

JNCC/MSS Partnership Report Series

Report No. 7

Central Fladen MPA Video Analysis Report on Imagery Analysis, Density Assessments and Results

Benson, A., Boblin, E., Sotheran, I., O'Connor, J. & Weetman, A.

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JNCC

For further information please contact:

Joint Nature Conservation Committee
Monkstone House
City Road
Peterborough PE1 1JY
www.jncc.gov.uk

Marine Monitoring Team (marinemonitoring@jncc.gov.uk)

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Author affiliation:

Alison Benson (ENVISION)
Eloïse Boblin (ENVISION)
Ian Sotheran (ENVISION)
Joey O'Connor (JNCC)
Adrian Weetman (Marine Scotland Science)

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Executive Summary

Marine Scotland Science (MSS) collect *Nephrops* underwater television (UWTV) footage annually. Data from 2019 and 2020 collected inside and adjacent to Central Fladen Marine Protected Area (MPA) by MRV *Scotia* (ICES 2020) was made available to JNCC.

Approximately four and a half hours of footage from 27 video stations was analysed in BIIGLE to identify transects where the Burrowed mud (Sea pens and burrowing megafauna and tall sea pen components) Priority Marine Feature (PMF) was present. Video imagery was analysed to assign broadscale habitats and biotopes from the 'Marine habitat classification of Britain and Ireland' version 15.3 (MNCR), identify conspicuous taxa, record evidence of human impacts, calculate the density of burrows and sea pens at each station and evaluate the extent to which the analysis results could be used to assess the Burrowed mud and Sea pen and Burrowing Megafauna Communities features.

The video records were reviewed in BIIGLE to assess the video quality and split it into habitat segments based on areas of continuous seabed habitat type greater than or equal to 5m, with each habitat segment then annotated at the Tier 1 level with broadscale habitat (MNCR Level 3), image quality scores from the JNCC and NMBAQC quality guidance, biotope assignment up to Level 6 of the MNCR hierarchy and any PMF habitats. Tier 2 information was added as point annotations for all burrow openings, mounds, *Nephrops norvegicus* burrow systems, conspicuous taxa, PMFs, non-native taxa, litter or evidence of anthropogenic impacts.

For the burrow/sea pen density assessment methodology, counts of all burrow openings, *Nephrops* burrow systems and sea pens were then undertaken for minute-long segments of the footage and recorded within the density assessment proforma provided by JNCC, counting all biota/burrows as they crossed the bottom of the screen. The burrow density assessment was used to ascertain the presence of the Sea pen and Burrowing Megafauna Communities features where the density of burrows (all burrow openings) was $\geq 1/\text{m}^2$ (burrows <3cm diameter).

None of the video tows were segmented on the basis of changes in broadscale habitat, with the majority of the substrate being composed of homogenous mud or sandy mud, with a low percentage of shell content. In total, 22 video stations were allocated the biotope 'Sea pens and burrowing megafauna in circalittoral fine mud' (SS.SMu.CFiMu.SpMg), four video stations were allocated 'Offshore circalittoral mud' (SS.SMu.OMu) and one video station was allocated 'Circalittoral mixed sediment' (SS.SMx.CMx). All video stations were assigned the NMBAQC image quality category 'Poor', and the JNCC image quality category 'Conspicuous fauna', due to issues with the footage being low resolution, elevated above the seabed and moving too fast/causing blurred imagery when the camera system moved upwards. Quality is likely to have been affected as imagery was initially recorded to hard drive and transferred to DVD, and then reformatted for upload to BIIGLE. The footage quality led to some uncertainty in taxonomic identification and lowered confidence in counts.

Taxa was recorded using 38 biota categories in BIIGLE, however some of these categories were of 'uncertain/unclear' observations and have been annotated with labels named 'uncertain' in BIIGLE. A reference collection was compiled including 38 images for 38 biota categories, five images for the five habitats and biotopes assigned, three images for the three burrow categories recorded, two images for the two litter categories observed, and one example of the probable trawl marks recorded.

The only PMFs or features of conservation interest identified during analysis were the sea pens *Pennatula phosphorea* and *Virgularia mirabilis*, and burrows (*Nephrops* burrow

systems and other) that are components of the Burrowed mud and Sea pen and Burrowing Megafauna Communities which were being assessed.

Quality Control procedures undertaken on 10% of the footage highlighted some uncertainty in identification and counts of biota and burrows, but these were considered acceptable given the footage quality. These issues were noted and reviewed when performing LARGO checks on all BIIGLE annotations. Burrows were recounted to check consistency of density assessment values, and despite discrepancies these were not considered to alter the feature assessment process.

Some issues were flagged during the QC process with regards to difficulties in annotating high numbers of burrows/biota in BIIGLE, and inconsistencies between density assessment counts and counts in BIIGLE. The differences in density assessment counts may potentially be due to constant disruption of the view of imagery when pausing to add annotations in BIIGLE, and reluctance to add a fixed record as an annotation to the paused video footage which may be blurred/unclear, where epifauna/burrows may be viewed more clearly in the moving imagery.

The burrow and density assessment methodology were undertaken successfully on the Central Fladen MPA UWTV, and although some minute-long segments were considered unsuitable for analysis due to being too short (<30 seconds) or the camera system being too high above/angled up from the substrate, the majority of footage was analysed and had burrow (all burrow openings) densities of $\geq 1/\text{m}^2$. Of the 27 video stations, 22 had all or more than half of the footage with a recorded burrow (all burrow openings) density of $\geq 1/\text{m}^2$, indicating the presence of the SPBMC feature, and supported the biotope allocation assigned during analysis in BIIGLE of 'Sea pens and burrowing megafauna in circalittoral fine mud' (SS.SMu.CFiMu.SpnMeg).

Limitations in this density assessment methodology are due to footage analysed having been collected for identifying *Nephrops* burrow systems and not for MPA feature monitoring, and the fact that burrows may be omitted from counts where the footage makes them difficult to see or identify accurately, which may affect the assessment of the PMFs, and management decisions based on this. However, where numbers of burrows and burrowing megafauna are marginal, this may indicate the absence of the features and be sufficiently taken into account by the thresholds being used. Footage quality also affected the taxonomical resolution of the results which may necessitate adaptation of indicators for assessment purposes.

It is recommended that burrow/sea pen density assessment counts are undertaken whilst observing the video footage without interruption from annotation in BIIGLE. Standard definition footage is best viewed on CRT monitors, and certain functions can be improved by using software which allows pausing and frame-by-frame manipulation, as well as interlacing/deinterlacing features, such as VLC. It is also recommended that if using *Nephrops* stock assessment UWTV data for Sea pen and Burrowing Megafauna Communities feature assessment, that some of the UWTV counts be validated by collecting some more targeted or higher quality footage (i.e., as from a dedicated MPA feature monitoring survey) and comparing density assessment results.

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Abbreviations

Cefas	Centre for Environment, Fisheries and Aquaculture Science
FOV	Field of View
ICES	International Council for the Exploration of the Sea
JNCC	Joint Nature Conservation Committee
LARGO	Label Review Grid Overview
MEDIN	Marine Environmental Data and Information Network
MNCR	Marine Nature Conservation Review
MSFD	Marine Strategy Framework Directive
MSS	Marine Scotland Science
MPA	Marine Protected Area
NMBAQC	North East Atlantic Marine Biological Analytical Quality Control Scheme
OSPAR	The Convention for the Protection of the Marine Environment of the North-East Atlantic
PMF	Priority Marine Feature
QC	Quality Control
SACFOR	Superabundant-Abundant-Common-Frequent-Occasional-Rare scale
SD	Standard Definition (Video Footage)
SPBMC	Sea pen and Burrowing Megafauna Communities
UWTV	Underwater Television
WoRMS	World Register of Marine Species

The Central Fladen MPA lies within the Fladen Grounds, a large area of mud in the northern North Sea. The mud habitat is characterised by sea pens and burrows made by crustaceans such as mud shrimp and the Norway lobster (*Nephrops norvegicus*). The Central Fladen MPA has been designated to protect the Burrowed mud (sea pens and burrowing megafauna and tall sea pen components) PMF in Scottish waters.

Approximately four and a half hours of footage from 27 video stations (Figure 1) was analysed in BIIGLE to identify transects where the Burrowed mud (sea pens and burrowing megafauna and tall sea pen components) PMF and OSPAR Sea-pen and Burrowing Megafauna Communities (SPBMC) feature are present.

1.1 *Nephrops* UWTV data

MSS have made a subset of their *Nephrops* UWTV data available to JNCC to support monitoring of the SPBMC feature, and have provided valuable input on the scope, methodology and results of this study. The *Nephrops* UWTV data collected annually is analysed by MSS for *Nephrops* stock assessment purposes¹, and is therefore being used opportunistically for the scope of work reported in this document, and is supplementary to the design and purpose of the *Nephrops* assessment surveys. As the data is not targeted to assessment of the Burrowed Mud PMF and Sea pen and Burrowing Megafauna Communities features, the survey approach used may introduce a bias. The coverage of the *Nephrops* surveys is limited to NEP grounds and images may not be representative of the fauna experienced in other marine areas around Scotland, be it either in MPAs or adjacent to the NEP survey grounds.

The *Nephrops* footage is generally recorded for 10 minutes per station, to achieve a minimum of seven minutes of good footage for MSS assessment. The elapsed timer is set to zero (when counts are begun) after a period (approx. one min) of acclimatisation for the reviewer. Any minute-long segment which is of poor quality which lasts more than 30 seconds, e.g., due to poor visibility, is discounted and ninth- and tenth-minute segments are used in their place. If the footage collected in the first eight minutes of the video tow is of good quality, video tows may be ended at this point resulting in shorter video tows, or in instances where hazards are encountered such as cables or pipes. Due to the differences in methodologies between the *Nephrops* stock assessment and the current analysis, values such as burrow counts may be identified or quantified in a different way and direct comparison with ICES *Nephrops* stock assessments may not be possible.

The video camera used for MSS *Nephrops* surveys (typically a Kongsberg OE-14366) is high quality but records in standard definition, which is best viewed with a CRT monitor to improve the experience of image quality. When viewed with LED, LCD or even an OLED screens (as for this scope of work) image quality experienced may have been poorer than with CRT monitors (which are designed for SD footage). The camera system setup is optimised for *Nephrops* identification, and as such may not be optimal for quantification of other biota such as sea pens, or other burrow systems. The variable elevation, angle and speed of the camera system discussed in this report, due to sea swell and movement of the vessel, is minimised through paying out of additional umbilical cable but cannot be avoided entirely.

¹ <https://www.ices.dk/community/groups/Pages/WGNEPS.aspx>

2 Methodology

The aims and objectives of the analysis are to assign broadscale habitats and biotopes to the video footage, identify conspicuous taxa, record evidence of human impacts, calculate the density of burrows and sea pens at each station and evaluate the extent to which the analysis results can be used to assess the Burrowed Mud PMF and Sea pen and Burrowing Megafauna Communities features.

Two methodologies were employed to achieve these objectives which are described below, with one methodology undertaken in BIIGLE and the other by completing the 'burrow/sea pen density assessment proforma' spreadsheet provided by JNCC.

The BIIGLE analysis methodology required splitting of the video imagery into segments on the basis of changes in broadscale habitat, and the burrow/sea pen density assessment methodology required splitting of the video imagery into segments of one-minute length for burrow/sea pen counts. These have been differentiated in the report as 'habitat segments' for the broadscale habitat and 'minute-long segments' for the density assessment counts, respectively.

2.1 Video analysis in BIIGLE

Video imagery was reviewed, processed and analysed as per the project specification provided for the project. Methodologies were further clarified during discussions with the JNCC at the inception meeting and early stages of the project, and analysis was conducted in line with the standards for analysis in Turner *et al.* (2016). Video imagery was analysed using the BIIGLE annotation platform (Langenkamper *et al.* 2017) to annotate the conspicuous epifauna identified at each video station. Conspicuous epifauna is understood to be biota that is large and clear enough to be reliably identified, dependent upon the quality of the imagery.

BIIGLE allows a collaborative approach to image analysis, such as amending the label tree (the list of available annotations) in consultation between analysts, and to allow review of annotation decisions in real time with the JNCC. Guidance for use of BIIGLE provided by JNCC and Cefas was followed. The taxonomic label tree for annotation of epibiota was provided by the JNCC, based on taxonomic structure completed recursively from the World Register of Marine Species (WoRMS), along with other label trees provided, as detailed below.

The video imagery was initially viewed in order to assess the video quality and to ascertain the presence of broadscale habitats and biotopes. Where changes in broadscale habitat type were observed, for areas of continuous seabed habitat type greater than or equal to 5m, the footage was split into habitat segments which would be treated and analysed as separate records. The allocation of segments was performed in BIIGLE by using the whole frame annotation tool with the label 'segment' (as specified by JNCC). Brief changes in substrate type lasting less than 5m were considered as incidental patches or as a 'habitat mosaic'.

Each habitat segment was then annotated with Tier 1 labels, including:

- Broadscale habitat, using the 'Marine habitat classification of Britain and Ireland Version 15.03' label tree, up to level 3 of the hierarchy.
- Imagery quality scores, assigned from both the 'JNCC Coarse Imagery Quality' and 'NMBAQC Video Quality' label trees, upon which the level of analysis was dependent

(e.g., no further analysis was undertaken if a score of 'substrate' or 'zero' was assigned).

- Biotope assignment, using the 'Marine habitat classification of Britain and Ireland' label tree, up to level 6 of the hierarchy where possible, in accordance with Parry (2019).
- The presence of Priority Marine Feature (PMF) Habitats, as described in Tyler-Walters *et al.* (2016), using the 'Priority Marine Feature' label tree.

The video footage was then viewed at normal speed, and paused as often as necessary to record the following Tier 2 information (where present) as point annotations, for all features and taxa:

- Burrows and mounds, using the 'Burrows' label tree.
- All conspicuous taxa, using the 'Biota' (Central Fladen Species list WoRMS – editable) label tree, particularly sea pens and burrowing taxa (e.g., including, but not restricted to, those listed in Table 6, Appendix 1).
- Priority Marine Features, as described in Tyler-Walters *et al.* (2016).
- Non-native taxa.
- The presence of litter, using the 'ICES/MSFD/OSPAR Litter Categories' label tree based on the categories listed in Annex 5.1 of the Joint Research Centres Guidance on Monitoring of Marine Litter in European Seas.
- Evidence of anthropogenic impacts on the seabed, using the 'Anthropogenic' label tree, such as trawl marks or physical damage.

The details were downloaded in BIIGLE annotation reports, which were then imported into the MEDIN compliant proforma.

Other aspects of the methodology were discussed and agreed with JNCC as follows:

- All burrow openings were annotated using the label 'Burrow opening', as well as any mounds observed, with the label 'Mound'. *Nephrops* burrow systems were annotated with the label '*Nephrops* burrow system', with only one annotation per burrow system/complex, in addition to the 'Burrow opening' annotations already given to each of the visible burrow entrances.
- At a later stage in the project, the label 'Uncertain *Nephrops* burrow system' was added to burrow systems which were uncertain due to a poor view of the burrows. For example, where their orientation in relation to the angle of the camera system meant burrow entrances were obscured, or where the camera system was moving too fast and the image was blurred.
- The presence of faunal turf at certain video stations was to be recorded during analysis, and a 'faunal turf' category was added to the 'Biota' label tree (Uncertain_Faunal turf). The majority of faunal turf was expected to be hydroids, but is likely to also have included bryozoans, and possibly some cryptic cnidaria and polychaete tubes where the video quality did not allow clear identification of this type of epifauna.
- Due to the majority of burrow openings observed in the footage being <3cm diameter (approx. 1-3cm), it was decided that the presence of SPBMC would be calculated in the density assessment proforma where the density of burrows (all burrow openings) is $\geq 1/\text{m}^2$.

2.2 Burrow and sea pen density assessment method

The 'Burrow and sea-pen density assessment' methodology was a separate process to the analysis of the video footage in BIIGLE, and the proforma provided by JNCC was used to record the densities of burrows and sea pens. The number of all burrow openings (including *Nephrops* burrow entrances), as well as the *Nephrops* burrow systems, and each species of sea pen were quantified by counting them as they crossed the bottom of the screen by tallying or with a tally counter. The authors note it takes a considerable amount of time and training to gain the field and workshop experience required to correctly identify *Nephrops* burrow systems with confidence.

The burrow and sea pen density assessment counts were performed on minute-long segments of the footage from each of the video stations (approx. 10 mins long each), with the start and end time of segments taken from .DAT files provided by MSS to align with their *Nephrops* burrow counting methodology. Counts of burrows and sea pens were undertaken for each of the minute-long segments of the video footage. Field of View measurements were then calculated (using camera angles and height above seabed) to give the width of the bottom of the screen from which the swept area/per minute was derived.

Minute-long segments which could not be analysed due to quality issues (allocated a JNCC quality score of 'substrate' or less) were omitted from density calculations by completing the 'suitable for analysis' field of the proforma which highlights these minute-long segments as 'Not analysed' for SPBMC presence calculation.

According to the definitions for the Burrowed mud PMF and Sea pen and Burrowing Megafauna Communities (SPBMC) feature assessments, as provided in the project specification, where burrows are 'Frequent' on the SACFOR scale, SPBMC are considered present (e.g., large burrows (>3cm diameter) at $\geq 0.1/\text{m}^2$). Due to the majority of burrow openings observed in the footage being <3cm diameter (approx. 1-3cm), the presence of SPBMC was calculated in the density assessment proforma where the density of burrows (all burrow openings) are $\geq 1/\text{m}^2$.

It should be noted that quantification of burrow openings is not directly equivalent to the number of burrowing megafauna present, particularly where burrow systems (e.g., *Nephrops* burrow complexes) commonly have multiple burrow entrances.

2.3 Reference collection

A reference collection was built as the analyses progressed, with the best observations noted and frame captures collated for each taxon or biota category identified, as well as for litter categories, trawl marks, and burrow categories. Each image was then reviewed, and the taxon/biota highlighted with a box. The file was then saved with the taxon/biota name and the site identification, to form the filename structure:

Taxa_Label_VideoNumber_BiigleTime

(e.g., 'Lithodes maja_FL20050_01.02.67.PNG' see Figure 2).

In addition to the taxon/species reference collection, a biotope/habitat reference collection was also built with good images of each biotope/habitat recorded. Again, the files are saved and named with biotope/habitat name and video station reference as part of the filename.



Figure 2. Example of reference collection image showing *Lithodes maja*.

2.4 Quality control (QC) of incoming data

All imagery was provided online via BIIGLE along with metadata and survey notes in an accompanying spreadsheet. The imagery initially underwent a Quality Control (QC) process whereby data were checked to ensure all footage was present as listed within the metadata, and that all footage received had associated metadata accompanying it.

2.5 Internal QC of video analysis

Whilst undertaking the analysis, the analysts noted issues that led to ambiguity in either the annotation of epifauna or in the Tier 1 labelling process. Following the analysis of all imagery, the analysts reviewed all annotation categories using the 'LARGO' function (Label Review Grid Overview) within BIIGLE, with particular focus on these annotations or Tier 1 labels to ensure that the process had been undertaken consistently. LARGO² allows annotations with the same label to be viewed as thumbnails in a regular grid, which can then be selected to change labels, attach new labels or delete labels more efficiently. For labels or categories where ambiguity occurred most often, each category was reviewed using LARGO by two or more analysts and a collective decision made to amend annotations where inconsistencies had occurred. These checks are described in the later QC Section 3.7.

A further 10% of the footage (three video stations) were chosen randomly and reviewed by another analyst to check for omissions, certainty of identification, and any misidentification. Notes were made from this review and recorded in a spreadsheet to present the findings, detailing any common issues arising which may need to be addressed within the entire data set.

² <https://biigle.de/manual/tutorials/largo/largo>

3 Results of BIIGLE analysis

All footage from the 27 video stations provided was analysed in BIIGLE as per the methodology outlined in Section 2. Full results of the analyses were exported from BIIGLE. The following sections describe the results of the analysis in BIIGLE (summarised in Table 1).

Table 1. Summary of analysis results for video stations at Central Fladen MPA, showing Broadscale Habitat, MNCR Code, Presence of probable Trawl Marks (T) / Litter (L) (no. of observations in brackets) and notes made during analysis.

Video Station	Broadscale Habitat	MNCR Code	Anthropogenic Impact (No. of observations)		Notes
FL19033	SS.SMu	SS.SMu.CFiMu.SpnMeg	T (1)		Many Virgularia
FL19034	SS.SMx	SS.SMx.CMx			Much faunal turf
FL19035	SS.SMu	SS.SMu.CFiMu.SpnMeg	T (3)		Some poorer quality
FL19036	SS.SMu	SS.SMu.CFiMu.SpnMeg			
FL19037	SS.SMu	SS.SMu.CFiMu.SpnMeg			Many (poss) Flabellum
FL19038	SS.SMu	SS.SMu.CFiMu.SpnMeg	T (4)		Many (poss Callianassid) burrows
FL19050	SS.SMu	SS.SMu.CFiMu.SpnMeg	T (1)		Some poorer quality Buried biota (small, white)
FL19051	SS.SMu	SS.SMu.CFiMu.SpnMeg			Some poorer quality
FL19052	SS.SMu	SS.SMu.CFiMu.SpnMeg	T (16)		Some poorer quality
FL19053	SS.SMu	SS.SMu.CFiMu.SpnMeg	T (2)		
FL19054	SS.SMu	SS.SMu.CFiMu.SpnMeg		L (1)	Numerous shrimp
FL19055	SS.SMu	SS.SMu.CFiMu.SpnMeg			Some poorer quality
FL19056	SS.SMu	SS.SMu.CFiMu.SpnMeg			
FL19059	SS.SMu	SS.SMu.CFiMu.SpnMeg			
FL19060	SS.SMu	SS.SMu.CFiMu.SpnMeg			
FL20039	SS.SMu	SS.SMu.CFiMu.SpnMeg	T (4)		Buried biota (crabs?)
FL20040	SS.SMu	SS.SMu.CFiMu.SpnMeg		L (1)	Pennatula lying flat
FL20041	SS.SMu	SS.SMu.CFiMu.SpnMeg	T (16)		
FL20042	SS.SMu	SS.SMu.CFiMu.SpnMeg		L (2)	Buried biota (crabs?)
FL20043	SS.SMu	SS.SMu.OMu			
FL20044	SS.SMu	SS.SMu.OMu			
FL20045	SS.SMu	SS.SMu.OMu		L (1)	Many urchins/uncertain biota
FL20046	SS.SMu	SS.SMu.CFiMu.SpnMeg			Many urchins at end
FL20047	SS.SMu	SS.SMu.OMu	T (2)		Shelly, many Actiniaria, gastropod shells
FL20049	SS.SMu	SS.SMu.CFiMu.SpnMeg	T (4)		Many urchins at end
FL20050	SS.SMu	SS.SMu.CFiMu.SpnMeg			Many (poss) Flabellum and Actiniaria, shelly patches
FL20051	SS.SMu	SS.SMu.CFiMu.SpnMeg	T (3)		Many urchins, pagurids

3.1 BROADSCALE HABITAT AND BIOTOPE ALLOCATION

None of the video stations were segmented based on changes in broadscale habitat or MNCR biotopes, as the seabed was relatively uniform and homogenous within each video station. Most of the substrate was composed of mud or sandy mud, with a small percentage of shell content. Some video stations had greater amounts of shell in patchy distribution, and only one video station had enough shell content to be allocated a mixed sediment habitat. The following habitats/biotopes and associated broadscale habitat (MNCR Level 3) were allocated during the analysis in BIIGLE and are listed with the number of video stations allocated, with the distribution shown in Figure 3:

- 22 video stations were assigned the broadscale (MNCR Level 3) habitat of 'Sublittoral cohesive mud and sandy mud communities' (SS.SMu) and the biotope 'Sea pens and burrowing megafauna in circalittoral fine mud' (SS.SMu.CFiMu.SpnMeg) due to the high numbers of burrows and sea pens observed there.
- Four video stations were assigned the broadscale (MNCR Level 3) habitat of 'Sublittoral cohesive mud and sandy mud communities' (SS.SMu) and the habitat 'Offshore circalittoral mud' (SS.SMu.OMu), due to the lower numbers of burrows observed there, and often high numbers of urchins.
- One video station was annotated with the broadscale (MNCR Level 3) habitat of 'Sublittoral mixed sediment' (SS.SMx) and the habitat 'Circalittoral mixed sediment' (SS.SMx.CMx), due to the absence of burrows observed there, and high shell and silt content of the substrate.

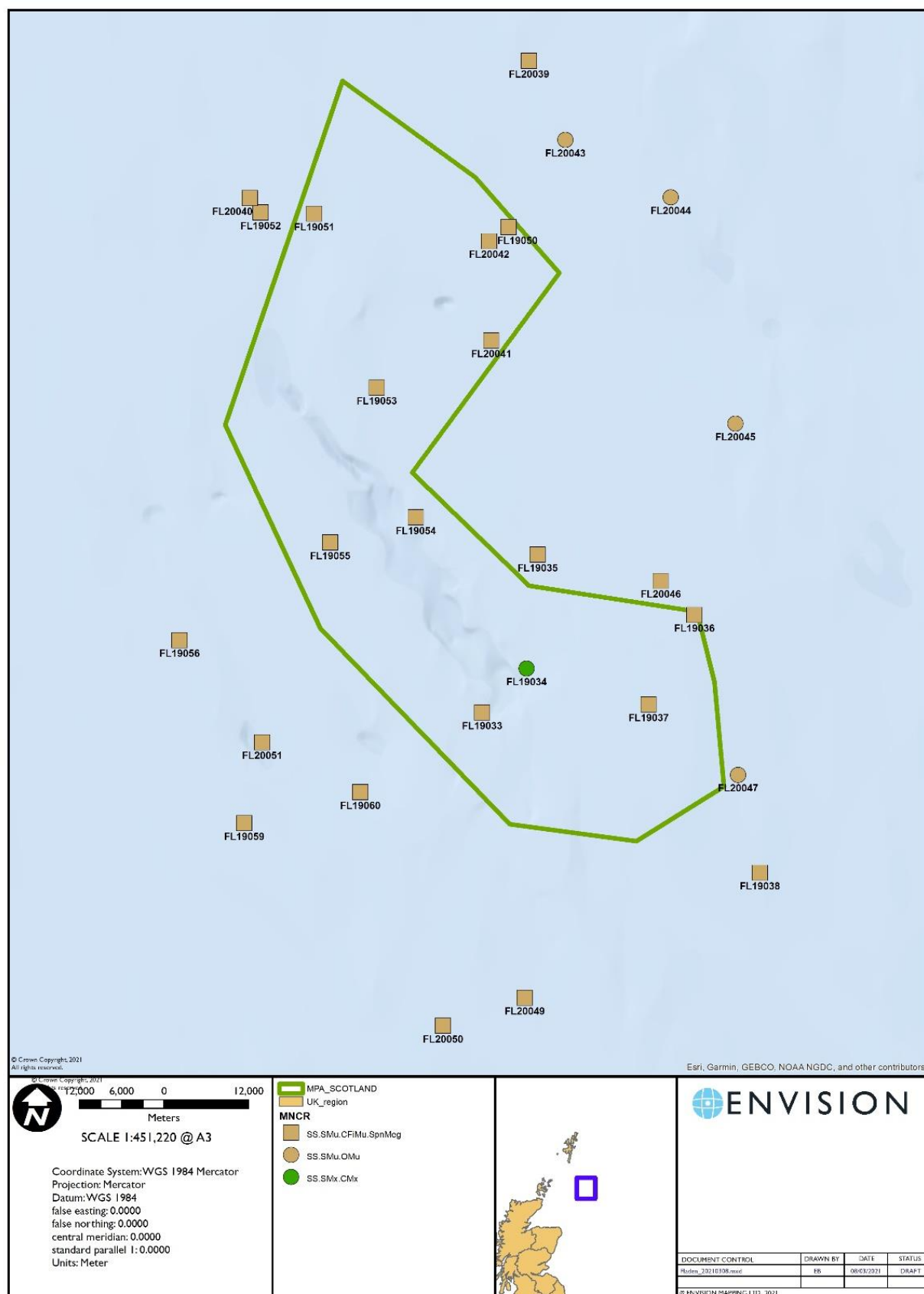


Figure 3. Distribution of habitats/biotopes (MNCR code) assigned at each video station during analysis.

3.2 Image quality

Footage from all 27 of the video stations was assigned the NMBAQC image quality category 'Poor', and the JNCC image quality category 'Conspicuous fauna' (Table 2 and Table 3). Whilst the camera system was operated at a relatively constant height throughout the video tows, with no turbidity issues and with the seabed always in view, the imagery was not of high enough resolution or close enough to the seabed for a clear view of all epifauna. As the camera was towed along the seabed there were periods of upwards, faster movements which resulted in blurring of the imagery and the upward angle of the camera system at these times also meant that burrows/biota became less visible. Quality is likely to have been affected as imagery was initially recorded to hard drive and transferred to DVD, and then reformatted for upload to BIIGLE.

Table 2. Summary of NMBAQC image quality categories (Turner *et al.* 2016).

Quality Category	Proportion of Tow Negatively Affected	Organism Enumeration	Biotopes
Excellent	<5%	Quantitative	Level 5
Good	5-20%	Quantitative	Level 5
Poor	20-50%	Qualitative	Level 3
Very Poor	50-80%	Not recommended	Level 2/3
Zero	>80%	Data not usable	Data not usable

Table 3. JNCC image quality categories.

Imagery Quality Level	Description
Fauna	Most fauna can be identified (e.g., including smaller taxa such as brittlestars, etc.)
Conspicuous fauna	Large and conspicuous fauna can be identified (e.g., sponges, soft corals, etc.)
Substrate	The substrate type can be identified, but the fauna cannot (e.g., the water column is obscured / the camera is too high off the seabed)
Zero	No visibility of the seabed, substrate cannot be identified.

Some video stations had slightly poorer quality than others, either being elevated higher above the seabed for longer periods, or with more variability in height of the camera system which decreased the quality. These issues did not affect more than 50% of the entire tow, so the 'Very poor' or 'Substrate' imagery quality categories were not assigned, however the quality assessment in the density assessment proforma does indicate some minute-long segments where the quality was affected (video stations FL19035, FL19050, FL19051, FL19052, FL19055: see Table 1 and Table 5).

Whilst conspicuous fauna was visible and could be identified to a certain extent, the view of most organisms was not clear and led to uncertainty in taxonomic identification and less confidence in counts. Quality may also have affected the ability to identify and count burrows and sea pens to some extent (discussed in Section 3.6).

3.3 Taxa recording

All taxa were annotated with Tier 2 labels in BIIGLE using the point tools for all epifauna. As mentioned in Section 3.2, the quality of the footage was 'Poor' and caused uncertainty in taxonomic identification and less confidence in counts. The following epifauna were recorded in the imagery, and explanation of the taxonomic identification is as follows. Rows with unclear/ uncertain observations are marked with an asterisk * and shaded in grey (Table 4):

Table 4. Epifauna annotations recorded during analysis of Central Fladen MPA UWTV footage.

BIIGLE Annotation	Epifauna includes
Actiniaria	All anemones, including uncertain <i>Bolocera tuediae</i> , Hormathiidae, possible Actinostola
Anthozoa	Uncertain Ceriantharia/Actiniaria
Asteroidea	All starfish
<i>Bolocera tuediae</i>	<i>Bolocera tuediae</i>
Buccinidae	Buccinidae: live
Caridea	Caridea
Cephalopoda	All squid
Cnidaria	Possible Flabellum / uncertain small Pennatula / anemone
Crustacea	Potential crab
Echinoidea	All urchins (majority potentially <i>Gracilechinus acutus</i> but not clear)
Gadidae	Potential <i>Melanogrammus aeglefinus</i> / other gadids
Hormathiidae	Potential <i>Actinauge richardii</i> / other Hormathiidae
<i>Lithodes maja</i>	<i>Lithodes maja</i>
Lotidae	Rockling
<i>Myxine glutinosa</i>	<i>Myxine glutinosa</i>
Nemertesia	Nemertesia
<i>Nephrops norvegicus</i>	<i>Nephrops norvegicus</i>
Ophiuroidea	All brittle stars
Paguridae	All hermit crabs
<i>Pennatula phosphorea</i>	<i>Pennatula phosphorea</i>
Pisces	All fish, uncertain spp.
Pleuronectiformes	All flatfish
Porifera	All porifera
Rajidae	All rays, uncertain spp.
Spatangoidea	All heart urchins
Uncertain Biota*	Uncertain observations
Uncertain Biota A _Halcampoides/Corymorpha*	Uncertain: potential <i>Halcampoides abyssorum</i> / <i>Corymorpha nutans</i>
Uncertain Biota B_Echinothuriidae*	Uncertain: potential Echinothuriidae
Uncertain Biota C_Tubes*	Uncertain: potential polychaete tubes
Uncertain Biota D_Gastropods live*	Uncertain: shells, but uncertain whether live/hermit crabs
Uncertain Biota E_Salmacina*	Uncertain: Salmacina
Uncertain Biota F_Geodiidae*	Potential <i>Geodia</i> sp., one example, uncertain
Uncertain_ <i>Arctica islandica</i> live*	Closed shell lying on substrate, may not be living as not in substrate
Uncertain_Bivalvia siphons*	Potential bivalve siphons

Uncertain_Faunal Turf*	Faunal turf (uncertain: may include hydrozoa, bryozoa, tube worms extended, cryptic anemones)
Uncertain_Naticidae egg collars*	Moon snail egg collars
Unidentifiable Burrowers	Epifauna observed in burrows, uncertain ID
<i>Virgularia mirabilis</i>	<i>Virgularia mirabilis</i>

Due to uncertain views or imagery quality, the observation recorded under 'Uncertain Biota' could not be identified to any reliable taxonomic level. These may include observations of polychaete worms, Aphroditidae, crabs, Echinoidea, Gastropoda, Hyalinoecia tubicola, Ophiuroidea, Scaphandridae, Spatangoidea and other taxa which were not clearly distinguishable in the footage, often partially buried in the sediment. 'Uncertain_Faunal turf' was recorded and comprised of unclear possible hydrozoa/bryozoa/tube worms/cryptic anemones. Other annotations were recorded for potential bivalve siphons (Uncertain_Bivalvia siphons), moon shell egg collars (Uncertain_Naticidae egg collars), one potential Geodia sponge (Uncertain Biota F_Geodiidae), and one potential *Arctica islandica* (Uncertain_Arctica islandica live) which was closed but lying on the surface and may not have been living.

As these unclear/uncertain observations (rows with unclear/ uncertain observations are marked with an asterisk * and shaded in grey Table 4) are not 'Conspicuous fauna' (biota that is large and clear enough to be reliably identified) these may need to be removed from further analysis but have been left in for context.

3.4 Litter, 'Non-native Invasive Species' (NIS) and other impacts or modifiers

Four video stations have been identified as potentially having items of anthropogenic origin in them (shown in Table 1, with the number of observations at each video station shown in brackets). These observations were annotated at the Tier 2 level by the addition of the 'F2: Rope' or 'F5: Other' label from the 'Litter (MSFD)' labels, as it is not possible to tell what substance the litter is made out of. The rope observed in video station FL20042 is buried in the substrate but exposed at this location next to another unidentifiable item. The other three instances of litter are all similarly unidentifiable objects.

Furrowed mud was observed in 11 of the video stations and was recorded as an indication of the probable presence of trawl marks (see Table 1, with the number of observations at each video station shown in brackets). No instances of Non-native Invasive Species were recorded in the imagery.

3.5 Reference collection

A reference collection of still images was compiled to provide examples of the epifauna observed: the collection included 38 images of 38 biota categories in total, as well as two images of the two litter categories and one image of a probable trawl mark. Five reference collection images were provided for the broadscale habitats and biotopes recorded, along with three images of the three burrow categories recorded. It should be noted that each taxon/category can potentially cover more than one species, and these should not be considered as the only potential examples.

3.6 Taxa and features of conservation importance

The only Priority Marine Features or features of conservation interest identified during analysis were the sea pens *Pennatula phosphorea* and *Virgularia mirabilis*, and burrows

(*Nephrops* burrow systems and other) that are components of the Burrowed mud and Sea pen and Burrowing Megafauna Communities features which are being assessed in this study. No 'Mounds' were observed within the footage.

Burrows and sea pens were observed at all video stations with the exception of FL19034. *Pennatula phosphorea* was absent from four further video stations: FL19056, FL19059, FL20044 and FL20045. *Nephrops* burrow systems (both certain and uncertain) were absent from four further video stations: FL20043, FL20044, FL20045 and FL20047.

3.7 QC of imagery

Three video stations (10% of the footage) were chosen randomly and checked for QC purposes by a second analyst, who checked all Tier 1 labelling (including quality categories, the broadscale habitat and MNCR code allocated). All Tier 2 annotations were then checked by clicking on the annotation and verifying the identification and certainty of annotations. If annotations numbered over 100 for the video station, the QC analyst performed an independent count of that annotation and compared results. The footage was then watched in entirety to check for any biota that had not been recorded.

Although agreement between analysts was generally considered to be good, some discrepancies were noted. The majority of these arose where the view of the epifauna was uncertain, which is attributed to the quality of the footage and was noted and considered for all checks in LARGO. A number of uncertain observations were picked up during the QC procedure, and these were considered by both analysts and either removed or the label category amended accordingly (e.g., annotation moved to 'Biota' or different taxonomic level if unclear). Uncertainty was noted in several of the biota categories (e.g., Echinoidea, *Pennatula*, burrow openings) but any differences in numbers were considered acceptable given the footage quality. All burrow openings counts were double checked when reviewing the density assessment proforma.

All annotations within the analysis were then checked using the LARGO function on BIIGLE, with all analysts checking the annotations for consistency of category use. Where annotations were considered inappropriately labelled, points were reannotated to the correct category or removed.

A summary of all the actions undertaken during internal QC procedures for the analysis is provided in Appendix 2 (Table 7 to Table 10).

4 BIIGLE and analysis issues

4.1 Analysis of video in BIIGLE

Direct counts while letting the video footage run (without stopping to add annotations) seem to capture higher numbers (burrows/sea pens), even if only counting the individuals that cross the bottom of the screen. Epifauna often appeared clearer in the moving image, rather than a blurred still frame, where analysts were reluctant to add a fixed record as an annotation to an uncertain image.

4.2 Annotating high numbers

Where epifauna, e.g., *Virgularia* were numerous they needed to be counted methodically using a systematic 'virtual row' based count as this limited double counting or omission of

individuals. This affected the annotations as they could not always be placed at the clearest point, and therefore image thumbnails in LARGO may appear as uncertain observations.

Additionally, there are difficulties in adding labels to biota/burrows occurring in very high numbers in BIIGLE, particularly in poor quality imagery. It is necessary when annotating in BIIGLE to pause the video footage to add annotations, which breaks up and disrupts the analysts view of the imagery and biota/burrows which can look clearer when viewed in moving imagery. Often when the imagery is paused, the frame is blurred when the image is motionless, and the analyst is less likely to add a fixed record as an annotation to a blurred and/or uncertain image. Also, when the video replay is restarted in BIIGLE, the annotations disappear and can cause difficulty in monitoring the numbers, particularly when the annotation symbols in the 'rows' below the imagery overlies one another and cannot easily be selected. The points can be selected in the 'Annotations' tab in the right-hand bar of BIIGLE, but these are not in chronological order (dependent on when the annotation was added, rather than time in video footage) and cannot necessarily be used to move through annotations sequentially. Occasionally, when selecting annotations in this manner, the annotation points are not visible, adding to difficulties with checking prior annotations.

4.3 Counts

Imagery quality may have affected the ability to count sea pens and burrows to some extent. Sea pens were easiest to identify at the top of the screen where the camera angle is widest and lighting angles mean the shape and shadows cast by epifauna standing proud of the substrate could be seen more easily. Density assessment counts were performed by counting biota/burrows as they crossed the bottom edge of the imagery, and therefore sea pens were harder to count at this point, where the angle of imagery was less oblique.

When imagery is fast moving or blurred resulting in poor quality imagery, the burrows can be harder to identify and can be confused with small cnidaria/sea pens/heart urchins or other round/dark epifauna, therefore decreasing the confidence of counts.

4.4 Litter Categories

The MSFD litter categories on the 'MPA imagery analysis_JNCC' label tree was complex to follow as they are based on what the litter is made out of. For example, rope or line can be observed that is impossible to tell what it is made of. In these cases, 'litter' can only be categorised as Miscellaneous F5: Other.

4.5 Suggested BIIGLE Improvements

It should be noted that some of these issues were communicated with BIIGLE hosts during the contract and have been resolved (indicated in the text).

- An easier approach for annotating large numbers of biota/burrows in BIIGLE. One suggestion is to add your own number (from a tally count) to a polygon drawn around the periphery of the biota on the paused image.
- Backup/Undo function for Largo so any mistaken Largo actions can be resolved (this has been noted by BIIGLE hosts – issue resolved).
- When selecting an annotation within imagery, highlight the annotation as a different shape or size, not just in red (can be hard to see).
- Annotations list (right hand bar in BIIGLE) be listed chronologically in time throughout video, rather than order of when they were annotated).

- Annotations 'dots' sometimes do not appear when selected, either in rows below imagery or in 'Annotations' list of right-hand bar in BIIGLE, making them very difficult to track (need to be deleted and added again) – is there a reason for this?
- There is no 'capture screenshot' function for video imagery.
- Scroll bar at side of the annotations rows under the imagery can cover some of the points, making it difficult to check these annotations during QC procedures. Suggested solution: Remove or move to one side (issue resolved).
- When adding point annotations to video, one has to select the point annotation tool, click on the epifauna, then click on the tick, meaning three clicks for each annotation, which is time consuming when annotating very numerous epifauna, e.g., urchins. Suggested solution: keep annotation tool selected until another tool is chosen, or annotation tool is deselected. Shortcuts are also available for selection of annotation tools (issue resolved).

5 Results of Burrow and Sea pen Density Assessment

5.1 Method

The 'Burrow and sea-pen density assessment' methodology was a separate process to the analysis of the video footage in BIIGLE, and the proforma spreadsheet provided by JNCC was used to record the densities of burrows and sea pens. The numbers of burrows and sea pens were quantified by counting all burrow and sea pen species annotations as they crossed the bottom of the screen by tallying or with a tally counter.

The burrow and sea pen density assessment counts were performed on minute-long segments of the footage (video tows of approx. 10 minutes at each video station), with the start and end times of the minute-long segments taken from .DAT files provided by MSS to align with their *Nephrops* burrow counting methodology. Counts of burrows and sea pens were undertaken for each of the minute-long segments of the video footage.

Minute-long segments that were not analysed due to quality issues (due to periods where the camera was too high above or angled up from the substrate) were omitted from density calculations by completing the 'suitable for analysis' field of the proforma which highlights these minute-long segments as 'Not analysed' for SPBMC presence calculation.

5.1.1 Field of view calculations

Field of View (FOV) measurements were then calculated (using camera angles and height above seabed) to give the width of the bottom of the screen from which the swept area/per minute was derived. The following calculation was used:
FOV width:

$$= \text{Camera height} * 2 / \cos(\text{Lower Edge} * 3.142 / 180) * \tan(\text{Horizontal Angle} * 3.142 / 360)$$

The swept area/per minute was calculated by multiplying the average FOV width for each minute-long segment by the distance covered by the camera system in each minute (provided in metadata) to give the area covered in m².

5.1.2 *Nephrops* burrow system counts

Nephrops burrow systems were also counted following guidance available from ICES workshops and reports (ICES 2011, 2017; Weetman [undated]), counting burrow systems with burrow entrances which were crescentic, shallow, ≥5cm, had 'runways' or 'deltas' (often

with tracks/ejecta), and where linear or more complex systems (T-shaped, four-hole entry) were evident. For these counts, each burrow system was counted only once, regardless of whether only one burrow entrance was visible or whether multiple entrances of a more complex burrow system were observed.

Where the burrow entrance was not clear (due to orientation of burrows in video footage, or potentially a collapsed burrow), or where burrows were $\leq 5\text{cm}$ wide, had only a single entrance or burrow entrances been very close together ($\leq 20\text{cm}$ apart), or where the view was unclear, an annotation of 'Uncertain *nephrops* burrow system' has been recorded, which can be considered for future counts if necessary.

Note where *Nephrops* stock assessment analysts are confident an entrance displays the required features as associated with *Nephrops* burrows, they count regardless of entrance size and, following ICES standards, burrow systems are counted regardless of position to neighbouring complexes/entrances.

5.1.3 Notes

Please note:

- At seven video stations the start of the transect (i.e., when counting started) occurred over 30 seconds after the start of recording of the footage (highlighted in orange on proforma: FL19036, FL19037, FL19038, FL19056, FL20040, FL20043, FL20050); for these stations any comparisons made between the annotation counts on BIIGLE and the density proforma counts should be made from the start of the transect not the start of recording.
- At these and some additional video stations the 10th segment was less than a minute (highlighted in yellow on proforma: FL19034, FL19036, FL19037, FL19038, FL19051, FL19056, FL20040, FL20043, FL20045, FL20050). Counts were still performed on segments over 30 seconds.
- At video stations FL19038 the 10-minute-long segment was less than 30 seconds so was not used for analysis.
- At video station FL19036 several minutes of footage were missing, with six-minute-long segments suitable for analysis.

As mentioned previously in Section 4.3, imagery quality may have affected the ability to count sea pens and burrows to some extent. Sea pens were easiest to identify at the top of the screen where the camera angle is widest and lighting angles mean the shape and shadows cast by epifauna standing proud of the substrate could be seen more easily. Density assessment counts were performed by counting biota/burrows as they crossed the bottom edge of the imagery, and therefore sea pens were harder to count at this point, where the angle of imagery was less oblique.

Burrows were easiest to identify at the bottom of the image where the angle of the camera is angled down, and therefore this approach was more reliable for burrows. However, when imagery is fast moving or blurred resulting in poor quality imagery, the burrows can be harder to identify and can be confused with small cnidaria/sea pens/heart urchins/bivalve siphons or other round/dark epifauna, therefore decreasing the confidence of counts.

Differences were also noted when comparing burrow or sea pen density counts with the counts in BIIGLE. It would be expected that the density assessment counts would be lower than the counts in BIIGLE, as counts were only made of burrows or sea pens when they crossed the bottom of the screen, as opposed to all observations being annotated in BIIGLE in the entire Field of View. This, combined with additional time at the beginning of the video

footage being annotated in BIIGLE before the counts started and the sea pens being more difficult to count at the bottom of the screen (due to camera angle), would suggest that density assessment counts would be lower than BIIGLE annotation counts.

Discrepancies between density assessment counts and BIIGLE annotation counts were noted, and in some cases, the density assessment counts were greater than the annotation counts in BIIGLE, e.g., burrows (all burrow openings), and for *Virgularia* at video stations where numbers were very high. This is likely due to the difficulty in adding labels to biota/burrows occurring in very high numbers in BIIGLE and in poor quality imagery (discussed in Section 4). To mitigate for this, the burrow density assessment counts (and a subsection of the sea pen counts) have been double checked for accuracy, and although there are small discrepancies in recounts, the numbers are consistent enough for confidence in the counting analysis.

5.1.4 Burrow density assessment results

According to the definitions for the Burrowed mud PMF and Sea pen and Burrowing Megafauna Communities (SPBMC) feature assessments, as provided in the project specification, where burrows (all burrow openings) are 'Frequent' on the SACFOR scale SPBMC are considered present (e.g., large burrows (>3cm diameter) at $\geq 0.1/\text{m}^2$). However, due to the majority of burrow openings observed in the footage being <3cm diameter (approx. 1-3cm), the presence of SPBMC was calculated in the density assessment proforma where the density of burrows (all burrow openings) is $\geq 1/\text{m}^2$.

The majority of footage had burrow (all burrow openings) counts of $\geq 1/\text{m}^2$ and therefore indicates the presence of the Sea pen and Burrowing Megafauna Communities feature at many of the video stations (see Table 5, with distribution shown in Figure 4). If the SPBMC feature can be allocated where the majority of a video station had a burrow density of $\geq 1/\text{m}^2$, then this is true for video stations where more than half of the minute-long segments that were analysed have this value. Of the 27 video stations where footage was taken in the Central Fladen MPA, 22 have all or more than half of the footage with a recorded burrow density of $\geq 1/\text{m}^2$, indicating the presence of the SPBMC feature, and supporting the biotope allocation assigned during BIIGLE analysis of 'Sea pens and burrowing megafauna in circalittoral fine mud' (SS.SMu.CFiMu.Spnmeg) (see Table 5 and Figure 4).

Minute-long segments that were analysed and had a burrow (all burrow openings) density of $\leq 1/\text{m}^2$ occurred at 13 video stations (Table 5). Two video stations (FL19034 and FL20045) had a burrow density of $\leq 1/\text{m}^2$ in all 10-minute-long segments, and at three video stations (FL20043, FL20044 and FL20047) over half the minute-long segments analysed had a burrow density of $\leq 1/\text{m}^2$. These five video stations (marked with an asterisk * and shaded grey in Table 5) could therefore be considered not to meet the criteria for allocation of the SPBMC feature using this methodology, and these video stations are also the five stations that were allocated biotopes other than 'Sea pens and burrowing megafauna in circalittoral fine mud' (SS.SMu.CFiMu.Spnmeg) during analysis (Table 5 and Figure 4).

An alternative approach could also be taken using the average burrow (all burrow openings) density per video station, averaging the burrow densities for each of the minute-long segments that were analysed across the whole station. As shown in Table 5, the average burrow densities also support the biotope allocation assigned during BIIGLE analysis for all but one of the video stations. For video station FL20047, the average burrow density for the whole tow is $\geq 1/\text{m}^2$, however only four of the minute-long segments are $\geq 1/\text{m}^2$, with six of the minute-long segments having a burrow density of $\leq 1/\text{m}^2$. As a greater proportion (temporally and spatially) of the video station has a burrow density of $\leq 1/\text{m}^2$, it would therefore suggest that the video station as a whole should not be assigned the SPBMC feature.

Of the two approaches, using the number of minute-long segments with a burrow (all burrow openings) density of $\geq 1/\text{m}^2$ to inform assessment seems a more accurate way of indicating the presence of the SPBMC feature, as it allows greater spatial definition and reflects the variability in burrow density in the area with more accuracy. Using the average burrow density over the whole station may result in a burrow density of $\geq 1/\text{m}^2$ where only a small proportion of the station may have a very high number of burrows. This would not accurately reflect the seabed characteristics of the whole video station and may allow small patches of very high burrow density to overly influence the results for the larger area covered by the whole tow.

Table 5. Summary of burrow density assessment for each video station at Central Fladen MPA, showing MNCR Code (from BIIGLE analysis), average burrow density (all burrow openings) per station, number of minute-long segments with SPBMC feature presence (from density assessment calculation)/ the total number of minute-long segments analysed, and the number of minute-long segments not analysed (due to times/quality). (The five video stations marked with an asterisk * and shaded grey in Table 5 could be considered not to meet the criteria for allocation of the SPBMC feature using the methodology).

Video Station	MNCR Code	Av. Burrow Density per station	No. of minute-long segments with SPBMC feature (burrow density $\geq 1/\text{m}^2$) / total no. of minute-long segments analysed	No. of minute-long segments - Not Analysed
FL19033	SS.SMu.CFiMu.SpnMeg	2.77	10 / 10	-
FL19034*	SS.SMx.CMx	0.00	0 / 10	-
FL19035	SS.SMu.CFiMu.SpnMeg	2.85	9 / 9	1 (quality)
FL19036	SS.SMu.CFiMu.SpnMeg	3.24	6 / 6	4 (short video)
FL19037	SS.SMu.CFiMu.SpnMeg	3.41	10 / 10	-
FL19038	SS.SMu.CFiMu.SpnMeg	4.07	9 / 9	1 (<30s)
FL19050	SS.SMu.CFiMu.SpnMeg	2.94	8 / 8	2 (quality)
FL19051	SS.SMu.CFiMu.SpnMeg	2.30	9 / 9	1 (quality)
FL19052	SS.SMu.CFiMu.SpnMeg	1.82	7 / 8	2 (quality)
FL19053	SS.SMu.CFiMu.SpnMeg	3.29	10 / 10	-
FL19054	SS.SMu.CFiMu.SpnMeg	5.53	10 / 10	-
FL19055	SS.SMu.CFiMu.SpnMeg	2.82	8 / 9	1 (quality)
FL19056	SS.SMu.CFiMu.SpnMeg	1.65	9 / 10	-
FL19059	SS.SMu.CFiMu.SpnMeg	6.47	10 / 10	-
FL19060	SS.SMu.CFiMu.SpnMeg	4.94	10 / 10	-
FL20039	SS.SMu.CFiMu.SpnMeg	1.65	9 / 10	-
FL20040	SS.SMu.CFiMu.SpnMeg	1.48	10 / 10	-
FL20041	SS.SMu.CFiMu.SpnMeg	4.27	10 / 10	-
FL20042	SS.SMu.CFiMu.SpnMeg	1.67	7 / 10	-
FL20043*	SS.SMu.OMu	0.78	2 / 10	-
FL20044*	SS.SMu.OMu	0.81	4 / 10	-
FL20045*	SS.SMu.OMu	0.56	0 / 10	-
FL20046	SS.SMu.CFiMu.SpnMeg	1.53	7 / 10	-
FL20047*	SS.SMu.OMu	1.10	4 / 10	-
FL20049	SS.SMu.CFiMu.SpnMeg	2.23	9 / 10	-
FL20050	SS.SMu.CFiMu.SpnMeg	1.97	9 / 10	-
FL20051	SS.SMu.CFiMu.SpnMeg	6.06	10 / 10	-

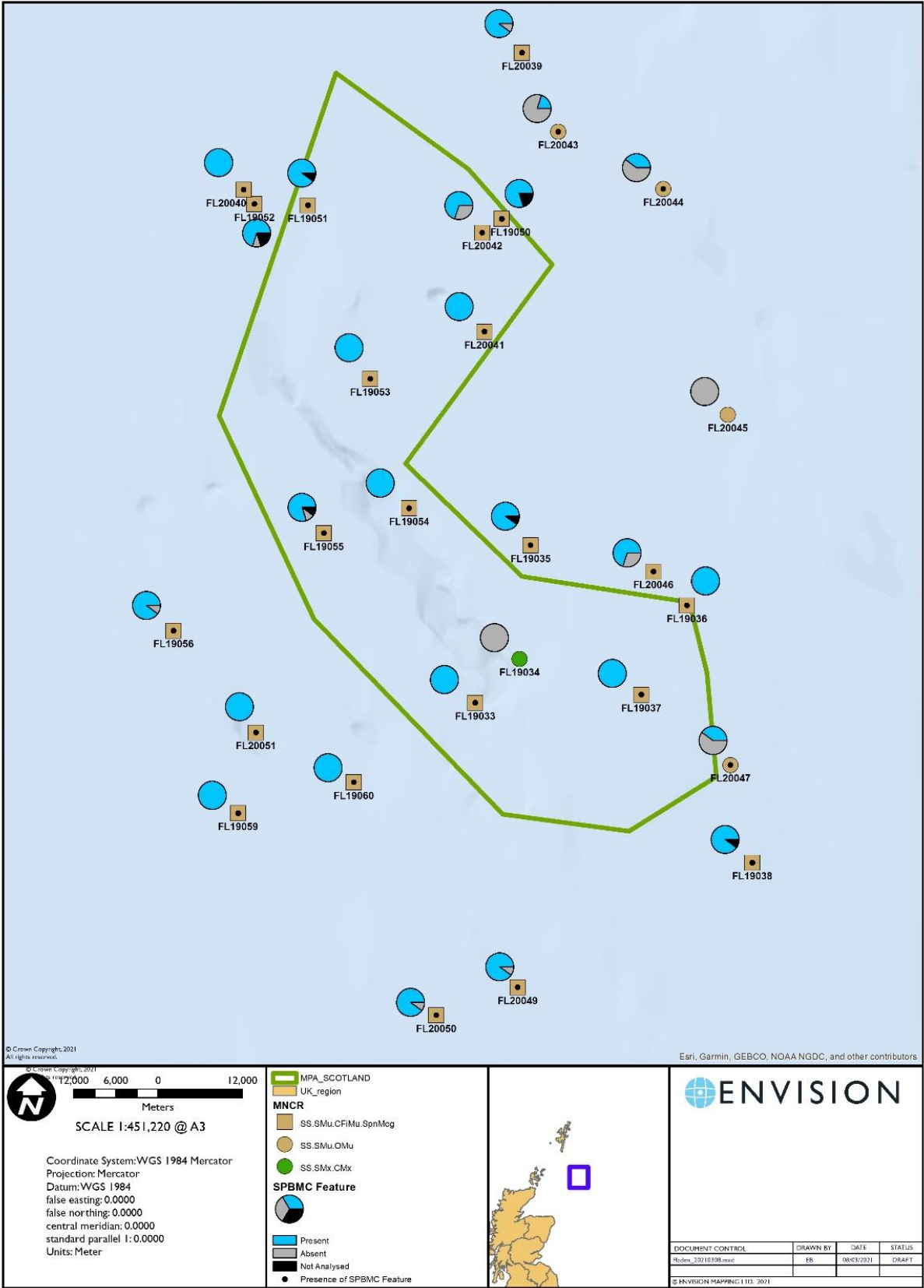


Figure 4. Location of video stations where the SPBMC feature was present, with MNCR code assigned from BIIGLE analysis also shown. Each point has a pie-chart indicating the proportion of minute-long segments with SPBMC feature present / absent / not analysed.

6 Data acquired

The approach used within this project to identify the presence of Burrowed mud and Sea pens and Burrowing Megafauna Communities features has been undertaken successfully with the Central Fladen MPA UWTV footage, and the results appear to have identified video stations where the SPBMC feature is present.

Burrow density is a defining characteristic for classifying SPBMC. The approach taken assumes that where burrows (all burrow openings) are 'Frequent' on the SACFOR scale (large burrow (>3cm diameter) at $\geq 0.1/\text{m}^2$) SPBMC are considered present (irrespective of the presence or absence of sea pens) (Robson 2014). Due to the majority of burrow openings observed in the footage being <3cm diameter (approx. 1-3cm), the presence of SPBMC was calculated where the density of burrows (all burrow openings) is $\geq 1/\text{m}^2$.

Should the SPBMC feature be allocated where the majority of minute-long segments from each of the video stations had a burrow (all burrow openings) density of $\geq 1/\text{m}^2$, then of the 27 video stations where video footage was taken in the Central Fladen MPA, 22 video stations had all or more than half of the footage with a recorded burrow density of $\geq 1/\text{m}^2$. This could indicate the presence of the SPBMC feature, and also supports the biotope assigned during BIIGLE analysis of 'Sea pens and burrowing megafauna in circalittoral fine mud' (SS.SMu.CFiMu.SpnMeg).

The remaining five video stations did not have a majority of minute-long segments with a burrow (all burrow openings) density of $\geq 1/\text{m}^2$, and had also been assigned other biotopes during analysis, e.g., 'Offshore circalittoral mud' (SS.SMu.OMu), and 'Circalittoral mixed sediment' (SS.SMx.CMx) due to the lack of burrows observed.

Whilst this approach appears to have been successful with the data analysed in this project (Central Fladen MPA UWTV) footage, limitations of this method should be considered before use in the long term of newly acquired footage collected for the same purpose (*Nephrops* stock assessment UWTV footage).

6.1 Limitations

From an assessment perspective, the taxonomical resolution of the analysis results is likely to be too broad to calculate (or improve) trait-based indicators that rely in the estimation of taxa sensitivity to a certain pressure (e.g., The Physical Damage indicator (BH3) or the Typical Species Composition indicator (BH1)). In general, if benthic community data is to be extracted from *Nephrops* imagery, indicators may need to be adapted to work at such taxonomical resolution and/or caution taken when comparing these data with survey data provided at species level.

For the burrow and sea pen density assessment, segmenting the analysis into minute-long sections allows for quality of video footage and burrow densities to be assessed in more detail than assessing the whole video station area at once, and also allows field of view calculations to be more specific to each minute-long segment of the footage. However, when using data extracted from each video station it may not be appropriate to use data from each minute-long segment as an individual sample, unless using the assumption that a segment of footage of at least 5m length also covers a width of 5m and would therefore represent an area of $>25\text{m}^2$.

As already discussed in Sections 3.2, 3.3 and 5.1.3, issues with imagery quality did lower confidence in the identification and counts of both biota and burrows. Whilst the imagery

may be sufficient quality for identification and counts of large burrows within *Nephrops* burrow systems, this may not be the case for all, or smaller, burrows.

A majority of the imagery was of a relatively consistent height above the seabed with no turbidity issues and with the seabed always in view, but the resolution was low and camera system not close enough to the seabed for clear identification of much of the epifauna. Some sections of the footage had a more variable elevation and the angle of the system fluctuated. In these cases, as the camera system moved upwards, the faster movement caused blurring and the angle of the imagery was less beneficial for observations of small vertical burrows, which were most easily counted at the bottom of the imagery when the camera system was near horizontal or coming to rest on the seabed.

Where these quality issues occur, there is a chance that burrows may be missed, and counts be less consistent due to lack of certainty and confusion with other biota (small cnidaria/sea pens/heart urchins/bivalve siphons or other round/dark epifauna). In locations where numbers of burrows are marginal in respect of the density threshold being used, this may affect the assessment of the Priority Marine Features (Burrowed Mud and SPBMC) and future management decisions based on this.

However, where the numbers of burrows and burrowing megafauna are marginal, it may be that this is already considered by the threshold, and these numbers are in fact not sufficient to warrant status as the Burrowed Mud or SPBMC feature. Certainly, from review and analysis of the footage in this study, the results appear to support the results from the density assessment methodology.

6.2 Recommendations

Due to the difficulties experienced with annotating high numbers of burrows/biota in BIIGLE, it is recommended that the burrow/sea pen density assessment counts are undertaken whilst observing the video footage without interruption from annotation in BIIGLE. Standard definition footage is also best viewed on CRT monitors, and certain functions can be improved by using software which allows pausing and frame-by-frame manipulation, as well as interlacing/deinterlacing features (e.g., VLC) which are not available in BIIGLE.

Given that the UWTV footage is collected regularly in areas of burrowed mud (*Nephrops* grounds) and would be a consistent source of data for Sea pen and Burrowing Megafauna Communities feature assessment, there may be value in comparing footage from other surveys in the same area with the *Nephrops* stock assessment UWTV footage. Collecting more targeted/higher resolution footage could be used to validate the density counts from UWTV data and could verify whether the methodology consistently picks up similar burrow densities or variability in burrow density between the different data sources.

7 References

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8 Appendix 1

Table 6. From Table 7 of project specification document: 'Species list of burrow/mound forming species and sea-pens which have the potential to occur at Central Fladen MPA. This species list is based on the burrowing species referenced in (ICES 2011). Please note that it is not expected that all these species will occur at the site, nor is this an exhaustive list.

Name	Common Name	Taxonomy	Reason for inclusion
<i>Pennatula phosphorea</i>	Phosphorescent sea-pen	Pennatulacea	Sea-pen
<i>Virgularia mirabilis</i>	Slender sea-pen	Pennatulacea	Sea-pen
<i>Funiculina quadrangularis</i>	Tall sea-pen	Pennatulacea	Sea-pen
<i>Cepola rubescens</i>	Red band fish	Pisces	Burrow forming
<i>Gobius niger</i>	Black goby	Pisces	Burrow forming
<i>Maxmuelleria</i>		Polychaeta	Mound forming
Bivalve siphons		Mollusca	Burrow forming
<i>Upogebiidae</i>		Decapoda	Burrow forming
<i>Calocaris macandreae</i>		Decapoda	Burrow forming
Chaetopteridae (tube or worm)		Polychaeta	Burrow forming
<i>Callinassa subterranea</i>		Decapoda	Burrow forming
<i>Pestarella tyrrhena</i>		Decapoda	Burrow forming
<i>Nephrops norvegicus</i>		Decapoda	Burrow forming
<i>Goneplax rhomboides</i>	Angular crab	Decapoda	Burrow forming
<i>Jaxea nocturna</i>		Decapoda	Burrow forming
<i>Lumpenus lampretaeformis</i>		Pisces	Burrow forming
<i>Myxine glutinosa</i>	Hagfish	Pisces	Burrow forming
<i>Lesueurigobius friesii</i>	Fries's goby	Pisces	Burrow forming
<i>Alpheus glaber</i>	Pistol shrimp	Decapoda	Burrow forming

9 Appendix 2

The following tables (Table 7 to Table 10) show notes from the QC of the imagery analysis, which summarise the steps taken for this procedure.

Table 7. QC notes and actions from FL19035.

Tier 1 Category	Annotation	QC Notes	Action
JNCC Quality	Conspicuous Fauna	Agree	N/A
NMBAQC Quality	Very Poor	Poorer quality, but issues <50% - Poor	Amend to Poor
Broadscale Habitat	SS.SMu	Agree	N/A
MNCR code	SS.SMu.CFiMu.SpnMeg	Agree	N/A
Tier 2 Annotation	QC Notes	Review	Action
Trawl Mark	OK	OK	N/A
Actiniaria	OK	OK	N/A
Asteroidea	OK	OK	N/A
Biota	Check: point 5 poss fish, point 7 poss remove	Biota point 7 (02:21:86) too uncertain	Remove point 7 (02:21:86)
Burrow opening	>100 count: 241 (original), 410 (QC)	Some smaller burrow openings not annotated	Reviewed video and added burrow annotations
Caridea	OK	OK	N/A
Echinoidea	OK	OK	N/A
<i>Myxine glutinosa</i>	Point 1 uncertain	Acceptable annotation	N/A
<i>Nephrops</i> burrow system	Check: point 16	All <i>Nephrops</i> burrows systems checked	All <i>Nephrops</i> burrows systems checked
<i>Pennatula phosphorea</i>	Check: points 8, 9, 10, 12, 13, 18, 28, 39, 43, 45, 46, 47, uncertain	Some are uncertain, some variation between analysts, potential overlap with Cnidaria (poss Flabellum)	Include uncertainty due to image quality in report
Pleuronectiformes	OK	OK	N/A
<i>Virgularia mirabilis</i>	>100 count: 192 (original), 191 (QC)	OK	N/A
Zoarcidae	OK	OK	N/A
General Review	Review	Action	
Check 02:47 in burrow?	Too uncertain	N/A	
Pleuronectiformes?: 01:05	Confirmed Pleuronectiformes	Annotation added	
Echinoidea?: 02:44	Too uncertain	N/A	
Biota?: 02:53	Confirmed <i>Virgularia mirabilis</i>	Annotation added	
Echinoidea at 04:37?	Confirmed Echinoidea	Annotation added	
Biota?: 08:49 - Actiniaria?	Potential Actiniaria	Change annotation	
Biota?: 10:03	Uncertain, but potential faunal turf	Annotation added	
Biota?: 01:48	Uncertain, but potential faunal turf	Annotation added	
Mound?: 02:47	No action required	N/A	
Biota (fish/squid) at 08:01	No action required	N/A	

Table 8. QC notes and actions from FL19052.

Tier 1 Category	Annotation	QC Notes	Action
JNCC Quality	Conspicuous Fauna	Agree	N/A
NMBAQC Quality	Poor	Agree	N/A
Broadscale Habitat	SS.SMu	Agree	N/A
MNCR code	SS.SMu.CFiMu.SpnMeg	Agree	N/A
Tier 2 Annotation	QC Notes	Review	Action
Trawl Mark	OK	OK	N/A
Actiniaria	OK	OK	N/A
Asteroidea	OK	OK	N/A
Biota	Some biota could be faunal turf but uncertain	OK	N/A
Burrow opening	>100 count: 211 (original), 220 (QC)	OK	N/A
Echinoidea	Check: points 45, 58, 62, 64, 71	Some are uncertain, some variation between analysts	Include uncertainty due to image quality in report
<i>Myxine glutinosa</i>	OK	OK	N/A
<i>Nephrops</i> burrow system	OK	All <i>Nephrops</i> burrows systems checked	All <i>Nephrops</i> burrows systems checked
Paguridae	OK	OK	N/A
<i>Pennatulula phosphorea</i>	Check: point 40	Some are uncertain, some variation between analysts, potential overlap with Cnidaria (possibly Flabellum)	Include uncertainty due to image quality in report
Pleuronectiformes	OK	OK	N/A
Rajidae	OK	OK	N/A
<i>Virgularia mirabilis</i>	>100 count: 178 (original), 140 (QC)	Some variation between analysts	Include uncertainty due to image quality in report
General Review	Review	Action	
Bivalvia?: 04:35	Too uncertain	Record as Burrow opening	

Table 9. QC notes and actions from FL20043.

Tier 1 Category	Annotation	QC Notes	Action
JNCC Quality	Conspicuous Fauna	Agree	N/A
NMBAQC Quality	Poor	Agree	N/A
Broadscale Habitat	SS.SMu	Agree	N/A
MNCR code	SS.SMu.OMu	Possibly Sandy Mud? Leave as SS.SMu.OMu	N/A
Tier 2 Annotation	QC Notes	Review	Action
Asteroidea	OK	Checked together	Some moved > Ophiuroidea
Biota	OK	Checked together	Some removed, some moved > faunal turf
Gadidae	OK	OK	N/A
Hydrozoa	OK	OK	N/A

Ophiuroidea	OK	OK	N/A
Pisces	Check all	Checked all 'Pisces' together	Some moved > Gadidae
Pleuronectiformes	OK	OK	N/A
Burrow openings	>100 count: 192 (original), 201 (QC)	OK	N/A
Pennatula phosphorea	OK	OK	N/A
<i>Virgularia mirabilis</i>	OK	OK	N/A
<i>Myxine glutinosa</i>	Point at 02:31 should be removed	Already had Pisces annotation	Myxine label removed
General Review	Review		Action
Shells?: e.g 03:49:01	Uncertain if alive, remain as Biota or not annotated		N/A
'Biota' general	Check all data		Reviewed in LARGO
'Pisces' general	Check all data		Reviewed in LARGO

Table 10. QC notes and actions from LARGO checks of all data

Tier 1 Annotation	Action
Conspicuous Fauna	Checked, all fine
Poor	Checked, all fine
Very Poor	Mis-annotation, changed to 'Poor'
Good	Mis-annotation, changed to 'Poor'
SS	Mis-annotation, changed to 'SS.SMu'
SS.SMu	Checked, all fine
SS.SMx	Checked, all fine
SS.SMu.CFiMu.SpnMeg	Checked, all fine
SS.SMu.CSaMu	Biotope options reviewed, changed to 'SS.SMu.OMu'
SS.SMu.OMu	Checked, all fine
SS.SMx.CMx	Checked, all fine
Tier 2 Annotation	
Actiniaria	3 moved to Bolocera tuediae, 7 moved to Hormathiidae, 5 moved to Anthozoa
Adamsia palliata	Removed - too uncertain
Anthozoa	Reviewed: to include uncertain ceriantharia/actiniaria
<i>Arctica islandica</i>	Checked, all fine (include 'uncertain' in label name)
Asteroidea	Checked, all fine
Biota	Moved 1 to Biota A_halcampoides/corymorpha, 1 to Actiniaria, 1 removed (too uncertain), moved 8 to Biota D_Gastropods possible, moved 8 to Biota C_tubes, moved 2 to Biota E-Salmacina (include 'uncertain' in label names)
Bivalvia	Moved 1 to biota, too uncertain (include 'uncertain' in label name)
<i>Bolocera tuediae</i>	Checked, all fine
Buccinidae	Moved 1 to Paguridae, moved 1 to Biota
Caridea	Removed 1, too uncertain
Cephalopoda	Checked, all fine
Chordata	Moved to Biota, not certain enough for separate category
Cnidaria	Moved 2 to Biota A_Halcampoides/Corymorpha, moved 5 to Actiniaria
Decapoda	Changed to Crustacea

Demospongiae	Checked, uncertain but leaving in to highlight (include 'uncertain' in label name)
Echinodermata	Moved to Biota B_Echinothuriidae (include 'uncertain' in label name)
Echinoidea	Checked, all fine
Gadidae	Checked, all fine
Halcampoides	Moved to Biota A_Halcampoides/Corymorpha (include 'uncertain' in label name)
Hormathiidae	Category added, for Hormathiidae that were clear enough (from Actinaria)
Hydrozoa	Checked, all fine - using for faunal turf (change label name to 'faunal turf')
<i>Lithodes maja</i>	Checked, all fine
Lotidae	Category added, changed all Zoarcidae to this
Mollusca	Removed, uncertain
<i>Myxine glutinosa</i>	Checked, all fine
Naticidae	Checked - potential moon snail egg collars, leave in (include 'uncertain' in label name)
Nemertesia	Checked, all fine
<i>Nephrops norvegicus</i>	Checked, all fine
Ophiuroidea	Checked, all fine
Paguridae	Moved all hermit crabs to this category, checked, all fine
Paguroidea	Moved to Paguridae
Pagurus	Moved to Paguridae
Pagurus prideaux	Moved to Paguridae
Pectinidae	One moved to Biota, removed 3 as too uncertain
<i>Pennatula phosphorea</i>	Checked, all fine
Pisces	Checked, all fine
Pleuronectiformes	Removed 1, too uncertain
Polychaeta	Moved to Biota C_Tubes
Porifera	Checked, all fine
Rajidae	Checked, all fine
Sabelliidae	All moved to Biota C_Tubes
Serpulidae	All removed, too uncertain, could just be shell
Spatangoidea	checked, all fine
Unidentifiable Burrowers	Removed 2, not in actual burrow, uncertain moved to Biota
<i>Virgularia mirabilis</i>	Checked, all fine
Zoarcidae	Changed all 4 to Lotidae
Burrows	
Burrow opening	Checked, all fine
<i>Nephrops</i> burrow system	Checked, all fine
Uncertain <i>Nephrops</i> burrow system	Checked, all fine
Litter/Anthropogenic	
F – Miscellaneous	Changed to 'F5. Other'
F2. Rope	Checked, all fine
F5. Other	Checked, all fine
Trawl Mark	Checked, all fine



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