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Mapping of the Haig Fras Site of Community Importance (SCI)

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Summary

This report describes the results from multidisciplinary field surveys of the Haig Fras reef complex, presently designated as a Site of Community Importance (SCI) and a candidate Special Area of Conservation (cSAC). Since the designation of Haig Fras as an SCI, new evidence has come to light suggesting that the Annex I reef habitat, for which the site was selected, extends outside the existing site boundary, prompting the present investigation to map the full extent of reef habitat at Haig Fras. The Centre for Environment, Fisheries and Aquaculture Science (Cefas) and the Joint Nature Conservation Committee (JNCC) jointly surveyed the Haig Fras complex, collecting remotely sensed multibeam data and directly observed ground-truthing data. These datasets have been analysed to determine the full extent of the Annex I reef and produce an updated habitat map of the area.

The total area of Annex I reef identified is approximately 176km^2; 26km^2 (15%) of which sits outside of the current SCI boundary. The predominant biotope observed on the rocky reef was A4.212: *Caryophyllia smithii*, sponges and crustose communities on wave-exposed circalittoral rock.

Sedimentary habitats present between the rocky reef outcrops have been characterised, mapped and assigned mostly to the biotope A5.15: Deep circalittoral coarse sediment. Although patches of boulders and cobbles were observed in the area, the acquired evidence did not meet published criteria for the identification and assignation of stony reef. Small patches of circalittoral rock surrounded by sediment were detected on the acoustic data record, however, there was no direct observation of these patches from ground-truthing samples.

Updated maps depicting the distribution of identified EUNIS habitat types and Annex I reef are presented.

Contents

1 Introduction and Objectives

Haig Fras is an isolated, fully submarine bedrock outcrop located in the Celtic Sea, 95km northwest of the Isles of Scilly. It is the only substantial area of bedrock reef habitat in the Celtic Sea beyond the coastal margin. It is surrounded by a sedimentary seabed at approximately 100m depth below Chart Datum (CD). Haig Fras supports a variety of faunal assemblages, ranging from those characterised by jewel anemones and Devonshire cup corals near the peak of the outcrop, to those comprising encrusting sponges, crinoids and Ross coral towards the base of the rock, where boulders surround its edge (Rees 2000).

Since the feature's recommendation as a Special Area of Conservation (SAC) to the European Commission for the protection of Annex I reef habitat (JNCC 2008), and its subsequent designation as a Site of Community Importance (SCI), new evidence has been collected from sonar data gathered from commercial fishing vessels (Olex bathymetry data), which suggests that the reef habitat extends beyond the designated SCI boundary (Figure 1). In addition, anecdotal evidence suggests that fishing vessels have been towing trawls between the two main reef peaks, evidenced by bathymetry data (Figure 1), but the precise nature of the seabed here is not known. It was the purpose of this investigation to conduct a dedicated multidisciplinary survey of the Haig Fras area, both to confirm its extent in relation to the existing SCI boundary and to produce an updated habitat map. Such information may be of use in revising the site boundary to encompass the entire Annex I reef present.

Two multidisciplinary surveys aboard the RV *Cefas Endeavour* were conducted to support this investigation: the first (initiated in January 2011 and completed during March/April 2011) collected multibeam bathymetric, backscatter and associated ground-truthing data from the principal rock outcrops that constitute the reef complex. The second (in July 2012) collected similar data from the central area of the SCI, between the two larger rock outcrops (Coggan, 2012). The second survey served to infill the data gaps produced by the first, and to determine the presence and location of stony reef in the area.

The objectives of this investigation were:

1. To conduct an acoustic survey to map the extent of the Annex I reef habitat at Haig Fras.
2. To collect ground-truth data from representative locations within the survey area to characterise the seabed habitats present at Haig Fras.
3. To produce a habitat map of Haig Fras.

1.1 Geological and biological context

Haig Fras is an isolated, fully submerged, steep sided, granite bedrock outcrop of Permian age, approximately 45km long, which emerges from the seabed that comprises Devonian-Carboniferous sedimentary rocks, and rises to *c*. 40 m depth. It was discovered and named in 1962 by Smith *et al* (1965) and was described by Edwards (1984) as the surface expression of a 'batholith', a large igneous intrusion formed from cooled magma in the Earth's crust. Jones *et al* (1988) considered it to be a Variscan intrusion, and concurred with Edwards (1984) that it was probably a separate structure to the main southwest England 'Cornubian Batholith' that crops out as the Scilly Isles and in mainland Cornwall, for example at Land's End, St Austell, Bodmin Moor and Dartmoor.

Four distinct biotopes were observed at Haig Fras by Rees (2000): (i) one dominated by jewel anemone *Corynactis viridis* on rock, (ii) one dominated by Devonshire cup coral *Caryophyllia smithii* on rock, (iii) one characterised by cup sponges and erect branching sponges on rock, and (iv) a complex community with red encrusting sponge, Devonshire cup coral *Caryophyllia smithii* and featherstars on boulders. He noted that the bryozoan *Pentapora foliacea*, squat lobster *Munida* sp. and brittlestars were also common.

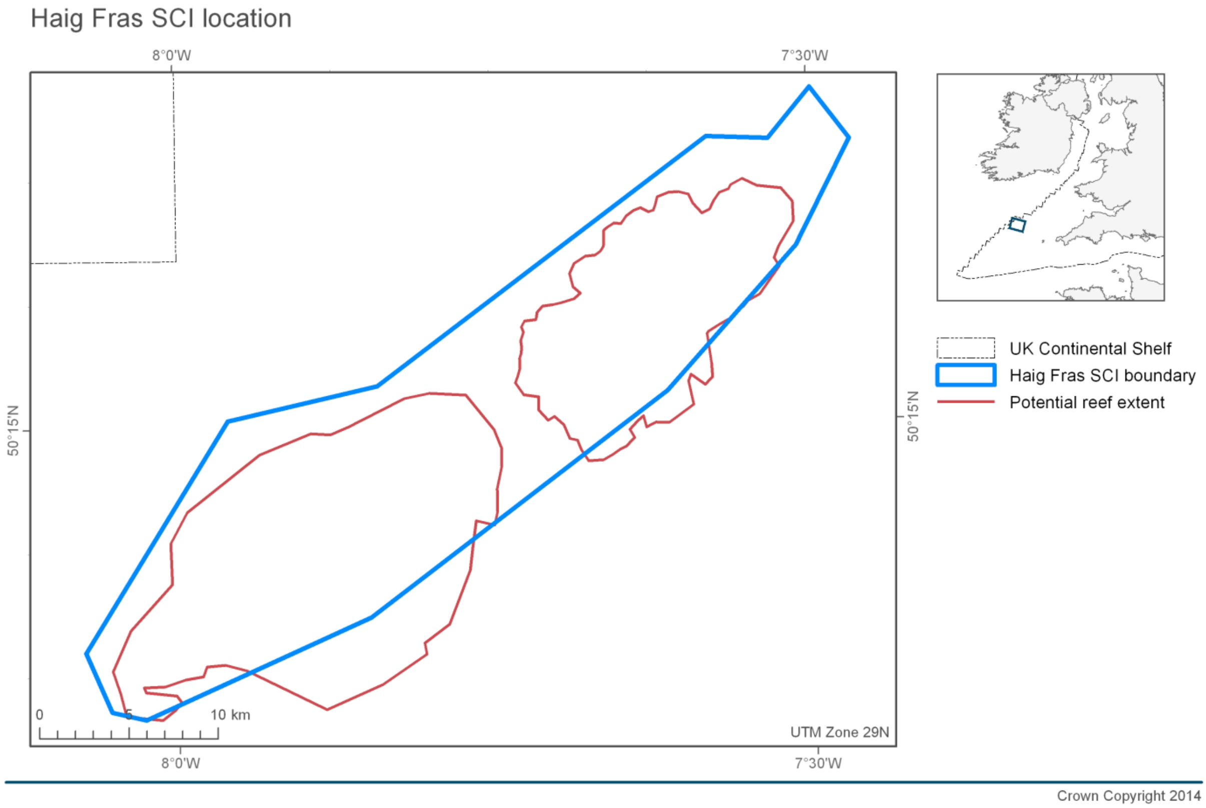

Figure 1. Map showing the predicted Annex I reef from Olex bathymetry data and Haig Fras SCI boundary.

2 Survey Design and Methods

2.1 Planning

During the 2011 survey, multibeam prospecting lines were run over Haig Fras at a very coarse scale to detect the approximate boundary of the outcrop feature (Figure 2). The boundary of the outcrop was defined at 31 crossing points along the prospecting lines and the predicted extent of the feature subdivided into seven sections for survey ('survey 'boxes') to be studied acoustically in a systematic fashion (Figure 2). Full-coverage acoustic data was not obtained from all survey boxes, as data acquisition lines were terminated beyond the reef feature boundary. Large gaps in the acoustic data record collected in 2011 were used to delineate the area between the two principal outcrop features to be targeted by the 2012 acoustic data infill survey.

Processed multibeam and backscatter imagery was used to assist in the optimum location of sites for ground-truthing with underwater video cameras and sediment grabs (Figure 3). Camera transects were selected to ascertain the extent and characteristics of observed habitats, as well as to define potential differences between areas of contrasting backscatter intensity. Grabs were also targeted at areas of differing backscatter intensity on sedimentary substrates.

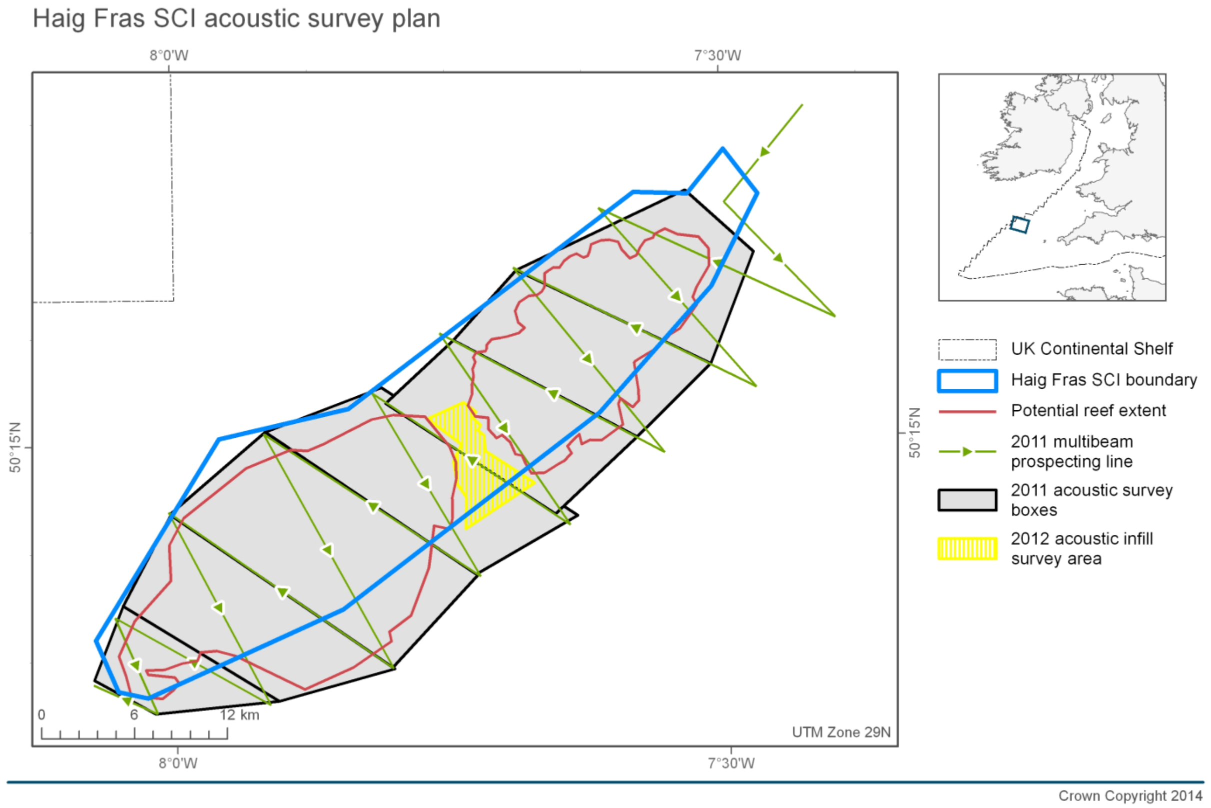

Figure 2. Haig Fras SCI combined acoustic survey plan for 2011 and 2012 surveys.

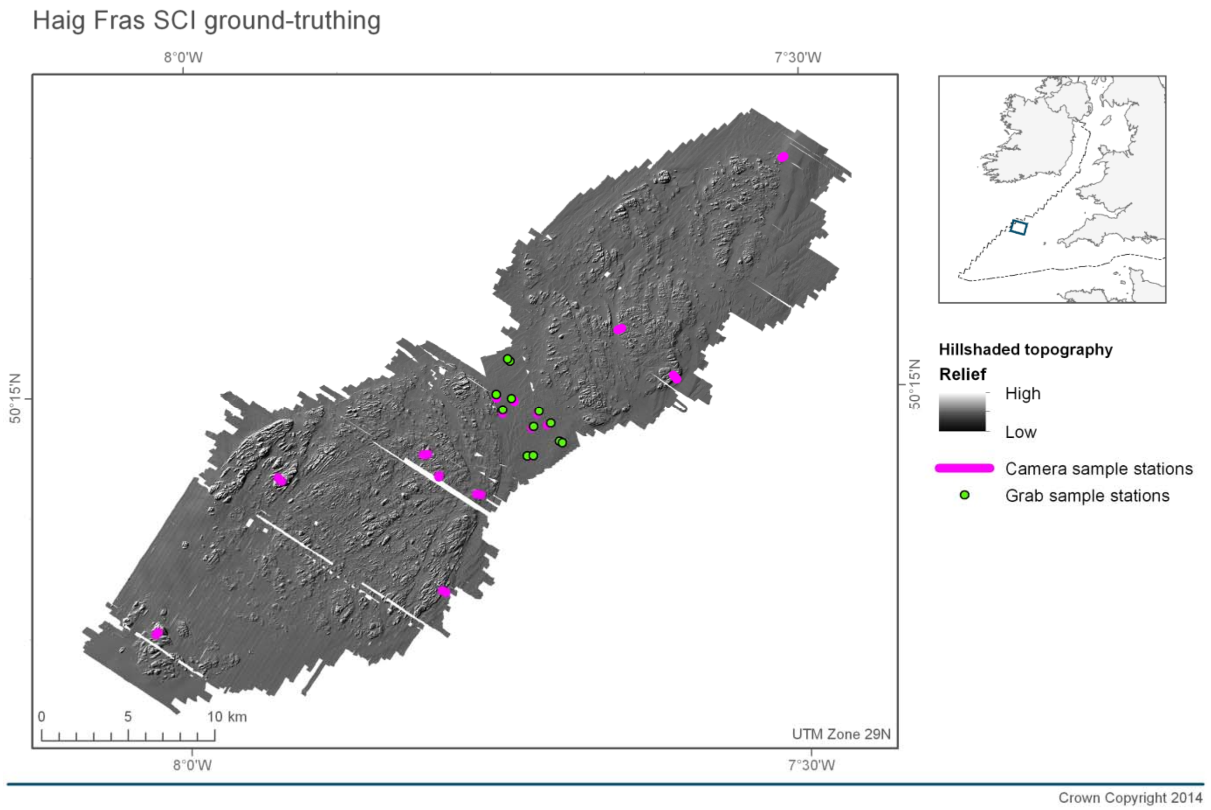

Figure 3. Location of ground-truthing stations, including camera tows and Hamon grab samples from both 2011 and 2012 surveys.

2.2 Multibeam data acquisition

Multibeam bathymetry and backscatter data were acquired using two Kongsberg multibeam systems run simultaneously. The EM3002D system was used on the 2011 survey, so this was used again in 2012 to maximise consistency between the backscatter data from the two surveys. The newer, more advanced EM2040 system was also used, and was the preferred instrument for deriving bathymetric data. This was operated at 200kHz to prevent interference with the 300kHz frequency of the EM3002D system. On both survey occasions, the multibeam system was deployed on the drop keel of RV *Cefas Endeavour*, which was lowered to its full extent to minimise the effect of bad weather on the acoustic signal. Positioning data were obtained using a CNAV 3050 DGPS, with kinematic position derived from the St Mary's reference station (Isles of Scilly), and corrected for the movement of the multibeam heads with an MRU5 motion reference unit. Variations of sound velocity with water depth were recorded daily using a CTD (conductivity temperature depth) probe and applied during multibeam data acquisition.

2.3 Ground-truth sampling

2.3.1 Underwater video and photography

Underwater video footage and photographic stills of the rock outcrop were acquired using a Kongsberg camera and flash setup (models OE14-208 and 11-242, respectively) mounted on a lightweight aluminium drop-camera frame. High-power LED strip lights and a four-point laser system (to provide scale) were also mounted. A live feed from the camera to the deck of the survey vessel allowed for direct observation of the seabed during sample acquisition.

The MESH 'Recommended operating guidelines for underwater video and photographic imaging techniques'[1] were followed during video sample acquisition. At each sampling site, the vessel's dynamic positioning system (DP) was used to set the course and speed of the tow. Photographs were taken at approximately one minute intervals and opportunistically at particular features of interest. All video footage and still photographs have been digitised and delivered to the JNCC.

2.3.2 Grabs

Sedimentary habitats targeted during the 2012 acoustic data infill survey were ground-truthed by a combined grab and underwater camera system. The system comprised a $0.1m^2$ mini Hamon grab fitted with a video camera, the combined gear being known as a HamCam. This allowed an image of the undisturbed seabed surface to be obtained before acquiring each grab sample. Samples were collected from anywhere within a 100m bullring (created using the Tower survey logging system) centred on the target location. On recovery, the contents of the grab were emptied into a large plastic bin and a representative sub-sample of sediment (approx. 0.5 litres) taken for particle size analysis (PSA). The PSA sample was stored in a labelled plastic container and frozen ready for transfer to a laboratory ashore. The remaining sample was photographed and the volume of sediment measured and recorded. Benthic fauna were collected by washing the sample with sea-water over a 1 mm mesh sieve. The retained >1 mm fraction was transferred to a labelled container and preserved in buffered 4% formaldehyde for later analysis ashore.

2.4 Data and sample processing

2.4.1 Multibeam bathymetry and backscatter

Semi-automated and further manual cleaning of the multibeam soundings was undertaken using CARIS HIPS to produce a clean bathymetry surface. Tide-height data were smoothed and applied to reduce the depth data to CD using the UKHO VORF (Vertical Offshore

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[1] Source URL: www.searchmesh.net/pdf/GMHM3_Video_ROG.pdf

Reference Framework) model. Backscatter data were processed using QPS FMGT (Fledermaus Geocoder Toolbox) software, to produce georeferenced backscatter mosaics.

2.4.2 Multibeam image analysis

Object-based image analysis (OBIA) using the eCognition v8.8 software was used to map broadscale habitats. OBIA has been used extensively in terrestrial remote sensing applications (Blaschke 2010), but has also been used successfully for mapping benthic habitats (Lucieer 2008; Lucieer and Lamarche 2011). It has several advantages over traditional pixel-based image analysis approaches, for instance: (i) partitioning an image into objects is akin to the way humans conceptually organise the landscape/seascape to comprehend it; (ii) using image objects instead of pixels as basic units is less computationally intensive; (iii) image objects exhibit useful features (e.g. shape, texture, contextual relationships with neighbouring objects) that pixels lack; (iv) image objects are easily integrated into vector GIS (Hay and Castilla 2006).

OBIA consists of a two-step approach including segmentation and classification. The aim of the segmentation is to divide the image into meaningful objects of variable sizes, based on their spectral and spatial characteristics. The resulting objects can be characterised by various features, such as layer values (mean, standard deviation, skewness, etc.), geometry (extent, shape, etc.) and texture. The classification is based on combinations of these image object features.

Multibeam backscatter strength, multibeam bathymetry and seabed roughness were used as input image layers. Previous studies have demonstrated the importance of the primary data layers bathymetry and backscatter for substrate and habitat prediction (e.g. Diesing *et al* 2012). Roughness was selected as it was expected to differentiate relatively flat sedimentary areas from rugged bedrock morphology. Roughness is a derivative of bathymetry – it was calculated as the difference between the minimum and maximum values of a cell and its eight neighbours in a 3x3 kernel (Wilson *et al* 2007). Roughness has the same unit as the input layer (i.e. metres).

Segmentation was carried out using the ‘multiresolution segmentation’ algorithm in eCognition. The algorithm is an optimisation procedure, which locally minimises the average heterogeneity of image objects for a given resolution of image objects. Starting from an individual pixel (or existing image object), it merges pixels (or image objects) consecutively until a certain threshold, defined by the scale parameter (see below) is reached.

The goal of any segmentation is to create meaningful objects that are as large as possible and as small as necessary. The size of the objects can be influenced by the scale parameter, which is an abstract term that determines the maximum allowable heterogeneity for the resulting image objects. Larger scale parameters will result in larger objects, given constant heterogeneity of the input image layer. Likewise, lower heterogeneity will result in larger objects, given a constant scale parameter. Several scale parameters were trialled and a value of 5 was chosen.

The object heterogeneity, to which the scale parameter refers, is defined by the composition of the homogeneity criterion. This criterion defines the relative importance of colour (the main information from an image) versus shape of objects. If a high weighting is given to colour, the object boundaries will be determined predominantly by variations in colour of the image (e.g. backscatter strength). The shape criterion is influenced by values representing smoothness and compactness, both of which can be weighted. A high value for smoothness results in smoother boundaries of the objects, whereas a high value for compactness increases the overall compactness of image objects. Values of 0.9 for colour, 0.1 for shape, 0.5 for smoothness and 0.5 for compactness were applied.

Segmentation and classification were performed separately for rock and sediment substrates. Initially, a multiresolution segmentation was carried out on the roughness layer. Subsequently, neighbouring image objects were merged as long as their difference in roughness remained below a certain threshold using the 'spectral difference segmentation' algorithm. A threshold of 0.1m for roughness was determined through trials. Finally, small objects with an area <100 pixels (equivalent to 2,500m^2) were merged with neighbouring objects based on similarities in backscatter strength and roughness. In this way, the number of objects was reduced significantly, whilst at the same time the objects more closely resembled 'real' substrate patches.

The classification of the created image objects was carried out in several steps and used the 'assign class' and 'classification' algorithms in eCognition. Choices on thresholds for separation of habitats were informed by the available ground-truthing information; however samples were not used as training data in a strict sense. Initially, rocky substrate was separated from sediment where object mean values exceeded -24.5 dB for backscatter strength and 0.35m for roughness. Ground-truth information for these areas of high backscatter indicated the presence of the biotopes A4.1: Atlantic and Mediterranean high energy circalittoral rock and A4.2: Atlantic and Mediterranean moderate energy circalittoral rock. A threshold of 67m water depth was chosen to differentiate between these two different-energy habitats (this value was derived from camera tow DC04). In the absence of more ground-truth data, this boundary should currently be considered as tentative. Modelled data layers showing combined energy at the seabed were consulted but they did not agree with observations from the acquired video footage. The most likely reason for this mismatch is that the model is too coarse and the complex bathymetry of Haig Fras is not resolved sufficiently in the model, leading to an underestimate of the energy regime.

Previously created but unclassified objects were removed to allow for a segmentation specifically tailored to mapping sediment. This was performed on the backscatter strength data using the multi-resolution segmentation algorithm, followed by a spectral difference segmentation with a threshold of 5 dB and the removal of small objects <100 pixels (see above).

Because survey effort was focussed on detecting and characterising rock habitats, there was limited ground-truthing data on sedimentary habitats. Therefore, it was only possible to differentiate between sediments with no or low gravel content, and those with increased gravel fraction based on backscatter strength. It is well established that the intensity of the backscatter signal is governed by the relative amount of the gravel fraction in the sediment. Even a limited amount of gravel (*c*. 5%) will increase the backscatter strength noticeably (Goff *et al* 2000; 2004). Based on this knowledge, it was possible to distinguish between 'coarse and mixed sediment' on the one hand and 'sand and mud' on the other. Given the depth of the seabed around Haig Fras, it is assumed that all sedimentary habitats fall within the deep circalittoral zone (this was confirmed by the analysis of photographic stills). A threshold of -24 dB was determined by expert judgement after trialling several threshold values until an acceptable differentiation was achieved. The threshold was applied to differentiate between the biotopes A5.15: Deep circalittoral coarse sediment or A5.45: Deep circalittoral mixed sediments and A5.27: Deep circalittoral sand or A5.37: Deep circalittoral mud.

The resulting objects labelled with their respective class membership were exported as an ArcGIS shapefile.

2.4.3 Underwater video and stills analysis

Each video tow was analysed by an individual viewing the footage several times, first to detect and record any changes in habitat type (or biotope) across the entire transect, and second, to describe the physical features and quantify the epifauna characterising each habitat type observed. Physical features recorded included the proportion of different substrate types, inclination, texture, stability and formations. Epifauna were quantified according to the MNCR SACFOR abundance scale (S = Superabundant, A = Abundant, C = Common, F= Frequent, O = Occasional, R = Rare). A minimum of three photographic stills was analysed from each of the different biotope sections identified in the video transect. Epifauna from stills were also recorded using the SACFOR scale. All information extracted from the video and photographic still samples was recorded on the Marine Nature Conservation Review (MNCR) Habitat recording forms[2].

Distinct habitat types identified from video footage were described and classified according to both the MNCR and EUNIS[3] habitat type classification systems. Throughout the report, the term 'biotope' is used interchangeably with 'habitat type' regardless of the level within the classification hierarchy that is being described.

2.4.4 Grab sample analysis

PSA samples were processed following standard laboratory operating procedures to extract the particle size distribution data. Raw phi class data have been combined and expressed as percentage gravel, sand and mud fractions.

Faunal samples were processed to extract, identify and enumerate all captured benthic fauna. Taxon abundance data per sample have been subjected to standard univariate and multivariate analyses using the PRIMER software package (Clarke and Gorley 2006).

2.5 Data QA/QC

All activities in the field and laboratory were performed according to the recommendations in the following documents:

- Biological Monitoring: General Guidelines for Quality Assurance document (ICES 2004)
- Quality Assurance in Marine Biological Monitoring (Addison 2010)
- MESH Recommended operating guidelines for underwater video and photographic imaging techniques
- IHO order 1a standards for hydrographic surveys[4]

Grab samples, together with video and photographic stills, have been processed by specialist benthic taxonomists and results checked following the recommendations of the National Marine Biological Analytical Quality Control Scheme.

3 Results and Data Analysis

3.1 Bathymetric and backscatter maps

The Haig Fras rock outcrop is easily distinguishable from the surrounding seabed by its distinct rugged topography (Figure 4). Jones *et al* (1988), who carried out a radiometric survey of the Haig Fras reef complex, found three separate granite exposures which they labelled N.E. (North-East), Central and S.W. (South-West) granites. These exposures are clearly observed in the newly acquired multibeam bathymetry data. Figure 4 also shows the complexity of the seabed, with several rock pinnacles rising to up to 40m depth, jointing of the granitic rocks, and areas of relatively flat and smooth seabed in between rock outcrops.

[2] http://jncc.defra.gov.uk/page-2683

[3] http://eunis.eea.europa.eu/index.jsp

[4] https://www.iho.int/iho_pubs/standard/S-44_5E.pdf

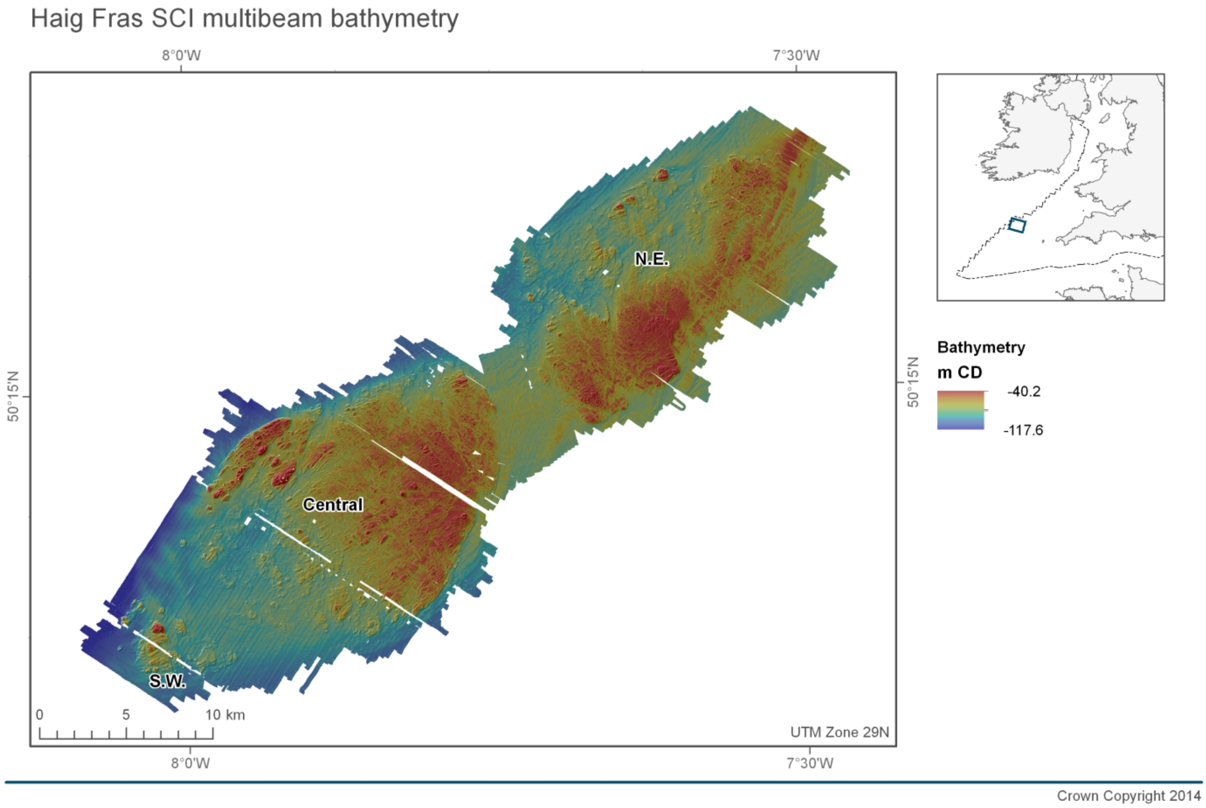


Figure 4. Multibeam bathymetry of the Haig Fras survey area showing the three principal granite exposures originally described by Jones *et al* (1988).

A map of backscatter strength is shown in Figure 5. Moderately high intensity and heterogeneous backscatter characterises large parts of the seabed, predominantly where the seabed has a rugged topography. This backscatter texture is typical for bedrock exposed at the seabed. In the vicinity of the bedrock, areas of high intensity and homogeneous backscatter are visible as dark areas in Figure 5. In places, they form features known as 'sorted bedforms' (Murray and Thieler 2004). Given their high backscatter and what is known about sorted bedforms, they most likely consist of coarse-grained sediment. The remainder of the seabed is characterised by moderate-to-low intensity backscatter, characteristic of sandy or muddy substrates.

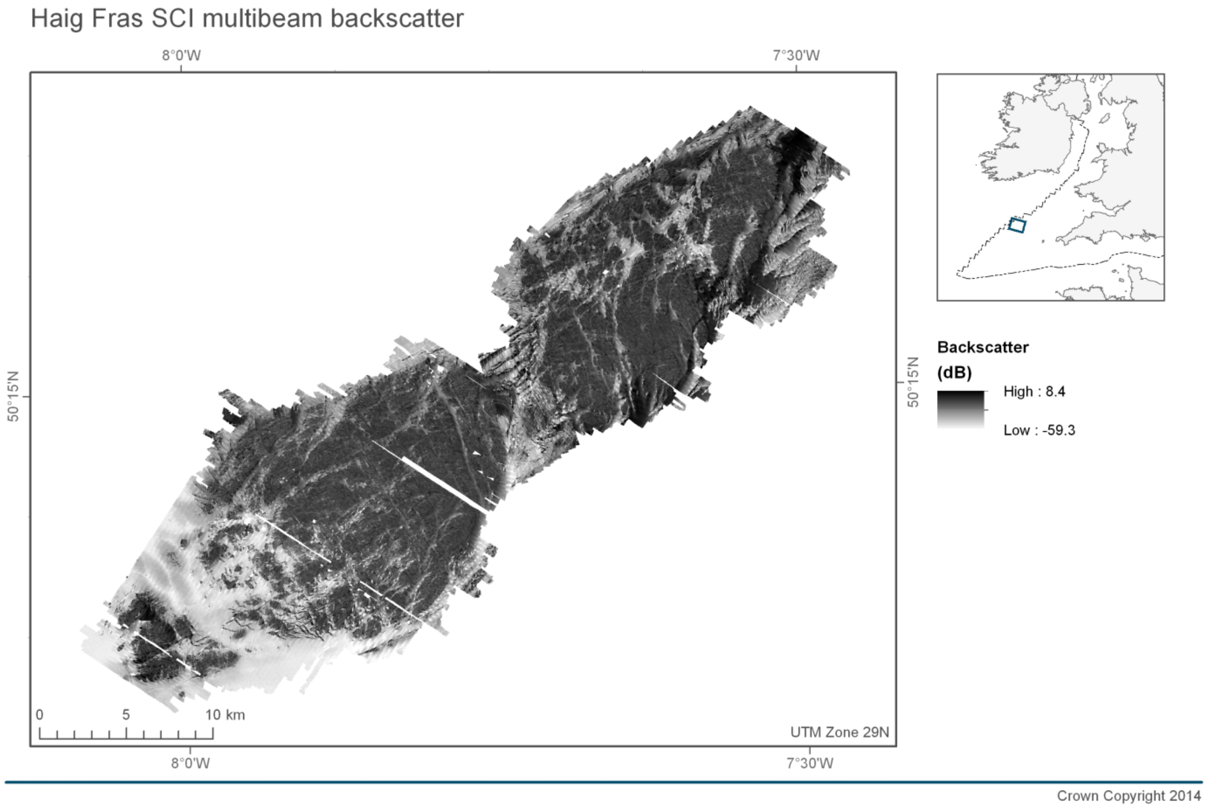


Figure 5. Multibeam backscatter strength in the Haig Fras survey area.

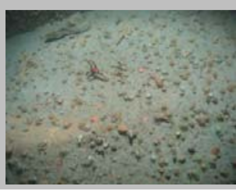
3.2 Seabed imagery

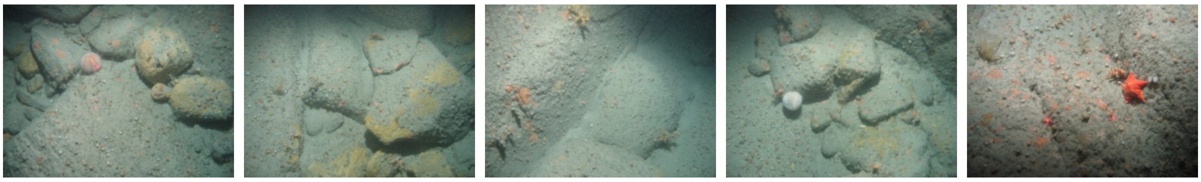
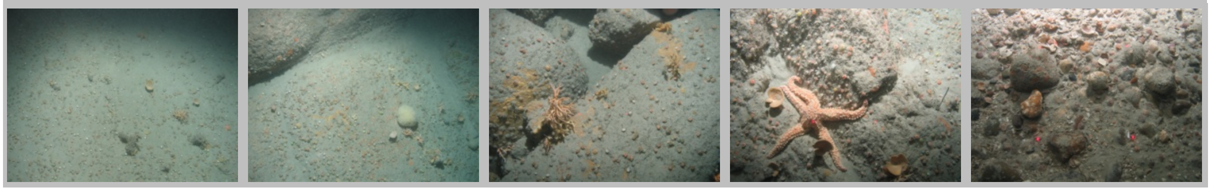
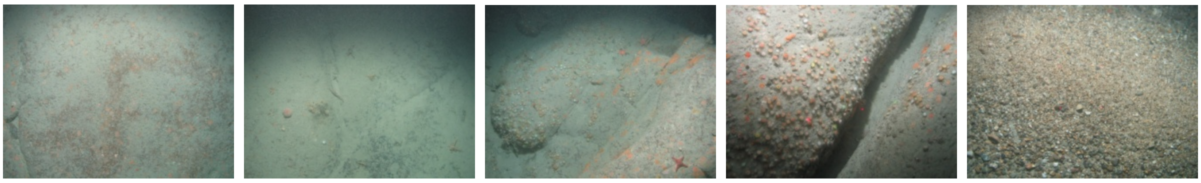
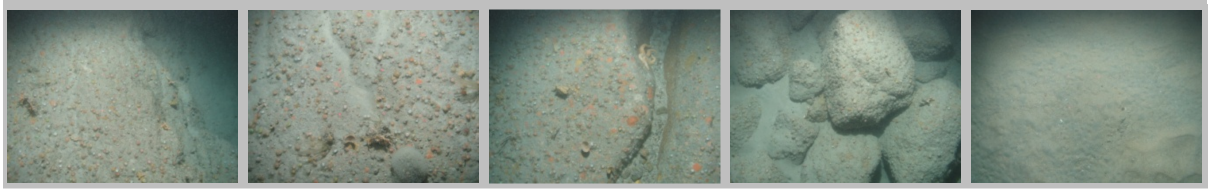
Table 1 presents the description of each section (habitat type) observed on the video footage recorded at each camera sampling station, together with example photographs taken of each habitat type. Note that a single camera transect was sampled at each ground-truthing station, with the exception of six stations in the infill survey area, where the transect started at one station and finished at another (HFI01 to HFI02, HFI09 to HFI10 and HFI11 to HFI12).

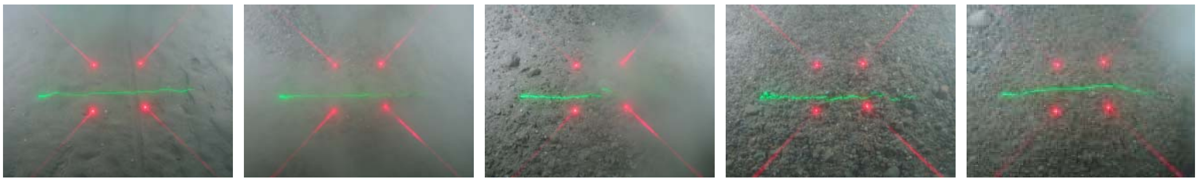
Table 1. Habitat descriptions and example still photographs of sections observed on the video footage from each camera sample station. DC: drop camera (station code nomenclature assigned to 2011 survey); HFI: Haig Fras Infill (station code nomenclature assigned to 2012 survey).

Sample station	Video section	Habitat description
DC01	S1	Encrusted bedrock with patches of boulders. Silt on rocks and patches of Brachiopods
	S2	Mixture of sand and *Glycymeris* shells




Sample station	Video section	Habitat description
DC02	S1	Encrusted bedrock with patches of boulders. Silt on rocks and patches of Brachiopods
		
DC03	S1	Encrusted bedrock and boulders. Large patches of sand over the bedrock in places
		
DC04	S1	*Corynactis viridis* encrusted bedrock
	S2	Encrusted bedrock with patches of boulders. Silt on rocks and patches of Brachiopods
		
DC05	S1	Encrusted bedrock and boulders. Silt on rocks and patches of Brachiopods
	S2	Mixed sediment with encrusted cobbles
		
DC06	S1	Heavily silted bedrock
	S2	Encrusted bedrock and boulders. Silt on rocks and patches of Brachiopods
	S3	Coarse sediment
		
DC08	S1	Encrusted bedrock and boulders. Silt on rocks and patches of Brachiopods
	S2	Sand with occasional boulder
		

Sample station	Video section	Habitat description
DC09	S1	Encrusted bedrock with brittlestars. Silt on rocks and patches of Brachiopods
		
DC10	S1	Sand with occasional cobbles
	S2	Encrusted bedrock and boulders. Silt on rocks and patches of Brachiopods
		
HFI01-02	S1	Fine rippled sand with empty shells and shell fragments with dense patches of pebbles, shell and granules
		
HFI03	S1	Small boulders, cobbles pebbles and shell fragments on coarse sand
		[tow terminated after one minute due to technical fault]
HFI03b	S1	Cobbles, pebbles, shell fragments and sand with occasional boulders
		
HFI04	S1	Bryozoa encrusted cobbles and pebbles on coarse granules and muddy sand
		
HFI05	S1	Encrusted cobbles and pebbles on coarse sand with shell debris
		

Sample station	Video section	Habitat description
HFI06	S1	Coarse rippled sand with shell fragments
		
HFI07	S1	Small boulders, cobbles and pebbles creating mosaic on coarse sediment
		
HFI08	S1	Small boulders, cobbles, pebbles and shell fragments on coarse sand
		
HFI09-10	S1	Slightly rippled muddy sand with occasional dense patches of Bryozoa encrusted cobbles, pebbles and shell
		
HFI11-12	S1	Fine rippled sand with minimal shell debris
	S2	Cobbles and pebbles compressed into muddy sand
		

The difference in habitat type between samples targeting rock outcrop (prefixed DC) and those targeting sediment (prefixed HFI) is striking. While there is no doubt that the physical and biological characteristics of rock reef are represented in samples from the rock outcrop, such evidence is less convincing in samples from sedimentary areas. Within the sedimentary habitat, patches of coarse sediment and hard substrates occur, however none of these areas conforms unequivocally to the accepted definition of rocky or stony reef (see Section 4.2 for further rationale supporting this assessment).

Since video samples from the 2011 survey targeted the rock outcrop and those from the 2012 survey targeted the sediment area between outcrops, differences in epifaunal assemblage composition between substrates and surveys would be expected. In addition, each set of samples was processed by different institutions, potentially introducing bias and accentuating the difference between datasets, which would be impossible to filter out. For these reasons, further comparative analyses have not been conducted on the combined epifaunal datasets from each survey, as the differences inherent in the combined dataset would override any subtler difference in epifaunal assemblage composition within each habitat type. Biotope assignations to distinct video segments from both surveys are reported later in the report (Section 3.4).

3.3 Grab sample data

Grab samples were obtained only from the sediment substrate known to occur in the area between the two principal rocky outcrops (i.e. the acoustic data infill survey area).

3.3.1 PSA

Of the 12 ground-truthing stations targeted, grab sampling for sediment was successful at 11 stations (no sample from HFI08). Any description of broadscale pattern in sediment distribution is limited by the small number of samples taken, but available data (Table 2) do suggest that seabed sediments are predominantly coarser in the shallower areas – where prevailing currents may be stronger – and becoming gradually finer with depth down the northwest- and southeast-facing slopes of the infill survey area (Figure 6).

Table 2. Summary results from PSA of sediment samples, together with sediment description according to Folk[5] and EUNIS classification systems.

Sampling station	% Gravel	% Sand	% Mud	FOLK	EUNIS
HFI01	1	74	25	mS	A5.2: Sublittoral sand
HFI02	61	34	5	msG	A5.4: Sublittoral mixed sediment
HFI03	41	57	2	sG	A5.1: Sublittoral coarse sediment
HFI04	39	59	2	sG	A5.1: Sublittoral coarse sediment
HFI05	55	42	3	sG	A5.1: Sublittoral coarse sediment
HFI06	9	72	19	gmS	A5.4: Sublittoral mixed sediment
HFI07	38	58	4	sG	A5.1: Sublittoral coarse sediment
HFI09	3	75	22	(g)mS	A5.2: Sublittoral sand
HFI10	9	83	8	gS	A5.4: Sublittoral mixed sediment
HFI11	0	90	10	S	A5.2: Sublittoral sand
HFI12	57	28	15	msG	A5.1: Sublittoral coarse sediment

[5] http://www.emodnet-seabedhabitats.eu/PDF/GMHM3_Detailed_explanation_of_seabed_sediment_classification.pdf

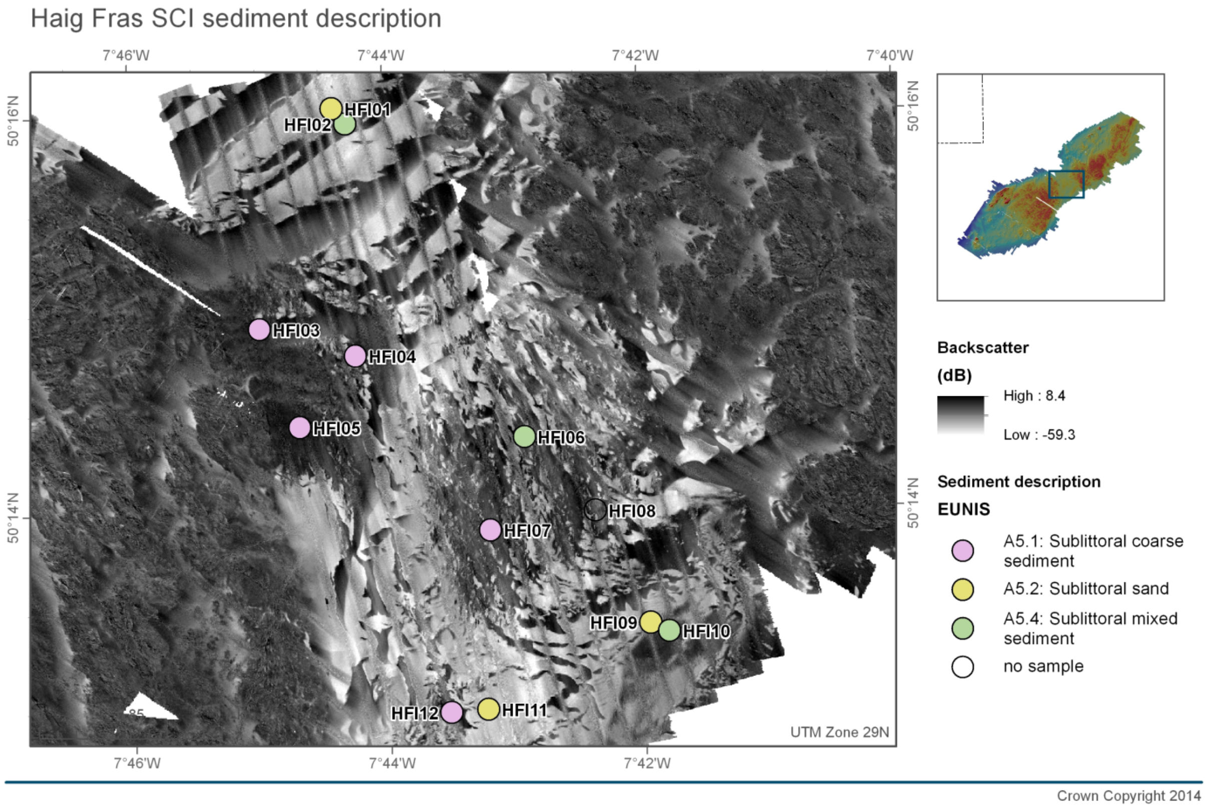


Figure 6. Spatial distribution of sediment samples described according to the EUNIS classification system against a background of multibeam backscatter.

3.3.2 Infauna

Taxon abundance data extracted from ten successful faunal grab samples were analysed. The number of taxa (including colonial taxa) recorded from each sample ranged between 16 and 36; faunal abundance per sample (excluding colonial taxa) ranged between 24 and 122 organisms. Assemblage composition analysis revealed two statistically distinct assemblages when analyses were performed using taxon abundance data (Figure 7), this difference was not evident when analyses were performed on taxon presence-absence data alone. This result suggests that the infaunal assemblage across the survey area is taxonomically homogeneous, with local variation in the relative abundance of certain taxa. The relative abundance of each taxon and its contribution to the similarity within each distinct assemblages identified is presented in Annex 2.

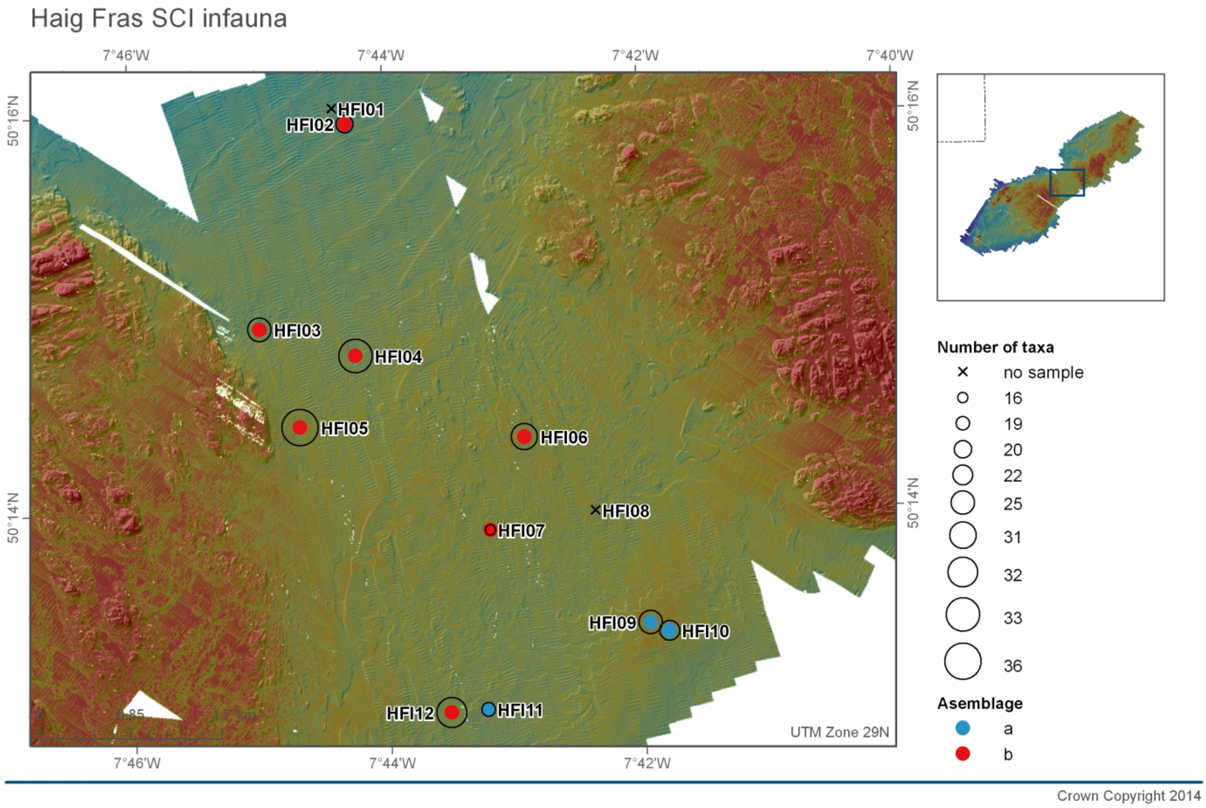


Figure 7. Number of infaunal taxa per grab sample and distribution of distinct assemblages identified.

3.4 Biotopes

MNCR and EUNIS habitat type codes (or biotopes) were assigned to each section identified from the video transects (Table 3). As expected, the difference in biotope allocation between surveys is striking, with all stations from the 2011 survey of the outcrop being classified as circalittoral rock and those from the 2012 infill survey being classified as circalittoral sediment of varying coarseness. Figures A1.1 to A1.18 in Annex 1 show each video transect classified by biotope overlain on the bathymetry map created by this investigation.

Table 3. EUNIS and MNCR biotope codes for each section identified from the camera transect stations.

Camera transect	Habitat section	EUNIS code	MNCR code	Description
DC1	S1	A4.212	CR.MCR.EcCr.CarSp	*Caryophyllia smithii*, sponges and crustose communities on wave-exposed circalittoral rock
	S2	A5.45	SS.SMx.OMx	Offshore circalittoral mixed sediment
DC2	S1	A4.212	CR.MCR.EcCr.CarSp	*Caryophyllia smithii*, sponges and crustose communities on wave-exposed circalittoral rock
DC3	S1	A4.212	CR.MCR.EcCr.CarSp	*Caryophyllia smithii*, sponges and crustose communities on wave-exposed circalittoral rock
DC4	S1	A4.132	CR.HCR.XFa.CvirCri	*Corynactis viridis* and a mixed turf of crisiids, *Bugula*, *Scrupocellaria*, and *Cellaria* on moderately tide-swept exposed circalittoral rock
	S2	A4.212	CR.MCR.EcCr.CarSp	*Caryophyllia smithii*, sponges and crustose communities on wave-exposed circalittoral rock
DC5	S1	A4.212	CR.MCR.EcCr.CarSp	*Caryophyllia smithii*, sponges and crustose communities on wave-exposed circalittoral rock
	S2	A5.45	SS.SMx.OMx	Offshore circalittoral mixed sediment
DC6	S1	A4.3	CR.LCR	Low energy circalittoral rock
	S2	A4.212	CR.MCR.EcCr.CarSp	*Caryophyllia smithii*, sponges and crustose communities on wave-exposed circalittoral rock
	S3	A5.15	SS.SCS.OCS	Offshore circalittoral coarse sediment
DC8	S1	A4.212	CR.MCR.EcCr.CarSp	*Caryophyllia smithii*, sponges and crustose communities on wave-exposed circalittoral rock
	S2	A5.27	SS.SSa.OSa	Offshore circalittoral sand
DC9	S1	A4.2121	CR.MCR.EcCr.CarSp.Bri	Brittlestars overlying coralline crusts, *Parasmittina trispinosa* and *Caryophyllia smithii* on wave-exposed circalittoral rock
DC10	S1	A5.27	SS.SSa.OSa	Offshore circalittoral sand
	S2	A4.212	CR.MCR.EcCr.CarSp	*Caryophyllia smithii*, sponges and crustose communities on wave-exposed circalittoral rock
HFI01-02	S1	A5.27	SS.SSa.OSa	Offshore circalittoral sand
	S2	A5.15	SS.SCS.OCS	Offshore circalittoral coarse sediment
HFI03	S1	A5.15	SS.SCS.OCS	Offshore circalittoral coarse sediment
HFI03b	S1	A5.15	SS.SCS.OCS	Offshore circalittoral coarse sediment
HFI04	S1	A5.15	SS.SCS.OCS	Offshore circalittoral coarse sediment
HFI05	S1	A5.15	SS.SCS.OCS	Offshore circalittoral coarse sediment
HFI06	S1	A5.27	SS.SSa.OSa	Offshore circalittoral sand
HFI07	S1	A5.15	SS.SCS.OCS	Offshore circalittoral coarse sediment
HFI08	S1	A5.15	SS.SCS.OCS	Offshore circalittoral coarse sediment

Camera transect	Habitat section	EUNIS code	MNCR code	Description
HFI09-10	S1	A5.15	SS.SCS.OCS	Offshore circalittoral coarse sediment
HFI11-12	S1	A5.27	SS.SSa.OSa	Offshore circalittoral sand
	S2	A5.15	SS.SCS.OCS	Offshore circalittoral coarse sediment

The majority of the rocky reef observed was assigned to the biotope A4.212: *Caryophyllia smithii*, sponges and crustose communities on wave-exposed circalittoral rock, as it was predominantly characterised by *Caryophyllia smithii* and sponges. The bedrock associated with this biotope was generally silted, suggesting a moderate to low-energy environment. The brachiopod *Neocrania anomala* was also present, sometimes at very high density (common to abundant). *N. anomala* is usually associated with low-energy circalittoral rock biotopes such as A4.314: *Neocrania anomala* and *Protanthea simplex* on sheltered circalittoral rock (not formally recorded in this investigation). The recorded biotope A4.212 on Haig Fras may be an intermediate variant between the pre-defined moderate and low energy circalittoral rock biotopes. As this biotope was observed along the majority of the camera transects, it is likely that this is the most prevalent biotope across the whole rock outcrop.

Section 1 of transect DC4 was assigned to the biotope A4.132: *Corynactis viridis* and a mixed turf of crisiids, *Bugula*, *Scrupocellaria*, and *Cellaria* on moderately tide-swept exposed circalittoral rock. This biotope was also recorded by Rees (2000), in his 'Zone 1', in shallow areas where *Corynactis viridis* was predominant. It is probable that other such shallow parts of the reef complex represent the same biotope. Section 1 of transect DC6 was classified as A4.3: Low energy circalittoral rock; this was because the bedrock was heavily silted and little encrusting fauna were visible. The sediments observed on the video footage ranged from sand, to coarse sediment, to mixed sediments.

In the infill survey area, video segments classified as the biotope A5.27: Offshore circalittoral sand corresponded with samples whose PSA results indicated a predominantly sandy substrate (HFI01, HFI06 and HFI11). Equally, there was close correspondence between video sections classified as the biotope A5.15: Offshore circalittoral coarse sediment and samples whose PSA results indicated the predominance of gravel (see Table 2 and Figure 6). No epifaunal taxa were characteristic, or exclusive to either, of the identified sedimentary biotopes.

3.5 EUNIS habitat map

Habitats identified though OBIA (Section 2.4.2) were classified according to the EUNIS classification system and mapped at Levels 3 (rock) and 4 (sediment). The resulting map is shown in Figure 8.

3.6 Extent of Annex I reef

The biotopes A4.1: Atlantic and Mediterranean high energy circalittoral rock and A4.2: Atlantic and Mediterranean moderate energy circalittoral rock that have been mapped in Figure 8 satisfy the criteria of 'hard compact substrata... arising from the sea floor', which are critical for defining Annex I reef according to the Interpretation Manual of European Union Habitats (European Commission 2007). In total, an area of 176km^2 representing Annex I rocky reef was identified within the survey area; the extent of the mapped reef is shown in Figure 9. Of the total area of reef mapped, 150km^2 (85%) lies within the current SCI boundary, and 26km^2 (15%) is outside.

Video imagery has shown that the rock substrate is colonised by epifauna typical of geogenic reefs, such as *Caryophyllia smithii*, *Neocrania anomala* and *Corynactis viridis*.

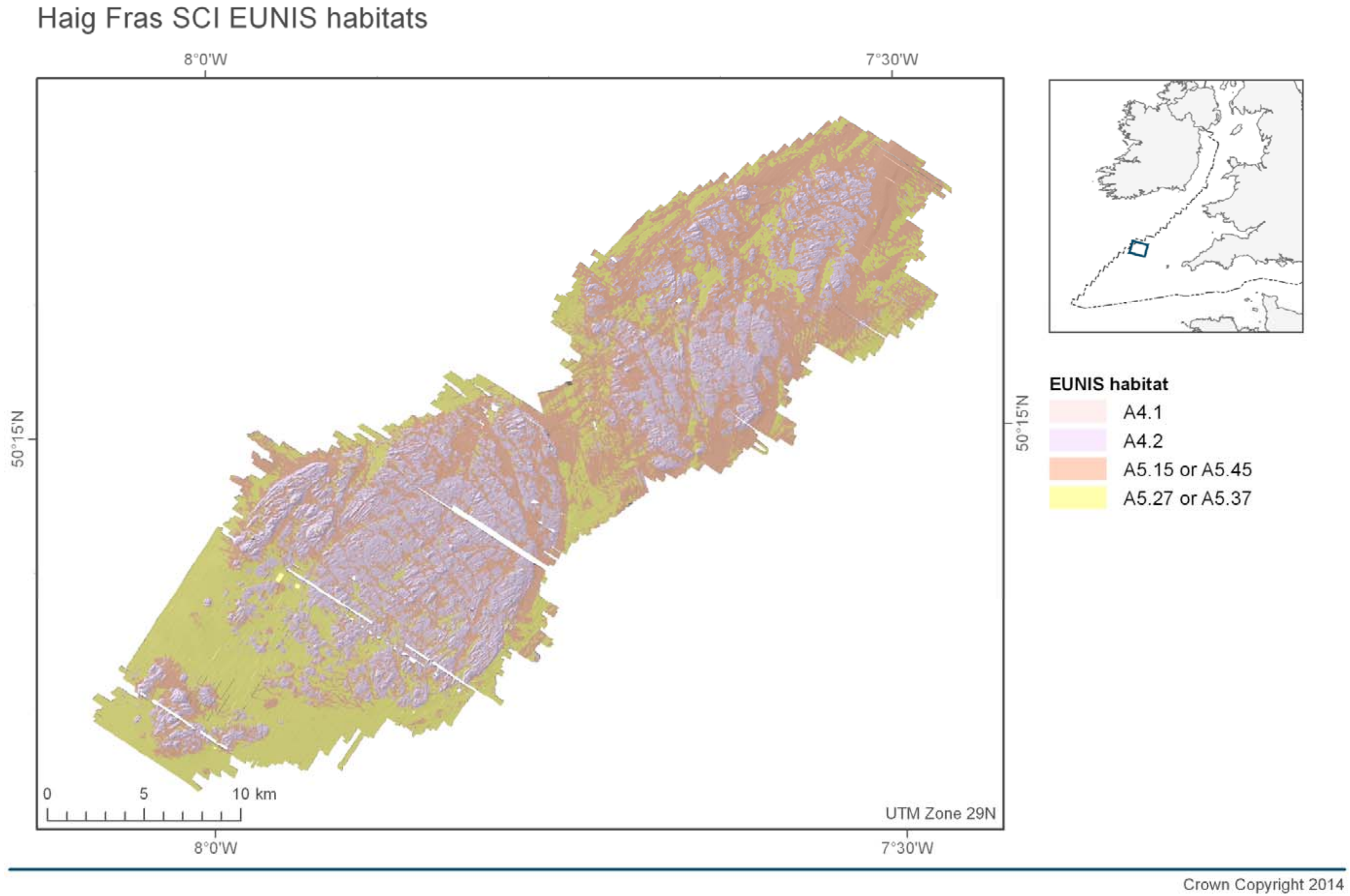


Figure 8. Extent of EUNIS habitat types identified in the Haig Fras survey area.

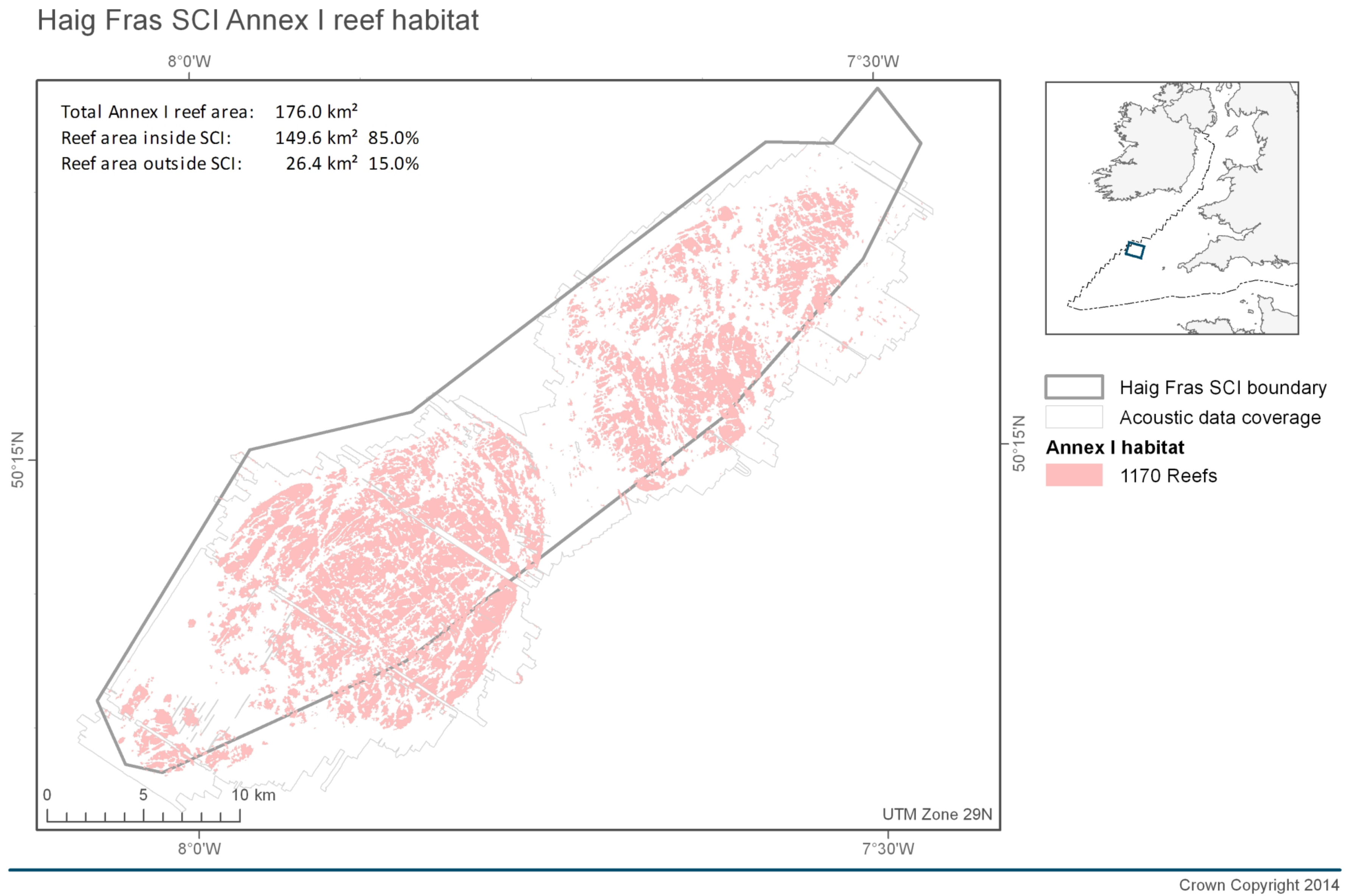


Figure 9. Extent of Annex I reef in relation to the Haig Fras SCI boundary.

3.7 Evidence of fishing activity

Figure 10 shows the location of observed static fishing gear observed at the Haig Fras SCI during the 2011 survey. No evidence of bottom contact fishing gear (i.e. trawl scars) was observed during surveys.

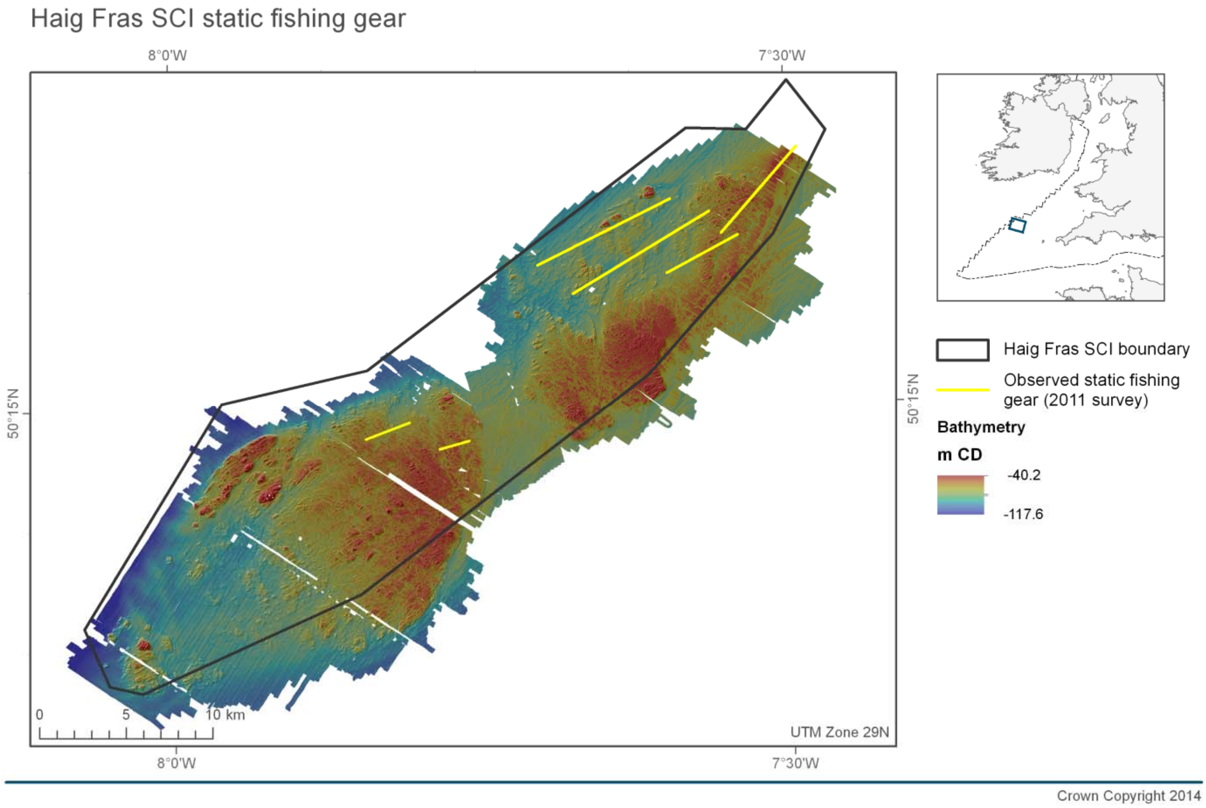


Figure 10. Location of observed static fishing gear during the 2011 survey.

4 Discussion

4.1 Site overview

Multibeam bathymetry data showed water depths ranging from 40m at the shallowest points to 118m at the deepest. Bathymetry data also showed the complexity of the seabed, with several rock pinnacles rising to up to 40m below CD, jointing of the granitic rocks, and areas of relatively flat and smooth seabed in between rock outcrops.

The multibeam backscatter in the vicinity of the bedrock outcrop showed that there were bedforms with sorted sediment which most likely consist of coarse-grained sediment. However, a distinction between coarse sediment and mixed sediment is difficult to make based on their acoustic characteristics alone. The remainder of the seabed was characterised by moderate to low backscatter strength, which is a characteristic signature of sandy or muddy substrates.

Ground-truthing samples confirmed the presence of rock, often covered in a fine veneer of silt, and sedimentary habitats of varying coarseness between the two larger bedrock outcrops. Based on video footage and still images, the majority of the bedrock outcrop was assigned as the biotope A4.212: *Caryophyllia smithii*, sponges and crustose communities on wave-exposed circalittoral rock.

Interestingly, areas classified as the biotope A4.212: *Caryophyllia smithii*, sponges and crustose communities on wave-exposed circalittoral rock also contained the brachiopod *Neocrania anomala*, sometimes in high numbers. This species is characteristic of less exposed, low-energy rocky habitats, so its presence in such high numbers could be indicative of a less-exposed variant of the assigned biotope. As the A4.212 biotope was evident along the majority of camera transects (all deployed deeper than 67m), it is likely that this variant of the assemblage is the most prevalent across the deeper reef within the Haig Fras complex. The shallowest transect (DC4_S1) in water depths shallower than 67 m was classified as the higher-energy biotope A4.132: *Corynactis viridis* and a mixed turf of crisiids, Bugula, Scrupocellaria, and Cellaria on moderately tide-swept exposed circalittoral rock. This biotope was also recorded by Rees (2000) in 'Zone 1'of Haig Fras. The hydrodynamic regime of an area is well known to be a controlling influence on the distribution of benthic organisms. In this area, it can be expected that hydrodynamic energy decreases with depth and hence, that similarly shallow and exposed pinnacles of the Haig Fras reef should exhibit the same assemblage.

4.2 Identification, delineation and mapping of Annex I reef

Whilst it is relatively straightforward to map rocky reef consisting of exposed bedrock expressed as positive features at the seabed, mapping stony reef is more challenging due to the small size of the features and the lack of a distinctive acoustic signature. The 2012 infill survey targeting the relatively flat seabed between the two larger rock outcrops of the Haig Fras complex was specifically designed to map stony reef. The video tows and photographic stills often showed cobbles and boulders. Based on the analysis of acoustic data, most of the mapped area was assigned to the biotope A5.15: Deep circalittoral coarse sediment, i.e. the predominant or most conspicuous habitat type. Locally, however, small patches of cobbles and boulders occurred. These patches were not observed on the acoustic data record in a size large enough to be attributed to EUNIS habitat type A4: Circalittoral rock and other hard substrata. In some cases there is an argument for some of the video tows (HFI03, HFI05 and HFI08, and parts of HFI04 and HFI07) to be described as a mosaic habitat of coarse sediment and hard substrate. However, because these hard substrate habitats cannot be distinguished acoustically from the coarse sediment habitats within which they occur, it is not possible to delineate and map them separately.

A similar difficulty was encountered when attempting to delineate and map areas of cobbles and boulders based on the video data record, areas which might qualify as stony reef. In most cases the observed cobbles and boulders made up less than 40% of the seabed sediment composition. The maximum proportion of cobbles and boulders was 35% in any of the 10 minute video tows (40% was observed in the truncated one minute video tow at HFI03 – see Table 1). Following the stony reef definition from Irving (2009), most of the area where cobbles and boulders were observed would qualify as 'low resemblance to being a stony reef'. Irving (2009) also included an aspect of elevation in his definition. Whereas some of the criteria for 'medium elevation' were met (>64mm diameter particles, >5m elevation), most of the observed cobbles and boulders were partially buried and would only meet the criteria for 'low elevation'. Irving (2009) further proposed that stony reefs should have an extent >25m^2. In the context of the acquired video tows (undertaken at 0.5 knots), this would require the cobble and boulder patches to be continuously visible for at least 20 seconds to meet the criterion (5m tow length and assuming a patch would extend for 5m wide outside field of view). This was only observed at stations HFI03, HFI05, HFI08, parts of HFI04 and HFI07. In addition, very few epifaunal organisms were observed in the video footage when compared with other areas of confirmed stony reef (e.g. Wight-Barfleur cSAC; Barrio Froján *et al* in press). Irving (2009) states that for areas to have a high resemblance to stony reef, >80% of species present must be epifaunal. Given the low number of epifaunal taxa observed in relation to the relatively higher number of infaunal taxa sampled using the grab (i.e. <80% of the organisms observed were epifauna), together with the scoured appearance of cobbles and boulders and the presence of >60% sediment in the video samples, it is concluded that the coarser elements of the sedimentary area surveyed can only qualify as having low resemblance to stony reef.

According to the draft guidance provided by JNCC (Guide Definitions for Substrate Types Used in EUNIS and the Marine Habitat Classification of Britain and Ireland), if a low score is noted in any of the four elements characteristic of reef habitats (composition, elevation, extent or biota) a strong justification would be required for an area to be considered as part of the Marine Natura 2000 site network of qualifying reefs in terms of the EU Habitats Directive. Low scores have been attained for three out of the four reef assessment elements in all tows, therefore, the criteria for assigning observed patches of cobble and boulders as stony reef are not met in the Haig Fras survey area.

Within the infill area, small patches of circalittoral rock were delineated using OBIA, based on roughness and backscatter data. No video footage of these patches was available to confirm the classification. Although topographically distinct and similar to other rocky areas, the elevation was not as high as in other areas, and backscatter data do not reveal the same characteristics as in other bedrock areas. Therefore, although some of the characteristics are similar to other bedrock areas, without directly observed evidence, it cannot be confirmed that these patches have the same characteristics as those delineated and validated in other areas.

4.3 Site boundary

An area of 176km^2 representing Annex I rocky reef was identified within the survey area; 150km^2 (85%) of this lies within the current SCI boundary, and 26km^2 (15%) is outside (Figure 9). This and other factors should be considered by the JNCC to determine whether the site boundary ought to be revised to encompass the entire extent of the rocky reef habitat.

4.4 Survey and data limitations

Further ground-truthing data would be necessary to discriminate and validate the predicted extent of identified biotopes. This would require additional camera transects on different parts of the reef and grab sampling of the sedimentary features to better inform the acoustic data analysis.

5 Conclusion

The present investigation has succeeded in achieving the objectives defined at the outset.

The full extent of the Haig Fras rocky outcrop was surveyed and an area of approximately 176km^2 has been classified as rocky reef.

Ground-truthing samples were collected and processed to identify and characterise the resident benthos. The predominant biotope observed on the rocky reef was A4.212: *Caryophyllia smithii*, sponges and crustose communities on wave-exposed circalittoral rock. Based on available guidelines and gathered evidence, patches of coarser sedimentary habitats bore only a low resemblance to the published definition of stony reef, therefore, they cannot be designated as such.

Maps depicting the distribution of identified EUNIS habitat types and Annex I reef have been produced showing the distribution of rocky reef to extend beyond the current limits of the Haig Fras SCI. JNCC may wish to consider whether the Haig Fras SCI boundary ought to be revised to encompass the entire extent of the rocky reef habitat.

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7 Annexes

Annex 1: Video tow tracks

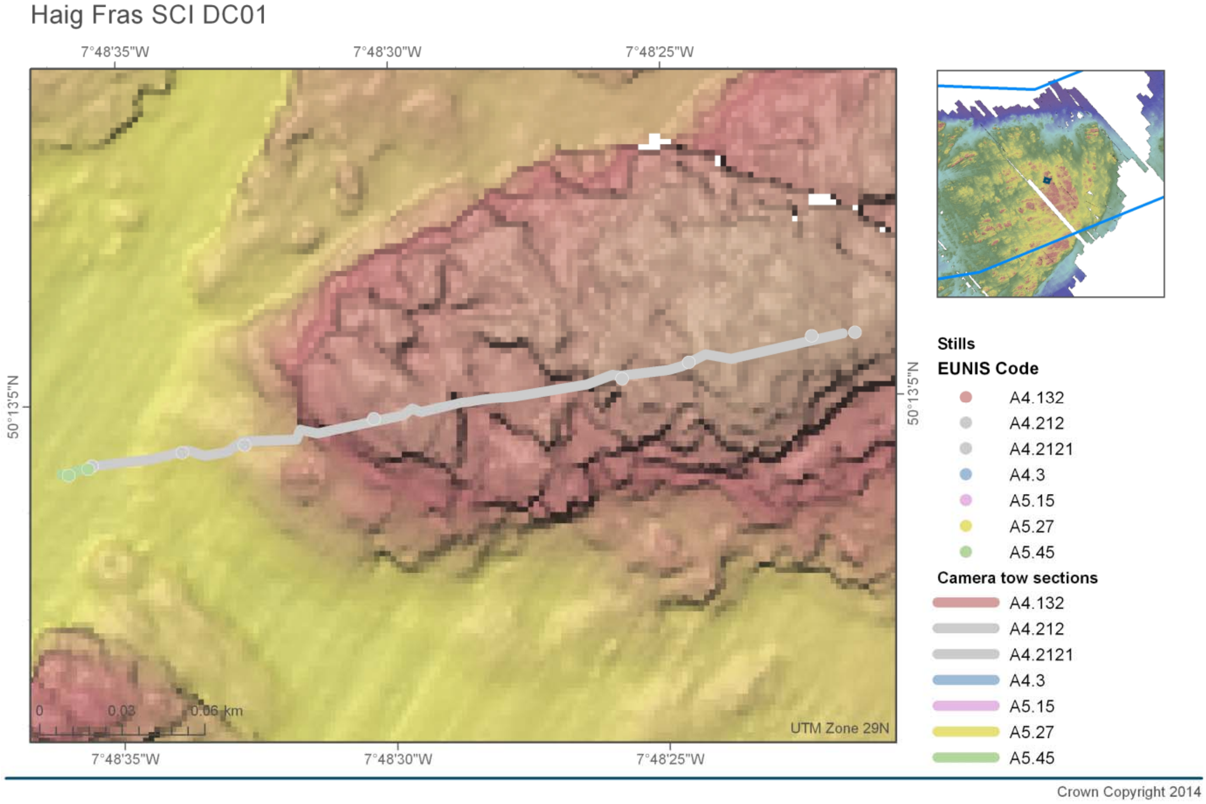

Figure A1.1. Drop camera transect DC01 separated into biotope sections overlaying the multibeam bathymetry.

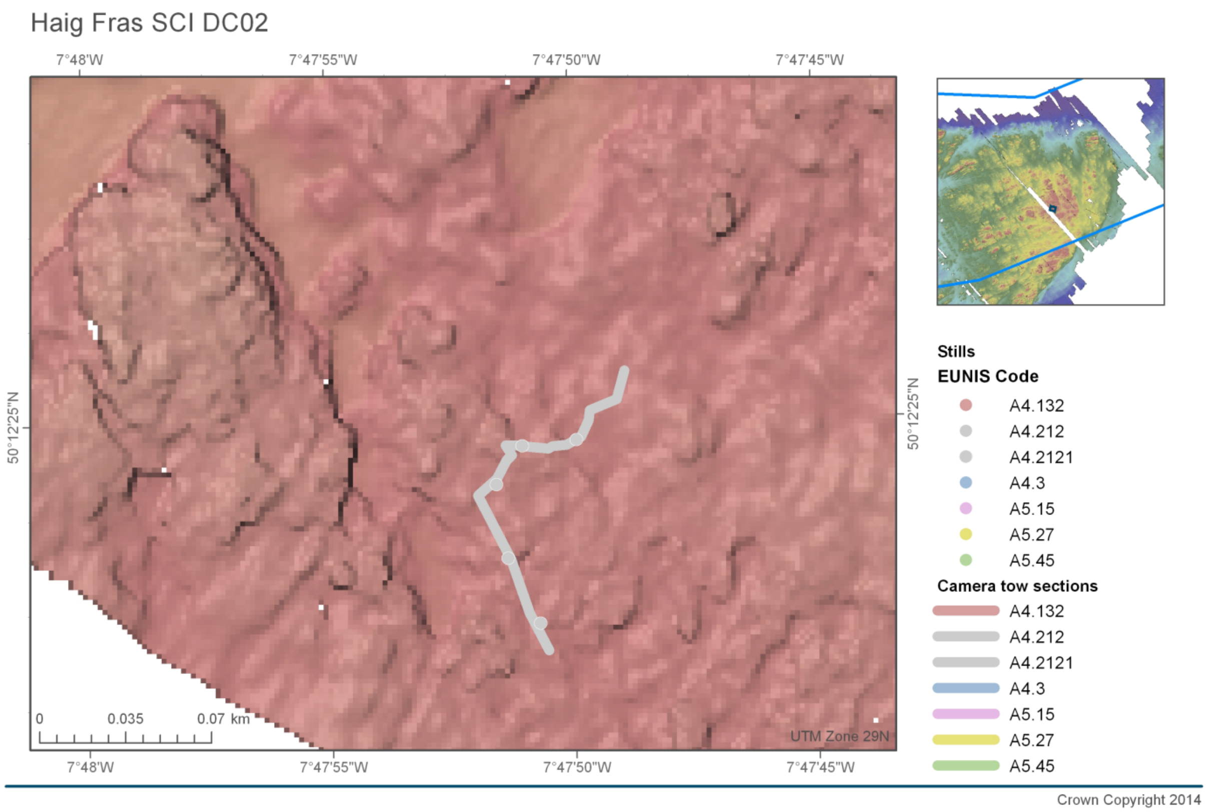

Figure A1.2. Drop camera transect DC02 separated into biotope sections overlaying the multibeam bathymetry.

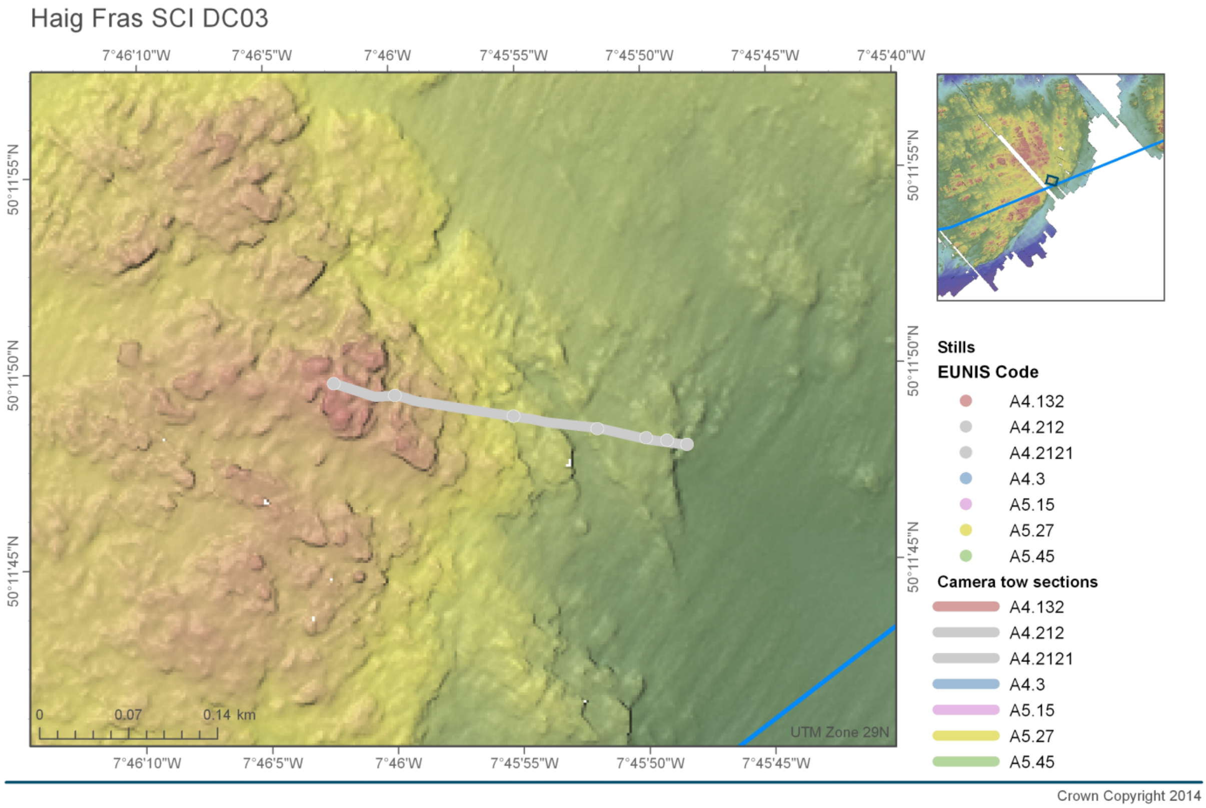

Figure A1.3. Drop camera transect DC03 separated into biotope sections overlaying the multibeam bathymetry.

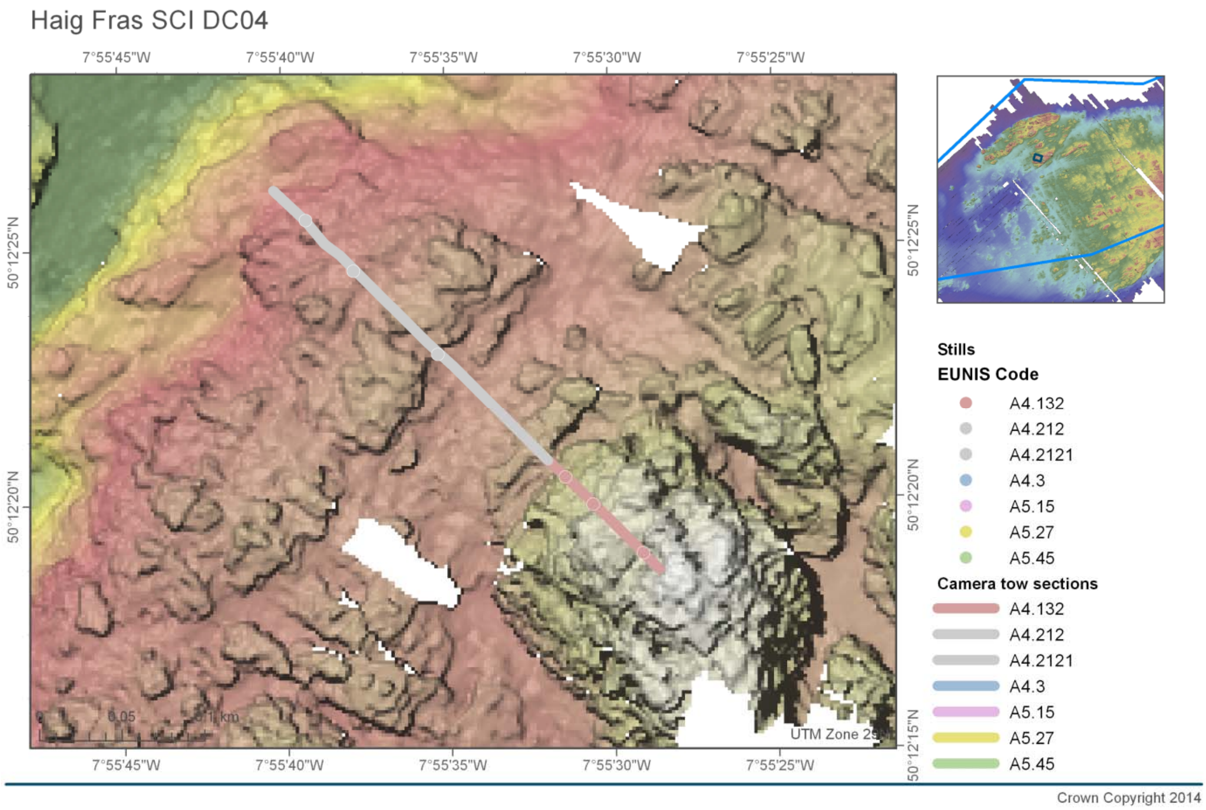

Figure A1.4. Drop camera transect DC04 separated into biotope sections overlaying the multibeam bathymetry.

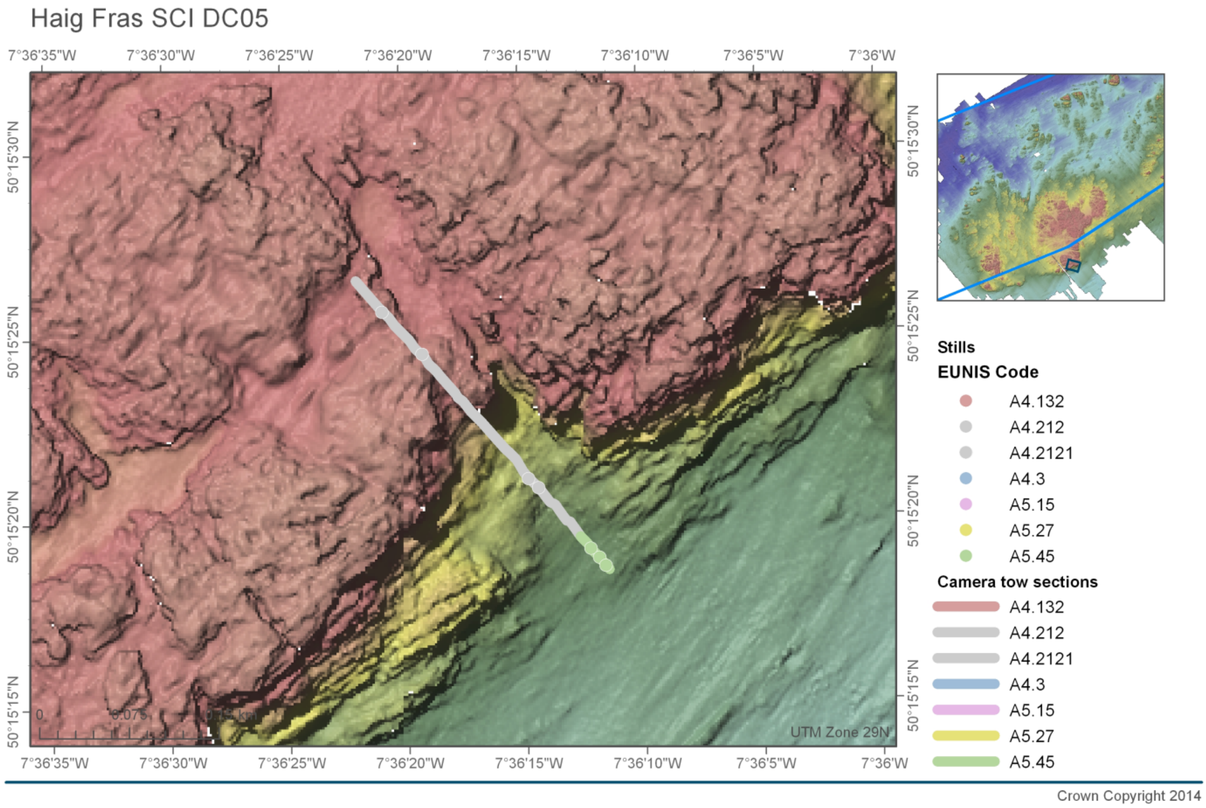

Figure A1.5. Drop camera transect DC05 separated into biotope sections overlaying the multibeam bathymetry.

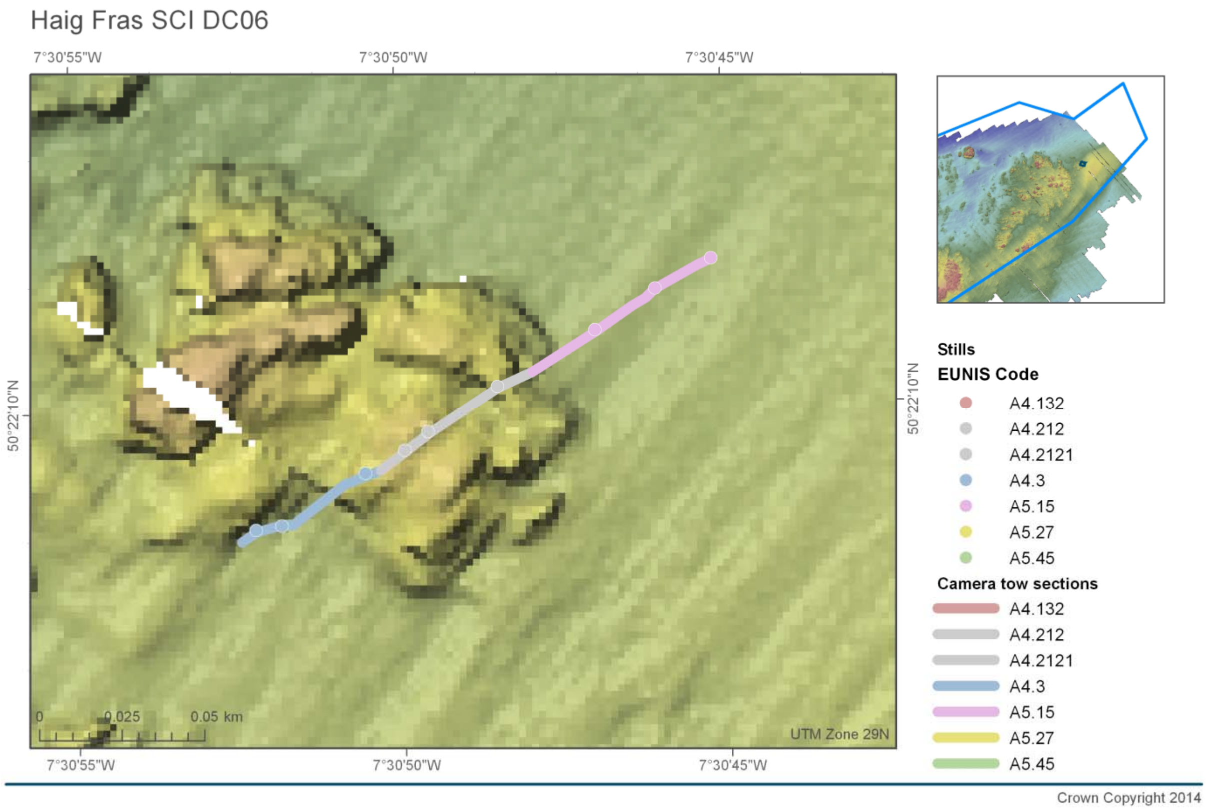

Figure A1.6. Drop camera transect DC06 separated into biotope sections overlaying the multibeam bathymetry.

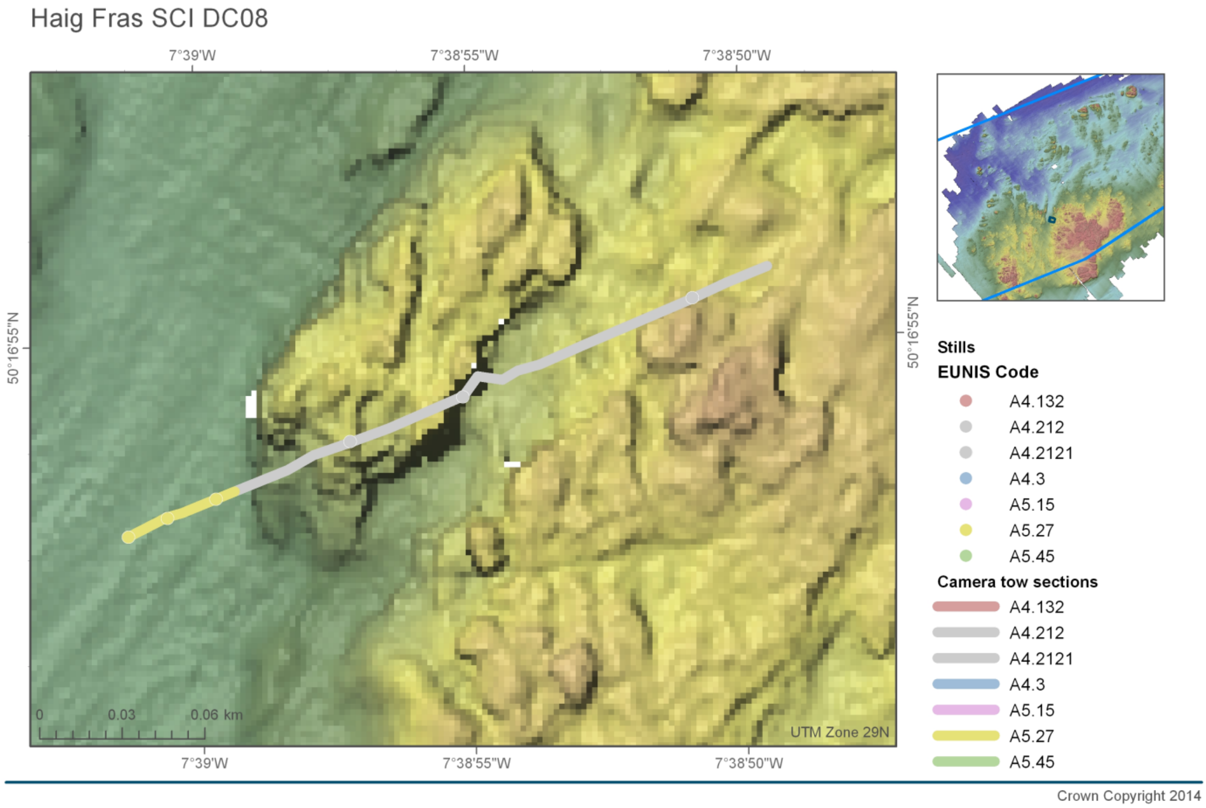

Figure A1.7. Drop camera transect DC08 separated into biotope sections overlaying the multibeam bathymetry.

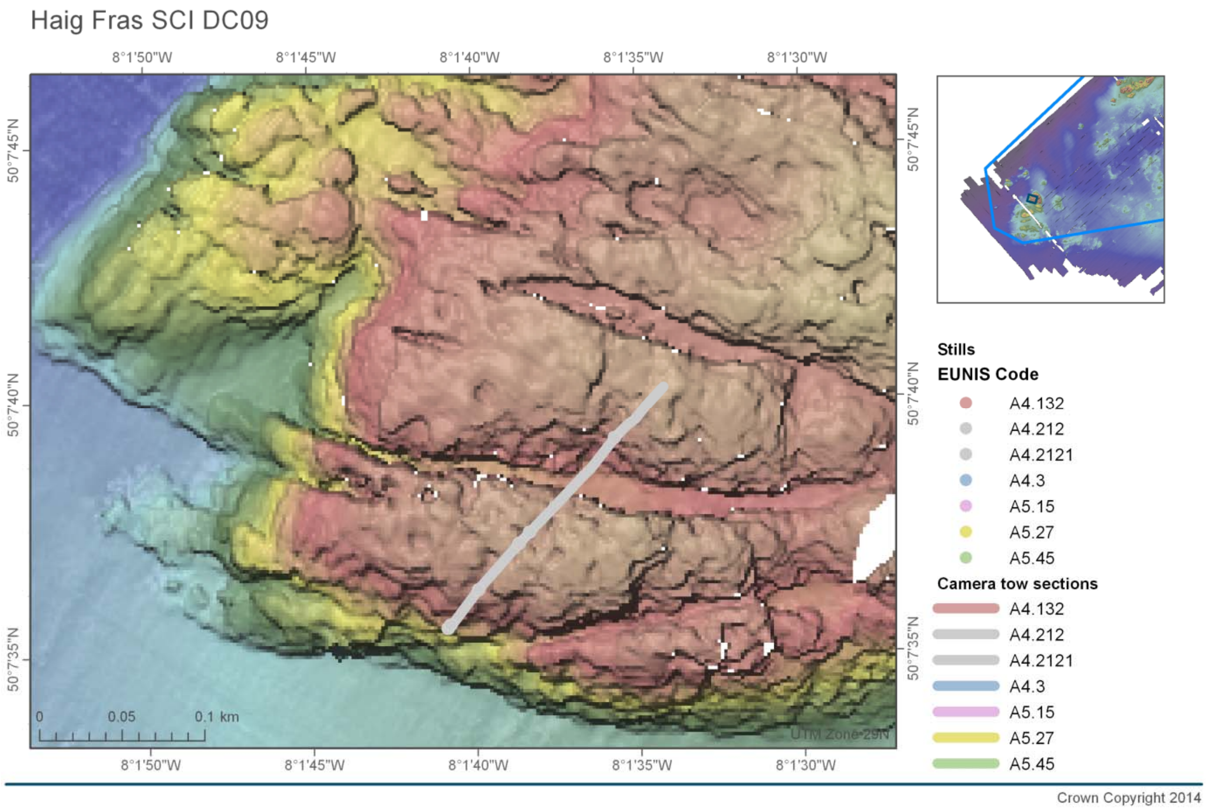

Figure A1.8. Drop camera transect DC09 separated into biotope sections overlaying the multibeam bathymetry.

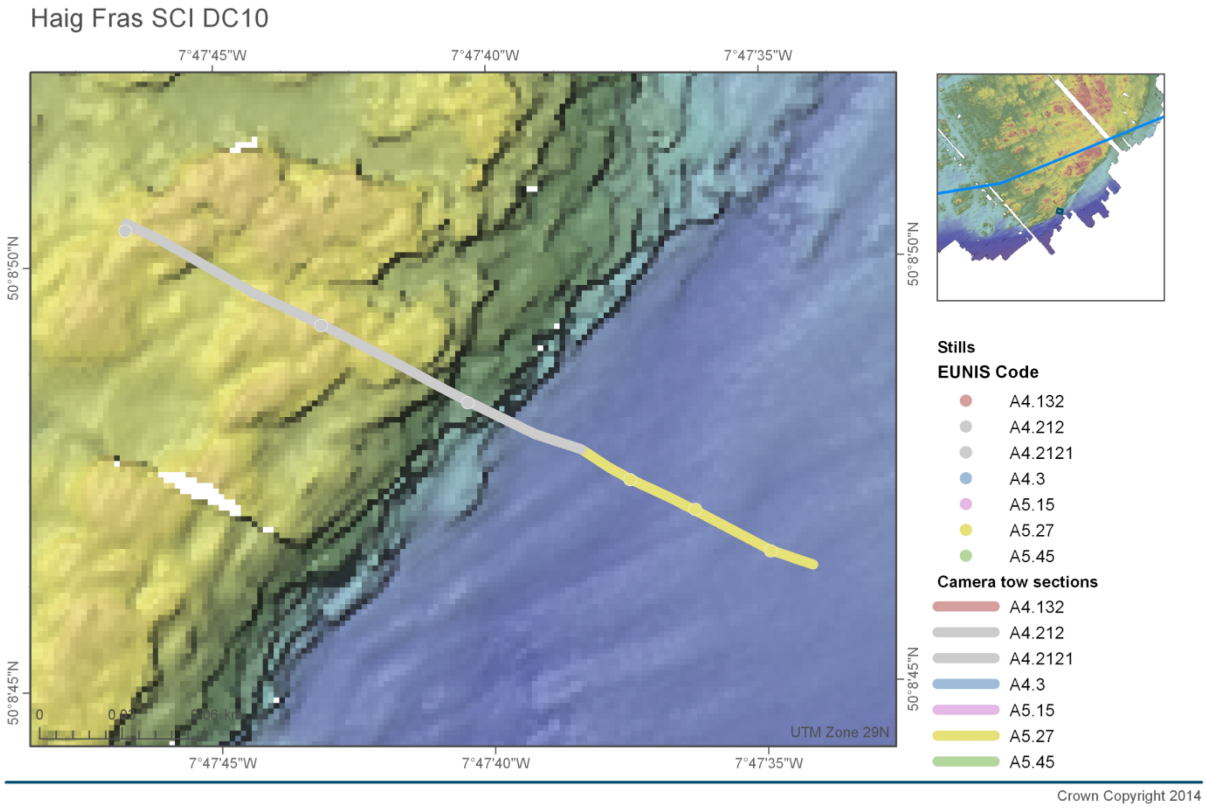

Figure A1.9. Drop camera transect DC10 separated into biotope sections overlaying the multibeam bathymetry.

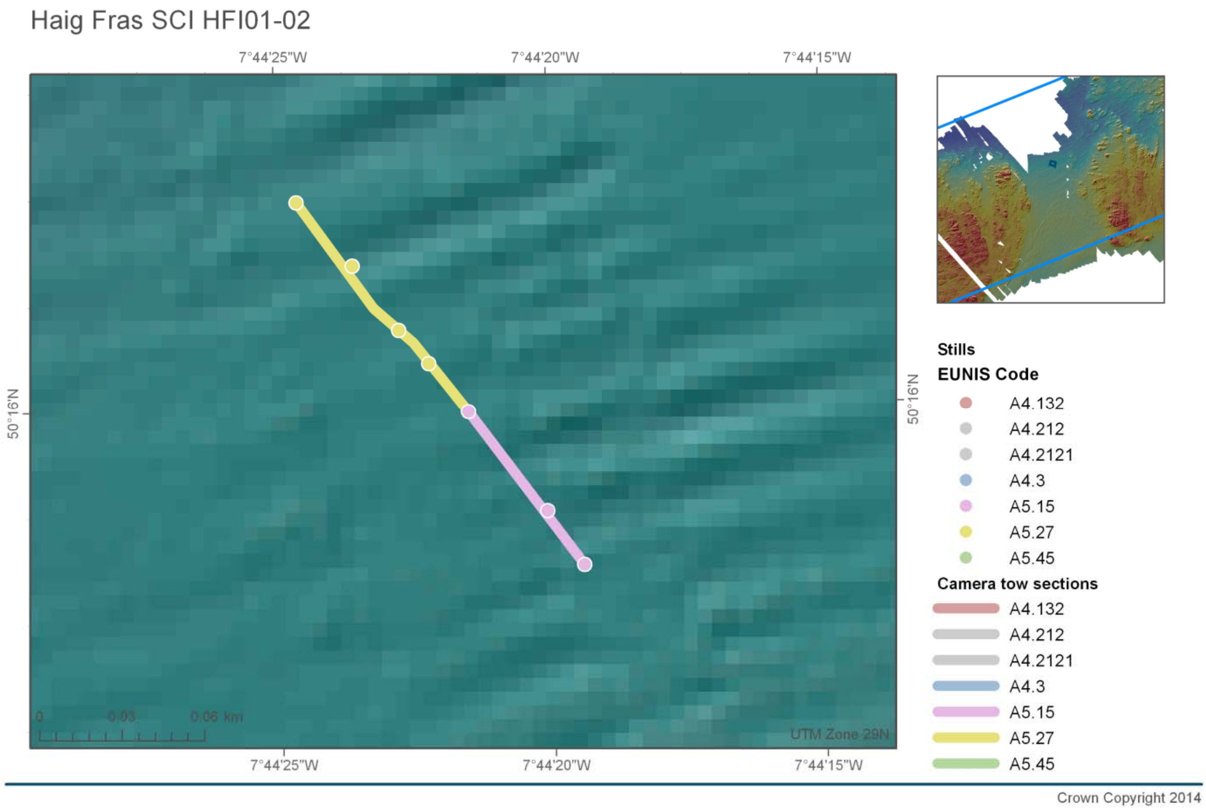

Figure A1.10. Drop camera transect HFI01-02 separated into biotope sections overlaying the multibeam bathymetry.

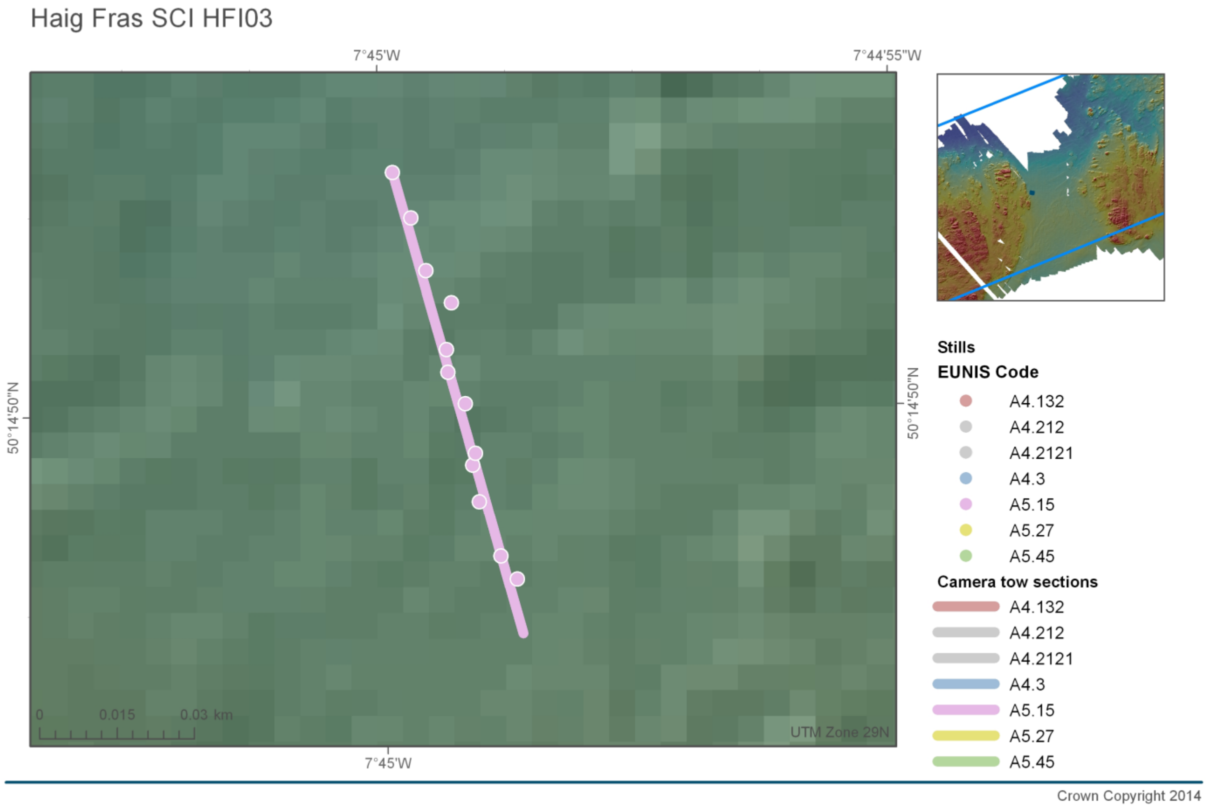

Figure A1.11. Drop camera transect HFI03 separated into biotope sections overlaying the multibeam bathymetry.

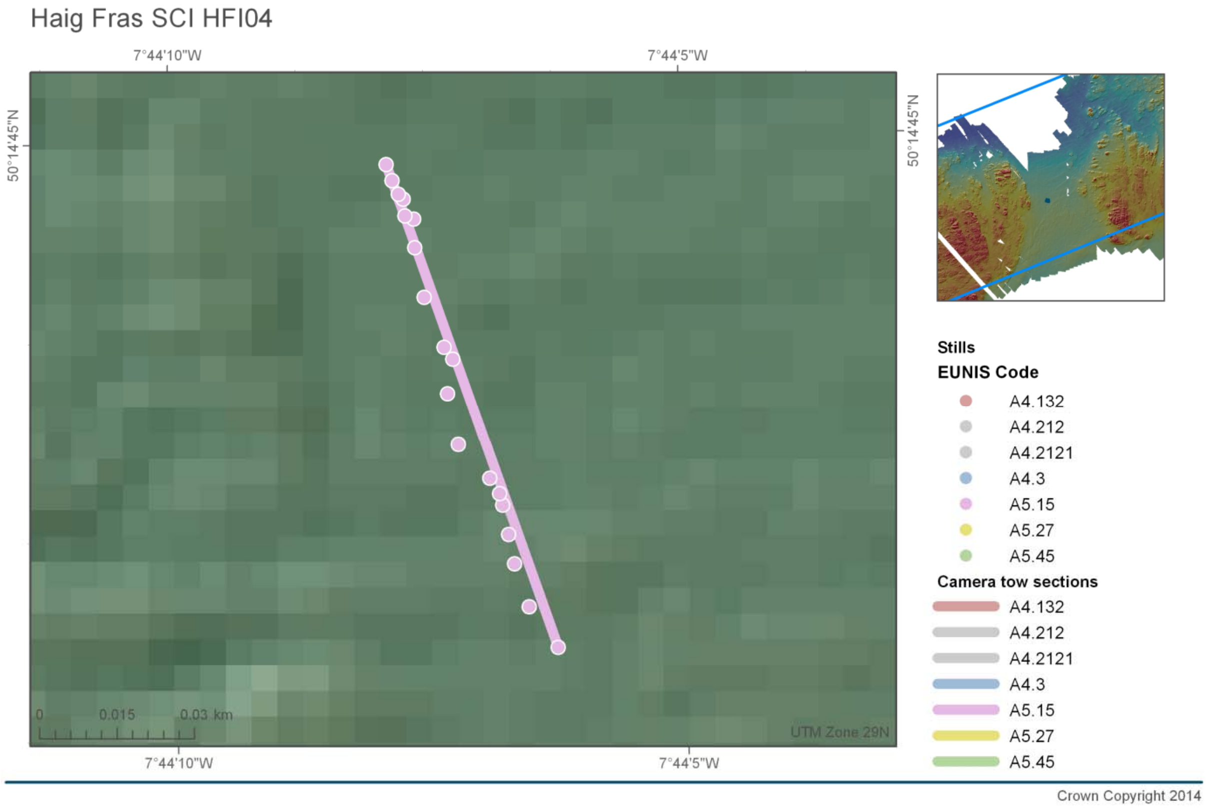

Figure A1.12. Drop camera transect HFI04 separated into biotope sections overlaying the multibeam bathymetry.

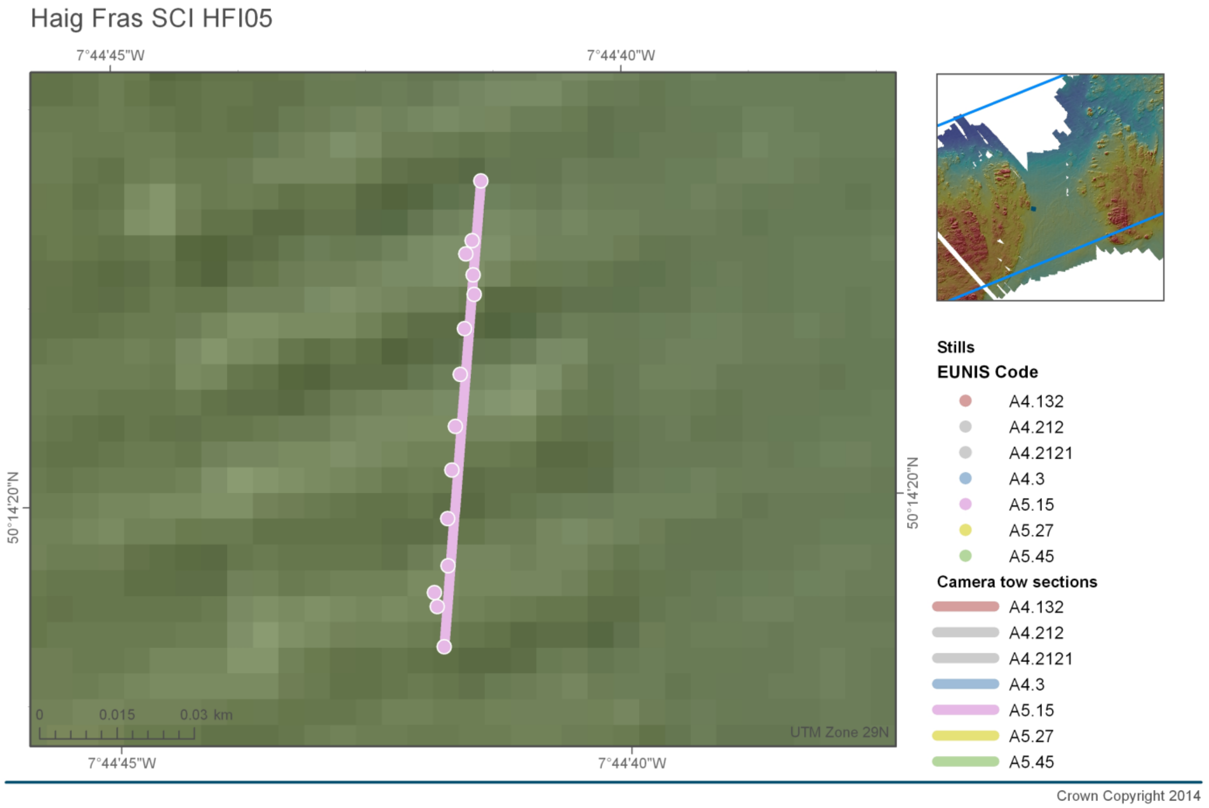

Figure A1.13. Drop camera transect HFI05 separated into biotope sections overlaying the multibeam bathymetry.

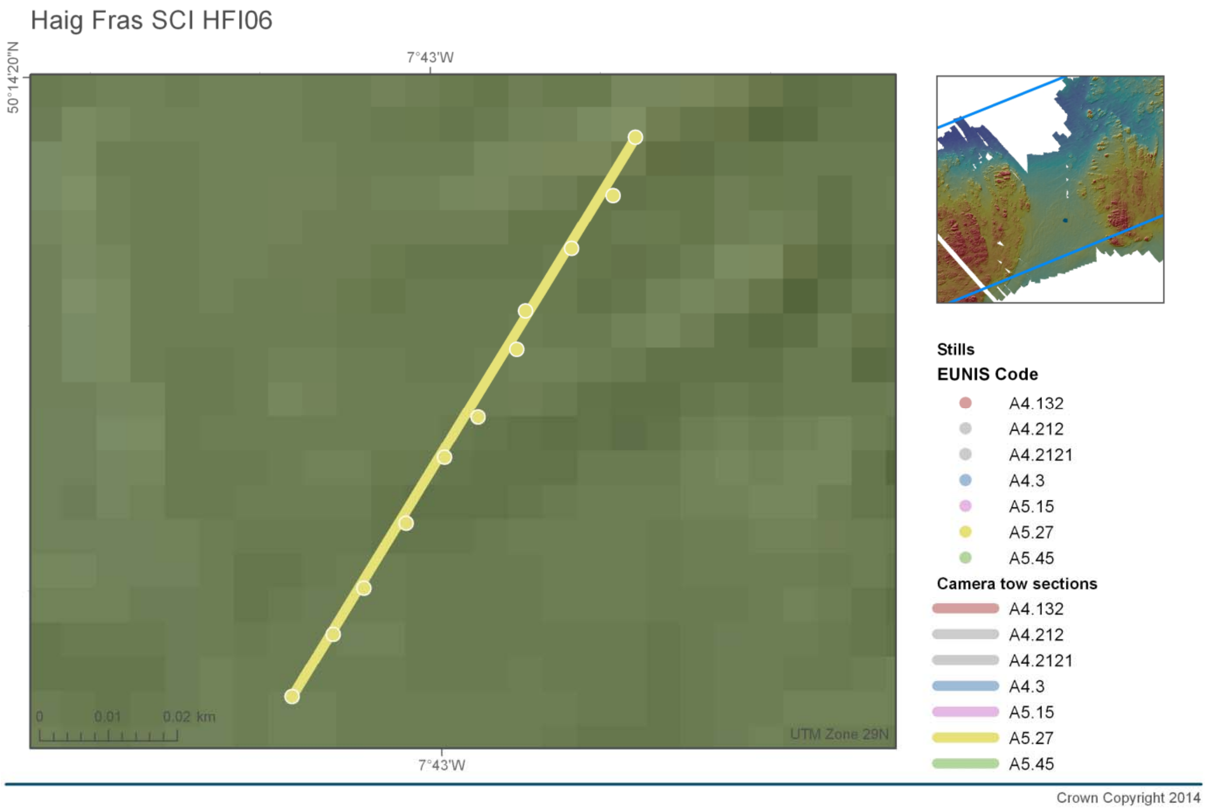

Figure A1.14. Drop camera transect HFI06 separated into biotope sections overlaying the multibeam bathymetry.

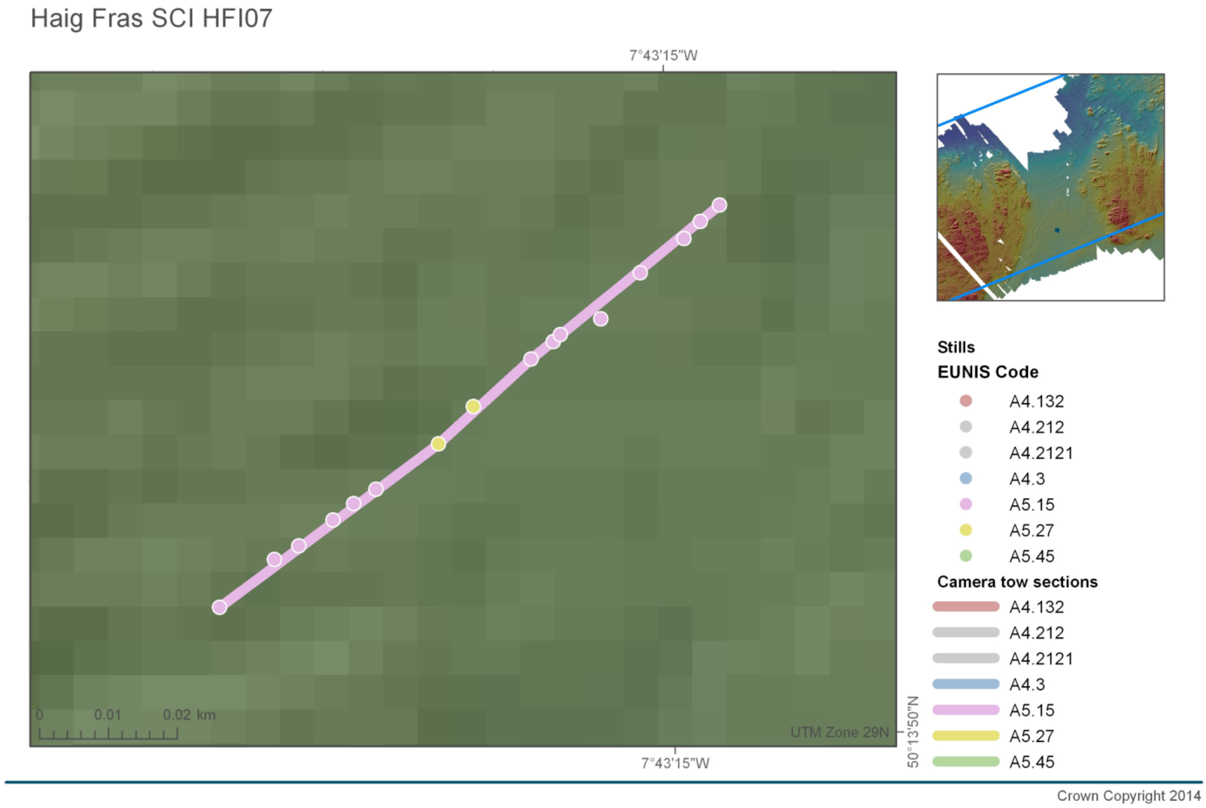

Figure A1.15. Drop camera transect HFI07 separated into biotope sections overlaying the multibeam bathymetry.

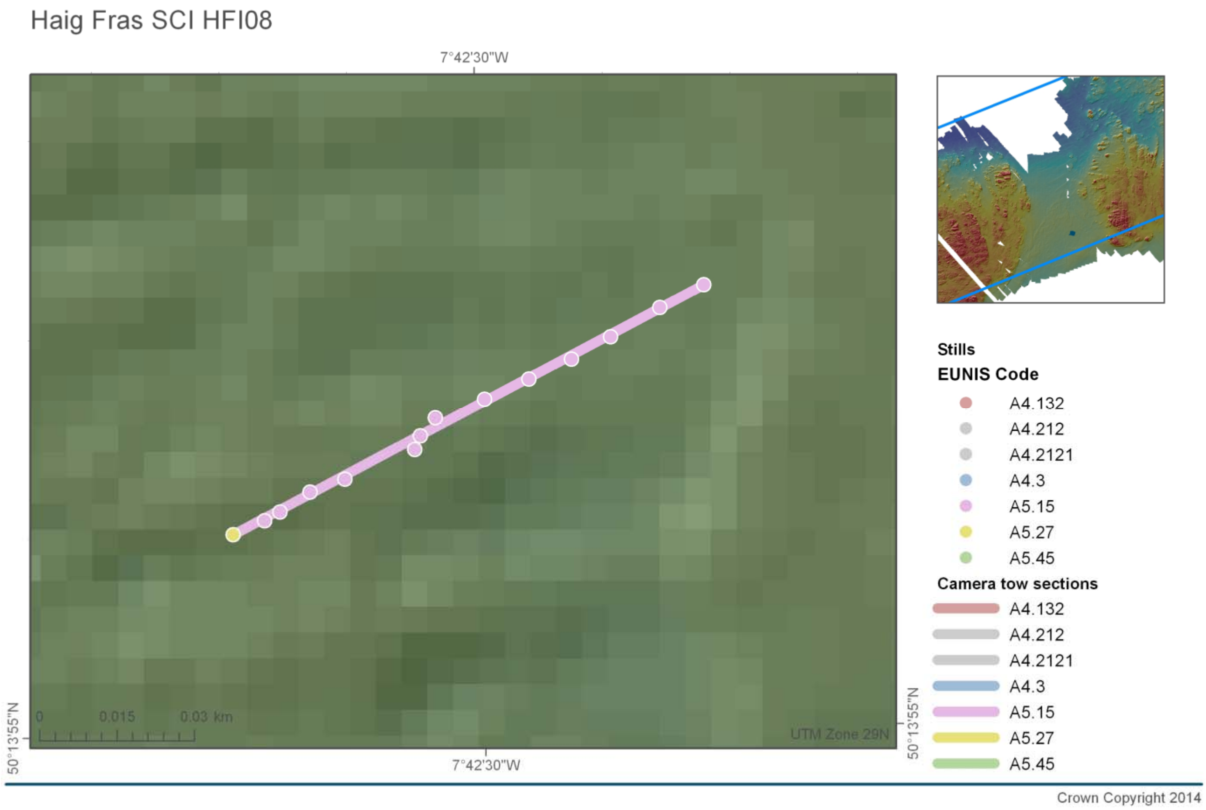

Figure A1.16. Drop camera transect HFI08 separated into biotope sections overlaying the multibeam bathymetry.

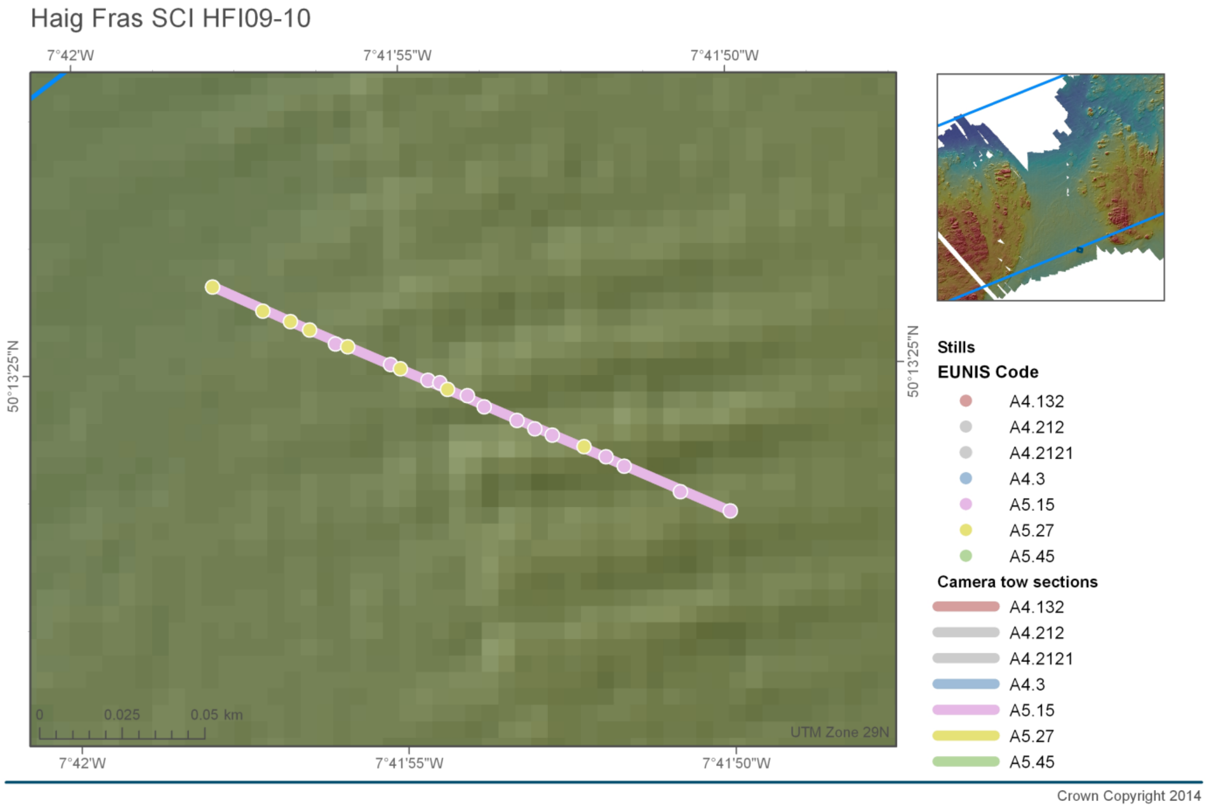

Figure A1.17. Drop camera transect HFI09-10 separated into biotope sections overlaying the multibeam bathymetry.

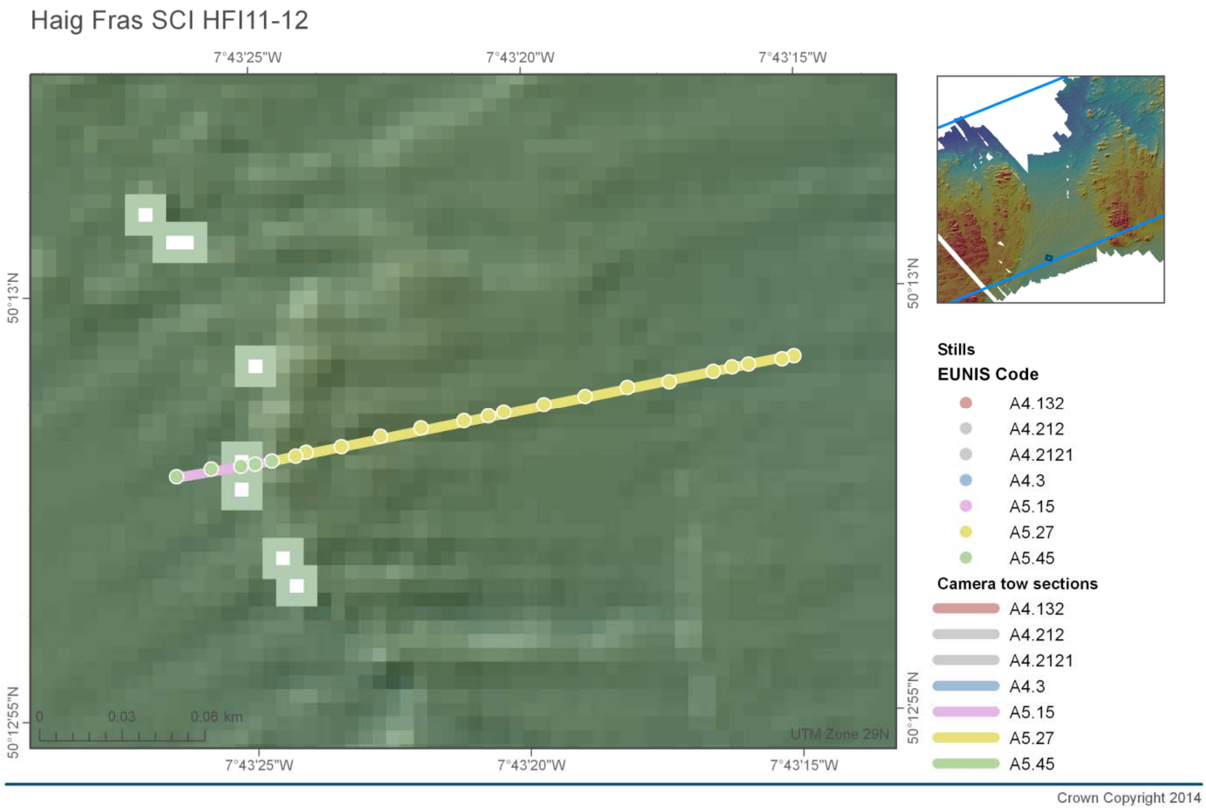

Figure A1.18. Drop camera transect HFI11-12 separated into biotope sections overlaying the multibeam bathymetry.

Annex 2: Infaunal taxa by assemblage

Relative abundance of taxa belonging to the two distinct assemblages (a and B) identified through multivariate analysis of square-root transformed infaunal abundance data. Also listed is the relative contribution of each taxon to the similarity within each assemblage identified.

Relative abundance

Taxa	Assemblage a	Assemblage B	Total
Lumbrineris gracilis	1.73	1.58	3.31
Chaetozone christiei	0.67	2.22	2.89
Dasybranchus	0.8	1.97	2.77
Echinocyamus pusillus	2.22	0.34	2.56
Notomastus	0.33	1.75	2.08
NEMERTEA	0.67	1.2	1.87
Glycera lapidum (agg)		1.79	1.79
Glycera oxycephala	1.14	0.59	1.73
Goniadella gracilis		1.73	1.73
Spiophanes kroyeri	0.33	1.27	1.6
Aponuphis bilineata	0.33	1.26	1.59
SPATANGOIDA (juv)	1.25	0.29	1.54
Abra prismatica	1.52		1.52
Polycirrus	0.91	0.29	1.2
Galathowenia oculata	0.47	0.63	1.1
Aonides paucibranchiata	0.8	0.29	1.09
Poecilochaetus serpens	0.8	0.29	1.09
Goniada maculata	0.67	0.34	1.01
Chone		0.97	0.97
Pisione remota		0.95	0.95
Polygordius		0.84	0.84
Glycera rouxii	0.67	0.14	0.81
Owenia fusiformis	0.67	0.14	0.81
Aricidea simonae	0.8		0.8
Urothoe elegans	0.8		0.8
Amphiuridae (juv)	0.33	0.43	0.76
Aspidosiphon muelleri		0.74	0.74
Phaxas pellucidus	0.47	0.25	0.72
Parathelepus collaris		0.66	0.66
Sphaerosyllis bulbosa		0.66	0.66
Eulalia mustela		0.63	0.63
Glycinde nordmanni		0.63	0.63
Bathyporeia elegans	0.47	0.14	0.61
Pistella lornensis	0.33	0.25	0.58
Gnathia oxyuraea	0.58		0.58
Grania		0.49	0.49
Peresiella clymenoides		0.49	0.49
Aglaophamus rubella	0.33	0.14	0.47
Euspira pulchella	0.33	0.14	0.47
Scalibregma inflatum	0.33	0.14	0.47
Ampharete lindstroemi		0.43	0.43
Atylus vedlomensis		0.43	0.43
Magelona minuta		0.43	0.43
Abra nitida		0.35	0.35
Aphelochaeta "sp A"	0.33		0.33
Cerianthus lloydii	0.33		0.33
Chaetozone zetlandica	0.33		0.33

Similarity contribution

Taxa	Assemblage a	Assemblage b	Total
Lumbrineris gracilis	4.97	2.64	7.61
Echinocyamus pusillus	5.92	0.1	6.02
Glycera oxycephala	3.95	0.38	4.33
NEMERTEA	1.4	2.82	4.22
Dasybranchus	1.2	2.94	4.14
Chaetozone christiei	1.2	2.51	3.71
Notomastus		3.37	3.37
Glycera lapidum (agg)		3.34	3.34
Aponuphis bilineata		2.41	2.41
Goniadella gracilis		2.35	2.35
Abra prismatica	2.08		2.08
Goniada maculata	1.4	0.11	1.51
Poecilochaetus serpens	1.35	0.1	1.45
Polycirrus	1.35	0.1	1.45
Owenia fusiformis	1.4		1.4
Glycera rouxii	1.35		1.35
Urothoe elegans	1.35		1.35
Aonides paucibranchiata	1.2	0.12	1.32
Aricidea simonae	1.2		1.2
Spiophanes kroyeri		1.06	1.06
Chone		0.9	0.9
Aspidosiphon muelleri		0.72	0.72
Pisione remota		0.64	0.64
Galathowenia oculata		0.62	0.62
Glycinde nordmanni		0.62	0.62
Ampharete lindstroemi		0.52	0.52
Parathelepus collaris		0.47	0.47
Polygordius		0.46	0.46
Grania		0.43	0.43
Atylus vedlomensis		0.42	0.42
Eulalia mustela		0.36	0.36
Sphaerosyllis bulbosa		0.36	0.36
Hydroides norvegica		0.16	0.16
Peresiella clymenoides		0.15	0.15
Harpinia antennaria		0.14	0.14
Ophiodromus pallidus		0.14	0.14
Mediomastus fragilis		0.13	0.13
Scoletoma magnidentata		0.13	0.13
SPATANGOIDA (juv)		0.13	0.13
Amphiuridae (juv)		0.12	0.12
Laonice bahusiensis		0.11	0.11
Dipolydora coeca (agg)		0.1	0.1
Eunereis longissima		0.1	0.1
Magelona minuta		0.1	0.1
Scalibregma celticum		0.1	0.1
Serpulidae		0.1	0.1
Sphaerosyllis taylori		0.1	0.1

Relative abundance

	Assemblage		
Taxa	a	B	Total
Clymenura	0.33		0.33
Echinocardium flavescens	0.33		0.33
Euclymene "sp A"	0.33		0.33
Glyphohesione klatti	0.33		0.33
Harmothoe glabra	0.33		0.33
Kurtiella bidentata	0.33		0.33
Lucinoma borealis (juv)	0.33		0.33
Phoronis	0.33		0.33
Sabellaria spinulosa	0.33		0.33
Spiophanes	0.33		0.33
Sthenelais limicola	0.33		0.33
Dipolydora coeca (agg)		0.29	0.29
Eunereis longissima		0.29	0.29
Golfingia margaritacea		0.29	0.29
Harpinia antennaria		0.29	0.29
Hydroides norvegica		0.29	0.29
Laonice bahusiensis		0.29	0.29
Mediomastus fragilis		0.29	0.29
Ophiodromus pallidus		0.29	0.29
Scalibregma celticum		0.29	0.29
Scoletoma magnidentata		0.29	0.29
Serpulidae		0.29	0.29
Sphaerosyllis taylori		0.29	0.29
Ophelia celtica		0.25	0.25
Terebellides stroemi		0.25	0.25
Ampelisca spinipes		0.2	0.2
Aricidea laubieri		0.2	0.2
Eumida sanguinea		0.2	0.2
MYODOCOPIDA		0.2	0.2
Tharyx killariensis		0.2	0.2
Timoclea ovata		0.2	0.2
Amphicteis gunneri		0.14	0.14
Amphipholis squamata		0.14	0.14
Animoceradocus semiserratus		0.14	0.14
Branchiostoma lanceolatum		0.14	0.14
Cheirocratus intermedius		0.14	0.14
Cirrophorus branchiatus		0.14	0.14
Corbula gibba		0.14	0.14
Cylichna cylindracea		0.14	0.14
Edwardsia claparedii		0.14	0.14
Glycera alba		0.14	0.14
Glycera fallax		0.14	0.14
Harmothoe extenuata		0.14	0.14
Hippomedon denticulatus		0.14	0.14
Hyalinoecia tubicola		0.14	0.14
Jasmineira caudata		0.14	0.14

Similarity contribution

	Assemblage		
Taxa	a	b	Total
Abra nitida			
Aglaophamus rubella			
Ampelisca spinipes			
Amphicteis gunneri			
Amphipholis squamata			
Animoceradocus semiserratus			
Aphelochaeta "sp A"			
Aricidea laubieri			
Bathyporeia elegans			
Branchiostoma lanceolatum			
Cerianthus lloydii			
Chaetozone zetlandica			
Cheirocratus intermedius			
Cirrophorus branchiatus			
Clymenura			
Corbula gibba			
Cylichna cylindracea			
Echinocardium flavescens			
Edwardsia claparedii			
Euclymene "sp A"			
Eumida sanguinea			
Euspira pulchella			
Glycera alba			
Glycera fallax			
Glyphohesione klatti			
Gnathia oxyuraea			
Golfingia margaritacea			
Harmothoe extenuata			
Harmothoe glabra			
Hippomedon denticulatus			
Hyalinoecia tubicola			
Jasmineira caudata			
Kurtiella bidentata			
Lucinoma borealis (juv)			
Malmgrenia arenicolae			
Malmgrenia ljungmani			
MYODOCOPIDA			
Myrtea spinifera			
Ophelia celtica			
Ophelina cylindricaudata			
Paguridae (juv)			
Palliolum tigerinum (juv)			
Phaxas pellucidus			
Phoronis			
Pistella lornensis			
Praxillella affinis			

Relative abundance				Similarity contribution			
	Assemblage				Assemblage		
Taxa	a	B	Total	Taxa	a	b	Total
Malmgrenia arenicolae		0.14	0.14	*Protodorvillea kefersteini*			
Malmgrenia ljungmani		0.14	0.14	*Pseudomystides limbata*			
Myrtea spinifera		0.14	0.14	*Sabellaria spinulosa*			
Ophelina cylindricaudata		0.14	0.14	*Scalibregma inflatum*			
Paguridae (juv)		0.14	0.14	*Sige fusigera*			
Palliolum tigerinum (juv)		0.14	0.14	*Spiophanes*			
Praxillella affinis		0.14	0.14	*Sthenelais limicola*			
Protodorvillea kefersteini		0.14	0.14	*Syllis* "sp D"			
Pseudomystides limbata		0.14	0.14	*Syllis* "sp G"			
Sige fusigera		0.14	0.14	*Syllis parapari*			
Syllis "sp G"		0.14	0.14	*Terebellides stroemi*			
Syllis parapari		0.14	0.14	*Tharyx killariensis*			
Vitreolina philippi		0.14	0.14	*Timoclea ovata*			
Westwoodilla caecula		0.14	0.14	*Vitreolina philippi*			
Syllis "sp D"				*Westwoodilla caecula*			
Grand Total	25.4	37.5	62.91	Grand Total	31.3	32.7	64

Joint Nature Conservation Committee

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