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Analysis of seabed video and stills data collected by drop down camera on the Solan Bank Reef SCI (1714S) (2014)

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Summary

Marine EcoSol was contracted by the Joint Nature Conservation Committee (JNCC) to analyse seabed imagery collected in 2014 from the Solan Bank Reef Site of Community Importance (SCI). This report details the video and stills analysis methods employed and summary results of the analysis.

The objectives of the imagery analysis were to:

1. Undertake a taxonomic analysis of fauna and characterise habitats from stills and video collected from the 1714S Solan Bank Reef SCI cruise to:
   - Identify and quantify all epifaunal species.
   - Identify and quantify all sponge morphological types.
   - Note the presence of anthropogenic impacts.
   - Delineate Annex I reef habitat (including subtypes).
   - Assign biotopes to habitats present.
   - Note the presence of Priority Marine Features.

2. Report average time spent determining:
   i. Sponge morphological abundance and diversity.
   ii. Sponge species abundance and diversity per still image and per 10 or 20 second video segment analysed.

3. Discuss success and limitations of different trialled methods.

4. Enter results into Marine Recorder.

Due to project time constraints and imagery analyses taking significantly longer than anticipated, three different methods of analysis were used to analyse the 156 video transects, identified by JNCC for analysis. Of the original 166 video transects, only 156 had high enough quality for video analysis, however stills from all 166 were analysed. Of these transects, six were subdivided and analysed in ten second sections; 73 were divided into 20 second sections and 77 transects were divided into, and analysed, as distinct habitats each lasting longer than 60 seconds. Of the total 1,701 stills selected for analysis, approximately one every minute of video recorded, 1,696 images were analysed. The remaining images were not deemed high enough quality (e.g. as the camera was too far from the seabed or lighting too poor to undertake analysis).

All distinct habitats identified within the Solan Bank Reef SCI seabed imagery survey were allocated to three broad-scale habitats: subtidal coarse sediments, subtidal mixed sediments, and greater than half of samples allocated to the third broad-scale habitat, moderate energy circalittoral rock. Within this last habitat complex, four biotopes and seven sub-biotopes were identified, all from the ‘Echinoderms and crustose communities’ biotope complex.

Annex I Reef habitat subtypes were assigned to stills and distinct habitats within video clips. Due to the sparse and sand-scoured look of the reefs observed in some imagery, surveyors were not confident in assigning some areas with the Annex I reef designation, although the areas met the reef criteria. As a result, surveyor confidence was attributed to Annex I reef assignment, with assignments qualitatively split into ‘low’, ‘medium’ and ‘high’ confidence by surveyors. From analysis of the stills, 34% of transects contained habitats assigned as stony or bedrock Annex I Reef subtypes with high or medium confidence. Twenty-eight percent of transects contained habitats assigned as stony or bedrock Annex I reef subtypes with high or medium confidence from analysis of video imagery.

From analysis of 1,696 stills, a total of 17,500 observations were made of 320 different taxa. The average number of taxa recorded per still (taxon richness) was 10.3 (+/- 0.14 standard error), with the greatest taxon richness of 28 recorded in two stills from the same transect. The average taxon richness per transect, recorded from analysis of the stills, was 10.1 (+/- 0.3 SE). The transect with the greatest average taxon richness was transect RSS82_S164, with an average taxon richness of 22 (+/- 1.56 SE).

At least one taxon was observed in 93% of stills. The most frequently recorded phyla were: Bryozoa comprising 31% of all taxa observations; then Echinodermata making up 14% of observations; and followed by Annelida, representing 12% of all taxa observations. Of all taxa observations recorded (fauna and flora), 42% were crustose in life form.

Of the nine sponge morphology types used to classify sponges, all nine were identified in the stills and/or video imagery analysed. One hundred and fifty-six of the 166 stills transects analysed contained at least one or more morphology. The dominant sponge morphologies identified within stills were encrusting (88% of transects), massive (52% of transects) and flabellate (40% of transects), followed by the less common morphologies being globular (21% of transects), arborescent (11% of transects), and the rarer morphologies including papillate (5% of transects), repent (2% of transects), and with pedunculate and tubular both present in only 0.6% of transects and identified from stills only.

From analysis of 1,696 stills, 114 were thought to contain fragile sponge and anthozoan communities totalling 25% of transects analysed. Of these stills, 92 were assigned with low surveyor confidence, 18 with medium surveyor confidence, and only four stills were assigned this habitat with high surveyor confidence.

Five Scottish Priority Marine Features (PMFs) were identified in the Solan Bank Reef SCI 2014 seabed imagery. Three were mobile species: Whiting (*Merlangius merlangus*), present in seven transects overall; Cod (*Gadus morhua*), present in five transects; and Ling (*Molva molva*), also present in five transects. Two PMF species of low and limited mobility were also recorded: the Northern feather star (*Leptometra celtica*), present in one transect and the White cluster anemone (*Parazoanthus anguicomus*), present in 19 transects.

Evidence of human impact observed in the Solan Bank area including litter, fishing gear or other primary evidence was reported in eight transects. Broken erect bryozoans (secondary or indirect evidence) were reported within three transects.

Times were recorded for the specific tasks of identifying and enumerating sponge morphologies and identifying and enumerating sponge and anthozoan taxa within a subset of 431 stills. This subset of stills was not chosen randomly; instead midway through the image analysis, surveyors began auditing time for various tasks within the analysis. Within these stills, on average 12% of the stills analysis time was spent identifying and enumerating sponge morphologies, and 14% of analysis time was spent identifying and enumerating sponge and anthozoan taxa. The remaining stills analysis time was spent identifying all other taxa, substrates, biotopes and features of interest.

Due to the linear process of analysing video it was not possible to audit the time it took for only the identification and enumeration of sponge morphologies, and only the identification of sponge and anthozoan taxa, as these could not be separated from the analysis of all taxa and other features of interest. However, proportional analysis times extrapolated from stills analysis times and applied to the video analysis, suggested it could have taken 0.52 and 0.59 minutes respectively to identify and enumerate sponge morphologies and sponge and anthozoan taxa per 20 second video section, and 0.65 minutes and 0.75 minutes respectively per 10 second video section for sponge morphologies and sponge and anthozoan taxa. The longer average analysis times for 10 second video sections compared to 20 second video sections, provides evidence of a training effect. The relatively few 10 second sections (486) for which these average times were calculated, were analysed at the beginning of the project compared with the larger sample size of 20 second video sections (4,015) being analysed later in the project.

One of the main lessons learnt from this project was the longer than anticipated length of time it took to analyse video using the 10 or 20 second subsections method, compared with where video is divided into natural breaks when the habitat changes. Transects split into 10 second subsections took on average 7.08 hours to analyse (5.3 minutes per subsection), 20 second subsections took on average 3.75 hours (4.2 minutes per subsection), whereas those analysed as habitats took on average 1.4 hours to analyse (62 minutes per habitat).

It was the opinion of the surveyors working on this project that the 20 second sub-sectioning method used for over 50% of videos analysed did not greatly improve accuracy of abundance measures, compared with normal habitat analysis of the video. The sparse and sand-scoured nature of the substrates, and the general low abundances and diversity of sponges and anthozoans reduced (in the authors opinion) the need to subsection the video compared with very complex habitats, such as dense turfs of sponges, hydroids and bryozoans, or areas with hundreds or thousands of individuals per square metre, such as horse mussel beds. In these more complex habitats, it is easy to miss individual taxa when counting or scoring over larger areas (i.e. during several minutes of video). Therefore the more focused approach of dividing the video into 20 second sections would likely achieve more accurate abundance estimates and reduce chances of missing taxa within the video.

Contents

1 Introduction

Marine Ecological Solutions (hereafter Marine EcoSol) was contracted by JNCC to analyse seabed imagery from the Solan Bank Reef Site of Community Importance (SCI).

The seabed survey of the Solan Bank Reef SCI was organised by JNCC but undertaken jointly by JNCC and Marine Scotland Science (MSS) staff in 2014 from the MRV Scotia. The vessel departed from Aberdeen on 28 October 2014, and returned on 9 November 2014.

Both still imagery and video data were collected from 166 transects using a Drop Down Video (DDV) frame. Imagery was collected from the Solan Bank Reef SCI area in line with the JNCC survey plan (O'Connor 2014) with aims to:

1. Ascertain whether DDV derived underwater camera video and stills data can be used to sufficiently estimate sponge morphological abundance and anthozoan abundance per unit area (e.g. video transect or still image).
2. Assess whether sufficient abundances of different sponge morphologies are present at Solan Bank Reef SCI to test the indicator at this site.
3. Ascertain whether underwater camera video and stills data can be used to measure patchiness of sponge and other epifaunal communities, which may be a response to physical damage.
4. Initiate collection of potential baseline data on sponge morphological abundance and epifaunal composition and abundance to enable future testing of the indicator.

To help achieve JNCC's aims as stated above, the objectives of the current contract were to:

a) Undertake a taxonomic analysis of fauna and characterise habitats from stills and video collected from the 1714S Solan Bank Reef SCI cruise to:
   - Identify and quantify all visible and mobile taxa.
   - Identify and quantify sponge morphological types.
   - Note the presence of anthropogenic impacts.
   - Delineate Annex I reef habitat (including subtypes).
   - Assign biotopes to habitats present.
   - Note the presence of Priority Marine Features.
b) Report on methods and results from imagery analysis.
c) Report average time spent determining (i) sponge morphological abundance and diversity and (ii) sponge species abundance and diversity per still image and per video segment analysed. Discuss success and limitations of different trialled methods.
d) Enter results into JNCC's marine benthic sample database called Marine Recorder (URL[1]).

This report addresses objectives a) to c) stated above. It does not attempt to answer JNCC's overall survey and project aims (1 to 4 above) as these will be reported upon separately elsewhere.

The focus of this report is the methods and methodological limitations trialled and identified during the imagery analysis. Summarised results from the analyses are also presented, however it should be noted, the bulk of data from this project is held within Excel spreadsheets and Marine Recorder (URL[1]), a database application used by JNCC and other organisations to store marine benthic sample data such as species, physical attributes and biotopes.

1.1 Background

Solan Bank Reef was submitted to the European Commission to become a candidate Special Area of Conservation (cSAC) on 31 August 2012 (URL[2]). In November 2013 the site was approved and adopted by the EC as a Site of Community Importance (SCI) (Commission of The European Community 2007 & URL[3]). Under the Offshore Marine Conservation (Natural Habitats *etc*.) Regulations 2007 (as amended) (URL[4]), Solan Bank Reef has to be designated as Special Area of Conservation (SAC) within six years of its adoption as an SCI by the EC.

The Solan Bank Reef SCI covers an area of 856km^2 within the Atlantic Biogeographic region (URL[5]), approximately 50km from the north coast of mainland Scotland. The feature for which Solan Bank Reef SCI was designation for is Annex I Reef. Figure 1.1 shows the location and extent of the Solan Bank Reef SCI.

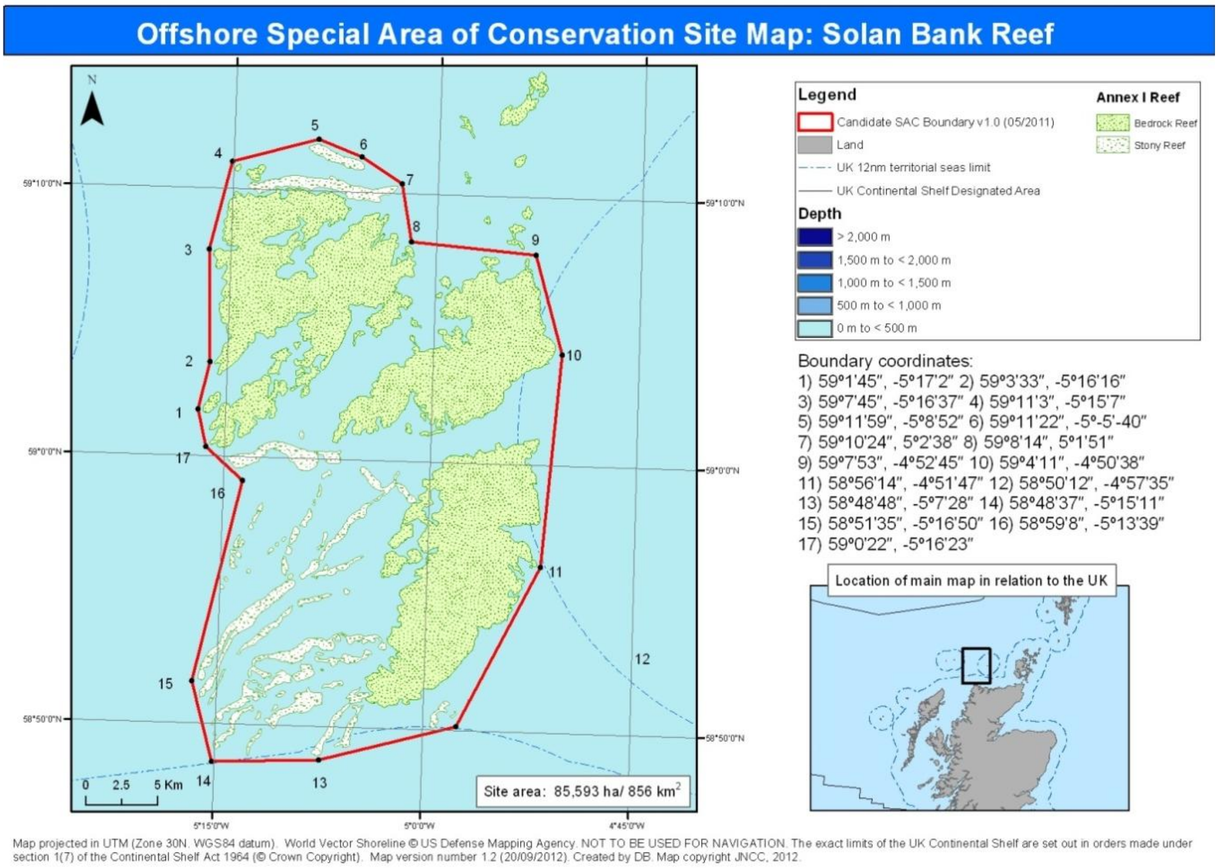

Figure 1.1. Overview of Solan Bank Reef SCI (JNCC 2012).

The SCI contains bedrock and stony reef ranging in depth from approximately 20 to 90 metres below sea level (JNCC 2012) and comprises different energy levels. Areas of bedrock subjected to high levels of scour are sparse in fauna, allowing only scour-tolerant organisms such as *Spirobranchus* to thrive. Areas of bedrock that experience less scour can exhibit more biodiversity and can contain fragile sponges and anthozoan communities, as well as bryozoans and hydroids. Reef communities can also support encrusting bryozoans, encrusting coralline algae, caryophyllid cup corals, ophiuroids, *Alcyonium digitatum*, and *Corynactis viridis* (McLeod *et al* 2005).

A previous JNCC commissioned survey on the Solan Bank Reef SCI was undertaken during 24 - 29 May 2008 (Whomersley e*t al* 2010). During this survey, acoustic data, video and still imagery and substrate samples from benthic grabs were collected. These data were used with Civil Hydrography Programme (CHP) bathymetry data to estimate the extent of substrate that qualified as Annex I habitat (O'Connor 2014). Data collected indicated that a number of different sponge morphologies were present at the site.

The aim of the Scotia 1714S survey was to collect evidence to aid development of a national indicator of 'Good Environmental Status' for fragile sponge and anthozoan communities as part of the UK's obligation under the Marine Strategy Framework Directive (O'Connor 2014). The indicator proposal can be found in *JNCC report*, No. 524 (Haynes *et al 2014*; see Indicator 2 'SpongeMorphAntho'). Testing and validation of this indicator had not been carried out previous to this survey due to a shortage in biological and environmental data. The Scotia 1714S survey collected initial baseline data on epifaunal communities and environmental variables in the Solan Bank SCI to assist in determining if the indicator is viable for UK offshore waters (O'Connor 2014). The offshore location of the site meant that sponge morphology abundance data was derived entirely by imagery collected from a drop down video (DDV) frame. Consequently the analysis of this imagery as part of the current Marine EcoSol contract aims to establish whether remotely captured imagery is sufficient to measure sponge morphology diversity and abundance.

2 Methods

Underwater video was captured during the JNCC Scotia 1714S survey using a drop frame mounted SubC 1 Alpha High Definition (HD) video camera, and photographs (stills) using a Kongsberg OE 14-408 digital camera (10 Mega Pixels) with dedicated flash unit. The drop frame was fitted with two pairs of orthogonal fan lasers, projecting a continuous centre square of 64 mm onto the seabed (O'Connor 2014). This scaling device was visible within the video, but was typically bleached-out by the camera flash, within stills. Hanging below the drop-frame was a weight of 64mm diameter, suspended 1.25m below the camera lens by a rope. The weight was generally visible within stills and provided a secondary means of scaling objects. Further details of sampling strategy and rationale are provided in the JNCC Scotia 1714S survey plan (O'Connor 2014), and the Scotia 1714S Cruise Report (JNCC 2014) gives details of the drop camera frame and the camera specifications.

The nominal viewing angles of the two cameras were 61 degrees (stills) and 60 degrees (video). When the camera was 1.25m above the seabed, the field of view of the stills camera was calculated to be approximately $1m^2$ (1125 x 870mm), and for the video camera, to be approximately $0.7m^2$ (1100 x 625mm). It should be noted both cameras were at variable heights above the seabed throughout this survey.

The operation of the stills camera and frequency of photographs taken during each video transect, was manually controlled by staff on the vessel who watched the drop frame view in real time using a Kongsberg 14-366 colour TV camera with feed to the surface (JNCC 2014). Stills were taken typically at 10-30s intervals, when the drop frame was at a suitable height off the seabed. HD video was recorded continuously throughout each video transect. Drop frame position and therefore geographic coordinates were recorded throughout each video transect, using a Sonar Scout Ultra-Short Base Line (USBL) acoustic transponder. For further technical details relating to onboard survey methods, see the JNCC Scotia 1714S survey plan (O'Connor 2014) and Scotia 1714S Cruise Report (JNCC 2014).

Video transects were a minimum of ten minutes in duration and estimated to be a minimum of 150 metres long (O'Connor 2014). During each drop frame deployment, the survey vessel executed a controlled drift at approximately 0.3 knots through the specified transect (JNCC 2014). The height of the drop frame off the seabed was variable as was the topography, and was winch-controlled, the operator of which had sight of the video monitor (JNCC 2014).

2.1 Prior to imagery analysis

To ensure consistency between surveyors, and prior to any analysis, the recording protocols were confirmed with JNCC and practised internally. During this process several terms required definition and further explanation so a set of rules and processes were developed as are described in the following sections.

2.1.1 Quality Assurance (QA) before imagery analysis

To ensure all surveyors undertook analysis and recording in the same way, and to minimise inter-surveyor variability, the first few days of analysis were used for Quality Assurance (QA) purposes. Whilst working together, the team watched and split the first few video transects and analysed the video samples and several corresponding stills. This ensured recording was consistent and any difficulties in species or substrate identification were highlighted and addressed. During this initial group-scoring, a set of rules was created to overcome differences in interpretation between surveyors and to ensure the highest level of recording consistency was maintained between the seven surveyors working on this project. Any resulting changes to pre-defined analysis and recording protocols were agreed and the recording *pro forma* updated accordingly. The resulting recording protocol was written out and a copy kept by each surveyor as a reminder.

2.1.2 Stills per minute (subsample)

In total 4,630 stills were taken during the 166 video transects comprising this survey. The scope of this image analysis project was to analyse a subset of this total, approximating one still per minute of video. Prior to imagery analysis and before any stills were viewed, stills were automatically selected (non-randomly) at approximately one minute intervals from the complete list of stills. Although a random selection of stills would possibly have been more statistically robust, it would have been more logistically difficult to achieve with this number of stills and transects, and it was agreed during discussions with the JNCC project manager, that a non-random approach to image selection was acceptable. Additionally, a random selection method could possibly select all images from a limited portion of the transect only, therefore potentially missing entire features or habitats. A time-interval based selection method selects stills from all parts of the transect and was therefore less likely to miss features or habitats.

To create the subsection list of stills for analysis, a value of one minute was added to the fix time of the first photograph in every transect, then repeated for the second and third still, until the transect end time was reached. This provided a model one-minute-interval subset throughout the duration of each transect. Within Microsoft Excel the Vlookup function was used to select the nearest actual still fix time to the model one-minute-interval subset. The result was a reduced list of stills per transect with a one minute interval between each still. Although stills were not selected randomly, this selection process was unsupervised, so surveyor bias was not introduced during the selection process.

2.1.3 Recording pro forma

To consistently record the relevant information required to meet the project objectives, four recording pro forma were developed, within Microsoft Excel, based upon those regularly used by the Centre of Environment, Fisheries and Aquaculture Science (Cefas) for imagery analyses relating to the Marine Conservation Zones (MCZ) project[2].

Habitat information, physical data and other metadata obtained prior to, and during, the analysis of video and stills, were recorded in separate pro formas, each set out similarly. Each spreadsheet row represented a sample (still, video section or video habitat), identified by a unique sample reference and each column, a separate item of information to be recorded about each sample (attribute). To help reduce different interpretations of questions and therefore reduce inter- and intra-surveyor-variability in terms of the types of answer a person could give, drop-down menus and look-up values were used for many sample attributes.

Taxon abundance was recorded in separate pro formas (stills and video), with taxa representing spreadsheet rows and unique sample references identifying samples within separate columns. Each pro forma spreadsheet was further divided into two sheets: one recording counts and percentage cover abundance data, and a second sheet recording semi-quantitative abundances data according to the Marine Nature Conservation Review (MNCR) SACFOR scale (Connor *et al* 2004).

Surveyors were each provided:

1. An audit spreadsheet showing which video transects and stills each surveyor was required to analyse, which imagery they were required to re-analyse for QA

[2] http://jncc.defra.gov.uk/page-2409

purposes, and allowing capture of information relating to how long each still and video took to analyse.
2. A video analysis pro forma detailing the full list of video transects to be analysed, including metadata provided by the client (times, dates, depths and coordinates).
3. A stills analysis pro forma detailing the one-minute-interval list of stills to be analysed, including metadata provided by the client (times, dates, depths and coordinates).
4. Two taxa matrix pro formas to record abundance information from stills and video.

2.1.4 Stills field of view:

Prior to starting imagery analysis, to estimate the field of view within the stills and therefore the area of seabed sampled, a selection of stills was viewed and classified using a qualitative scale of camera proximity to the seabed. Five classes, zero (closest) to four (furthest), were assigned and defined as:

- Category 0: The drop-frame was sitting on the seabed and the camera was therefore closest to the seabed. The weight and rope, normally suspended below the drop-frame, were not visible within the image. Images were typically slightly to very over-exposed and taxa and substrates (if not too over-exposed) were clearly visible.
- Category 1: The weight was visible and clearly on the seabed, usually lying on its side and the rope was slack or also partly lying on the seabed. Images were well lit and taxa and substrates clearly visible.
- Category 2: The weight was on the seabed and the rope was tight indicating the camera was approximately 1.25 metres off the seabed. To confirm the weight was on the seabed, little or no shadow was visible beside the weight. Images were well lit and taxa and substrates clearly visible.
- Category 3: Weight is off - but still close to - the seabed, indicated by little or no gap between the weight and its shadow (i.e. gap of less than 1 x diameter of the weight. The images were slightly darker but taxa and substrates still visible and identifiable. Smaller and more difficult to identify taxa were potentially missed or unidentifiable from images within this category.
- Category 4: Weight is well off the seabed, indicated by a large gap between the weight and its shadow (maximum of 2 x diameter of the weight). The images were quite dark and this image category formed the maximum distance from the seabed, that taxa and substrates were considered identifiable. However, smaller and more difficult to identify taxa were more likely to be missed or unidentifiable from images within this category.

Table 2.1. Average width (+/- Standard Error), height and field of view for each stills field of view category, calculated from a minimum of five stills from each category. Further details and calculations are provided in Appendix 1, with example images of field of view categories in Appendix 2.

Field of View category	**Still Width cm (SE)**	**Still Height cm (SE)**	**Still Area m^2 (SE)**
0 camera very close, no weight visible	58 (7.1)	44 (5.4)	0.3 (0.07)
1 weight on seabed, rope slack	83 (6.9)	62 (5.1)	0.5 (0.09)
2 weight on seabed, rope tight	118 (1.5)	88 (1.1)	1.0 (0.03)
3 weight off seabed, shadow close	151 (7.9)	111 (5.4)	1.7 (0.16)
4 darker, taxa visible, shadow gap	201 (12.8)	148 (11.2)	3.0 (0.42)

Multiple images from each field of view category were identified and used to measure the field of view in metres squared (image width x height). Three methods were used to provide a quantified scaled within multiple photographs, from which the field of view could be calculated and averaged from several photographs (Table 2.1):

1. Where the 64mm laser centre-square was clearly visible in the photograph, this was used as a scale to measure the image dimensions. However the laser scale was visible in only a small proportion of the photographs, due to the bleaching effect of the camera flash units.
2. Where the 64mm laser centre-square was not visible and for the field of view categories where the weight was both on the seabed, and clearly visible (categories 1 and 2 only), the diameter of the weight (64mm) was used instead of the laser centre-square.
3. Where neither the laser centre-square nor the weight were visible within the photographs (category 0), or where the weight was not on the seabed (categories 3 and 4), the scale was obtained from the video, and this scale then applied to the photographs (Figure 2.1). To do this, the video was viewed and a screen-grab obtained within 2 frames of the still being taken (visible within the video using frame-by-frame advance). From the video screen-grab, the laser centre-square was measured to provide a scale in the video at the same location as the photograph was taken. An object such a cobble or boulder, clearly visible in both the video screen-grab and the photograph was measured in both, to give a known dimension in the photograph, from which the photograph dimensions (width x height) were measured, and the field of view calculated (Figure 2.1).

The example shown in Figure 2.1 displays a screen-grab from video (left) taken at the same time as the photograph on the right, and shows the laser centre-square (note the white at the bottom of the video screen-grab shows the flash unit has just fired). The yellow arrow on the video screen-grab shows a known distance in the video (64mm). By measuring the yellow arrow on the video (19mm) and the boulder within the video (red arrow = 78mm), the actual boulder size was calculated as 263mm (64/19*78). Assuming the video and stills cameras were mounted at similar heights on the drop-frame, the boulder in the photograph was also 263mm in length (blue arrow) and the dimensions of the photograph were therefore 3.37 (64/19) times their measured dimensions (273mm x 366mm = 920mm x 1233mm). From these values the field of view was calculated as photograph height x width (920mm x 1233mm = 1.1m^2). Further examples of different fields of views in stills and video grab images are provided in Appendix 2.

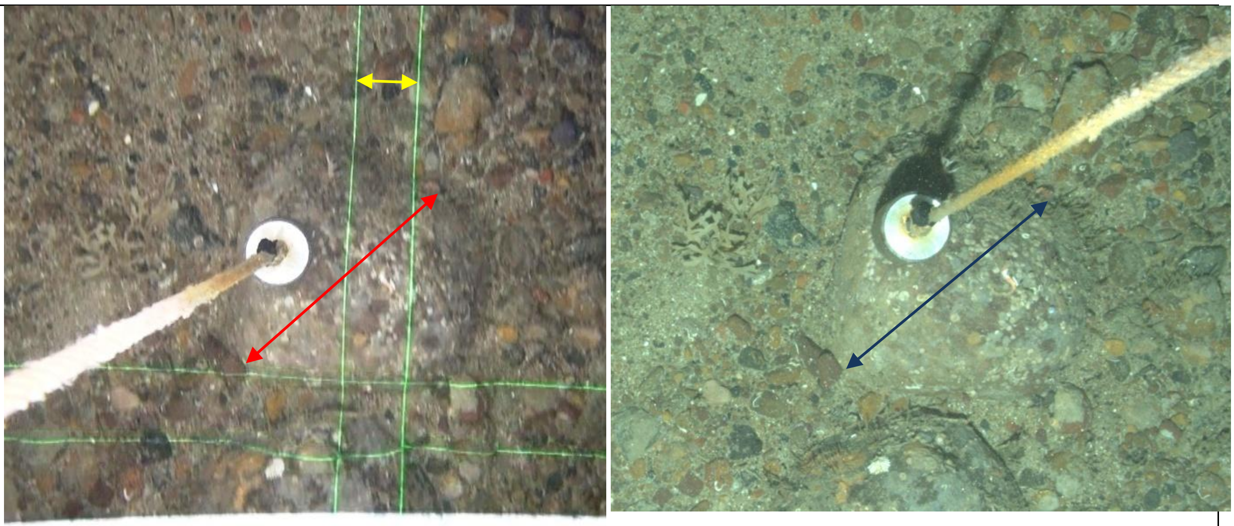

Figure 2.1. Examples of measuring the field of view in photographs where the laser centre-square was not visible in the still and the weight was not on the seabed.

2.1.5 Annex I Reef and elevation

Annex I Reef habitat subtypes were assigned to stills and video clips using information and definitions from CEC (2007), Blythe-Skyrme *et al* (2008) and Irving (2009). Reef habitat included hard compact substrata comprising biogenic concretions (biogenic reef) or substrata of geogenic origin comprising bedrock (bedrock reef) or boulders and cobbles (stony reef). To be assigned as Annex I Reef habitat, the hard substrata had to be topographically distinct from the surrounding solid or soft seafloor, and had to be deemed greater in area than 25m^2 (an area of 5m x 5m) based on guidance for designating biotopes from Connor *et al* (2004). To be assigned as stony reef, an area required greater than 10% (more typically 30%) cover of boulders and cobbles, and the majority of any fauna present had to be dependent upon the hard substrata, rather than any sediment elements of the seafloor.

To help improve the consistency of multiple surveyors assigning the presence of the Annex I Reef feature and subtypes to substrates within stills and video samples, subjective terms used within reef definitions by Irving (2009) were further defined and guidance developed that was specific to the sand scoured, sparsely populated, reef being viewed as part of this project. As a result, confidence levels were agreed that allowed surveyors to tentatively assign an area as Annex I Reef (i.e. with low confidence) as well as provide more confident and therefore robust Annex I Reef assignments. For the Annex I stony reef subtype, comprising boulders and cobbles, the summary definitions table from Irving (2009), shown below in Box 2.1, was used to classify areas as low, medium or high confidence stony reef. Areas classified as low confidence would be assigned as 'potential Annex I stony reef' and areas assigned as medium or high confidence would be interpreted as 'Annex I stony reef'.

Box 2.1. Defining low, medium and high 'reefiness' of Annex I Stony Reef
Taken from Irving (2009).

Characteristic	**Not a 'stony reef'**	**'Resemblance' to being a 'stony reef'**		
		Low[1]	**Medium**	**High**
Composition:	**<10%**	10-40% Matrix supported	**40-95%**	**>95% Clast supported**
Notes: Diameter of cobbles / boulders being greater than 64mm. Percentage cover relates to a minimum area of 25m^2. This 'composition' characteristic also includes 'patchiness'.				
Elevation:	**Flat seabed**	<64mm	**64mm-5m**	**>5m**
Notes: Minimum height (64mm) relates to minimum size of constituent cobbles. This characteristic could also include 'distinctness' from the surrounding seabed. Note that two units (mm and m) are used here.				
Extent:	**<25m^2**	**>25m^2** ⟶		⟶
Biota:	**Dominated by infaunal species**			**>80% of species present composed of epifaunal species**

[1] When determining whether an area of the seabed should be considered as Annex I stony reef, if a 'low' is scored in any of the four characteristics (composition, elevation, extent or biota), then a strong justification would be required for this area to be considered as contributing to the Marine Natura site network of qualifying reefs in terms of the EU Habitats Directive.

The stony reef definitions provided by Irving (2009) were designed to be applied to areas greater than 25m^2. Therefore to apply these rules to photographs, with areas ranging from 0.5m^2 to 3m^2, the minimum rock composition, within stills, for low confidence Annex I stony reef, was raised from 10% to 30% cover of cobbles or boulders. For areas within the video the minimum composition remained at 10% cover of cobbles.

For the Annex I bedrock reef subtype, two confidence levels were applied; ‘potential bedrock reef’ and ‘confirmed bedrock reef’. The potential category was deemed necessary because the analysis revealed areas of bedrock almost completely devoid of life. These areas did not conform to the author’s idea of ‘reefiness’, showing evidence of geological rather than biological features. It was assumed these low-lying bedrock areas were sand-scoured sediment-rock interfaces and were regularly inundated and exposed by the surrounding mobile sediments. The confirmed bedrock category was applied to areas of bedrock with reef-like sessile fauna and flora present.

In terms of reef elevation, several ranges were created based partly on the stony reef summary definitions table from Irving (2009), and partly from an initial viewing of the imagery to get a feel for what was detectable from the generally downward facing imagery. In some cases elevation was not discernible so an ‘unknown’ category was included. Other categories were: <64mm, 64mm to 1m, 1.1m to 5m, 5.1m to 10m and >10m. When estimating the elevation of stony reef, cobbles and boulders were assumed to be round in shape, so any area with cobbles (64mm to 256mm) or small boulders (256mm to 512mm) was assigned an elevation of ‘64mm to 1m’. Similarly areas with medium sized boulders (512mm to 1,024mm) were classified as either ‘64mm to 1m’ or ‘1.1m to 5m’ elevation category. Areas with large boulders (>1,024mm) were generally assigned the ‘1.1m to 5m’ elevation category, or larger as required.

2.1.6 Sponge morphological types

Sponge morphologies were identified based upon a combination of images (Figure 2.2), descriptions, resources and publications including: Bell & Barnes (2001) and various subsequent publications by the same author and associates (e.g. Bell *et al* 2006); monitoring protocols developed by Whittington *et al* (2007); and more specifically, identification rules developed during a quality assurance exercise conducted during a dive monitoring project for Natural Resources Wales (NRW) in 2007 (formerly Countryside Council for Wales – CCW), further details of which are shown in Appendix 3. It should be noted these rules were devised for divers sampling *in situ*, who were able to touch the sponges if required. Obviously this was not possible in the present project, so to adapt these rules for imagery analysis, any mention of touching or feeling sponge attributes were ignored.

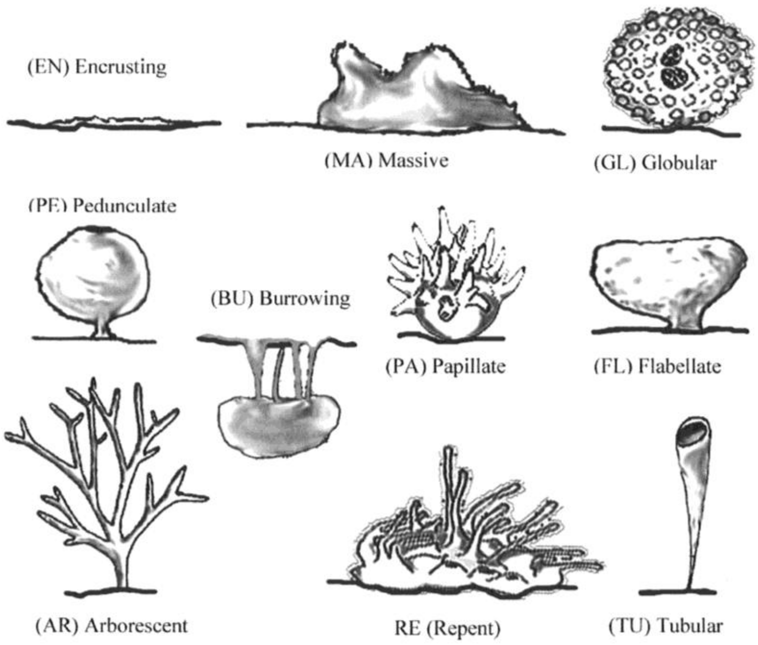

Figure 2.2. Sponge morphological types (Berman *et al* 2013, after Bell *et al* 2006).

Quantification of sponge morphologies required individual sponges to be counted, or the area they occupied be estimated as a percentage of the total area visible. Morphologies tending to cover an area (i.e. encrusting, massive and in some cases repent) were to be enumerated by estimating percent cover, whereas the remaining erect morphologies were to be individually counted. Sponge morphology example images, showing those considered to 'cover an area' and those considered 'erect', are provided in Table 3.6 within section 3.5. Further examples of sponge morphologies are provided in the image reference collection, collated as part of this project (Appendix 14).

It should be noted that the burrowing sponge morphology was not included in the present project, as it was not deemed possible to identify this from images alone.

2.1.7 Fragile sponge and anthozoan communities

The definition of fragile sponge and anthozoan communities was taken from the UK Biodiversity Action Plan Priority Habitat Descriptions (updated December 2011). Although this document provides a general habitat description and example biotopes where the habitat might be present, it was not deemed useful in providing specific detail of when an area (photograph or video sample) should be assigned the habitat. Instead, Tables 2.5 and 2.6 in Haynes *et al* (2014) (provided in Appendix 4), were used as a guide to sponge and anthozoan species considered to be indicative of the presence of the fragile sponge and anthozoan communities, when found in sufficient numbers.

Based on the BAP habitat description and information from Haynes *et al* (2014), rules and guidance were developed to help multiple surveyors consistently assign the presence of this habitat using high, medium and low confidence scores as follows:

- Low confidence included presence of at least one individual of an erect sponge morphology (all except encrusting) and two anthozoan species listed in Haynes *et al* (2014) Table 2.6.
- Medium confidence included multiple erect sponge and anthozoan species in greater abundance (than low confidence), although not necessarily characterising the biotope.

- High confidence required multiple erect sponge and anthozoan species in high abundances, and as characterising species of the biotope.

2.1.8 Evidence of human impact

Evidence of human impacts were defined as primary or secondary evidence. Primary evidence included photographic evidence of litter or discarded/lost fishing gear. These were considered objective measures of impacts and were easy to identify. Secondary (suspected) evidence included more subjective and difficult to identify features, where no confirmed photographic evidence remained of the impact cause. These included suspected trawl marks (within sediments), for example where cobbles and small boulders are arranged in un-natural looking lines beside furrows; or suspected evidence of physical damage such as many examples of brittle slow-growing fauna being broken or lying on their side. The identification of these more-subjective measures of impacts were considered more likely to differ between surveyors, and would depend on the previous video analysis experiences of the surveyors.

2.1.9 Priority Marine Features (PMF)

Scottish Natural Heritage (SNH) and JNCC have generated a focused list of habitats and species to target nature conservation action in Scottish waters - Priority Marine Features (PMFs, SNH 2014; Tyler-Walters *et al* 2012). An additional objective of this project was to improve knowledge of the occurrence and distribution of species and habitats of recognised conservation importance in the Solan Bank area. Therefore, once taxa, species and biotopes were assigned, the surveyor decided if there was a match to any Scottish Priority Marine Features including habitats, mobile species or limited mobility species (PMF, SNH 2014).

2.1.10 Biotope classification

Biotopes or sub-biotopes (EUNIS level 5 or 6), or biotope complexes (EUNIS level 4) were assigned to each sample within the analyses i.e. all photographs, video subsections (10 and 20 seconds) and video habitats, each lasting longer than one minute. Biotopes were assigned using information from the shallow section of the Marine Habitat Classification for Britain & Ireland, (formerly v04.05) (URL[6]), associated JNCC physical and biological comparative tables (URL[7]), and JNCC guidance relating to definitions of a biotope (URL[8]). Appendix 8 provides representative images of biotopes identified during this project. Further examples are provided in an image reference collection provided as part of this project (Appendix 14).

Surveyors aimed at assigning rock biotopes at JNCC Habitat Classification levels four or higher (EUNIS level 5 or higher) and sediment biotopes at JNCC Habitat Classification levels three or higher (EUNIS level 4 or higher), however on occasions where the imagery was of poor quality or where critical information was absent, lower levels have been assigned.

Areas identified within video, with two or more biotopes mixed together, interspersed or regularly repeating, such as with waves of coarse and then fine sediments, were defined as being a mosaic of all contributing habitats/biotopes. However, as the area of each still was less than 25m^2, the Marine Nature Conservation Review (MNCR) recommended minimum area for assigning biotopes (URL[7]), stills were generally assigned a maximum of one biotope.

It should be noted that surveyors in the present study were made aware of proposed new biotopes (northern variants of existing biotopes) described from the Solan Bank area in a 2008 survey by Whomersley *et al* (2010). Further details of these proposed northern biotopes, including images, compiled from Whomersley *et al* (2010) are provided in Appendix 5.

Assignment of each biotope was accompanied by a confidence score for the assignment. Four confidence categories were used: ‘Certain Whole Record’ was used when a good biotope fit was found and the biotope described the entire habitat within the sample; ‘Certain Part Record’ was used in situations where the biotope in question was a good fit but only described part of the habitat present within the sample, used typically when describing mosaic habitats; ‘Uncertain Whole Record’ and ‘Uncertain Part Record’ were used in the similar situations, however when the biotope fit was not sufficiently close, and therefore confidence in the assignment was lower. Additionally, if a habitat was deemed to fit between two biotopes, or it was difficult to decide between two biotopes, then two biotopes were recorded and both categorised as ‘Uncertain Whole Record’.

When describing a habitat, if no biotope within the Marine Habitat Classification fit, the best fit was recorded and notes made as to why the fit was poor. In cases where the same or similar habitat was identified from different areas, and therefore could be clearly distinguished from existing biotopes, a new biotope was proposed to JNCC, or changes to existing biotopes were proposed that would improve the fit of the scrutinised habitat.

2.1.11 Visual quality of sample

The visual quality of all stills and video sections and habitats were subjectively assessed along a qualitative gradient from ‘Inadequate’, to ‘Poor’, to ‘Adequate’ to ‘Good’.

In addition video imagery that was analysed in 10 or 20 second sections was also assessed as either ‘0 – Unusable’, 1 – Partially Usable’ or ‘2 – Usable’. The idea being that any section of video classed as ‘unusable’ was not analysed, allowing the surveyor to move on to a section of video of higher quality. However, in practice this meant watching each video section once to assess the quality, and then, for all usable sections, again as many times as required, to actually analyse the imagery. This method therefore increased analysis time quite significantly. After trialling this initial method of assessing the video quality, all surveyors found it quicker to simply analyse the video section, obtain as much information as possible from the imagery, and then classify the image quality after analysis of each video section. To help minimise the subjectivity of assessing the video quality, the term ‘unusable’ was defined as meaning that one could not easily identify substrates, characterising taxa and biotopes.

Due to the bouncing effect of the drop-camera frame, presumably due to high swell, several transects comprised video where, within each 10 second video section, a large proportion e.g. seven seconds, were not usable (i.e. as the camera was too far off the seabed), and three seconds were quite clear and usable. As a result, it was agreed with the JNCC project manager, an approximate minimum of 25% of the video section should be clearly visible, for that video section to be classed as ‘partially usable’. Although this bouncing effect was apparent within 20 second video sections as well as in 10 second sections, the frequency of the bouncing was such that within each 20 second section, a greater proportion of the section was clear and usable, when compared to 10 second sections.

After analysis, all truly unusable video sections and stills were removed from the dataset, leaving only those deemed partially usable or usable.

2.2 Imagery analysis

Analysis of video and stills imagery was undertaken in a prescribed sequence with slightly different methods for analysing video compared to stills. In summary: Using non-specialist video viewing software that allowed video play at various speeds, pausing, advance-frame and the taking of screen snapshots (VideoLan VLC media player version 2 and Windows Media Player version 12), the video for an entire video transect (Marine Recorder Event) was viewed to identify and record changes in habitat (Marine Recorder Samples), aiming at identifying changes at EUNIS level 4 (biotope complexes) or higher. All the stills for the same transect (each still representing a separate Marine Recorder Sample), were then analysed to obtain the best resolution taxa information, ground-truth substrates present throughout the transect, and identify the likely biotopes present within the stills. Finally, the video was analysed, benefiting from high resolution information from the stills analysis, to help inform identification of taxa, substrates, features of interest and biotopes visible within the various habitats comprising the video transect. This process was then repeated for all transects where both video and stills were analysed.

2.2.1 Imagery analysis step 1: Habitat splits

The first stage of image analysis required each transect (Marine Recorder Event) be viewed once in real time, or up to 2x speed, and split into broad-scale habitats (Marine Recorder Samples) based upon broad changes in substrate composition and associated fauna. Resulting habitat splits were aimed at EUNIS level 4 or higher. During this view the following information was recorded or checked against the metadata provided by the client:

1. Event description: Summary of habitat(s) present within the entire transect (station).
2. For each distinct habitat identified (sample), a short summary description (fewer than 100 characters) including details of the dominant substrate(s) and biota present.
3. The start and end time of each distinct habitat (sample).

Where video transects comprised multiple habitats, separate rows were added to the video pro forma spreadsheet and all metadata updated or recorded.

2.2.2 Imagery analysis step 2: Stills analysis

Each one-minute-interval still (selected as described in section 2.1.2) within the corresponding transect (identified in section 2.2.1) was analysed using the following sequence and process. Firstly the target image was assessed for quality comparing to those taken immediately before and after the target image. If the target still was not considered of good enough quality, the surveyor could change to the still taken immediately before or after the still listed in their audit spreadsheet. Analysis required viewing the stills at multiple (zoom) scales with a minimum of: ‘Fit-to-screen’ allowing observation of the entire image to gain information about large taxa or features of interest or those covering large proportions of the image; and 100% (zoom scale) or greater to enumerate taxa and ground-truth sediment particle sizes. Analysis of stills required:

1. Briefly describing the substrate and habitat present in a short sentence (fewer than 100 characters).
2. Visually assessing the substrate composition using percent cover for each MNCR substrate type present.
3. Visually assessing the field of view within the image (section 2.1.4).
4. Identifying and quantifying all:

a. Erect epifaunal species present as far as possible (to the best taxonomic level) using counts which were then converted to SACFOR scale abundances using guidance from Connor *et al* (2004).
b. Colonial/encrusting epifaunal species present as far as possible (to the best taxonomic level) using percentage cover which were then converted to SACFOR scale abundances using guidance from Connor *et al* (2004).
c. Sponge morphology types: Using counts for erect, percentage cover for massive and encrusting morphologies, which were then converted to SACFOR scale abundances using guidance from Connor *et al* (2004) (section 2.1.6).

5. Where the identification of visible fauna was uncertain, this was noted using the 'Uncertain' qualifier associated to each taxon name.
6. Recording the presence and estimating the composition and elevation of Annex I Reef and subtype (section 2.1.5).
7. Recording the presence of the fragile sponge and anthozoan communities (section 2.1.7).
8. Recording the presence of and describing any visible impacts or other modifiers, such as trawl marks, discarded fishing gear, visible physical damage, evidence of strong currents (section 2.1.8).
9. Recording the presence of Priority Marine Features (section 2.1.9).
10. Identifying the biotope present (section 2.1.10).
11. Recording the visual quality of the image (section 2.1.11).
12. Summarising all above information into a single habitat description and in addition including descriptions of any life-forms present which could be identified to a specific taxonomic group e.g. mixed faunal turf; and providing reasons for any uncertainty relating to identification of fauna or substrates e.g. blurred image, partially concealed from view, cannot be identified by image alone.

2.2.2.1 Timing how long it took to identify sponge morphologies and sponge and anthozoan taxa

Part way through the analysis, when surveyors were deemed comfortable with all recording protocols and methods, surveyors were asked to analyse a subset of stills using a different sequence, to enable auditing how long specific analysis tasks took, specifically to:

a) identify sponge morphologies and undertake all associated data entry,
b) identify sponge and anthozoan taxa and associated data entry,
c) undertake the rest of the image analysis.

To answer these questions surveyors were asked to accurately record how long the following three tasks took for a subset of stills:

1) view the entire image at 100% or greater scale, to identify and enumerate all sponge morphologies, and then undertake all associated data entry;
2) view the entire image at 100% or greater scale, to identify and enumerate sponge and anthozoan taxa, and then undertake all associated data entry;
3) undertake the rest of the image analysis as described in section 2.2.2 (*Imagery analysis step 2: Stills analysis*).

Stills for this subset were not selected randomly. Prior to stills analysis, stills within transects were assessed to determine whether many images contained sponges. The intention was to select transects containing the greatest numbers of sponges and then to apply this method to all stills within those transects. However in practice, due to the overall low abundance of large conspicuous sponges in this area, this method was used for all stills within a transect, if notable numbers of sponges were observed in any stills within that transect.

Surveyors were asked to repeat the analysis as described above on a different subset of stills (by using alternate stills) but this time switching around tasks one and two (from the list above). By alternating between starting with task one and then starting with task two on different stills, it is possible to determine how long each different but related task took i.e. the two tasks were not independent of each other. Once sponge morphologies within a still had been assessed and enumerated,, it was quicker to identify and enumerate sponge species for the same still, so the resulting audited times would not be accurate for the second task within the same still. Additionally, as only a few sponges could be confidently identified to species or genus level, with the remaining taxa being identified using descriptive features such as morphologies, the two tasks were in most cases very similar.

However, this alternating of the two analysis sequences was not always undertaken consistently by all surveyors. This was identified at the analysis stage when it was noted there was no way to differentiate which sequence had been started with, and therefore there was no way to confirm if surveyors had consistently switched between the two methods.

2.2.3 Imagery analysis step 3: Video analysis

Video transects were analysed using three different methods as follows:

- The first six videos (4%) were divided into 10 second subsections and each section analysed separately.
- 73 (47%) videos were divided into 20 second subsections and each section analysed separately.
- 77 (49%) videos were divided into distinct habitats aimed at JNCC Habitat Classification level 3 (EUNIS level 4), with each habitat lasting longer than 60 seconds.

These methods were applied to increase the temporal resolution of the video analysis. Results may be used to inform assessment of whether high resolution video analysis (e.g. using 10 or 20 second subsections) is more appropriate than traditional video analysis (i.e. where videos were divided into distinct habitats aimed at JNCC Habitat Classification level 3 (EUNIS level 4), with each habitat lasting longer than 60 seconds) and/or stills analysis for identifying and enumerating sponge morphology types and associated epifaunal taxa and assessing patchiness of habitats (e.g. Annex I Stony Reef).

Analysis of video required multiple viewings of each video subsection or habitat and recorded the following information, using the following sequence:

1. Visually assessing the substrate composition using percent cover for each MNCR substrate type present.
2. Identifying and quantifying:
    a. Erect epifaunal species present as far as possible (to the best taxonomic level) using counts, which were then converted to SACFOR scale abundances using guidance from Connor *et al* (2004).
    b. Colonial/encrusting epifaunal species present as far as possible (to the best taxonomic level) using percentage cover, which were then converted to SACFOR scale abundances using guidance from Connor *et al* (2004).
    c. Sponge morphology types: Using counts for erect, percentage cover for colonial/encrusting, which were then both converted to SACFOR scale abundances using guidance from Connor *et al* (2004) (section 2.1.6).
3. Where the identification of visible fauna was uncertain, the taxonomic level was raised and/or the ‘Uncertain’ qualifier was associated to each taxon name.

4. Recording the presence and estimating the composition and elevation of Annex I Reef and subtype (section 2.1.5).
5. Recording the presence of the fragile sponge and anthozoan communities (section 2.1.7).
6. Recording the presence of and describing any visible impacts or other modifiers, such as trawl marks, discarded fishing gear, visible physical damage, evidence of strong currents (section 2.1.8).
7. Recording the presence of Priority Marine Features (section 2.1.9).
8. Identifying biotope(s) present (section 2.1.10).
9. Recording the visual quality of the imagery (section 2.1.11).
10. Summarising all above information into a single habitat description and in addition including descriptions of any life-forms present which cannot be identified to a specific taxonomic group, e.g. mixed faunal turf; and providing reasons for any uncertainty relating to identification of fauna or substrates e.g. blurred image, partially concealed from view, cannot be identified by image alone.

Recording the above information whilst viewing the video required the video to be regularly paused and reviewed, and for cumulative scores and counts of multiple taxa, substrate proportions and other features of interest to be kept. To do this surveyors used a combination of direct entry into excel spreadsheets (section 2.1.3), and keeping handwritten notes and records of counts and percent cover for taxa and substrates.

2.3 Quality Assurance of imagery analysis

To ensure species and habitat identification was consistent between surveyors, regular discussion was maintained between the surveyors throughout analysis. In addition, all surveyors saved screen-grabs of taxa from stills and video, and organised these by phyla. Screen grabs were taken of both identifiable taxa and also taxa that presented ID difficulties either due to image clarity or ID uncertainty. At least once a week during the analysis stage, the surveyors spent half a day together reviewing uncertain taxa, agreeing how to deal with them, the appropriate taxonomic level they should be recorded to, and where appropriate, any relevant qualifier.

After the analysis stage was complete, a minimum of 10% of video clips and all associated stills were re-analysed by a different surveyor, to ensure inter-surveyor variability was reduced to a minimum. If, after re-analysis, the Quality Assurance (QA) highlighted significant inter-worker variability, the two surveyors worked together to determine where discrepancies occurred and formulated specific rules to overcome such differences for future analysis. If significant differences were identified between surveyors, consistent errors were corrected post analysis (for instance, inconsistent misnaming of one taxa or substrate). The qualifiers of some taxa were changed as part of quality control to ensure consistency following surveyor discussions, whilst some taxa were merged (for instance, where several different encrusting sponges were considered the same sponge at different exposure levels), prior to Marine Recorder (MR) data entry.

As with the initial imagery analysis, Excel spreadsheets were used to audit which data were re-analysed for QA purposes and by whom. Recorded within the audit spreadsheets was the date of QA, the name of the QA surveyor, QA re-analysis results, comments relating to differences in results between surveyors, and any remedial actions undertaken.

2.4 Marine Recorder v5 data entry

Data from this survey was entered into Marine Recorder (MR) (URL[3]) as a single MR survey with a single MR location (Solan Bank). Survey and location boxes were drawn up in the GIS prior to data entry. Each video transect was entered as an MR event and each still and video habitat (aimed at EUNIS level 4 or higher) corresponded to an MR sample.

The spreadsheet based data import function available with MRv5 was used to import the bulk of data from this project. Although this import function imports a large proportion of the data, several fields relating to depths, substrate and surveyors do not import, and this data was entered manually.

Various attributes recorded during this project do not have corresponding fields within Marine Recorder therefore information regarding Annex I Reef subtypes, fragile sponge and anthozoan communities, Priority Marine Features (PMF), and evidence of human impacts were entered as text strings into the sample description field.

Abundance data generated from this project included both counts / percent cover, and SACFOR data for each taxon identified. As both abundance data types were entered into MR, a taxon comment was added to each taxon entry, stating that abundance was recorded in both ways, and caution should be taken, not to overstate abundance, when downloading and interpreting taxon data only from this dataset. The same comment was added to every sample description.

It should be noted that a biotope was used throughout this analysis that is not currently available in the JNCC Marine Habitat Classification or in Marine Recorder. Therefore all records from this survey of CR.MCR.EcCr.CarSp.PenPcom should actually read CR.MCR.EcCr.CarSp.PenPcom.2 which is a northern sparse and sand-scoured variant of this biotope, described by Whomersley *et al* (2010) for the Solan Bank area. Further details of this biotope as described by Whomersley *et al* (2010) are in Appendix 5. A note was made in the sample description of all samples where this biotope was used.

2.4.1 Marine Recorder data entry QA

When preparing Excel data-entry spreadsheets for import into GIS and entry into Marine Recorder (MR), a thorough process of data cleaning was undertaken to ensure the quality of data within these formats. Data cleaning included using: the ‘Spell Checker’ to ensure spelling mistakes were removed; the ‘Find and Replace’ function to remove any unwanted spaces or other characters; and Excel ‘text string’ and ‘value’ functions and calculations to validate data types within text and value specific fields.

During manual data entry into MR of remaining fields not imported using the bulk import tool, 10% of MR samples were compared with cleansed (after QA and QC) recording sheets. Where any differences between original and final formats were identified, remedial action was taken to ensure data quality. If frequent and consistent errors were identified, the data was explored to identify any data entry or data import systematic errors.

Upon completion of MR data entry, the Event and Sample Validation tools within MR were used to check the presence and consistency of data entered and identify any data inconsistencies. Any such errors identified were corrected.

[3] http://jncc.defra.gov.uk/page-1599

The Snapshot tool was used to further interrogate data entered into MR including data relating to taxa, which are not viewable within the sample validation matrices alone. Additionally coordinates entered into MR were checked by exporting a snapshot of the stills dataset into GIS and comparing the proximity of MR coordinates VS pre-MR coordinates. All stills were closer than 50 metres from each other and only 23 points were greater than 10 metres apart. This level of accuracy was deemed acceptable and any differences likely to be a result of coordinate conversions used from the original Eastings/ Northings (UTM30N) into Latitude/Longitude (WGS84).