of subtidal sand (2 km^2) midway along the southeast boundary, which represents the start of a gradient from mud to sand habitats that occurs moving east from Queenie Corner.

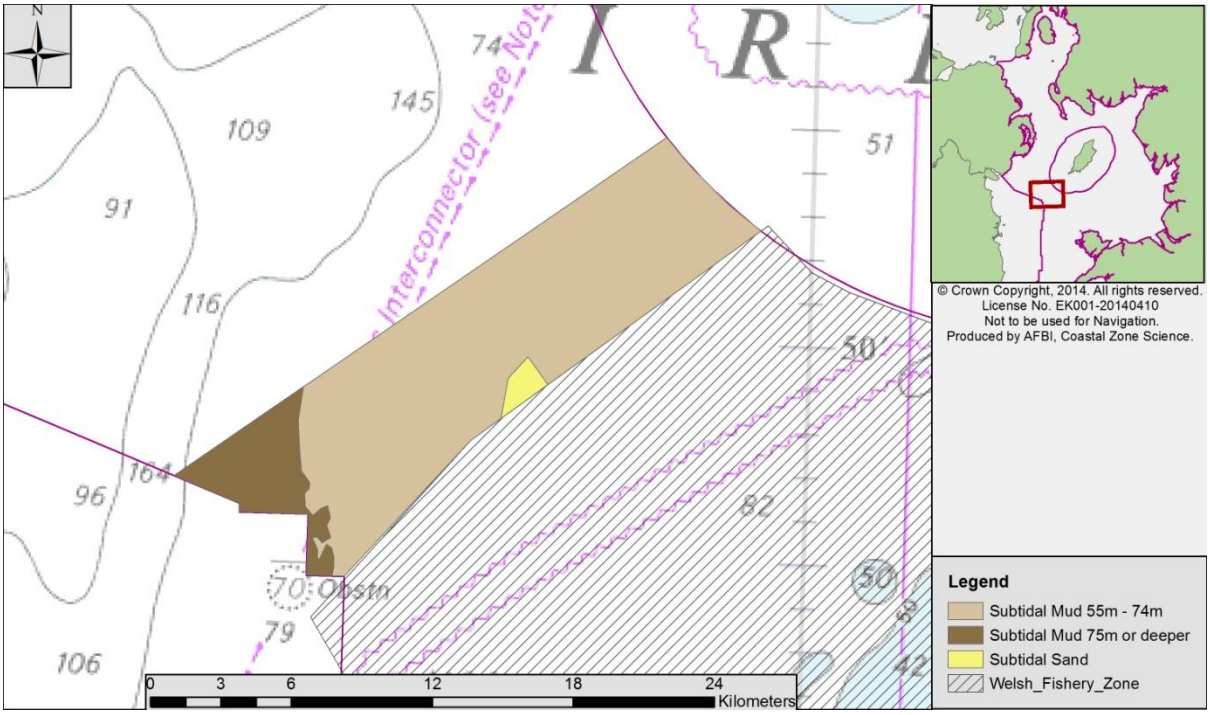

Figure 39. Predicted Habitat Map of Queenie Corner site.

2.5 Conclusions

The fishing effort and the habitat type evidence has been examined for four sites within the Irish Sea region in order to provide information that may be useful to the MCZ designation process, and allow consideration of which sites would provide adequate suitable habitat but minimal fisheries displacement, owing to the fact that following site designation management actions are likely to recommend banning of mobile gear as the mud habitat will be afforded the "recover" general management approach, due to the sensitivity of this habitat to such activity.

The Northern Ireland bottom trawling fishing effort has shown a general decline over the study period of 2006-2014, although with some increase in 2013 from 2012. By site, there is quite some variation, with the most stable effort pertaining to Slieve Na Griddle. South Rigg has shown a decline in fishing effort, while Queenie Corner has shown an increase. Average effort over this period still remains lower in Queenie Corner than in either South Rigg or Slieve Na Griddle, indicating that fisheries displacement from this site if closed to mobile gear will be less compared to the other two potential sites in the western Irish Sea. These VMS-based fishing effort data have been utilised by Cappell (2016) for a full socio-economic analysis of these sites.

There is now comprehensive habitat data for all sites that may be under consideration for Tranche 3 of the MCZ designation process, including Queenie Corner. The site boundary for Queenie Corner was reworked due to the newly required consideration of the Welsh Fishery Zone, which limited the extent of the site. Habitat evidence within this smaller site indicated that Queenie Corner has 145 km^2 of subtidal mud habitat (and 2 km^2 of subtidal sand habitat). This compares to 96 km^2 and 53 km^2 at South Rigg and Slieve Na Griddle sites respectively (Table 1). Species community analysis

shows that western Irish Sea mud communities vary notably from eastern Irish Sea, but that all three potential sites in the western Irish Sea contain a very similar mix of communities (in varying proportions).

Queenie Corner has extensive video and grab sample data coverage which together have provided data on both the epifaunal and infaunal characterising species, in addition to the sediment particle size data confirming sediment type. The spatial coverage of such data has permitted the drawing of habitat boundaries across the site. There is good evidence of the subtidal mud habitat in this area which supports burrowing megafauna communities, characterised by *Nephrops norvegicus,* and to the west, in deeper waters, *Calocaris macandreae,* with records of seapens (*Virgularia mirabilis*) across the site and also in some parts of the site notable densities of the sea potato *Brissopsis lyrifera.* There is a clear gradient in mud community from east to west in the site which coincides with the sediment granulometry, the bathymetry and the oceanographic setting, and also fishing activity. Such gradients on this site should be noted in any future monitoring programme. The M-AMBI index showed values above 0.4 (from a 0-1 scale) with least 'disturbed' areas to the east of the site, and slightly disturbed areas to the west of the site, indicating that much of the site could be considered to be in moderate to good condition in terms of the benthic infaunal community composition. With such evidence as presented in this report, there is a case for Queenie Corner to be considered as a potential alternative to South Rigg and Slieve Na Griddle in terms of its habitat presence and extent. The only issue may be the allocation of quotas of subtidal mud habitat to depth bands in the western Irish Sea, as Queenie Corner has only 19 km^2 of its subtidal mud habitat in waters deeper than 75m. Whether such deeper mud areas contain notably different benthic communities is not clear from this study; the cluster analysis showed that Queenie Corner contained the same range of communities as those found in deeper waters of Slieve Na Griddle and South Rigg, however the extent of these communities does differ due to the differing proportions of each site that fall into deeper waters/different oceanographic conditions.

The designation of the Mud Hole site would not address the present 'gap' in subtidal mud habitat representation in the Irish Sea region MCZs, as this site does not represent the diversity of mud communities found exclusively in the western Irish Sea, and the site also doesn't harbour any waters deeper than 75m. It could be suggested that with both the designation of West of Walney MCZ and the addition of subtidal mud as a feature at Fylde MCZ in January 2016 that the eastern Irish Sea mud habitat is well covered in the MCZ network, and therefore sites for designation in Tranche 3 ought to focus on those habitats found in the western Irish Sea. The information within the report provides clear suggestions considerate of both habitat type and the potential for fisheries displacement in those western Irish Sea sites, suggesting that designation of Queenie Corner remains the "least worst" option in spite of limitations of depth of mud habitat.

References

AFBI, 2015. Alternative Marine Conservation Zones in Irish Sea mud habitat: potential for fisheries displacement and an assessment of habitat condition and potential management scenarios. Report to Seafish. Available at: http://www.seafish.org/media/Publications/Seafish_2015_Alternative_MCZs_in_Irish_Seafinal.pdf

Afonso-Dias, M.S. 1997. Variability of *Nephrops norvegicus* (L.) populations in Scottish waters in relation to the sediment characteristics of the seabed. Ph.D. thesis, University of Aberdeen.

Borja, A., J. Franco, V. Pérez, 2000. Marine Pollution Bulletin, 40(12): 1100-1114.

Borja, A., I. Muxika, J.G. Rodríguez, 2009. Marine Ecology, 30: 214-227

BRIG (ed. Ant Maddock), 2008. (Updated Dec 2011). UK Biodiversity Action Plan; Priority Habitat Descriptions.

Cappell, R. 2016. Cappell, R., The value of proposed Irish Sea Marine Conservation Zones to the Northern Irish fishing industry. Poseidon Report to the Seafish Northern Ireland Advisory Committee. Available at: http://www.seafish.org/media/1627434/poseidon_ni_mcz_valuation_report_february_2016.pdf

Cappell, R., Nimmo, F. and Rooney, L. 2010. *The value of Irish Sea Marine Conservation Zones to the Northern Irish fishing industry*. Poseidon Report to the Seafish Northern Ireland Advisory Committee. [ONLINE] Available at http://www.seafish.org/media/Publications/Poseidon_NI_MCZ_valuation_final_report_August_2012__2_.pdf [Accessed 10/11/2013]

Clarke, K.R. 1993. Non-parametric multivariate analyses of changes in community structure. Australian Journal of Ecology 18: 117-143.

Clarke, K.R., Warwick ,R.M. 2001. Change in marine communities: an approach to statistical analysis and interpretation, 2nd edition. PRIMER-E, Plymouth, 172pp.

Connell, J. H. 1978. Diversity of tropical rainforests and coral reefs. Science, 199, 1304–1310.

Connor, D.W., Allen, J.H., Golding, N., Howell, K.L, Lieberknecht, L. M., Northen, K.O. and Reker, J.B. 2004. The Marine Habitat Classification for Britain and Ireland Version 04.05 JNCC, Peterborough. ISBN 1 861 07561 8 (internet version). www.jncc.DEFRA.gov.uk/MarineHabitatClassification

Defra, 2013. Marine Conservation Zones: Consultation on proposals for designation in 2013 Annex A.2 - Irish Sea Conservation Zones sites requiring further consideration

Defra, 2015. Marine Conservation Zones Consultation on Sites Proposed for Designation in the Second Tranche of Marine Conservation Zones. January 2015, 30pp. Available at: https://consult.defra.gov.uk/marine/tranche2mczs/supporting_documents/Consultation%20Document%20Final.pdf

Fariña, A.C., González Herraiz, I., Freire, J. and Cancelo, J.R. 2003. Exploring long-term variability of *Nephrops norvegicus* population and fishery off North Galicia (NW Spain). Working Paper.

Huston M. A. 1979 A general hypothesis of species diversity. Am. Nat. 113, 81–101. doi:10.1086/283366

ICES, 2007. Workshop on the Use of UWTV Surveys for Determining Abundance in *Nephrops* Stocks throughout European Waters. 17–21 April 2007, Heraklion, Crete, Greece. ICES CM 2007/ACFM:14. 198 pp.

ICES, 2012. ACOM advice June 2012, *Nephrops* in Subarea VII, ICES Advice 2012, Book 5. http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2012/2012/Nep-VII.pdf

JNCC, 2014. JNCC clarifications on the habitat definitions of two habitat FOCI. Peterborough, UK. Available at: http://jncc.DEFRA.gov.uk/pdf/Advice_Document_MudHabitats_FOCIdefinitions_v1.0.pdf

OSPAR, 2008. Descriptions of habitats on the OSPAR list of threatened and/or declining species and habitats, (Reference Number: 2008-07).

OSPAR, 2010. Background Document for Seapen and Burrowing megafauna communities. Available at: http://www.ospar.org/documents/dbase/publications/p00481/p00481_seapen%20and%20burrowing%20megafauna.pdf

WGSFD. 2013. ICES Report of the Working Group on Spatial Fisheries Data (WGSFD).

VMStools . 2013. VMStools 0.67, 'R' package for analysing fisheries VMS (Vessel Monitoring System).