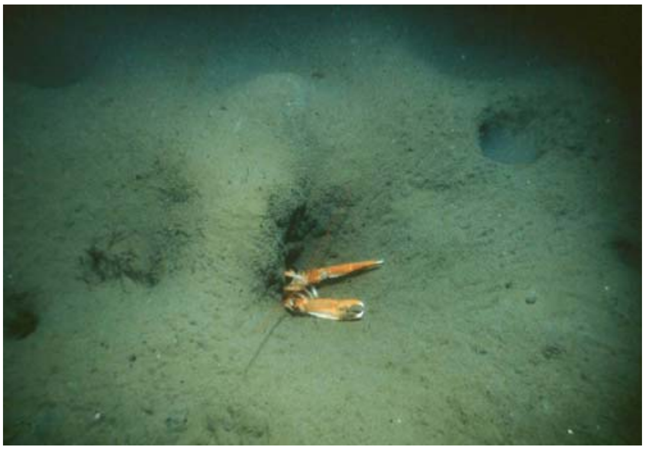
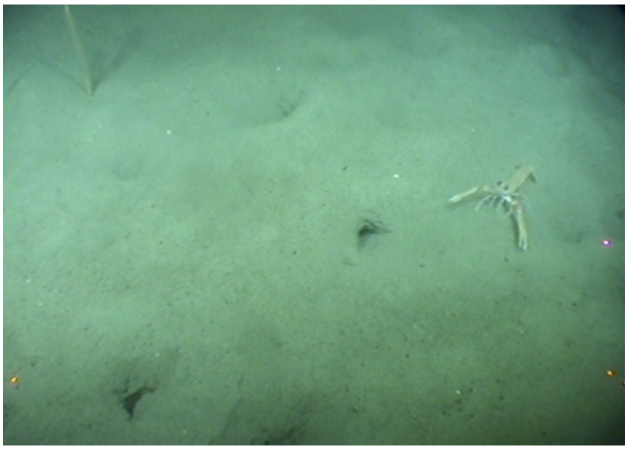
Alternative Marine Conservation Zones in Irish Sea mud habitat: potential for fisheries displacement and an assessment of habitat condition and potential management scenarios.





Prepared by AFBI Fisheries and Aquatic Ecosystems Branch for Seafish

September 2015

www.afbini.gov.uk

Document version control:

Version	Issue date	Modifier	Note	Issued to and date
1.0	25/06/2015	AFBI_AC_LR	First draft	Seafish, MS
1.1	30/06/2015	AFBI_AC_LR	Amended draft	Seafish
1.2	13/08/2015	AFBI_AC_LR	Amended draft	Seafish,
1.3	18/08/2015	AFBI_LR	Layout amendment	Seafish, SNIAC, DEFRA, JNCC
1.4	08/09/2015	AFBI_LR	Text & map amendment	Seafish, SNIAC, DEFRA, JNCC

Document title: Alternative Marine Conservation Zones in Irish Sea mud habitat: potential for fisheries displacement and an assessment of habitat condition and potential management scenarios.

Status: Version 1.4

Date: 08/09/2015

Completed by: A. Clements and L. Rooney

Approved by: M. Service

Further information

Agri-Food and Bioscience Institute (AFBI)

Fisheries & Aquatic Ecosystems Branch

Coastal Zone Science Group

Newforge Lane

Belfast

BT9 5PX

Tel: 028-90255472

Table of Contents_

Table of Figures

Executive Summary

Areas of potential alternative Marine Conservation Zone (MCZ) sites representing mud habitat within the UK Irish Sea regional sea were selected at a stakeholder engagement meeting in October 2014. In order to assess the suitability of these sites within the Irish Sea regional area, existing data were examined to assess habitat condition, variation and how well these meet the mud habitat criteria set by the UK government. *Nephrops* stock assessment video surveys were utilised along with grab sample data, across both eastern and western Irish Sea areas. Macroinvertebrate community analysis was undertaken on the grab infaunal data, along with analysis of sediment parameters. The level of disturbance was also examined through benthic community assessment relating to successional stage.

MCZ site management options were discussed based upon the current UK MCZ designation process and how these could be enacted. Where a feature of conservation interest is known to be vulnerable to a pressure, management plans seek to reduce this pressure. As such, it is likely that limitation of fishing effort will be included in the management of mud habitats. The impact of fisheries closures is discussed, with respect to the likelihood of effort displacement. Fisheries effort at each site was assessed through analysis of VMS (vessel monitoring system) data over a seven year period (2007-2013), with a further monthly breakdown of effort patterns for 2013. A number of studies have emphasised the importance of assessing potential fisheries displacement in the establishment of marine protected areas (MPAs), which include MCZs. Where possible, fisheries displacement should be minimised due to both the impact on the fishing industry and the wider ecosystem impacts of potential intensification of fishing effort on remaining fishing grounds, which may undermine the conservation objectives of a MPA network. Collaborative conservation and fisheries management measures are advocated.

Using results from the benthic community analyses together with results from the fishing effort analysis, two of the potential alternative MCZ sites are suggested to be taken forward by the relevant governing bodies for MCZ designation: West of Walney (which is currently in the DEFRA Tranche 2 MCZ designation process) *(Site D)* and "Queenie Corner", southwest of the Isle of Man, which may be a merged site of three suggested areas *(Sites A, B & J)* which overlap (Figure Ex1). The original site boundaries used in this study were the result of sketched areas from a stakeholder workshop; suggestions for the redrawing of these boundaries based on both the fishing effort data and the benthic community data are included in this report. Together, these two sites represent quite different mud communities, and are subject to different natural and anthropogenic pressures, and would contribute to the ecological connectivity of the UK MCZ network whilst minimising the impact to the fishing industry which relies heavily on the *Nephrops* grounds of the Irish Sea.

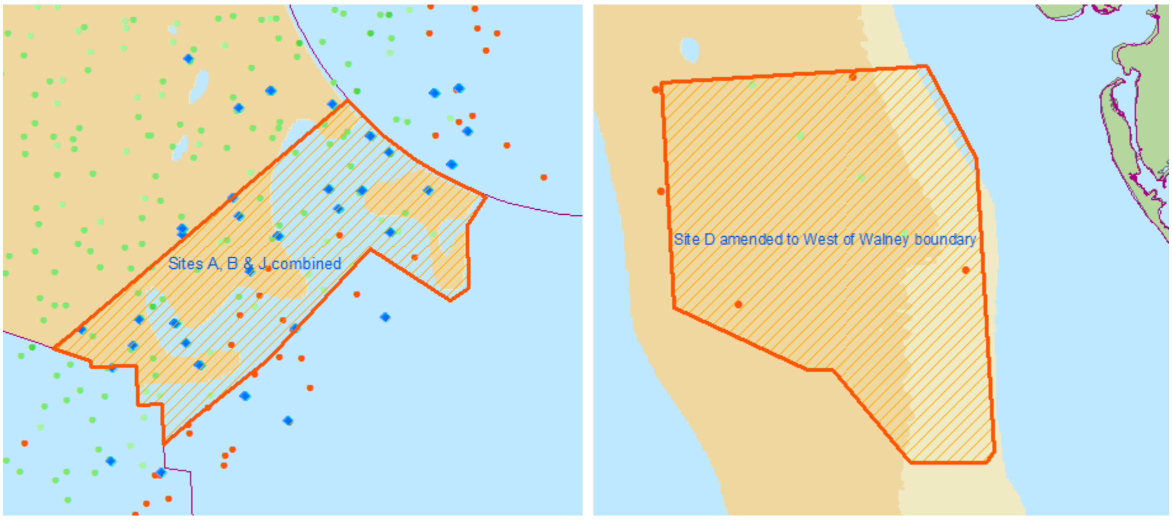


Figure Ex1. Close up of the areas final areas suggested for further progression in the MCZ process. Sites A, B & J combined (& amended to CP2 region boundary), also referred to as Queenie Corner and Site D, amended to West of Walney boundary.

Introduction

Background

The UK government is required under the Marine Bill (Marine and Coastal Access Act, 2009) to designate areas of offshore UK waters as Marine Conservation Zones (MCZs). MCZs are designed to protect nationally important marine wildlife, habitats, geology and geomorphology; sites are selected to protect not just the rare and threatened, but the range of marine wildlife found in UK waters. The network of MCZs will also serve a role in achieving Good Environmental Status for biodiversity indicators under the EC Marine Strategy Framework Directive (2008/56/EC).

A "Marine Conservation Zone Project" was set up in 2008 led by the Joint Nature Conservation Committee (JNCC) and Natural England to identify and recommend MCZs to government. Within the Irish Sea, the "Irish Sea Conservation Zones" project[1] was established, with 19 sites recommended to government in 2011 (see Figure 2, page 9). This project involved stakeholder engagement and analysis of ecological information following the "Ecological Network Guidance" produced by JNCC and Natural England[2]. The guidance states that the broad scale habitat "Subtidal mud" and habitats of conservation importance (habitat FOCI (features of conservation importance)) within subtidal mud- "Mud habitats in deep water" and "Seapens and burrowing megafauna communities"- must be protected within the MCZs of the regional area (Irish Sea). A subset of MCZ sites focussed on protecting these habitats, as proposed by the Irish Sea Conservation Zones project, have been contested by the fishing industry, with concerns raised over the socio-economic impact of potential fisheries displacement (Cappell *et al*., 2010) should these sites require fisheries closures as part of their management. Notably, these are sites "Slieve Na Griddle", "South Rigg" (both in the western Irish Sea) and "Mud Hole" (eastern Irish Sea) which fall within well established *Nephrops* fishing ground. The *Nephrops* fishery is the most important fishery in Northern Ireland (in consideration of the fishery value). Due to the concerns raised by the industry formal inclusion of these sites in Tranche 1 and Tranche 2 of the MCZ designation process by DEFRA was postponed pending further consultation with fisheries stakeholders. Following a meeting of DEFRA, JNCC, Department of Environment (Northern Ireland), Department of Agriculture and Rural Development (DARD, Northern Ireland) and representatives of the fishing industry in 2014, a recommendation was made that DARD and AFBI work with the fishing industry to propose alternative MCZ sites for the protection of subtidal mud, with these sites to be considered for Tranche 3 of the MCZ designation process.

AFBI convened a workshop on 15th October 2014, with 17 participants including fishing industry (NIFPO and ANIFPO), government bodies and NGO representation. During this workshop the ecological network guidance was revisited, along with available broad scale habitat data and fishing activity data (derived from vessel monitoring system (VMS) information), and small working groups independently suggested sites throughout the eastern and western Irish Sea region which may have the least impact to the Northern Ireland fishing industry but may contain qualifying habitat. These

[1] http://www.irishseaconservation.org.uk/
[2] http://jncc.DEFRA.gov.uk/pdf/100705_ENG_v10.pdf

were sketched during the workshop on a chart and subsequently digitised for use in Geographical Information Systems (GIS). A "traffic light" system was used by the whole group to rate preference for the suggested alternative sites. The minutes of this workshop are included in the Appendix of this report.

Following the stakeholder workshop, funding was secured by Seafish to examine the suggested alternative sites in terms of (a) existing patterns of fishing activity at each site, and therefore risk of fishery displacement, and (b) the habitat condition at each of the sites through analysis of available benthic community data. The latter work was also used to inform potential management scenarios. The results of this project were presented at a further workshop on 11th May 2015 to 12 participants, including fishing industry representation (NIFPO, ANIFPO and NFFO), and the list of alternative MCZ sites narrowed down based on the information obtained by the project. This final subset of alternative MCZ sites will in due course be formally suggested to DEFRA for inclusion in Tranche 3 of the MCZ designation process, in place of the Slieve Na Griddle, South Rigg and Mud Hole sites initially suggested by the Irish Sea MCZs project.

Report content

This report is divided into two parts:

Part I addresses fishing activity patterns in the Irish Sea inside and outside the proposed alternative MCZ sites (example in Figure 1). This involves a seven year VMS analysis (2007-2013) with the collation of intensity results, using the ICES VMS processing method (as developed by Mat Lundy/Marine Fisheries at AFBI). Focus will be on spatial and temporal patterns in fishing activity, with an additional monthly breakdown of activity on top of the annual variation. The potential impact of fisheries displacement is examined from a literature review, and suggestions are made for the re-drawing of the sketched alternative site boundaries to minimise likelihood of fisheries displacement.

Part II addresses how well the proposed alternative MCZ sites may compare to the habitat criteria set out by JNCC for subtidal mud, and what current condition these sites are in which may inform management targets for the sites, should they become designated. Such information is vital to consideration of likely management options for Irish Sea mud MCZ sites. Scenarios from other Marine Protected Areas were reviewed to inform the potential management options and their possible impact.

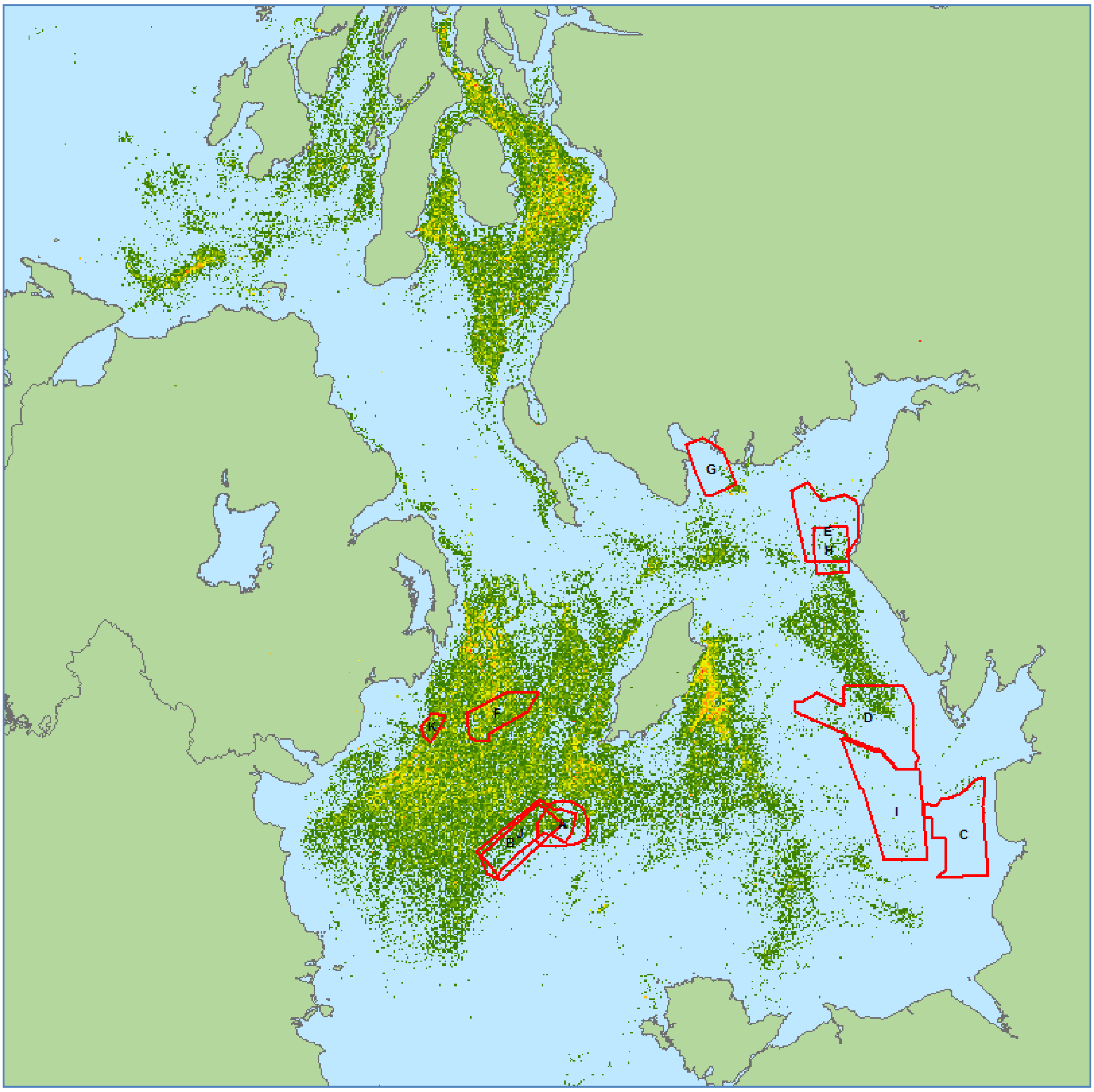


Figure 1. Suggested alternative sites and 2013 VMS effort hours

Part I: Analysis of VMS data and the potential for fisheries displacement.

1.1 Methodology

Data from 2007 to 2013 inclusive were used for these analyses. Data were sourced from DARD and represent the entire UK fleet. For 2007 to 2012 this included all vessels 15m and over in length and for 2013 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 > 52N & <56N, >8W & <3W were extracted from national data records for all UK flag vessels. All vessels within the dataset are anonymised, preventing identification of individual vessels. 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 (VMStools, 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 summary data from marine fisheries were plotted in GIS. The effort hours in each of the alternative sites were calculated and the results can be seen in the figures and tables below. The sites with the least amount of fishing activity were identified. A number of alternate sites were identified that represent three spatial zones: Western Irish Sea, Eastern Irish Sea and North Eastern Irish Sea.

Eleven alternative sites were proposed labelled A – K; each is presented in turn showing the percentage of total UK fishing intensity (total UK effort hours by year) within each site and two maps to illustrate the spatial variation of this fishing distribution over a temporal range. Following the development of the alternate sites, a traffic light rating system was used to indicate level of agreement of each site amongst stakeholders, with red being little agreement and green being good agreement. This rating was factored into the recommendation of the sites with the least impact to fishing activity.

A ranking system was developed to rate each site in terms of suitability to be designated an MPA in terms of offering the least potential fishing displacement, size of site and connectivity. Spatial analysis of the annual VMS intensities highlighted some repeated fishing behaviours in terms of site preference. In a number of the proposed alternative sites it was clear that an amendment to the site layout could minimise fishing displacement. Revised site designs are proposed and can be seen in the 'Redrawing of Potential Sites' section of the report.

The initially proposed MCZs from the Irish Sea Conservation Zones project can be seen in Figure 2, and the newly proposed areas from the stakeholder engagement event in October 2014 are shown in Figure 3 below.

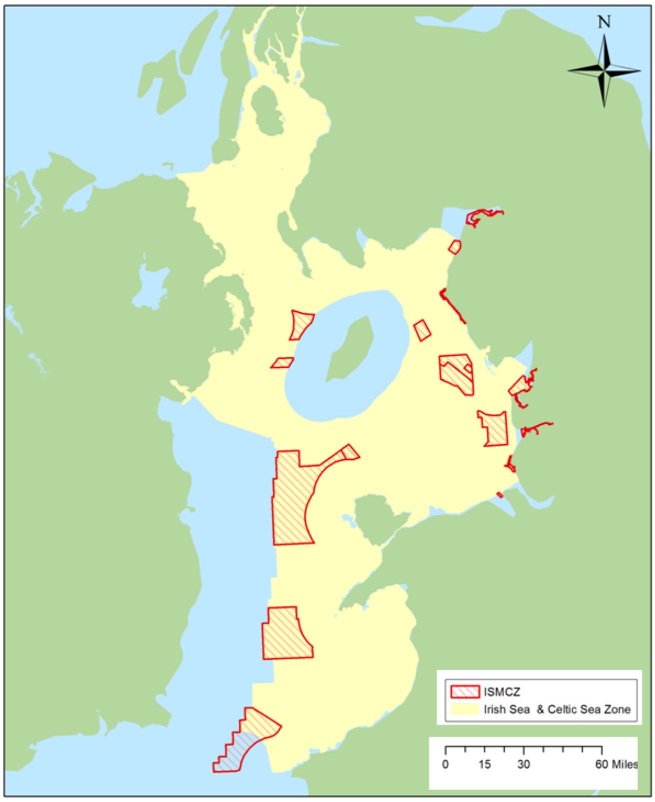


Figure 2. Existing proposal sites

<u>Limitations:</u>

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 on the eastern Irish Sea.

In 2013 vessel monitoring systems (VMS) were required on vessels 12m and above (rather than 15m 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 2007 – 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.

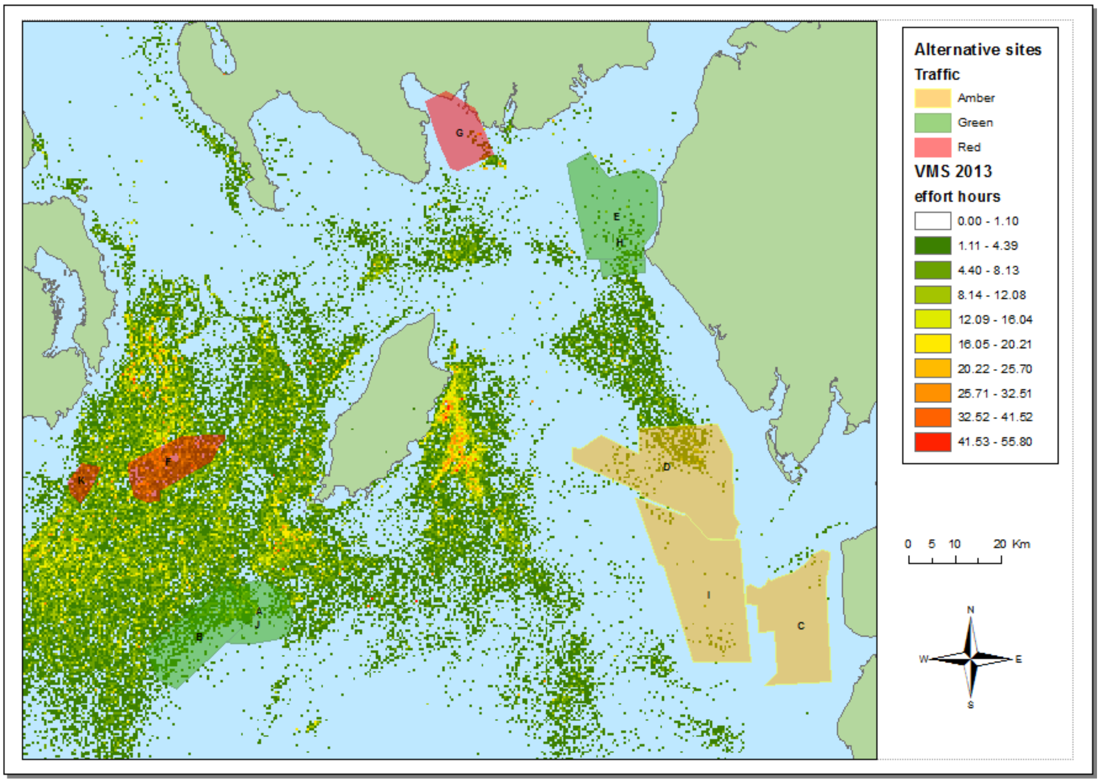


Figure 3. Site preference: Traffic light system on newly proposed sites

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 (and an additional monthly unit of effort for 2013). Each site is overlaid on these grids. Summaries are presented below of the extraction of effort hours in each of the new areas A – K.

The total activity in each site (the total annual effort hours) for the whole UK fleet can be seen in Table 1. Figure 4 shows the proposed alternative areas.

Table 1. Seven year analysis – sum of activity (effort hours) per year

Area	Total 2007	Total 2008	Total 2009	Total 2010	Total 2011	Total 2012	Total 2013	7 Year Total
A	1044	440	733	707	1007	953	1284	6168
B	1569	587	2024	1182	1123	1024	1845	9354
C	175	38	0	14	78	8	22	335
D	4790	1678	3075	1148	821	568	1183	13263
E	1106	533	899	701	865	497	347	4948
F	5744	4902	6329	5166	4855	4429	4456	35881
G	302	173	48	65	97	285	160	1130
H	1051	578	930	660	752	366	305	4642
I	733	796	181	256	214	215	122	2517
J	2059	812	2314	1524	1382	1425	2501	12017
K	1684	1423	1482	1508	1778	1168	736	9779

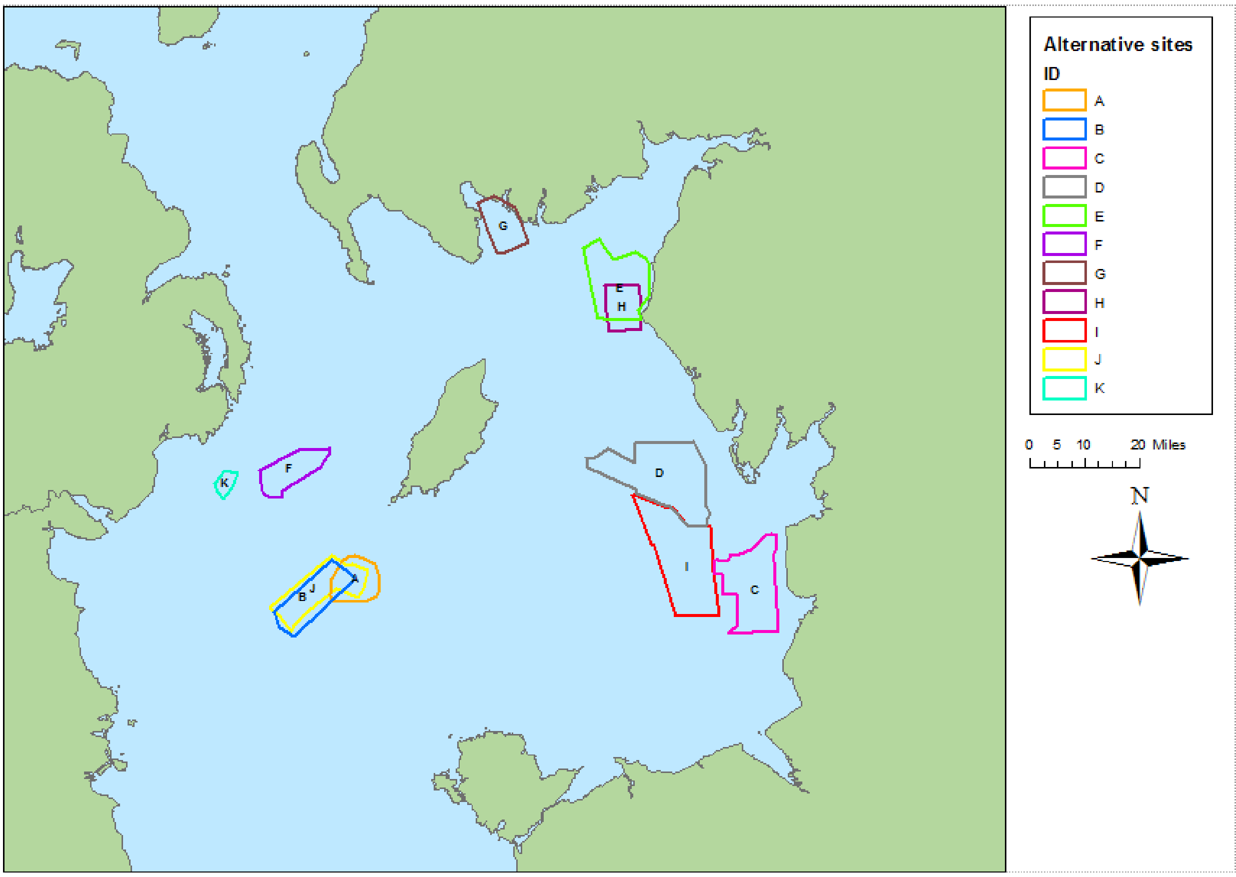


Figure 4. Newly proposed alternative sites – Labelled A - K

Table 2 shows the annual average intensity (effort hours) in each 0.25km^2 grid cell across each site and for each site, for each year of investigation. This allows a comparison between sites, by removing the effect of site size. E.g. Site A has a mean 1.78 effort hours per intensity grid within the site in 2007 and Site D has a mean 2.31 effort hours per intensity grid within the site in 2009.

Table 3 illustrates the percentage of total annual effort hours per intensity grid of the total UK fleet in these areas over each year. For example, in 2007 if total UK fishing effort is 100%, only 0.37% of that effort is in site A. It can been seen in Tables 2 and 3 that Site F has the highest amount of average effort and the greatest proportion of total annual effort hours. The results in Tables 2 and 3 are illustrated graphically in Figures 5 and 6.

Table 2. Seven year Intensity average across each site

Area	2007	2008	2009	2010	2011	2012	2013
A	1.78	0.75	1.25	1.20	1.71	1.62	2.18
B	1.89	0.71	2.44	1.42	1.35	1.23	2.22
C	0.97	0.21	0.00	0.08	0.43	0.04	0.12
D	3.60	1.26	2.31	0.86	0.62	0.43	0.89
E	1.53	0.74	1.24	0.97	1.19	0.69	0.48
F	8.85	7.55	9.75	7.96	7.48	6.82	6.87
G	2.38	1.36	0.38	0.51	0.76	2.24	2.62
H	2.57	1.41	2.27	1.61	1.84	0.89	5.53
I	0.85	0.92	0.21	0.30	0.25	0.25	0.14
J	2.16	0.85	2.43	1.60	1.45	1.49	2.62
K	12.66	10.70	11.14	11.34	13.37	8.78	5.53

Table 3. Seven year analysis - Percentage of total annual effort hours:

Area	% effort 2007	% effort 2008	% effort 2009	% effort 2010	% effort 2011	% effort 2012	% effort 2013	7 year mean % effort
A	0.37	0.20	0.23	0.25	0.35	0.41	0.56	0.32
B	0.55	0.26	0.65	0.42	0.39	0.44	0.80	0.45
C	0.06	0.02	0.00	0.00	0.03	0.00	0.01	0.02
D	1.69	0.76	0.99	0.41	0.28	0.25	0.51	0.66
E	0.39	0.24	0.29	0.25	0.30	0.22	0.15	0.27
F	2.03	2.21	2.03	1.82	1.67	1.92	1.93	1.94
G	0.11	0.08	0.02	0.02	0.03	0.12	0.07	0.07
H	0.37	0.26	0.30	0.23	0.26	0.16	0.13	0.25
I	0.26	0.36	0.06	0.09	0.07	0.09	0.05	0.15
J	0.73	0.37	0.74	0.54	0.47	0.62	1.08	0.58
K	0.59	0.64	0.47	0.53	0.61	0.51	0.32	0.55

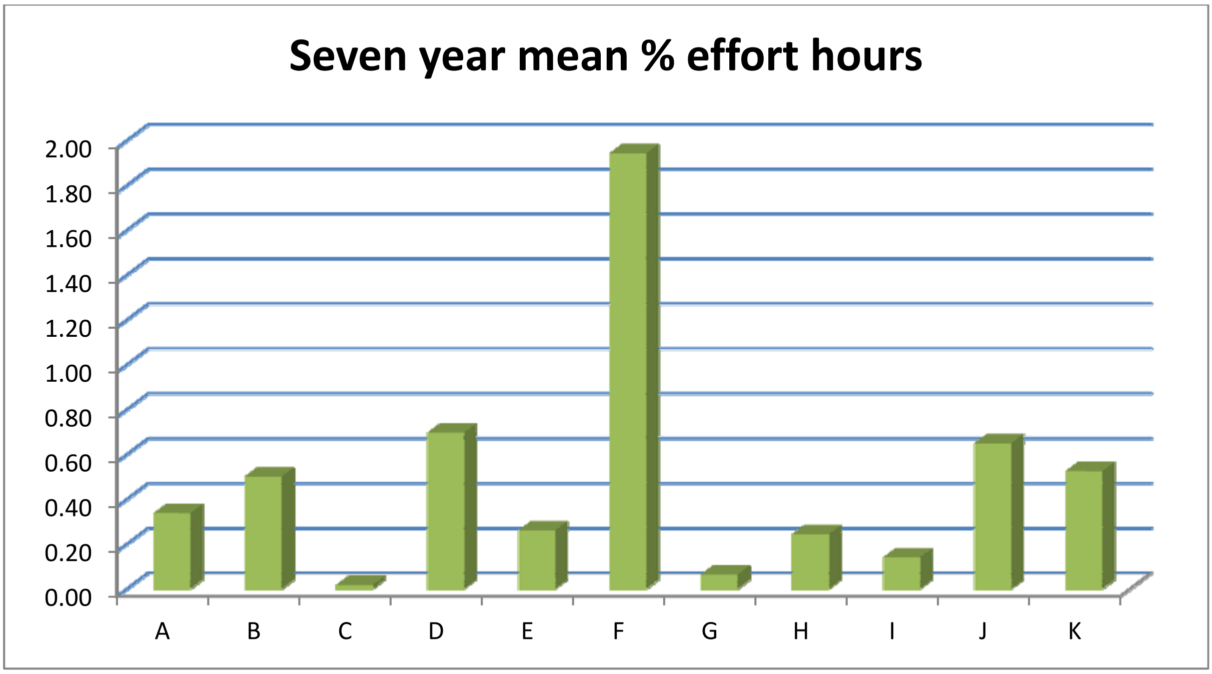


Figure 5. Plot of Seven year mean percentage of total effort hours at each suggested alternate site

It can be seen from Figure 5 that Site F is the most heavily fished areas in terms of total UK effort, while Site C is the lowest with very little activity.

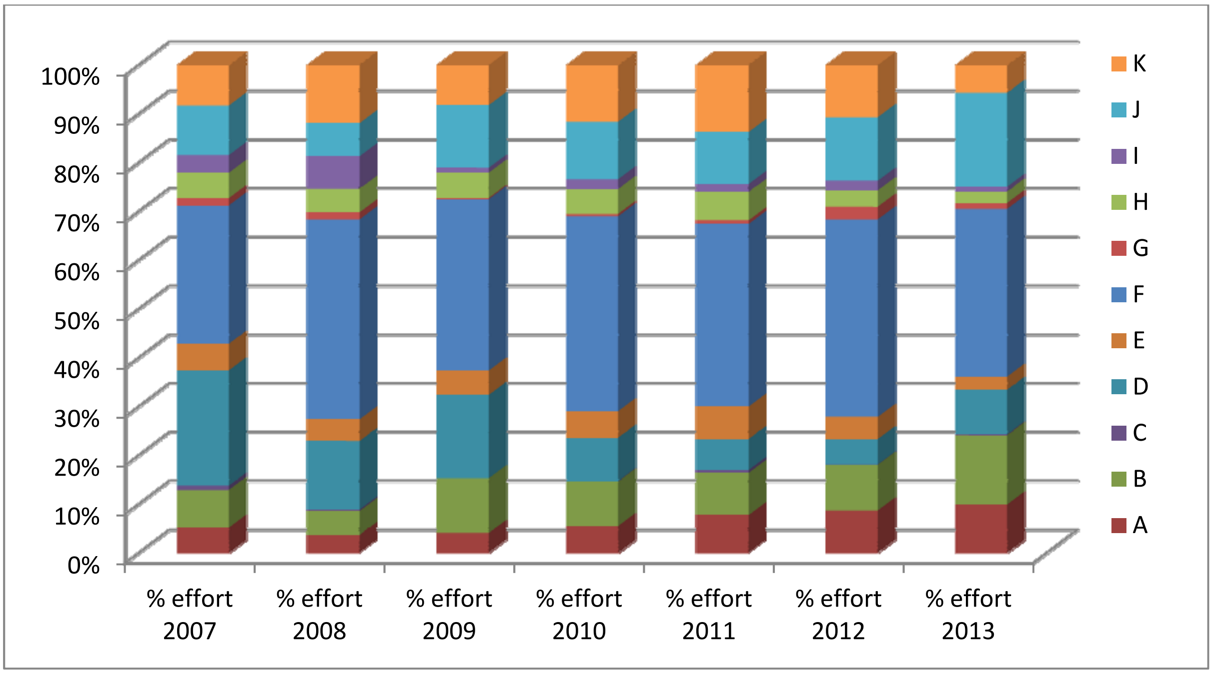


Figure 6. Seven year percentage of total effort hours at each alternate site – Annual proportion of effort *only within proposed alternative sites

Figure 6 demonstrates the annual variability in activity between these sites as percentage effort for each year. For example, Site D has a much greater percentage of activity in 2007 compared to 2012/2013, while Sites B and J have seen an increase in their proportion of effort.

Figure 7 shows a decrease of effort in these sites from 2007 until 2011 and in the last two years effort has increased to 4.36% of total UK effort.

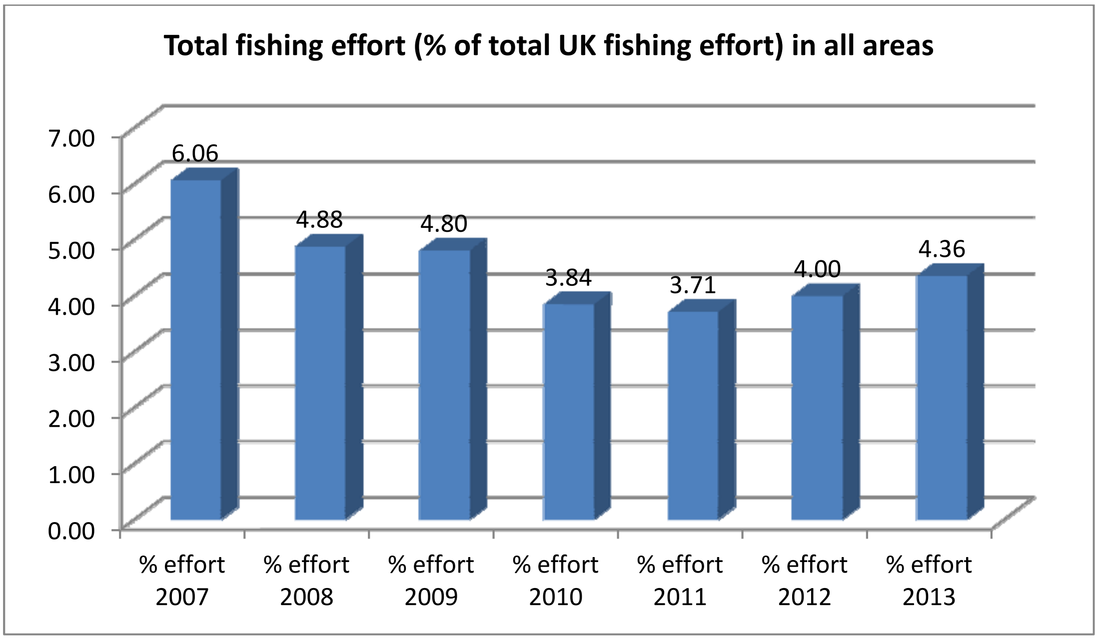


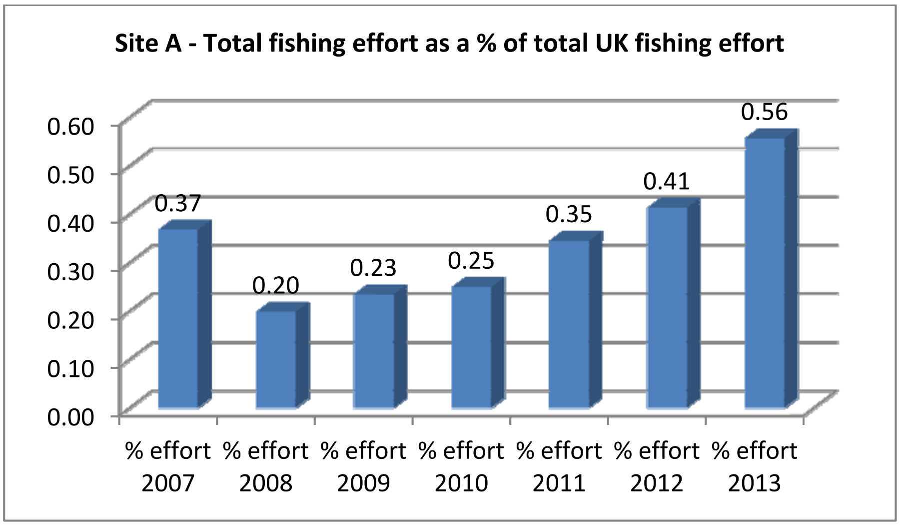
Figure 7. Seven year total percentage effort hours at each alternate site

1.2.1 Site breakdown

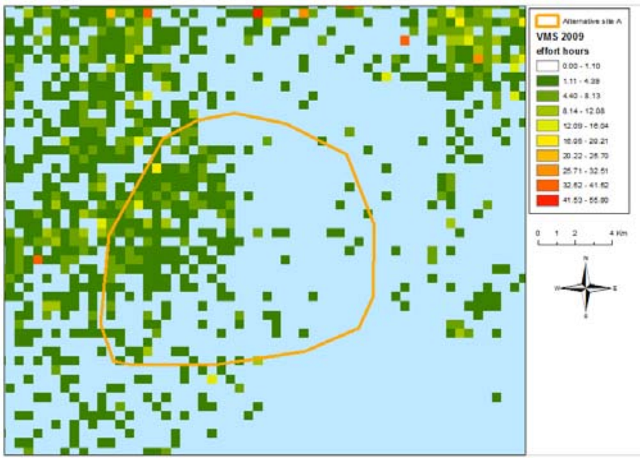
Below is a presentation of the breakdown of effort on each site (A to K) over the seven year period of investigation. There is also a geographical representation of that change in effort over two selected years, to highlight the spatial variation as well as the variation of intensity of fishing within each site. Note that when smaller vessels were included in the VMS scheme (12m length and over) in 2013 this may explain some notable changes between the previous years and 2013, as in some areas this may represent different fishing activity which wasn't previously captured in VMS data.

Please note the scale of the charts when comparing figures as these are scaled to compare inter-annual variability.

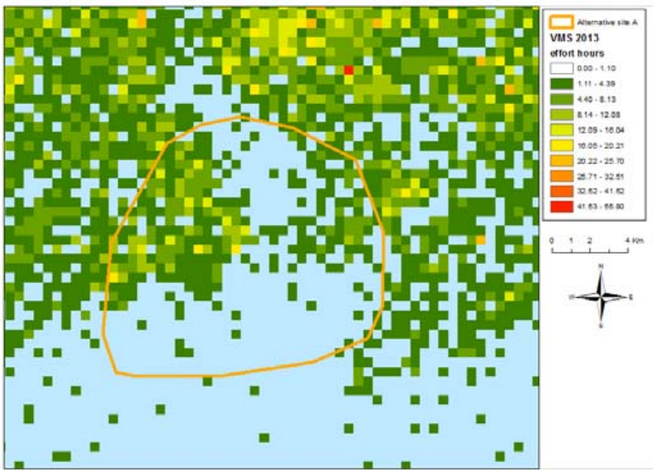
Site A



2009

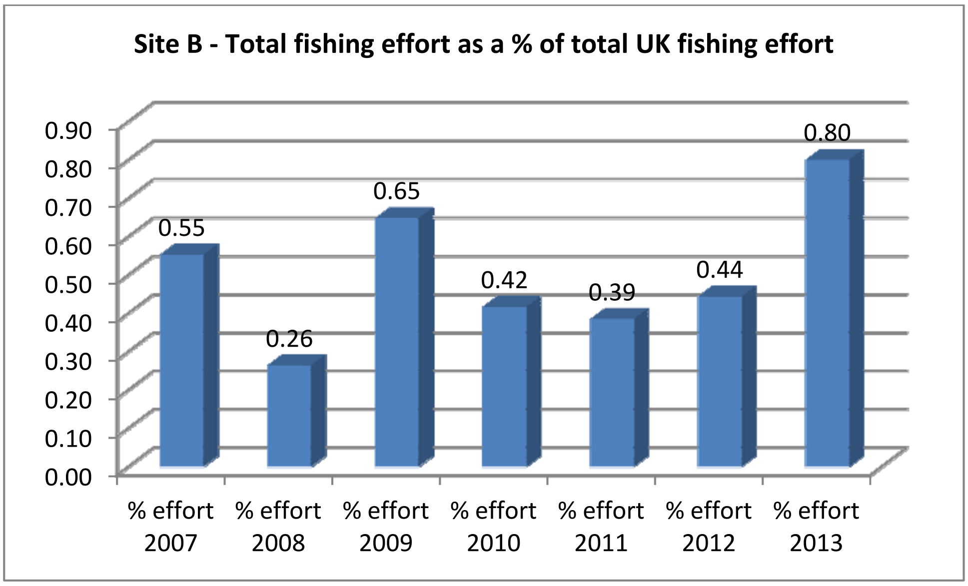


2013

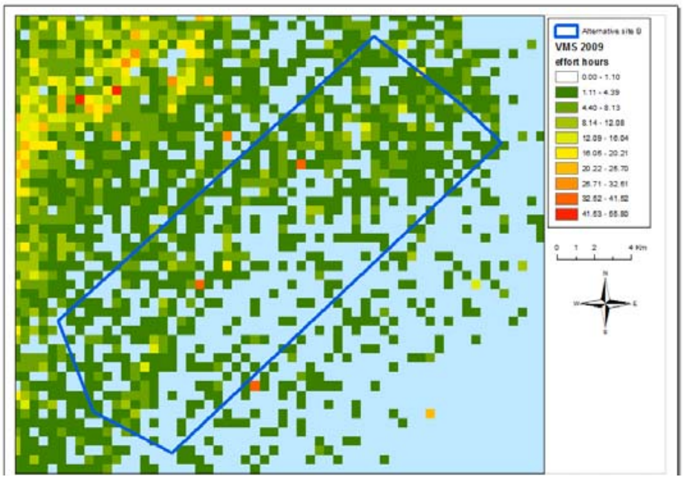


Site A is also known as Queenie Corner and is 166 km^2 in size. In terms of habitat, this area is not all mud and is a transition area into sand and gravels. Its outer eastern edge is typically fished for queen scallops. The proportion of UK total annual effort rises from a low of 0.21% in 2008 to a high of 0.56% in 2013. The southern end of the site is spatially less fished than the northern extent.

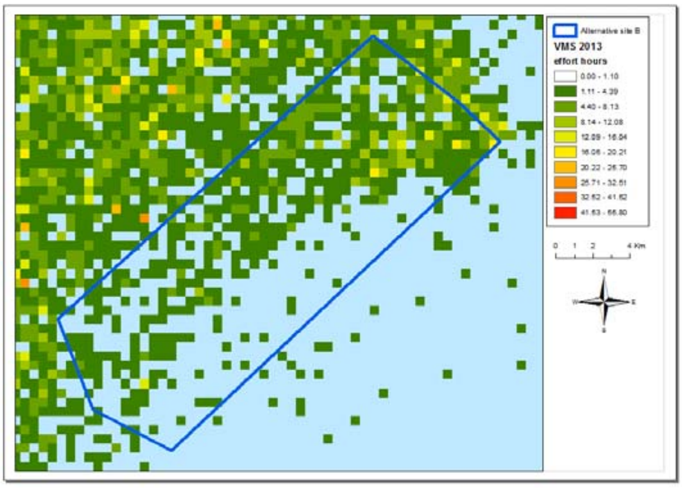
Site B



2009

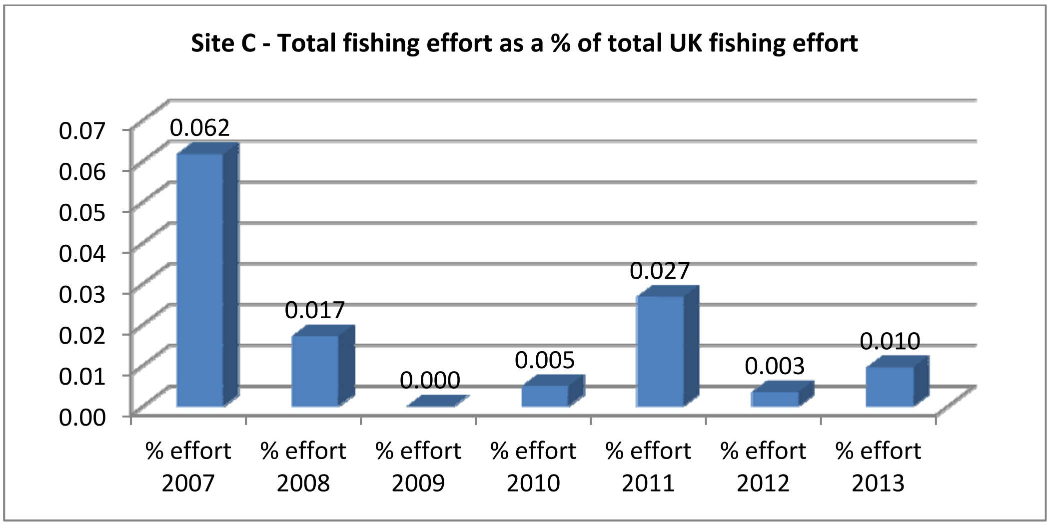


2013

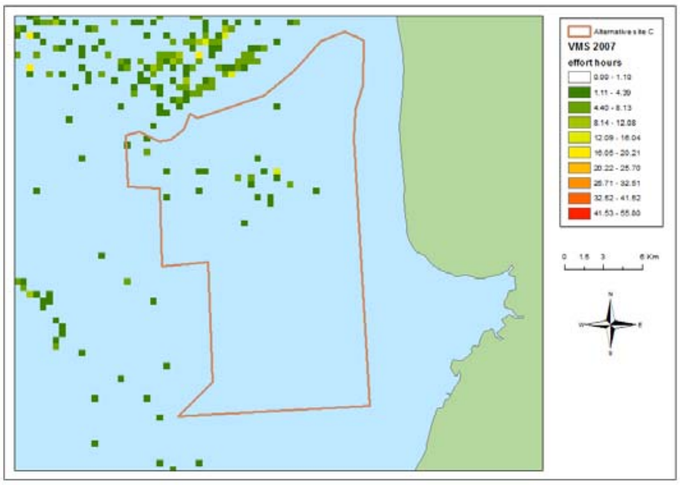


Site B shares part of site A and site J. It covers 228 km^2. In terms of habitat, this area is not all mud and is a transition area into sand and gravels. The proportion of UK total annual effort rises from a low of 0.26% in 2008 to a high of 0.80% in 2013. Displacement may be a concern if this area was closed to fishing.

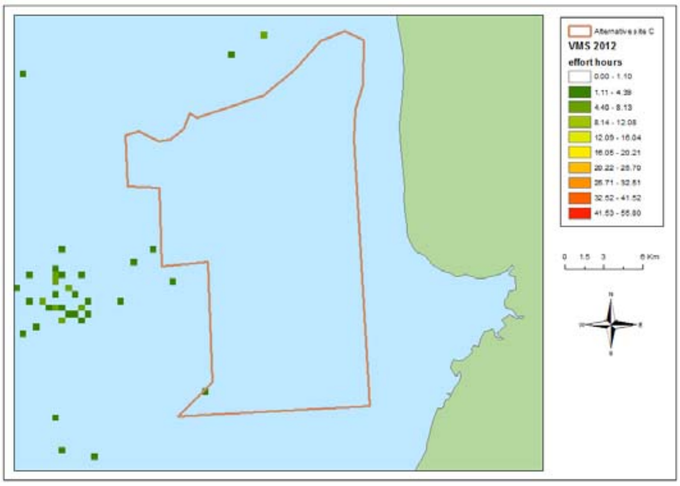
Site C



2007

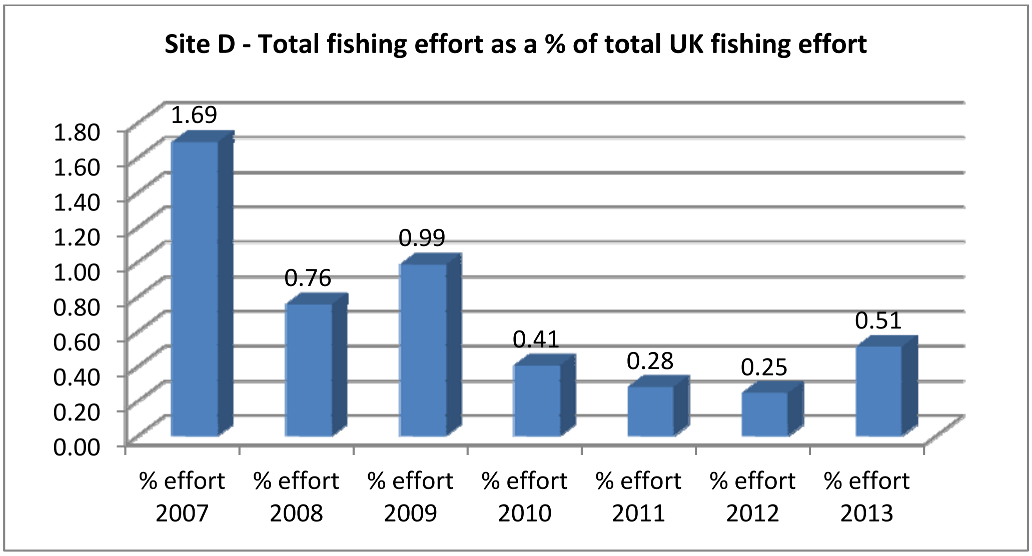


2012

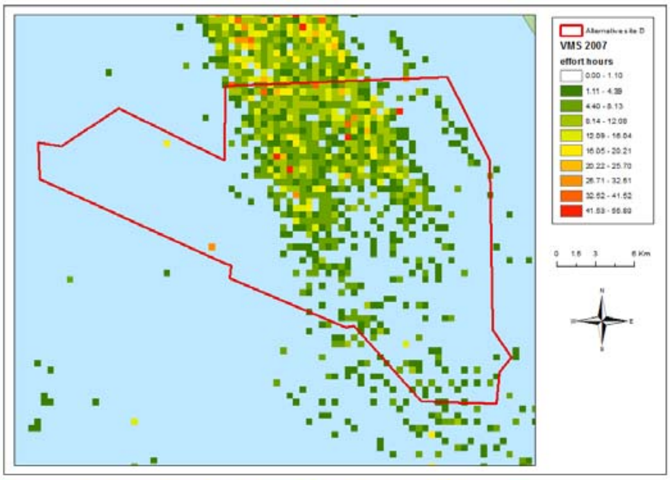


Site C is the most eastern site and is almost 356 km^2 in size. The proportion of UK total annual effort is very low in comparison to the other sites and has fallen from a high of 0.062% in 2007 to a low of 0.003% in 2012. Of all the alternative sites this perhaps offers the least impact to fishing and would cause the least displacement of activity.

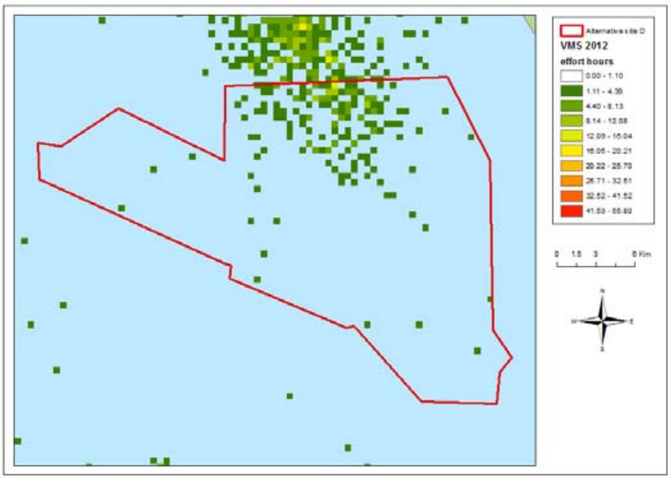
Site D



2009

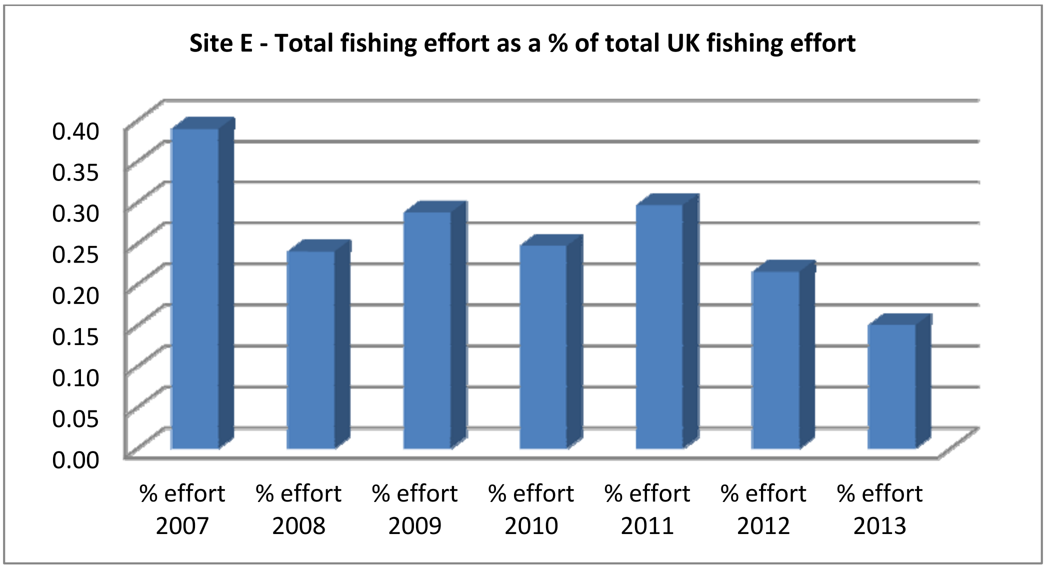


2012

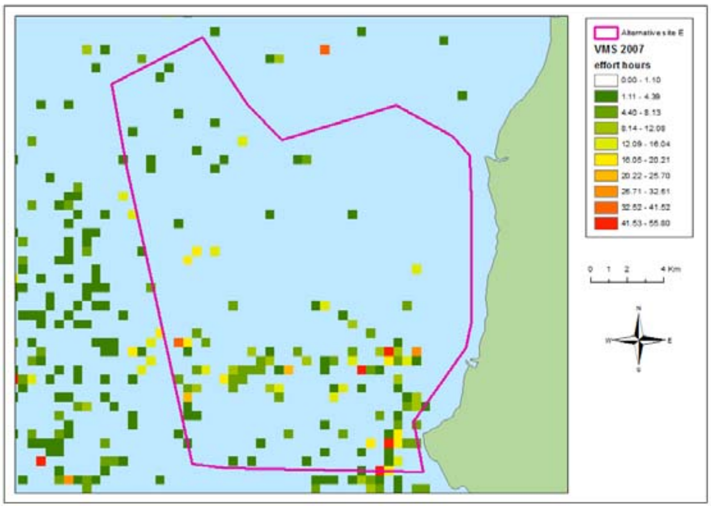


Site D is in the eastern Irish Sea and is the largest alternate site at 510 km^2. It has seen a changeable amount of fishing intensity over the period of investigation. The proportion of UK total annual effort is high in comparison to the other sites but has fallen from a high of 1.69% in 2007 to a low of 0.25% in 2012. The greatest fishing intensity is in the north and centre of the area while there has been less fishing intensity on the western and southern edge.

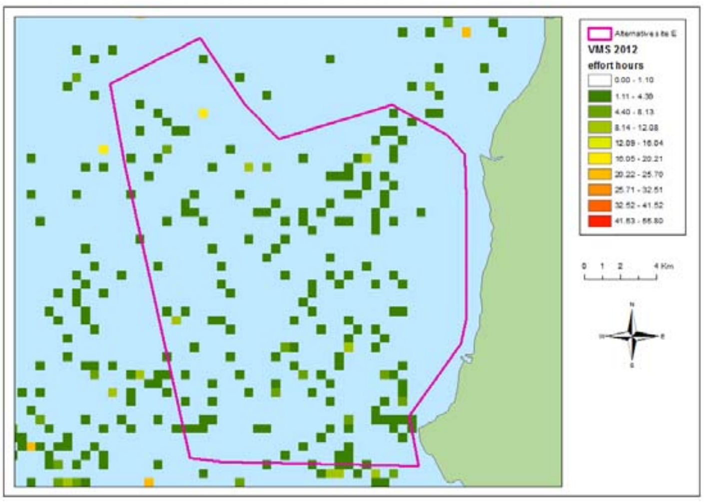
Site E



2007

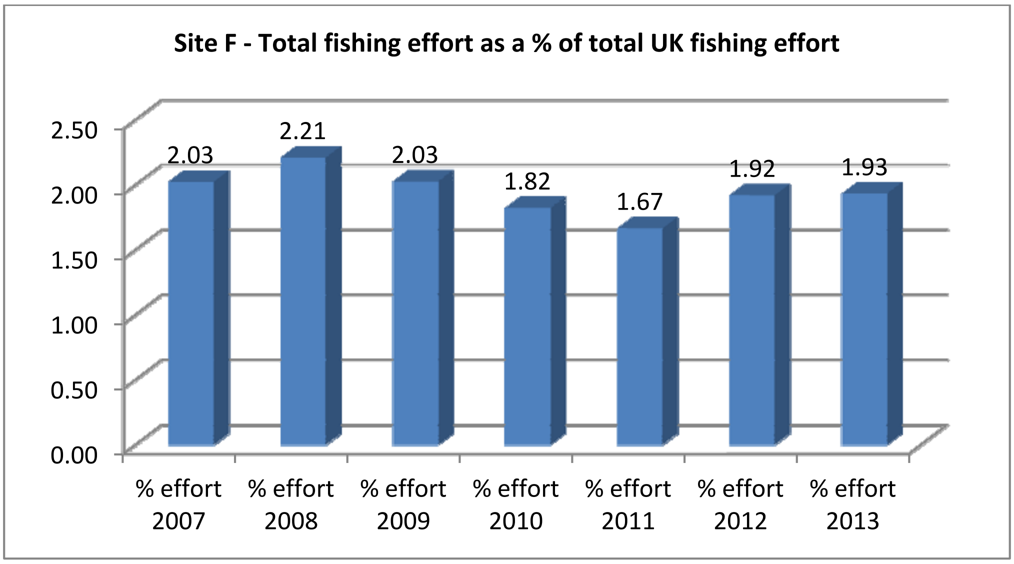


2012

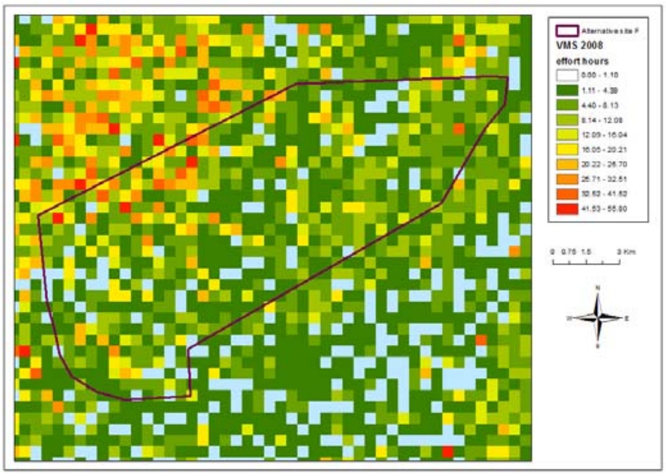


Site E is in the north eastern Irish Sea and is 334 km^2 in size. The proportion of UK total annual effort has fallen from a high of 0.39% in 2007 to a low of 0.15% in 2013. While the area has a wide distribution of activity in 2012 all of the other years show a higher concentration of activity in the south eastern corner.

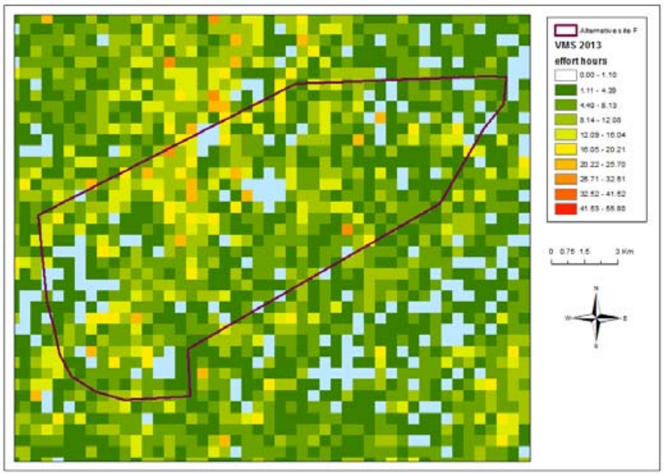
Site F



2008

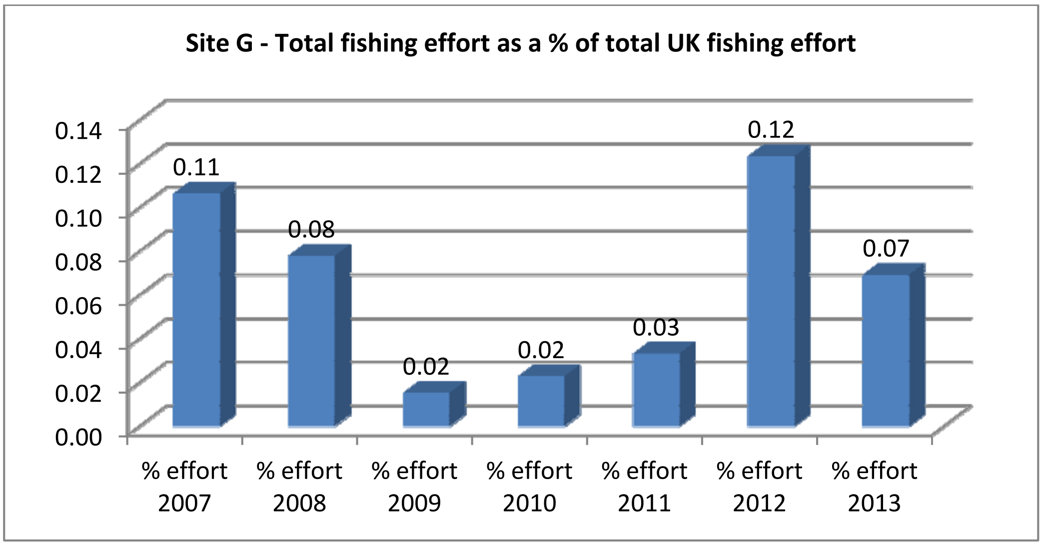


2013

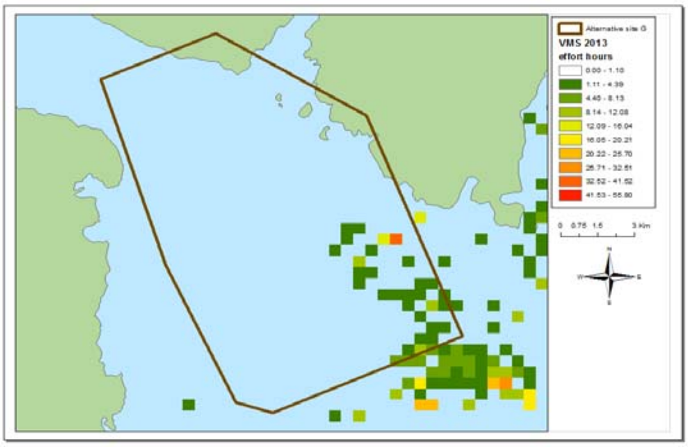


Site F is in the western Irish Sea and is one of the smaller alternate sites at 163 km^2 in size. The proportion of UK total annual effort has fallen slightly from a high of 2.21% in 2008 to 1.93% in 2013. The area is very intensively fished and would perhaps cause the most displacement if designated an MPA with restricted or no fishing.

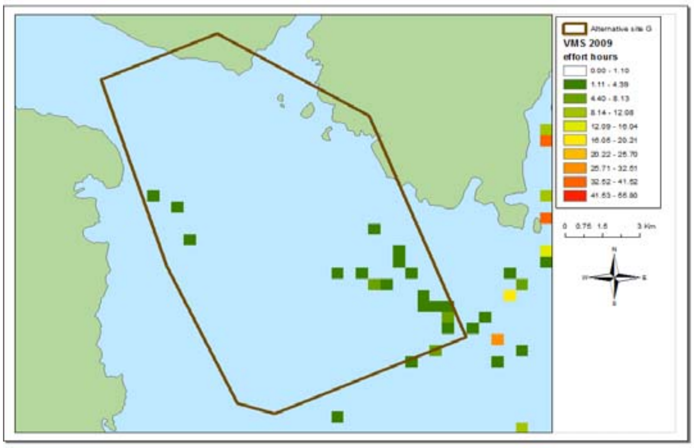
Site G



2009

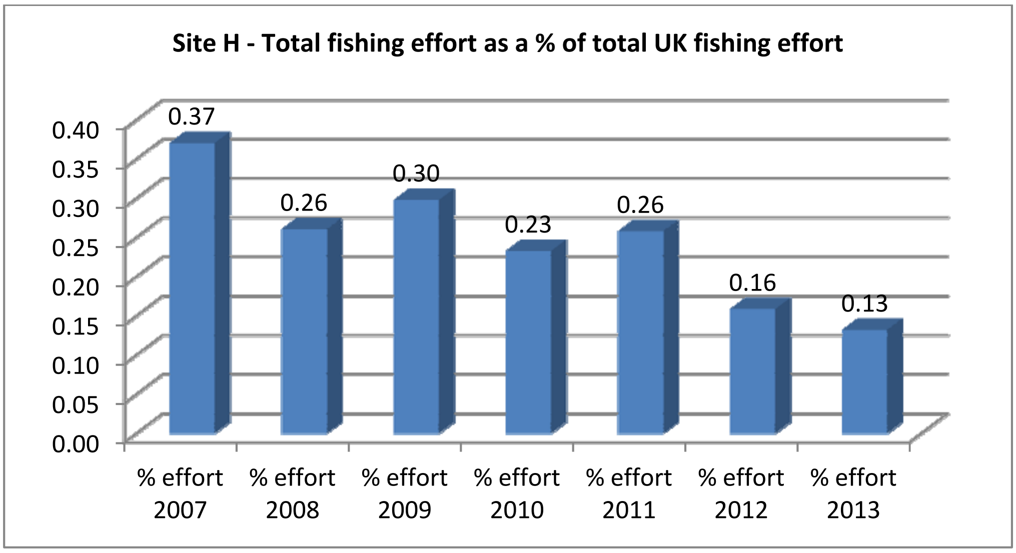


2013

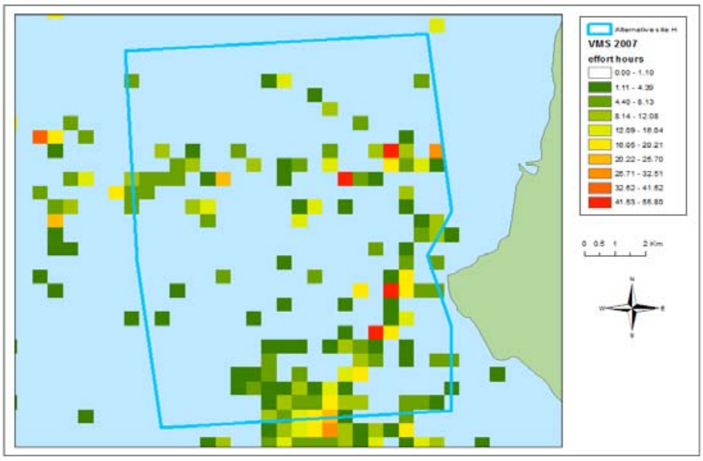


Site G is the most northerly alternate site and is 150 km^2 in size; the sketched polygon from the October workshop currently extends onto the land which therefore will require re-drawing should this site be progressed. The proportion of UK total annual effort is relatively low in comparison to the other sites. It has fluctuated from a low of 0.02% in 2009 to a high of 0.12% in 2012. This is one of the least intensively fished areas but also has a clear pattern of fishing activity concentrated in south eastern edge.

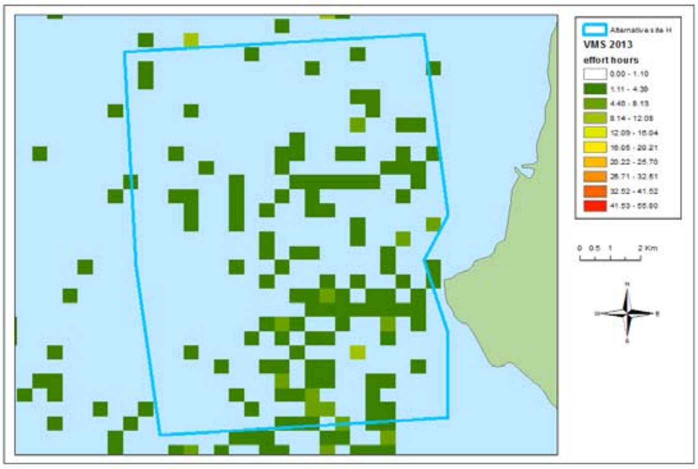
Site H



2007

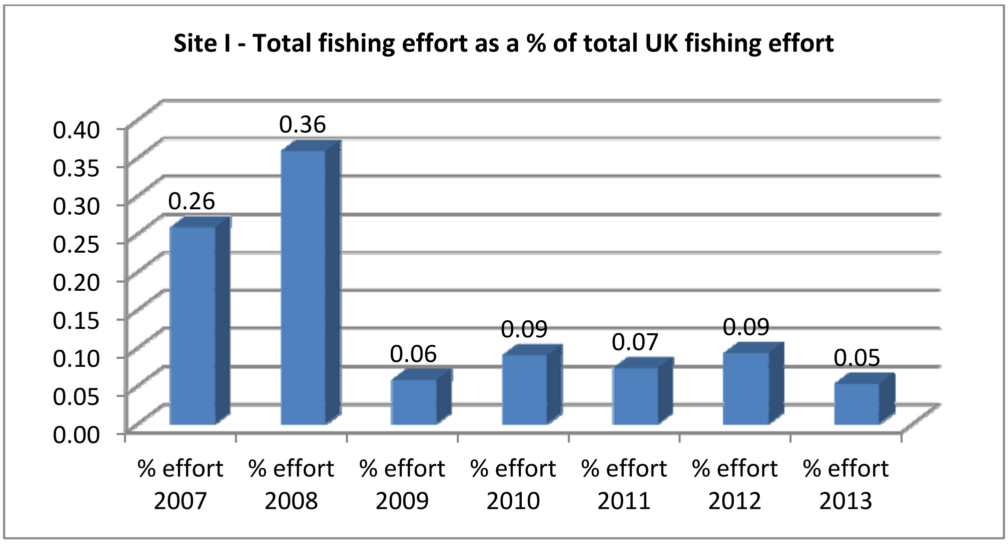


2013

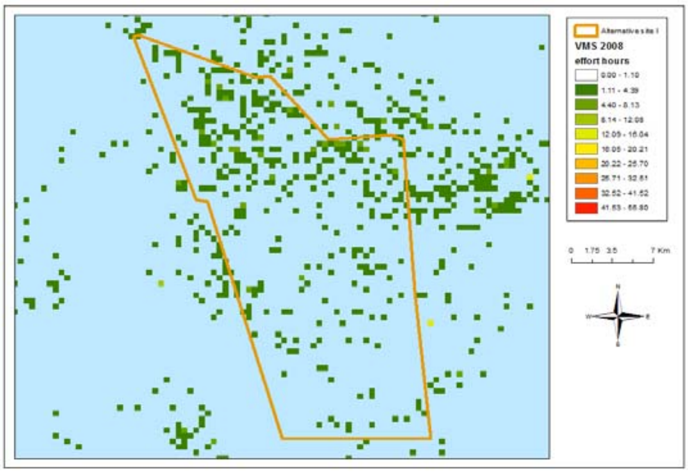


Site H is in the north eastern Irish Sea and overlaps with area E. It is 135 km^2 in size. From 2007 to 2013 there has been a downward trend in the proportion of UK total annual effort from a high of 0.37% in 2007 to a low of 0.13% in 2013. The higher concentration of activity is closest to the coast.

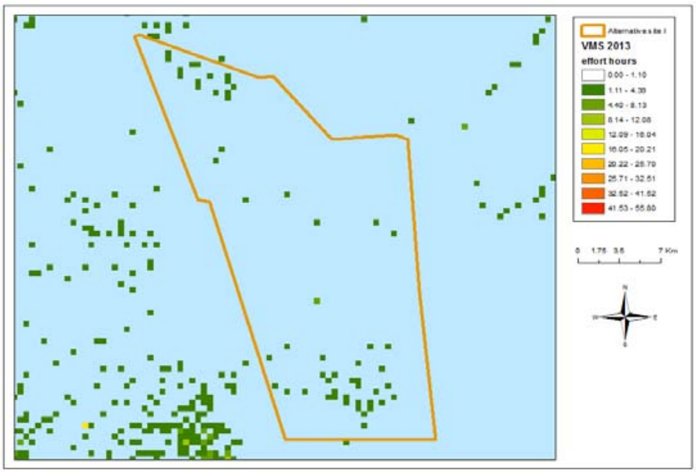
Site I



2008

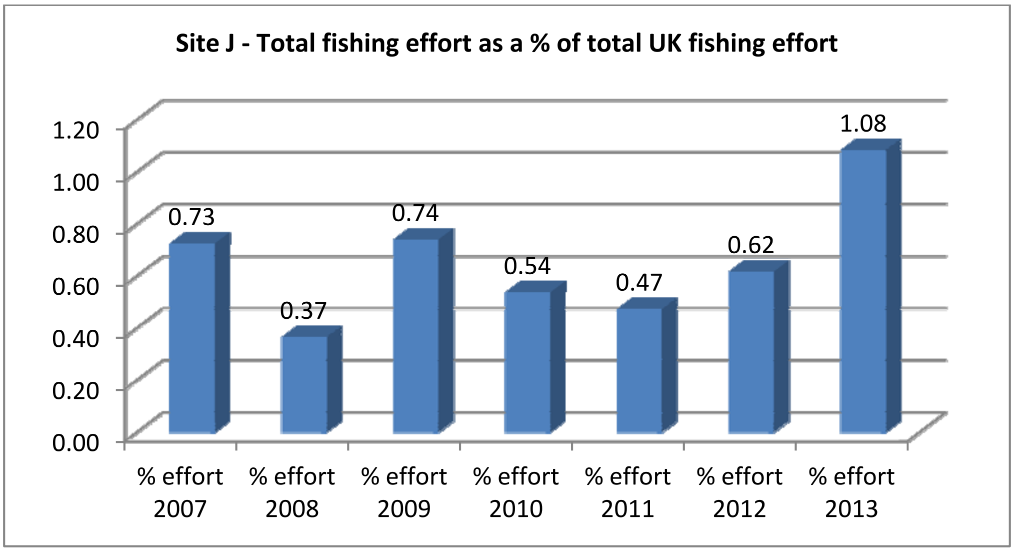


2013

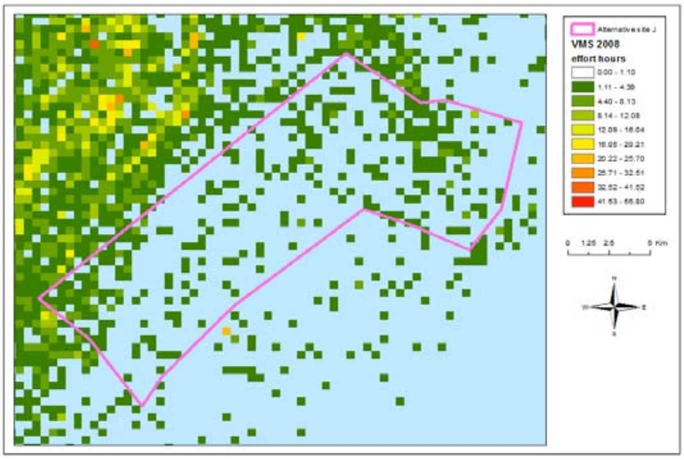


Site I is in the eastern Irish Sea and is one of the largest alternate sites at 501 km^2. It has a very low proportion of UK total annual fishing effort in comparison to the other sites; this has fallen from a high of 0.36% in 2008 to a low of 0.05% in 2013. Spatially there is no distinct pattern to fishing activity of the period of investigation. This area would perhaps cause little displacement if designated an MPA with restricted or no fishing.

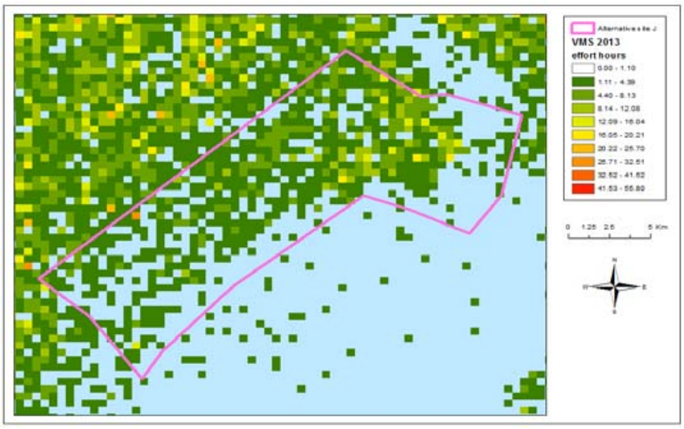
Site J



2008

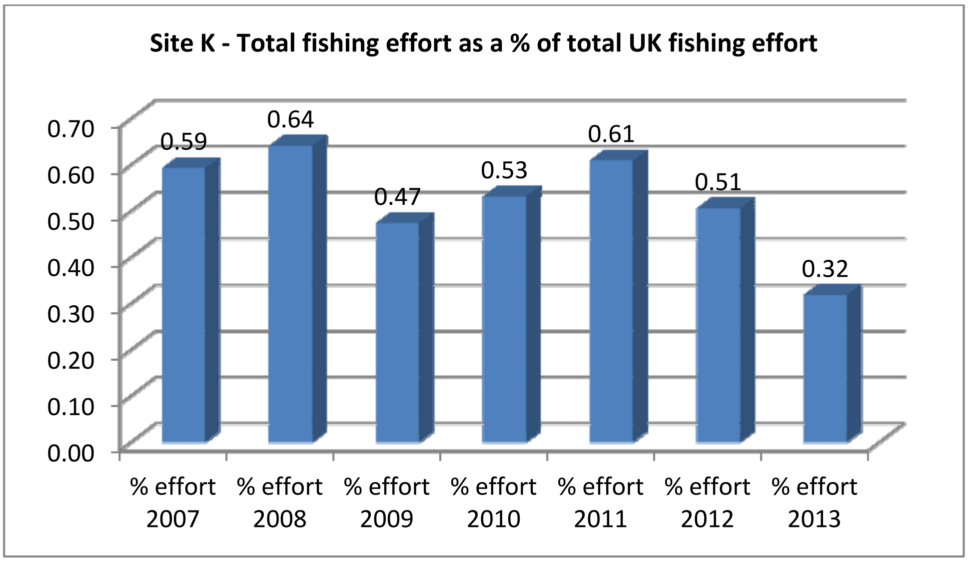


2013

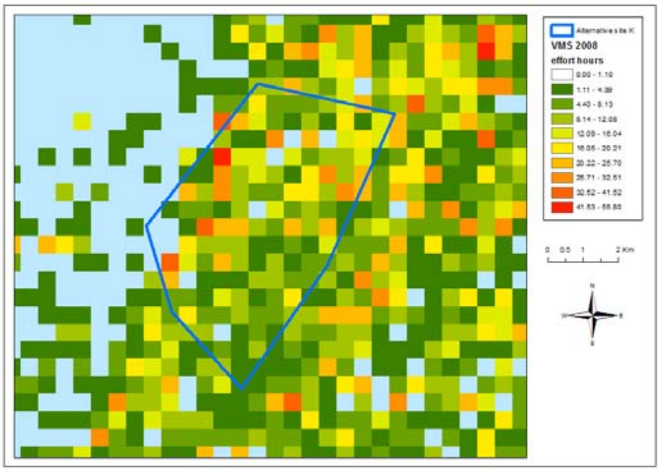


Site J is in the western Irish Sea and overlaps at the northern end with Site A, also known as Queenie Corner. It is 255 km^2 in size. In terms of habitat, this area may be a transition area from mud habitat into sand and gravels. The proportion of UK total annual effort shows a trend of increasing effort. It rises from a low of 0.37% in 2008 to a high of 1.08% in 2013. The area is now relatively intensively fished and would perhaps cause a high degree of displacement if designated an MPA with restricted or no fishing.

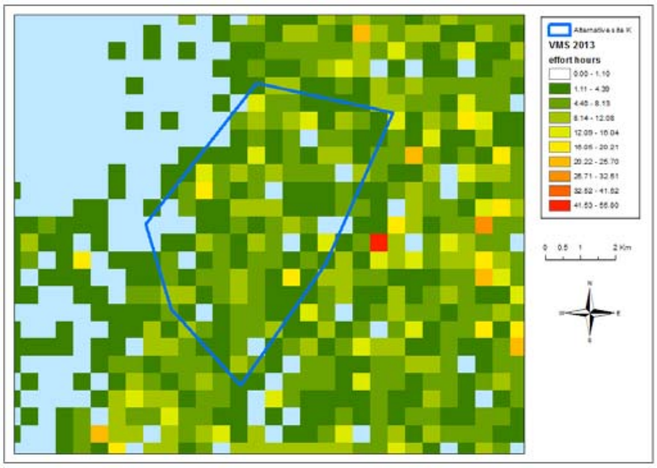
Site K



2008



2013



Site K is closest site to the County Down coast in the western Irish Sea. The area is the smallest suggested alternate and is 33 km^2 in size. For its size, it is intensively fished in terms of the proportion of UK annual effort. It is also one of the most spatially covered sites in terms of area fished at almost 90+ % coverage (based on effort area grid).

This is a well known *Nephrops* fishing ground. The total annual effort has fluctuated between 0.64% and 0.32%, with an average of 0.53%. The area would perhaps cause a high degree of displacement if designated an MPA with restricted or no fishing.

1.2.2 Monthly Breakdown: 2013 Effort hours

Fishing intensity in terms of effort hours per unit area (0.25km^2 grids) was calculated for the year 2013 in each of the proposed alternative sites and the results can be seen in Table 4 below. *See Appendix for maps of monthly spatial distribution.

Table 4. 2013 monthly breakdown of effort hours in each proposed area.

Areas	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
A	8	61	23	8	302	40	301	562	9	17	35	12
B	6	7	33	36	404	51	236	821	77	21	3	2
C	0	0	0	0	0	0	0	2	18	4	0	0
D	0	6	4	9	4	16	761	19	0	58	103	0
E	14	13	16	11	41	17	70	60	40	40	11	0
F	150	562	315	310	310	421	539	390	303	125	149	51
G	0	0	0	0	13	15	68	35	36	5	0	1
H	10	11	11	16	23	47	73	36	40	5	10	0
I	0	0	20	0	2	0	5	0	0	27	10	31
J	14	34	44	77	601	92	357	1204	123	25	10	2
K	112	68	2	21	44	98	101	203	37	3	35	4
Grand Total	313	762	468	488	1744	797	2511	3332	683	330	366	103

There is a variation in each site during the year with an overall peak of effort intensity in May, July and August, possibly related to weather conditions – see Figure 7 below.

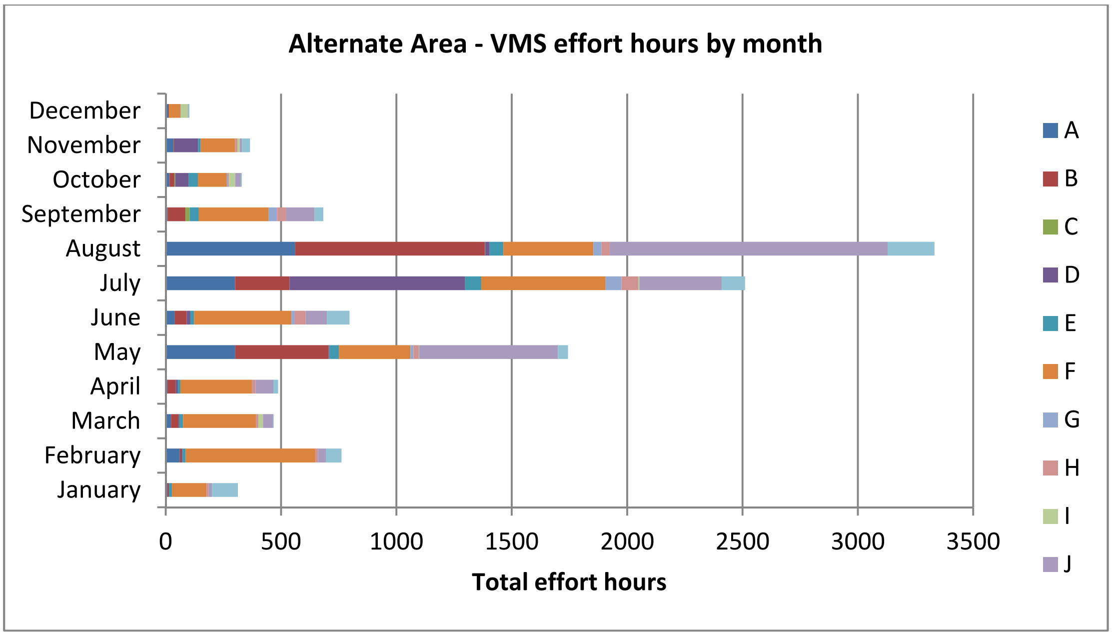


Figure 7. VMS effort hours by month and by alternate site in 2013.

Each of the proposed alternative sites is grouped spatially and their fishing activity is illustrated and described below.

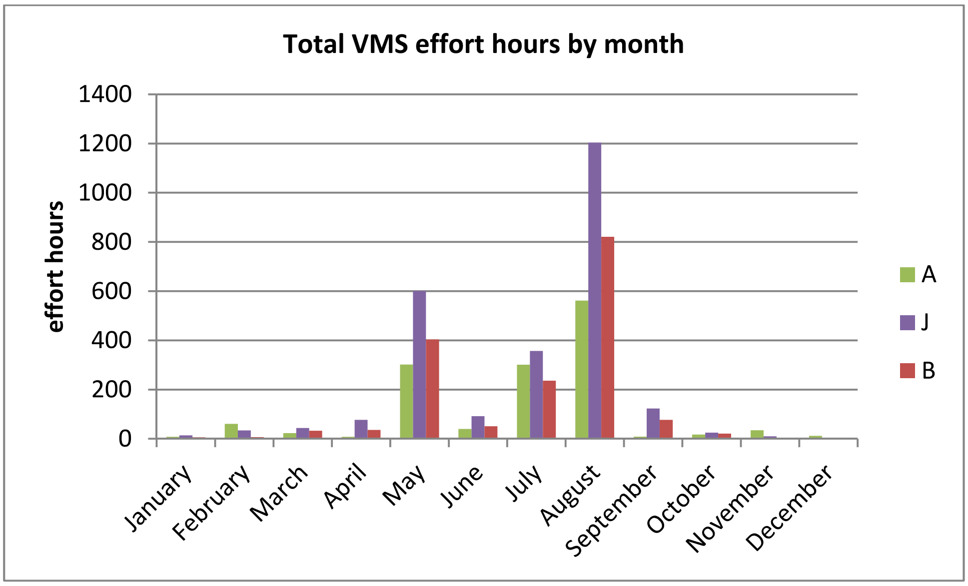


Figure 8. Sites A, J and B – "Queenie Corner" – total VMS effort hours by month in 2013

Figure 8 above for the "Queenie corner" sites shows that there is strong seasonality in fishing behaviour in these areas. Fishing in May and again in July and August is at a much higher intensity in terms of fishing effort hours than can be seen during the rest of the year. This may be due to the distance of these sites from fishing ports, with accessibility governed by weather conditions and also fuel prices.

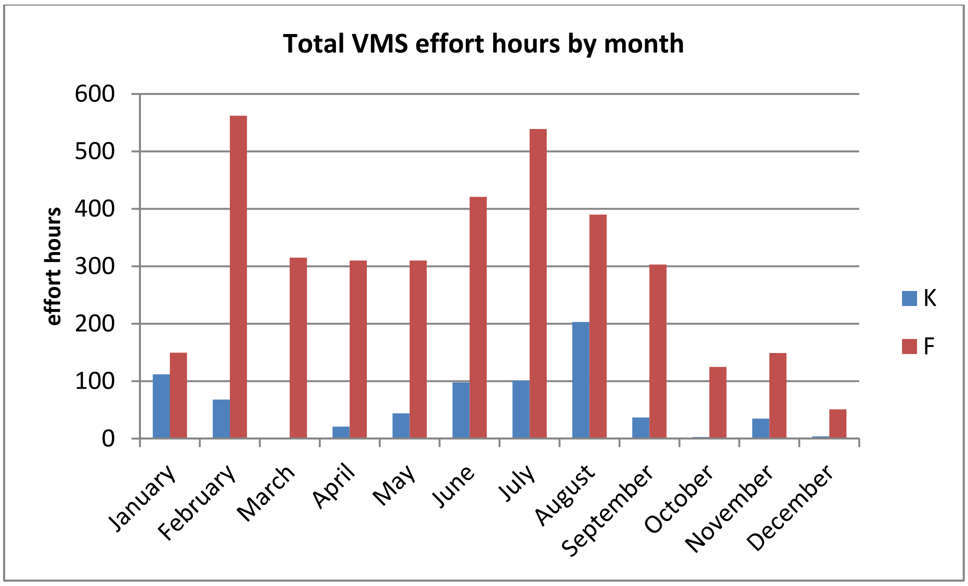


Figure 9. Sites K and F – Irish Sea: County Down Coast and South Rigg area - total VMS effort hours by month in 2013

Figure 9 above indicates that these sites are the most consistently fished with a high level of effort observed throughout much of the year; these are traditional *Nephrops* fishing grounds with good accessibility from the fishing ports. Area K is also near the inshore and may also have fishing effort from the inshore fishing (<12m length vessels), not recorded on the VMS.

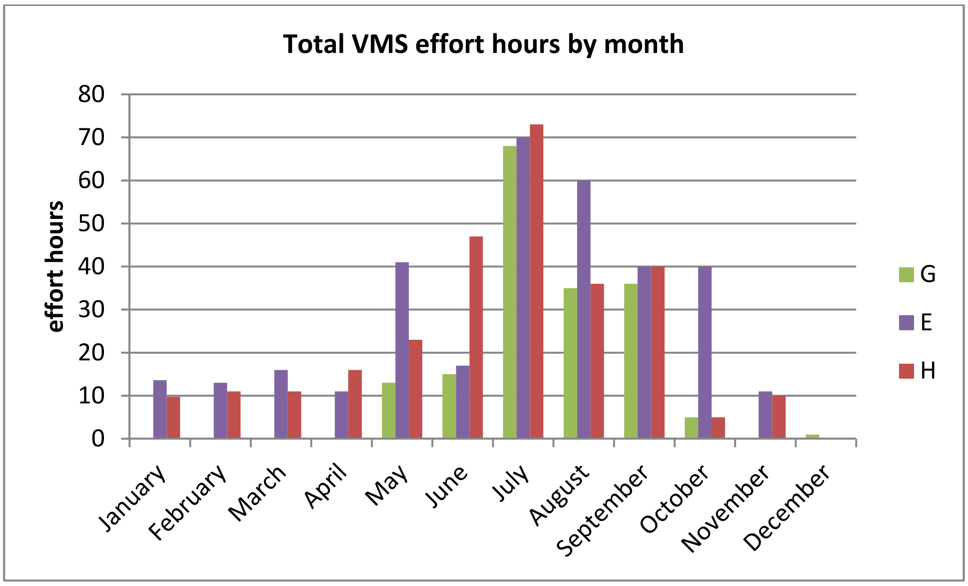


Figure 10. Sites G, E and F - North Eastern Irish Sea area - total VMS effort hours by month in 2013

Figure 10 above indicates that most fishing effort is concentrated between May and September with a baseline level maintained through at least 11 months of the year. There is almost no fishing in area G between January and April 2013. Access to these sites may be affected by weather conditions.

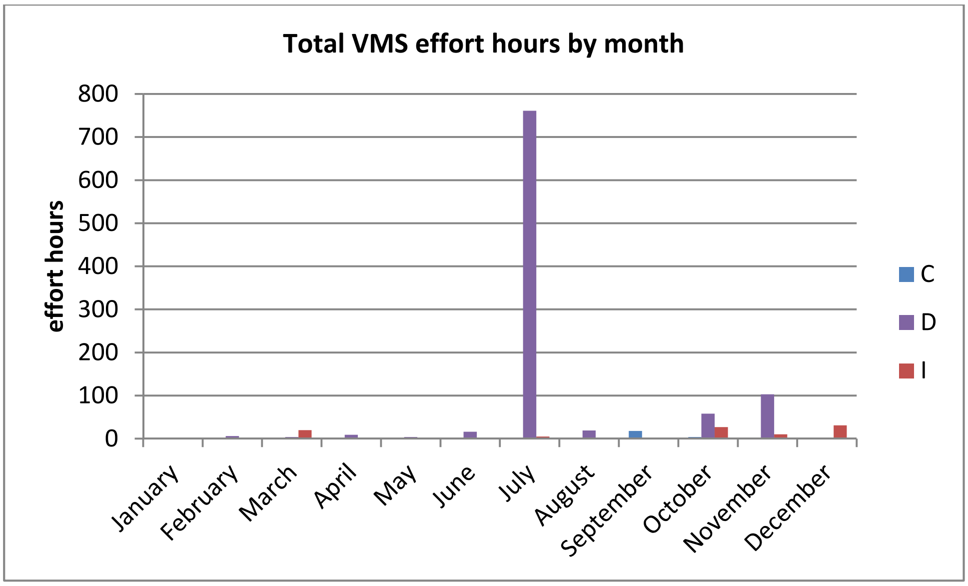


Figure 11. Sites C, D and I - Eastern Irish Sea area - total VMS effort hours by month in 2013

Figure 11 above shows that these sites are less intensively fished but a huge peak in fishing effort in July in area D can be observed. This suggests strong seasonality in fishing behaviour at this site.

1.3 Areas of least impact:

Table 5 below presents a summary of the sites following the VMS data analysis. This summary is described below and the results feed into Table 6 which a ranking system to help identify the sites of least impact to fishing, ability to fulfil JNCC requirement for connectivity and with the potential for redesign to further limit fishing displacement.

The sites coded green for highest level of agreement amongst stakeholders were A, B, E, H and J. Of these sites, E and H have the least amount of fishing effort and would likely induce the least fisheries displacement. Site E has an average of 0.26% of UK annual effort and Site H has an average of 0.24% of UK annual effort. These areas also overlap and have a combined size of 365 km^2. Part of this area is fished and shows repeated effort each year, it may be worthwhile factoring this in to a design of this site to cause minimal displacement effect.

Table 5. Summary of effort in areas and traffic light system

ID	Traffic	Area km^2	Seven year Mean % intensity effort	Irish Sea Zone	Redesign potential
Site A	Green	165.66	0.34	west	yes
Site B	Green	228.01	0.50	west	no
Site C	Amber	355.82	0.02	east	no
Site D	Amber	510.20	0.70	east	yes
Site E	Green	334.07	0.26	north east	yes
Site F	Red	163.64	1.94	west	no
Site G	Red	150.68	0.06	north east	yes
Site H	Green	134.79	0.24	north east	yes
Site I	Amber	500.67	0.14	east	no
Site J	Green	254.96	0.65	west	yes
Site K	Red	33.46	0.53	west	no

Of the amber sites C, D and I, C would has the least amount of fishing effort. All three of these sites would have a lesser impact on fishing and cause less displacement. Site C has an average of 0.02% annual effort, Site D has an average of 0.70% annual effort and Site I has an average of 0.14% annual effort. Site D does have a concentration of fishing in one specific area and perhaps this area could be removed in a potential redesign of the site. The total combined area of 1367 km^2. C, D and I are all in the eastern Irish Sea and are spatially linked.

Of the red sites, site G has the most potential, it is in the north east Irish Sea and has a spatially distinct pattern of fishery activity – meaning the proposed site could be amended in order to minimise the impact to fishing. The other red sites F and K, contain some of the highest fishing effort of all the proposed sites and would be the least desirable sites for MPA designation. If these areas were designated as MPAs with restricted fishing activity they would most likely to be affected by displacement.

1.4 Recommendations:

In order to objectively ascertain which site would be best for designation a ranking system was devised to factor size of area, mean fishing effort and potential to be redesigned to avoid higher intensity fishing areas (Table 6). A ranking of less than 20 is considered a suitable site for further consideration. Traffic light colour was not factored in to the ranking but as a descriptor after, e.g. Site G has a low score, making it a good potential site but it is not recommended as it was designated a red light site due to lack of agreement.

Table 6 – Recommended sites with least impact potential

ID	Traffic	Area Rank	Effort Rank	redesign index	coverage estimate	total	Zone	select	Area km^2
A	Green	7	6	1	7	**21**	west	*	165
B	Green	6	7	3	9	25	west		
C	Amber	3	1	3	1	**8**	east	*	355
D	Amber	1	10	1	5	17	east		
E	Green	4	5	1	4	**14**	north east	*	334
F	Red	8	11	3	11	33	west		
G	Red	9	2	1	2	**14**	north east		
H	Green	10	4	1	6	21	north east		
I	Amber	2	3	3	3	**11**	east	*	500
J	Green	5	9	1	8	23	west		
K	Red	11	8	3	10	32	west		
									1354

Consideration of the final ranking scores derived from a factor of size of area, mean annual effort, spatial coverage of fishing effort and redesign potential to minimise the displacement effect the following alternative sites would be recommended, with a site from each general location chosen in order to cover any potential differences in mud habitat and recognise connectivity of sites:

- **West** – Site A, "Queenie corner" (with possible site amendment) (165 km^2 and green-good agreement)
- **North East** – Site E (with possible site amendment) (334 km^2 and green-good agreement). *Site G, also has a low score in this region but is a red light site.
- **East** – Site C and Site I both scoring low scores – no obvious redesign possible (combined 855 km^2 –amber-medium agreement)

It is recommended that each of these sites is redesigned to minimise potential fisheries displacement and ensure maximum coverage of mud habitat.

An absolute minimum of 353 km^2 of mud habitat in Secretary of State waters in the Irish Sea regional sea (English inshore region, UK offshore region- excluding NI and Welsh inshore waters, and Scottish waters) is required to be designated by JNCC to meet the meet the mud MPA requirements. The sites selected will cover this requirement. The combined East group would meet this area requirement alone.

1.5 Literature Review: The impact of MPAs on fisheries displacement

If an MPA (Marine Protected Area) or MCZ (Marine Conservation Zone) is designated, management of activities to ensure the protected features are maintained or recovered into favourable condition is often required. For many habitats, fishing has been shown to have an adverse impact, and therefore sites may require fisheries management measures, through effort restrictions or prohibition. Where management involves activity restrictions, a review of 89 separate studies found that MPAs have higher average species diversity (20-30%), abundance and biomass (up to triple) compared to neighbouring areas outside the MPAs (Halpern, 2003). "No-take MPAs, where all fishing is prohibited, have been shown to provide benefits that include greater productivity of fish stocks due to increased densities, average sizes, and reproductive output." (Robb *et al*, 2011). In Canada, marine reserves where fishing is prohibited have shown an increase in diversity and abundance of marine species (Robb *et al*, 2011).

In the event of fisheries restrictions, the fishing industry may reduce total fishery effort (reduced landings) or fish in new areas, or more intensively in remaining grounds (Powers and Abeare, 2009). The decision making process is likely to economically focused - expected catch per unit effort (CPUE) versus the cost of moving to that area (Powers and Abeare, 2009). If the expected catch does not balance with the cost of moving, fishermen may have to cease fishing. If they have to cease fishing, they may be entitled to compensation as happens in many countries when MPAs are designated (Sen, 2001).

Alternatively if the expected CPUE versus the cost of moving is favourable or they are unable or unwilling to cease fishing, they will continue fishing and fishing effort from the MPA will be displaced. As such, "spatial analyses of effort are integral to the design of closed areas" (Powers and Abeare, 2009). It is therefore important when designating an MPA to assess current fishing effort, to enable an estimation of the likely displaced effort. In one example, an 'Ideal Free Distribution (IFD)' model was used to simulate the reallocation of fishing effort when areas are closed to fishing (Powers and Abeare, 2009). Redistribution of effort is complex, with a number of factors influencing where fishing effort will go: economic drivers appear to be the most significant, including value of catch, days at sea, cost of reaching a new location (e.g. fuel costs). In the Powers and Abeare (2009) study, displacement from the closed areas moved to where the CPUE was high and the cost to move there was low (based on the assumption that fish/catch abundance remains the same after the closure). This may be indicative that effort in the Irish Sea could move closer to the coast as the cost to move would be lower, but this could further intensify fishing in areas that are already quite heavily fished (Cappell *et al*.,2012). Discussion on ecological tipping points is appropriate in an intensively fished area, i.e. how much more pressure can the fishery tolerate in such areas before it starts to collapse (Service *et al*., 2013), and what are the wider impacts of such localised intensification versus the benefits of closed areas? Not understanding the consequences of displacement can lead to negative impacts on both fishermen and the marine environment (Valcic, 2009).

1.5.1. *Nephrops* populations (Mud habitat)

Nephrops populations are subject to annual variation and are dependent on a number of factors including environmental conditions (e.g. temperature, substratum, local hydrodynamic conditions etc.), fishing pressure, and density dependant factors e.g. sex ratios (e.g. Gonzalez Herraiz *et al.,* 2009). A 'lag effect' of changing conditions in producing a linked change in the density of *Nephrops* years later was documented by Gonzalez Herraiz *et al.* (2009). It is therefore possible that the effects of increased fishing pressure may not be witnessed immediately.

1.5.2. Managing displacement:

The benefits of MPA designation can be negated by the effect of fishing displacement (Greenstreet *et al.,* 2009). When combined with TAC (Total Allowable Catch) reductions the efficacy of MPAs may be improved. The indication from the literature is that displacement is more likely to occur if action is not taken to either minimise the area closed to fishing or by introducing reductions in TAC to reduce pressure on existing fisheries. It has been highlighted how important it is that the fishing industry as stakeholders are involved in the designation of MPAs (Pita *et al.,* 2013).

Outside the MPA, an under-fished area may be able to cope with displacement whereas a fully fished or overfished area is unlikely to cope without negative effects on the fishery. In this situation, studies have recommended a targeted buyout (Figure 12, from Sen, 2010).

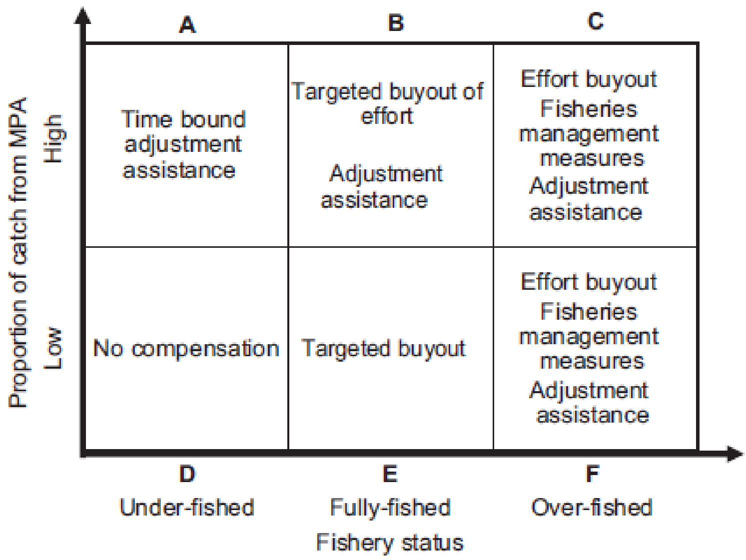


Figure 12. Suggested assistance outcomes for different displaced effort scenarios (Sen, 2010).

In Australia, following MPA creation and closure to fisheries, fishermen were compensated (where there was evidence of fishing in those locations). *Ex gratia* payments were also made (Sen, 2010). No compensation for crew or onshore dependant sectors such as fish processing was made, though this has been redressed in some Australian states, such as Western Australia.

The best option is perhaps to use the available information on fished areas within the proposed MPAs and redesign these zones to avoid some of the main fishing areas, therefore minimising the degree of displacement to a level that might be more easily absorbed by existing fisheries and avoid or reduce the need for reduction in TACs or introduction of compensation schemes. With this in mind, suggested redrawing of the alternative MCZ sites presented in this current study are presented below:

1.6. Redrawing of potential sites

Site A (West)

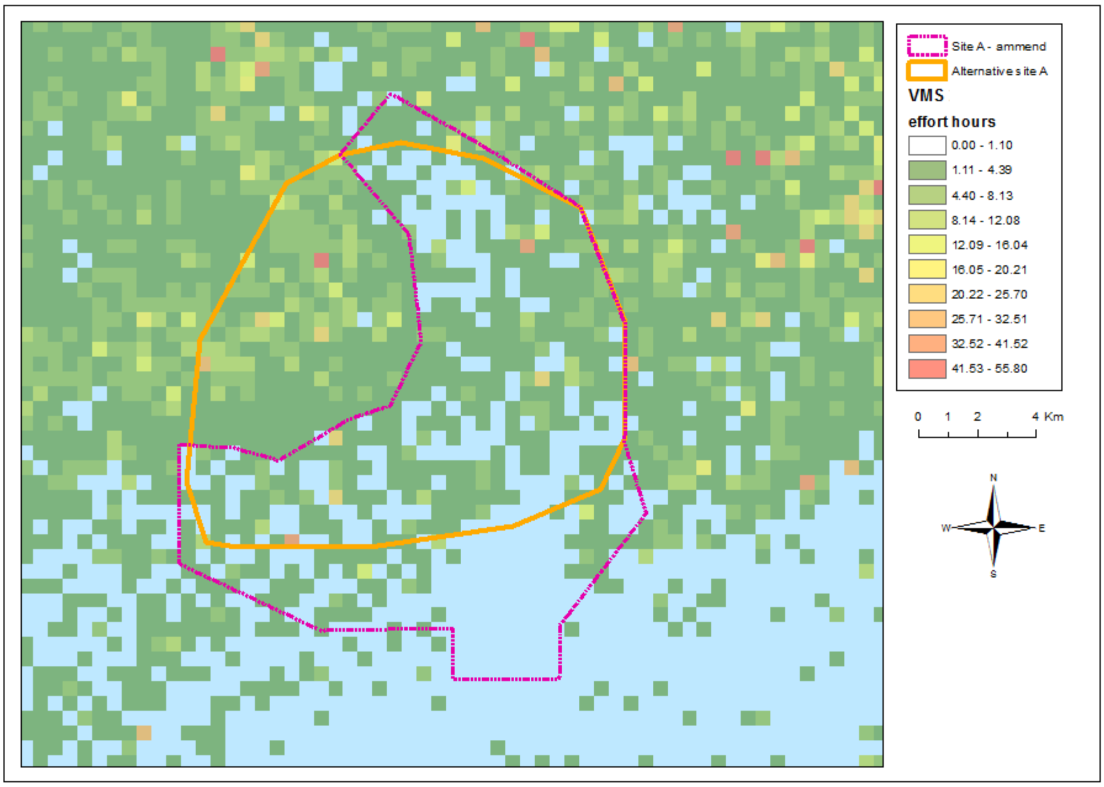


Figure 13. Site A – original alternative site and amended version in pink

Original size – 165 km^2
Redesigned size – 167 km^2

Site D (East)

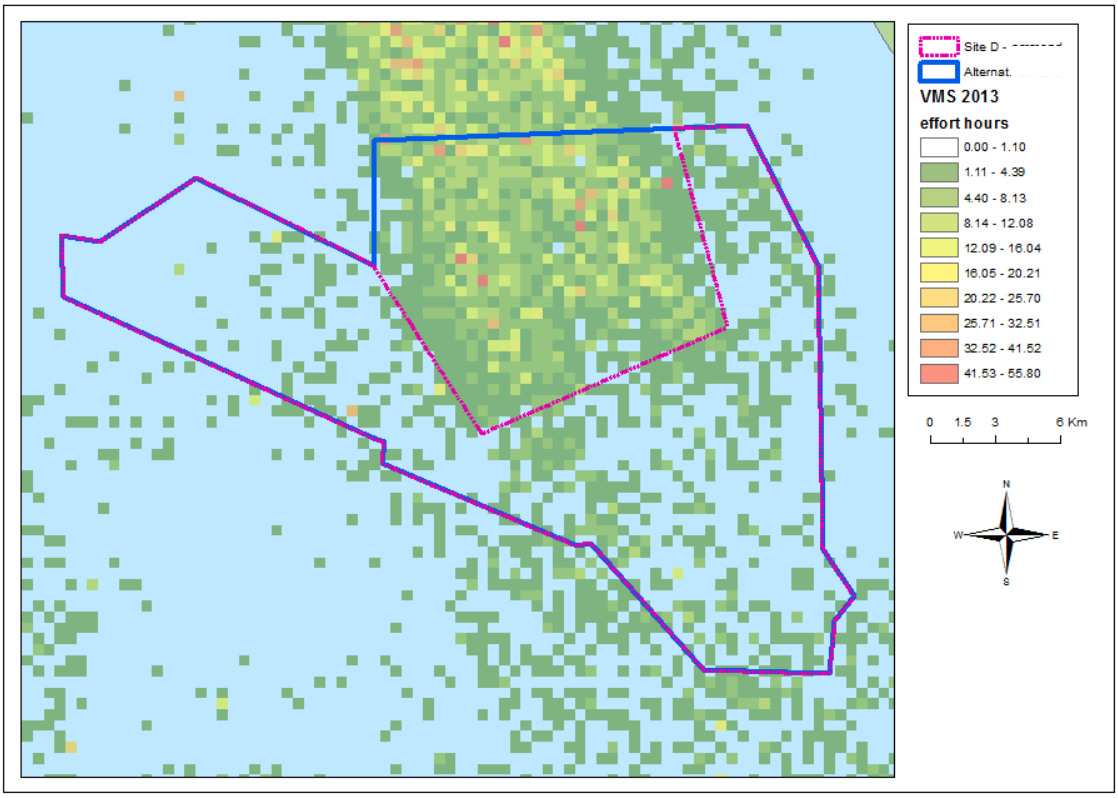


Figure 14a. Site D – original alternative site and amended version in pink

Original size – 510.2 km^2

Redesigned size – 343.45 km^2

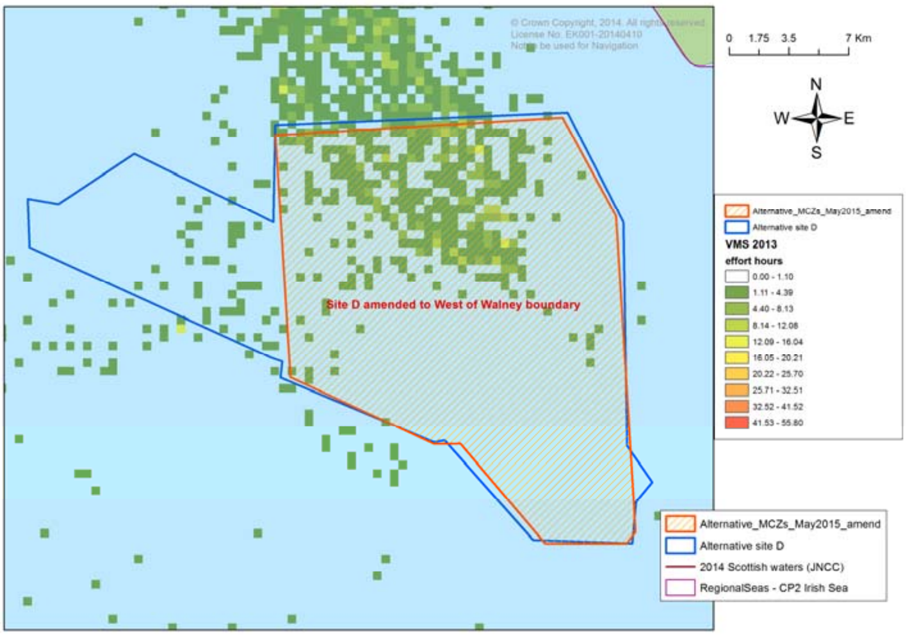


Figure 14b. Close up Site D, amended to West of Walney boundary.

Redesigned size – 388.71 km^2

Site E (North East)

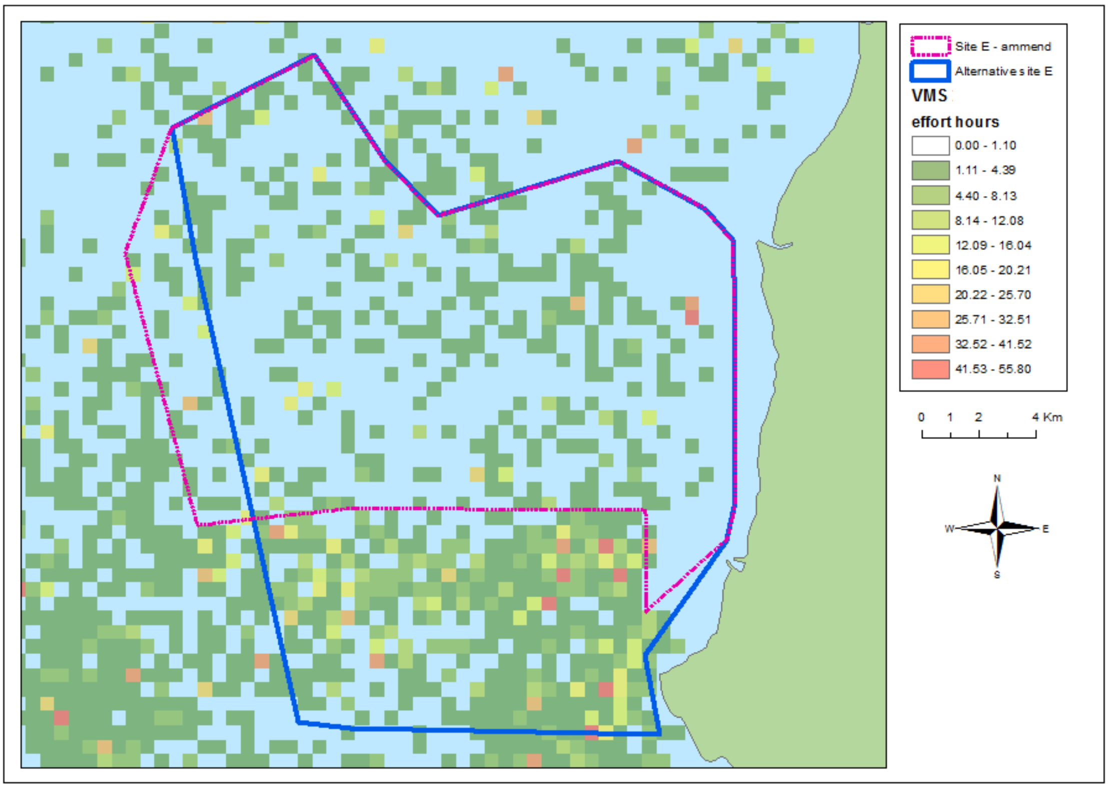


Figure 15. Site E – original alternative site and amended version in pink

Original size – 334.07 km^2
Redesigned size – 258.60 km^2

1.6.1. Site Redesign Summary

Sites A, D and E: these amended sites should minimise the impact of closure to fishing whilst still incorporating the mud zones. The total combined redesigned area is 769.05 km^2.

Part II: Defining Irish Sea mud habitat and "favourable condition", and a review of potential management options

2.1 Irish Sea mud MCZ "design criteria"

Following published information on the MCZ designation process by JNCC (see JNCC MCZ Advice Protocols[3]) and DEFRA's objectives for designation of representative proportions of EUNIS Level 3 "predominant", or "broad-scale", habitats mapped in UK waters, by regional sea area, the following criteria were applicable to identification of sites:

- "Subtidal mud" includes the habitat features of conservation interest (FOCI) "Mud habitats in deep water[4]" (>20m depth) and "Seapen and burrowing megafauna communities[5]" (the latter of which are rarely found shallower than 20m except in some sea loughs). The former can also include the latter.
- A minimum of 10% of the Irish Sea regional area's mud habitat within the Secretary of State's waters (excluding NI and Welsh inshore waters, and Scottish waters) needs designating, which based on the extent of mud habitat identified from EU SeaMap predicted broad-scale EUNIS habitats[6][7] for the CP2 Irish Sea regional sea area equates 353 km^2. This includes waters of all depths, and excludes Isle of Man waters.
- MCZ minimum size: For offshore sites, an area should have between 10km and 20km in their minimum dimension.
- Due to the devolution of the government Bills covering MPA designation, sites must be situated outside of Scottish waters. Northern Irish inshore waters, or areas straddling the inshore/offshore boundary, could be considered, although the minimum area does not account for these. Currently both Scotland and Northern Ireland have only small areas of mud habitat designated which fall within the Irish Sea regional sea area, and therefore the majority of the 353 km^2 is still in need of designation through new MCZ sites.
- Following the definition for mud habitat provided above, new MCZ areas should ideally target waters >20m depth (or where these is good evidence of seapens and burrowing megafauna in shallower areas)
- For connectivity, more than one site in the regional sea should be designated, preferably representing a range of communities. This requires evidence of the distribution of benthic communities across mud habitats in the Irish Sea.

[3] http://jncc.DEFRA.gov.uk/page-5999
[4] http://jncc.DEFRA.gov.uk/page-6024
[5] http://jncc.DEFRA.gov.uk/page-6028
[6] Information contained here has been derived from data that is made available under the European Marine Observation Data Network (EMODnet) Seabed Habitats project (www.emodnet-seabedhabitats.eu), funded by the European Commission's Directorate-General for Maritime Affairs and Fisheries (DG MARE).
[7] EUNIS = European Nature Information System, available at: http://eunis.eea.europa.eu/

The Irish Sea regional sea area, predicted mud habitat split by that falling within Scottish inshore waters and other UK waters, and split further by the 20m contour line is provided in Figure 16 below.

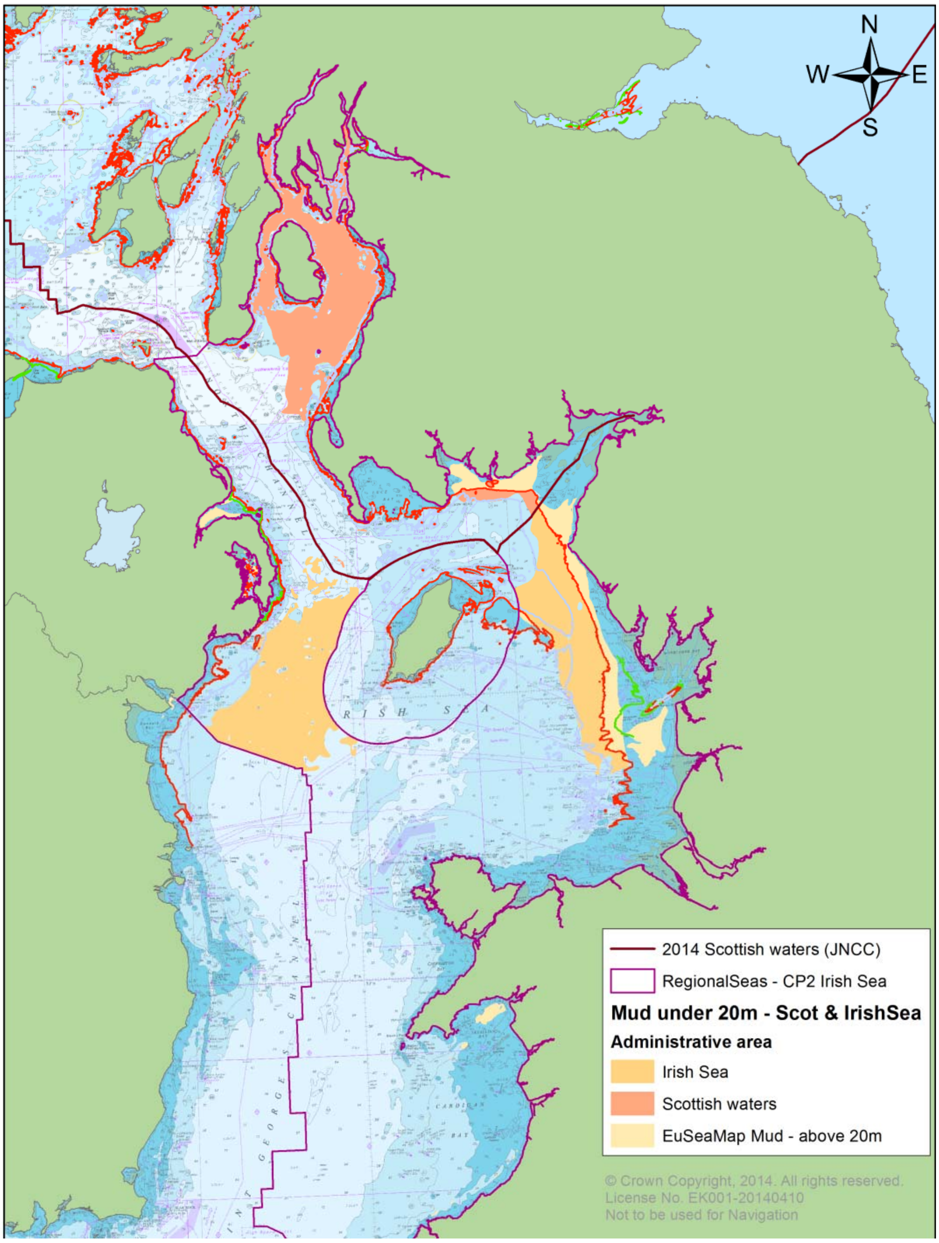


Figure 16. Target mud habitat in the Irish Sea regional sea area.

2.1.1. Definitions of target habitats

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)
- Two target '**habitats of conservation interest**':
    - "**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, which have been identified in the Irish Sea following data analysis completed for this project:

Table 7. Mud habitat biotopes identified within the Irish Sea (this study)

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 the shallower seapen biotope 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.

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 <u>due</u> to trawling. Without trawling (for example, through fisheries closures as a management measure implemented in an MCZ) there is the potential for competitor and perhaps predator populations (such as cod) to increase. This issue will be revisited in section on Management options.

2.2 Methodology

To assess the distribution of habitats of conservation interest within the EU SeaMap predicted mud area, the following data sources were used:

- **Underwater video** – *Nephrops* stock asssessment (ICES FU14 and FU15)
- **Day grab data** (sediment descriptions and infaunal communities)
    - 328 samples analysed across Eastern and Western Irish Sea, from AFBI data archives and Walney development survey data accessed from the Crown Estate data portal (http://www.marinedataexchange.co.uk/)

2.2.1. Underwater video analysis

The 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. For ICES FU15 (western Irish Sea), notes of seapens viewed on the video footage were also used to provide an additional data layer. Seapens were not always assigned to a particular species, however from discussion with analysts and viewing of a subset of footage these seapens appear to be mostly the species *Virgularia mirabilis.*

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 the remainder sieved using a 1mm sieve, with the residue preserved in formalin and processed for species abundance.

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

As the grab samples came from a wide range of survey campaigns, each resulting species abundance data matrix was checked with the WoRMS directory for species nomenclature, and colonial species removed. Notes of shell fragments were removed and juvenile species were removed. All separate datasets were merged into one species abundance matrix for further analysis.

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 also constructed to aid the analysis of the species data. This consisted of the sediment grain size data as noted above, and also the nearest VMS-derived fishing intensity results (from averaged 2007-2013 VMS data) and the nearest video *Nephrops* burrow density data. Nearest data were extracted within GIS; VMS data were spatially coincident with all grab sample sites, while the *Nephrops* burrow density data were not. A limit of 2.5km distance was imposed in the calculation of nearest burrow density data.

The "Bio-env" routine was used to examine the influence of percentage mud (silt/clay), grain size sorting, mean grain size, VMS derived fishing intensity and nearest *Nephrops* burrow count data on the sample species assemblages.

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 17 below.

Finally, 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.

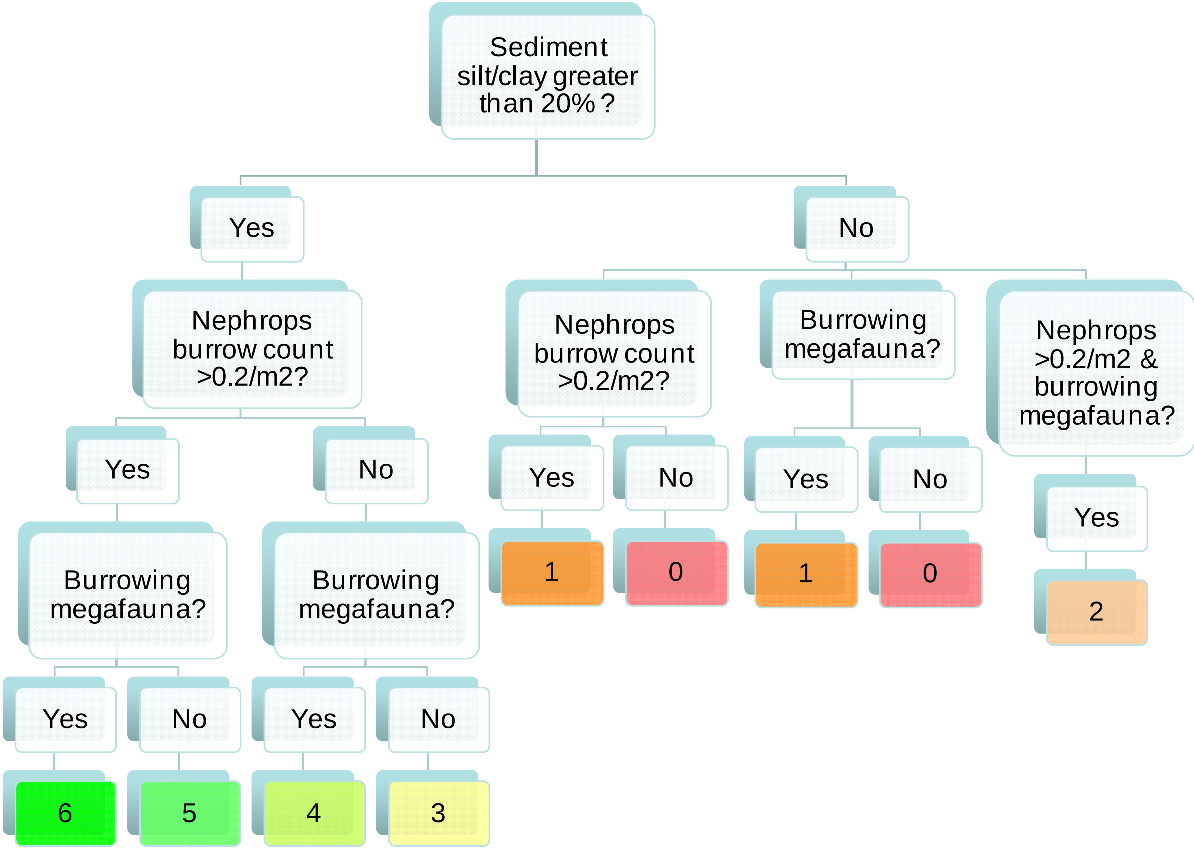


Figure 17. “Burrowed mud index” developed using decision tree

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
- VMS fishing intensity (average from 2007-2013)
- Nearest *Nephrops* burrow density
- Species diversity
- Species even-ness
- Cluster identifier
- Biotope
- Burrowed mud index
- Presence of burrowing megafauna species

These data permit each alternative MCZ site to be assessed for its suitability in terms of habitat, and provide a guide to the disturbance level of the site and identify potentially undisturbed areas which could be considered reference sites.

2.3 Results

2.3.1. Underwater video data

Nephrops burrow data from ICES FU14 (Eastern Irish Sea) were made available from Cefas courtesy of Ana Leocadio for the years 2013 and 2014. Stations were approximately 6.3km apart and each year the same station is revisited (within 500m). Densities in FU14 don't appear to exceed 0.8 burrows/m^2. Figure 18 shows that a clear boundary to the *Nephrops* ground is evident where burrow densities fall below 0.2 burrows per m^2. In some areas this appears to occur up to 8km from the predicted edge of the mud habitat (as defined in EU SeaMap).

FU15 (Western Irish Sea) burrow data are held by AFBI and data from 2003-2014 were available, providing a denser total coverage of sampling stations as station locations differ each year (see Figure 19), although within one year stations are approximately 8.4km apart. Densities in FU15 are notably higher than in FU14, with densities 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. 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)

The seapens data from the FU15 video surveys appear to show a concentration of records to the southeast of the EU Seamap predicted mud (Figure 20 below), and a number of records to the north of the mud area. In general, there are more seapen records near the edge of the mud area and known *Nephrops* ground (extending into Isle of Man and Republic of Ireland waters), possibly where fishing intensity is less due to lower *Nephrops* densities in these areas.

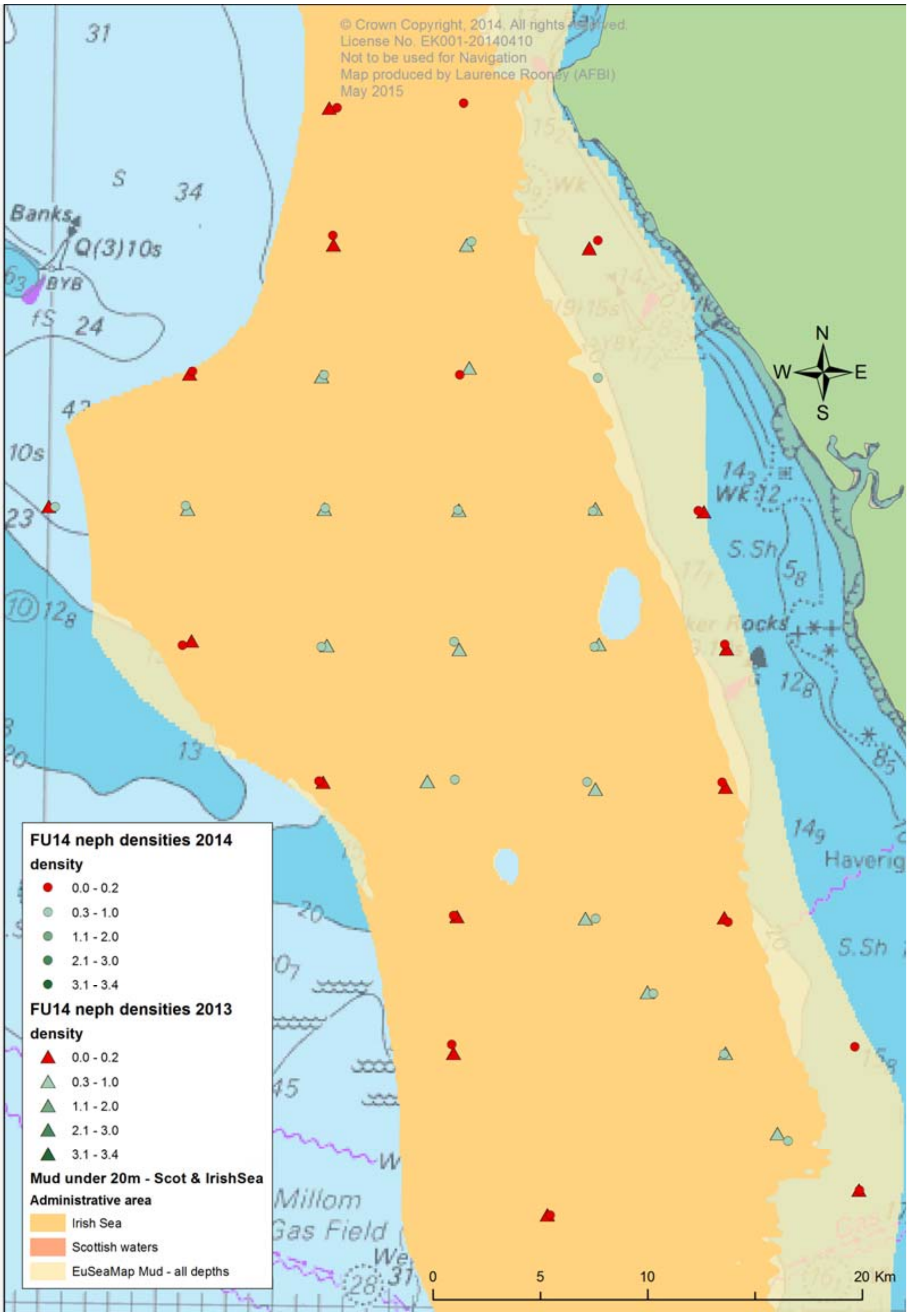


Figure 18. ICES FU14 Nephrops burrow density data (plotted by station midpoint)

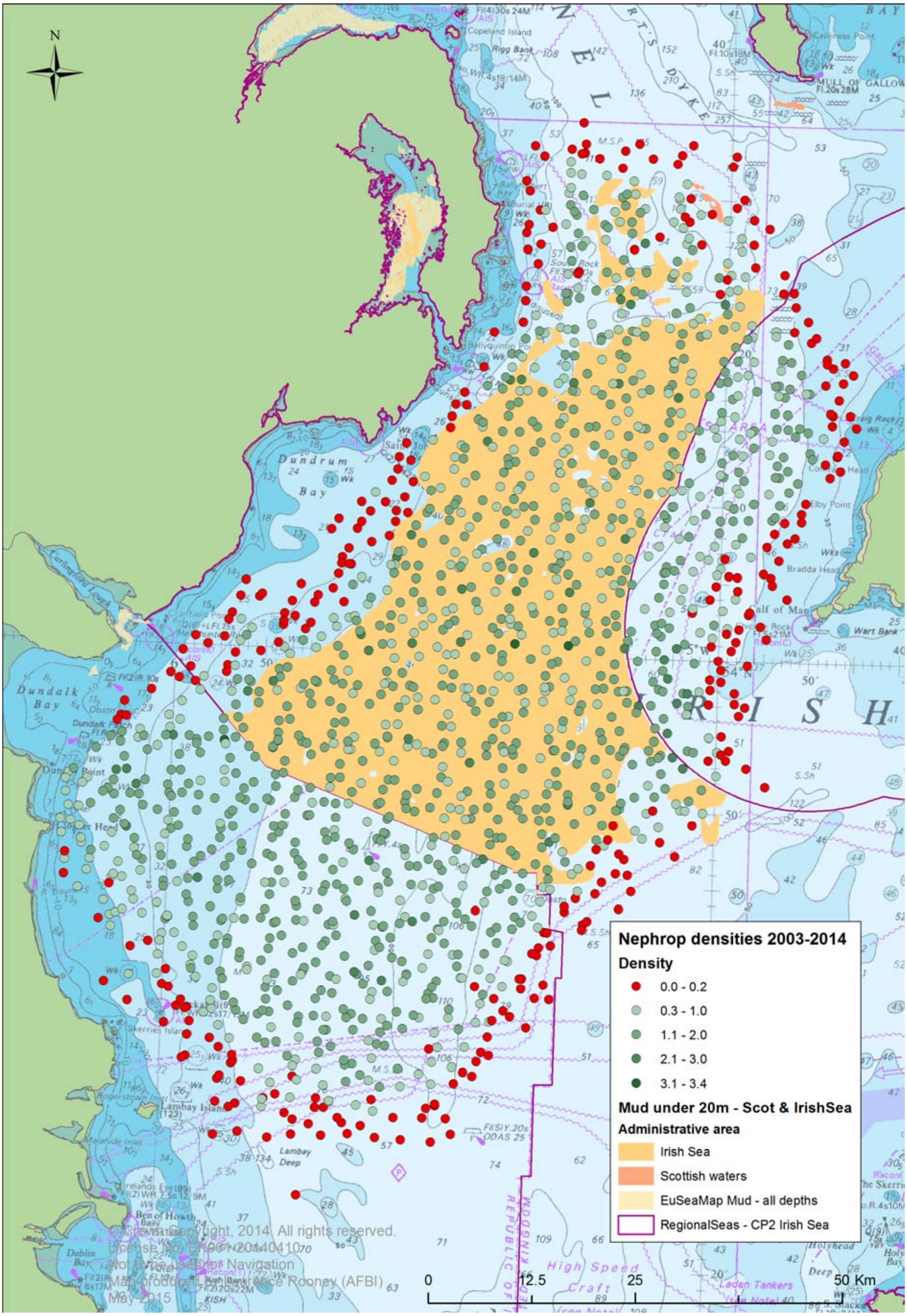


Figure 19. ICES FU15 Nephrops burrow density data (plotted by station midpoint)

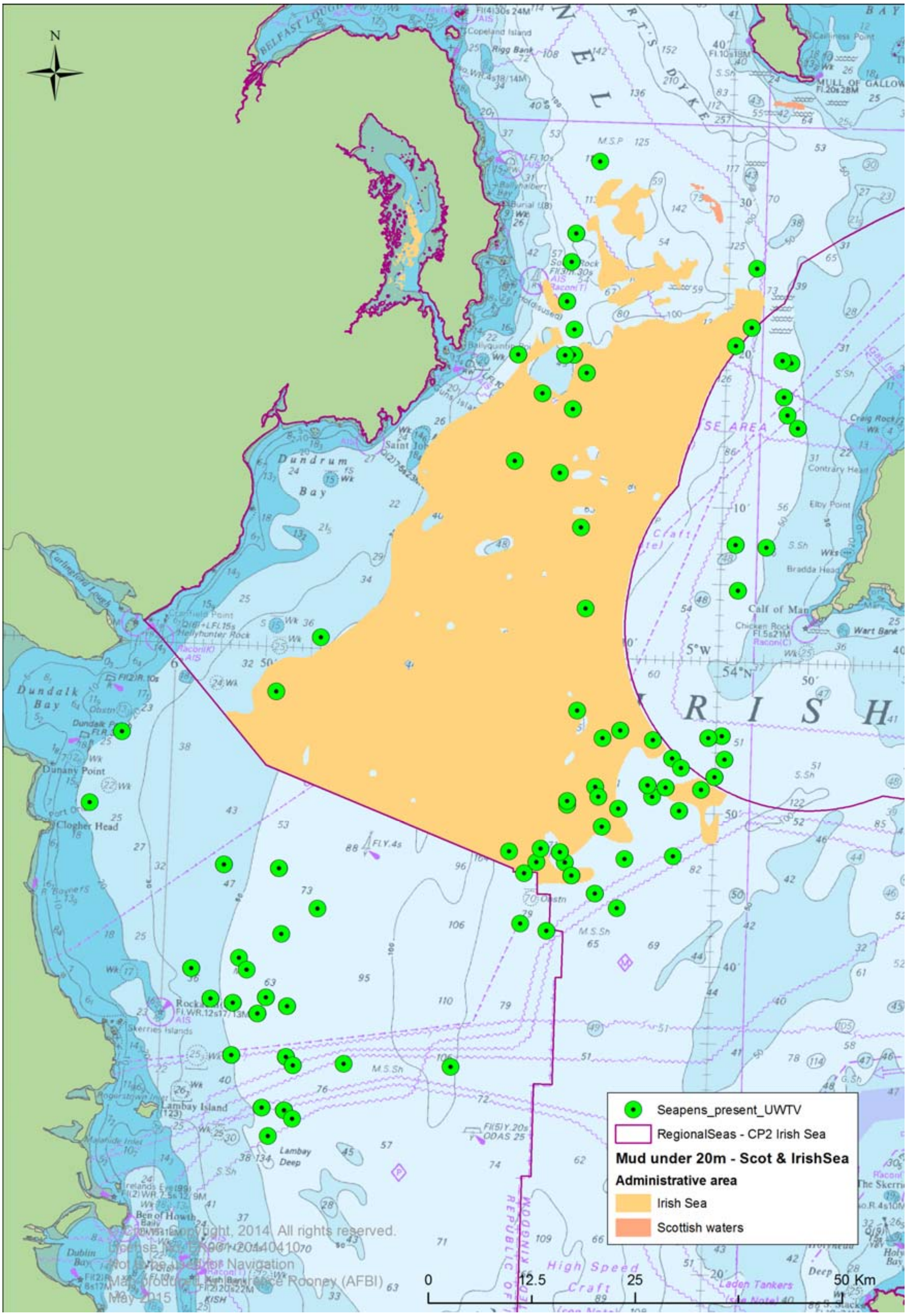


Figure 20. Seapen distribution from FU15 video data (all years, plotted by station midpoint)

2.3.2. Grab sample data

A total of 432 species were identified in the grab samples.

2.3.2.1 Univariate analysis

The diversity indices (e.g. Shannon's diversity index in Figure 21 and Margalef's index of species richness in Figure 22) 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 the North-west Irish Sea mounds. 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. Species equitability (Pielou's evenness index) showed a very different spatial pattern to the diversity indices (Figure 23 below), with many of the highest evenness results found in the western Irish Sea *Nephrops* ground, but also some of the lowest evenness results (low evenness means increased dominance by a small number of species). The eastern Irish Sea showed a more generalised trend with lower evenness found across much of the Walney area, and slightly higher evenness found to the west and north of the mud patch.

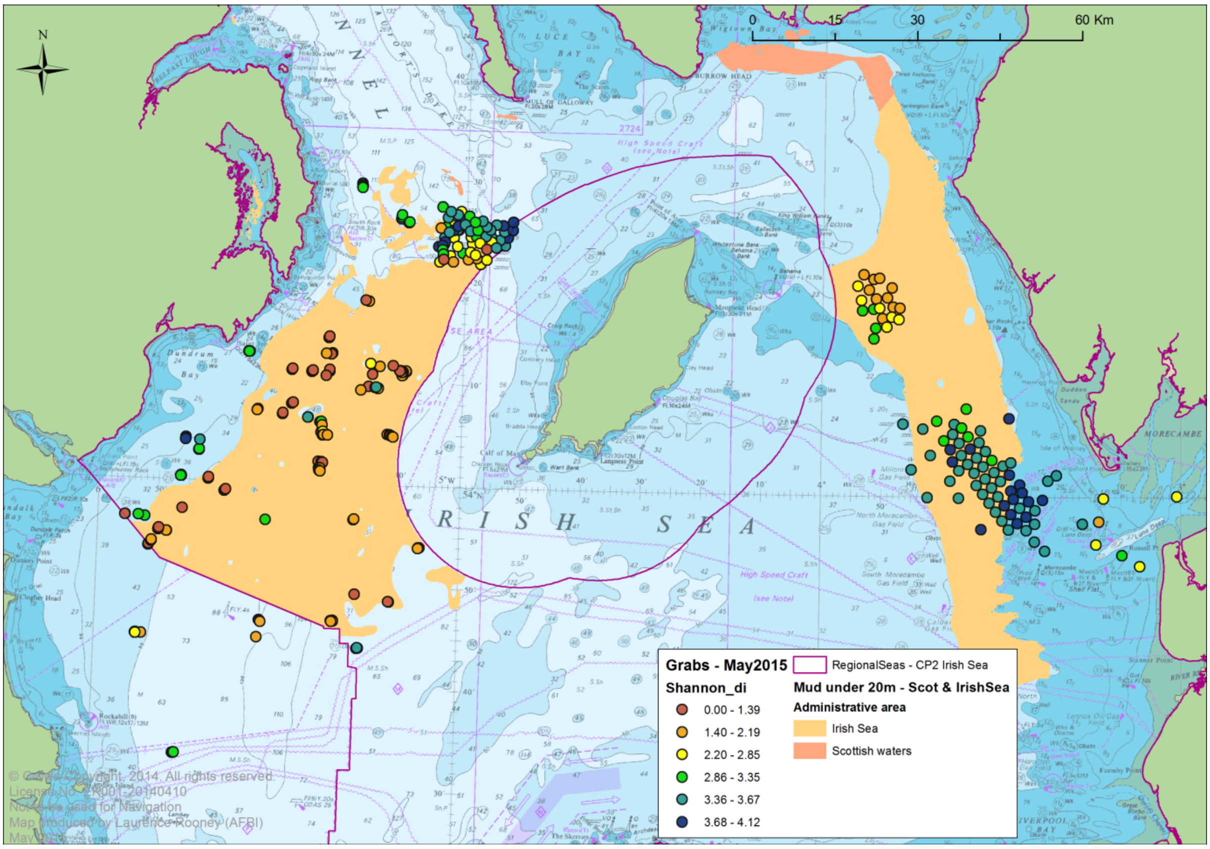


Figure 21. Shannon's diversity index for grab sample sites

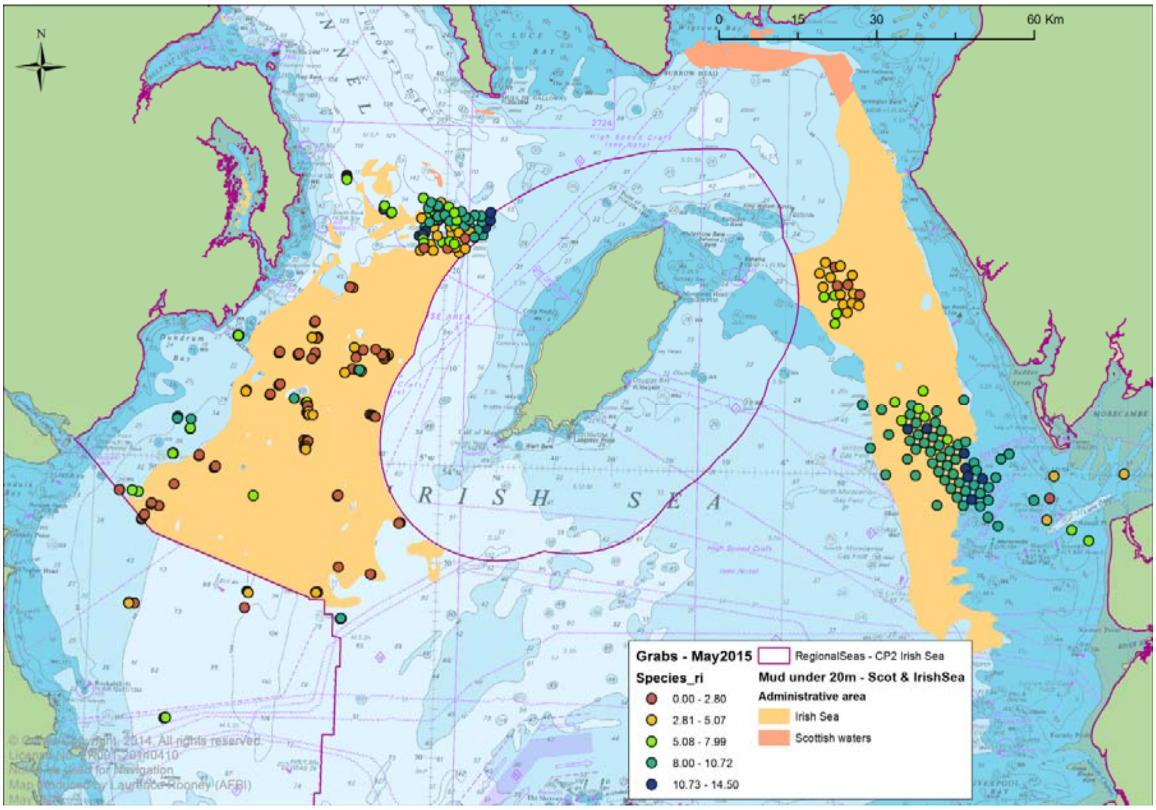


Figure 22. Species richness for grab sample sites

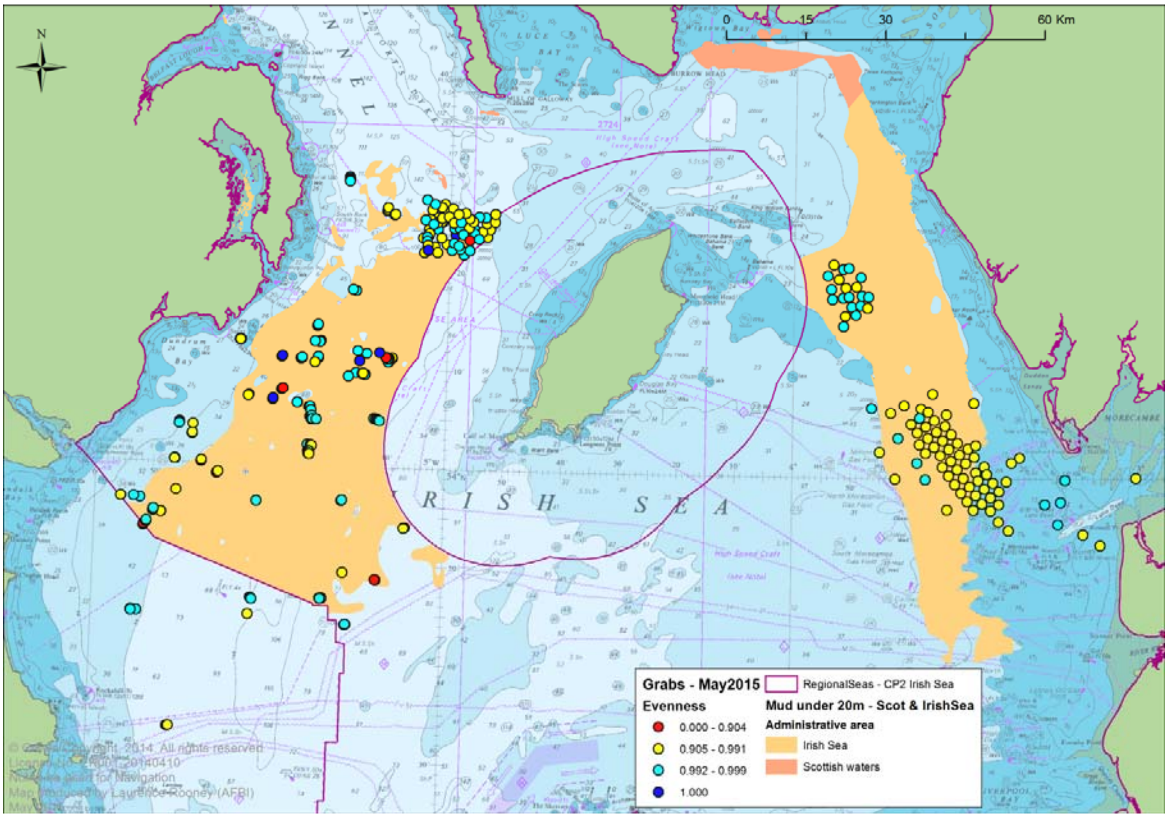


Figure 23. Evenness (equitability) for grab sample sites

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 evenness has been impacted by disturbance, only that there are geographical differences and additional analyses are used in this study to further investigate such differences.

2.3.2.2. Multivariate analysis

The cluster analysis used a 5% significance level and identified a total of 65 clusters from the 328 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 5.648, 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. Figures 24 and 25 below show the MDS plots symbolised by cluster, which shows how these group relative to each other in multidimensional space. The stress level is 0.18 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 (by superimposing these on the MDS plots, and the similarity calculated from cluster analysis) enables reassurance that similar patterns in differences between samples can be seen. The similarity as determined by the cluster analysis is overlaid on the samples in multidimensional space in Figure 24.

It is clear from that there is a strong geographical trend in the cluster distribution (sample names provided in Figure 25 MDS plot are linked to survey site), which can also be viewed in Figure 26. For instance, the eastern Irish Sea samples are aggregated around the right-hand side of the MDS plots, which cover a number of clusters. South Rigg samples are found to the bottom of the right-hand side of the MDS plot, while the MCZ samples from the western Irish Sea are found mostly belonging to just two clusters, found in the left-hand side of the MDS plots. The North Channel peaks/NW mounds sites are located to the bottom of the plot.

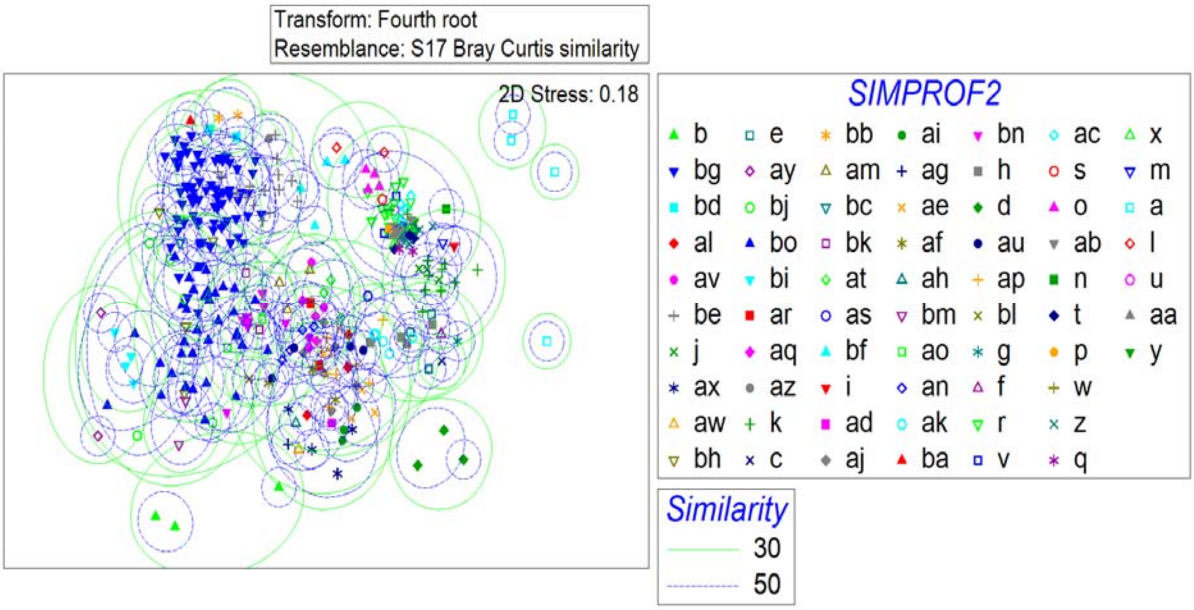


Figure 24. MDS plot coded by cluster ("SIMPROF2") with % similarity overlaid

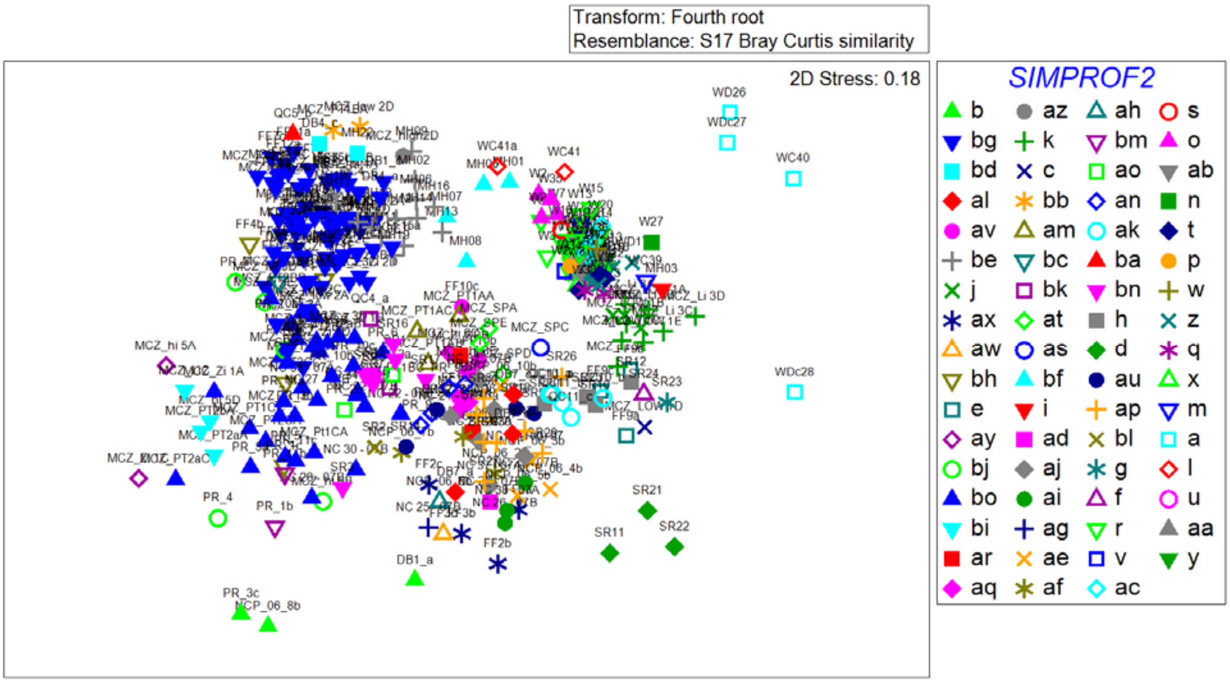


Figure 25. MDS plot coded by cluster ("SIMPROF2") with sample labels shown

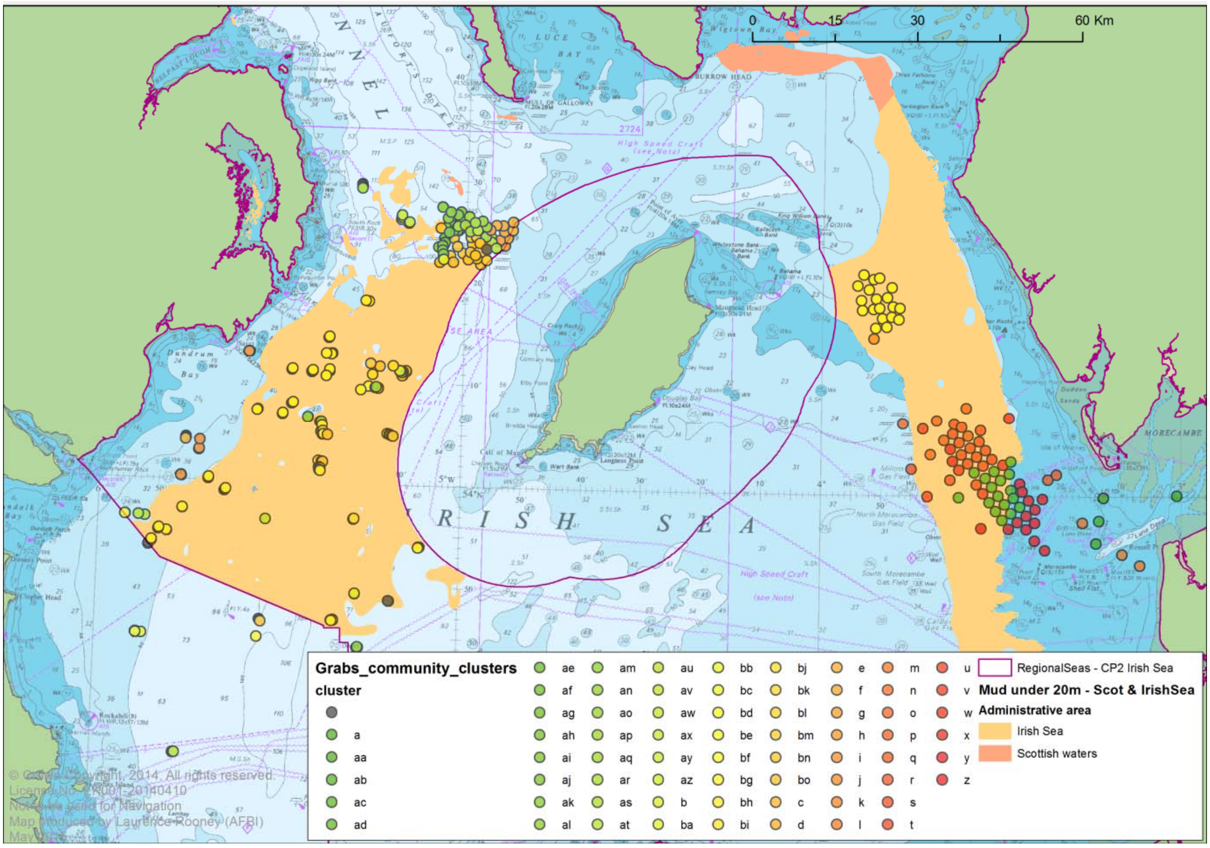


Figure 26. Grab samples coded by cluster

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 27-31 below) and then also on maps (Figures 32-36).

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 27 and 32) appears to be found exclusively in the western Irish Sea, along with *Calocaris macandreae*- although interestingly rarely at the same sites; *Callianassa subterranea* appears restricted to the eastern Irish Sea. However, *Goneplax rhomboids* and *Jaxea nocturna* are distributed across a small number of sites in both the eastern and western Irish Sea.

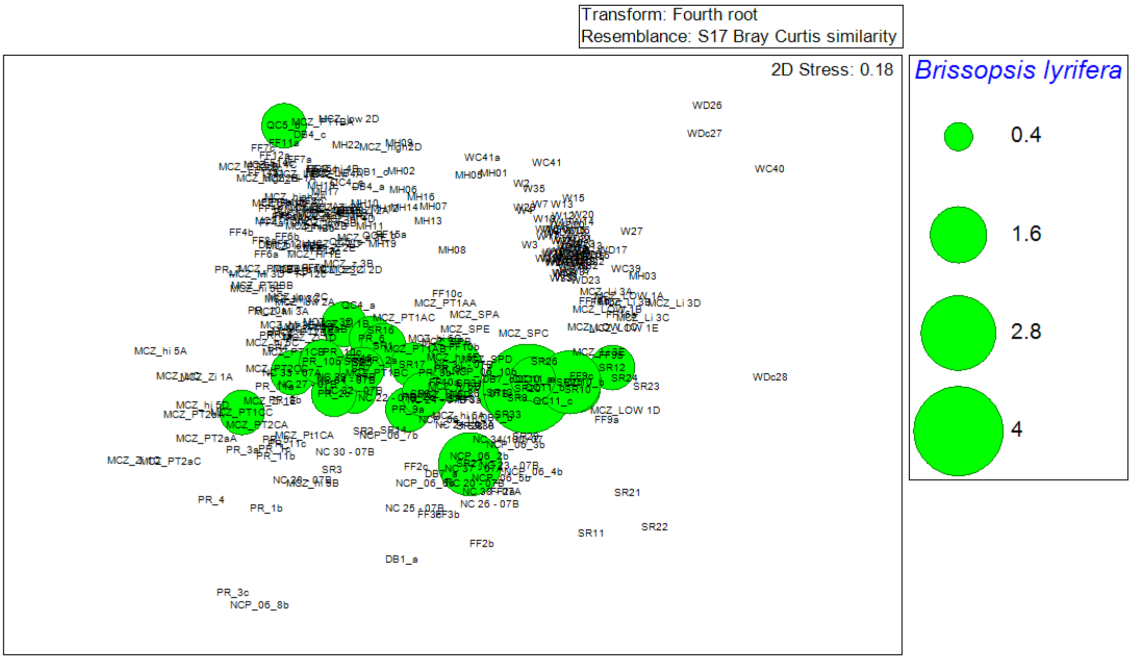


Figure 27. MDS plot with sample labels and *Brissopsis lyrifera* abundance (fourth root transformed) overlaid

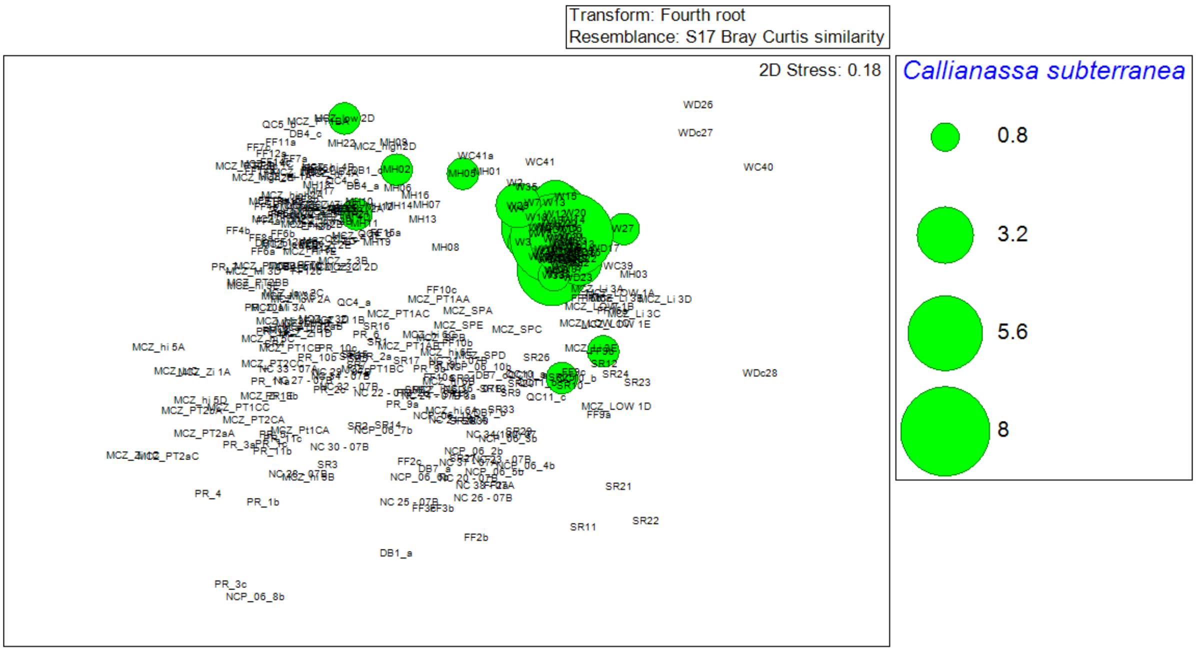


Figure 28. MDS plot with sample labels and *Callianassa subterranea* abundance (fourth root transformed) overlaid

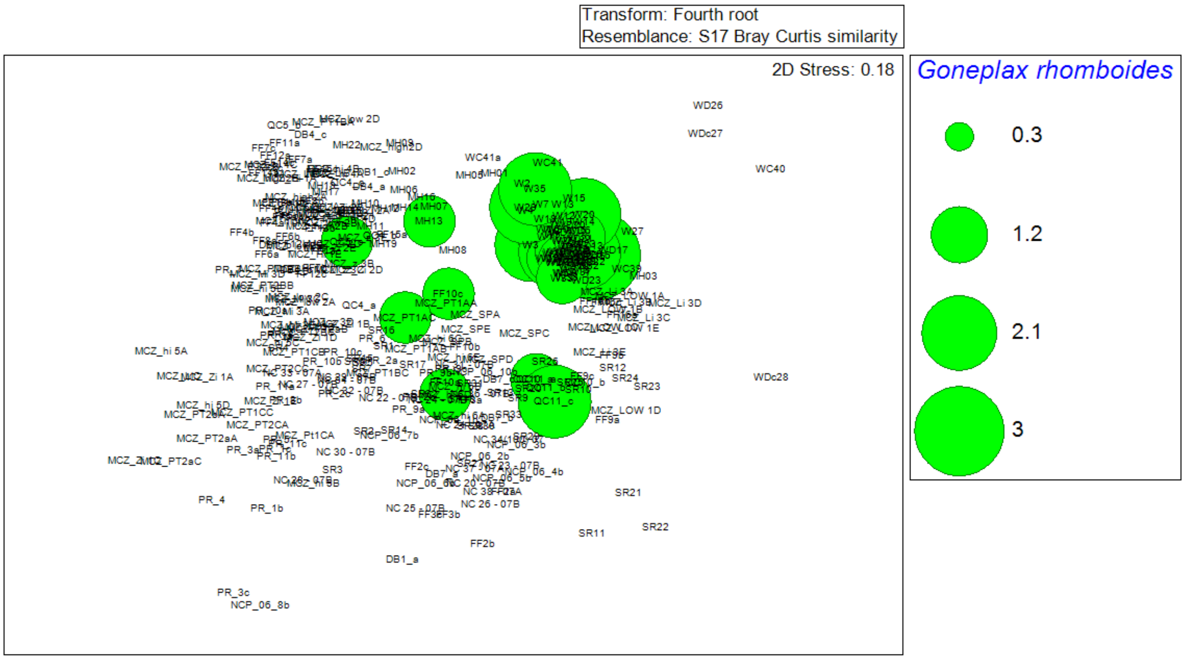


Figure 29. MDS plot with sample labels and *Goneplax rhomboides* abundance (fourth root transformed) overlaid

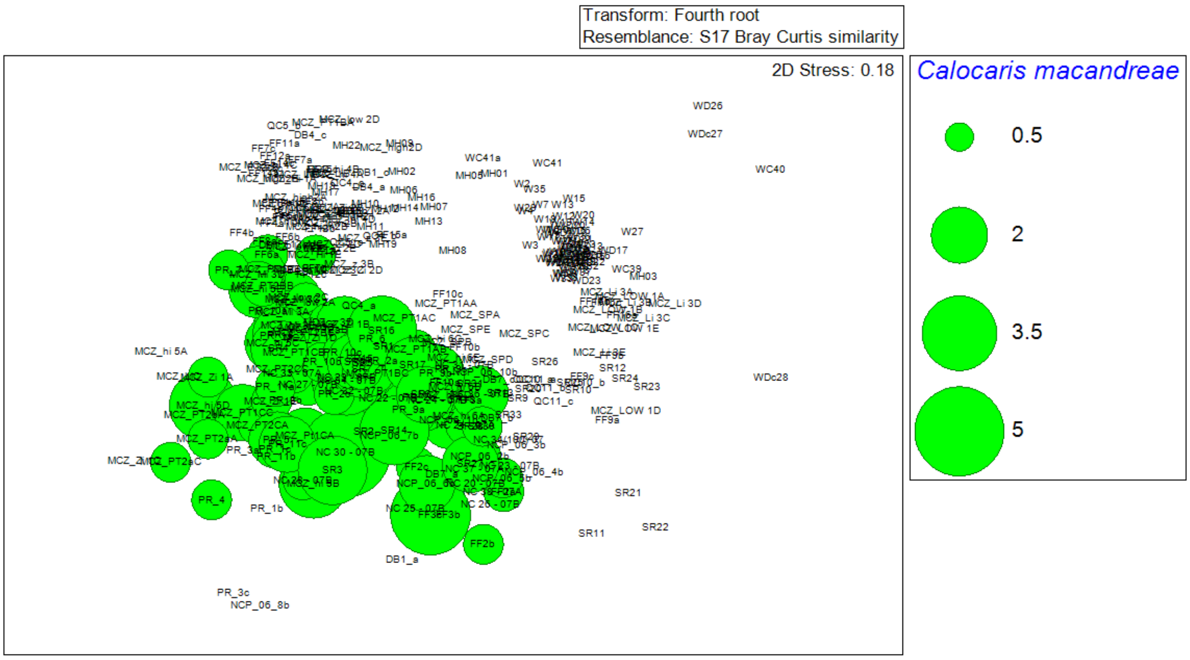


Figure 30. MDS plot with sample labels and *Calocaris macandreae* abundance (fourth root transformed) overlaid

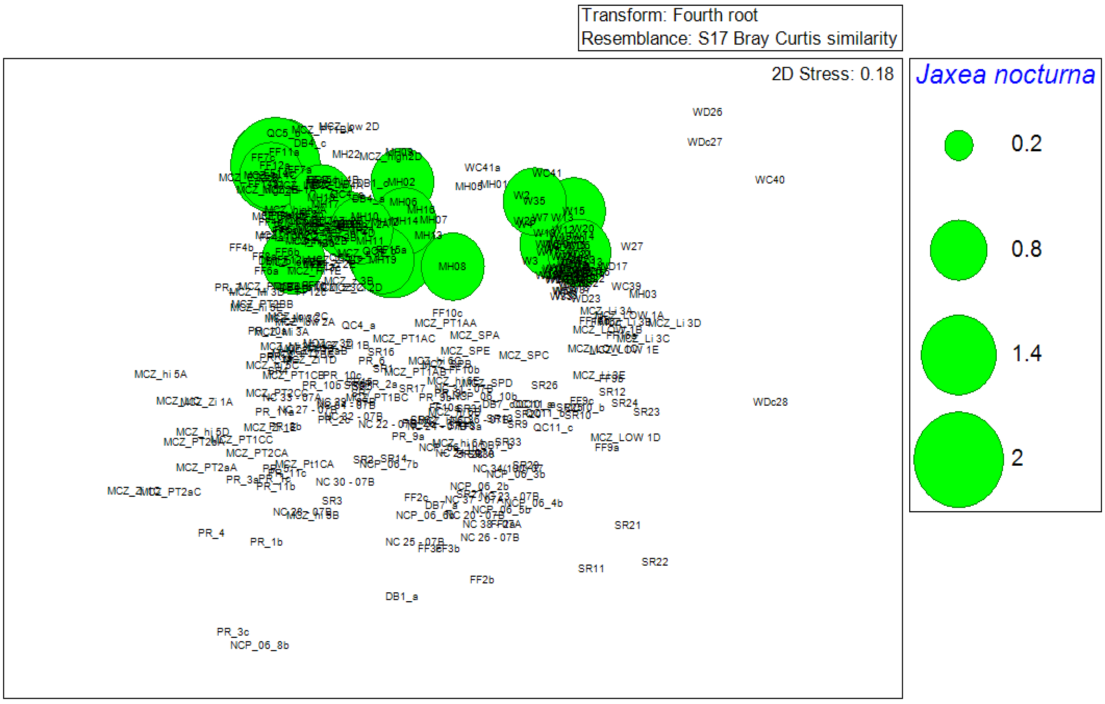


Figure 31. MDS plot with sample labels and *Jaxea nocturna* abundance (fourth root transformed) overlaid

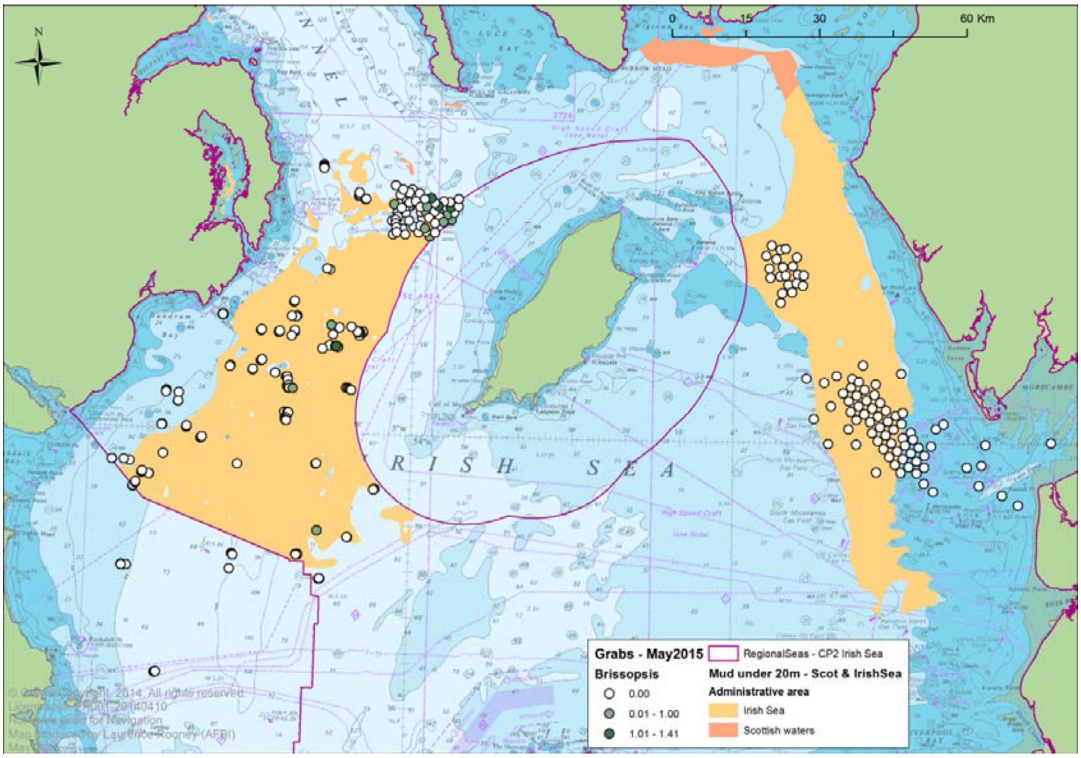


Figure 32. Map of grab sample sites with abundance (fourth root transformed) of *Brissopsis lyrifera* shown.

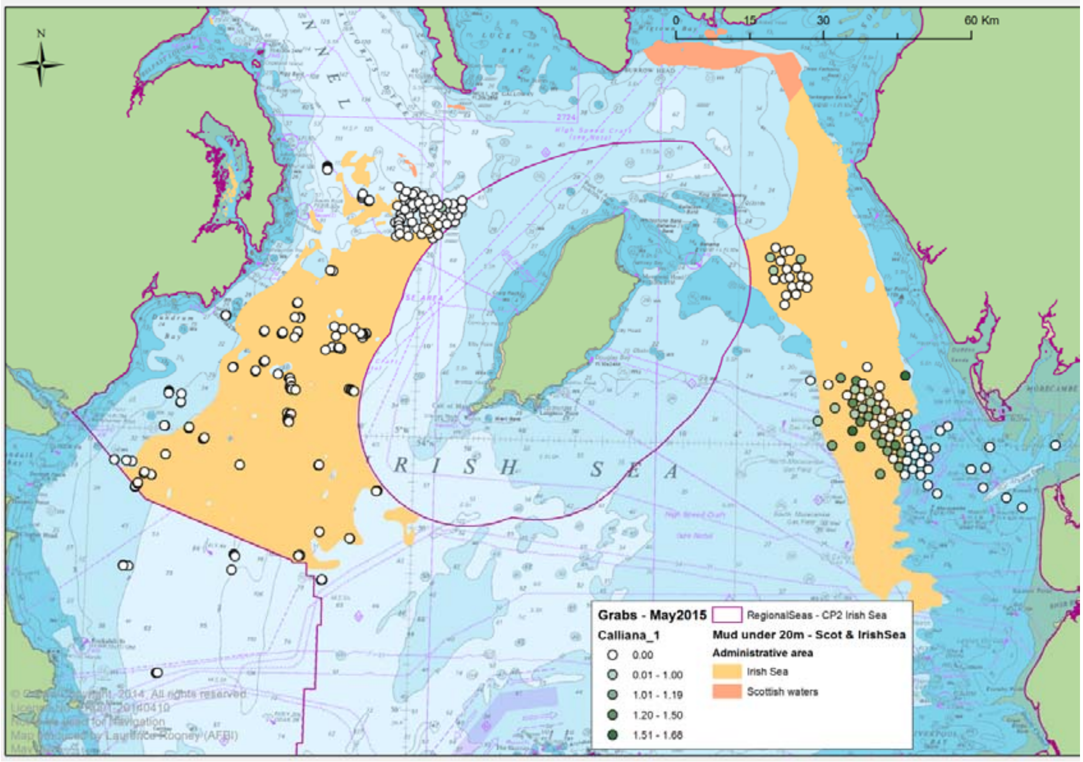


Figure 33. Map of grab sample sites with abundance (fourth root transformed) of *Callianassa subterranea* shown.

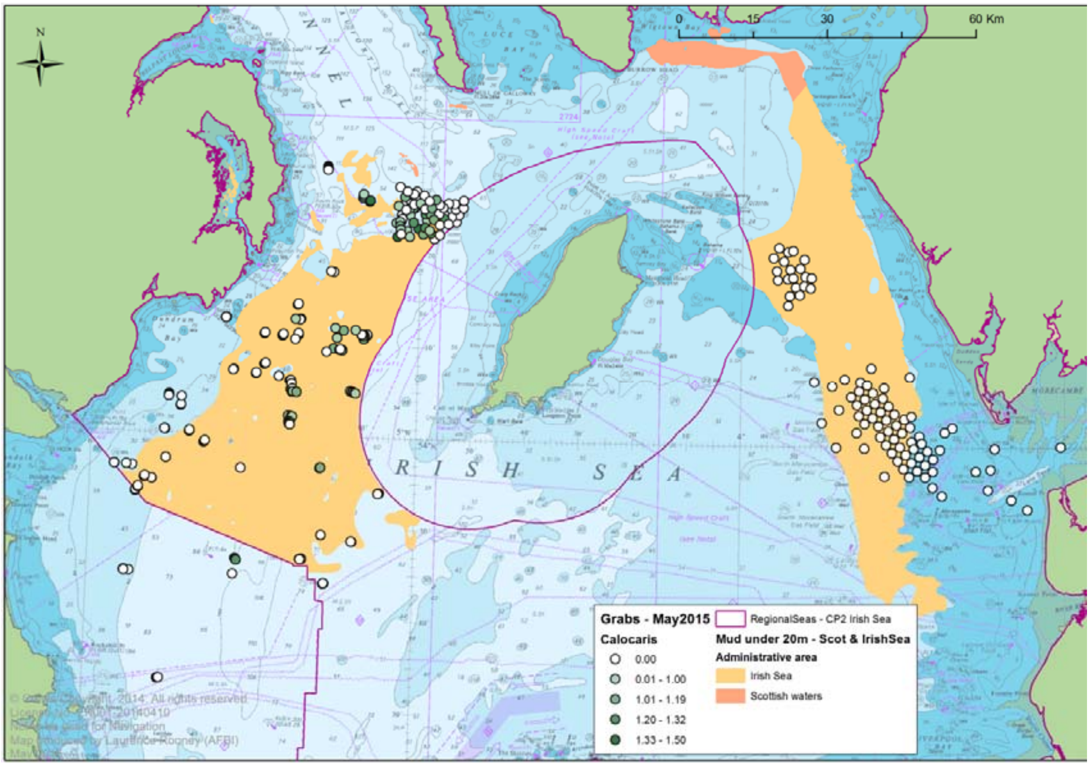


Figure 34. Map of grab sample sites with abundance (fourth root transformed) of *Calocaris macandreae* shown.

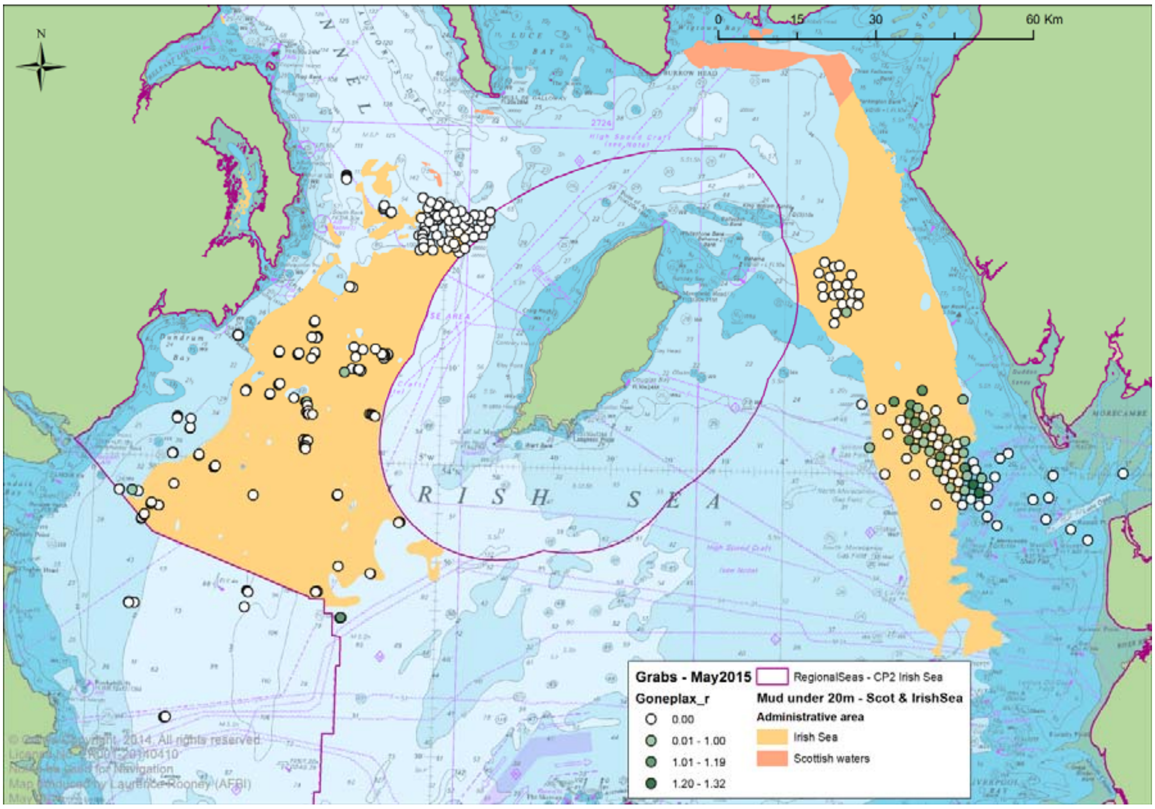


Figure 35. Map of grab sample sites with abundance (fourth root transformed) of *Goneplax rhomboides* shown.

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 median 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 (mean grain size, sorting and percentage silt and clay) and mean VMS intensity (as a measure of fishing intensity), and species assemblages found within the samples. The best correlation (sample statistic (Rho): 0.326, at a significance level of 0.1%) was with mean grain size, sorting and mean VMS together.

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 8 and Figure 36 below.

A total of one biotope complex (SS.SSa.CMuSa) and five biotopes were identified. The biotope complex (EUNIS 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 (as confirmed through the BIO-ENV analysis detailed above) 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.

Table 8. 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.*

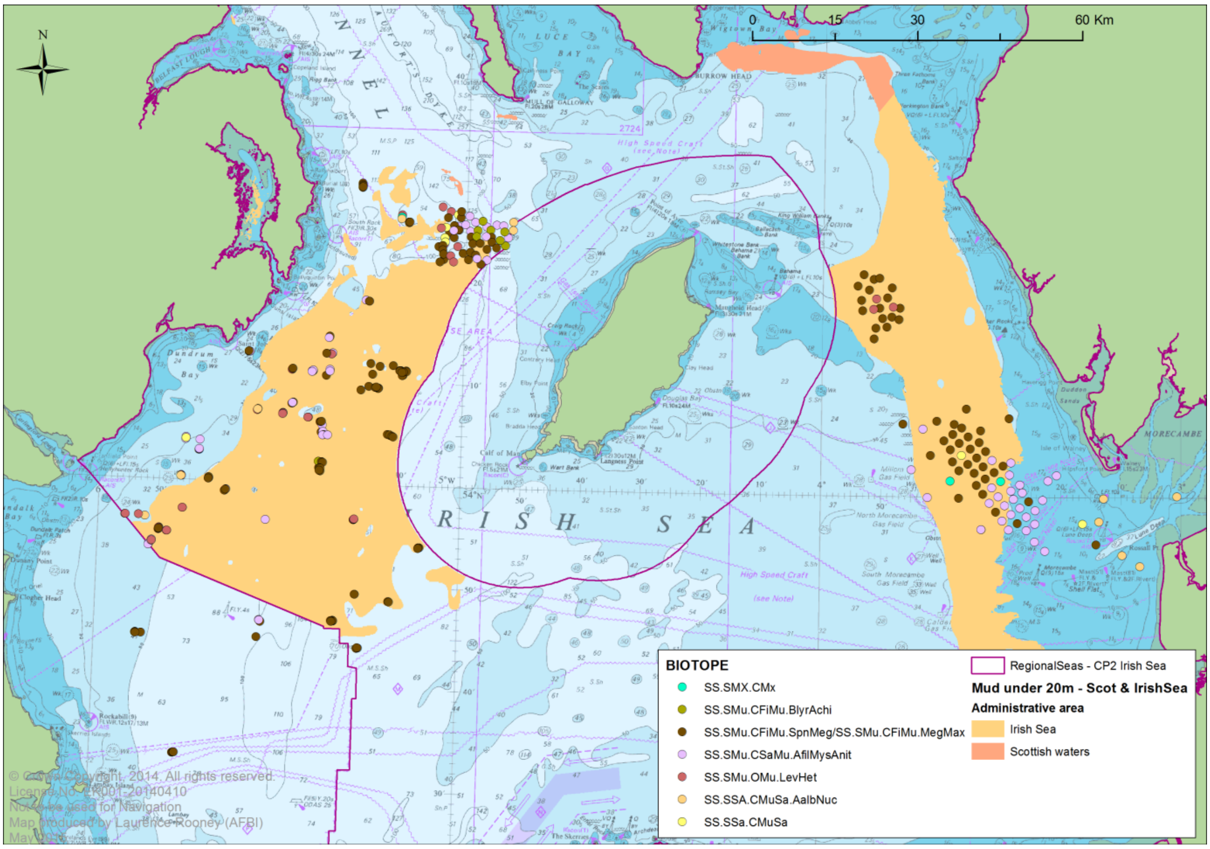


Figure 36. Map of grab sample sites coded by biotope

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 Figure 37 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.

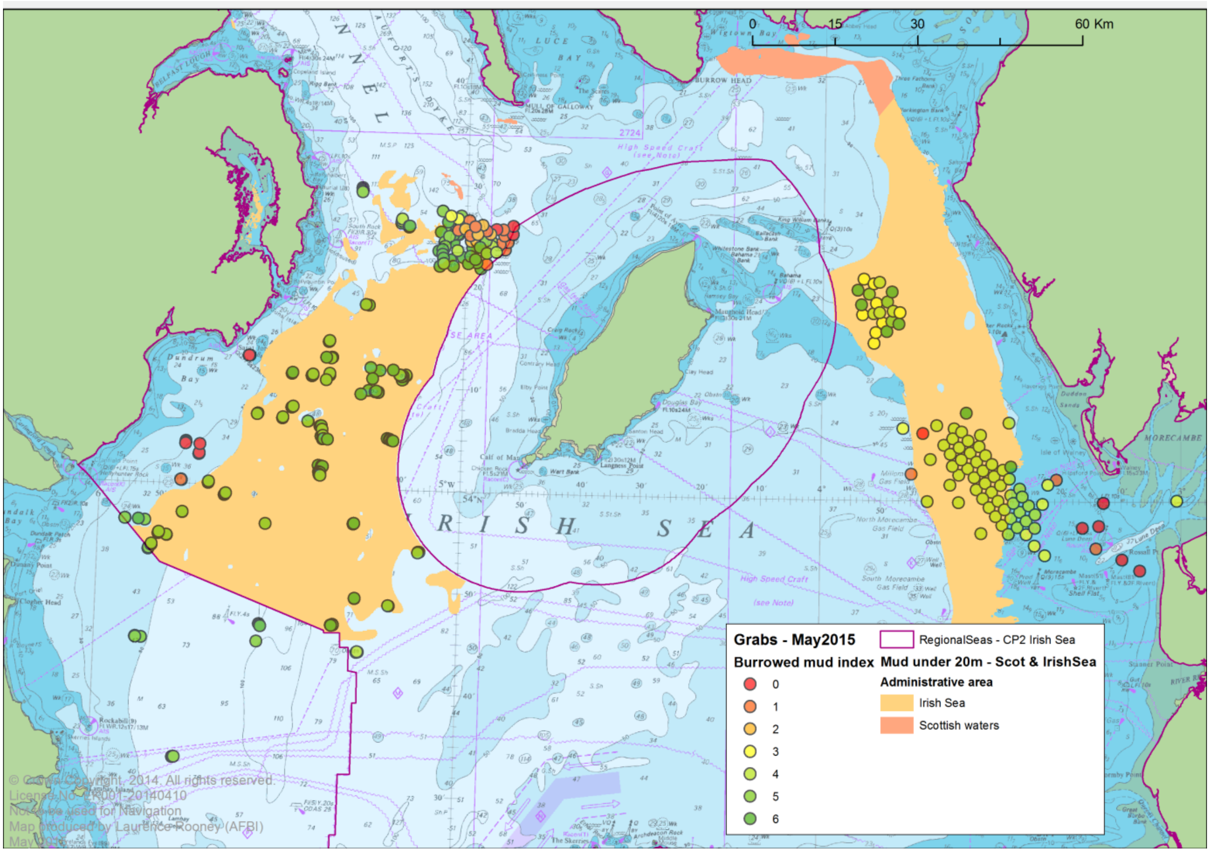


Figure 37. Map of grab sample sites coded by "burrowed mud index"

To investigate the condition of the communities sampled by grabs, AMBI was applied. AMBI assesses the quality of benthic macroinvertebrates assemblages by calculating the homonymous index based on data for species characteristics (such a feeding type, reproductive mode etc. to inform whether each species is an *r, k* or *T* strategist, and thus successional stage represented by the community) at each site, such that a "disturbance classification" can be yielded. This has been applied to study the impacts of pollution, fish farms and many other forms of disturbance or enrichment upon benthic habitats. The results (Figure 38) indicate that most samples fall into the "slightly disturbed" category, with only a small number of "extremely disturbed" sites identified. There are also a small number of "undisturbed" sites, spread quite widely in the western Irish Sea, and in some locations near the "Mud Hole" in the eastern Irish Sea.

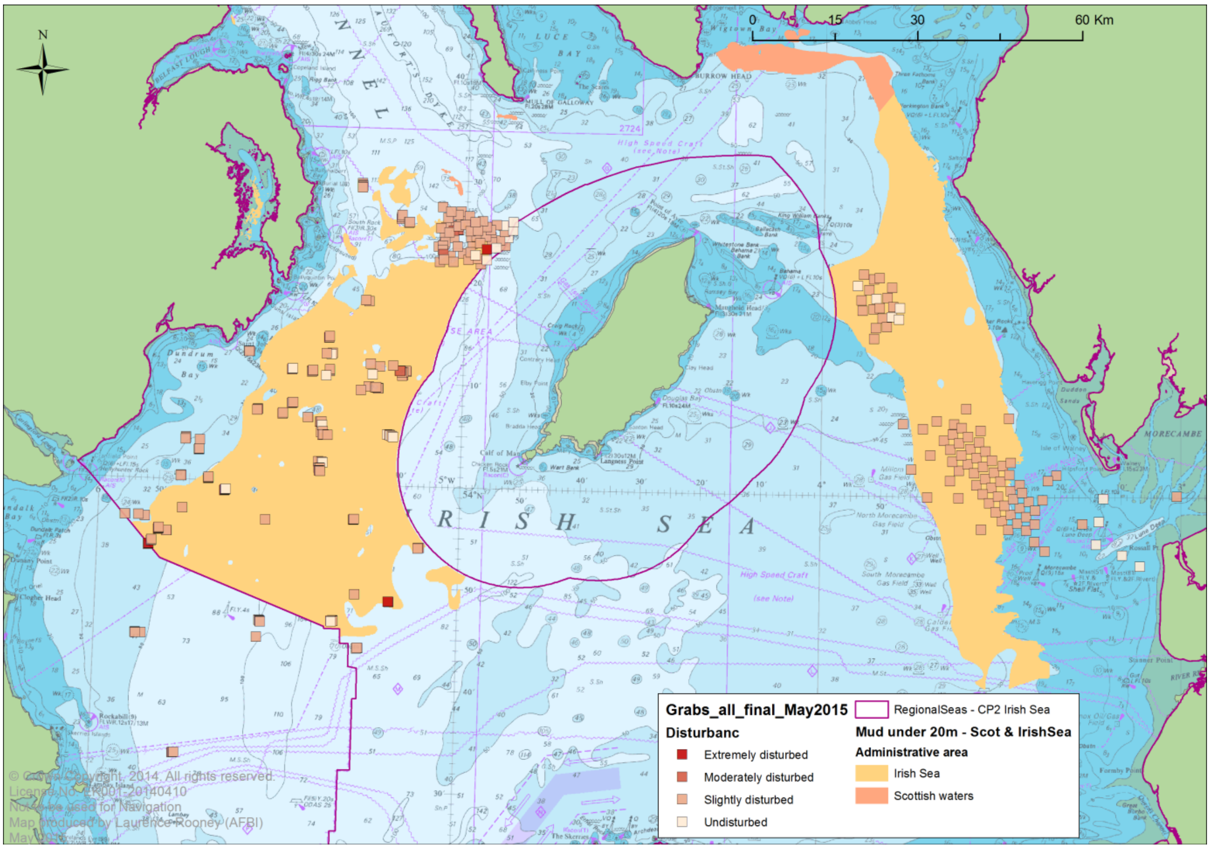


Figure 38. Map of grab sample sites coded by AMBI disturbance category

It is recommended that to further investigate the current status of assemblages sampled by grab sampling that a biological traits analysis approach be undertaken. There is biological traits information for 157 of the 432 species found in the samples.

In addition, to further tease apart the influence of fishing intensity on benthic assemblages, specific studies could address how the macroinvertebarte assemblages differ at different levels of fishing intensity over the same mud habitat.

2.4 What are the likely management options?

In the current DEFRA Tranche 2 of MCZ designations, Irish Sea sites with mud habitat features have been attributed a "Recovery" status. This suggests that either (a) the conservation feature (mud habitat) is sensitive to current pressures which have modified the habitat condition, or (b) the habitat may be highly vulnerable to pressures that are likely to affect the habitat condition. There is an abundance of evidence documenting the vulnerability of mud habitats to demersal towed fishing gears (e.g. Kaiser *et al.,* 2002). Fished areas appear to support a modified biological community with ***lower diversity, reduction or loss of long-lived filter-feeding species and increased abundance of opportunistic scavengers*** (e.g. *Nephtys* sp., - see Ball *et al.,* 2000; Tillin *et al.,* 2006; Osgard *et al.,* 2008). Osgard *et al.* (2008) found that *Calocaris macandreae* abundance was significantly depleted in trawled areas, in spite of being a deep burrowing species which may be considered superficially as potentially fairly tolerant to trawling disturbance.

Reviewing the data presented in this report, Part I demonstrated the level of fishing intensity across both eastern and western Irish Sea, with the vast majority of mud habitat showing regular fishing activity. The grab sample data indicate that there is some disturbance to the majority of mud habitat sample sites, and seapens appear restricted to the boundaries of the *Nephrops* grounds where fishing intensity is reduced. It is likely that any MCZ designation in this region will require a management plan that will be likely to include a reduction in demersal towed gears, due to their known impact on mud communities. JNCC has stated that spatial and temporal measures could be viable, and "adaptive management" is an option[8]. There could also be suggestions made to gear modifications which may limit the impact of fishing activity on the conservation feature.

Currently there are no offshore MCZs designated for mud habitat, and therefore it is not possible to draw any parallels between potential management and management in practise with respect to fishing activities. The five designated offshore MCZs do not currently have site specific fisheries management measures, and are technically covered by the CFP only. However, discussions are being led by the Marine Management Organisation with stakeholders regarding fisheries management for some sites, and for the North East of Farnes Deep MCZ JNCC has produced a draft "fisheries options" paper regarding potential management options[9]

In Scotland, there is a voluntary closure to fishing over part of the South Arran MPA, however this closure does not encompass the burrowed mud habitat area.

JNCC has produced a "Fisheries Management Factsheet"[10] outlining the proposed methodology for implementing fisheries management measures for conservation of MCZ features in England, Wales and Northern Ireland (both inshore and offshore). This outlines the regulatory framework and involvement of stakeholders, however this has yet to be implemented at sites due to the infancy of the MCZ process.

One example of an offshore MPA where fisheries closures have been implemented is the Darwin Mounds cSAC/SCI. This was enacted by the European Commission following recommendation by the relevant UK governing authority – in this case Marine Scotland:

> *"Under council regulation (EC) No. 602/2004, fishing vessels are prohibited from using any bottom trawl or similar towed nets within an area covering the boundary of the Darwin Mounds cSAC/SCI. The site falls outside the UK's 12 nautical mile limit and it is exclusively managed under the EU Common Fisheries Policy. Marine Scotland are the lead authority regarding implementation and compliance of the imposed measures."*

This was deemed appropriate due to the vulnerability of the cold water coral reefs - the designated feature- and evidence of trawl damage to these reefs.

---

[8] See JNCC Marine Conservation Zones Newsletter Issue 2: http://jncc.DEFRA.gov.uk/page-5458
[9] http://jncc.DEFRA.gov.uk/pdf/North%20East%20of%20Farnes%20Deep%20options%20paper%202014%2005_08%20final.pdf
[10] http://jncc.DEFRA.gov.uk/PDF/MCZ_FisheriesManagementFactsheet.pdf

2.4.1. Reference areas, or identification of "favourable condition"

The identification and use of **reference areas** has been recommended in the MCZ designation process to allow development of management targets. In the case of the Irish Sea regional sea area, the grab sample sites which were classified as "undisturbed" by the AMBI analysis, and which are also classified as appropriate mud habitat (as shown by the "burrowed mud index") may provide examples of such reference areas. Figure 39 below highlights some such potential candidate sites. Further analysis of the macroinvertebrate assemblages represented by the grab sample data at each of these sites is recommended, and where possible evidence of condition should also be examined through video techniques to determine extent of bioturbation and the abundance of seapens and *Nephrops* in such areas.

There are notable issues with determining reference areas and reference macroinvertebrate assemblages in areas which are likely to have been modified through fishing activity over long time periods. There is a suggestion that the high abundance of *Nephrops* over fished grounds may in fact be due to the fishing activity itself and its impact on *Nephrops* competitors and its predators (Ball *et al.*, 2000). Ball *et al.* (2000) indicate that *Nephrops* is part of a sub-climax ecological community, which would otherwise be less dominated by *Nephrops* and include other crustacean, molluscs and echinoderms. As *Nephrops* forms a key component of "burrowing megafauna" used in the identification of mud habitat suitable for designation, there is a possibility that should fishing pressure be reduced this community would shift away from one with characterising burrowing megafauna.

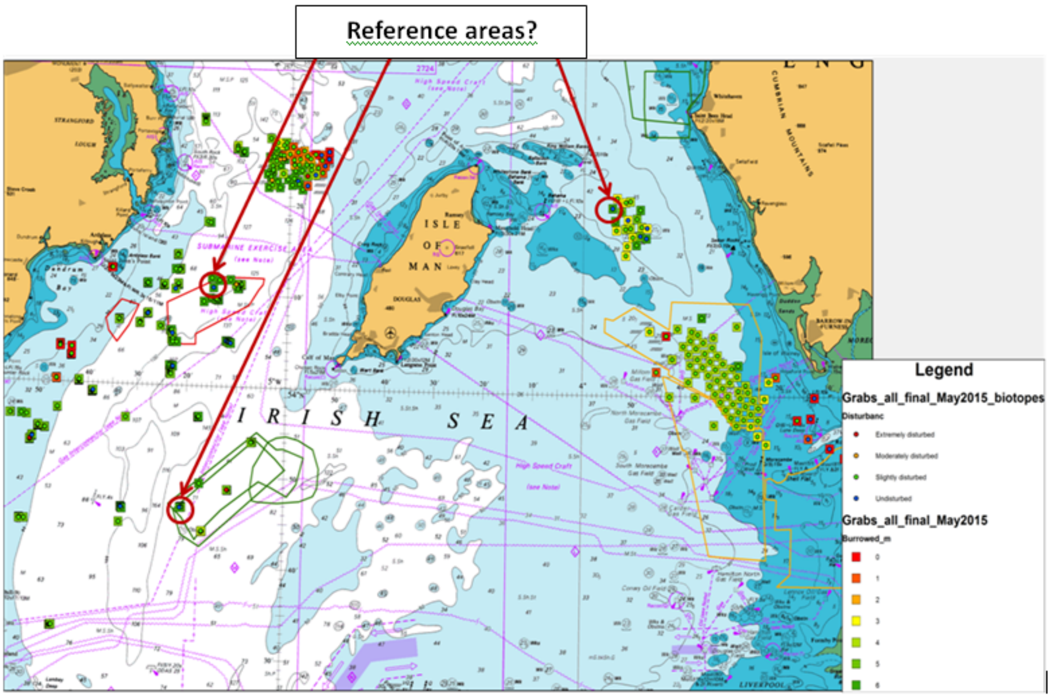


Figure 39. Map of grab sample sites showing burrowed mud index and disturbance category to facilitate identification of reference sample sites. Alternative MCZ sites are also overlaid.

Assuming that a suitable reference area and reference community can be identified, and there is adequate knowledge of how existing pressures (natural and anthropogenic) may be affecting the reference area, then a key management question is how soon can a modified community return to a reference (un-impacted) state? This question relies on a strong understanding of how management actions may reduce pressures to facilitate a shift in community composition – with allowance for how these may or may not be compounded by climate change. An example from George's Bank, North America, indicates that habitat restoration took up to ten years following complete fisheries closure over a gravel habitat (Asch and Collie, 2008). In habitats subject to little natural disturbance (e.g. storms affecting physical abrasion through wave action etc.), such as many deep mud habitats, it is possible that it could take substantial time periods to return to an "unimpacted" state.

2.4.2. If areas are closed to trawling, is effort displaced?

If a designated area is closed to fishing, the impacts to the fishing industry must be considered. There is the immediate question of where the effort goes that was expended in the designated area prior to closure: is this effort lost (reduced landings/reduced income), or is it displaced? Secondly, are there any benefits to the fish stock from closure that may offset the impact of effort displacement/loss?

Finally, if effort is displaced, does this result in a concentration of effort on spatially-limited grounds, and how does this affect the stock and benthic habitat outside of the closed areas? Is it possible to induce local "tipping points" from over-exploitation?

It is not possible within this study to examine all these questions in depth, and a literature review is presented in section 1.5 above; this is an area of focus for fisheries researchers currently, however, as also outlined in section 1.5 there are some pertinent findings which are of relevance to *Nephrops* fisheries:

OSPAR (2010) stated that "Discussions are needed around whether setting aside some of the habitat from fishing effort could also contribute to sustaining/improving the *Nephrops* stock". The assumption in this statement is that if a portion of the spawning stock portion is protected, could this act to enhance recruitment? So far, model simulations have been used to examine this question and the results are unclear. Enhanced stock where it occurs may not be enough to compensate for loss of fishing ground and yield (e.g. Smith and Jensen, 2008). Models also showed that larger closed areas led to potentially large oscillations in *Nephrops* yield, and average size of *Nephrops* was reduced through the concentration of fishing on remaining ground (Smith and Jensen, 2008). Under the assumptions made, a closed area would reduce the weight and value of the catch in a Norway lobster fishery (Smith & Jensen, 2008). It should be noted however that these are model simulations, and that there is a paucity of evidence from real scenarios to draw on. There is one relevant example from a *Nephrops* ground is the Porcupine Bank closure; this was in effect only during months of peak emergence (May-July) thereby protecting females and juveniles. This has led to a recovery in the stock due to better recruitment (ICES, 2012), however it also led to fishing effort becoming concentrated on parts of the ground not covered by closure; the wider ecosystem impact of this is unknown (Power and Lordan, 2012).

The VMS data analysis in Part I of this report shows that the vast majority of all suitable *Nephrops* habitat is fished to some degree within the Irish Sea. MCZ closures could therefore act to concentrate fishing on the remaining ground, rather than exploiting new grounds, as no such ground remain in the region. This may pose a risk to the area outside of the MCZ in terms of stock sustainability and wider habitat and species impacts. In turn this may also affect connectivity through larval recruitment for species within the MCZs. There is evidence that *Nephrops* fisheries have experienced reduced returns through over-exploitation (Farina & Gonzalez Herriaz, 2003; Sarda, 1998), which could happen with concentration of effort.

2.5 Conclusions

There is good evidence of both the distribution of infaunal macroinvertebrate communities and *Nephrops* burrow densities across the predicted mud habitat in the Irish Sea regional sea from grab sample data and *Nephrops* video surveys. Many of the grab sample sites, when combined with information on nearest *Nephrops* burrow densities, suggest that there are communities and sediment types indicative of habitats of conservation interest (seapen and burrowing mud, and mud in deep water). These vary between eastern and western Irish Sea mud areas, as indicated by community cluster analysis, and which needs consideration in designing the MCZ network. Characterising species for the constituent biotopes have been provided, and the condition of the assemblages assessed. From overlaying VMS data, the potential for fisheries displacement may be minimised by careful targeting of MCZ sites. From the suggested alternative sites identified by stakeholders in October 2014, two clear areas emerge as containing (a) suitable habitat for designation, and (b) the "least worst" fisheries displacement potential. These are highlighted in Figure 40 below. The site highlighted in the eastern Irish Sea (site D) overlaps the West of Walney proposed MCZ, which is currently in DEFRA's Tranche 2 designation process. The sites in the western Irish Sea (sites A, B and J), dubbed "Queenie corner", have not currently been included in the formal designation process. In Part I of this report, site A has been redrawn to minimise potential fishery displacement, however as this is a recognised transition zone between mud and sand habitats, further consideration is needed to potentially look at merging the three sites A, J and B and agreeing a boundary that captures the mud habitat while minimising potential fisheries impact. This would be dependent upon additional data on the mud-sand boundary in this area, and condition of these habitats.

The impact of MCZ site management involving fisheries closures is a key issue, not only from an industry perspective but also an ecological one. Should closure of a site result in the concentration of fishing effort on the remaining *Nephrops* ground this could affect stock sustainability and involve increasing seabed habitat disturbance. Ongoing studies regarding the impact of closed areas on fisheries, and the resulting ecological impacts, should be considered carefully during the setting of management options and where possible mutual benefit to both habitat/feature of conservation interest condition and fisheries stock management should be prioritised.

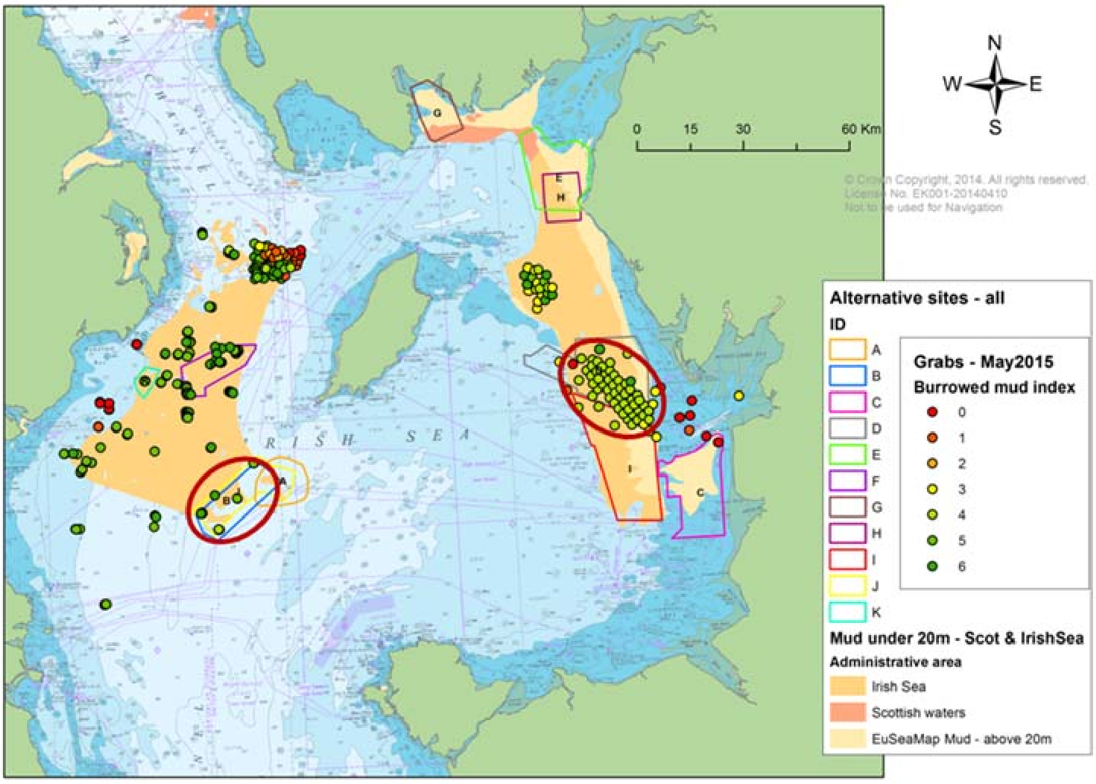


Figure 40. Map of grab sample sites showing burrowed mud index with alternative MCZ sites overlaid. Areas suggested for further progression in the MCZ process are highlighted.

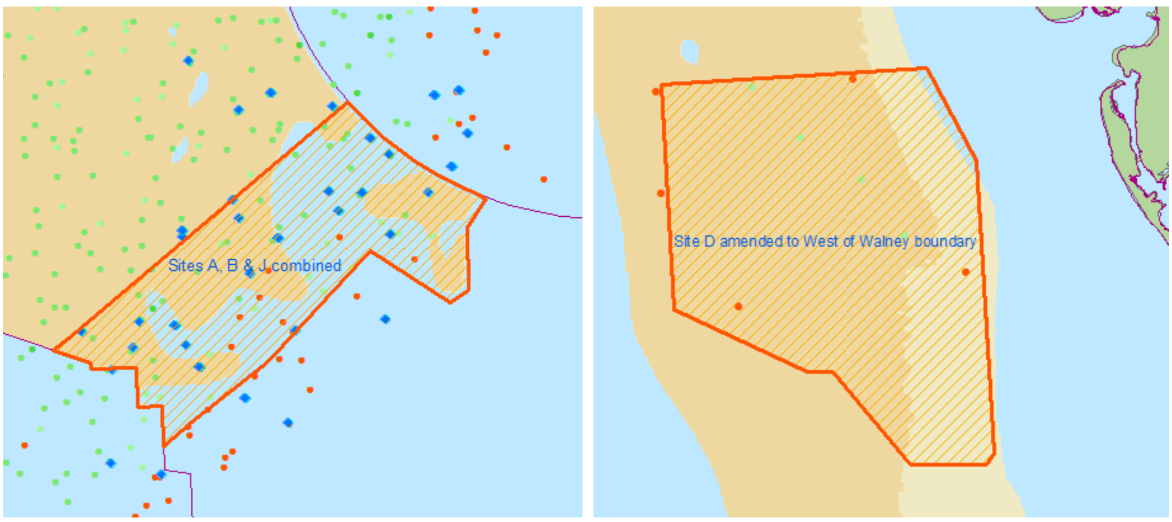


Figure 41. Close up of the areas suggested for further progression in the MCZ process. Sites A, B & J combined (& amended to CP2 region boundary), also referred to as Queenie Corner and Site D, amended to West of Walney boundary.

References

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.

Asch, R.G. and J.S. Collie. 2008. The role of bottom fishing and ecological succession in structuring the benthic megafaunal community. Fishery Bulletin 106: 438-456.

B. J. Ball, G. Fox, and B. W. Munday. 2000. Long- and short-term consequences of a *Nephrops* trawl fishery on the benthos and environment of the Irish Sea. ICES J. Mar. Sci. (2000) 57 (5): 1315-1320 doi:10.1006/jmsc.2000.0924

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

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

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.

González Herraiz, I., Torres, M. A., Fariña, A. C., Freire, J. and Cancelo, J. R. 2009. The NAO index and the long-term variability of *Nephrops norvegicus* population and fishery off West of Ireland. *Fisheries Research,* 98**,** 1-7.

Greenstreet, S. P. R., Fraser, H. M. and Piet, G. J. 2009. Using MPAs to address regional-scale ecological objectives in the North Sea: modelling the effects of fishing effort displacement. *ICES Journal of Marine Science: Journal du Conseil,* 66**,** 90-100.

Halpern, B. S. 2003. The impact of marine reserves: do reserves work and does reserve size matter? *Ecological Applications,* 13**,** 117-137.

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

Kaiser, M. J., Collie, J. S., Hall, S. J., Jennings, S. and Poiner, I. R. 2002. Modification of marine habitats by trawling activities: prognosis and solutions. Fish and Fisheries, 3: 114–136. doi: 10.1046/j.1467-2979.2002.00079.x

Olsgard F., Schaanning M., Widdicombe S., Kendall M. and Austen M. 2008. Effects of bottom trawling on ecosystem functioning. Journal of Experimental Marine Biology and Ecology, 366, 123-133.

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

Pita, C., Theodossiou, I. and Pierce, G. J. 2013. The perceptions of Scottish inshore fishers about marine protected areas. *Marine Policy,* 37**,** 254-263.

Power, J and Lordan. C. 2012. A review of the effects of bottom trawling on sediments; sea pens and burrowing megafauna biotope complexes. Marine Institute. Unpublished.

Powers, J. E. and Abeare, S. M. 2009. Fishing effort redistribution in response to area closures. *Fisheries Research,* 99**,** 216-225.

Robb, C. K., Bodtker, K. M., Wright, K. and Lash, J. 2011. Commercial fisheries closures in marine protected areas on Canada's Pacific coast: The exception, not the rule. *Marine Policy,* 35**,** 309-316.

Sarda, F. (Ed). 1998. *Nephrops norvegicus* comparative biology and fishery in the Mediterranean Sea. Scientia Marina, 62(Suppl. 1): pp. 143.

Sen, S. 2010. Developing a framework for displaced fishing effort programs in marine protected areas. *Marine Policy,* 34**,** 1171-1177.

Service, M., Rooney, L., Cappell, R. And Gilmore, L. 2013. Fisheries Resource Access Mapping Project: The Co. Down Wind Resource. AFBI - Poseidon Report to the Seafish Northern Ireland Advisory Committee. [ONLINE] Available at http://www.seafish.org/ [Accessed 10/10/2014]

Smith, I. P., and Jensen, A. C. 2008. Dynamics of closed areas in Norway lobster fisheries. ICES Journal of Marine Science, 65: 1600–1609.

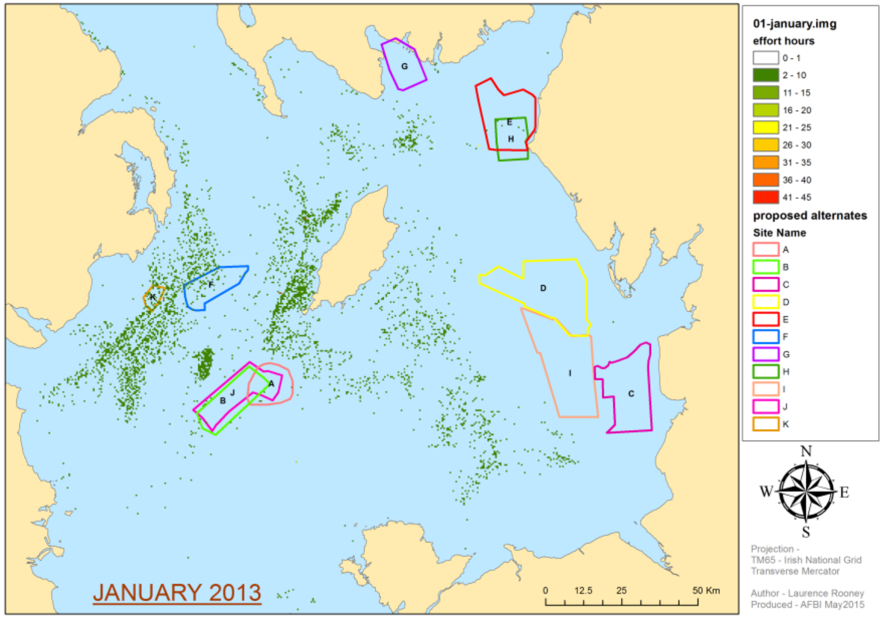
Tillin, H. M., Hiddink, J. G., Jennings, S., & Kaiser, M. J. 2006. Chronic bottom trawling alters the functional composition of benthic invertebrate communities on a sea-basin scale. Marine Ecology Progress Series, 318, 31-45.

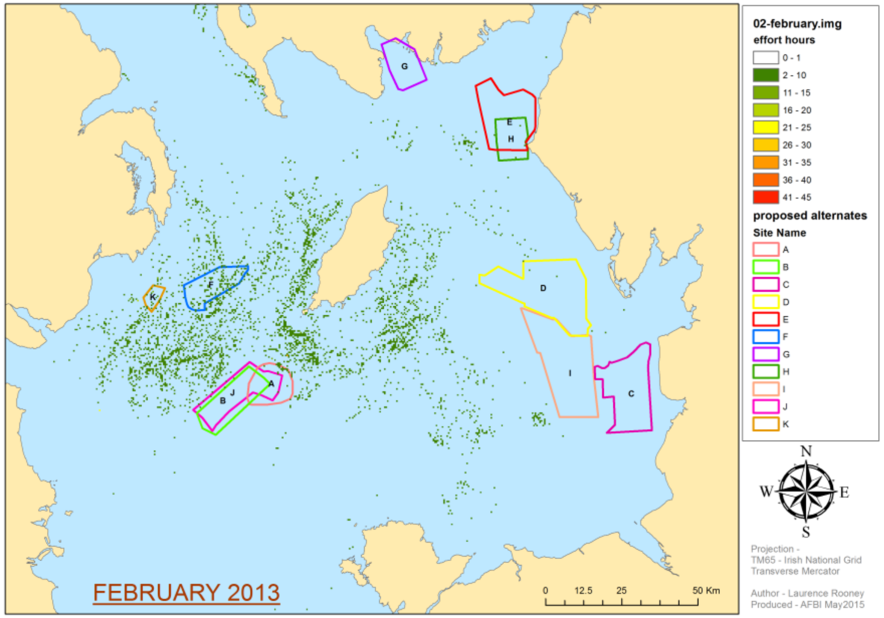
Valcic, B. 2009. Spatial policy and the behavior of fishermen. *Marine Policy,* 33**,** 215-222.

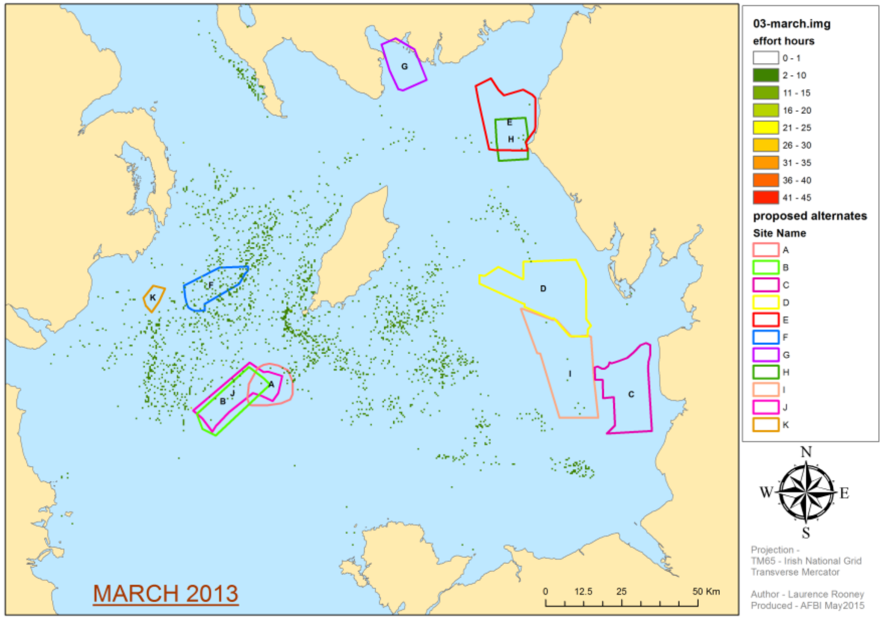
WGSFD. 2013. ICES Report of the Working Group on Spatial Fisheries Data (WGSFD).

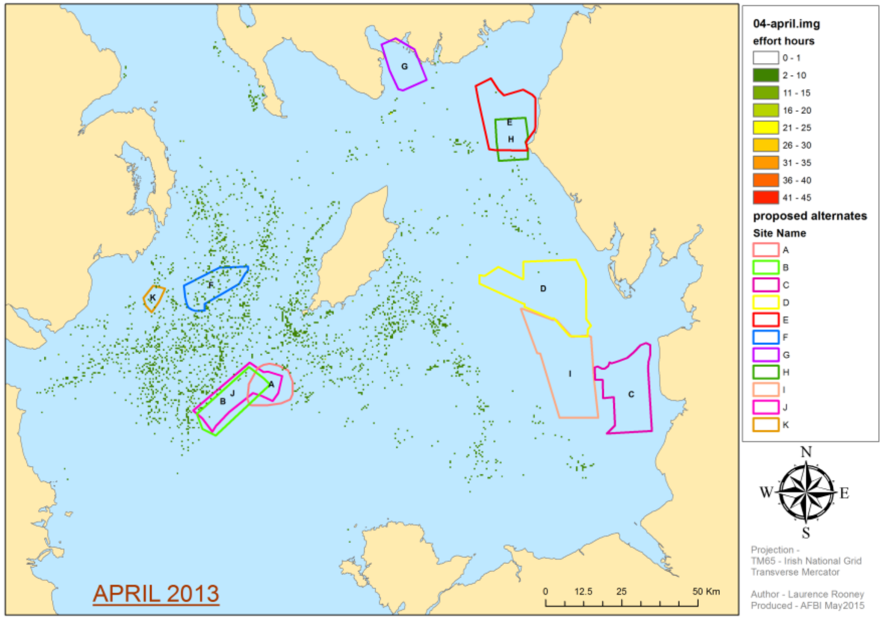
VMStools . 2013. VMStools 0.67, ‘R’ package for analysing fisheries VMS (Vessel Monitoring System).

Appendices

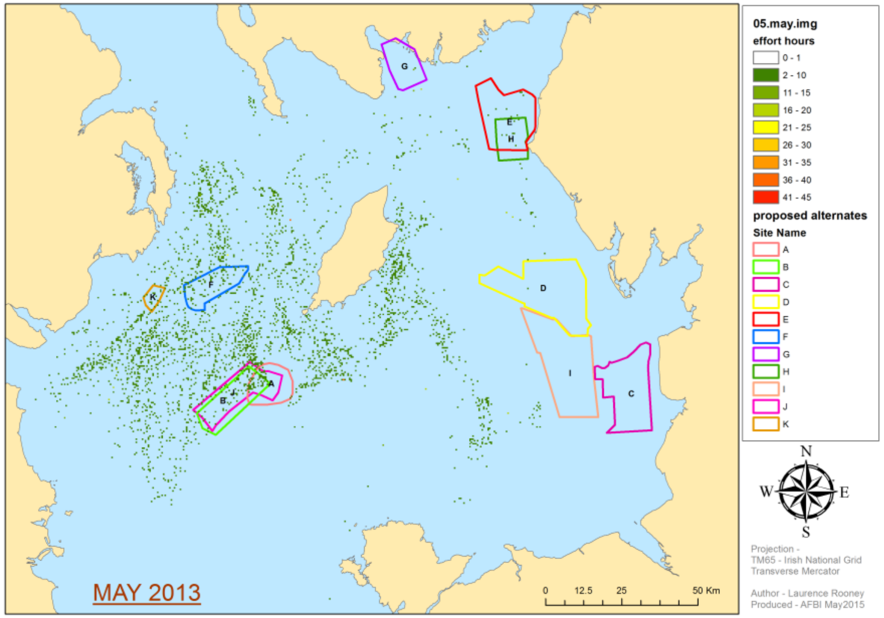


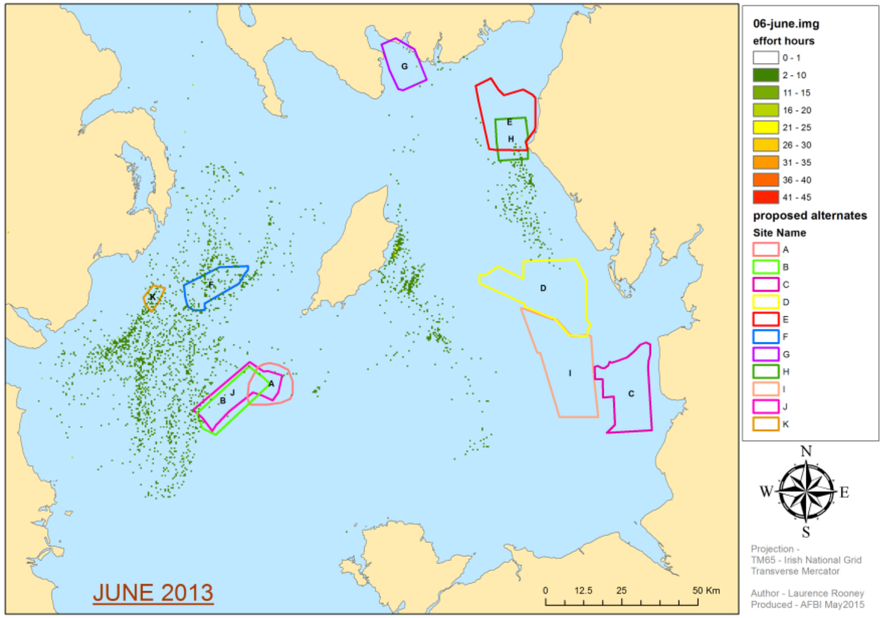


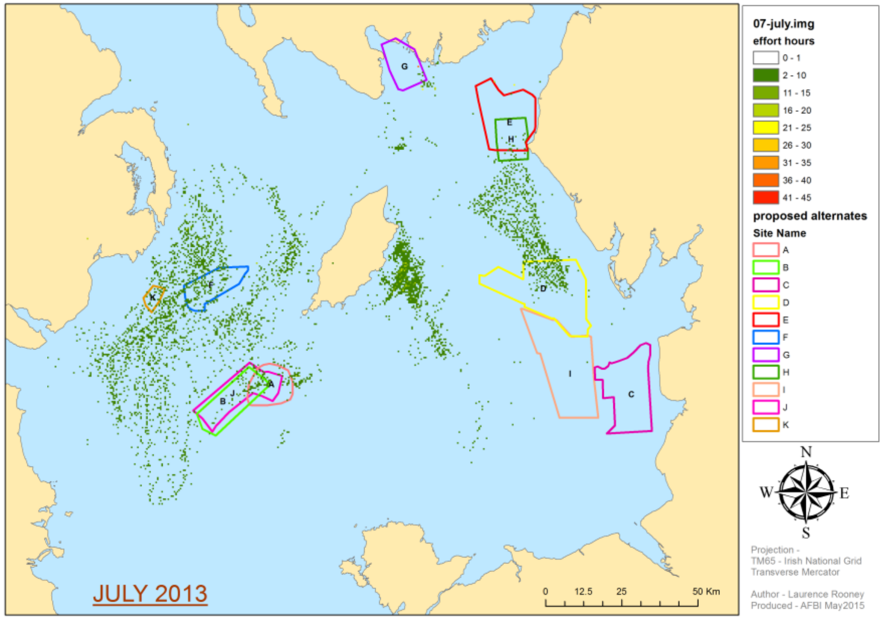


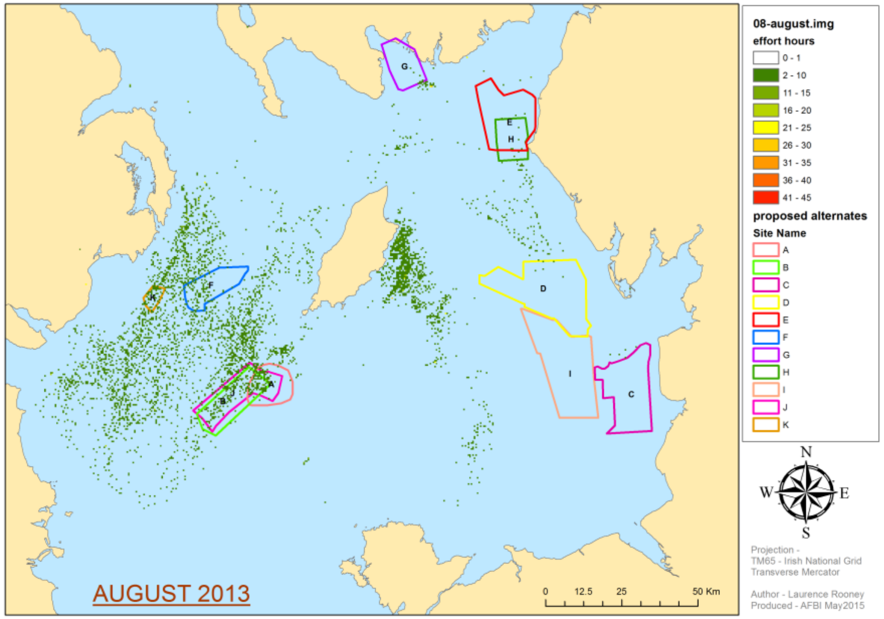


Monthly Breakdown – UK VMS 2013 – Activity in Proposed Alternate MCZs by month

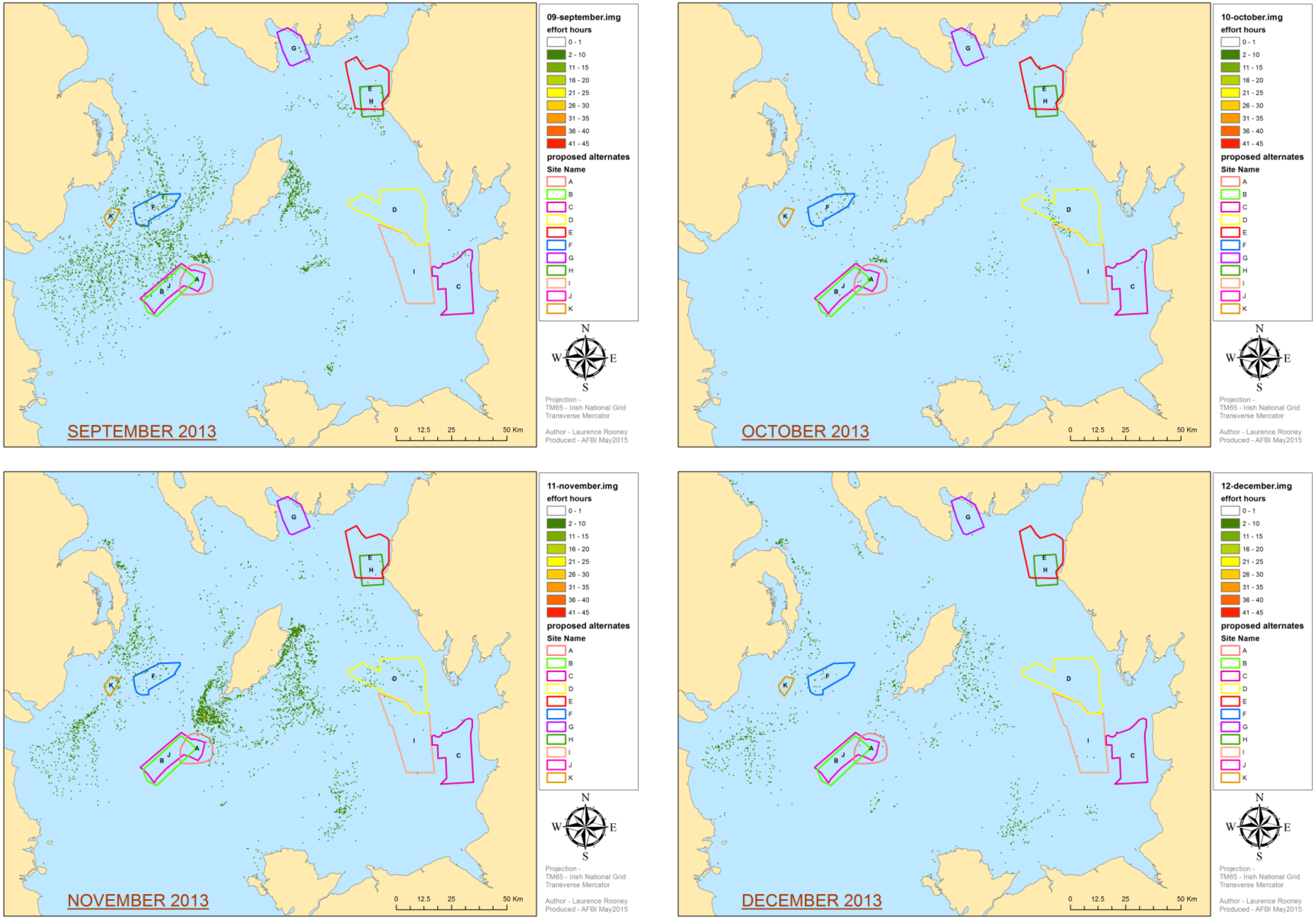








Monthly Breakdown – UK VMS 2013 – Activity in Proposed Alternate MCZs by month



Monthly Breakdown – UK VMS 2013 – Activity in Proposed Alternate MCZs by month

Marine Conservation Zone workshop

Location - Millbrook Lodge - Ballynahinch

Date - 15th October 2014

Attendees:

Name	Organisation
Dick James (DJ)	NIFPO
Samuel Warnock (SW)	NIFPO
Davy Hill (DH)	ANIFPO
Alan McCulla (AMC)	ANIFPO
Kenny Bodles (KB)	NI Marine Task
Chris Lumb (CL)	Natural England
Ollie Payne (OP)	JNCC
Declan Tobin (DT)	JNCC
Nuala McQuaid (NMQ)	DoE Marine Division
Joe Breen (JB)	DoE Marine Division
Colin Armstrong (CA)	DoE Marine Division
Claire Vincent (CV)	DoE Marine Division
Dan McEvoy (DME)	DARD
Matthew Service (MS)	AFBI (Chair)
Laurence Rooney (LR)	AFBI
Glaucia Hamilton (GH)	AFBI (Secretary)
Annika Clements (AC)	AFBI

Apologies:

Name	Organisation
Lynn Gilmore	Seafish
Judith Farrell	NIFPO
Paddy Campbell	DARD
Mark McCaughan	DARD

Main Agenda Items:

A Definition of Mud Habitat: what do we want?
B Management and monitoring
C Where do we have mud and what is already excluded?
D Pressures
E Selection of alternative sites (All participants)

Definition of Mud Habitat: what do we want?

The objectives of the workshop were to assess possible alternatives to the existing proposed MCZ sites, looking at the wider Irish Sea area as a whole and to outline monitoring requirements and strategies. When choosing potential MCZ sites it is crucial to have in mind that mud habitats exhibit spatial variations in extent and type (***DT***). Therefore, it is important to ensure representivity of different habitats, while temporal variations are essential to show seasonal and yearly changes to the biota. MCZ sites should be selected taking into consideration site exclusions due to fisheries closures, cables and pipes etc.

MCZs have a focus on protecting the range of biodiversity of the Irish Sea; within this "regional sea" there is a UK government target to protect a minimum of 10% of the total mud habitat through MCZ designations. (10% is recommended by OSPAR as a resilience minimum – ***OP***). An MCZ should be a minimum area of $25km^2$ and within an MCZ any patch of mud must be at least $1km^2$. The importance of representing a range of mud habitats is emphasised, i.e. both eastern and western Irish Sea, and not only *Nephrops* ground. MCZ sites should have at least two features of conservation importance and the sites have to be "ecologically connected"; ideally sites should be no more than 80 km apart (distance ascertained by JNCC studies - ***OP***).

Management and monitoring

MCZs should aim to protect the biodiversity, the structure and function of the seabed, enhance sustainability of fisheries and conserve "naturalness". Potential indicators for the monitoring programme are size and abundance of commercial *Nephrops*, borrow density, mud particle type and size and abundance of erect epifauna e.g. seapens. These data have already been collected by AFBI and others and would be available as a baseline study for the monitoring programme (***MS***). Currently what is lacking is clear definition of favourable condition and targets.

Currently there are no consistent guidelines on how socioeconomic impacts are assessed and what level of socioeconomic impact isn't acceptable.

It was clear to the working group that the designation of MCZs stills needs clearer understanding. Management options and possible restrictions to commercial fishing and other activities still lack clarity. There was genuine interest from everyone involved in the workshop to come up with MCZ locations which would have the least impact to everyone. ***JB*** – evidence needs to be gathered – site specific management would be introduced. Will to protect fisheries as much as is possible.

Where do we have mud and what is already excluded?

The Irish Sea area designated by the DEFRA CP2 Reporting Area - covers Northern Irish, English and Scottish waters however it came to light during the discussions that all mud within the Irish Sea area within Scottish waters is unlikely to be included in the 10% mud MCZ designation. This is a significant area. JNCC/DEFRA gaps analysis could not include Clyde/Scottish waters as deemed unlikely that Scotland will designate MPAs in this area, so cannot contribute to the 10%. Existing MCZs such as Strangford Lough can be included but will form a tiny fraction as fairly small area of mud deeper than 20m.

In the workshop there were further discussions about the Scottish government's designations and other transboundary designations from other jurisdictions such as the Republic of Ireland - if Scotland did designate some of their Irish Sea mud areas, it may have an impact on the NI fleet.

Pressures

ANIFPO (***AMC***) raised the point that MCZs shouldn't mean closure to fisheries although fishermen representatives weren't convinced that mobile gear wouldn't be banned with the implementation of MCZs in the Irish Sea, due to the known sensitivity of mud habitats to trawling. It was brought to everybody's attention that potential sites for MCZ designation could be created in rocky areas surrounded by mud, or mud areas protected by other features that may mean fishing pressure is less and closure of such areas would have less impact on fishing activity. However, industry representatives believe that these areas are more limited than suggested, and could not greatly contribute to the 10% area required.

If a mud habitat has been shown to be sensitive to trawling (which is the case in JNCC MCZ literature), it is likely that mud MCZ management will have to involve some management of fishing activity. The fishing industry therefore requests that sites are located where the impact is lightest on them, in terms of restricting their existing fishing grounds. This is of increasing importance with the incoming fisheries landings obligation legislation, where the fleet need flexibility to avoid "bycatch hotspots" (which likely are highly mobile). ***AMC*** raised the issue of displacement of activity i.e. same level of activity over smaller area increasing pressure per unit area.

Summary of Take home messages/ Round up:

MS – How is favourable condition defined? What are the Irish doing? More detail on Co-location

AC – look further at the data that we have. How is favourable condition defined? Community structure designation

CV – Discussed the difficulties of co-location, adding MCZ on wind farm sites. How might it work? MCZ could come earlier than wind farms. There may be licensing implications.

NMQ – Raised the issue that the MCZ sites are not to be created only on *Nephrops* grounds.

DJ – Noticed common features in all 3 groups as regards to picking favourable MCZ sites and said that the Scottish issue had to be sorted. (Commonality of agreement on sites was encouraging).

JB – Emphasized that it is not clear what the implications of the MCZs are in relation to the fishing activities, will it be sufficient to reduce stock instead of banning fishing practises. VAMS + local scale management

CL – all mud is not equal.

KB – guidelines layout – fisheries advisers – not to take areas away from fishing grounds. ECN weighting within principles

DT – guidelines have been laid out, they are not a dictat.

OP – Need to come up with some boundaries and area to avoid DEFRA going ahead with the areas that they have chosen.

CA – Marine license, see the bigger picture, how to monitor programmes.

AM – Better late than never! Touched on the landing obligation as an issue that hasn't been taken into consideration while trying to create MCZs.

DM – sustainability of NI fleet (best outcome for both sides). Do you displace fishing to another area? The discard ban will have an impact.

LR – emphasized the importance of having criteria mapped (e.g. habitat, depth) in order to allocate suitable MCZ sites.

Action points and outstanding issues:

1. What is favourable condition? Need to work up data to examine biotopes and characteristic species – the focus needs to ensure not only *Nephrops* ground is examined

2. What plans does the Republic of Ireland have for MCZ designation? Will they be incorporating sites in the western Irish Sea mud patch?

3. Does Scotland plan to designate any of the Clyde mud area?

4. A management options paper (similar to that produced in the Scottish MPA approach) would be very useful to help liaise with fisheries stakeholders. This needs to address how future changes in fisheries legislation will impact the industry and impact choice of sites (e.g. Fisheries landings obligation). How existing policy tools can support management of sites should be addressed.

5. Further work on how the choice of sites will work as an ecologically coherent network is needed.

6. A paper examining whether displacement of fishing activity occurs following fisheries closures for MPA site management is needed using existing cases. Is effort displaced or is there overall loss to industry? What is the impact of fishing adjacent areas "harder" to make up for the loss of income from a closure?

7. How can co-location be handled, especially with respect to wind and tidal development areas? Difficult to assess whether it is feasible to co-locate when developments are still undecided/going through licensing. However, the respective license authorities could work towards a consistent approach or assessment methodology.

Alternative Sites:

After initial presentations, based around the mud area in the Irish Sea illustrated below in Figure 1, three groups were formed in order to discuss potential alternative sites. Each group then used the map in Figure 2 to discuss and draw out potential areas. Additionally, a GIS project was also available on a laptop to investigate certain areas in more detail, if participants had any queries. This GIS project included the following layers:

- EU SeaMap substrates
- EUNIS level 3 habitat coverage (modelled and surveyed)
- VMS data
    - Integrated and processed VMS data to give a five year average for the western Irish Sea
    - Processed VMS intensity for eastern and western Irish Sea
- Seapen presence from underwater video footage collected during *Nephrops* burrow density assessment in the Irish Sea
- Existing SAC designations
- Proposed MCZ sites
- Crown Estate leased development areas

Following group discussions, the workshop reconvened to discuss each group's ideas en masse. A summary of these discussions is provided below each group's alternative site maps using a "traffic light" system.

The formations of the groups were as follows; each group incorporated a mix of industry and government representatives:

Group 1:

Name	Organisation
Dick James	NIFPO
Davy Hill	ANIFPO
Ollie Payne	JNCC
Joe Breen	DoE Marine
Laurence Rooney	AFBI

Group 2:

Name	Organisation
Alan McCulla	ANIFPO
Kenny Bodles	NI Marine Task
Declan Tobin	JNCC
Colin Armstrong	DoE Marine
Annika Clements	AFBI

Group 3:

Name	Organisation
Samuel Warnock	NIFPO
Chris Lumb	Natural England
Nuala McQuaid	DoE Marine
Claire Vincent	DoE Marine
Dan McEvoy	DARD
Matthew Service	AFBI

Mud area identified from EU SeaMap project:

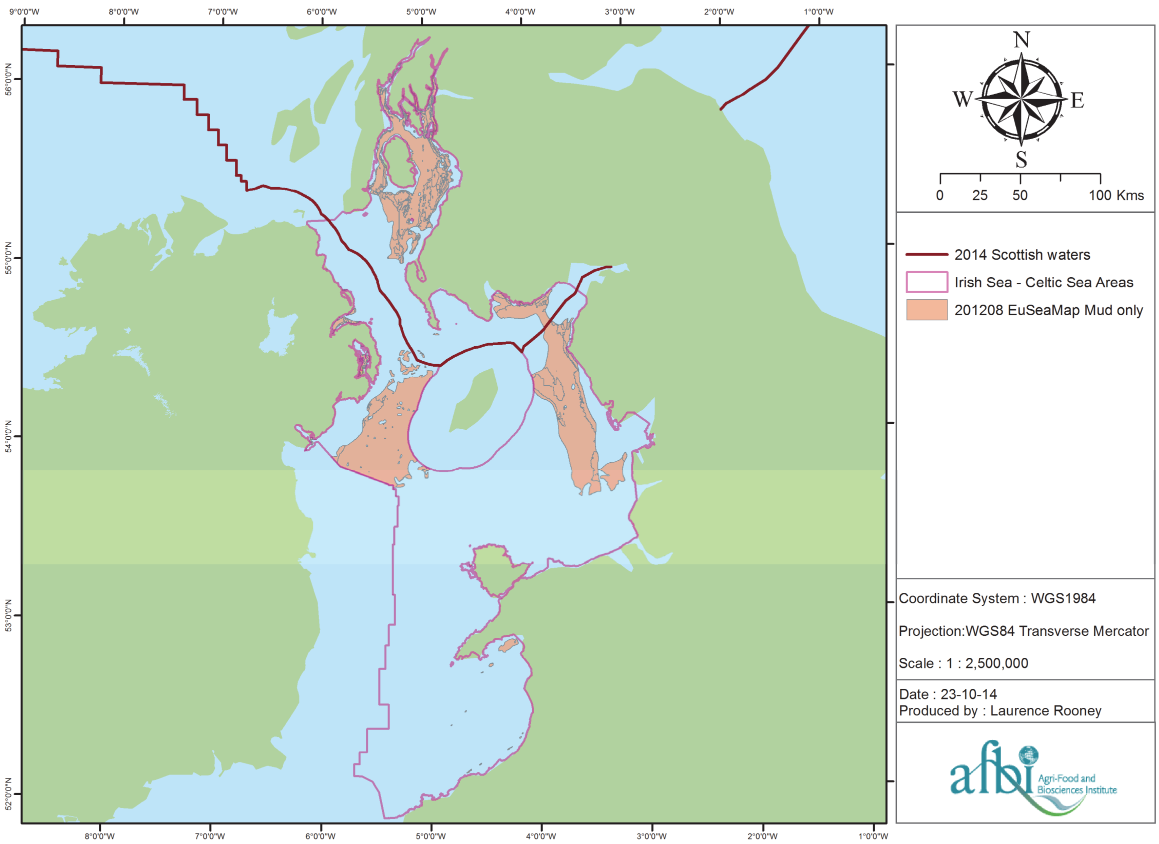


Figure 1 - showing the CP2 regional sea area, the sites available for MCZ mud designation and the Scottish waters boundary line.

The area of mud eligible for designation has been subsequently calculated to be **7218.05** Km^2 for the entire Irish Sea regional area (as defined by DEFRA).
A substantial amount of the mud, **2561.46** Km^2 (35%), is within Scottish waters. The remainder of **4656.59** Km^2 (65%) is in the rest of the Irish Sea area.

10% of the total Irish Sea area requires designation for mud habitat, this equates to **721.81** Km^2. Due to the assumption that Scotland will not be designating further MPAs within their section of the Irish Sea regional area, this means that 15.5% of UK offshore, Northern Irish and English mud areas within the Irish Sea region require MCZ designation.

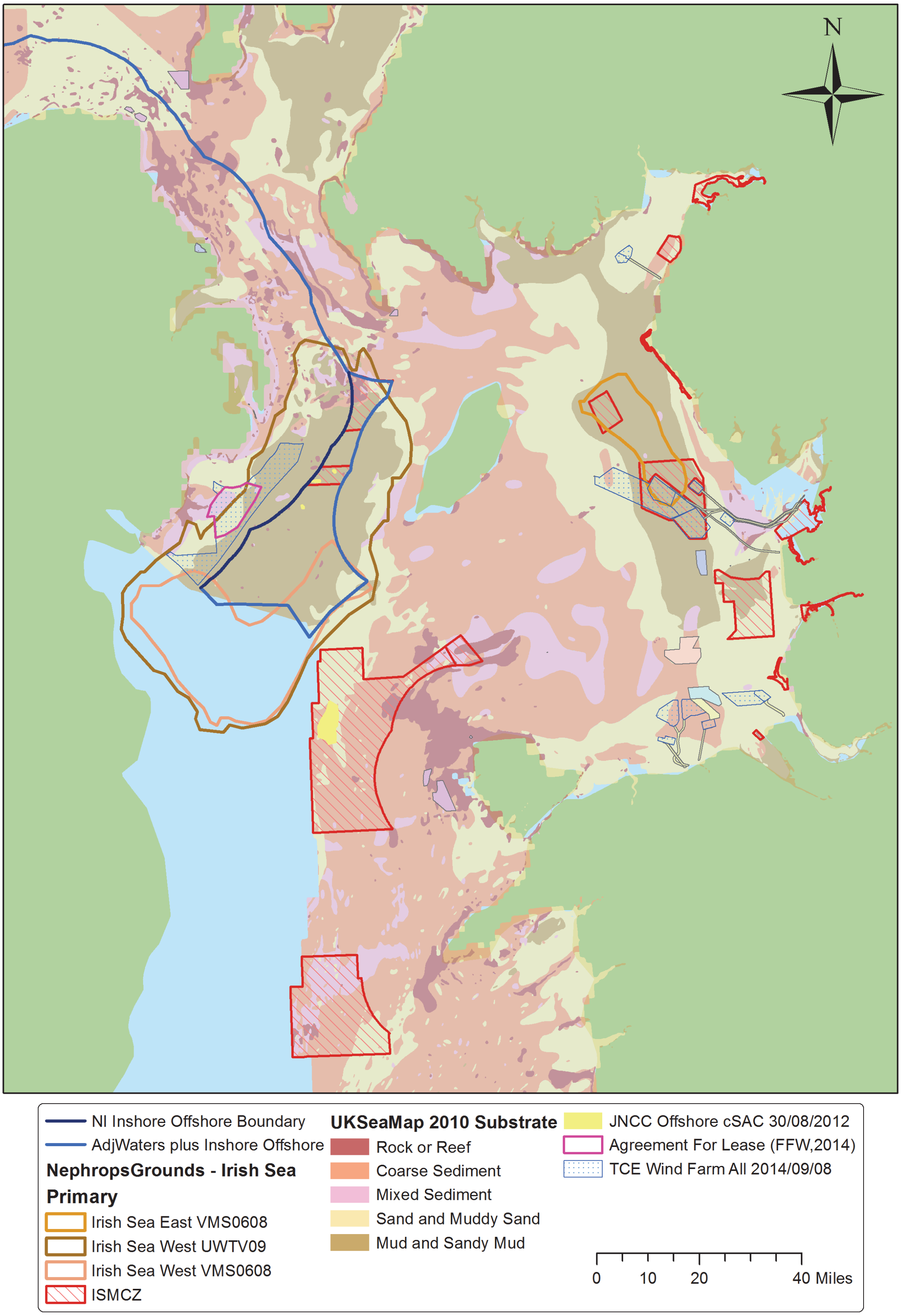


Figure 2 – Northern Ireland Offshore boundary, UKSeaMap2010 Substrate map, *Nephrops* fishing groups, Existing proposed MCZs, Proposed renewable designations

Individual groups' proposed alternative sites:

The results from each group are shown in Figures 3 – 5, with a compilation illustrated in Figure 6.

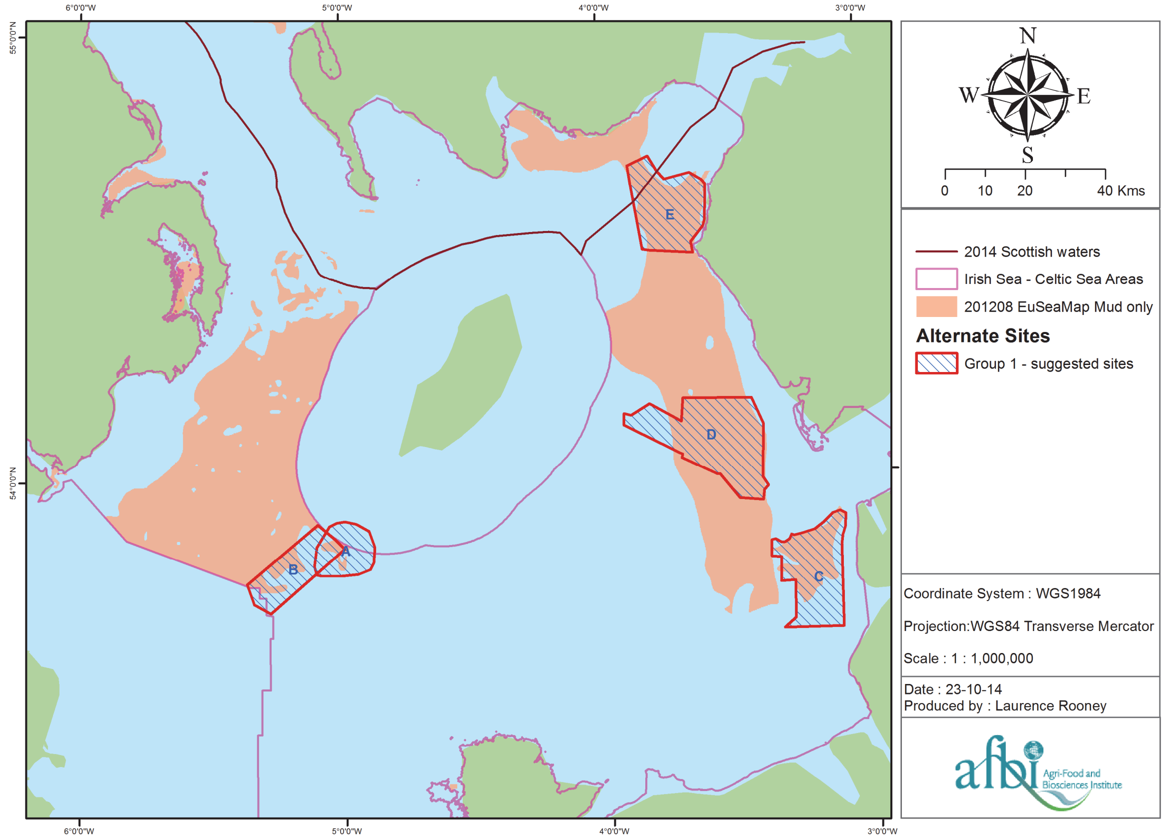


Figure 3 – Group 1 – suggested alternate sites

Table 1 – Breakdown of Group 1 suggestions:

ID	Km^2	% of Mud	Traffic light	Notes
A	165.7	2.3	Green	Queenie corner + mixed fishery
B	228.0	3.2	Green	mixed fishery
C	355.8	4.9	Amber	extended
D	510.2	7.1	Amber	redraw - extend and co-locate
E	334.1	4.6	Green	Whiting may be a problem. North of St Peas

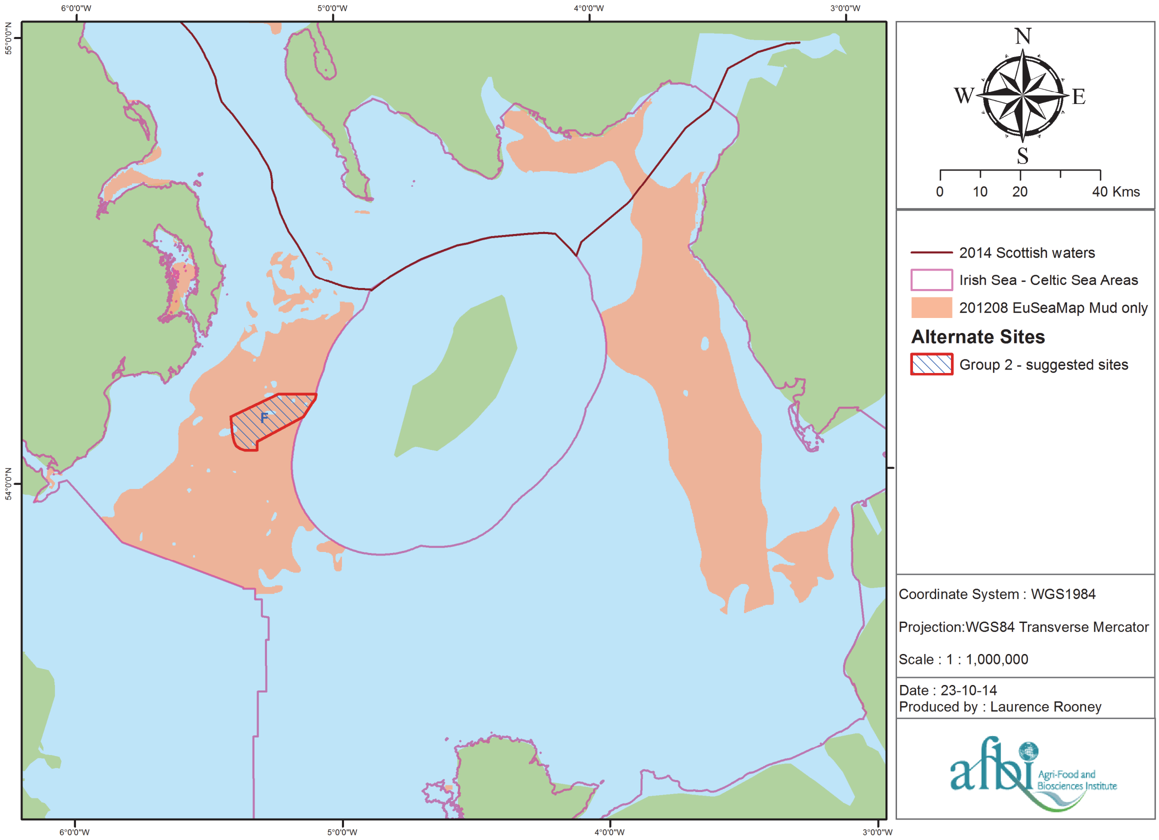


Figure 4 – Group 2 – suggested alternate sites

Table 2 – Breakdown of Group 2 suggestions:

ID	Km^2	% of Mud	Traffic light	Notes
F	163.64	2.3	Red	Extension of currently proposed ISCZ

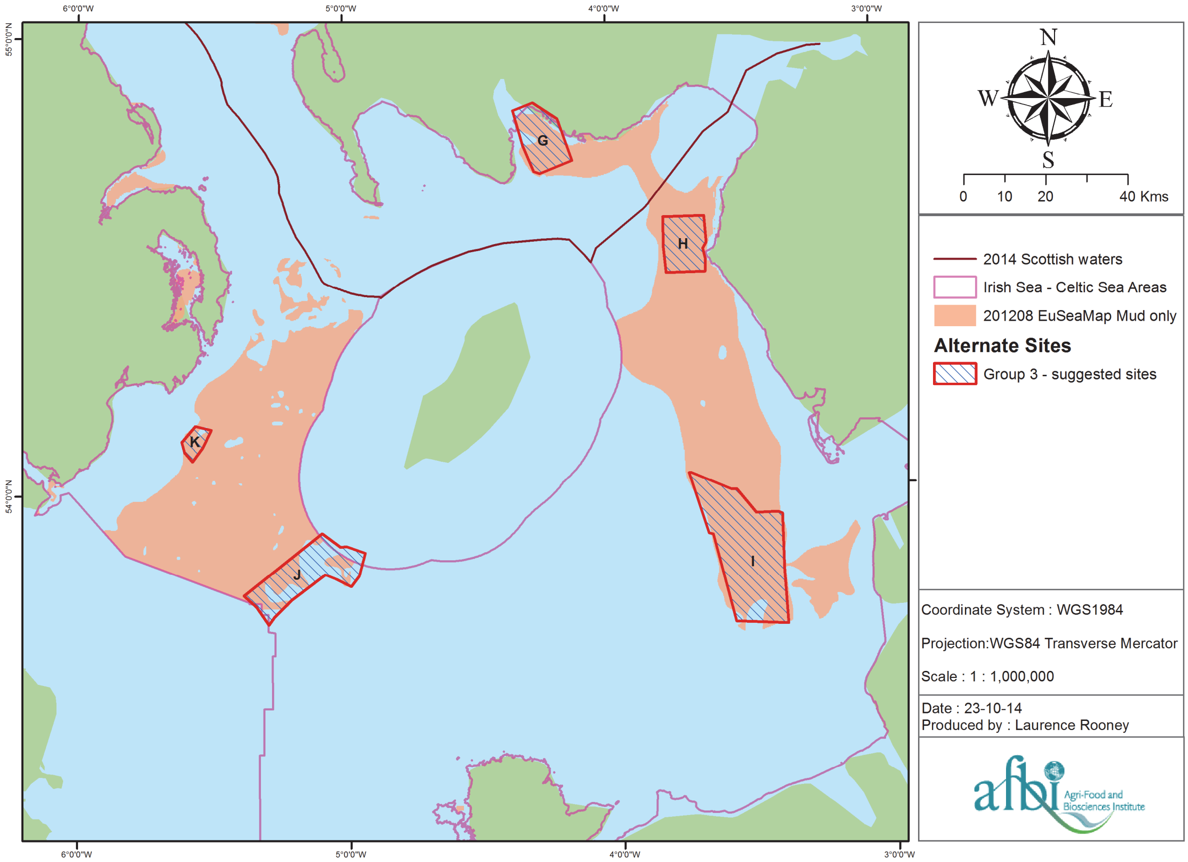


Figure 5 – Group 3 – suggested alternate sites

Table 3 – Breakdown of Group 3 suggestions:

ID	Km^2	% of Mud	Traffic light	Notes
G	150.7	2.1	Red	Whytown Bay - possibility
H	134.8	1.9	Green	Possibly contentious at St Peas Head - Whitehaven
I	500.7	6.9	Amber	Possibly for sandy mud
J	255.0	3.5	Green	Queenie corner - multi fishery
K	33.5	0.5	Red	Outer edge of proposed wind farm

Polygons from each group were compiled and colour coded (using a traffic light system) to show level of agreement between groups. The results can be seen in Figure 5.

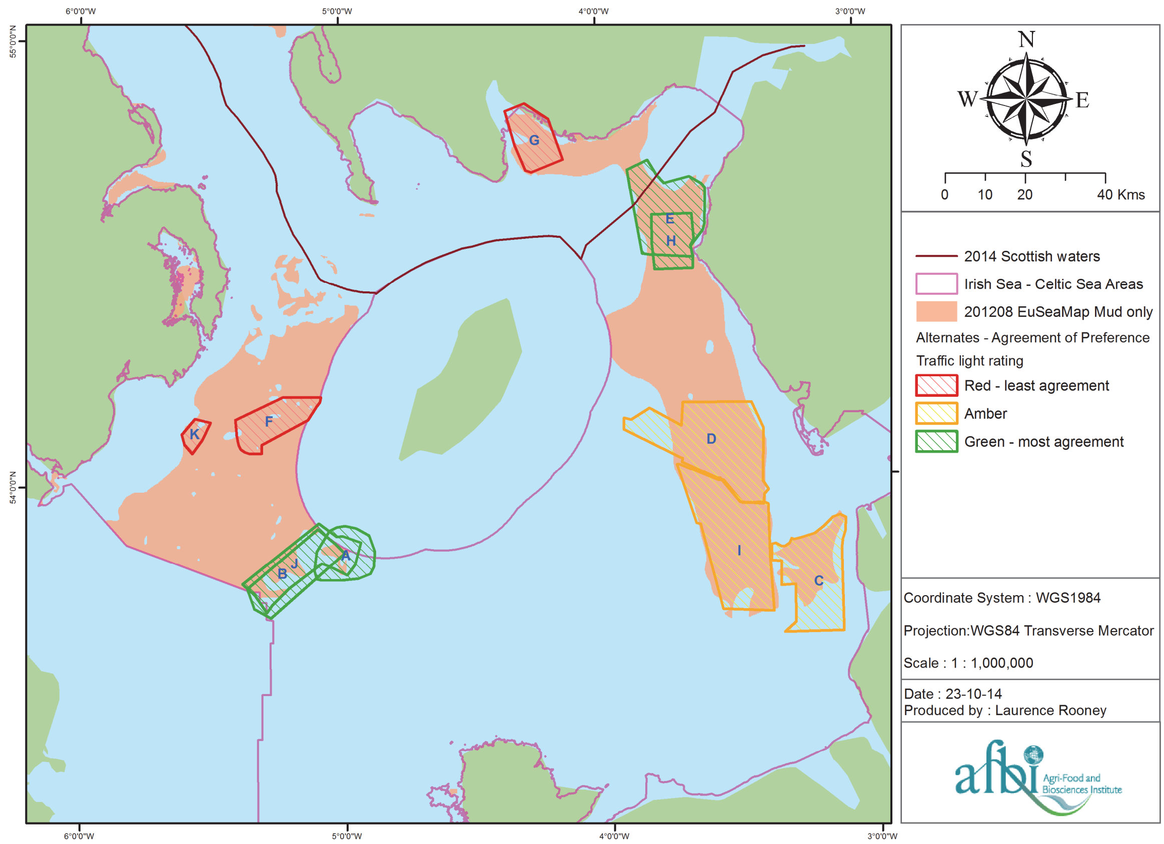


Figure 6 – Group compilation – all suggested alternate sites: using a traffic light system

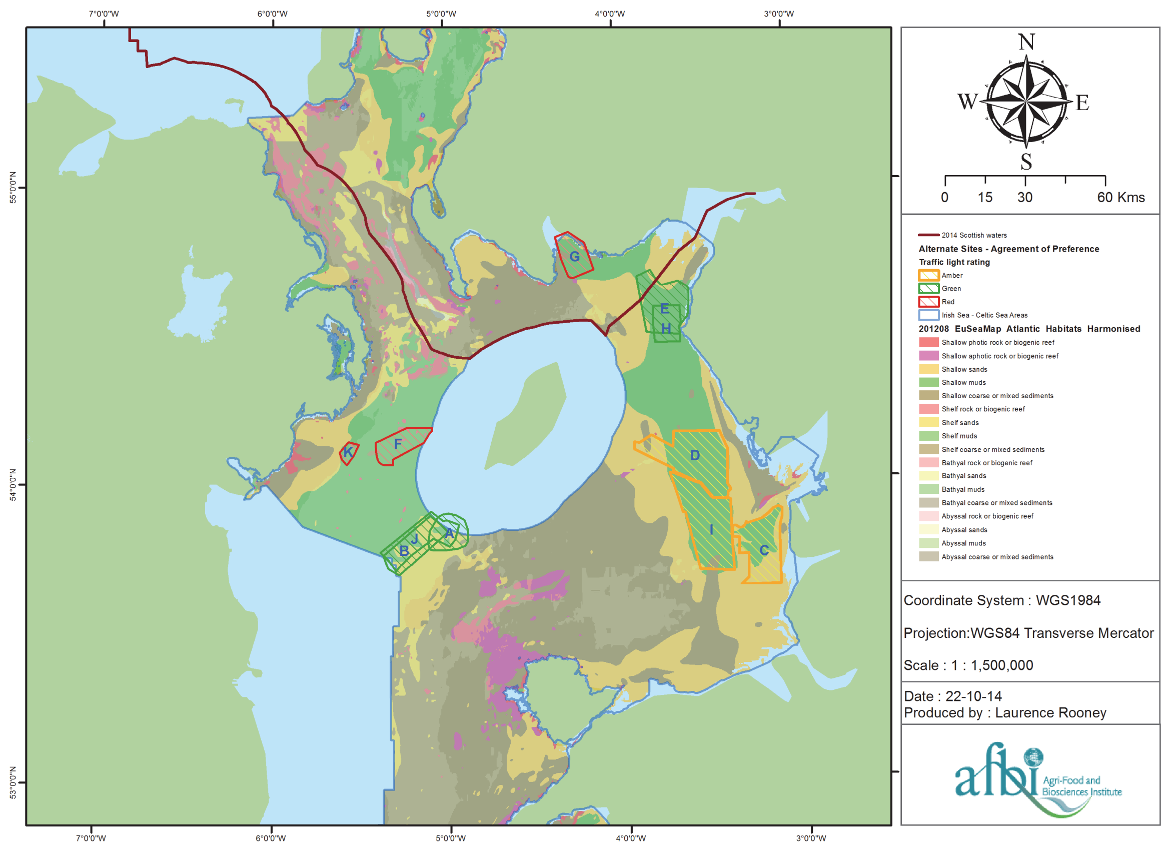


Figure 6B– Group compilation – all suggested alternate sites: using a traffic light system & habitats

* It should be noted that these areas have been drawn from areas sketched at the workshop and will need refinement. A small proportion of "green" area is drawn from the Isle of Man waters which are not technically within the CP2 region. Overlapping suggested sites have been merged into a single area for the combined area calculation so as not to overestimate the total size.

Table 4 - The combined alternate sites areas

Type of area	Size of Area (Km^2) *	% (of 7218 km^2)	% outside Scotland
Red	348	4.8	7.5
Amber	1364	18.9	29.3
Green	754	10.4	16.2
total	2466	34.2	53.0

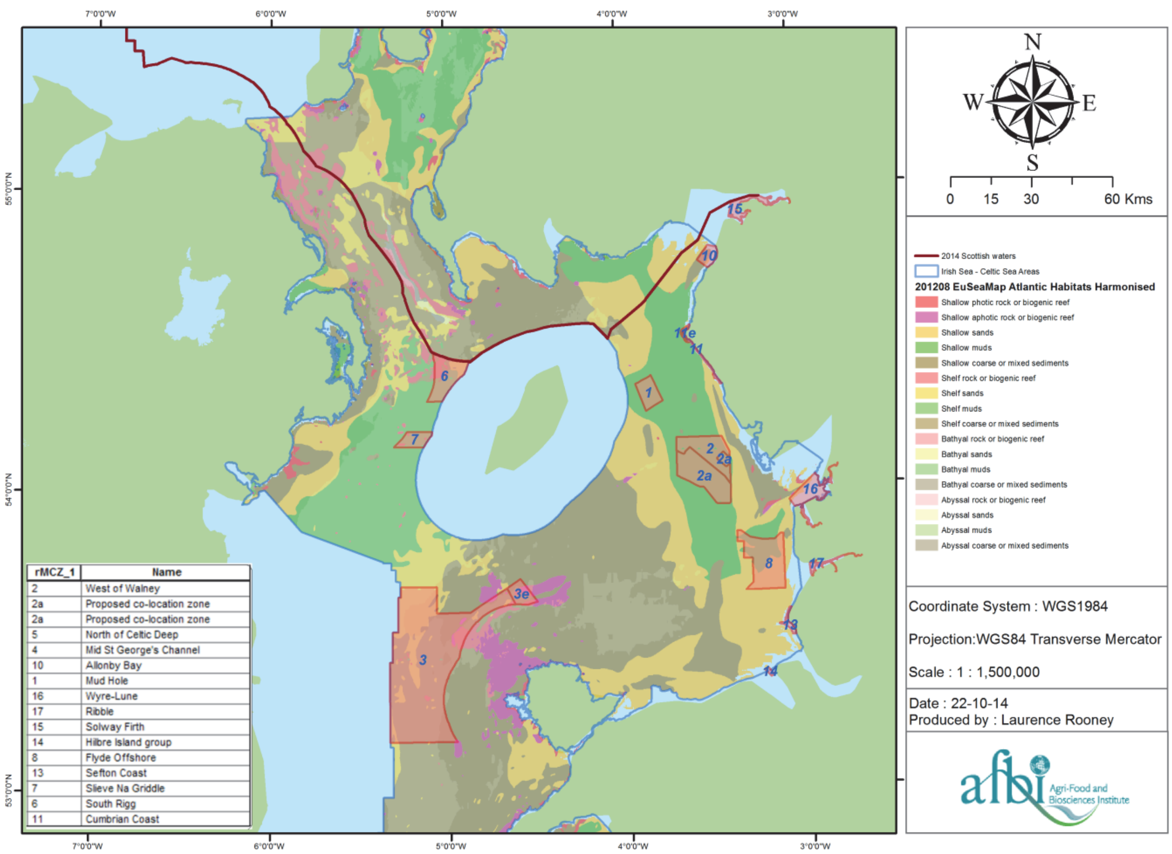


Figure 7 – Existing proposed MCZ's in the Irish Sea region – EuSeaMap habitats underlain.

The current MCZs for mud, namely 1, 6, 2a and 2b illustrated in Figures 8, are overlaid with the 2011 Northern Ireland VMS. A high level of fishing activity currently takes place within these areas.

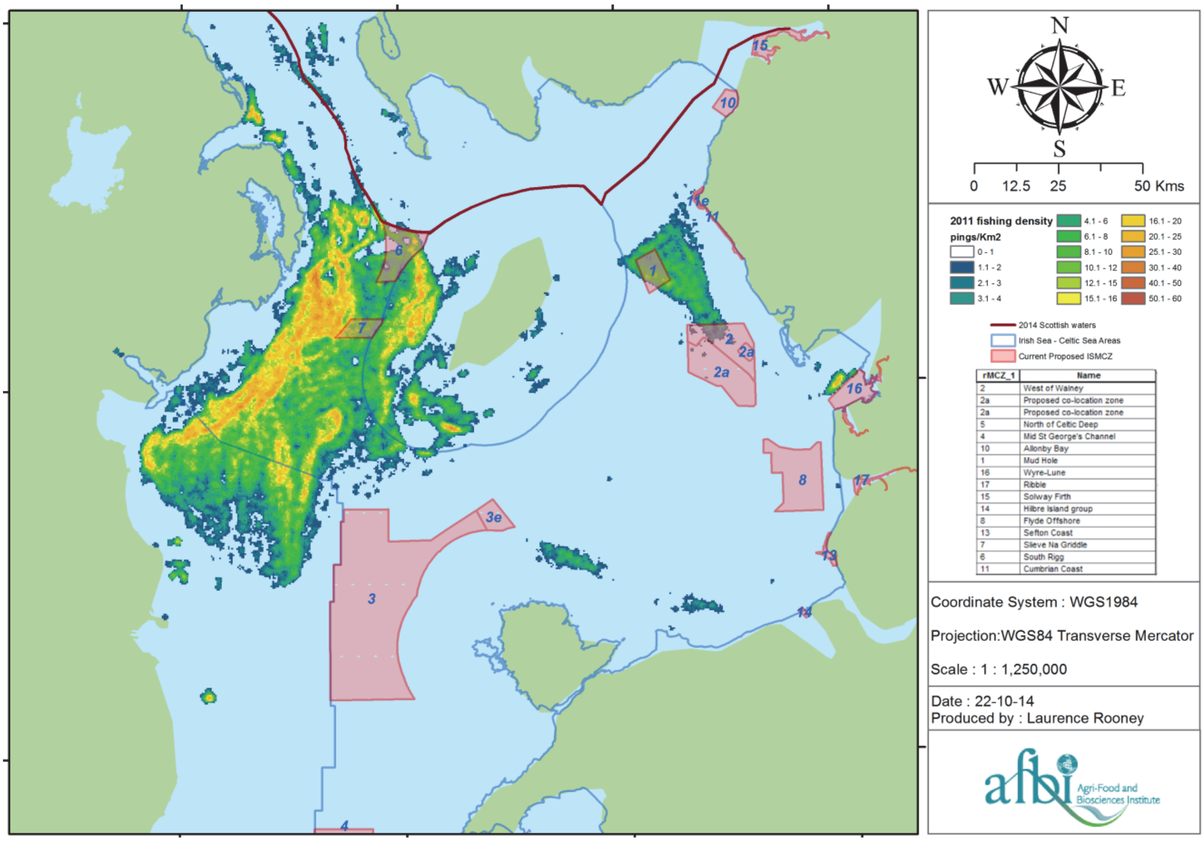
More detail can be seen in the Seafish funded Poseidon report from 2012 – 'The Value of Irish Sea Marine Conservation Zones to the Northern Irish Fishing Industry' (Cappell, R., Nimmo, F. Rooney, L.) (http://www.seafish.org/media/Publications/Poseidon_NI_MCZ_valuation_final_report_August_2012__2_.pdf)

An annual average of 6.97% of total fishing activity between 2007 and 2010 was within the proposed marine conservations zones (Cappell *et al.,* 2012). This does not represent the value of these areas to the fishery. A summary of the value of landings for the period 2007-2010, from within the proposed MCZ areas can be seen in Table 5.

Table 5 – Value of landings within existing proposed MCZs (Cappell *et al* 2012).

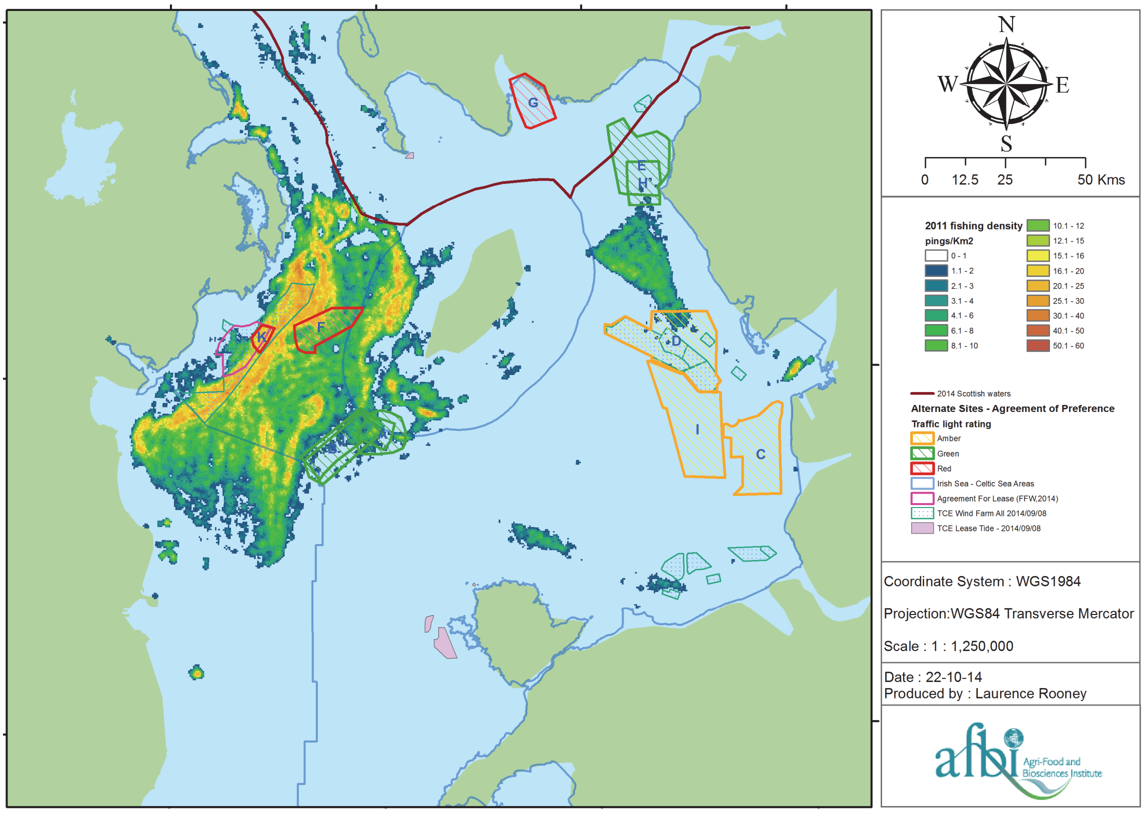
		Average 2007-2010 total landings value ICES rectangles	% of MCZ fishing within rectangle	value within MCZ
South Rigg	6	£10,216,799	6%	£646,006
Slieve Na Griddle	7	£7,905,299	3%	£255,790
Mud Hole	1	£1,016,154	15%	£154,451
West of Walney	2a	£1,016,154	8%	£79,393
Co-location zone	2b	£1,016,154	4%	£41,579
Total		**£11,232,953**		**£1,177,218**

source: AFBI/DARD/Poseidon



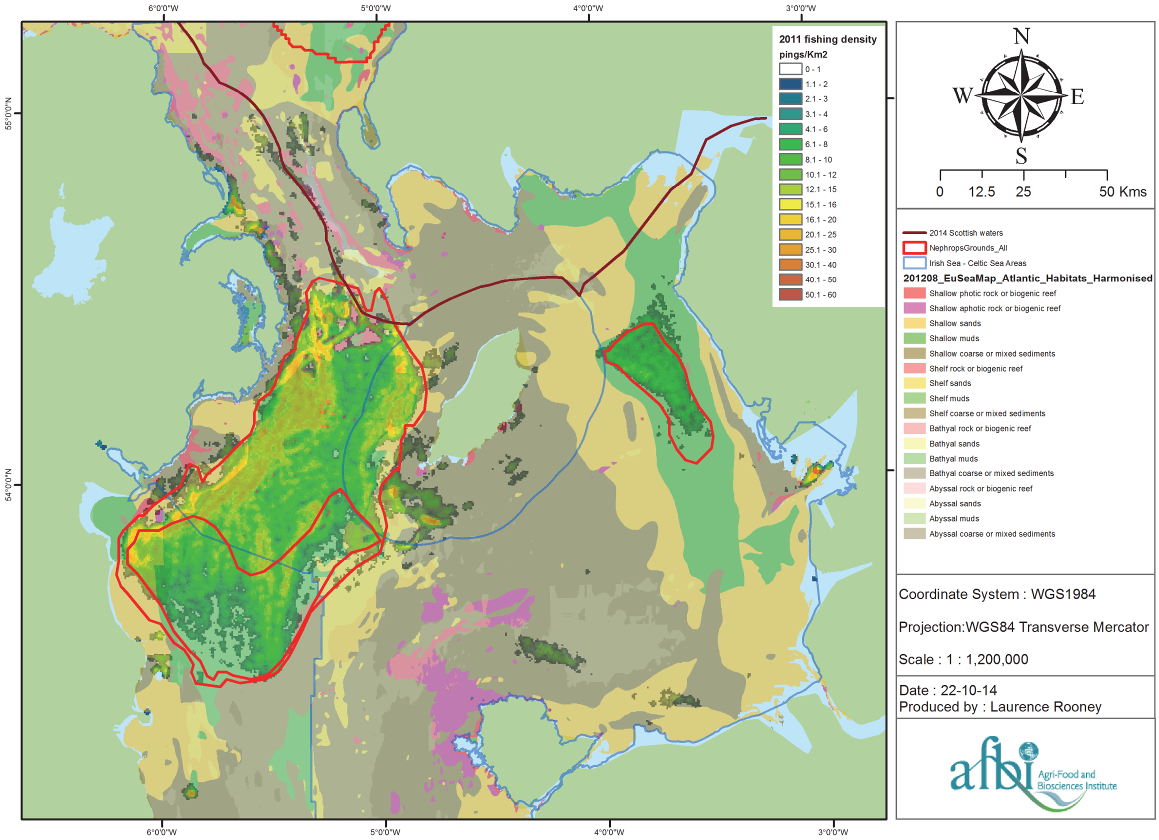
<u>Figure 8 – Existing proposed MCZ's in the Irish Sea region and 2011 NI VMS.</u>

Figure 9 shows the suggested alternate sites on top of the 2011 Northern Ireland VMS data. Details of exactly how much of the fishing area might be impacted have not been calculated within this report, however visually it can be noted that the "green" sites appear to have less fishing activity within them compared to the existing proposed sites in Figure 8.



<u>Figure 9 – 2011 NI VMS in the background with alternate sites highlighted in traffic colour system. Map also shows sites designated for potential renewable energy development.</u>

Figure 10 illustrates that the *Nephrops* fishing ground extends outside the CP2 regional seas designation and onto areas not defined as “mud to sandy mud” in the EuSeaMap Atlantic Habitats map.



<u>Figure 10 – 2011 NI VMS with *Nephrops* fishing grounds (red outline) and EuSeaMap habitats underneath</u>

References:

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 21/10/2014]

Appendix –Document Maps

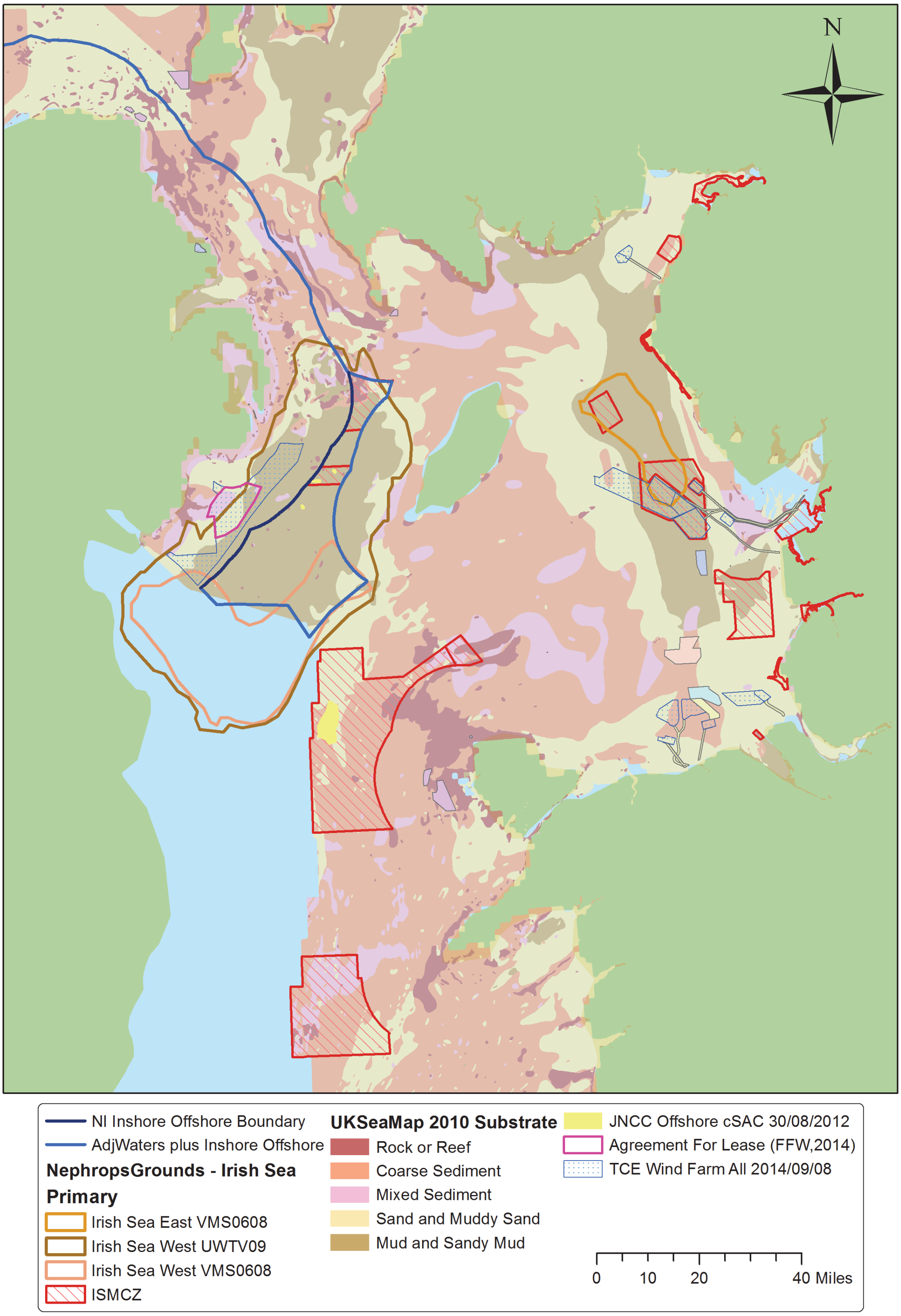


Figure 2 – Northern Ireland Offshore boundary, UKSeaMap2010 Substrate map, *Nephrops* fishing groups, Existing proposed MCZs, Proposed renewable designations

Figure 1 - showing the CP2 regional sea area, the sites available for MCZ mud designation and the Scottish waters boundary line.

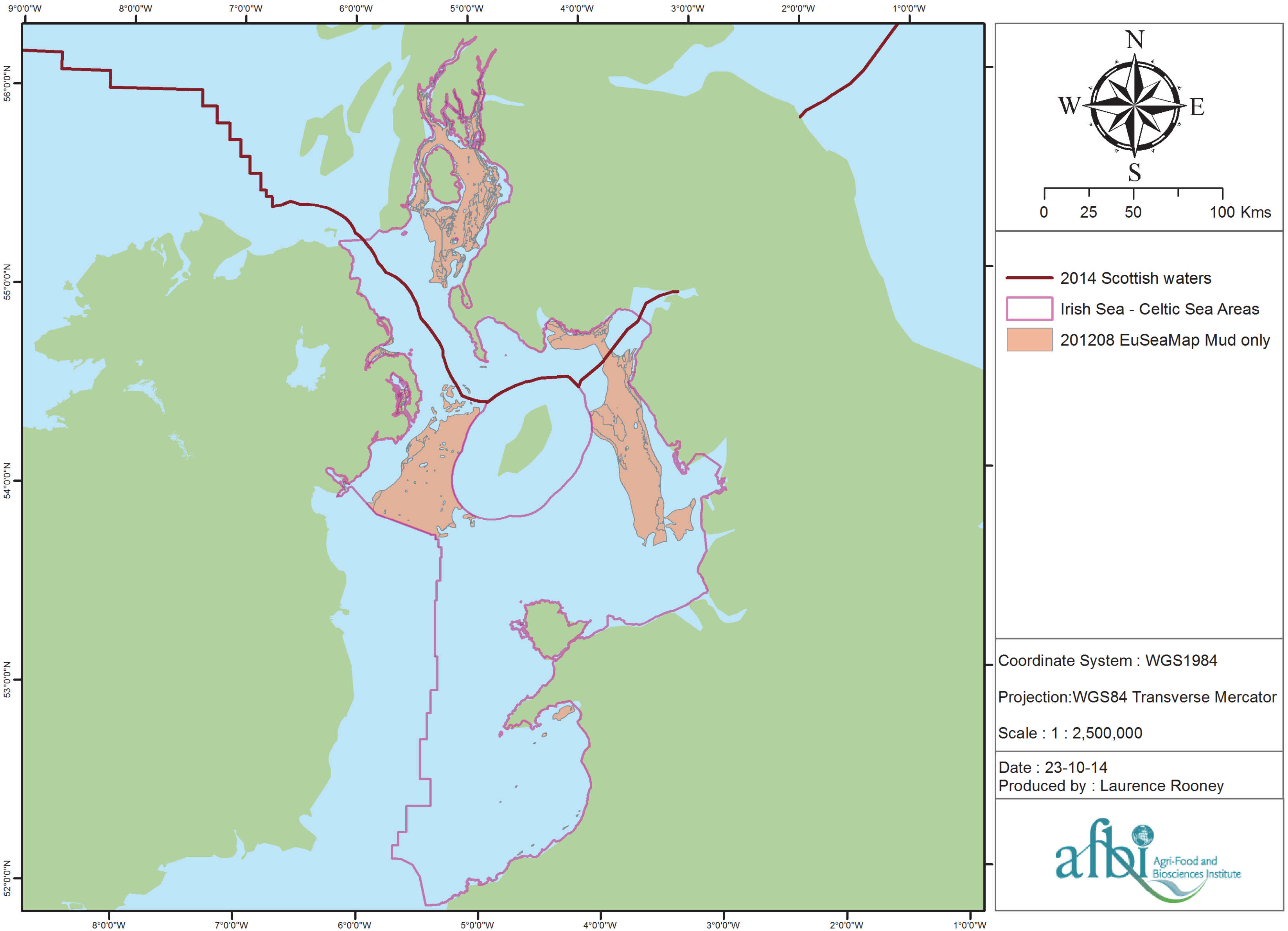


Figure 3 – Group 1 – suggested alternate sites

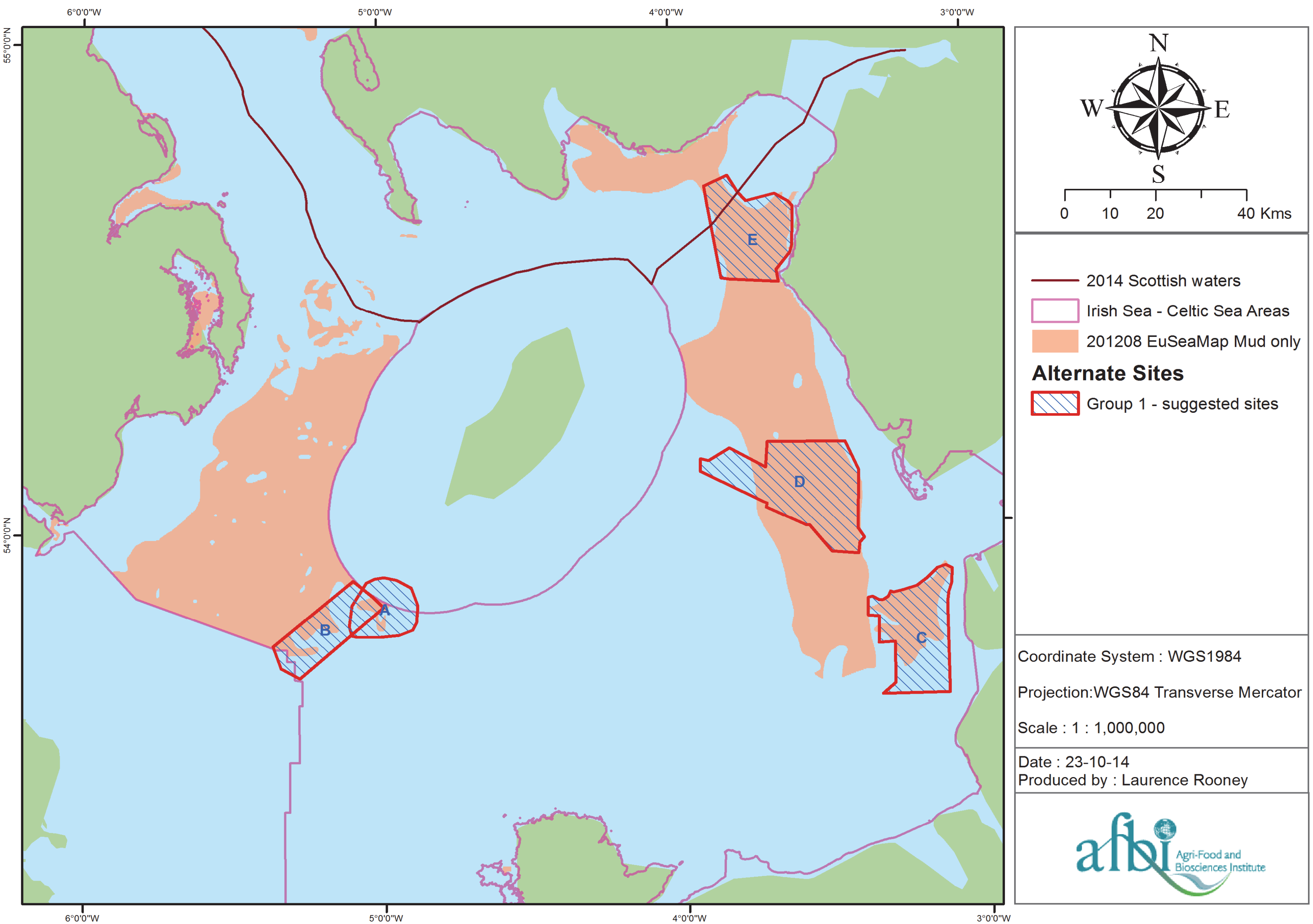


Figure 4 – Group 2 – suggested alternate

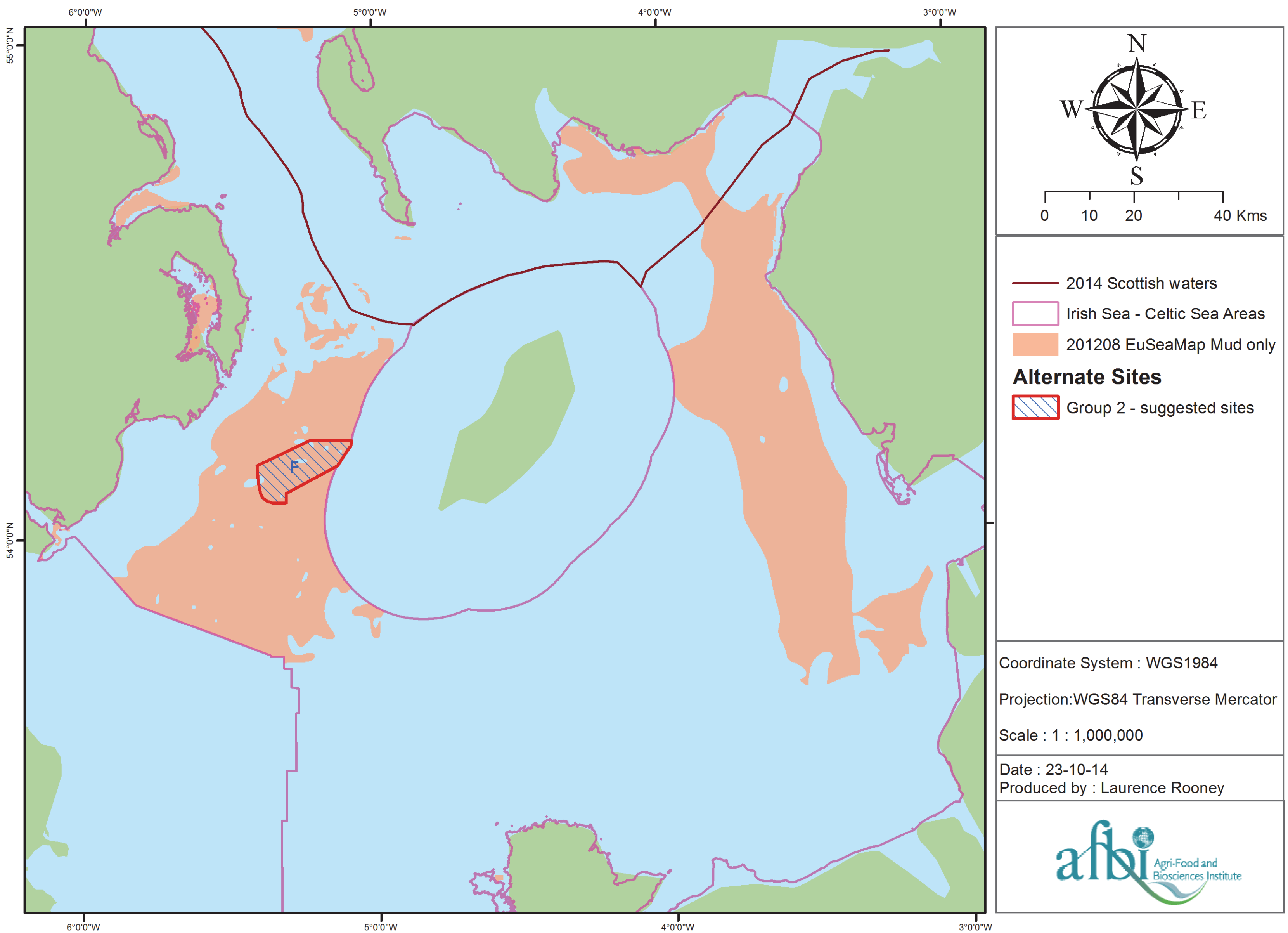


Figure 5 – Group 3 – suggested alternate sites

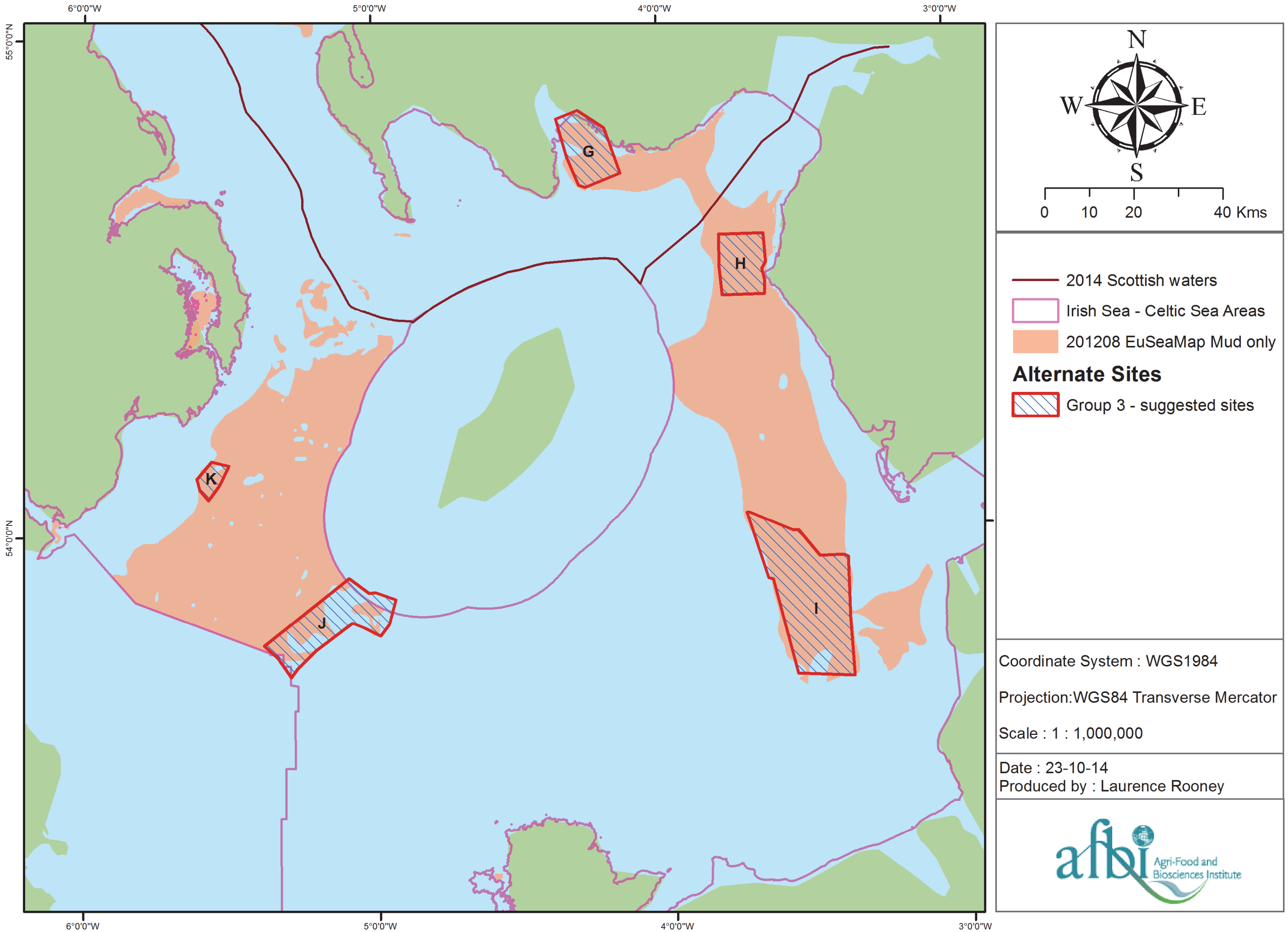


Figure 6 – Group compilation – all suggested alternate sites: using a traffic light system

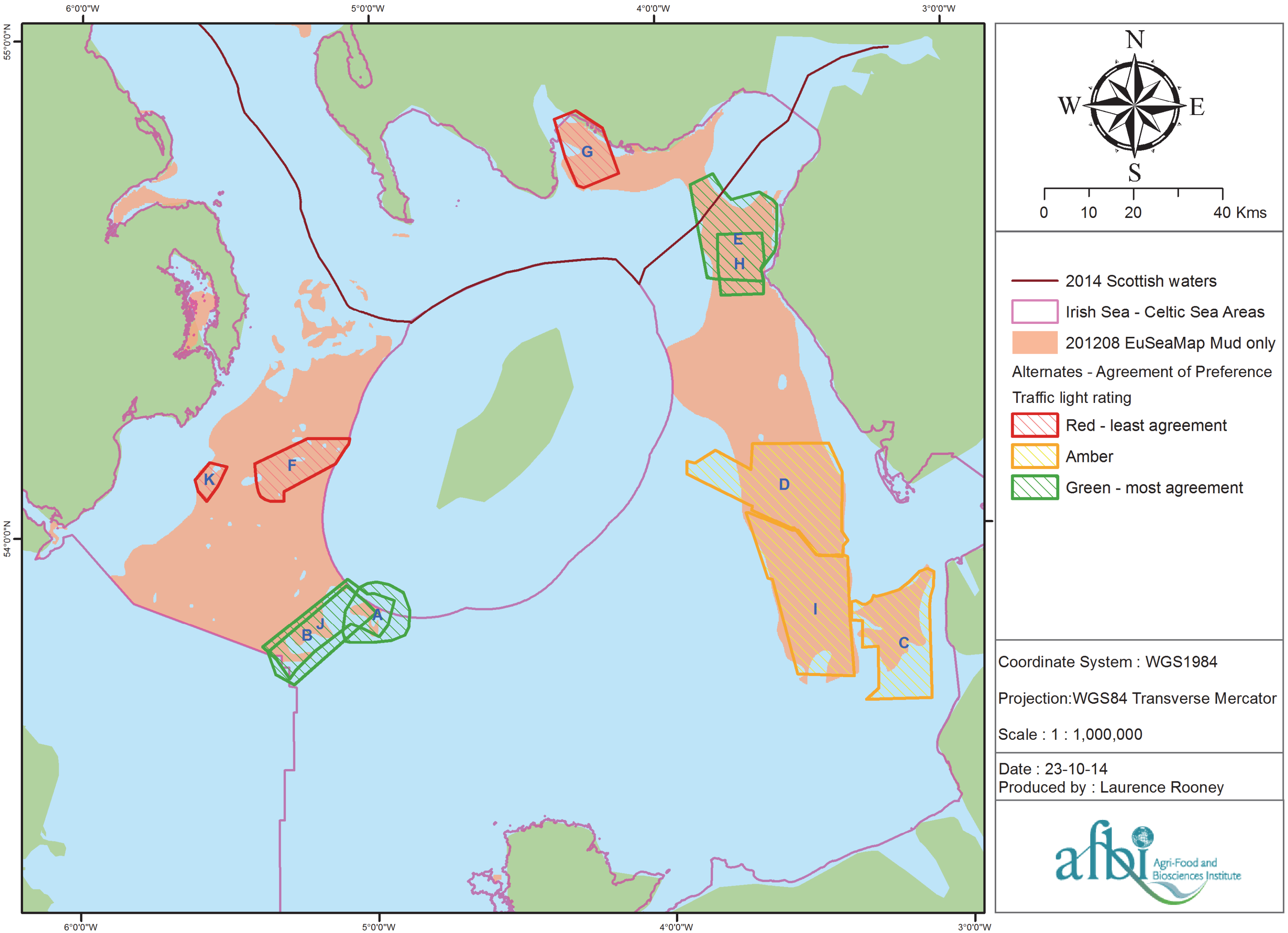


Figure 6B– Group compilation – all suggested alternate sites: using a traffic light system & habitats

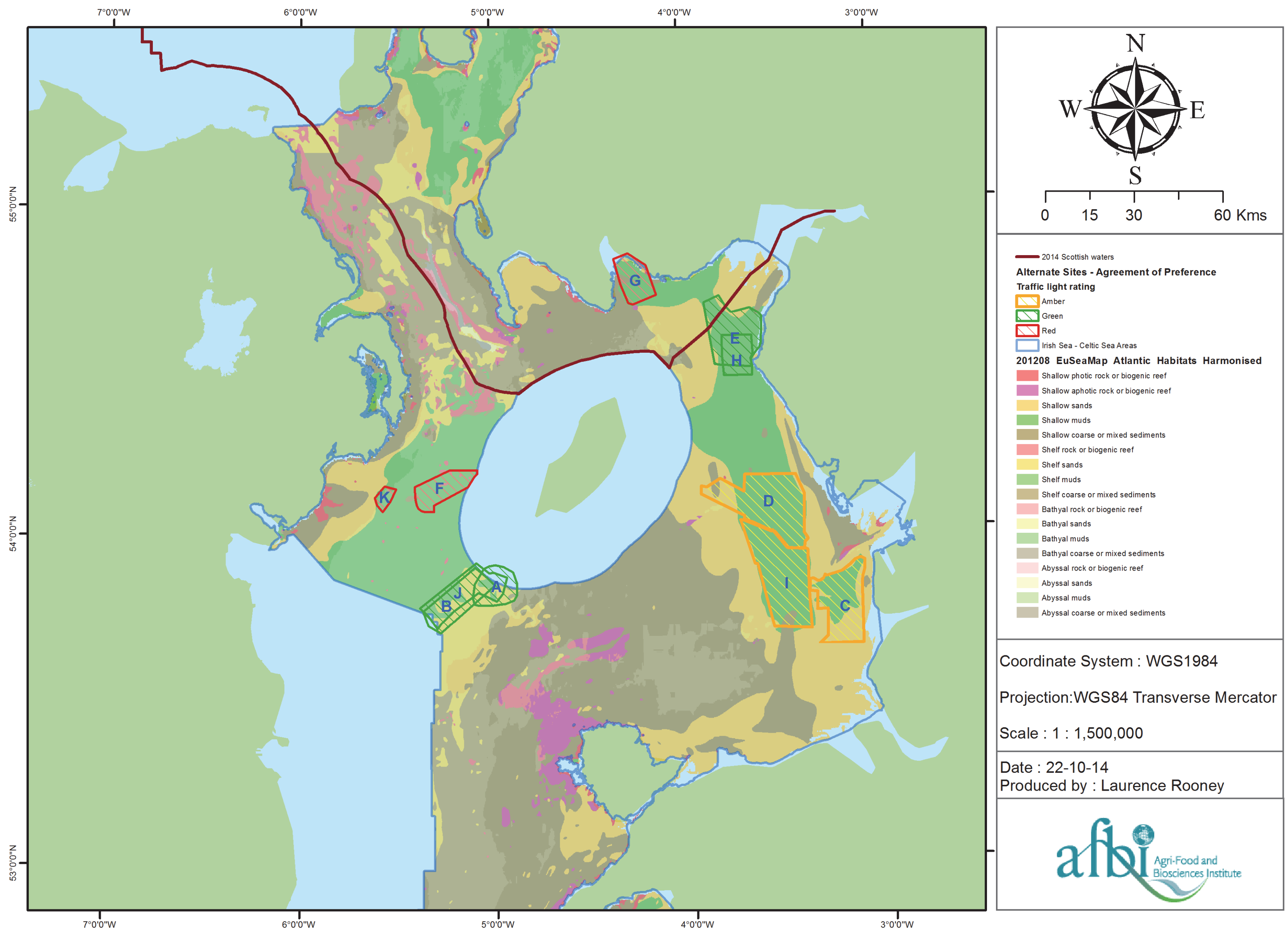


Figure 7 – Existing proposed MCZ's in the Irish Sea region – EuSeaMap habitats underlain.

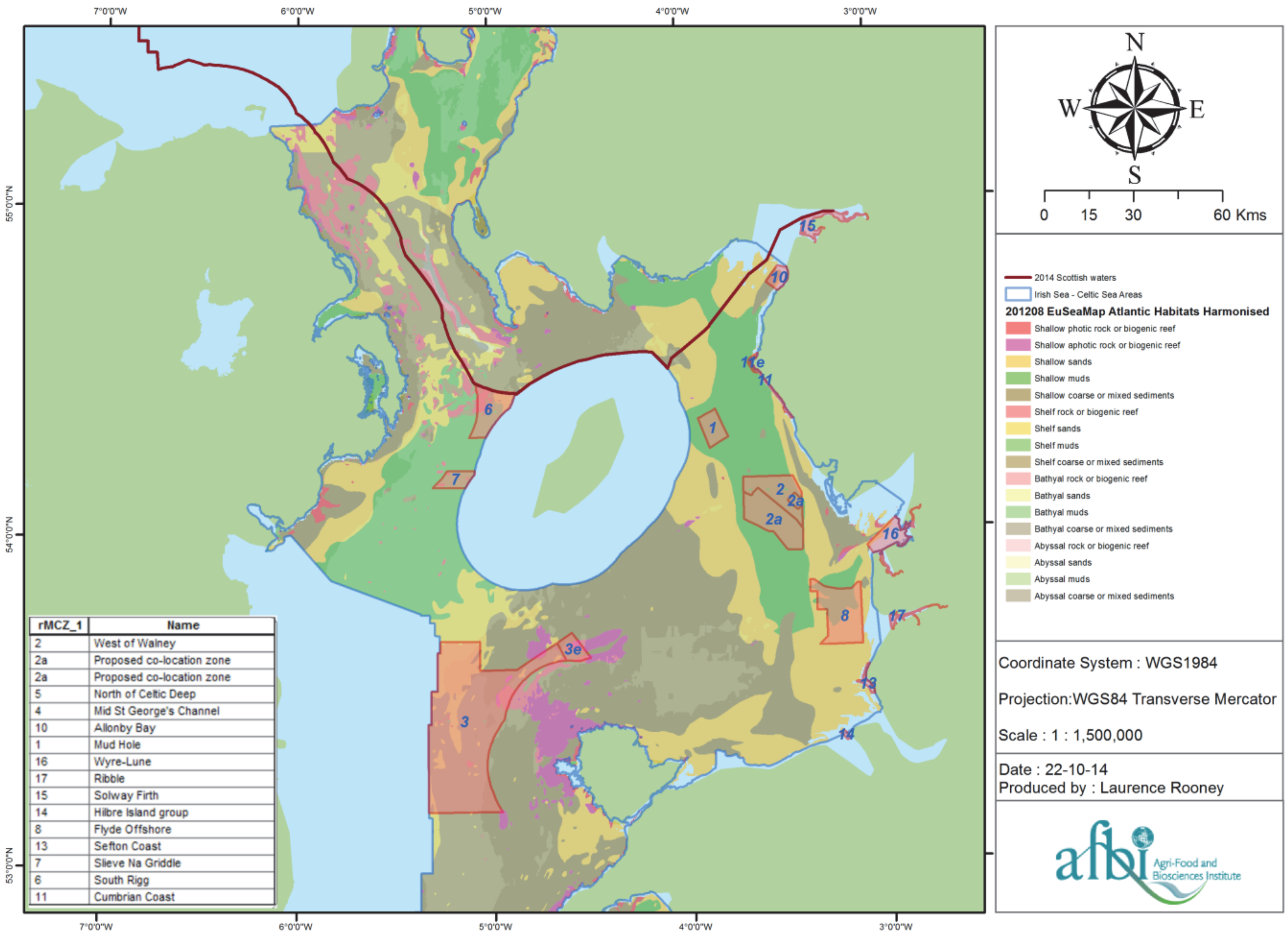


Figure 8 – Existing proposed MCZ's in the Irish Sea region and 2011 NI VMS.

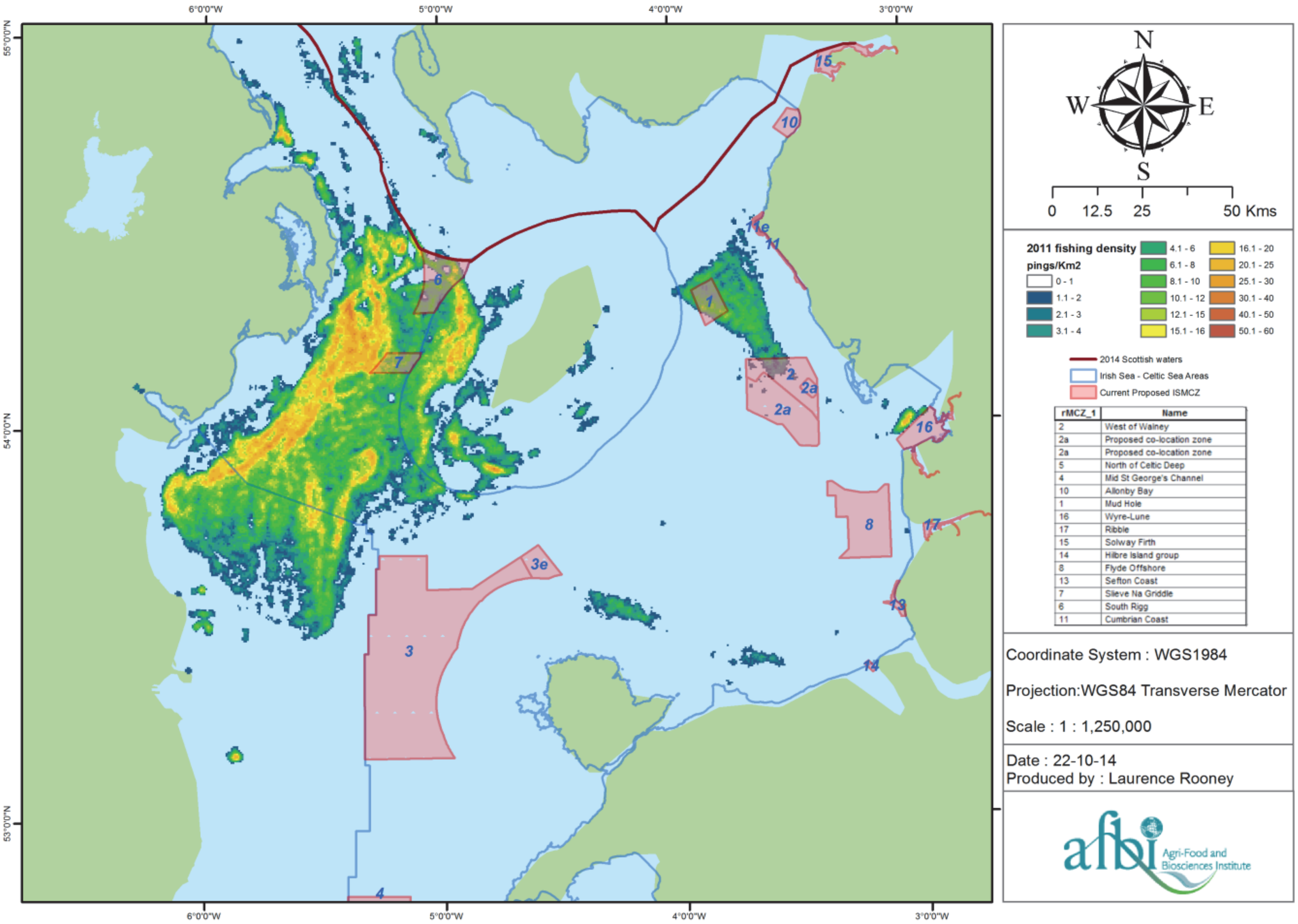


Figure 9 – 2011 NI VMS in the background with alternate sites highlighted in traffic colour system. Map also shows sites designated for potential renewable energy development.

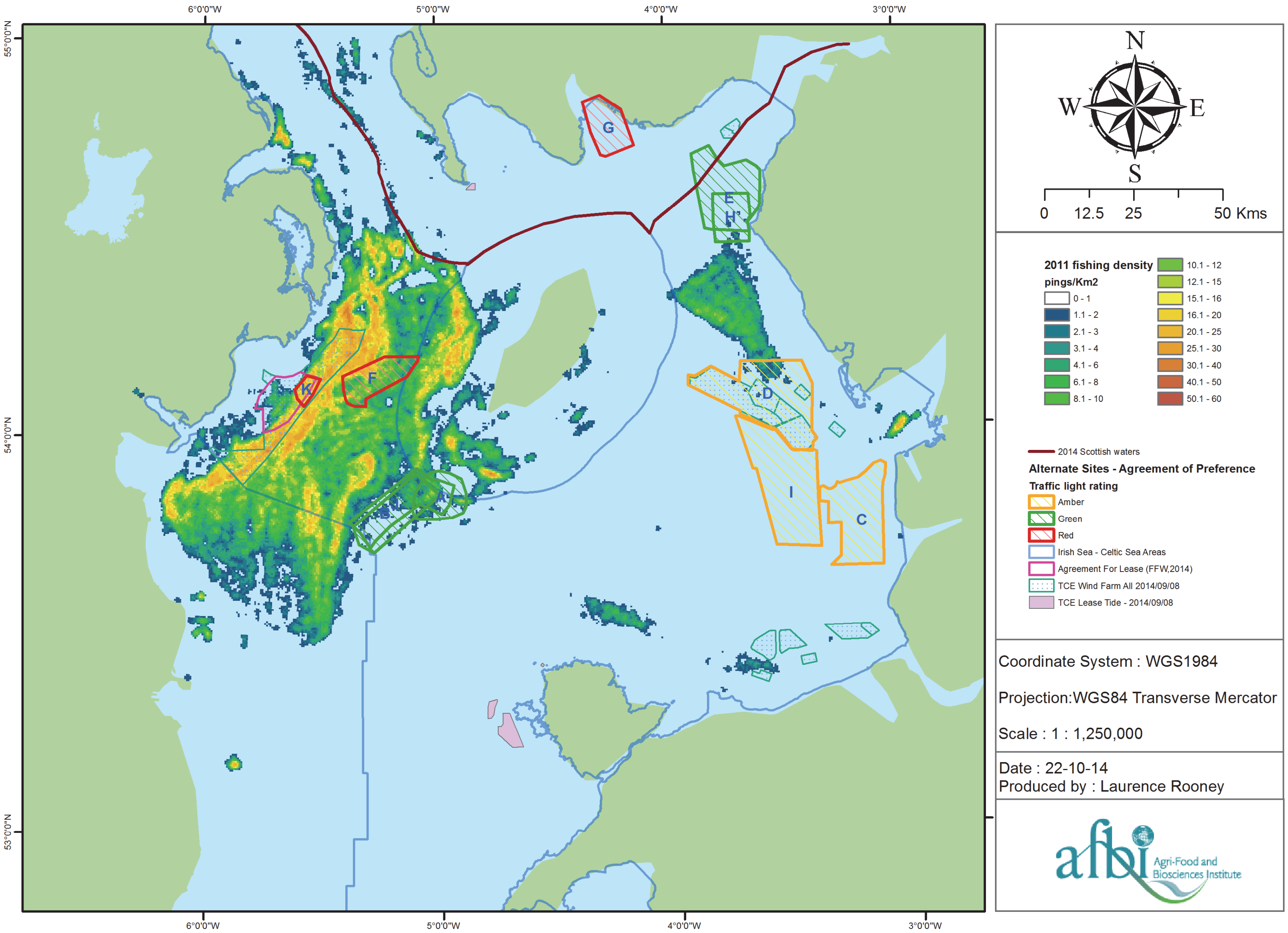


Figure 10 – 2011 NI VMS with *Nephrops* fishing grounds (red outline) and EuSeaMap habitats underneath