Pembrokeshire Marine Habitat

Compensation Survey - Habitat Assessment Report

Pembrokeshire Marine / Sir Benfro Forol Special Area of Conservation – Habitat Compensation Plan Compliance Summary

Valid for

#GL22_DC Cable Marine

Greenlink Interconnector Project

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Index of Revisions

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Baseline Seabed Survey Compliance with Habitat Compensation Plan

Greenlink Interconnector Limited (GIL) has been granted the necessary consents and licences to install and operate an electricity interconnector (Greenlink) between County Wexford (Ireland) and Pembrokeshire (Wales). The Greenlink subsea cables will cross the Pembrokeshire Marine / Sir Benfro Forol Special Area of Conservation (SAC) for approximately 50km.

In determining Marine Licence CML1929, the HRA process conducted by Natural Resources Wales (NRW) concluded that where external cable protection is deposited on the SAC's Primary Reef Feature this would constitute an adverse impact on site integrity and that compensatory measures will be required. In accordance with Licence Condition 3.26 the Greenlink Pembrokeshire Marine SAC Habitat Compensation Plan (HCP) (CEA, 2022) has been approved and provides details of the agreed compensation.

External cable protection in the form of rock revetment will be required across two Reef sub-types within the SAC: Stony Reef and Biogenic Reef. Due to the nature of the habitats and associated communities in the areas where rock protection is required, it has been agreed that the revetment structure itself will act as compensatory habitat.

The HCP establishes a protocol for post-installation monitoring, the objective of which is to 'establish that the compensatory habitat (rock revetment) provides a comparable ecological function to that of the baseline Reef habitat'. To enable future monitoring to determine the success of the habitat compensation, a baseline benthic habitat survey was undertaken in May 2023. The baseline survey was completed ahead of the works that disturbed the seabed (e.g., pre-lay grapnel run / seabed clearance) at pre-determined locations along the proposed Greenlink cable route to provide a monitoring baseline for future post-installation monitoring surveys. The key objective of the post-installation monitoring surveys, as set out in the HCP, is to 'establish that the compensatory habitat (rock revetment) provides a comparable ecological function to that of the baseline Reef habitat'.

In keeping with the HCP, the baseline survey involved the collection of high-resolution seabed video and stills along triplicate transects at 12 pre-determined stations using a Drop-Down Camera (DDC) system. Stations were located in areas of suspected stony and biogenic reef identified from the analysis of data collected during earlier geophysical surveys. Each transect was divided into two sections: 'rock revetment' and 'control' to the north west and south east of the area possibly requiring external rock protection.

Following data collection, images were analysed against Annex I Stony Reef and Biogenic Reef qualifying criteria. Crucially any reef present in images was assessed for extent, biotic communities, and elevation. In addition to Annex I Reef assessments, images were also evaluated for broadscale habitat types, substrate, bedforms and the presence of further Annex I habitats, Features of Conservation Importance (FOCI), and Invasive Non-Native Species (INNS). Epifaunal community composition was analysed in the seabed imagery and fauna was identified to the lowest possible taxonomic level. Faunal density was calculated for each morphotype.

The baseline survey successfully assessed 12 locations for the presence of Annex I Reef habitat and determined the ecological function of reef and habitats present at each location. As outlined in the HCP, the baseline investigation collected data from 'impact' (potential rock revetment) and 'control' stations. The analysis of seabed imagery and the presentation of findings in a technical report produced by Ocean Ecology will allow for accurate assessment of the performance of compensatory habitat in future monitoring surveys at 2-, 4-, and 6-years post-installation as described in P-021001_EC_12340_A001_GL22_ABD090 - Offshore Cable Maintenance Methodology. The level of detail provided in the technical report allows for replicability

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of both the field survey and imagery analysis. Full references are provided to underpin survey methods, seabed imagery analysis, and reef assessment. Good data visualisation is provided in the technical report in the form of charts and maps which will allow for the comparison of baseline data with future datasets and allow an assessment of the performance of any compensation measures required.

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Greenlink Interconnector – Pembrokeshire Marine Habitat Compensation Survey: Habitat Assessment Report

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Details

Version	Date	Description	Author(s)	Reviewed By	Approved By
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Updates

Section	Description	Page
Throughout	Revisions following client comments	

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Non-Technical Summary

Ocean Ecology Limited (OEL) were commissioned by Greenlink Interconnector Limited (GIL) to undertake a pre-construction Annex I reef habitat assessment survey along the proposed Greenlink subsea cables crossing the Pembrokeshire Marine / Sir Benfro Forol Special Area of Conservation (SAC) in order to establish a baseline for future monitoring efforts.

Efforts were targeted at 12 stations where Annex I stony and biogenic reef habitats were interpreted based on the review of acoustic data (side scan sonar, SSS, and multibeam echosounder, MBES). The survey was undertaken in May 2023 and involved the collection of high-resolution seabed video and stills along transects using a Drop-Down Camera (DDC) system fitted with a freshwater housing. Following data collection, all images were analysed using the Bio-Image Indexing and Graphical Labelling Environment (BIIGLE) annotation platform by experienced marine ecologists. This ensured the assessment of the imagery against the various Annex I stony reef and biogenic reef qualifying criteria (composition, elevation, extent and biota) was undertaken in an auditable and transparent manner that can easily be reviewed and validated by regulatory bodies (and others) if required.

The acoustic information available for stations TR1 to TR8 indicated the presence of medium stony reef with interpretation suggesting that stations TR1 – TR5 were located over a continuous Annex I stony reef spanning the whole extent between these stations, while stations TR6 – TR8 were placed over patches of Annex I stony reef. Imagery analysis found that stations TR1, TR2, TR3 and TR4 were described as mosaic habitats of rock and coarse sediments, largely representing both European Nature Information System (EUNIS) biotopes A5.141 '*Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles' and A4.213 '*Urticina felina* and sand-tolerant fauna on sand-scoured or covered circalittoral rock' across both the proposed rock revetment and control areas. Following the methods of Irving (2009), these stations were described as discrete areas of Annex I low stony reef, as the composition and elevation observed did not meet the criteria of a medium stony reef and the presence of a mosaic habitat suggested a patchy nature of this feature. Station TR5 was the only of these to show evidence of continuous low stony reef following these methods. Interpretation of geophysical data suggested that stations TR6, TR7 and TR8 comprised of discrete areas of Annex I stony reef interspersed with coarse sediments. Seabed imagery analysis from these stations suggested they were dominated by coarse sediments representative of EUNIS habitat complex A5.14 'Circalittoral coarse sediment', interspersed with patches of mosaic habitat made of A5.14 and A4.13 'Mixed faunal turf communities on circalittoral rock'. In some instances, this mosaic habitat qualified as low stony reef following the criteria of composition, elevation and extent of Irving (2009) as modified by Collins (2010b), but did not meet the criteria for medium stony reef as in the interpretation of acoustic data.

Following assessment of the biota at these stations, many of the images initially described as low stony reef were deemed 'not a reef' as they did not support 'key species' and 'reef species' typically associated with stony reef habitats. This included all images initially described as reef that fell within the proposed rock revetment area. A total of 19 images within the control region were assigned as 'possible reef' with one 'key species' and between 5 and 20 'reef species' identified in each image. Images assigned as 'possible reef' were largely sporadic and generally occurred in instances where the biota of surrounding imagery were not deemed characteristic of Annex I reef. The only exceptions to this were stations TR2 where imagery analysis suggested a small patch of possible Annex I reef in the north, and TR3 where a small, low confidence patch of possible reef was identified in the northern control region.

Seabed imagery analysis did not corroborate the interpretation of the acoustic data at TR9 as no Annex I biogenic reef was observed at this location. Station TR9 was dominated by A5.44 'Circalittoral mixed sediments', in places supporting *S. spinulosa* (A5.611), however the *S. spinulosa* biotope observed at this station did not meet the criteria to qualify as Annex I biogenic reef. Interpretation of the acoustic information available for TR10, TR11 and TR12 suggested the presence of a potential biogenic reef, however, seabed imagery analysis only partially supported this. Station TR10 was dominated by mixed sediments with an area to the northeast of the cable, within the control area, supporting *S. spinulosa* and qualifying as Annex I low reefiness biogenic reef. Station TR12 was dominated by mixed sediments (A5.44) supporting *S. spinulosa* with only the area to the southeast qualified as Annex I low reefiness biogenic reef, including an area within the proposed rock revetment.

1. Introduction

1.1. Project Overview

Greenlink Interconnector Limited (GIL), the developer, has been granted the necessary consents and licences to install and operate a 500 MW electricity interconnector (Greenlink) between Great Island, County Wexford (Ireland) and Pembroke, Pembrokeshire (Wales). The offshore cable system will run from Baginbun Beach, County Wexford to Freshwater West, Pembrokeshire; a length of 159 km.

The Greenlink subsea cables will cross the Pembrokeshire Marine / Sir Benfro Forol Special Area of Conservation (SAC) for approximately 50 km, starting at the landfall at Freshwater West, Pembrokeshire (Figure 1). The preference is to bury the cables in sediment – a process that will not affect the integrity or coherence of the European Site Network. However, sediment conditions may not be suitable for burial in all locations, and the deposit of external cable protection may be required. If external cable protection is required on the SAC's Primary Feature Reef, Natural Resources Wales (NRW) Technical Experts have advised that this would be considered a significant loss of Annex I habitat and that compensatory measures will be required.

As such, a monitoring plan has been proposed; the objective of which is to establish that if compensatory habitat is required, it provides a comparable ecological function to that of the baseline reef habitat, thus restoring the habitat to a level that is determined to be at least equal to if not enhanced compared to baseline conditions and allows the continued ecological functioning of the area. In order to inform the monitoring plan and establish baseline conditions of reef habitat, a Drop-Down Camera (DDC) survey was undertaken at 12 locations along the Greenlink Interconnector cable route (Figure 1).

1.2. Aims and Objectives

The key objective of the benthic habitat compensation survey, as set out in the Pembrokeshire Marine SAC Habitat Compensation Plan (Siemens Energy, 2022) is to '*establish that the compensatory habitat (rock revetment) provides a comparable ecological function to that of the baseline Reef habitat*'. This will be accomplished through addressing the following aims:

- Conduct a full reef assessment of any areas of potential geogenic and biogenic reef habitats following industry standard guidance and practices such as Irving (2009) and Gubbay (2007) (detailed further in Section 5.1);
- Describe the epibenthic communities present along pre-defined survey transects, including biotopes and covering biodiversity, function, abundance, extent, species richness, representativeness, rarity and sensitivity.
- Identify and assess the status of species and habitats of conservation importance, including Annex I protected species and habitats (such as *Sabellaria spinulosa*

biogenic reef or stony reef), and Annex V species[1] of the Habitats Regulations, species listed under Schedule 5 of the Wildlife & Countryside Act[2], OSPAR species and habitats[3] and designated features of the Marine Protected Area (MPA) network (e.g., SAC and Marine Conservation Zone (MCZ) features); and

- Confirm the presence/absence of any invasive non-native species (INNS), species non-native to UK waters and species non-native to the local habitat types (e.g., hard-substrate specialists in a wider sedimentary habitat).

This will be achieved using DDC and subsequent detailed analysis of seabed video and stills imagery collected over time. This report presents baseline conditions of reef habitats present along the section of the Greenlink Interconnector cable crossing the Pembrokeshire Marine / Sir Benfro Forol SAC prior to the cable installation.

[1] https://jncc.gov.uk/our-work/article-17-habitats-directive-report-2019-species/
[2] https://www.legislation.gov.uk/ukpga/1981/69/schedule/5
[3] https://www.ospar.org/work-areas/bdc/species-habitats/list-of-threatened-declining-species-habitats

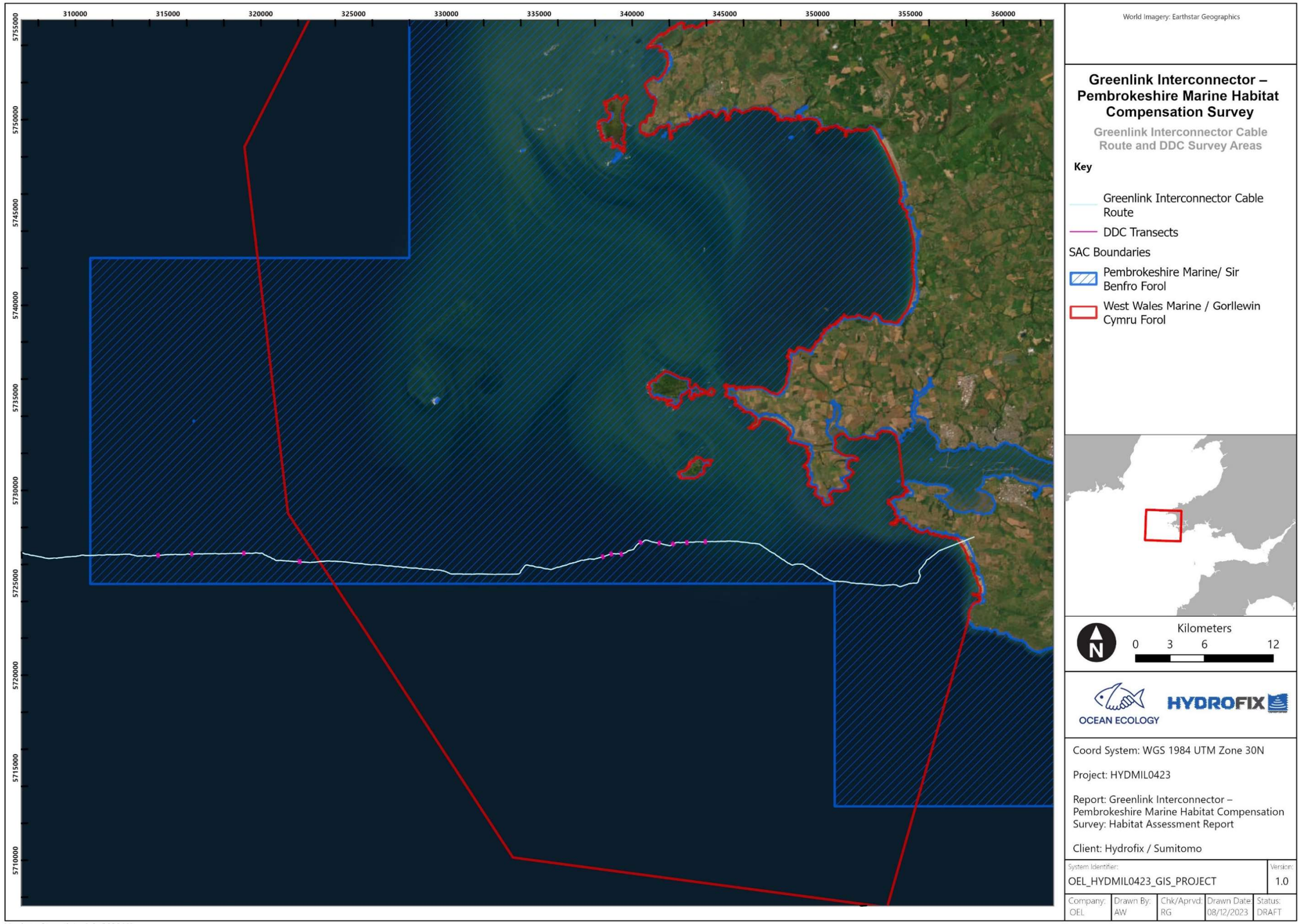

Figure 1 Overview of survey area.

2. Current Understanding

The planned Greenlink subsea cables will run from landfall at Freshwater West and run off the southwest of Pembrokeshire into the southern Celtic Sea. The cable route will cross the Pembrokeshire Marine SAC for approximately 50 km.

2.1.1. Designated Sites

The proposed cable route and benthic habitat compensation survey areas intersect and lie close to a number of MPAs, including the Pembrokeshire Marine / Sir Benfro Forol SAC, as set out below and presented in Figure 1.

Pembrokeshire Marine / Sir Benfro Forol SAC

The proposed cable route intersects the Pembrokeshire Marine / Sir Benfro Forol SAC which is a designated marine protected area covering 1,380 km^2 in southwest Wales. This SAC is designated for the protection of the following habitats and species:

- Annex I reef
- Fragile sponge & anthozoan communities on subtidal rocky habitats
- Maerl
- Mussel beds
- *Musculus discors* beds
- *Ostrea edulis* beds
- Seagrass beds

Further features designated within this SAC include:

- Estuaries
- Large shallow inlets and bays
- Reefs
- Sandbanks which are slightly covered by seawater all the time
- Mudflats and sandflats not covered by seawater at low tide
- Coastal lagoons
- Atlantic salt meadows
- Submerged or partially submerged sea caves
- Grey seal (*Halichoerus grypus*)
- Shore duck (*Rumex rupestris*)
- Sea lamprey (*Petromyzon marinus*)
- River lamprey (*Lampetra fluviatillis*)
- Allis shad (*Alosa alosa*)
- Twaite shad (*Alosa fallax*)
- Otter (*Lutra lutra*)

Of particular interest to this survey are Annex I biogenic and geogenic reef habitats.

West Wales Marine SAC

The proposed cable route intersects the West Wales Marine SAC which is situated off the coast of Wales extending from the Llŷn peninsula in the north, to Pembrokeshire in the south-west. The SAC has been identified as an area of importance for harbour porpoise (*Phocoena phocoena)*.

Skomer, Skokholm, and the Seas off Pembrokeshire Special Protection Area (SPA)

The proposed cable route intersects the Skomer, Skokholm, and the Seas off Pembrokeshire Special Protection Area (SPA) which is situated off the extreme southwest tip of Pembrokeshire and extends to the southwest into the Celtic Sea. This SPA is protected for the seabird assemblages of international importance and the following specific bird species:

- European storm petrel (*Hydrobates pelagicus*)
- Red-billed chough (*Pyrrhocorax pyrrhocorax*)
- Short-eared owl (*Asio flammeus*)
- Manx shearwater (*Puffinus puffinus*)
- Atlantic puffin (*Fratercula arctica*)
- Lesser black-backed gull (*Larus fuscus*)

2.1.1. Annex I Habitats

The Greenlink subsea cables will cross the Pembrokeshire Marine / Sir Benfro Forol Special Area of Conservation (SAC) and the preference is to bury the cables in sediment, a process that will not affect the integrity or coherence of the European Site Network. However, seabed conditions may not be suitable for burial in all locations due to the presence of Annex I reef habitats and the deposit of external cable protection may be required in the form of a rock revetment. If external cable protection is deposited on the SAC's Primary Feature Reef, Natural Resources Wales (NRW) Technical Experts have advised that this would be considered a significant loss of Annex I habitat and that compensatory measures will be required.

Reefs

For the purposes of the European Commission (EC) Habitats Directive, the Interpretation Manual of European Union Habitats – EUR25 (CEC, 2013) defines Annex I 'Reefs' as *'Reef can be either biogenic concretions*[4] *or of geogenic origin*[5].

[4] concretions, encrustations, corallogenic concretions and bivalve mussel beds originating from dead or living animals, i.e. biogenic hard bottoms which supply habitats for epibiotic species.
[5] reefs formed by non-biogenic substrata.

They are hard compact substrata [6] *on solid and soft bottoms, which arise from the sea floor* [7] *in the sublittoral and littoral zone*[8]*. Reefs may support a zonation of benthic communities of algae and animal species as well as concretions and corallogenic concretions'*.

Following this definition, Annex I reef habitats protected under the Habitats Directive can be classified into the following subtypes discussed in detail below:

- Bedrock - encompassing "hard compact substrata", specifically, "rocks (including soft rock, e.g. chalk)" of "geogenic origin";
- Stony - encompassing "hard compact substrata", specifically, "boulders and cobbles (generally >64 mm in diameter" of "geogenic origin";
- Biogenic (encompassing "biogenic concretions").

The following reef habitat has been previously recorded within the survey area:

Stony Reef

Stony reef habitats occur when stable hard substrata, namely cobbles and boulders > 64 mm in diameter arise from the surrounding habitat, creating a habitat colonised by a variety of species. Numerous SAC sites have been designated in UK waters to protect stony reef habitats and associated communities. Such communities can be highly diverse, supporting assemblages of various coral, sponges, ascidians, fish and crustaceans. These associated communities vary dramatically according to environmental variables and may incorporate species that occupy a range of trophic levels. The complexity of habitat created by stony reefs often supports a higher abundance of mobile fauna such as echinoderms and various crabs, hermit crabs, and squat lobsters, as well as fish species for which these species represent key prey items.

***Sabellaria spinulosa* Reef**

Previous surveys undertaken in 2018/2019 (MMT, 2019) found the presence of reefs created by the Ross worm *S. spinulosa which* may form biogenic reefs that can stabilise cobble, pebble and gravel habitats and provide a consolidated habitat for epibenthic species (Pearce et al., 2011). These reefs form solid, raised structures above the surrounding seabed and often support a rich diversity of flora and fauna compared to surrounding areas of relatively homogenous sediment habitat.

[6] rocks (including soft rock, e.g. chalk), boulders and cobbles (generally >64 mm in diameter). Such hard substrata that are covered by a thin and mobile veneer of sediment are classed as reefs if the associated biota are dependent on the hard substratum rather than the overlying sediment.
[7] the reef is topographically distinct from the surrounding seafloor.
[8] the reefs may extend from the sublittoral uninterrupted into the intertidal (littoral) zone or may only occur in the sublittoral zone, including deep water areas such as the bathyal. Where an uninterrupted zonation of sublittoral and littoral communities exist, the integrity of the ecological unit should be respected in the selection of sites.

3. Survey Design

3.1. Sampling Rationale

The Monitoring Plan proposed that seabed imagery was to be acquired and analysed at 11 stations, while an additional station was added by GIL prior to survey mobilisation to better cover an area of potential biogenic reef, making a total of 12 stations to be sampled.

As it cannot be predicted where full cable burial will not be achieved, all stations were surveyed ahead of the pre-lay grapnel run / seabed clearance to provide a monitoring baseline for future monitoring surveys post-installation. Monitoring will be undertaken in the same season at 2, 4 and 6-years post-installation. The sampling plan has been produced based on a detailed review and interpretation of the geophysical data (multibeam echosounder (MBES) bathymetry, side scan sonar (SSS)) (Siemens Energy, 2022).

MBES and SSS data were reviewed simultaneously to position stations onto potential reef identified within the Greenlink Interconnector cable corridor, where it intersects the Pembrokeshire Marine / Sir Benfro Forol SAC.

Differing substrate types were inferred from SSS based on reflectivity where hard substrate would show greater reflectivity than sediments. Seabed elevation was determined by review of MBES which presents water depth. The 12 DDC transects were positioned to ground-truth and delineate stony and biogenic (*S. spinulosa*) reef habitats and confirm the presence/absence of key features of conservation interest (e.g. pink sea fan colonies and fragile sponge and anthozoan communities).

Sampling stations were also located in consideration of all surface, subsurface, and subsea hazards and their respective exclusion / buffer zones including a thorough assessment of Potential Unexploded Ordnance (pUXO).

3.2. Sampling Design

The sampling design for the DDC survey is summarised as follows:

- Eight stations (1-8) located within the stony reef sub-type (corresponding to approximately one transect every 1 km);
- One station (9) located in the low reefiness biogenic reef sub-type;
- Three stations (10, 11, 12) located in an area deemed to represent potential biogenic reef sub-type

At each site, three replicate at approximately 200 m video transects were conducted perpendicular to the cable route. Replicate transects were placed at approximately 50 m apart, and each one intersected the cable route at the transect mid-point. Each transect was split into three sections for analysis; cable footage and north/west and south/east control footage. Control footage was obtained at a minimum of 20 m distance from the rock revetment, giving at approximately 75 m of footage for each control section.'

The sampling plan is summarised in Table 1 and mapped in Figure 2, Figure 3 and Figure 4.

Table 1 DDC transect locations by reef sub-type.

Reef Sub-Type	Station	Transect	Length (m)	Start (DD)		End (DD)	
				Latitude	Longitude	Latitude	Longitude
Stony Reef	1	1.1	200	51.661816	-5.261781	51.663613	-5.261848
		1.2	200	51.661806	-5.262457	51.663603	-5.262525
		1.3	200	51.661795	-5.263239	51.663592	-5.263307
	2	2.1	200	51.661551	-5.276202	51.663347	-5.276321
		2.2	200	51.661534	-5.276877	51.66333	-5.276997
		2.3	200	51.661513	-5.277659	51.66331	-5.277779
	3	3.1	200	51.661211	-5.29067	51.663009	-5.290726
		3.2	200	51.661203	-5.291346	51.663001	-5.291402
		3.3	200	51.661194	-5.292128	51.662991	-5.292184
	4	4.1	200	51.661001	-5.304867	51.662759	-5.304266
		4.2	200	51.661088	-5.305529	51.662847	-5.304927
		4.3	200	51.66119	-5.306294	51.662948	-5.305693
	5	5.1	200	51.661753	-5.317871	51.663376	-5.319114
		5.2	200	51.661636	-5.318481	51.663239	-5.31979
		5.3	200	51.661488	-5.319198	51.663077	-5.32055
	6	6.1	200	51.6564	-5.334064	51.658129	-5.334851
		6.2	200	51.656213	-5.334767	51.65797	-5.335376
		6.3	200	51.656105	-5.335516	51.657859	-5.336151
	7	7.1	200	51.655859	-5.341539	51.657576	-5.342393
		7.2	200	51.655734	-5.342185	51.657452	-5.343039
		7.3	200	51.655591	-5.342933	51.657308	-5.343786
	8	8.1	200	51.654576	-5.348312	51.656298	-5.349142
		8.2	200	51.654485	-5.348957	51.656198	-5.349835
		8.3	200	51.654367	-5.349663	51.656072	-5.350577
Low Reefiness Biogenic Reef	9	9.1	200	51.656125	-5.629878	51.657923	-5.629897
		9.2	200	51.656122	-5.630554	51.65792	-5.630573
		9.3	200	51.656119	-5.631336	51.657917	-5.631355
Potential Biogenic Reef	10	10.1	200	51.655736	-5.670686	51.657534	-5.670714
		10.2	200	51.655732	-5.671362	51.65753	-5.67139
		10.3	200	51.655728	-5.672145	51.657525	-5.672172
	11	11.1	200	51.655094	-5.697317	51.656888	-5.697511
		11.2	200	51.655066	-5.697991	51.65686	-5.698185
		11.3	200	51.655033	-5.698771	51.656827	-5.698966
	12	12.1	200	51.656125	-5.629878	51.657923	-5.629897
		12.2	200	51.656122	-5.630554	51.65792	-5.630573
		12.3	200	51.656119	-5.631336	51.657917	-5.631355

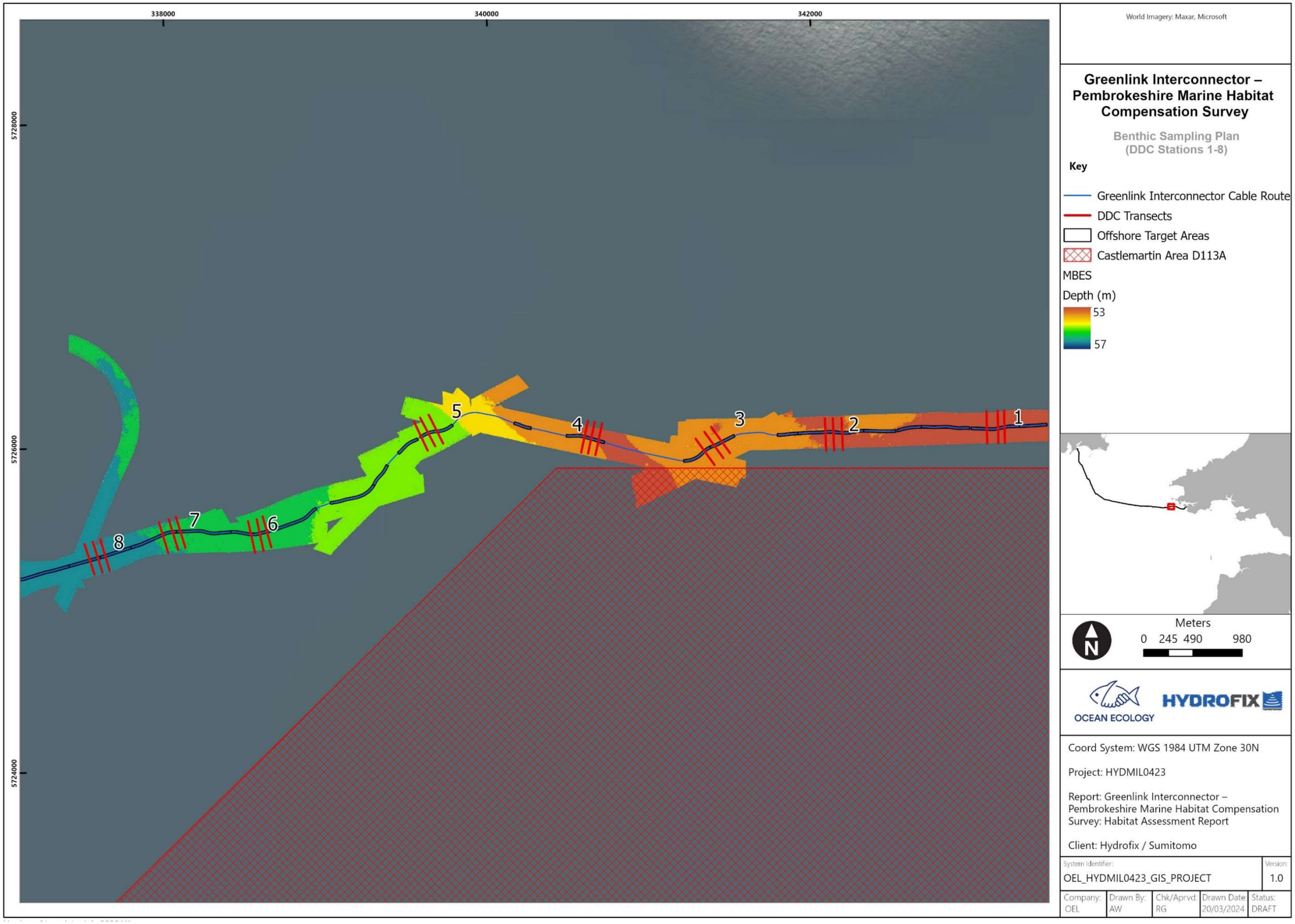

Figure 2 Drop Down Camera Transect Stations 1-8 (Stony Reef).

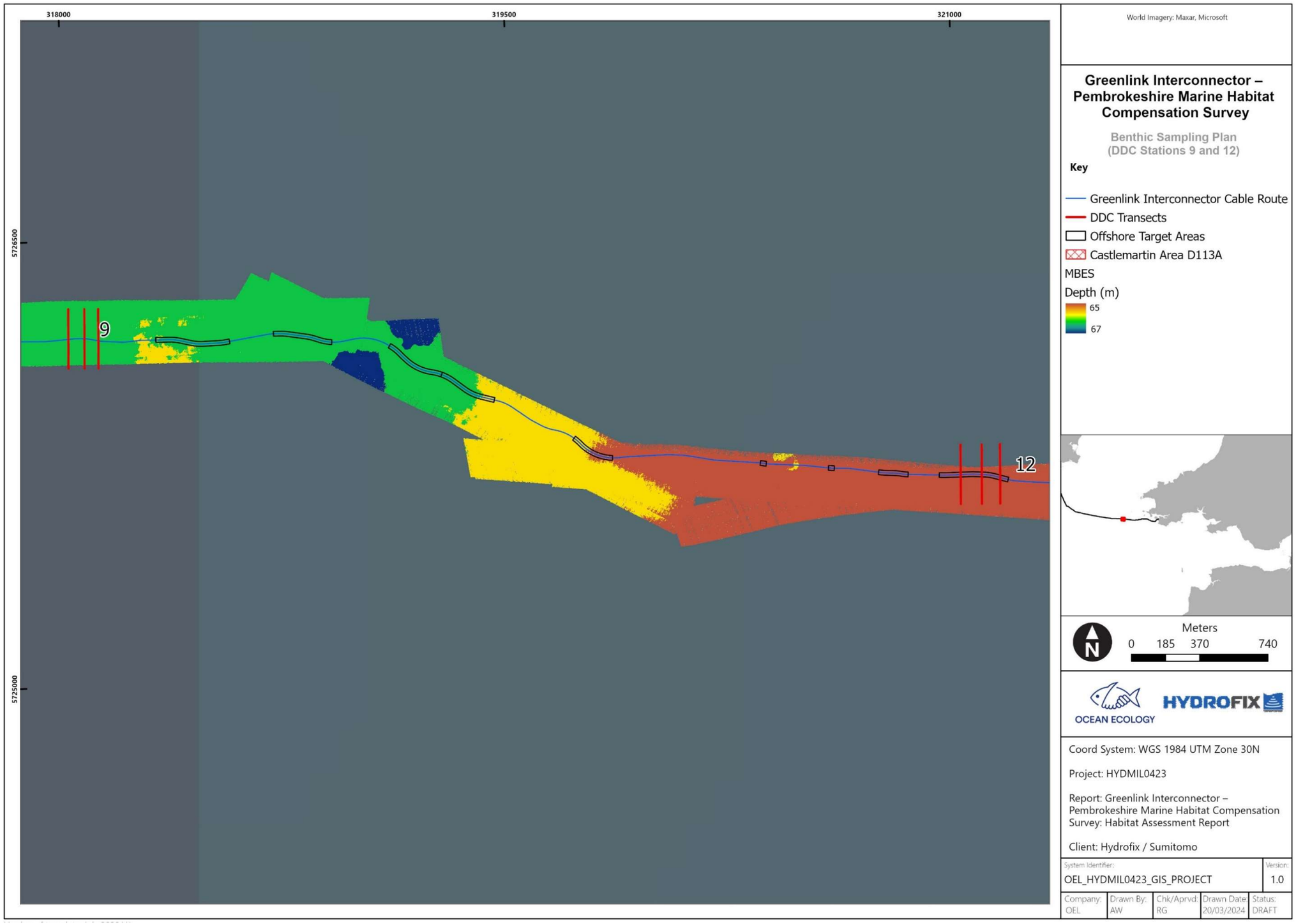

Figure 3 DDC transect Station 9 (biogenic reef) and 12 (potential biogenic reef).

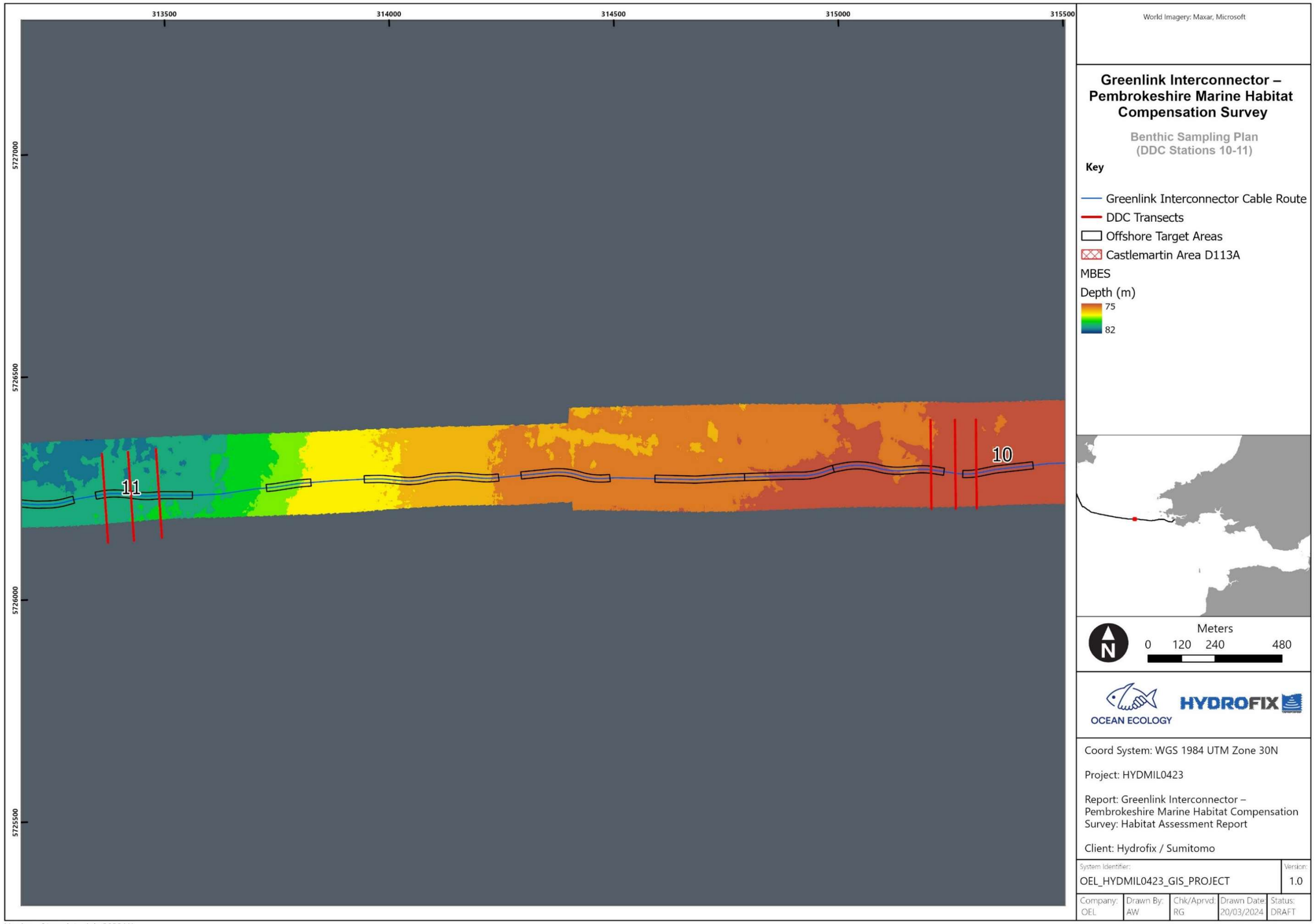

Figure 4 DDC transect stations 10 and 11 (potential biogenic reef).

4. Methods

4.1. Project Parameters

4.1.1. Horizontal Datum

Table 2 Geodetic parameters.

GPS Satellite System Geodetic Parameters	
Spheroid Name	WGS 1984
Projection	Universal Transverse Mercator (UTM)
Zone	30 N
Prime Meridian	Greenwich
Prime Meridian	0.000000000000000
Conversion factor to metres	1.000000000000000
Semi-Major Axis (a)	6 378 137.000 m
Semi-Minor Axis (b)	6 356 752.314 m
Inverse Flattening (1/f)	298.257 223 563
Flattening (f)	0.003352810664747
First eccentricity (e)	0.081819190842621
First eccentricity squared (e^2)	0.006694379990141
Second eccentricity (e')	0.082094437949696
Second eccentricity squared (e'^2)	0.006739496742276

4.1.2. Datum Transformation Parameters

All data is referenced to WGS84 UTM 30N, with no datum transformation need. No conversion or test coordinate has been provided by the Client.

4.1.3. Vertical Datum

All altitude and depth data above seabed was referenced to Lowest Astronomical Tide (LAT). All depth data below the seabed was referenced to LAT with depth below seabed included in brackets. LAT was derived using a Vertical Offshore Reference Model (VORF).

4.1.4. Unit Format and Conversions

The following units have been used throughout this project and expressed using the following conventions.

Table 3 Project unit format and convention details.

Unit Formats and Conventions	
Geographical Coordinates	Latitude N DD˚MM.mmmmmm' to 6 decimal places. Longitude E/W DD˚MM.mmmmmm' to 6 decimal places.
Grid Coordinates	Meters in the following format: Easting EEE EEE.eee m to 3 decimal places. Northing NNN NNN.nnn m to 3 decimal places.
Linear distances	Meters to 1 decimal places.
Offset measurement sign conventions	Meters in the following format: 'Y' is positive forward 'X' is positive to starboard 'Z' values are positives upwards from the waterline
Time	Local unless otherwise stated.

4.2. Survey Vessel

The Marine and Coastal Agency (MCA) Category 2, 11.7 m dedicated survey vessel '*Argyll Explorer*' (Plate 1), undertook the DDC survey, mobilising and operating out of Milford Haven.

Table 4 Vessel details.

Vessel Name	Argyll Explorer
Call Sign	MDAH2
MMSI	235057487
Mobilisation Port	Milford Haven
Length	11.7 m
Beam	5.5 m
Draft	1.5 m

Plate 1 OEL's dedicated survey vessel, '*Argyll Explorer*.

4.3. Survey Navigation

The vessel was equipped with a Hemisphere V104s Global Positioning System (GPS) compass system. The Hemisphere V104s's internal GPS receiver automatically searched for and used a minimum of 4 GPS satellites and managed the navigation information required for position to within 3 m (95% accuracy). The V104s also automatically tracked a Satellite-Based Augmentation System (SBAS) differential correction to improve its position accuracy to better than 1.0 m 95%.

The V104s had an integrated gyro and two tilt sensors to provide an accurate heading for the navigation software.

4.4. Subsea Positioning

The vessel was equipped with an Easytrak Nexus 2 Lite Ultra-Short Baseline (USBL) system and 1329A Omni-directional +/-90° Micro Beacons for subsea positioning of the camera. The Easytrak Nexus 2 Lite is an advanced USBL positioning and tracking system that determines the position of dynamic subsea targets through the transmission and reception of acoustic signals between the submerged transceiver and a target beacon. The USBL was fully calibrated prior to survey operations using a Valeport SWiFT sound velocity profiler (SVP). Readings were obtained daily from both the up-cast and down-cast.

In shallow water depths it may not be possible to acquire an accurate subsea position with the USBL system. In this case a fixed offset was used to collect subsea positional data of the survey equipment. During each DDC deployment, the length of winch wire required to reach the seabed was recorded using graduated marks on the winch wire. The depth of the camera system was also recorded using the camera's in-built depth sensor to allow for the calculation of the camera system offset from the stern of the vessel using the following formula:

$$a=\sqrt{c2-b2}$$

Where a = offset, b = water depth and c = length of winch wire.

The offset calculated was then assigned into the Navigation software for the vessel navigation during that station.

4.4.1. Navigation Software

A vessel-based positioning system was employed utilizing EIVA NaviPac V4.6 software to ensure the accurate positioning of the vessel and subsea positioning of the sampling equipment via the USBL system as well as recording continuous track plots of the sampling equipment and recording sampling fixes. A navigation screen, displaying EIVA Helmsman Display was provided at the helm position of the vessel for the Officer on Watch as well as for the Environmental Scientist on the bridge.

4.4.2. Positional Checks & Calibrations

The GPS has an internal precision calculation which outputs a graphical representation of horizontal accuracy, displaying numerical precision as easting and northing. The accuracy of vessel heading, and reference systems was verified during mobilisation using agreed reference points.

As internal sensors were used for pitch and roll data within the USBL head, a static USBL calibration was completed during mobilisation to align USBL heading with survey navigation heading. This was achieved by deploying an Easytrak beacon from a referenceable position on the vessel, for example the bow centre line, and aligning the position in NaviPac to visually ascertain if there were any positioning anomalies.

4.5. Seabed Imagery Collection

Seabed imagery (simultaneous video and stills) was acquired at each station in line with NMBAQC Epibiota Remote Monitoring from Digital Imagery Operational Guidelines. This utilised OEL's SubC Rayfin PLE camera system, set up to obtain 1080p High Definition (HD) video and 20 Megapixel (MP) still images. The camera system (Plate 2) consisted of a SubC Imaging Rayfin PLE camera mounted in a Clear Liquid Optical Chamber (CLOC) (otherwise known as a 'freshwater lens') filled with fresh water to ensure imagery of suitable quality was obtained regardless of turbidity. The frame included LED strip lamps and a 10 cm point laser scaling array that was projected into the field of view, a 300 m umbilical and topside computer. The camera was powered with the use of an Uninterruptable Power Supply (UPS) to ensure no damage was caused should the vessel lose power or in case of a power surge. A full redundancy SubC Rayfin PLE camera system was stored onboard for use if required.

The CLOC was height and angle adjustable providing a variety of options for view, lighting, and focal length to maximise data quality with respect to prevailing conditions (e.g., high turbidity).

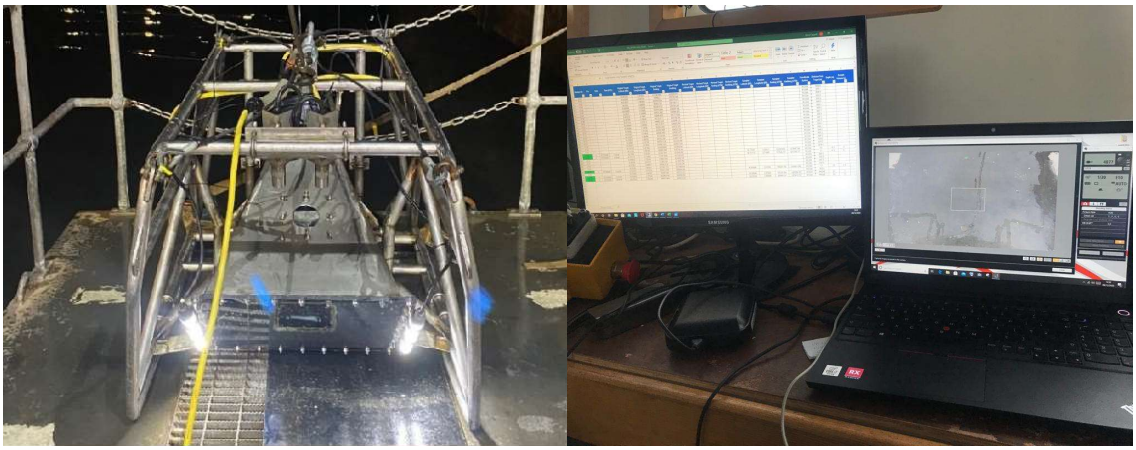

Plate 2 Left: OEL CLOC camera system. Right: The camera system topside setup.

The DDC system was deployed from the aft deck of the *Argyll Explorer* using the stern A-frame and A-frame winch to lower/raise the DDC system. A separate camera umbilical was hand managed on deck and fastened to the winch when necessary.

Videos were recorded in a digital format direct to topside hard disk drives (HDDs) and digitally overlaid retrospectively with information including project, date, time, depth and coordinates.

All DDC transects were sampled in line with the Joint Nature Conservation Committee (JNCC) epibiota remote monitoring operational guidelines (Hitchin et al., 2015). The camera was deployed to the seabed over the target start / end transect location and slowly 'flown' just above the seabed along the transect to obtain both continuous video footage and still images. A live feed was displayed on a monitor and photographs were taken continually along the selected transects. Whenever a photograph was taken this information was relayed to the on-line surveyor and a positional fix taken of the USBL (Ultra Short Baseline) beacon.

The camera was flown (or a bed-hopping approach was used where visibility/tide did not allow) above the seabed during camera transects at a consistent speed of 0.5knots (0.25m/s-1) or less. This allowed for the collection of continuous videos of the seabed and allow for high quality still images to be taken at 5 second intervals and at the boundaries of any key features or change in habitat.

Where conditions allowed, approximately 6-8 photographs of the proposed rock revetment (10 m) per transect and approximately 50-60 photographs for each control section (75 m) either side of the revetment were collected, with the aim of collecting 60-70 images for analysis per 200 m transect. All footage underwent a preliminary review *in situ* by the OEL's onboard Environmental Scientists.

5. Laboratory Analysis & Interpretation

5.1. Seabed Imagery Analysis

All seabed imagery analysis collected by DDC was undertaken in consideration of the latest NMBAQC/JNCC Epibiota Quality Assurance Framework (QAF) guidance and identification protocols available on the NMBAQC website. Final datasets are presented using the latest NMBAQC/JNCC epibiota monitoring proformas available for stills and video footage and were quality assured using the QAF form check and comparison tools.

The seabed imagery analysis was undertaken in two stages using the Bio-Image Indexing and Graphical Labelling Environment (BIIGLE) annotation platform (Langenkämper et al., 2017). The first stage, "Tier 1", consisted of labels that referred to the whole image being assigned providing appropriate metadata for the image including European Nature Information System (EUNIS) habitat classifications assigned in line with Parry, 2019. The second stage, "Tier 2", was used for enumerating epibiotal abundance and cover within each image and to assign percentage cover of reef types.

A full reef habitat assessment (HA) was conducted on all DDC imagery to determine whether habitats met the definitions of Annex I reef habitats as detailed in Table 5 and Table 6. Biogenic and geogenic reef habitat classification also considered the work of Collins (2010a) and Collins (2010b) to produce a single overarching reef structure measure for images where potential Annex I reef was identified. The latest JNCC guidance on the characterisation of 'low resemblance' Annex I stony reef was also considered (Golding et al., 2020) (Table 7).

The annotation label tree used during analysis had major headings for each of the reef types. Under each reef type, labels were assigned for each of the categories required to determine whether Annex I reef habitat was present (Table 5 and Table 6).

Table 5 Characteristics of stony reef (Irving, 2009).

Characteristic	'Reefiness'			
	Not a Reef	Low	Medium	High
Composition (proportion of boulders/cobbles (>64 mm))	<10 %	10-40 % matrix supported	40-95 %	>95 % clast-supported
Elevation	Flat seabed	<64 mm	64 mm – 5 m	>5 m
Extent	<25 m^2	>25 m^2		
Biota	Dominated by infaunal species	-		>80 % of species present composed of epibiotal species

Table 6 Characteristics of *Sabellaria spinulosa* reef (Gubbay, 2007).

Characteristic	'Reefiness'			
	Not a Reef	Low	Medium	High
Elevation (cm)	< 2	2 – 5	5 – 10	> 10
Extent (m^2)	< 25	25 – 10,000	10,000 – 1,000,000	> 1,000,000
Patchiness (% Cover)	< 10	10 – 20	20 – 30	> 30

Table 7 Biota requirements for the assignment of low stony reef (Golding et al., 2020).

	Key Species	Reef Species
Reef	≥ 3	≥ 20
Possible Ref	> 1 and < 3	> 5 and < 20
Not a Reef	No Key Species	< 5

5.1.1. Tier 1 Analysis

The first stage, "Tier 1", consisted of assigning labels that referred to the whole image, providing appropriate metadata for the image. Metadata "Image Labels" included:

- Broadscale Habitat (BSH) type.
- Substrate type (and percentage cover in 10% intervals).
- Bedforms present.
- The presence of any Annex I habitats, Features of Conservation Importance (FOCI), Habitats of Conservation Importance (HOCI) and Invasive Non-Native Species (INNS).
- The presence of any visible impacts or other modifiers (such as discarded fishing gear or marine litter (as per the Marine Strategy Framework Directive (MSFD) categories), visible physical damage to the seabed, evidence of strong currents, non-native species, etc.).
- Image quality categories (including "Not Analysable" category).

Depending on the presence of reef, this also included:

- Extent: As it is not possible to fully determine the extent of reef habitats from a single image alone this label will be used to identify areas that are highly unlikely to constitute reef habitats. An example is an image that shows a large boulder being preceded and succeeded by images of unconsolidated sandy sediments.
- Biota: Labels assigned to determine whether epifauna dominate the biological community observed.
- Elevation: Labels assigned depending on reef type. Laser points will be used to assist in the assignment of categories.

5.1.2. Tier 2 Analysis

The second stage, "Tier 2", was used to enumerate epibiotal abundance within each image for all visible flora and fauna. This was undertaken as follows:

- Using the BIIGLE Annotation Platform, (detailed below) enumeration of all visible taxa was undertaken using points for enumerable "count" taxa and polygons for ground-covering taxa; to enable calculation of percentage cover for these taxa.
- Where an individual of a "count" taxon overlay a ground-cover taxon, then this individual was still counted (i.e., a point annotation was added for the count taxa over the polygon of the ground-cover taxon).
- Identification of any INNS and species non-native to UK waters. Information was also included on species non-native to the local habitat types (e.g. hard-substrate specialists in a wider sedimentary habitat).

The substratum observed in each still image was recorded as a percentage cover of CATAMI (Althaus et al., 2015) substratum types where possible. Determination of sediment type (such as coarse, mixed, sand etc.) was facilitated using the adapted Folk sediment trigon (Long, 2006) incorporated into a sediment category correlation table. Percentage cover of the different substrate types was used to determine and assign EUNIS codes and BSH.

6. Results

Twelve DDC stations were surveyed and 36 transects analysed in total (three transects per station) to investigate the presence of Annex I habitats across the Greenlink subsea cables.

Each transect was divided into two sections: rock revetment and control to provide baseline information on the condition of reef habitats. To note that each station is made of two control sections one to the north and one to the south of the cable. It is noteworthy that as this is a pre-installation assessment, no rock revetment has been put in place yet and instead the natural habitat has been assessed to provide baseline information on the condition of reef habitats. This baseline will be used for comparison with future monitoring data to assess whether the rock revetment, if installed, acts as an adequate form of compensation compared to pre-installation habitats.

Along 11 of the 36 transects surveyed it was not possible to analyse the minimum of six still images along the proposed rock revetment section as set out in the Pembrokeshire Marine SAC Habitat Compensation Plan (Siemens Energy, 2022). This was due to a combination of factors such as poor visual quality of the still imagery and video footage that prevented the collection of screenshots usable for analysis and/or overlapping of adjacent photos. The latter was due to the camera hovering over the same area of seabed resulting in several photographs of the same location. Table 8 provides a summary of the transects at which less than six stills were captured across the proposed rock revetment section.

Full DDC video and still image logs are provided in Appendices I and II. The full imagery analysis proforma and Annex I reef assessment are provided in Appendices III and IV.

Table 8 Overview of transects at which it was not possible to collect the minimum of 6 photographs along the proposed rock revetment section.

Transect	Stills	Screenshots	Total number of photographs
TR1.3	2	2	4
TR2.3	3	2	5
TR4.3	3	0	3
TR7.2	1	2	3
TR7.3	3	1	4
TR9.2	4	0	4
TR9.3	2	3	5
TR11.1	1	0	1
TR11.3	2	1	3
TR12.1	2	1	3
TR12.3	2	0	2

6.1. Epifaunal Community Composition

All taxa visible in the seabed imagery were identified to the lowest practicable taxonomic level with solitary taxa counted and colonial or turf forming taxa assigned a percent cover. These were then aggregated into 16 functional morphotaxa groupings as listed below:

- Octocorallia
- Annelida
- Anthozoa
- Bryozoa
- Cnidaria
- Crustacea
- Ctenophora
- Echinodermata
- Faunal burrow
- Faunal crust
- Faunal turf
- Hydroids
- Mollusca
- Porifera
- Tunicata
- Vertebrata

Based on the still image area, density for each morphotaxa was calculated (individuals / m^2) (Appendix V). It was possible to group transects based on their epifaunal community composition. Table 9 and Figure 5 illustrate the top three morphotaxa in terms of density at each transect, while Table 10 and Figure 6 show the top three colonial or turf forming morphotaxa dominating the epifaunal community.

The most commonly occurring epifaunal taxa recorded across the survey area were the sea anemone *Urticina* sp. occurring in 18 % of the images followed by hermit crabs of the family Paguridae recorded in 14 % of the images.

Several economically important species were recorded across the survey area. The queen scallop (*Aequipecten opercularis*) was recorded at three images along transect TR1.1 and two images along transect TR1.2 with an average of three individuals per m^2. The common whelk (*Buccinum undatum*) was recorded in 20 images with an average of 5 individuals per m^2 recorded across the survey area. Eleven of these 20 images were from transect TR1 with a maximum density of 20 individuals per m^2. The Atlantic spider crab (*Maja brachydactyla*) and velvet swimming crab (*Necora puber*) were recorded in one image each, the former along transect TR2 and the latter TR8 with a density of three individuals per m^2.

Table 9 Dominant morphotaxa densities (individuals / m^2) along each transect.

Dominant Morphotaxa	Transects	Dominant Morphotaxa	Average density (individuals / m^2) ± SE	% Contribution to community composition
Anthozoa Mollusca Tunicata	TR1	Anthozoa	2.74 ± 0.30	19%
		Mollusca	4.4 ± 0.44	30%
		Tunicata	3.56 ± 0.69	24%
	TR2	Anthozoa	4.2 ± 0.46	37%
		Mollusca	2.38 ± 0.51	21%
		Tunicata	1.8 ± 0.84	16%
Anthozoa Crustacea Mollusca	TR3	Anthozoa	2.49 ± 0.28	55%
		Crustacea	0.67 ± 0.15	15%
		Mollusca	0.65 ± 0.30	14%
	TR4	Anthozoa	2.15 ± 0.27	47%
		Crustacea	0.85 ± 0.16	19%
		Mollusca	1.08 ± 0.21	24%
	TR6	Anthozoa	1.31 ± 0.21	20%
		Crustacea	0.97 ± 0.20	15%
		Mollusca	3.87 ± 1.01	58%
	TR7	Anthozoa	2.28 ± 0.34	39%
		Crustacea	1.87 ± 0.24	32%
		Mollusca	0.58 ± 0.16	10%
Annelida Anthozoa Crustacea	TR5	Annelida	0.58 ± 0.13	14%
		Anthozoa	1.93 ± 0.24	46%
		Crustacea	1.05 ± 015	25%
	TR8	Annelida	0.79 ± 0.14	15%
		Anthozoa	1.19 ± 0.19	23%
		Crustacea	1.51 ± 0.19	29%
	TR10	Annelida	1.41 ± 0.22	23%
		Anthozoa	1.03 ± 0.22	17%
		Crustacea	2.34 ± 0.24	37%
	TR11	Annelida	6.08 ± 0.68	36%
		Anthozoa	5.06 ± 0.61	30%
		Crustacea	2.91 ± 0.30	17%
	TR12	Annelida	7.87 ± 1.04	68%
		Anthozoa	0.79 ± 0.18	7%
		Crustacea	1.8 ± 0.22	15%
Alcyonacea Anthozoa Crustacea	TR9	Alcyonacea	0.58 ± 0.13	11%
		Anthozoa	1.9 ± 0.25	35%
		Crustacea	1.9 ± 0.20	35%

Table 10 Dominant colonial and turf forming morphotaxa (% cover) along each transect.

Group	Transects	Dominant Morphotaxa	% Cover	% Contribution to community composition
Annelida Crustacea Faunal Turf	TR1	Annelida	5.29 ± 0.16	8%
		Crustacea	27.6 ± 0.99	44%
		Faunal turf	22.76 ± 0.89	36%
	TR7	Annelida	5.47 ± 0.41	18%
		Crustacea	8.43 ± 0.35	28%
		Faunal turf	12.05 ± 0.74	40%
Crustacea Faunal Crust Fauna Turf	TR2	Crustacea	13.08 ± 0.44	19%
		Faunal Crust	10.79 ± 0.40	16%
		Fauna Turf	36.09 ± 1.01	53%
	TR3	Crustacea	10.19 ± 0.39	21%
		Faunal Crust	9.56 ± 0.48	20%
		Fauna Turf	23.56 ± 0.86	48%
	TR4	Crustacea	11.65 ± 0.37	21%
		Faunal Crust	12.06 ± 0.50	21%
		Fauna Turf	26.55 ± 0.80	47%
	TR5	Crustacea	11.71 ± 0.37	19%
		Faunal Crust	15.69 ± 0.92	25%
		Fauna Turf	28.06 ± 1.06	45%
	TR6	Crustacea	7.02 ± 0.46	20%
		Faunal Crust	4.29 ± 0.30	12%
		Fauna Turf	19.50 ± 1.59	56%
	TR8	Crustacea	10.09 ± 0.45	27%
		Faunal Crust	4.8 ± 0.54	13%
		Fauna Turf	18.13 ± 1.22	48%
Annelida Faunal Crust Faunal Turf	TR9	Annelida	4.93 ± 0.48	6%
		Faunal crust	7.01 ± 1.34	9%
		Faunal turf	63.78 ± 2.43	83%
	TR10	Annelida	5.75 ± 0.82	11%
		Faunal crust	1.87 ± 0.54	4%
		Faunal turf	43.77 ± 2.24	84%
	TR11	Annelida	18.48 ± 1.47	26%
		Faunal crust	3.27 ± 0.23	5%
		Faunal turf	48.06 ± 2.04	68%
	TR12	Annelida	13.88 ± 1.36	21%
		Faunal crust	3.05 ± 0.21	5%
		Faunal turf	47.78 ± 2.05	72%

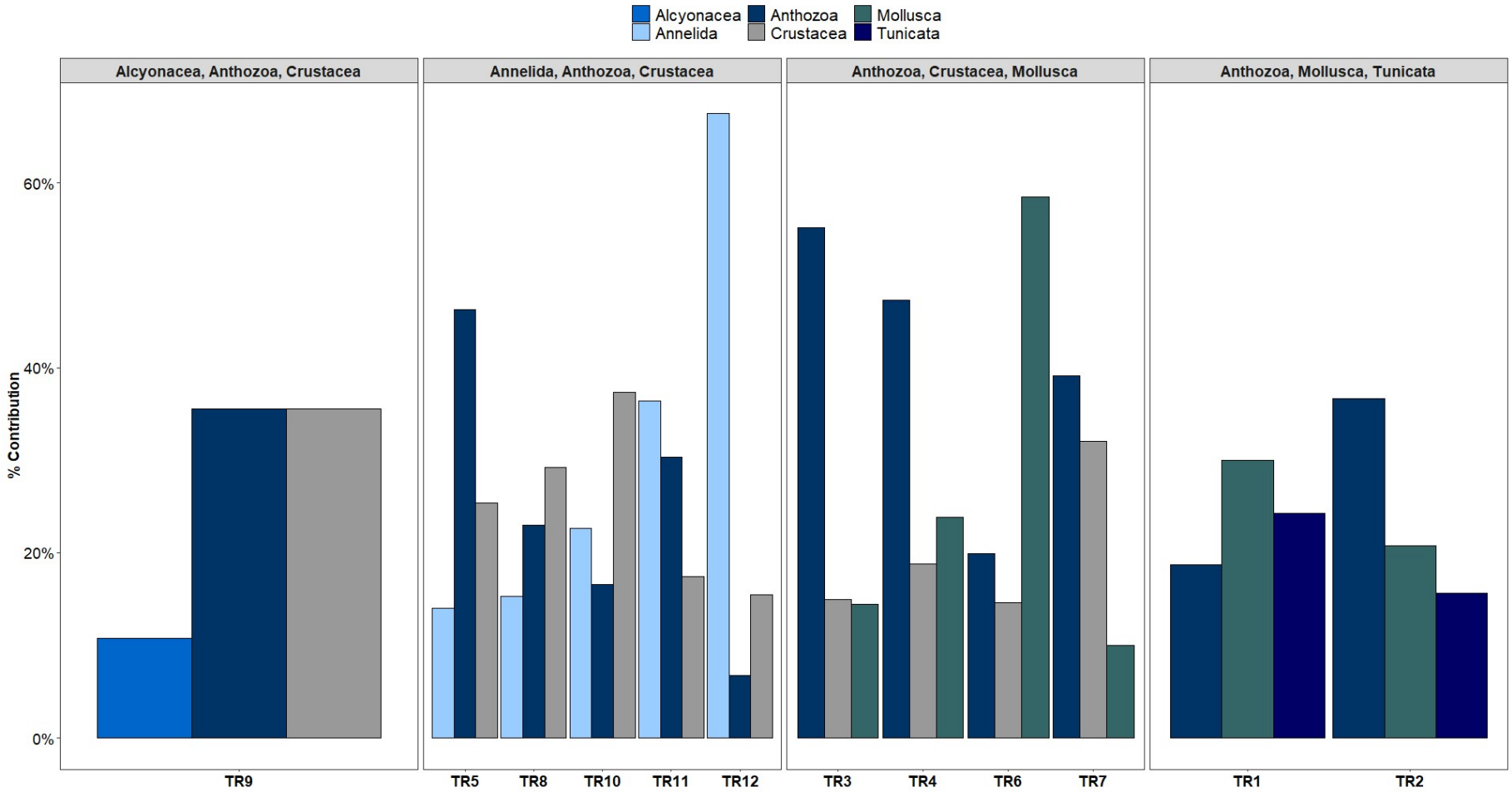

Figure 5 Percentage contribution to total community composition of the top three dominant morphotaxa densities at each transect.

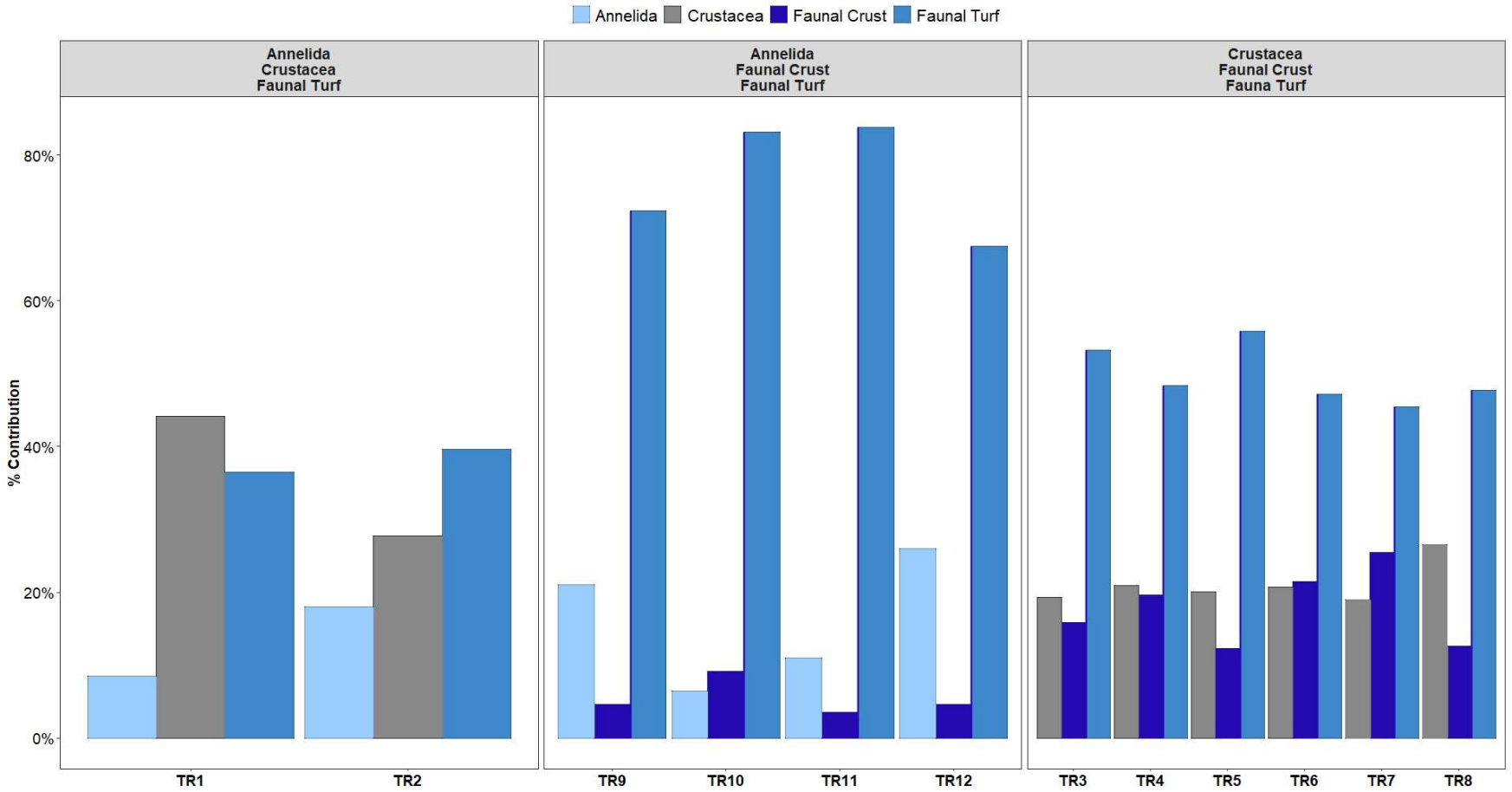

Figure 6 Percentage contribution to total community composition of the top three dominant colonial or turf forming taxa morphotaxa at each transect.

6.2. Proposed rock revetment

Analysis of the seabed imagery collected within the proposed rock revetment area at the 12 targeted stations identified 5 BSHs and 7 biotope complexes, including 5 mosaic habitats where rocky habitats were interspersed with coarse sediments (Table 11, Figure 7, Figure **8** and Figure 9). Example images collected from within the rock revetment area are provided in Appendix VI.

6.2.1. MPA Reef Feature Assessment

Following the criteria described in Irving (2009) as modified by Collins (2010b), Annex I stony reef was identified at stations TR1 to TR8 as images collected along these transects met the criteria for composition, elevation and extent allowing for the assignment of low stony reef.

Following the latest guidelines set out in Golding et al. (2020), no stations within the proposed rock revetment area qualified as Annex I reef, as none of the images analysed met the requirement for the biota category (Table 7). As none of the images analysed within the proposed rock revetment section met all four criteria (composition, elevation, extent and biota), none qualified as an Annex I stony reef.

The proposed rock revetment section of TR12 was characterized by the presence of *S. spinulosa* to the east constituting a low reefiness Annex I *S. spinulosa* reef, while the reminder of the area consisted of mixed sediment (Figure **10**).

No Annex I habitats were observed at TR9, TR10 and TR11 as they were characterised by the presence of circalittoral mixed sediments (A5.44) with *S. spinulosa* present but not in reef form.

Table 11 BSH and EUNIS classifications encountered in the proposed rock revetment section along the Greenlink subsea cables.

Station	BSH	EUNIS Classification	Annex I reef
TR1	A5.1/A4.2	A5.141/A4.213	Not a Reef
TR2	A4.1	A4.1342	Not a Reef
	A4.2/A5.1	A4.213/A5.141	
TR3	A4.2/A5.1	A4.213/A5.141	Not a Reef
TR4	A5.1	A5.14	Not a Reef
	A5.1/A4.1	A5.141/A4.13	
	A5.1/A4.2	A5.141/A4.213	
TR5	A4.1	A4.13	Not a Reef
TR6	A4.1/A5.1	A4.13/A5.14	Not a Reef
	A5.1	A5.14	
	A5.1/A4.1	A5.14/A4.13	
TR7	A4.1/A5.1	A4.13/A5.14	Not a Reef
	A5.1	A5.14	
TR8	A4.1	A4.13	Not a Reef
	A4.1/A5.1	A4.13/A5.14	
	A5.1	A5.14	
TR9	A5.4	A5.44	Not a Reef
	A5.6	A5.611	
TR10	A5.4	A5.44	Not a Reef
	A5.6	A5.611	
TR11	A5.4	A5.44	Not a Reef
	A5.6	A5.611	
TR12	A5.4	A5.44	Low Reefiness (Biogenic)
	A5.6	A5.611	

6.3. Control

Analysis of the seabed imagery collected along the 12 targeted transects within the control area identified 5 BSHs and 12 habitat complexes including 7 mosaic habitats where rocky habitats were interspersed with coarse sediments (Table 12, Figure 7, Figure **8** and Figure 9). Example images collected from within the control area are provided in Appendix VII.

6.3.1. MPA Reef Feature Assessment

Annex I stony reef was initially identified at stations TR1 to TR9 following the methods of Irving (2009) as modified by Collins (2010b), as images collected at these stations met the requirements for composition, elevation and extent (Table 5).

Following the revised methods of Golding et al. (2020), a total of 21 images collected from the control areas of stations TR1, TR2, TR3, TR5, TR6, TR7 and TR8 were initially assigned the label 'possible reef' as key and reef species associated with low stony reef habitats were identified in at least one image. Two key species associated with Annex I stony reef were identified across the control area (*Tubularia indivisa* and *Hemimycale columella*), however no more than one of these were identified in any one image. In all but two instances, between 5 and 20 'reef species' were also identified, confirming the assignment of 'possible reef' (Table 7). Two images collected from transect 3 replicate 1 were initially deemed 'possible reef' due to the presence of one 'key species' in both, however both contained less than five 'reef species' meaning they were ultimately assigned as 'not a reef'. Ultimately, 19 images qualified as 'possible reef' (Figure 11 and Figure 12).

Annex I *S. spinulosa* reef was observed at stations TR10 and TR12. No Annex I reef habitat was observed at station TR11 as it was characterised by the presence of circalittoral mixed sediments (A5.44) with *S. spinulosa* present but not in reef form (Figure **10**).

Table 12 BSH and EUNIS classifications encountered in the control sections along the Greenlink subsea cables.

Station	BSH	EUNIS Classification	Annex I Reef
TR1	A4.2	A4.213	Possible Reef
	A4.1	A4.13	
	A5.1/A4.2	A5.141/A4.213	
TR2	A4.2/A5.1	A4.213/A5.141	Possible Reef
	A4.2	A4.213	
TR3	A5.1/A4.2	A5.141/A4.213	Possible Reef
TR4	A4.1	A4.13	Not a Reef
	A5.1	A5.14	
	A5.1/A4.1	A5.141/A4.13	
	A5.1/A4.2	A5.141/A4.213	
TR5	A4.1	A4.13	Possible Reef
TR6	A4.1	A4.13	Possible Reef
	A4.1/A5.1	A4.13/A5.14	
	A5.1/A4.1	A5.14/A4.13	
	A5.1	A5.14	
TR7	A4.1/A5.1	A4.13/A5.14	Possible Reef
	A5.1	A5.14	
TR8	A4.1/A5.1	A4.13/A5.14	Possible Reef
	A4.1	A4.13	
	A4.2/A5.1	A4.2/A5.14	
	A4.2/A5.1	A4.213/A5.14	
	A5.1	A5.14	
TR9	A5.4	A5.44	Not a Reef
	A5.6	A5.611	
	A4.1	A4.13	
TR10	A5.4	A5.44	Low Biogenic
	A5.6	A5.611	
TR11	A5.4	A5.44	Not a Reef
	A5.6	A5.611	
	A4.1	A4.13	
TR12	A5.4	A5.44	Low Biogenic
	A5.6	A5.611	

TR1

The mosaic habitat comprising A5.141 '*Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles' and A4.213 '*Urticina felina* and sand-tolerant fauna on sand-scoured or covered circalittoral rock' dominated along both control sections (north and south of the cable) at TR1 which qualified as low resemblance stony reef following the criteria of composition, elevation and extent detailed in Irving (2009) and modified by Collins (2010b). However, the key species *T. indivisa*, a hydroid, was identified in only one image collected from the south of TR1.2 and in three images collected from the north of TR1.3. Further to this, between 7 and 19 'reef species' were also recorded in these images, qualifying them as 'possible reef'. These instances of possible reef were sporadic and occurred largely within areas of rocky substrate where the surrounding biota were not deemed representative of Annex I reef (Figure 11).

TR2

The mosaic habitat consisting of A4.213 and A5.141 dominated along both control sections of TR2 and qualified as low resemblance stony reef as per Irving (2009) as modified by Collins (2010b). However, the key species *T. indivisa* was only identified in 5 images obtained from this station, as well as between 5 and 8 'reef species' which suggested the presence of 'possible reef' (Golding et al., 2020). These 5 images were obtained from the northern control section of TR2.3 and suggested a small patch of 'possible reef' within a wider area of coarse sediment and mosaic habitat (Figure 11).

TR3

The mosaic habitat of A5.141 and A4.213 dominated along both control sections of TR3 which qualified as low resemblance stony reef following the methods of Irving (2009) as modified by Collins (2010b). Further investigation of the biota found at this location suggested the presence of a patch of 'possible reef', with *T. indivisa* and between 5 and 7 'reef species' identified in 5 images collected from TR3.1, mostly falling within the northern control area (Golding et al., 2020) (Figure 11).

TR4

A mosaic of the habitats A5.141 and A4.213 dominated the northern and southern control sections of TR4.1 and TR4.3, whilst a combination of A5.14 'Circalittoral coarse sediments' and the mosaic habitat A5.141/A4.13 'Mixed faunal turf communities on circalittoral rock' was found along TR4.2. None of these habitats met the criteria for annex I reef as outlined in (Golding et al., 2020).

TR5

The habitat complex A4.13 was observed along both control sections of TR5 and was classified as low resemblance stony reef across most of the station (Irving (2009) as modified by Collins

(2010b)). However, only in two images collected from the southern control sections of TR5.1 and TR5.2, the key species *H. columella*, an encrusting sponge, was recorded suggesting the presence of a patch of 'possible reef'. Five and 7 'reef species' were identified in these images, confirming the presence of 'possible reef' (Figure 12).

TR6

Most of both control sections were made of A5.14 with a small area to the east characterised by the mosaic habitat made of A5.14 and A4.13. Some of the mosaic habitat qualified as low resemblance stony reef following the methods of Irving (2009) as modified by Collins (2010b), however most of the control area did not. Only one image collected from the southern control section at TR6.2 was deemed to meet the criteria for biota suggesting a 'possible reef' at this location (Golding et al., 2020) (Figure 12).

TR7

Circalittoral coarse sediments (A5.14) dominated both control sections of TR7 with patches of the mosaic habitat made of A5.14 and A4.13. Most of the control sections were not deemed to qualify as Annex I reef and only a few instances of the mosaic habitat qualified as low resemblance stony reef (Irving (2009) as modified by Collins (2010b)). The key species *H. columella* along with 19 reef species was identified in only one image collected from the north of TR7.1, indicating the presence of 'possible reef' at this location (Figure 12).

TR8

Most of the control sections were dominated by coarse sediments (A5.14) with an area to the northwest characterised by the presence of habitat complex A4.13. Patches of the mosaic habitats A4.13/A5.14 and A4.2 'Atlantic and Mediterranean moderate energy circalittoral rock'/A5.14 were also observed to the east of TR8. Following the methods set out in Table 5, small patches of low stony reef were identified, however further investigation of the biota present at this location suggested the presence of possible reef in just one image obtained from the north of TR8.1 (Figure 12).

TR10

A5.44 'Circalittoral mixed sediment' dominated both control sections of TR10, with an area to the northeast characterised by the presence of A5.611 '*Sabellaria spinulosa* on stable circalittoral mixed sediment'. Some of this area was deemed to qualify as low reefiness Annex I *S. spinulosa* reef following the methods of Gubbay (2007) as modified by Collins (2010a). This was largely present in the northern control region of TR10.1 and confirms the interpretation of the acoustic data which suggested a potential biogenic reef at this station (Figure **10**).

TR11

Transect TR11 was characterised by circalittoral mixed sediments (A5.44) and *S. spinulosa* was observed in most of the still images collected (120 out of 159) corresponding to biotope A5.611 '*Sabellaria spinulosa* on stable circalittoral mixed sediments', however it was not deemed to meet the criteria listed in Table 6 to qualify as Annex I *S. spinulosa* reef.

TR12

The control sections of TR12 were dominated by the presence of mixed sediments (A5.44) supporting *S. spinulosa* in the south. The latter was deemed to qualify as low reefiness Annex I *S. spinulosa* reef, largely within the southern control area of replicate 1 (Figure **10**).

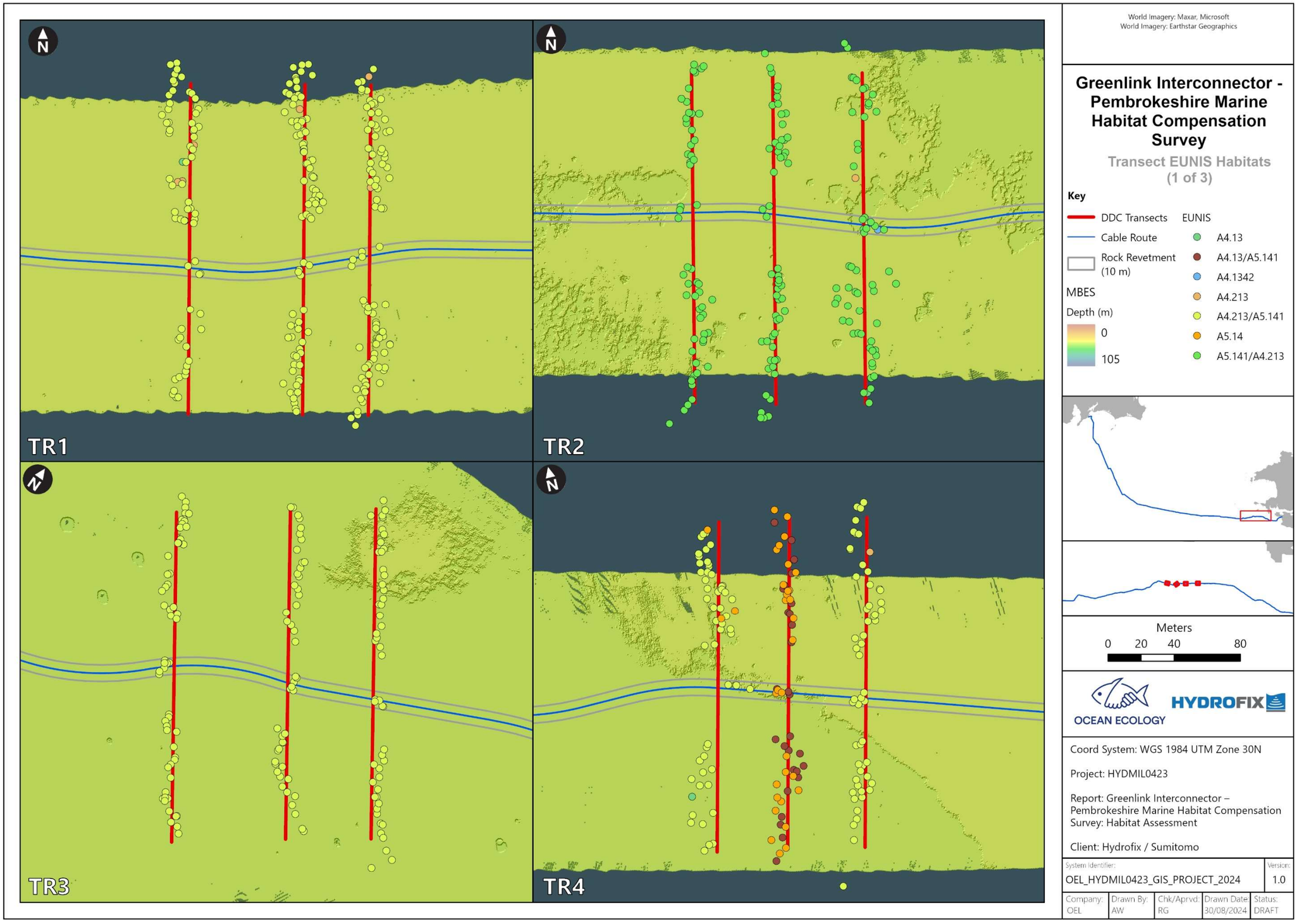

Figure 7 EUNIS habitats identified across the Greenlink subsea cable survey area (Stations 1 - 4).

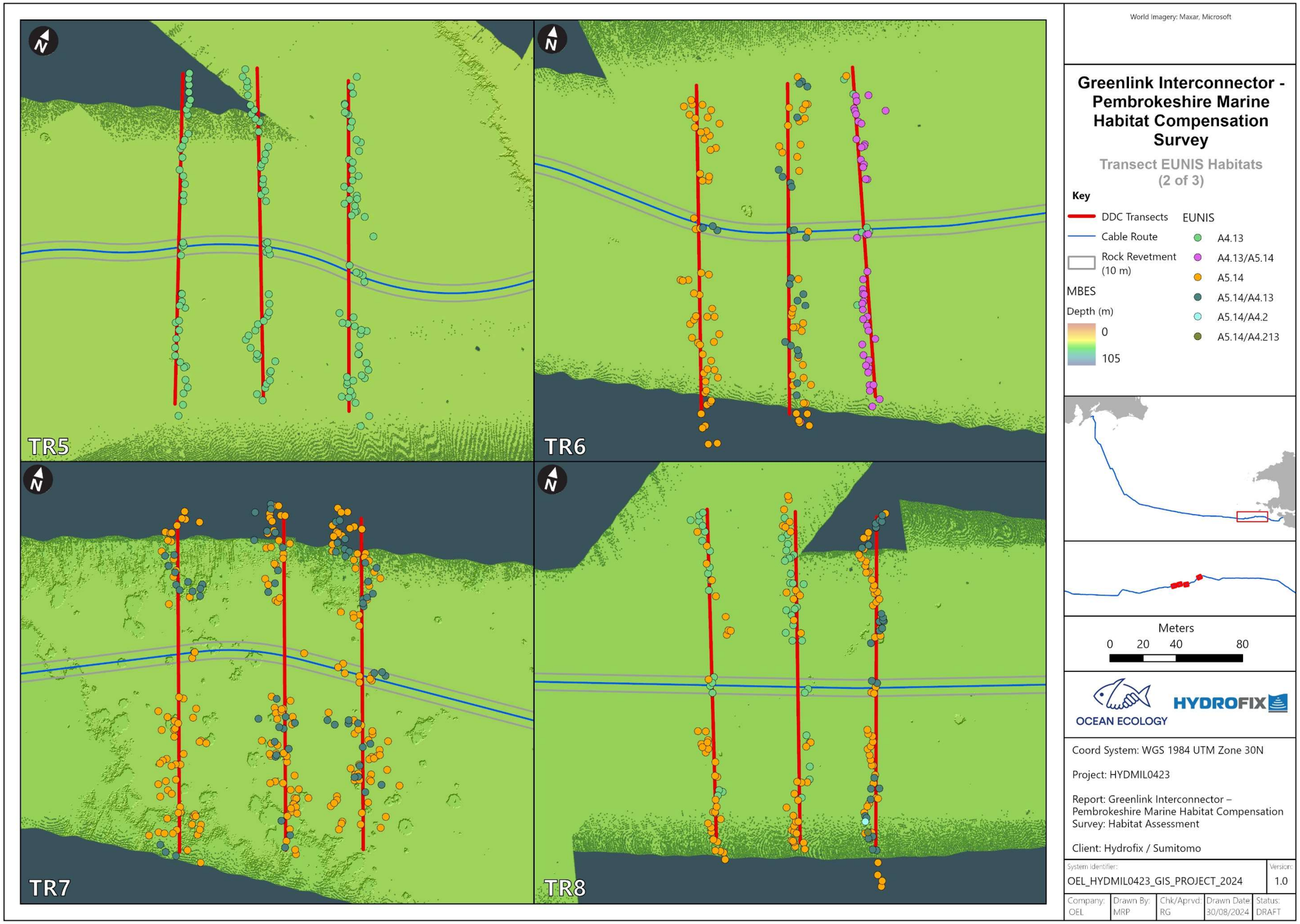

Figure 8 EUNIS habitats identified across the Greenlink subsea cable survey area (Stations 5 - 8).

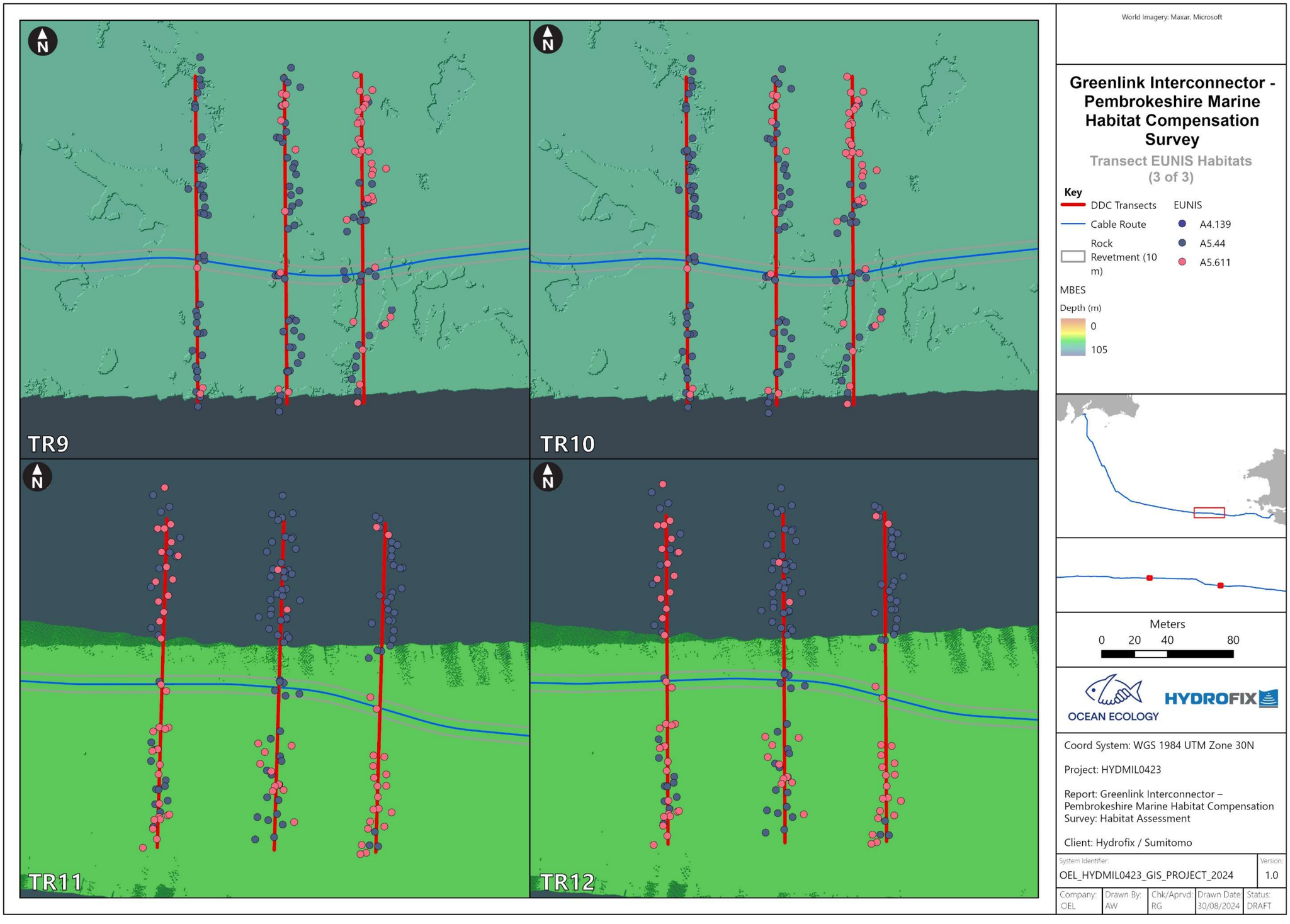

Figure 9 EUNIS habitats identified across the Greenlink subsea cable survey area (Stations 9 - 12).

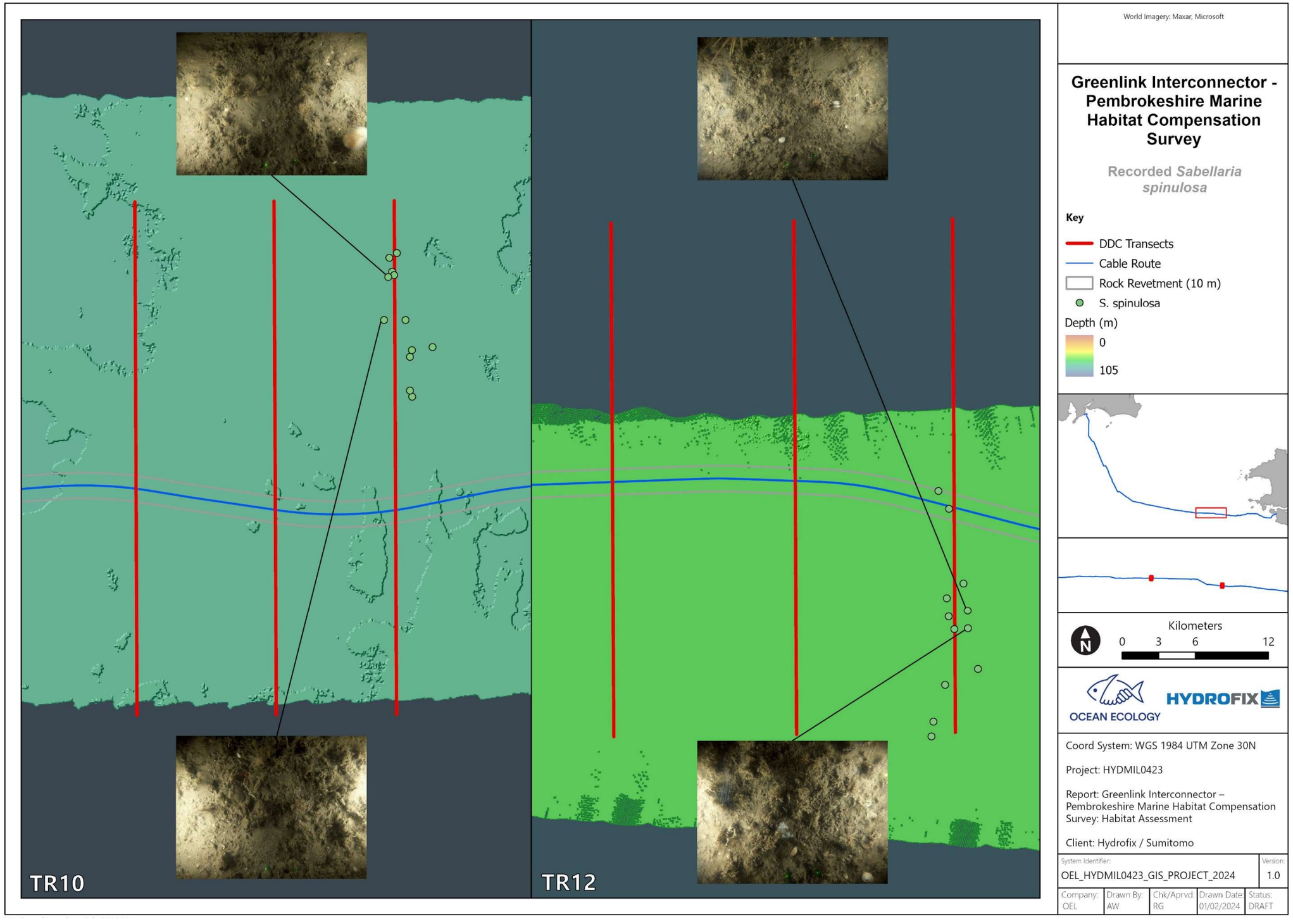

Figure 10 Annex I biogenic (*S. spinulosa*) reef identified in seabed imagery collected across the Greenlink subsea cable survey area.

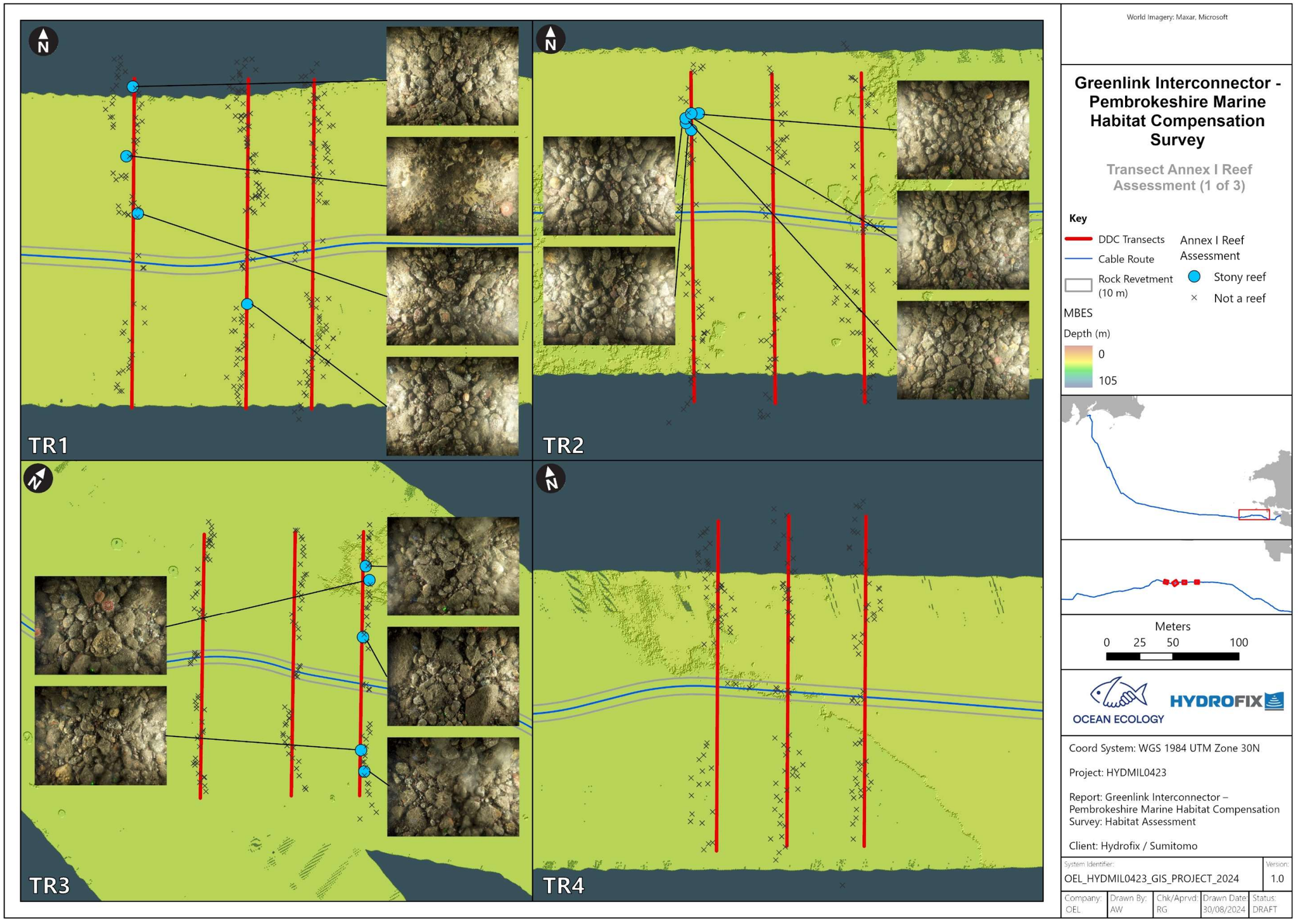

Figure 11 Possible Annex I low stony reef identified in seabed imagery across the Greenlink subsea cable survey area (Stations 1 – 4).

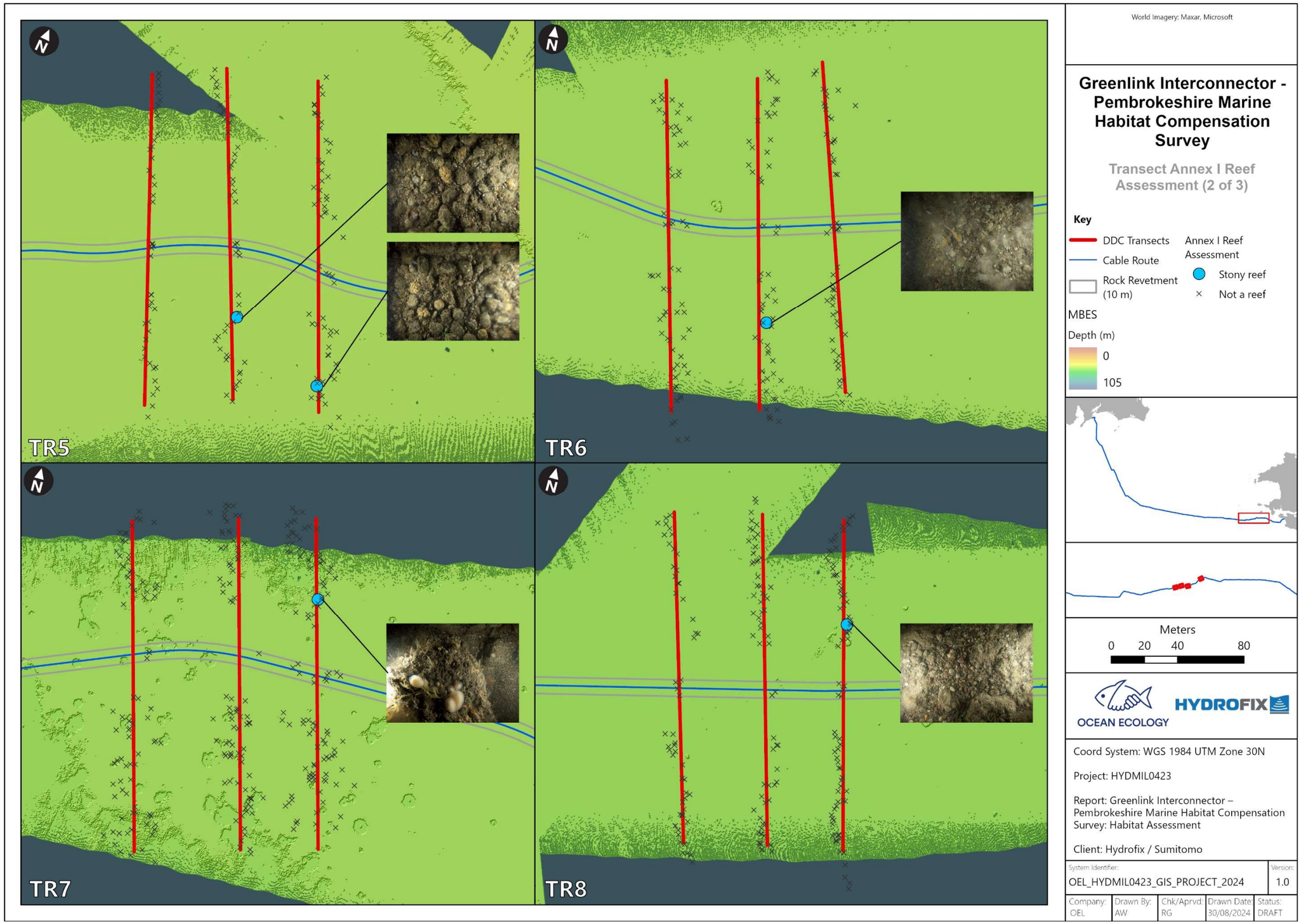

Figure 12 Possible Annex I low stony reef identified in seabed imagery across the Greenlink subsea cable survey area (Stations 5 – 8).

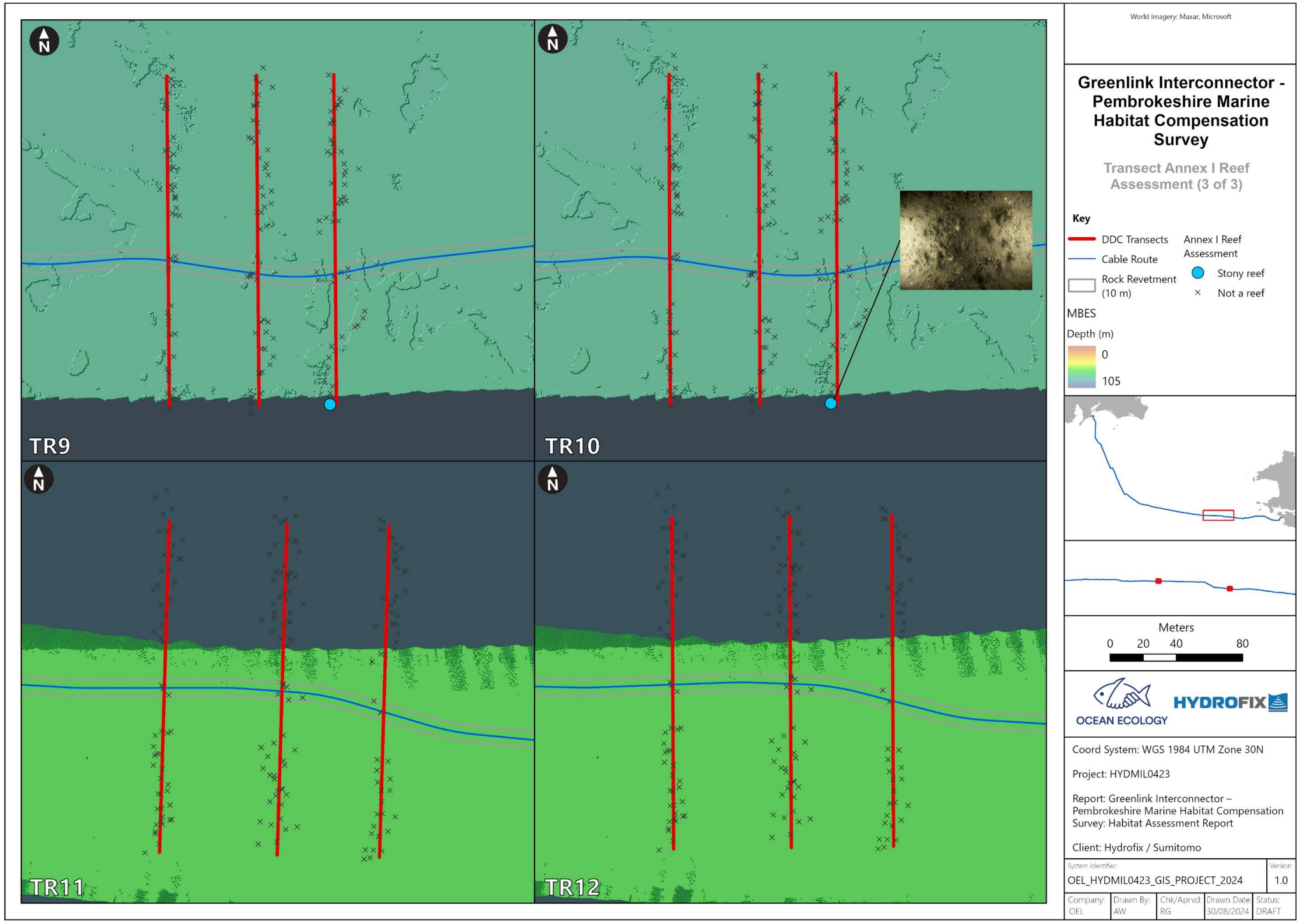

Figure 13 Possible Annex I low stony reef identified in seabed imagery across the Greenlink subsea cable survey area (Stations 9 – 12).

7. Discussion

OEL was commissioned by GIL to undertake an Annex I geogenic and biogenic reef habitat assessment to determine the presence of any Annex I reef habitats across the Greenlink interconnector cable where the subsea cables cross the Pembrokeshire Marine / Sir Benfro Forol SAC. This will inform the Pembrokeshire Marine / Sir Benfro Forol SAC habitat compensation plan.

The survey involved the collection of HD video and high-resolution seabed stills along transects using a DDC system fitted with a freshwater housing for surveying in areas of low visibility. Efforts were targeted at 12 stations (three transects per station) where Annex I reef habitats were thought to occur based on a detailed review of the geophysical data available for the survey area (Siemens Energy, 2022).

Following data collection, all images were analysed using the BIIGLE annotation platform by experienced marine ecologists. This ensured the assessment of the imagery against the various Annex I stony reef and *S. spinulosa* reef qualifying criteria (composition, elevation, extent and biota) was undertaken in an auditable and transparent manner that can easily be reviewed and validated by regulatory bodies (and others) if required.

The acoustic information available for the area underlying stations TR1 to TR8 suggested that a medium stony reef might be present. Interpretation suggested that stations TR1 – TR5 were characterised by continuous Annex I stony reef across the whole area made of cobbles and pebbles covered in faunal turf (Siemens Energy, 2022). Following analysis of imagery collected at these sites, stations TR1, TR2, TR3 and TR4 were described as mosaic habitats of rock and coarse sediments, largely representing both EUNIS biotopes A5.141 '*Pomatoceros triqueter* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles' and A4.213 '*Urticina felina* and sand-tolerant fauna on sand-scoured or covered circalittoral rock' across both the proposed rock revetment and control areas. Following the methods of Irving (2009) as modified by Collins (2010b), these stations were described as discrete areas of Annex I low stony reef, as the composition and elevation observed did not meet the criteria of a medium stony reef (as interpreted based on the acoustic data). The presence of a mosaic habitat suggested a patchy nature of this feature rather than the presence of a continuous stony reef. Station TR5 was the only of these to show evidence of continuous low stony reef following the methods of Irving (2009) as modified by Collins (2010b), with all images collected from both the proposed rock revetment and control areas assigned as A4.13 'Mixed faunal turf communities on circalittoral rock'.

Interpretation of geophysical data suggested that stations TR6, TR7 and TR8 comprised of discrete areas of Annex I stony reef interspersed with coarse sediments (Siemens Energy, 2022). Seabed imagery analysis from these stations suggested they were dominated by coarse sediments representative of EUNIS habitat complex A5.14 'Circalittoral coarse sediment', interspersed with patches of mosaic habitat made of A5.14 and A5.13 'Mixed faunal turf

communities on circalittoral rock'. In some instances, this mosaic habitat qualified as low stony reef following the criteria of composition, elevation and extent of Irving (2009) as modified by Collins (2010b), but did not meet the criteria for medium stony reef as in the interpretation of acoustic data.

The methods proposed in Golding et al. (2020) set out to further refine the guidance for defining stony reef, taking in to account assessment of the biota present in the imagery. Following these guidelines, many of the images initially described as low stony reef were deemed 'not a reef' as they didn't meet the criteria for biota shown in Table 7. This included all images initially described as reef that fell within the proposed rock revetment area. A total of 19 images, all within the control regions of the survey area, were assigned as 'possible reef' with one 'key species' and between 5 and 20 'reef species' identified in each image. The most commonly occurring 'key species' was the oaten pipes hydroid *T. indivisa*, a characterising taxon of tide-swept bedrock. The crater sponge *H. columella* was also observed and often found attached to hard substratum and characteristic of Annex I stony reef.

Images assigned as 'possible reef' following assessment of the biota were largely sporadic, located in both the northern and southern control areas and generally occurred in instances where the biota of surrounding imagery were not deemed characteristic of Annex I reef. The only exceptions to this were stations TR2 where imagery analysis suggested a small patch of possible Annex I reef in the north of TR2.3, and TR3 where a small, low confidence patch of possible reef was identified in the northern control region of TR3.1 (Figure 11 and Figure 12). All transects where at least one image was assigned as 'possible reef' (TR1 – TR8 with the exception of TR4) were located in the eastern (nearshore) region of the proposed cable route, with no Annex I low stony reef identified in the western region (TR9 – TR12). Transects TR1 - TR3 had the highest number of images qualifying as 'possible reef' with 14 out of the 19 qualifying images located along these transects. No images located within the proposed rock revetment were assigned as low stony reef following these criteria.

The acoustic information available for the area underlying station TR9 suggested that a low reefiness biogenic reef might be present (Siemens Energy, 2022). Seabed imagery analysis did not corroborate the interpretation of the acoustic data as no Annex I biogenic reef was observed at this location. More specifically, station TR9 was dominated by A5.44 'Circalittoral mixed sediments', in places supporting *S. spinulosa* (A5.611), however the *S. spinulosa* biotope observed at this station did not meet the criteria to qualify as Annex I biogenic reef. Nevertheless, seabed imagery analysis revealed the presence of some small areas to the south of the cable characterised by the habitat complex A4.13 'Mixed faunal turf communities on circalittoral rock' which qualified as Annex I low stony reef following the methods of Irving (2009) as modified by Collins (2010b). These features were located within the control area and were assigned as 'not a reef' following assessment of the biota present (Golding et al., 2020).

The acoustic information available for the area underlying stations TR10, TR11 and TR12 suggested the presence of a potential biogenic reef (Siemens Energy, 2022). Seabed imagery analysis only partially supported the interpretation of the acoustic data at these locations. Station TR10 was dominated by mixed sediments (A5.44 'Circalittoral mixed sediments') with an area to the northeast of the cable supporting *S. spinulosa* (A5.611 '*Sabellaria spinulosa* on stable circalittoral mixed sediment') and qualifying as Annex I low reefiness biogenic reef (12 images located in the northern control section of TR10.1). It is noteworthy that no Annex I biogenic reef was observed within the proposed rock revetment section of station TR10. Despite station TR11 being dominated by biotope A5.611, none of the images met the criteria to qualify as Annex I biogenic reef. Station TR12 was dominated by mixed sediments (A5.44) supporting *S. spinulosa* (A5.611) to the southeast and to the west. Only the area to the southeast qualified as Annex I low reefiness biogenic reef, including an area within the proposed rock revetment section (10 images from the southern control region and two images within the proposed rock revetment region of TR12.1). Both stations TR10 and TR12 where Annex I low reefiness biogenic reef was observed were located in the westernmost (offshore) region of the proposed cable route.

8. Conclusion

Following the methods of Irving (2009) as modified by Collins (2010b) as well as those proposed in Golding et al. (2020), a total of 19 images were assigned as possible low stony reef, meeting the criteria of elevation, extent, composition and biota. These images were collected from stations TR1, TR2, TR3, TR5, TR6, TR7 and TR8, all located in the eastern (nearshore) region of the proposed cable route. Fourteen of these 19 images were collected from TR1, TR2 and TR3. Images assigned as 'possible reef' were distributed across both the north and southern control regions, generally occurring in instances where the surrounding images were deemed not a reef. Two small patches of continuous reef were observed: in the northern control region of transect TR2.3, and the northern control region of TR3.1. No images collected from within the boundary of the proposed rock revetment met the criteria for Annex I low stony reef.

Annex I *S. spinulosa* biogenic reef was observed at stations TR10 and TR12, located in the westernmost (offshore) region of the survey area. At TR10, *S. spinulosa* reef was observed in the northern control region of transect TR10.1. At station TR12, *S. spinulosa* reef was recorded in the southern control region of TR12.1 as well as two images from within the boundary of the proposed rock revetment. The EUNIS biotope complex A5.611 '*Sabellaria spinulosa* on stable circalittoral mixed sediment' was observed in images collected from stations TR9 and TR11 however, these did not qualify as Annex I *S. spinulosa* biogenic reef.

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