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Report No. 27

CEND0617 Cruise Report: Monitoring Survey of Bassurelle Sandbank SAC and Wight-Barfleur Reef SAC

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EQA:

This report is compliant with the JNCC **Evidence Quality Assurance Policy** http://jncc.defra.gov.uk/default.aspx?page=6675.

Summary

This report summarises the operations and data acquired during cruise CEND0617 18 April – 5 May 2017. The cruise visited the Bassurelle Sandbank Special Area of Conservation (SAC) and the Wight-Barfleur Reef SAC. The first site surveyed was Bassurelle Sandbank (18 – 22 April), followed by Wight-Barfleur Reef (22 – 30 April), before returning to Bassurelle Sandbank (2 – 3 May).

The two key aims of the cruise were:

1. Collect evidence to inform Sentinel (Type 1) monitoring of the extent, distribution and physical structure of the Annex I feature within the Bassurelle Sandbank SAC and Wight-Barfleur Reef SAC.

2. Collect evidence to inform Sentinel (Type 1) monitoring of the diversity and structure of biological communities, and typical species, of the Annex I feature within the Bassurelle Sandbank SAC and Wight-Barfleur Reef SAC.

A variety of data types were collected during the survey.

At Bassurelle Sandbank, epibenthic communities were primarily sampled using a 2m scientific beam (Jennings) trawl (from 25 stations within the site boundary). Latterly, and by way of comparison with the beam trawl assessment, a camera system mounted to a towed sledge was used to survey epibenthic communities (from all stations surveyed with the scientific beam trawl and one extra). Macrofaunal communities and benthic sediments were sampled using a 0.1m^2 (mini) Hamon Grab from 100 stations across the survey area. A subset of these stations was targeted for replicate sampling (five from ‘A5.2 Sublittoral sand’ and five from ‘A5.1 Sublittoral coarse sediment’ habitats).

At Wight-Barfleur Reef, acoustic data was collected using a multibeam echosounder and / or a sidescan sonar from six nested boxes within the Wight-Barfleur Reef SAC. Epibenthic communities were assessed using a drop frame mounted high definition camera system (drop camera), capable of recording video footage and digital still images. A total of 82 stations were surveyed (13 - 15 within each nested box). Physical parameters were recorded using a sensor array fitted to the drop camera frame on each deployment and a continuously logging ship-based ‘ferrybox’ system.

Weather conditions were favourable throughout the survey period. However, strong tides affected the safe deployment of the drop camera at maximum flow. All survey objectives were completed successfully.

Contents

Figures and Tables

1 Background and Introduction

Cefas and JNCC undertook a survey of Bassurelle Sandbank Special Area of Conservation (SAC) and Wight-Barfleur Reef SAC between the 18 April and 5 May 2017, aboard the RV Cefas Endeavour. At the time of survey both sites were candidate Special Area of Conservation / Site of Community Importance (cSAC/SCI) and were approved as SACs in September 2017.

This report describes the survey activities undertaken at both sites, which were last surveyed by Cefas and JNCC in 2013 (Barrio-Frojan *et al.,* in press; Barrio-Frojan *et al.* 2017). Both sites are located within the UK marine area, in the English Channel (Figure 1).

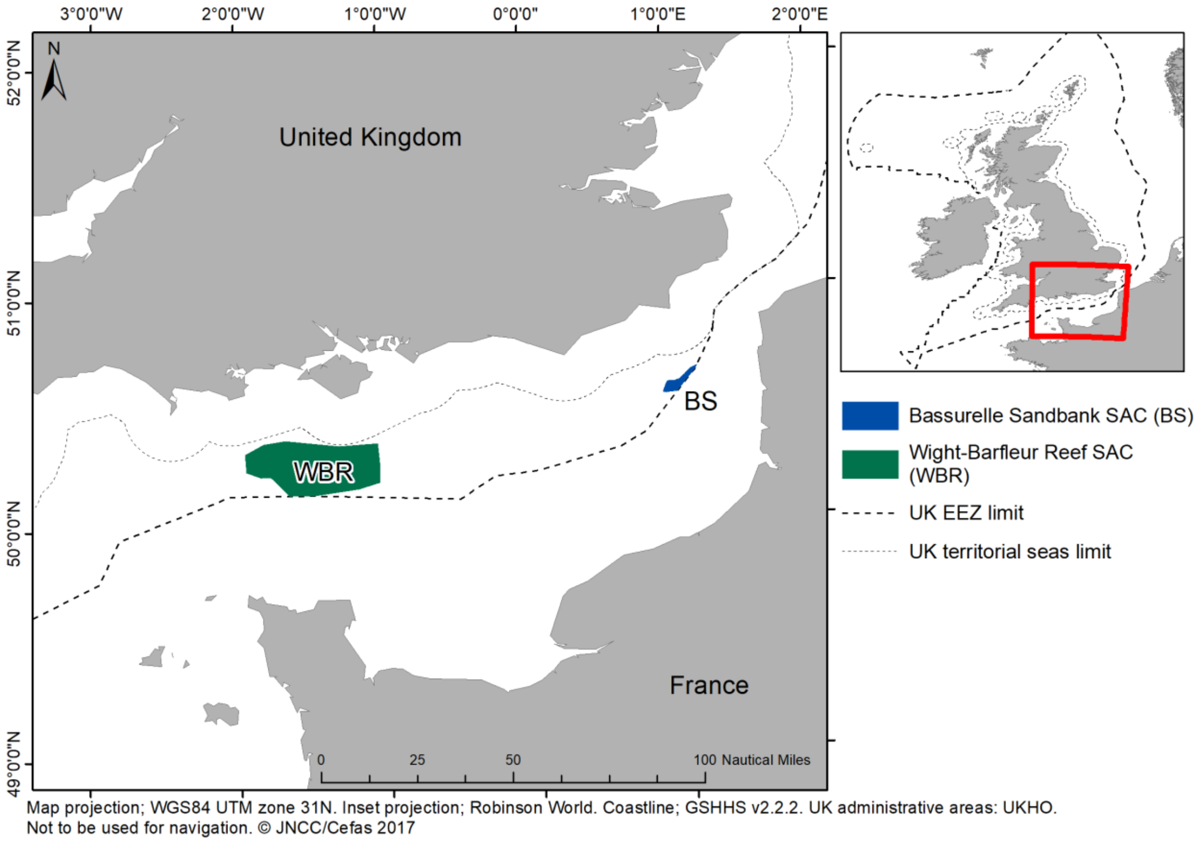


Figure 1. Overview of SAC locations visited during CEND0617.

1.1 Survey project team

The survey team for the duration of the fieldwork included marine scientists, hydrographers and technicians from the Joint Nature Conservation Committee (JNCC) and Centre for Environment, Fisheries and Aquaculture Science (Cefas) (Table 1).

Table 1. Roles and shifts for CEND0617.

Shift	Role
Across shift	Scientist In Charge (SIC) Data Manager Hydrographer
Day shift (12:00 – 00:00)	Shift Lead Benthic ecologist Marine Instrument Technician (MIST) Oceanographer Habitat mapper JNCC PoA lead
Night shift (00:00 – 12:00)	Shift Lead Benthic ecologist Marine Instrument Technician (MIST) Oceanographer Sedimentologist JNCC marine survey lead JNCC marine monitoring lead

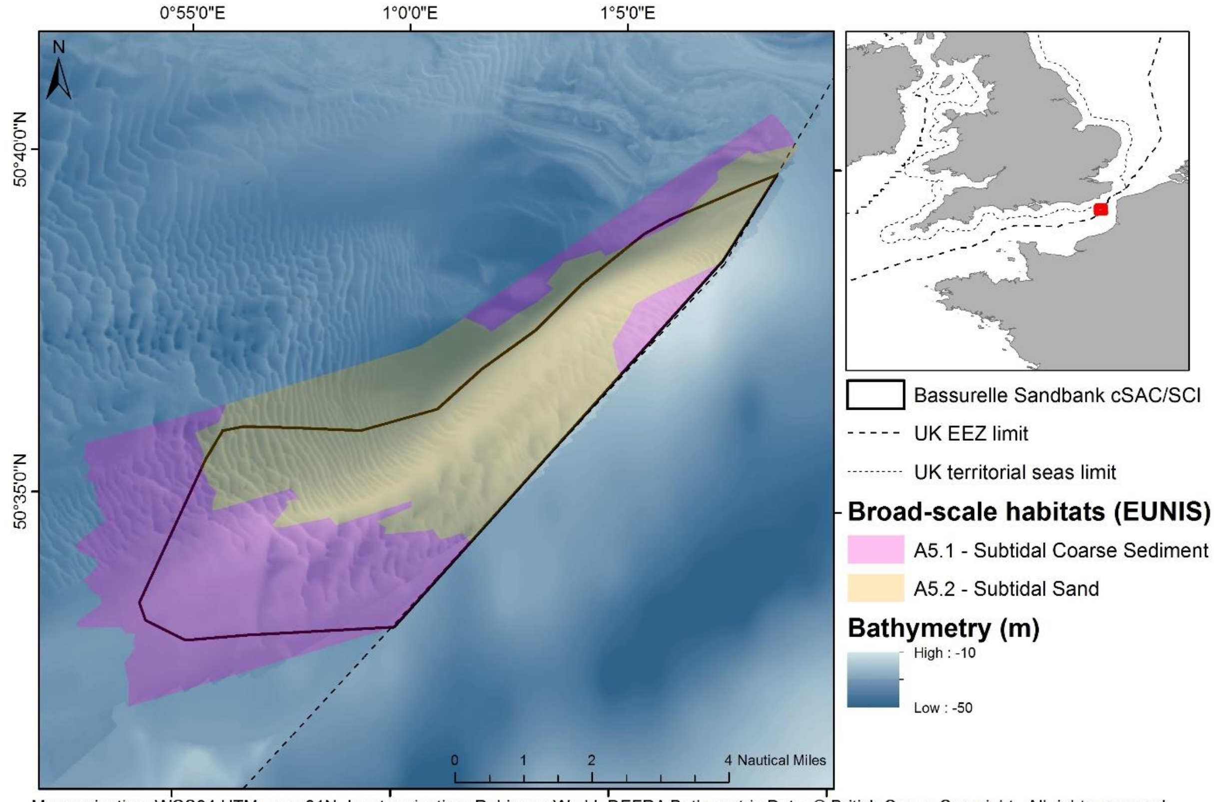
1.2 Site descriptions

1.2.1 Bassurelle Sandbank SAC

The Bassurelle Bank is an example of an open shelf ridge linear sandbank in the Dover Strait, which straddles the UK/France territorial boundary. The sandbank is mainly composed of very well sorted sand with some gravelly sand, and occasional shell patches. The surface tidal currents along the bank are weak to moderately strong (peak spring surface current velocity of 0.7m/s was observed during CEND0617). Sand waves and mega-ripples are abundant on parts of the bank and are up to 2.5m in height.

The Bassurelle Sandbank SAC consists of the part of the Bassurelle Bank within UK waters. The SAC is approximately 2.5km at its widest point, extends approximately 15km in a northeast-southwest direction to the UK/France territorial boundary, and has an area of 67km^2. In French waters the Bassurelle Bank is included in the “Ridens et dunes hydrauliques du détroit du Pas-de-Calais” Special Area of Conservation, however this survey was dedicated to UK waters only.

Two sedimentary habitats have been identified on the Bassurelle Sandbank SAC, ‘A5.1 Sublittoral coarse sediment’ and ‘A5.2 Sublittoral Sand’ were mapped following a 2013 survey, which was conducted to improve understanding of the habitats present and their associated benthic communities (Barrio-Frojan *et al.* 2017) (Figure 2). At the time of survey Bassurelle Sandbank was a candidate Special Area of Conservation / Site of Community Importance and was approved as a SAC in September 2017.



Map projection; WGS84 UTM zone 31N. Inset projection; Robinson World. DEFRA Bathymetric Data: © British Crown Copyright. All rights reserved. Permission Number Defra012012.002. Coastline; GSHHS v2.2.2. UK administrative areas: UKHO. Not to be used for navigation. © JNCC/Cefas 2017

Figure 2. Seabed topography at the Bassurelle Sandbank SAC with interpolated Broadscale Habitats generated as part of the site report (Barrio-Frojan *et al.* 2017). Note that the site has been accepted as a SAC since the production of this map.

1.2.2 Wight-Barfleur Reef SAC

Wight-Barfleur Reef is an area of bedrock and stony reef located in the central English Channel, between St Catherine's point on the Isle of Wight and Barfleur Point on the Cotentin Peninsula in northern France. The SAC is approximately 65km long (east to west), up to 26km wide and has an area of 1,373km^2. The depth within the site ranges from 25m to 100m, with the deepest areas to the south, and within a palaeovalley which runs along the south-east part of the site.

The large area of bedrock reef within the SAC is characterised by a series of well-defined exposed bedrock ridges forming horizontal and vertical reef. The southern area of the site is composed of flat, smooth mudstone and sandstone, with overlying coarse sediment (gravels, cobbles and boulders) which in places forms stony reef with consolidated cobbles and associated sponge communities. The south-eastern area of the site is characterised by a large palaeochannel known as the Northern Palaeovalley which forms a major channel running approximately north-east/south-west across the English Channel. Within the site the palaeovalley remains largely unfilled by soft sediments due to the strong currents in the area, and is characterised by a gravel, cobble and boulder substrate which in places forms stony reef. (Barrio-Frojan *et al.,* in press), (Figure 3). At the time of survey Wight-Barfleur Reef was a candidate Special Area of Conservation / Site of Community Importance and was approved as a SAC in September 2017.

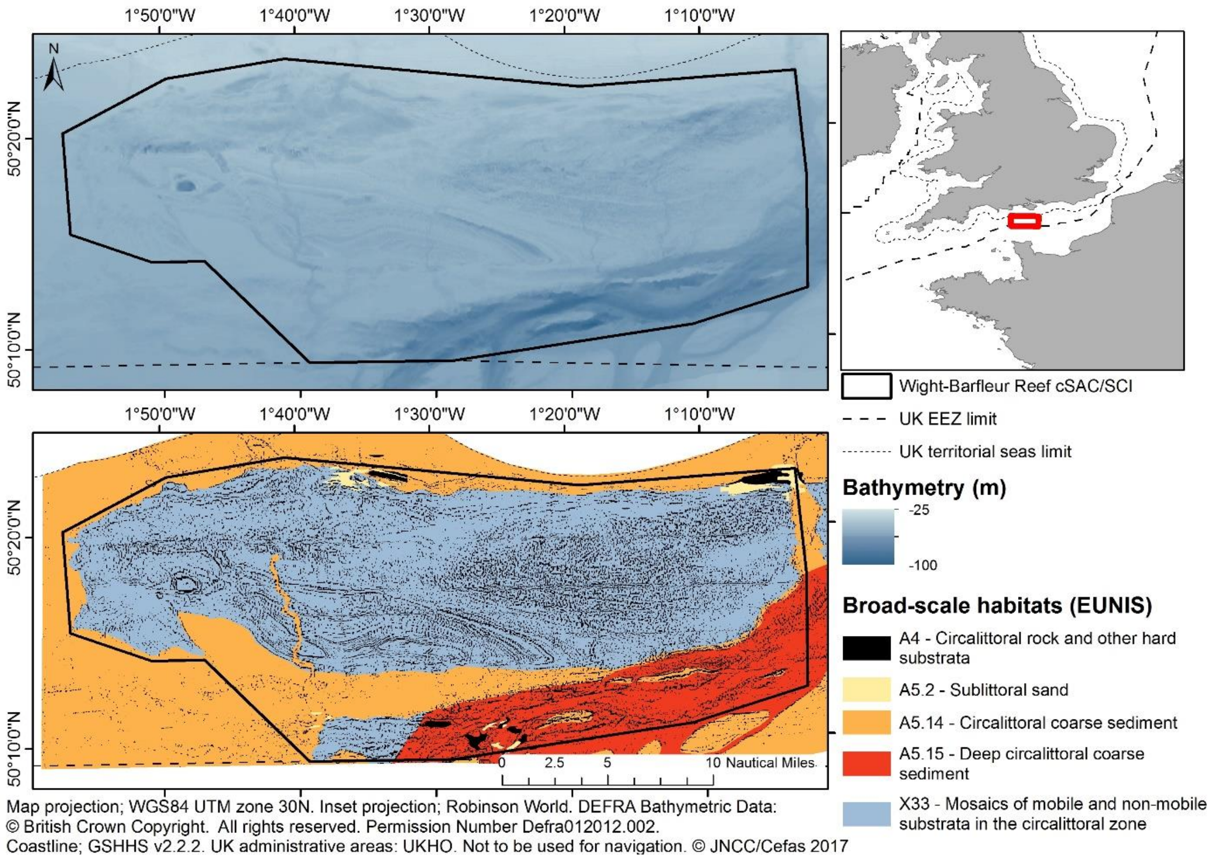


Figure 3. Seabed topography at the Wight-Barfleur Reef SAC with interpolated EUNIS Broadscale Habitats generated as part of the site report (Barrio-Frojan *et al.,* in press). Note that the site has been accepted as a SAC since the production of this map.

2 Survey objectives

The overarching aim of the survey was to acquire sentinel (or ‘Type 1’) monitoring data (Kröger & Johnston 2016), to contribute to the development of a monitoring time-series for the protected features of the Bassurelle Sandbank SAC (Habitats Directive Annex I ‘Sandbanks which are slightly covered by seawater all the time’) and the Wight-Barfleur Reef SAC (Habitats Directive Annex I ‘Reef’). This involved gathering evidence on the extent, distribution, structure and function of the habitat and biological communities of this Annex I feature, against which to infer the rate and direction of change in the long-term.

2.1 Objectives and priorities

The primary and secondary objectives of the survey are presented for Bassurelle Sandbank (Table 2) and Wight-Barfleur Reef (Table 3), and have been developed based on the feature attributes defined in the Conservation Objectives for the sites (JNCC 2012a, 2012b) (note that these were draft at the time of the survey). All survey objectives for both sites were achieved.

It is noted that the data from this survey will form part of a monitoring time-series, and that future repeat monitoring and evidence gathering will be required to fully investigate and understand the long-term variability in any parameters measured.

Table 2. Monitoring objectives for the 2017 survey of Bassurelle Sandbank SAC.

Objective	Sub-objective	Priority	Rationale	Gear requirement	Notes	Sub- objective Achieved
1. Collect evidence to inform Sentinel (Type 1) monitoring of the **extent, distribution and physical structure** of the features within the Bassurelle Sandbank SAC.	**1.1** Acquire sediment particle size data across the site.	**1**	Supply initial particle size datapoint for Annex I Sandbank monitoring time-series to evaluate physical change across the site. Analyse in conjunction with 2017 biological data to improve understanding of community distribution.	Hamon Grab	Systematic grid	Yes
	1.2 Acquire replicate sediment particle size samples from a subset of stations.	**3**	Subset of stations to be replicated to investigate small scale variability within the feature.	Hamon Grab	Subset of systematic grid from 1.1	Yes
2. Collect evidence to inform Sentinel (Type 1) monitoring of the **diversity and structure of biological communities, and typical species** within the Bassurelle Sandbank SAC.	**2.1** Acquire quantitative infaunal and epifaunal data across the extent of the feature (the entire site).	**1**	Supply initial datapoint for Annex I Sandbank monitoring time-series. The data will allow characterisation of the different communities and biological traits associated with the two Broadscale Habitats within the site. Allow statistical comparison of communities between 2017 and 2013.	2m Epifaunal beam trawl Hamon Grab	Trawl data collected in accordance with method used on 2016 JNCC/Cefas sandbanks survey (5 minute tows at 1 knot, 2 replicates per station) Grab data acquired simultaneous to Sub-objective 1.1 PSA sampling. Epifaunal beam trawls on subset of stations following grab collection	Yes

Objective	Sub-objective	Priority	Rationale	Gear requirement	Notes	Sub- objective Achieved
	2.2 Acquire replicate infaunal samples from a subset of stations.	**3**	Subset of stations to be replicated to investigate small scale variability within the feature.	Hamon Grab	Subset of systematic grid from 1.1	Yes
3. Investigate gear type comparison for epifaunal sampling	**3.1** Acquire video data along a limited number of transects and repeat the tow with a beam trawl.	**2**	Provide evidence to compare video data vs beam trawls, to inform JNCC approaches to sampling epifauna within MPAs with similar sediment types.	HD camera 2m Epifaunal beam trawl	Video data acquired in a different method to that originally planned and outlined in this sub-objective. See section 6.1 for more details	Yes

Table 3. Monitoring objectives for the 2017 survey of Wight-Barfleur Reef SAC.

Objective	Sub-objectives	Priority	Rationale	Gear requirement	Notes	Sub-objective achieved
1. Collect evidence to inform Type 1 (sentinel) monitoring of the **extent, distribution and physical structure** of the features within the Wight-Barfleur Reef SAC.	**1.1** Acquire high-resolution acoustic data from wide corridors to test and validate the site-wide Annex I Reef model generated from Astrium (and other) bathymetry data (see Figure 1).	**1**	Improve understanding of model validity and feature extent, as site is too large for full acoustic coverage.	Multibeam Echosounder (MBES) Sidescan Sonar (SSS)	Nested boxes – acoustic data gathered will be used to identify rock features to maximise chances of hitting designated feature with groundtruthing	Yes

Objective	Sub-objectives	Priority	Rationale	Gear requirement	Notes	Sub-objective achieved
	1.2 Ground truth the data acquired for Sub-objective 1.1, in terms of reef and non-reef	**1**	Improve understanding of model validity and feature distribution. To be partially achieved through Sub-objective 2.1.	HD camera	Reef and non-reef	Yes
	1.3 Acquire high-resolution acoustic and groundtruthing data (camera) within the south-east of the site, to determine whether this area constitutes Annex I feature.	**3**	Improve understanding of the feature extent within the site.	MBES SSS HD camera	Nested box included in this area	Yes
2. Collect evidence to inform Type 1 (sentinel) monitoring of the **diversity and structure of biological communities, and typical species** within the Wight-Barfleur Reef SAC.	**2.1** Acquire (semi-) quantitative epifaunal camera data across the extent of the feature.	**1**	Supply initial datapoint for Annex I Reef monitoring time-series and characterise the different communities and biological traits associated with the different Broadscale Habitats within the feature. Ground truth acoustic data acquired to achieve Sub-objective 1.1.	HD camera	Use results of newly acquired acoustic data within nested boxes to position stations in the field If acoustic data and model correlate, linear features can be used to position samples with higher confidence	Yes

Objective	Sub-objectives	Priority	Rationale	Gear requirement	Notes	Sub-objective achieved
3. Collect evidence on the **supporting processes** within the Wight-Barfleur Reef SAC.	**3.1** Acquire environmental data (temperature, chlorophyll concentration, pH (TBC), turbidity and dissolved oxygen) at the seabed.	**2**	Improve understanding of environmental processes within the site, and the influence of these processes on sponge distribution.	Ecosystem Monitoring version 2 (ESM2) CTD logger with additional sensors - mounted on camera frame	Water samples will be collected to calibrate sensors	Yes

3 Sampling design

3.1 Bassurelle Sandbank sampling design

The number of planned sampling stations were based on the results of a power analysis (see Appendix 4). 100 Sample stations were planned at Bassurelle Sandbank based on a regular triangular grid (stations were approximately 870m apart) across the SAC (Figure 4).

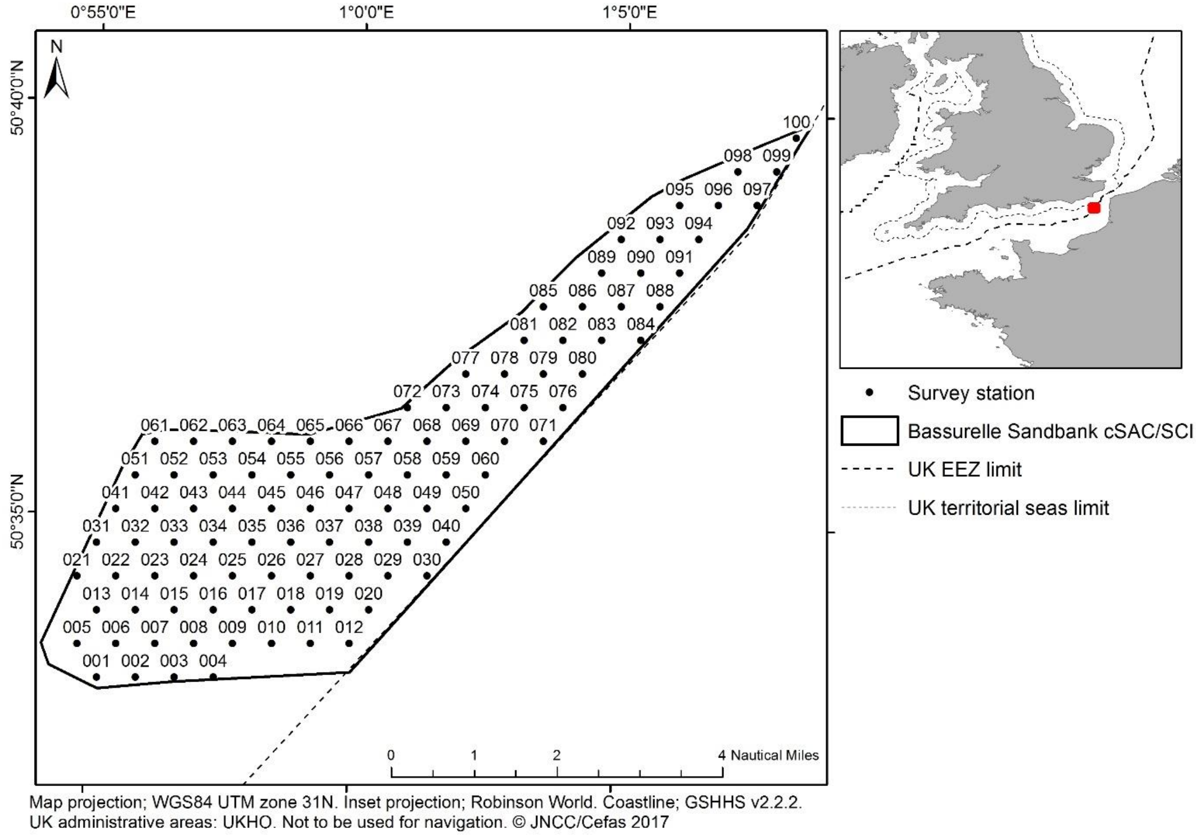


Figure 4. Location of the 100 survey stations at Bassurelle Sandbank (BSSS) visited during CEND0617. All station codes are labelled, but the BSSS prefix is not shown. Note that the site has been accepted as a SAC since the production of this map.

A single Hamon Grab was planned from each of the 100 stations to obtain macrofauna samples and a particle size distribution analysis (PSA) subsample, to supply initial data points for an Annex I Sandbank monitoring time-series (sub-objectives 1.1 and 2.1, Table 2).

An additional four replicate Hamon grabs (five replicates in total) from a subset of ten stations were planned to investigate small scale variability between replicate grab samples (sub-objectives 1.2 and 2.2, Table 2). The subset of ten stations were to be chosen during the survey based on the sites Broadscale Habitat (BSH) map and a review of the sediment samples to ensure a balanced design across the two BSH types present at Bassurelle Sandbank.

A subset of 25 stations were planned as imagery stations. These stations were to be chosen on survey based on the sites BSH map and a review of the sediment samples to ensure a balanced design across the two BSH types present at Bassurelle Sandbank. Imagery was collected for the purpose of comparing with epifauna data from scientific trawls (sub-objectives 3.1, Table 2).

A subset of 25 stations were planned as 2m scientific beam trawl stations. These stations were to be chosen on survey based on the sites BSH map and a review of the imagery and sediment samples, to ensure a balanced design across the two BSH types present at Bassurelle Sandbank. These samples were planned to supply initial datapoints for Annex I Sandbank monitoring time-series, to compare the data collected with that from imagery (sub-objective 2.1 and 3.1, Table 2). Note that this plan changed on survey and imagery was collected after scientific trawls (section 6.1).

3.2 Wight-Barfleur Reef sampling design

A total of six nested survey areas within the Wight-Barfleur Reef SAC were targeted, as full acoustic coverage of such an expansive site (1,373km^2) was not considered to be a viable monitoring strategy (Figure 5). Full coverage multibeam and sidescan sonar coverage was planned from each survey box (sub-objectives 1.1 and 1.3, Table 3). Based on the outputs of a power analysis (Appendix 4), a minimum of 13 drop camera stations were to be targeted in each survey box (sub-objectives 1.2 and 2.1, Table 3). The Ecosystem Monitoring Version 2 (ESM2) logger attached to the drop frame will provide high quality physical parameters to relate to various benthic observations and fulfil sub-objective 3.1 (Table 3).

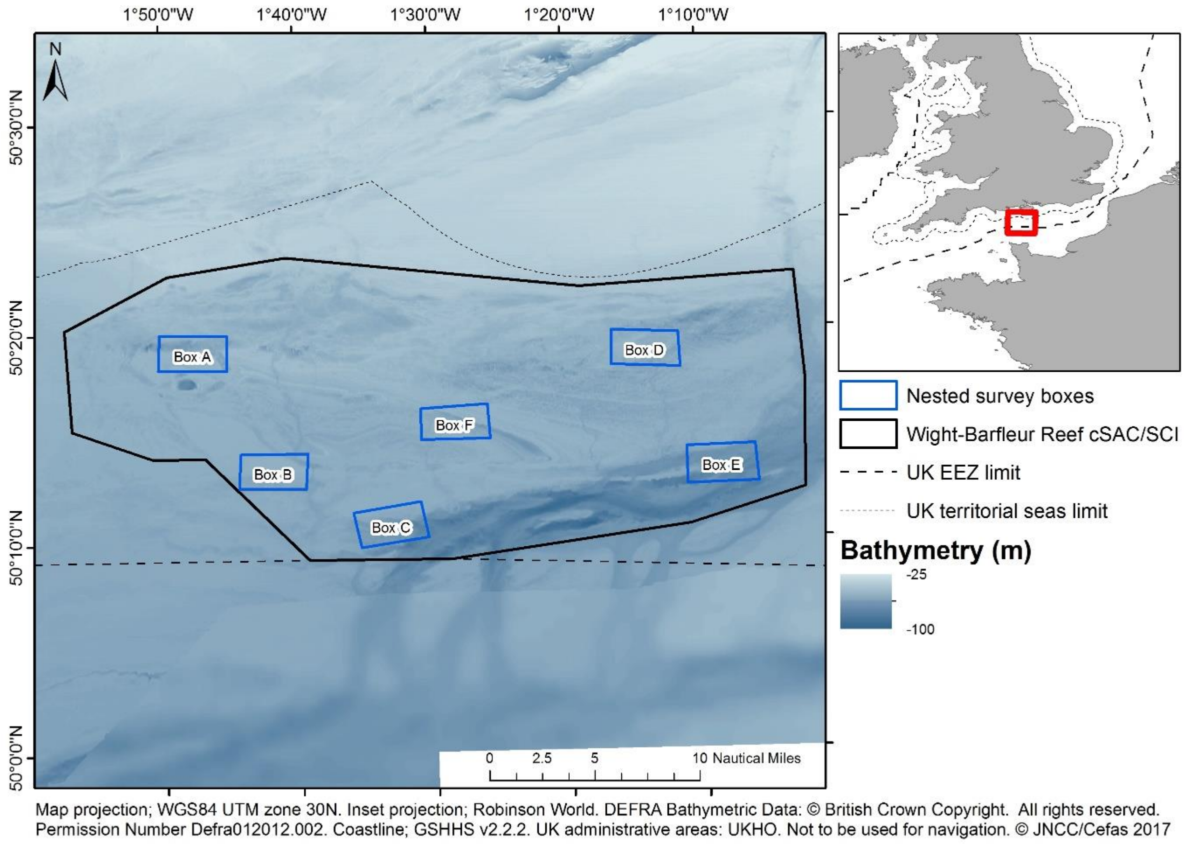


Figure 5. Location of the six nested survey boxes within the Wight-Barfleur Reef SAC site boundary. Note that the site has been accepted as a SAC since the production of this map.

The survey elements consisted of a four-stage process whereby acoustic data were acquired, processed and interpreted to inform the location of drop camera stations (this process is fully explained in sections 4 and 5).

4 Survey Operations

The 2017 surveys of Bassurelle Sandbank SAC and Wight-Barfleur Reef SAC were undertaken aboard the RV *Cefas Endeavour* (Appendix 1). Due to the very different seabed substrates present at Bassurelle Sandbank and Wight-Barfleur Reef, different sampling equipment was required at each site.

For the sedimentary habitats present at Bassurelle Sandbank, epifauna were sampled primarily using a scientific beam trawl (section 4.1), but also with a sledge mounted video/stills camera (section 4.2). For the rocky habitats at Wight-Barfleur Reef, epifauna were sampled using a drop frame mounted video/stills camera (section 4.3). In accordance with survey objective 3 (Table 3) a ESM2 data logger was attached to the drop frame at Wight-Barfleur Reef and the data calibrated and validated using the research vessel's ferry box (section 4.4 and 4.5).

Infauna and sediment samples were collected at Bassurelle Sandbank using a 0.1m^2 Hamon Grab (section 4.6). The hard substrate known to occur at Wight-Barfleur Reef was not suitable for grab sampling.

Acoustic surveys were conducted at the survey boxes at Wight-Barfleur Reef using multibeam and sidescan sonar (section 4.7).

Derivatives of the acoustic data were used to identify areas of ecologically relevant seabed following the process described in section 4.7.1. These areas were then targeted for sampling.

As acoustic data had previously been collected from Bassurelle Sandbank in 2013 (Barrio-Frojan *et al.* 2017), no acoustic survey of Bassurelle Sandbank was conducted during this cruise.

4.1 Scientific 2m (Jennings) beam trawl

The 2m scientific beam trawl design detailed in Jennings *et al.* (1999), for work in the North Sea and later in the English Channel, has been used as standard by Cefas for sampling epibenthic fauna (Figure 6). It has the advantage of being robust, easy to deploy, and produces manageable sample volumes for onboard sample processing. The design includes a heavy-duty steel beam, a chain mat to prevent the collection of large boulders, and chafers to limit net damage.

Permission to use a fine mesh liner, and to catch and retain undersize fish, was requested from the Marine Management Organisation (MMO), in advance of survey, using the MMO online exemption notification. The JNCC, in their role as the Statutory Nature Conservation Body, provided an Environmental Survey Assessment form. A copy of this notification was taken on board during CEND0617.

Figure 6. Deployment of the 2m scientific (Jennings) beam trawl from the aft of the RV *Cefas Endeavour*

All tows were carried out in a straight line, against the tide for five minutes' duration at 1.0 knot (approximately 150m). Tow distance is measured from the time that the warp has ceased paying out (LOCK) to the time that hauling begins (HAUL). Two replicate (parallel) tows were conducted within each target station to assess the validity of the catches. The entire catch was sorted, with sub-sampling only permitted to enumerate large abundances of certain species. A reference collection for each haul was kept for the purposes of quality assurance, this contained specimens of taxa that were not easily or rapidly identified in the field.

4.2 STR SeaSpyder "Telemetry" camera sledge system

Video observations were made, and digital still images acquired, using a STR SeaSpyder "Telemetry" camera sledge (CS) system deployed from the stern gantry. A video camera system mounted on a bespoke sledge was used to acquire high definition video footage and digital still images. Illumination was provided by six high intensity LED lights and a synchronised high-power flash unit. The camera was orientated to provide a forward oblique view of the seabed and a laser scaling device was fitted along the axis of the lens to project two illuminated spots, of fixed distance apart (250mm), onto the seabed. Floats were used to reduce the weight of the frame, thus limiting the sediment plume during tows. Details of equipment mounted on the camera sledge are provided in Appendix 1.

The stern gantry position reference was used for recording the position of camera sledge deployments. The position calculated by the ships High Precision Acoustic Positioning (HiPAP) system is considered more accurate than that of the deployment/steer point gantry. However, the Ultra-Short Base Line (USBL) HiPAP beacon attached to the camera sledge frame did occasionally fail during a tow due to shadowing effects of the vessel hull and turbulence/water bodies. In this case, the steer point gantry is considered accurate to within an area calculated using the winch cable out and actual water depth values.

Set-up and operation followed the MESH 'Recommended Operating Guidelines (ROG) for underwater video and photographic imaging techniques' (Coggan *et al*. 2007). The sledge was controlled by a winch operator who had sight of the video monitor; the amount of tow cable deployed was noted to allow a 'lay back' to be applied to estimate the position of the sledge, if required. Camera tows lasted a minimum of ten minutes, with the sledge being towed at 0.3 knots through a 100m diameter target 'bullring' with the station position at its centroid. Still images were captured at regular one-minute intervals with additional opportunistic images taken if specific features of interest were encountered during towing.

Video images were recorded simultaneously onto the local drives of two computers, the files renamed and copied onto the ships network. A video overlay was used to provide station metadata, time and position (of the GPS antenna) in the recorded video image. Field notes were made during each camera deployment, noting station and sample metadata, real-time observations of substrate and taxa, an initial assessment of the range of Broadscale Habitats (BSHs) seen, and the general quality of the imagery.

The internal clock of the camera used on the sledge was synchronised with GPS time to within one second. This clock creates a timestamp in the EXIF data stored in the digital image which is used to match the image to the positional reference. Positional fixes were taken, for both the stern gantry steer point and the position derived from HiPAP, continuously at five second intervals throughout the tow. This allows the position of the camera system on the seabed to be visualised. Still images can be geo-referenced by matching the time stamp of each image to the nearest fix taken (steer point or HiPAP position as appropriate).

4.3 STR SeaSpyder "Telemetry" drop camera system

Video and digital still imagery was acquired using a STR SeaSpyder "Telemetry" drop camera system (Figure 7). Set-up and operation followed the MESH 'Recommended Operating Guidelines (ROG) for underwater video and photographic imaging techniques' (Coggan *et al.* 2007). Details of equipment mounted on the camera sledge are provided in Appendix 1.

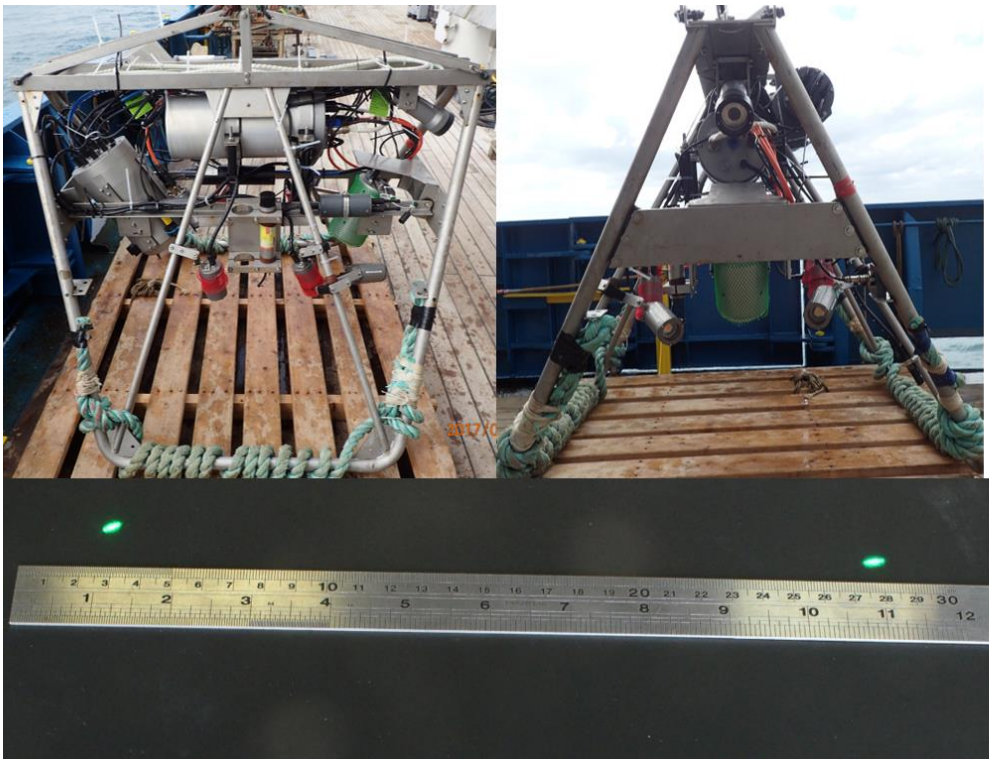


Figure 7. Drop frame mounted camera system with ESM2 logger and scaling lasers (spaced at 250mm).

High definition footage for semi-quantitative assessment of the benthos (with scaling lasers spaced at 250mm (Figure 7) and dedicated lighting) was acquired, using the downward facing camera, along predefined transects of approximately 100m. Speed over ground of the survey vessel was maintained at 0.3 knots for the duration of the tow.

Still images were captured: at one-minute intervals; when a change in substratum occurred; when appropriate to ensure availability of high quality images for later epifauna identification.

The side gantry position was used for recording drop camera deployments. The position calculated by the ships High Precision Acoustic Positioning (HiPAP) system is considered more accurate than that of the deployment/steer point gantry. However, the USBL beacon attached to the drop camera frame may fail during a tow due to shadowing effects of the vessel hull and turbulence/water bodies. If this is the case the steer point gantry is considered accurate to within an area calculated using the winch cable out and actual water depth values.

Positional fixes were taken, for both the side gantry steer point and the position derived from HiPAP, continuously at five second intervals throughout the tow. This allows the position of the camera system above the seabed to be plotted. Still images can be geo-referenced by matching the time stamp of each image to the nearest fix taken (steer point or HiPAP position as appropriate).

Video images were recorded simultaneously onto the local drives of two computers, the files renamed and copied onto the ships network. A video overlay was used to provide station metadata, time and position (of the GPS antenna) in the recorded video image. Field notes were made during each camera deployment, noting station and sample metadata, real-time observations of substrate and taxa, an initial assessment of the range of Broadscale Habitats (BSHs) seen and the general quality of the imagery.

The internal clock of the camera used on the sledge was synchronised with GPS time to within one second. This clock creates a timestamp in the EXIF data stored in the digital image which is used to match the image to the positional reference. Positional fixes were taken, for both the stern gantry steer point and the position derived from HiPAP, continuously at five second intervals throughout the tow. This allows the position of the camera system on the seabed to be visualised. Still images can be geo-referenced by matching the time stamp of each image to the nearest fix taken (steer point or HiPAP position as appropriate).

4.4 Ecosystem Monitoring Version 2 logger

A self-logging, Cefas built, instrument called an Ecosystem Monitoring Version 2 (ESM2) logger attaches to the drop camera frame to record a suite of environmental variables across the horizontal profile of each video tow. The ESM2 logger is fitted with a conductivity/ temperature (CT) sensor, chlorophyll fluorometer, oxygen optode and two optical backscatter sensors to gather salinity, chlorophyll, dissolved oxygen and turbidity data. The RV *Cefas Endeavour's* ‘ferrybox’ is an underway continuous logging system and was operated throughout cruise code CEND0617. This instrument measures the surface values of those same parameters recorded using the ESM2 logger, with an additional sensor measuring variable fluorescence (a measure of phytoplankton photosynthetic efficiency).

4.5 Water sample processing

As with most, if not all, *in-situ* instrumentation, ESM2 data need to be validated and the equipment calibrated to ensure robust datasets. Discrete water samples were collected using the continuous flow ‘ferrybox’ system for salinity, oxygen, suspended particulate matter (SPM) and chlorophyll.

Water for dissolved oxygen analysis was collected and carefully decanted into glass bottles of known volume to prevent bubble formation. Dissolved oxygen is fixed by the addition of a known volume of manganous sulphate. A known volume of alkaline iodide is then added to convert the fixed oxygen into iodine. The iodine concentration is then measured by titrating against sodium thiosulphate. The dissolved oxygen concentration is directly proportional to the titration of thiosulphate and iodine (Winkler 1888).

Salinity samples were collected by syphoning off water into rinsed clean glass salinity bottles. The lip and opening of the bottle were wiped clean to prevent salt formation and potential loss of determinant. An insert is placed in the neck of the bottle to prevent evaporation and the bottle is then capped and itemised and logged.

Chlorophyll samples were collected by syphoning off water into a high-density polypropylene sample bottle and 250ml of sample is then filtered through a glass fibre filter. The filters are folded in half and wrapped in foil and stored at -80^{o}C.

Suspended load samples were collected by syphoning off water into high density polypropylene sample bottles and 750ml of water was then filtered through pre-weighed polycarbonate filters.

It's important that the *in-situ* samples are taken from the same water mass the instruments are measuring. The drop camera frame (with the attached ESM2 logger and sensor array) was held at four m below sea level for a few minutes while taking the water sample from the ‘ferrybox’. The ship's thrusters are known to mix and ventilate the surface waters significantly, so they are not in use during this process.

Samples were taken every few hours over the tidal cycle to observe the full range of conditions experienced at the site.

4.6 0.1m^2 Hamon Grab

Sediment samples were acquired using a 0.1m^2 (mini) Hamon Grab, deployed from the starboard side of the RV Cefas Endeavour (Figure 8). The Hamon Grab is used to collect surficial sediment samples from coarse sediments to a depth of approximately 15cm (Oele 1978; Eleftheriou & Moore 2005; Ware & Kenny 2011). The system consists of an open bucket at the end of a levered stainless-steel arm which is released from a locked position upon impact with the seabed. The bucket collects a sediment sample as the cable is drawn through a series of pulleys once fired. The grab is winched to the deployment platform where the sediment sample is processed. The sample is assessed as valid upon successful operation and if the total volume is larger than a threshold suitable to the sediment type (in this case greater than four-five litres). An image is taken of the sediment once decanted from the grab. A circa 0.5 litre subsample is transferred into a labelled container for subsequent particle size distribution analysis and stored at -20°C. The remaining sediment is taken for benthic community analysis and is sieved on a 5mm and 1mm sieve station to remove fine sediment. Images of the material on each mesh are taken and the sample is recombined into a labelled container prior to fixation in buffered 4% formaldehyde.

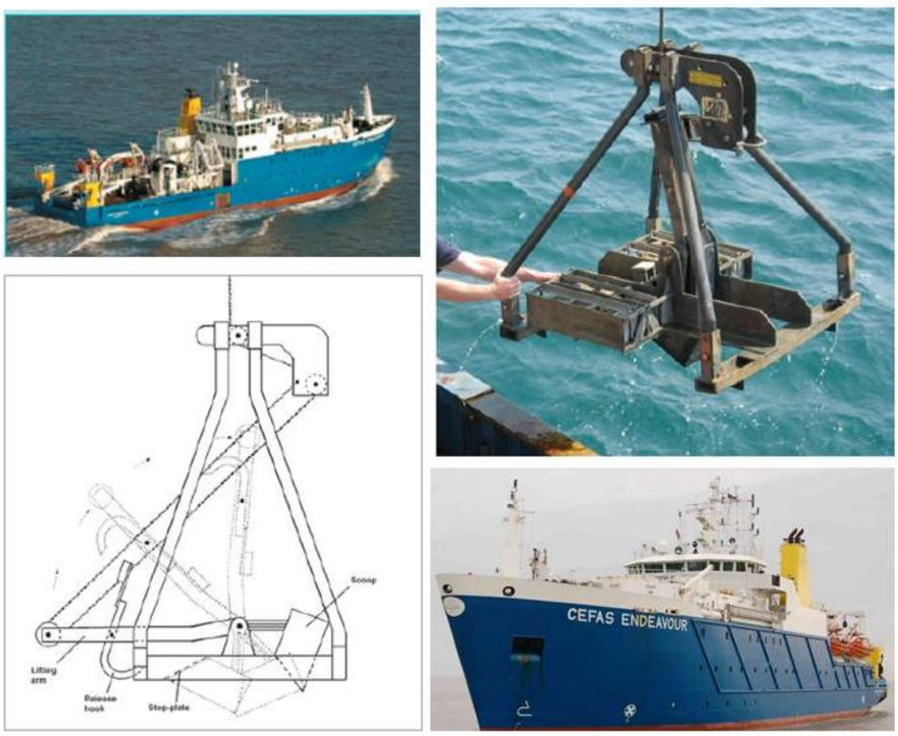


Figure 8 The 0.1m^2 (mini) Hamon Grab being deployed from the side (starboard) gantry of the RV *Cefas Endeavour*. Line drawing showing the operation of the grab is from Eleftheriou and Moore, 2005

4.7 Acoustic equipment

An Edgetech FS-4200 dual frequency (300/600kHz) sidescan sonar was used in combination with the Edgetech Discovery software for data recording. Data were recorded in XTF format and post-processed using the Triton Imaging software suite (Isis and TritonMap). Layback was applied using High Precision Acoustic Positioning (HiPAP) and / or the deployment gantry position offset, and the amount of cable required to maintain an altitude of 30m from the substratum.

Data were collected using a Kongsberg EM2040 multibeam echosounder (MBES), SBG motion reference unit (MRU) and CNAV 3050 high precision GPS. Bathymetry data were processed using CARIS HIPS and backscatter data were produced with the QPS FMGT software package.

Variations of sound velocity with water depth were determined using a SAIV conductivity, temperature, depth (CTD) probe with a sound velocity profile (SVP) measurement taken at least once every 24h when collecting MBES data; acquired SVP data were applied during multibeam data acquisition.

4.7.1 Acoustic Data Interpretation

Following the collection and a rapid initial processing of the SSS and MBES bathymetry and backscatter layers, survey sample boxes were classified using cluster analysis. The intent of this process was to use the abiotic variables collected during the acoustic survey to identify potential ecologically relevant zones and specifically areas of rocky substrate which might constitute the Annex I reef site feature. These areas of potential Annex 1 reef could then be targeted as monitoring stations using the video drop camera. This methodology was adapted from that proposed by Verfaillie *et al.* (2009), however, this was simplified due to the reduced number of abiotic variables available, and time available during the survey.

For each box a number of derivatives were calculated from the bathymetry data to further characterised the seafloor variability. These derivatives included: slope, curvature, benthic position index (BPI; calculated at a range of radii) and roughness. For each box, the derivatives were assessed, and a number were removed due to correlation with other layers or if it was evident that most variation within the layer was caused by artefacts present in the unprocessed bathymetry data. Software eCognition 9.2 was then used to perform an object-based image-analysis (OBIA) using the backscatter, bathymetry and associated derivatives. The aim of the segmentation was to divide the image into meaningful objects that represent areas of homogeneous values in the map image, based on their spectral and spatial characteristics. Segmentation was performed using the multiresolution segmentation algorithm based on the selected image layers for each box. Based on a process of trial and error, a scale parameter was selected to produce sufficiently large segments to be targeted by groundtruthing. The final segmentation was then exported from eCognition, having calculated for each segment the mean values of each image layer.

To determine potential ecologically relevant zones, K-means partitioning was performed in *R* based on the mean values for each segment. Segments are allocated to a cluster in which the distance to the centre is minimal. There are a number of methods for determining the optimal number of clusters with which to split the data (in particular see Milligan and Cooper (1985)). While the Calinski-Harabasz algorithm was used to support the decision regarding the number of clusters utilised in selection of stations for visual assessment, ultimately multiple numbers of clusters were trialled, and the final decision was based on expert judgement. The final product of this analyses was a map that divided the sample box into a number of different clusters based on the abiotic factors that could be targeted using ground truth samples.

Video tow lines (for sub-objectives 1.2, 1.3 and 2.1, Table 3) were then placed to target each of the possible clusters, with additional survey stations placed over features determined to be of interest, based on the MBES or SSS sonar acoustic data layers.

5 Cruise narrative

All times are GMT.

Survey equipment and consumables were mobilised in advance of sailing. All survey staff were aboard by 14:30 on 18th April 2017 for a vessel induction and familiarisation. The vessel departed Lowestoft at 02:30 on the 19th April 2017 and transited to Bassurelle Sandbank SAC; the first of two SACs to be surveyed during cruise code CEND0617. A water sample was collected on route, near to the Cefas Gabbard smart buoy, as part of a continual project to validate remotely sensed sea surface chlorophyll levels.

The survey commenced with a beam trawl deployment at 13:50 on 19th April 2017. The grab survey (which had been planned to occur first) was postponed due to a failed hydraulic hose on the side gantry. The beam trawl survey continued until 12:00 on 20th April 2017 when a replacement hose was collected from Folkestone using the fast rescue boat. A scheduled man overboard drill was conducted during this time. The grab survey commenced at 15:08 on 20th April 2017. The primary objective grab survey (100 sediment samples collected from 100 stations across the site for macrofauna and PSA) was completed at 18:00 on 21st April 2017. The secondary objective replicate grab sample survey was completed at 00:54 on 22nd April 2017 with a subset of ten stations resurveyed, collecting an additional four replicates for macrofauna and PSA. The remaining beam trawls were acquired and processed by 16:00 on 22nd April 2017. During this time, an issue with the stern gantry tow cable was discovered and the camera sledge work was postponed until the issue could be remedied (at least a 24-hour process). As the camera stations were a secondary priority objective, and the final objective left to complete at Bassurelle Sandbank, the decision was made to transit to Wight-Barfleur and begin survey work on high priority objectives required at the site.

The vessel departed the Bassurelle Sandbank SAC at 16:00 on the 22nd April 2017 and commenced transit to a suitable site to conduct the first of two planned multi beam echo sounder calibrations. A CTD probe was deployed and a series of run lines were acquired and processed to correct any offsets (heave, pitch and roll) in the acquisition software. The vessel was steered to perform a series of manoeuvres with the aim of configuring the motion reference unit. The multibeam echosounder (MBES) was ready to use, however, the sidescan sonar (SSS) software required some more time to set up. As SSS was to be used to identify potential patches of stony reef in the paleochannels for later groundtruthing, it was decided that SSS would not be required at survey boxes with no paleochannels. From the existing bathymetry data, box F had been identified as not containing paleochannels so the acoustic survey started here without SSS. The acoustic survey of the first nested survey area (box F) commenced, following a short transit, at 17:41 with a CTD deployment. All run lines were successfully surveyed using the MBES by 13:45 on the 23rd April 2017. In this time, the SSS had been fully set up and was ready to deploy. The MBES data from box F were processed and interpreted while a simultaneous survey (MBES and SSS) commenced at the second nested survey area (box E). All lines were successfully acquired from box E by 06:08 on the 24th April 2017 before the drop camera survey at box F got underway with a successful deployment at station F12 at 08:15. Strong tides prevented the use of the drop camera at peak flow, thus camera operations were restricted to easing and slack tides. The drop camera survey of box F was completed at 21:46 and a video transect was recorded at each of the 14 stations surveyed.

All MBES data from box E were processed and made available for interpretation to locate stations for the drop camera survey. However, not all SSS data were reviewed as processed data were not all available. The southern extent of box E appeared to consist of coarse sediment and the SSS data were consulted to help target stations on a region of suspected cobble reef.

Box D was surveyed initially using only the MBES, with the first survey run line completed at 01:43 on the 25th April 2017. At 06:30 the lead hydrographer noticed an issue with the MBES system which had invalidated the data acquired from box D overnight. The SSS was deployed at box D at 10:01 and the northern extent of site was surveyed using only this gear until the MBES issue was resolved. A simultaneous MBES and SSS survey commenced in the southern extent of box D at 20:15. MBES data were acquired from the northern extent of box D until 20:22.

The drop camera survey of boxes E and D commenced with a successful deployment at station E06 and was completed by 17:08 on the 27th April 2017. In this time 15 video transects were recorded at the 14 stations surveyed in box E. This is because station E07 had to be attempted a second time as the first transect was cut short due to strong tides. A video transect was recorded at each of the 15 stations surveyed at box D.

The simultaneous acoustic survey of box A commenced at 23:35 and was completed at 12:06 on the 28th April 2017. The second MBES calibration was conducted at a suitable site selected in proximity to the north-east of box A. A CTD was deployed at 12:30 and a series of run lines were acquired between 12:50 and 15:52.

The simultaneous acoustic surveys of boxes B and C commenced at 18:44 and were completed by 02:14 on the 30th April 2017.

The drop camera survey at box A commenced at 05:49 and the survey was halted to make an unscheduled crew transfer, using the Portland pilot vessel. The drop camera survey continued at box A at 15:26 and the remaining boxes (B and C) were surveyed in succession. The final camera deployment was concluded at 20:36 on the 1st May 2017. A video transect was recorded at each of the 15 stations surveyed at box A and at box C. At box B 14 video transects were recorded at the 13 stations surveyed. This is because station B11 had to be attempted a second time as the first transect was cut short due to strong tides.

Figure 9 demonstrates the order that the nested survey boxes were visited, and the activities undertaken on each visit to a given box.

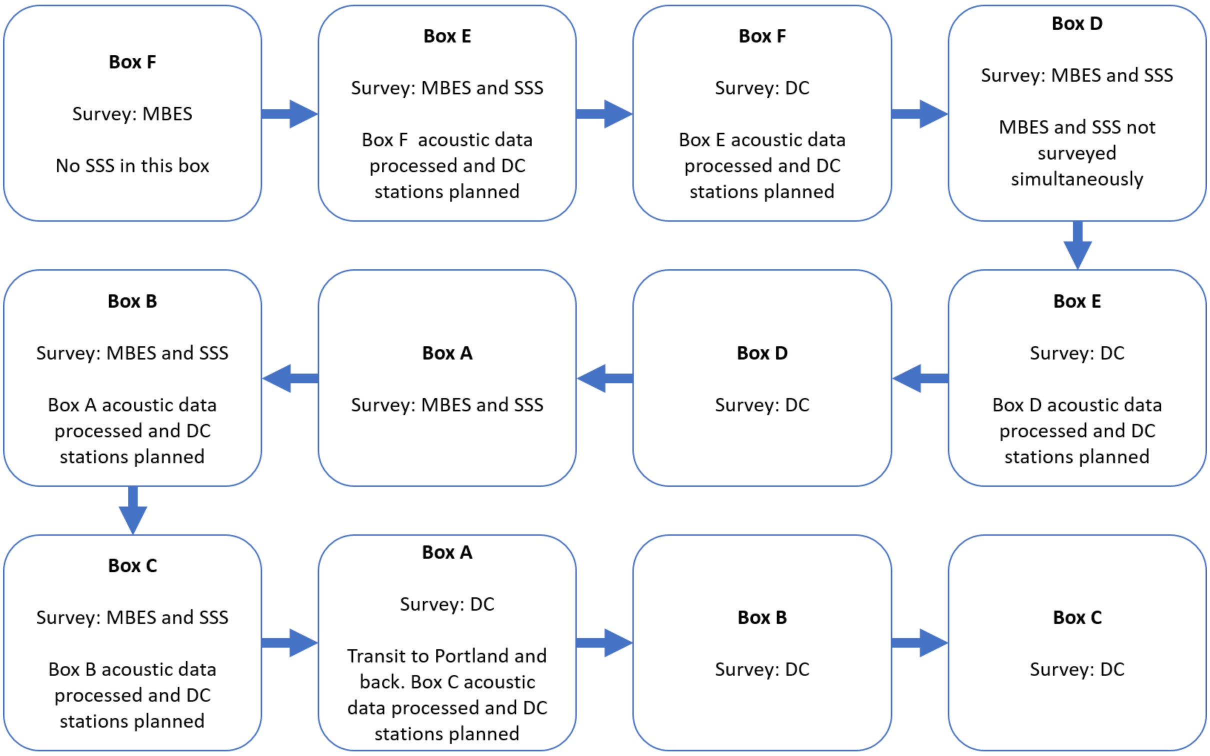


Figure 9. Diagram showing the order in which each nested survey box at Wight-Barfleur Reef was visited and the survey activities undertaken. Extra notes are provided for some box visits. These notes record things such as issues with specific survey gears or if acoustic data was being processed for the next box. MBES = multibeam eco sounder, SSS = sidescan sonar, DC = drop camera.

Before returning to Bassurelle Sandbank, the Nab Tower dredge disposal site was visited. A Hamon Grab survey of Nab Tower commenced at 00:00 on the 2 May. 57 Hamon Grab samples were collected as part of a UK wide monitoring programme of dredge disposal sites for the Marine Management Organisation. More detail on this work can be found in recent reports on the monitoring of the Nab Tower dredge disposal site (Bolam *et al*. 2016). By 15:00 on the 2 May, the sampling of Nab Tower was complete and transit to Bassurelle Sandbank began.

The stern gantry tow cable was repaired and tested before the vessel returned to the Bassurelle Sandbank SAC to conduct a seabed imagery survey of those stations previously sampled using the scientific beam trawl. The camera survey was conducted between 22:29 on 2 May 2017 and 19:04 on 3 May 2017. The vessel transited to Falmouth and was alongside by 09:00 on 5 May 2017. Frozen sediment samples for PSA were transported to the freezer storage at Cefas Lowestoft on the 5 May 2017. Sediment samples for infauna analysis and reference specimens from the beam trawl survey were transported to the Cefas storage facility in Pinbush industrial estate when the vessel returned to the Cefas Quay in Lowestoft on 12 May 2017. A summary of survey operation time is presented in Appendix 2.

6 Data acquisition

6.1 Bassurelle Sandbank data acquisition

A summary of all samples collected and their location at Bassurelle Sandbank is provided in Table 4, Figure 10, and summary sample metadata is presented in Appendix 3.

Sediment samples were acquired for particle size distribution analysis (PSA) and macroinvertebrate community analysis from all 100 planned stations (one replicate of each acquired at each station) using a 0.1m^2 Hamon Grab. These samples were collected to supply initial data points for an Annex I Sandbank monitoring time-series (sub-objectives 1.1 and 2.1, Table 2).

After the initial sampling of the 100 grab stations was complete, four additional replicate samples for PSA and macroinvertebrate community analysis were acquired from a subset of ten stations. Therefore, five replicates were collected at each of these stations in total. These samples were collected to investigate small scale variability between replicate grab samples (sub-objectives 1.2 and 2.2, Table 2). Five stations targeted ‘A5.1 Sublittoral coarse sediment’ and five targeted ‘A5.2 Sublittoral sand’. The location of the replicate stations was based on the map of Broadscale Habitats identified at Bassurelle Sandbank in 2013, and an initial assessment of sediments collected from the first 100 stations (i.e. the initial grab samples taken in the area of Sublittoral Course Sediment to the north of the SAC, indicated that this area had sandy substrate at the time of sampling) (Table 4, Figure 10).

A 2m scientific beam trawl was used to collect epifaunal samples at Bassurelle Sandbank. Two replicate hauls were conducted at 25 stations targeting both ‘A5.1 Sublittoral coarse sediment’ and ‘A5.2 Sublittoral sand’ habitats across the site (Table 4, Figure 10). These samples were collected to supply initial datapoints for Annex I Sandbank monitoring time-series (sub-objective 2.1, Table 2). Each haul covered approximately 150m (five minutes at one knot), representing a total swept area of approximately 600m^2 per station. Benthic macroinvertebrate samples were collected and processed onboard, as described in section 4.6.

Table 4. Summary of samples collected during the Bassurelle Sandbank SAC survey on cruise code CEND0617. Note that particle size and macrofauna are sub-sampled from a single grab.

Gear	Sample type	Number of samples	Analysis	Purpose	Remark
0.1m^2 (mini) Hamon Grab	Sediment	100	Particle size distribution	Type 1 monitoring	
0.1m^2 (mini) Hamon Grab	Sediment	100	Macrofauna	Type 1 monitoring	
0.1m^2 (mini) Hamon Grab	Sediment	40	Particle size distribution	Small scale variability at sample location	Station codes: BSSS012, BSSS018, BSSS029, BSSS079, BSSS084, BSSS089, BSSS010, BSSS019, BSSS081, BSSS083.
0.1m^2 (mini) Hamon Grab	Sediment	40	Macrofauna	Small scale variability at sample location	Station codes: as above.
2m Scientific Beam Trawl	Epifauna	25	Epifauna	Type 1 monitoring	Station codes: BSSS003, BSSS006, BSSS012, BSSS015,

					BSSS018, BSSS021, BSSS026, BSSS029, BSSS032, BSSS038, BSSS042, BSSS046, BSSS053, BSSS058, BSSS060, BSSS061, BSSS064, BSSS066, BSSS073, BSSS079, BSSS084, BSSS088, BSSS089, BSSS095, BSSS100. Beam trawls were processed aboard, and reference specimens are retained; enabling later confirmation of onboard identifications.
Camera sledge	Epifauna	26	Epifauna	Type 1 monitoring / gear comparison	Station codes: as above. An additional station (BSSS094) was surveyed using the camera sledge and does not have associated beam trawl data.

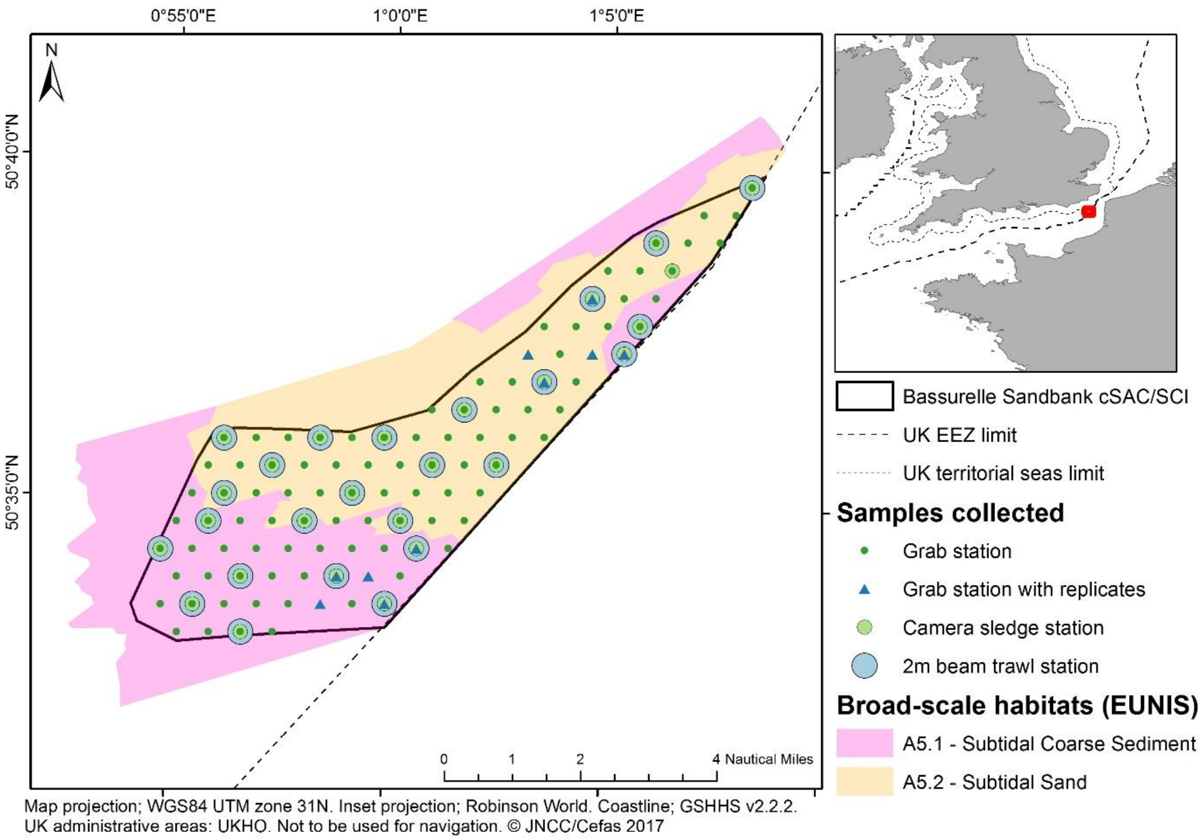


Figure 10. Location of the 100 sampling stations surveyed at the Bassurelle Sandbank SAC during Cruise CEND0617. The type of survey gear used at each station is shown along with the Broadscale Habitats identified by Barrio-Frojan *et al.* (2017). Note that the site has been accepted as a SAC since the production of this map.

Stills and video footage were recorded using a sledge mounted HD camera (section 4.2). Seabed imagery was additionally acquired from station BSSS094 in error, resulting in a total of 26 stations (Table 4, Figure 10). Seabed imagery was acquired after the trawl survey, rather than before, as had been originally planned, due to the lower priority of sub-objective 3.1.

Underwater visibility was poor at most stations, therefore video footage and still images may not be of adequate quality for a full statistical analysis. A summary of the video and stills data collected from Bassurelle Sandbank is provided in Table 5.

Table 5. Summary of the seabed imagery footage and number of stills collected from Bassurelle Sandbank SAC on cruise code CEND0617.

Number of video tows	**Total duration (HH:MM)**	**Total number of stills collected**	**Remark**
29	04:38	355	A total of 26 stations were surveyed with the camera sledge. Stations BSSS088 & BSSS100 were revisited to assess improvement in visibility. Station BSSS100 was surveyed three times; the first attempt was a partial tow and the second was very poor visibility (Station number 264); the second attempt was a full tow.

6.2 Wight-Barfleur Reef data acquisition

Multibeam data was collected within the six survey boxes and sidescan sonar data was collected within five of the survey boxes (not box F). Acoustic data was processed at sea and ecologically relevant areas were identified following the procedure described in section 4.7.1. This was used to plan 82 drop camera stations, where a total of 84 videos were recorded (some video transects were attempted more than once). Post survey it was noted that still images from the drop camera were slightly out-of-focus.

A summary of all acoustic data and imagery samples collected at Wight-Barfleur Reef is provided in Table 6 and Figure 11 to Figure 16.

Table 6. Summary of samples collected during the Wight-Barfleur Reef SAC survey on cruise code CEND0617. Note that some stations were attempted more than once, resulting in more videos than video stations.

Box	**Multibeam bathymetry & backscatter**	**Sidescan sonar**	**Approximate acoustic coverage (km^2)**	**Number of video stations sampled**	**Number of video tows (duration hh:mm)**	**Number of stills**
Box A	Full	Full	18.5	13	13 (02:28)	277
Box B	Full	Full	18	13	14 (02:33)	264
Box C	Full	Full	19	13	13 (02:19)	241
Box D	Full	Full	18.5	15	15 (02:44)	311
Box E	Full	Full	20	14	15 (02:29)	241
Box F	Full	None	17	14	14 (02:55)	302
Total	**37GB**	**79.4GB**	**111**	**82**	**84 (15:28)**	**1636**

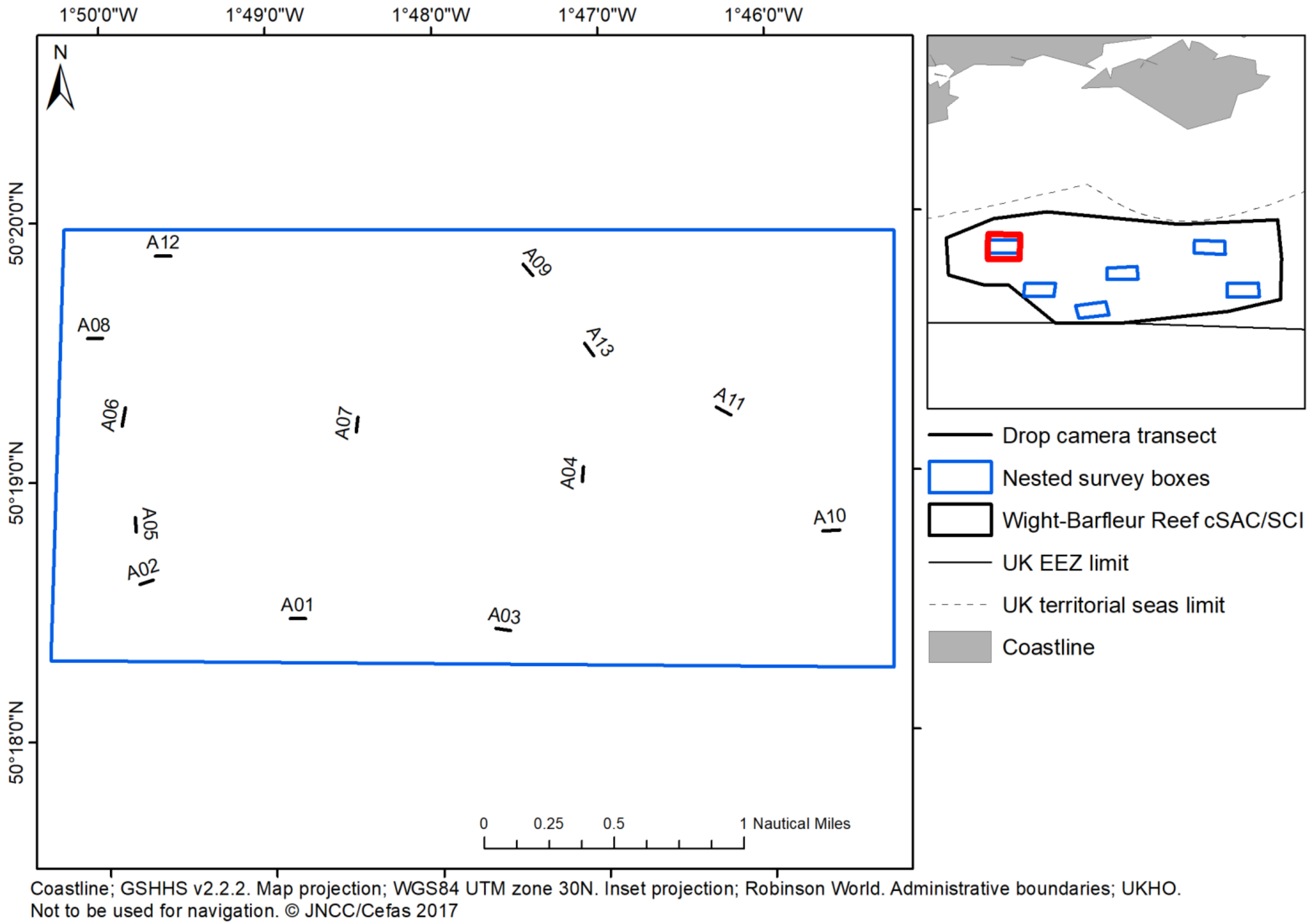


Figure 11. Box A drop camera transect locations visited during CEND0617. Full coverage multibeam and sidescan sonar also acquired in this box. Note that the site has been accepted as a SAC since the production of this map.

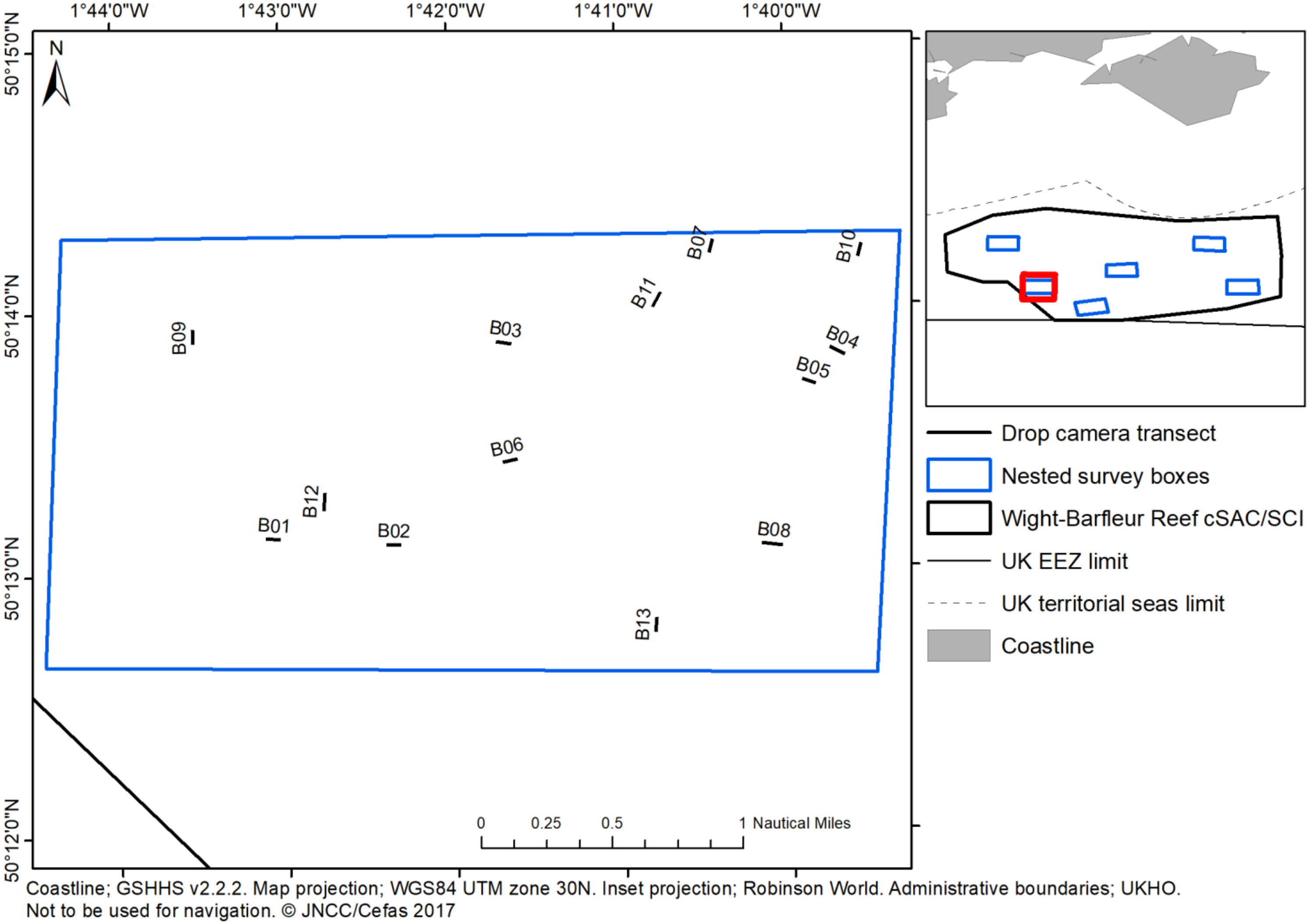


Figure 12. Box B drop camera transect locations visited during CEND0617. Full coverage multibeam and sidescan sonar also acquired in this box. Note that the site has been accepted as a SAC since the production of this map.

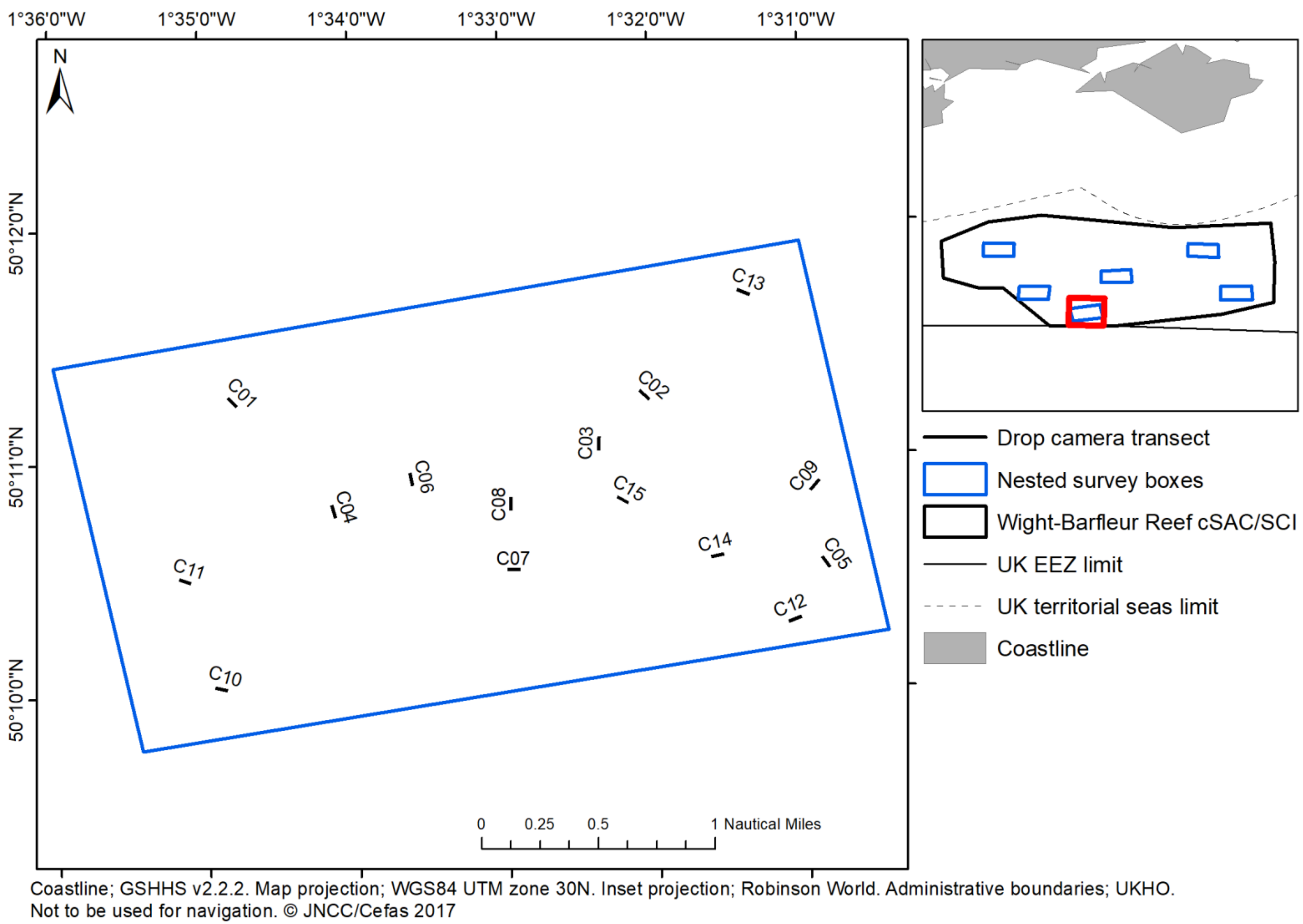


Figure 13. Box C drop camera transect locations visited during CEND0617. Full coverage multibeam and sidescan sonar also acquired in this box. Note that the site has been accepted as a SAC since the production of this map.

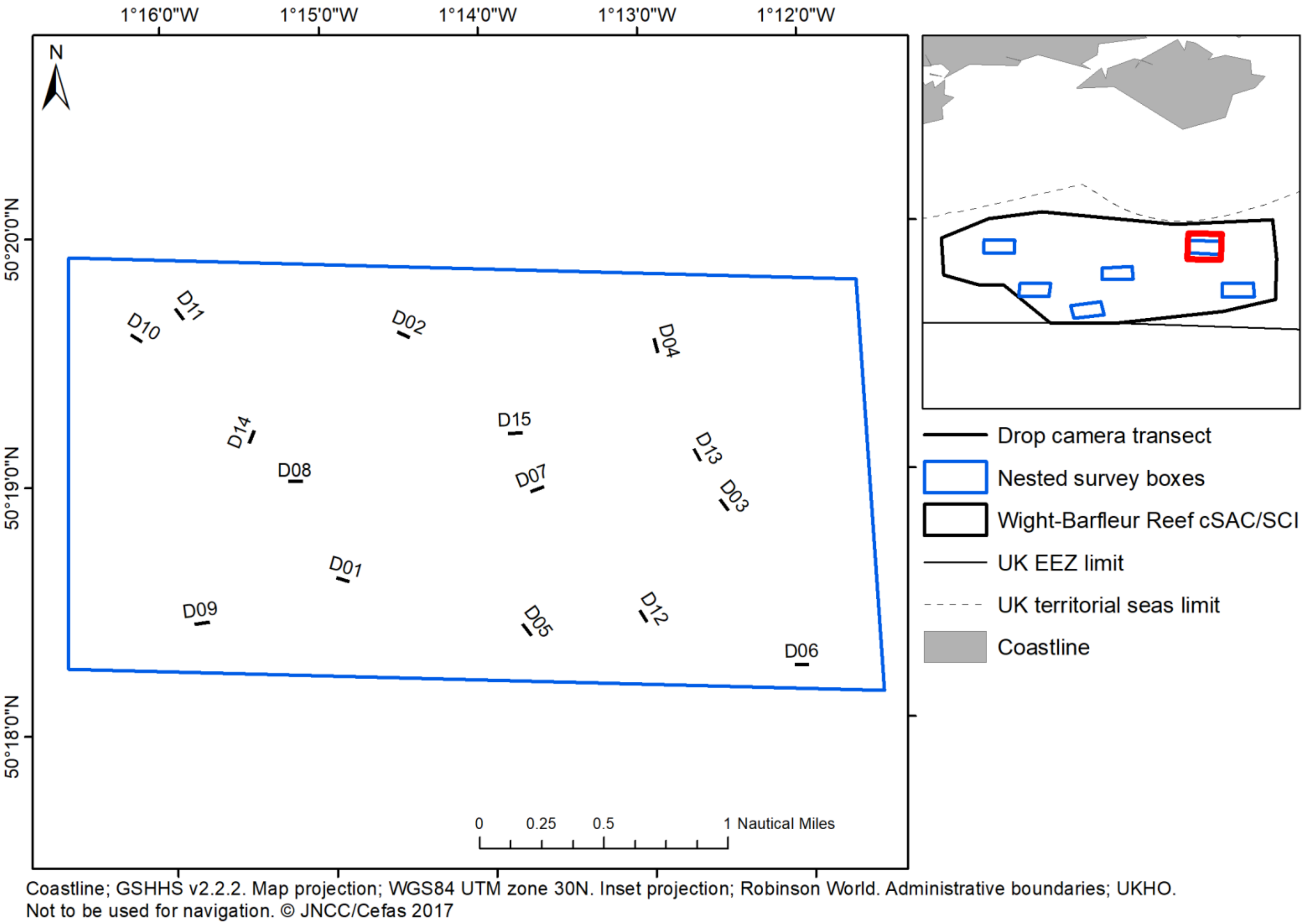


Figure 14. Box D drop camera transect locations visited during CEND0617. Full coverage multibeam and sidescan sonar also acquired in this box. Note that the site has been accepted as a SAC since the production of this map.

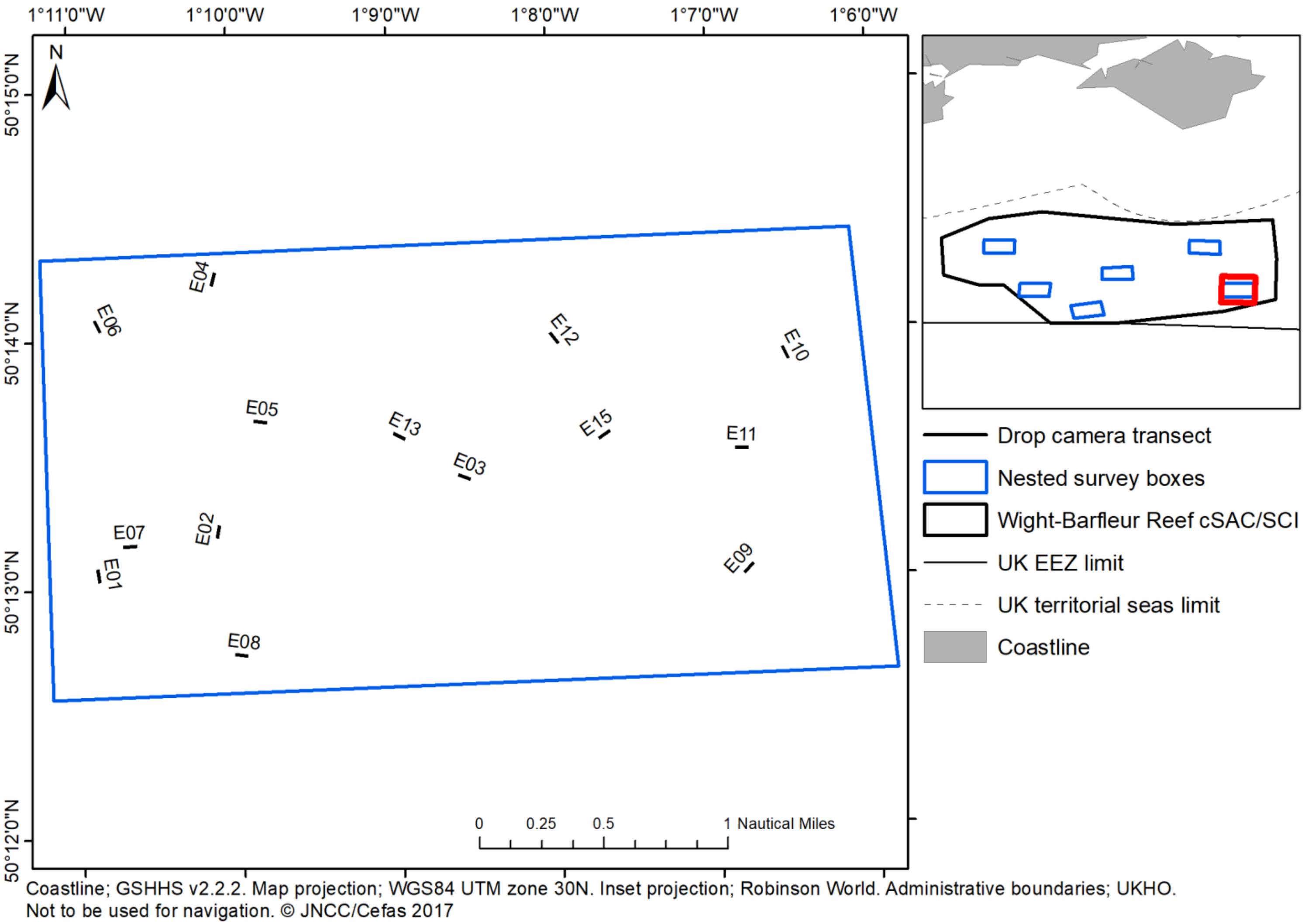


Figure 15. Box E drop camera transect locations visited during CEND0617. Full coverage multibeam and sidescan sonar also acquired in this box. Note that the site has been accepted as a SAC since the production of this map.

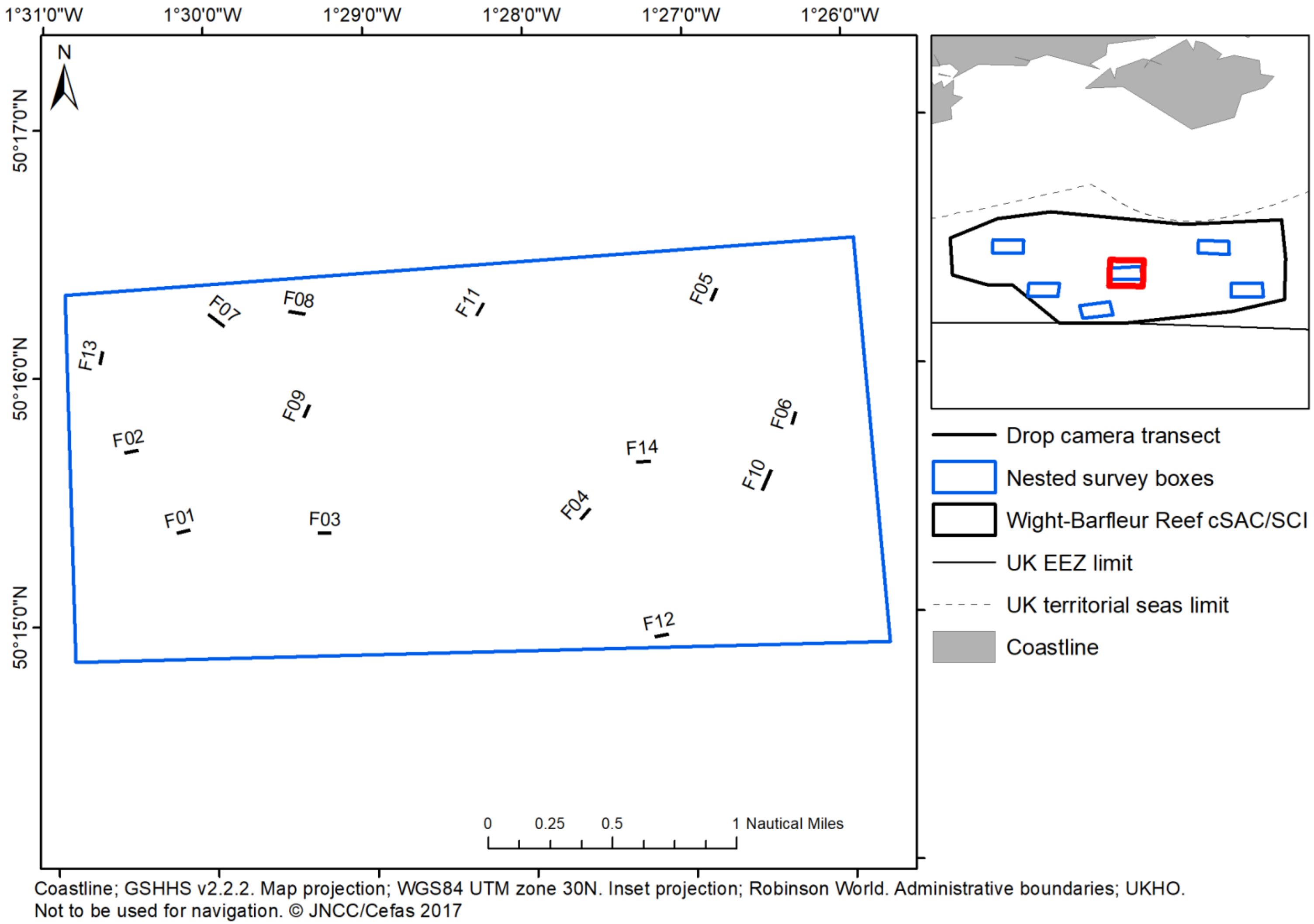


Figure 16. Box F drop camera transect locations visited during CEND0617. Full coverage multibeam was also acquired in this box. No sidescan sonar data was acquired at Box F. Note that the site has been accepted as a SAC since the production of this map.

7 Health and safety

Two ships drills were conducted during the survey. A safety induction to the vessel for scientific staff was carried out on 18 April 2017 and a man overboard drill was conducted at 16:30 on 20 April 2017.

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9 Appendices

Appendix 1. Vessel and equipment used

RV Cefas Endeavour

Port of registry	Lowestoft
Length OA	73.00m (excluding stern roller)
Length extreme	73.916m
Breadth (MLD)	15.80m
Depth (MLD)	8.20m
Design draft	5.00m
Deep draught	5.50m
LBP	66.50m
Gross tonnage	2983 tonnes
Net register tonnage	894 tonnes
Net lightship	2436 tonnes
Deadweight @ 5.00 m	784 tonnes
Deadweight @ 5.50 m	1244 tonnes
Displacement @ 5.00 m	3210 tonnes
Displacement @ 5.50 m	3680 tonnes
Builder	Ferguson Shipbuilders Limited, Port Glasgow
Commissioned	2003
Communications	In port BT Tel. Cellphone Voice/Fax/Data Radio TELEX Inmarsat C Fleet 77 (Inmarsat F) and VSAT (eutelsat) internet access
Endurance	42 days
Complement	En suite accommodation for 16 crew and 19 scientists with dedicated hospital facility
Propulsion system	AC/DC Diesel Electric 3 x diesel electric AC generators, individually raft mounted 2 x tandem electric DC motors Single screw
Power generation	3240Kw
Power propulsion	2230Kw
Thrusters	Bow thruster (flush mounted azimuthing) Stern thruster (tunnel)
Trial speed	14.4 knots
Bollard pull	29 tonnes
Call sign	VQHF3

Official number	906938
MMSI	235005270
Lloyds/IMO number	9251107
Side gantry	7.5 tonne articulated side A-frame
Stern gantry	25 tonne stern A-frame
Winches	3 x cranes 35tM, heave-compensated 2 x trawl winches 2 x drum winches, (1 double) Double barrel survey winch with motion compensation and slip rings Double barrel survey winch with slip rings Double barrel towing winch with slip rings Sidescan sonar winch with slip rings 3 x Gilson winches (one fitted to stern A-frame)
Transducers/Sea tube	Drop keel to deploy transducers outside the hull boundary layer in addition to hull mounted transducers 1.2m diameter sea tube/moon-pool
Acoustic equipment	Kongsberg Simrad: HiPAP 500 positioning sonar EK60, 38/120kHz scientific sounder EA 600, 50/200kHz scientific sounder Scanmar net mensuration system SH80 high frequency omni-directional sonar EM3002 swathe bathymetry sounder Hull mounted Scanmar fishing computer transducers
Boats	2 x 8m rigid work and rescue boats with suite of navigational equipment deployed on heave-compensated davits
Laboratories	8 networked laboratories designed for optimum flexibility of purpose four serviced deck locations for containerised laboratories
Special features	Dynamic positioning system Intering anti-roll system Local Area Network with scientific data management system Ship-wide general information system CCTV
Class	LRS 100A1+LMC UMS SCM CCS ICC IP ES(2) DP(CM) ICE class 2

Camera Frame Equipment

List of equipment mounted on sledge frame;

- Telemetry Operation over fibre optic cable
- 720p high definition video camera
- 18 mega pixels underwater digital stills camera
- High power camera flash
- 20W high intensity led lights x 6
- Dual scaling subsea lasers x 2 (spaced at 250mm)
- 250khz precision altimeter
- Combined compass & depth
- Temperature sensor
- Ultra-short base length positioning beacon

List of equipment mounted on drop frame;

- Telemetry Operation over fibre optic cable
- 1080p high definition video camera
- 720p forward facing video camera
- 18 mega pixels underwater digital stills camera
- High power camera flash

- 20W high intensity led lights x 6 (2 forward facing)
- Dual scaling subsea lasers x 2 (spaced at 250mm)
- 250khz precision altimeter
- Combined compass & depth
- Temperature sensor
- Ultra-short base length positioning beacon
- Ecosystem Monitoring Version 2 logger (ESM2 logger)

Positioning Software and Offsets

Vessel offsets are defined from the pitch roll centre of the vessel i.e. the Central Reference Point (CRP) is used by the Tower CEMAP software to calculate offsets to deployment gantry.

GPS fixes were recorded using the Tower Navigation system on RV *Cefas Endeavour*. This records the positional coordinates of the gantry from which the sampling equipment is being deployed, automatically compensating for the offset between these gantries and the GPS antenna, as well as the corrected position provided by the Ultra-Short Base Length HiPAP beacon, when in use.

The vessel offsets used to calculate a more accurate position for equipment deployed from the RV *Cefas Endeavour* are shown for the stern gantry, side gantry, and HiPAP (Figure 17 - Figure 19).

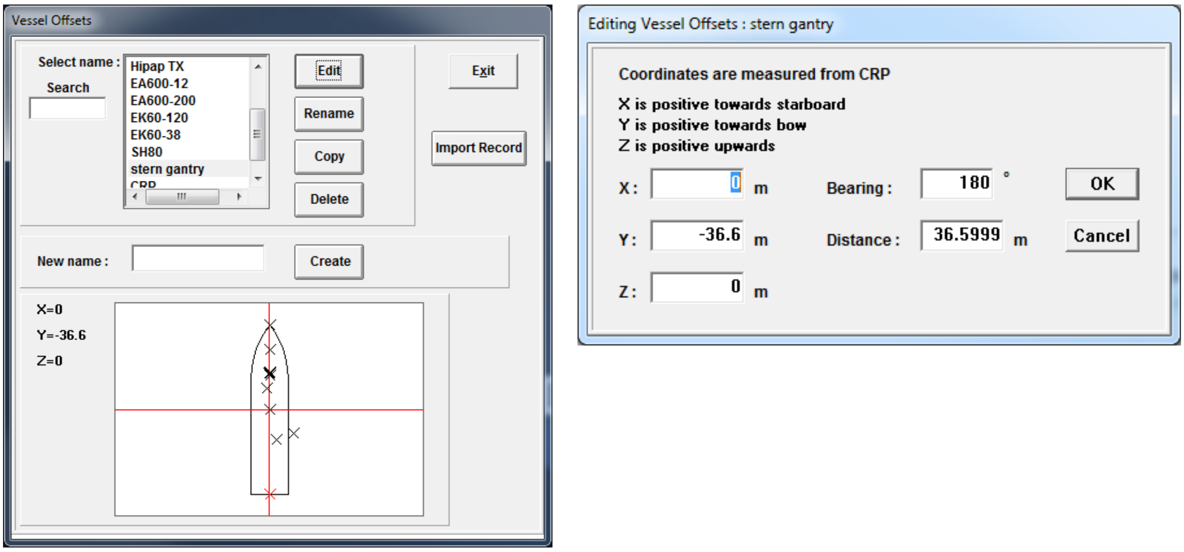

Figure 17. Stern Gantry vessel offsets in the Tower Navigation system.

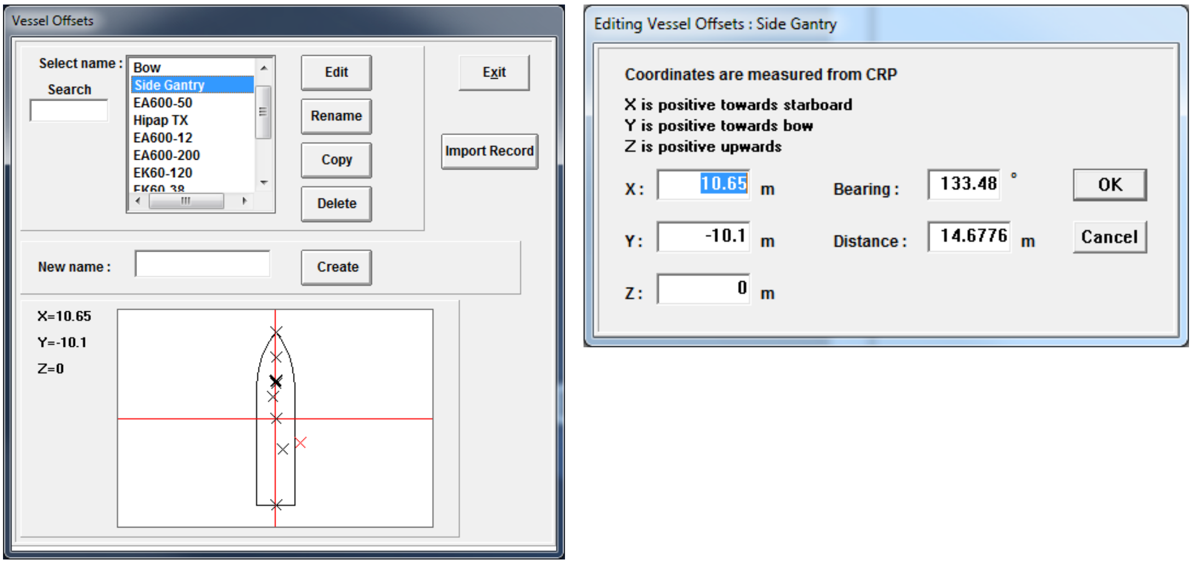

Figure 18. Stern Gantry vessel offsets in the Tower Navigation system.

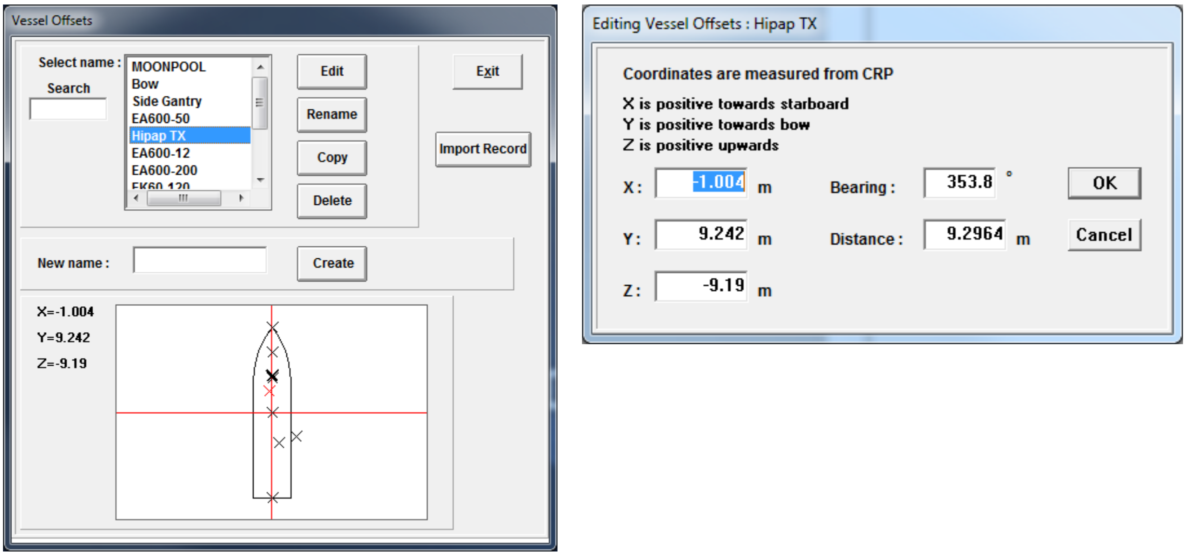

Figure 19. Stern Gantry vessel offsets in the Tower Navigation system.

Appendix 2. Summary of survey operation time

Table 7. Breakdown of survey operations.

Action	Cumulative time (HH:MM)	Remark
Mob/Demob	26:00	
In port	9:30	From 15:30 on the 18 May to 03:30 on the 19 May 2017.
Transit	76:40	Lowestoft to Bassurelle Sandbank; Bassurelle Sandbank to Wight-Barfleur Reef; Wight-Barfleur Reef to Nab Tower; Nab Tower to Bassurelle Sandbank; Bassurelle Sandbank to Falmouth.
Sampling	162:05	Beam trawls, Hamon grabs and camera sledges
Survey	119:25	Multibeam, sidescan sonar.
Equipment downtime	7:20	Collect and replace hydraulic pipe. Mitigated by collecting and processing beam trawl sample during downtime and by rescheduling a man over-board drill.
Nab Tower (Sampling)	15:00	Hamon Grab sampling at Nab Tower.
TOTAL	**416:00**	**Seventeen days and 8 hours**

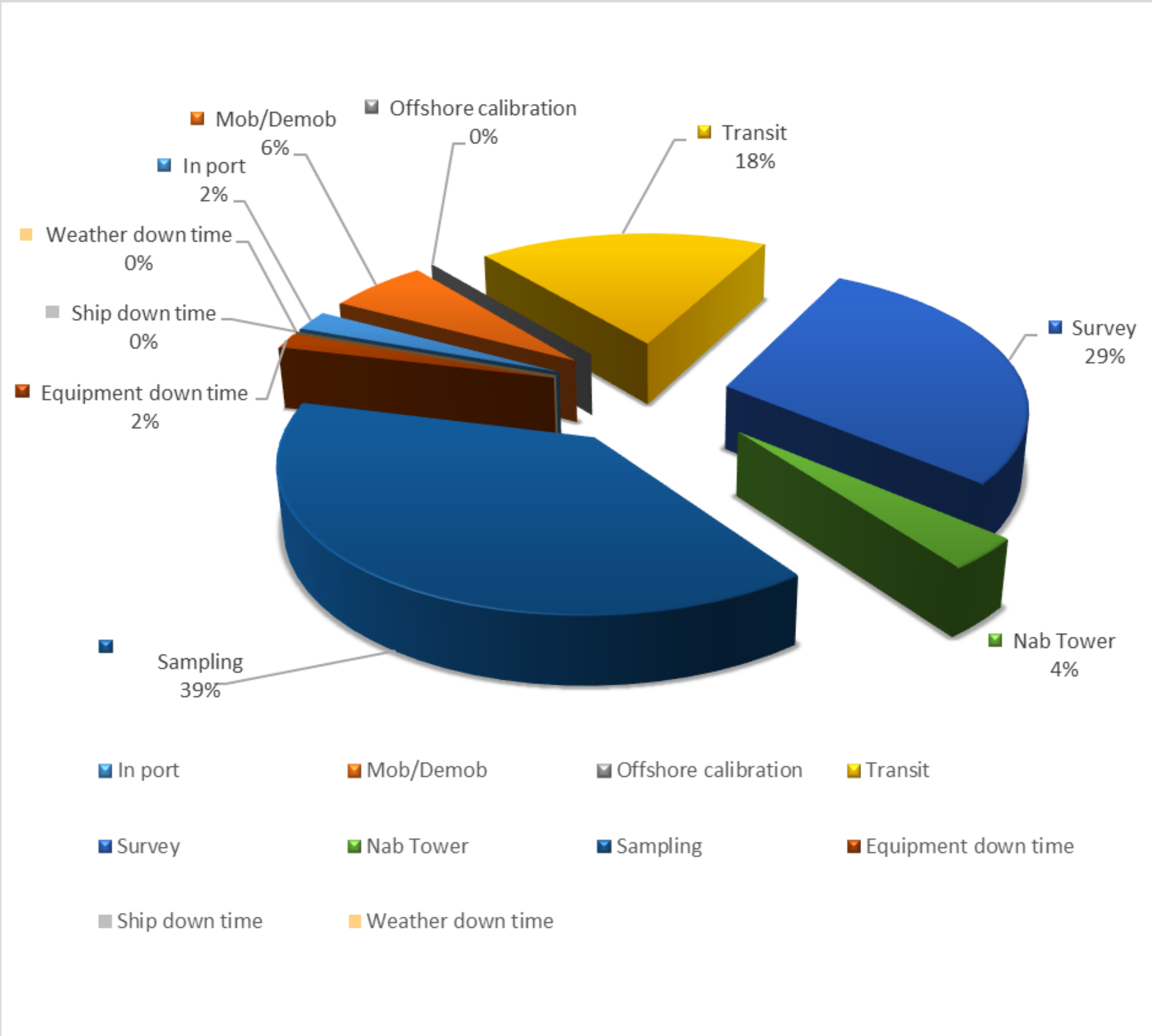

Figure 20. Summary of operations.

Appendix 3. Survey metadata

Survey metadata output for survey CEND0617 is presented for the camera sledge, scientific 2m beam trawls, and grab samples collected at Bassurelle Sandbank (Table 8, Table 9, and Table 10 respectively) and drop camera at Wight-Barfleur Reef (Table 11).

Table 8. Camera sledge sampling stations at Bassurelle Sandbank, showing the coordinates of start and end of line (SOL and EOL) in WGS1984 as well as vessel speed and number of still images taken on each tow.

Event ID	Date	Latitude SOL	Longitude SOL	Latitude EOL	Longitude EOL	Vessel Speed Knots	Number Of Stills
BSSS_CEND0617_BSSS100_STN_264_A1	02/05/2017	50.66224	1.136205	50.66228	1.136274	0.3	1
BSSS_CEND0617_BSSS100_STN_264_A2	03/05/2017	50.66187	1.136731	50.66272	1.136922	0.3	12
BSSS_CEND0617_BSSS088_STN_265_A1	03/05/2017	50.62826	1.096725	50.62818	1.095563	0.3	9
BSSS_CEND0617_BSSS021_STN_266_A1	03/05/2017	50.57082	0.914133	50.57064	0.912348	0.3	16
BSSS_CEND0617_BSSS006_STN_267_A1	03/05/2017	50.55736	0.927016	50.55713	0.925842	0.3	11
BSSS_CEND0617_BSSS003_STN_268_A1	03/05/2017	50.551	0.945681	50.5508	0.944483	0.3	15
BSSS_CEND0617_BSSS015_STN_269_A1	03/05/2017	50.56437	0.944736	50.56358	0.944249	0.3	17
BSSS_CEND0617_BSSS032_STN_270_A1	03/05/2017	50.57725	0.931617	50.57648	0.931145	0.3	14
BSSS_CEND0617_BSSS042_STN_271_A1	03/05/2017	50.58425	0.93687	50.58351	0.936483	0.3	19
BSSS_CEND0617_BSSS061_STN_272_A1	03/05/2017	50.59844	0.936546	50.59956	0.93648	0.3	15
BSSS_CEND0617_BSSS053_STN_273_A1	03/05/2017	50.59199	0.954862	50.59273	0.955121	0.3	18
BSSS_CEND0617_BSSS035_STN_274_A1	03/05/2017	50.57813	0.968022	50.57897	0.967807	0.3	12
BSSS_CEND0617_BSSS018_STN_275_A1	03/05/2017	50.56529	0.980374	50.56585	0.981238	0.3	10
BSSS_CEND0617_BSSS012_STN_276_A1	03/05/2017	50.55868	0.999284	50.55931	0.999997	0.3	12
BSSS_CEND0617_BSSS029_STN_277_A1	03/05/2017	50.57228	1.011018	50.57301	1.011907	0.3	12
BSSS_CEND0617_BSSS038_STN_278_A1	03/05/2017	50.57879	1.005244	50.57954	1.00578	0.3	17
BSSS_CEND0617_BSSS046_STN_279_A1	03/05/2017	50.58503	0.986213	50.58587	0.986832	0.3	12
BSSS_CEND0617_BSSS064_STN_280_A1	03/05/2017	50.59852	0.972957	50.59923	0.973601	0.3	12
BSSS_CEND0617_BSSS066_STN_281_A1	03/05/2017	50.59824	0.99746	50.59912	0.997709	0.3	12
BSSS_CEND0617_BSSS058_STN_282_A1	03/05/2017	50.59204	1.01696	50.59289	1.016687	0.3	11
BSSS_CEND0617_BSSS060_STN_283_A1	03/05/2017	50.59307	1.041801	50.59279	1.040304	0.3	12
BSSS_CEND0617_BSSS073_STN_284_A1	03/05/2017	50.60646	1.028661	50.60625	1.027381	0.3	11

BSSS_CEND0617_BSSS079_STN_285_A1	03/05/2017	50.61388	1.059637	50.6138	1.058324	0.3	11
BSSS_CEND0617_BSSS084_STN_286_A1	03/05/2017	50.62118	1.089717	50.62107	1.088417	0.3	12
BSSS_CEND0617_BSSS088_STN_287_A1	03/05/2017	50.62828	1.095607	50.6277	1.094832	0.3	8
BSSS_CEND0617_BSSS089_STN_288_A1	03/05/2017	50.6346	1.076383	50.63399	1.075578	0.3	11
BSSS_CEND0617_BSSS094_STN_289_A1	03/05/2017	50.64171	1.106612	50.64122	1.105914	0.3	8
BSSS_CEND0617_BSSS095_STN_290_A1	03/05/2017	50.64869	1.100083	50.64804	1.099242	0.3	11
BSSS_CEND0617_BSSS100_STN_291_A1	03/05/2017	50.66202	1.136106	50.66138	1.135285	0.3	14

Table 9. Scientific 2 m beam trawl stations at Bassurelle Sandbank, showing the coordinates of start and end of line (SOL and EOL) in WGS1984 as well as vessel speed.

Event ID	Date	Latitude SOL	Longitude SOL	Latitude EOL	Longitude EOL	Vessel Speed Knots
BSSS_CEND0617_BSSS100_STN_001_A1	19/04/2017	50.6624861	1.136686	50.6633521	1.1384635	1
BSSS_CEND0617_BSSS100_STN_001_B1	19/04/2017	50.662407	1.1370434	50.6634076	1.1390689	1
BSSS_CEND0617_BSSS095_STN_002_A1	19/04/2017	50.6486028	1.1009434	50.6476415	1.0991434	1
BSSS_CEND0617_BSSS095_STN_002_B1	19/04/2017	50.6484592	1.1011255	50.6475283	1.0993297	1
BSSS_CEND0617_BSSS089_STN_003_A1	19/04/2017	50.6347569	1.0770703	50.6337349	1.0754688	1
BSSS_CEND0617_BSSS089_STN_003_B1	19/04/2017	50.6347673	1.0768212	50.6337201	1.075208	1
BSSS_CEND0617_BSSS088_STN_004_A1	19/04/2017	50.6284466	1.0958258	50.6274182	1.0941353	1
BSSS_CEND0617_BSSS088_STN_004_B1	19/04/2017	50.6277425	1.095496	50.6277425	1.095496	1
BSSS_CEND0617_BSSS084_STN_005_A1	19/04/2017	50.6209373	1.0890558	50.6194879	1.0885878	1
BSSS_CEND0617_BSSS084_STN_005_B1	19/04/2017	50.6207554	1.0895891	50.6193971	1.0890995	1
BSSS_CEND0617_BSSS079_STN_006_A1	19/04/2017	50.6138629	1.0583404	50.6123311	1.0582789	1
BSSS_CEND0617_BSSS079_STN_006_B1	19/04/2017	50.6138815	1.058817	50.6124515	1.0587802	1
BSSS_CEND0617_BSSS060_STN_007_A1	19/04/2017	50.5930421	1.0413665	50.5917798	1.0400321	1
BSSS_CEND0617_BSSS060_STN_007_B1	19/04/2017	50.5931687	1.0407735	50.5918825	1.0393859	1
BSSS_CEND0617_BSSS029_STN_008_A1	19/04/2017	50.5726929	1.0118913	50.5736728	1.0142007	1
BSSS_CEND0617_BSSS029_STN_008_B1	19/04/2017	50.5722476	1.0111874	50.5729857	1.0131589	1
BSSS_CEND0617_BSSS012_STN_009_A1	19/04/2017	50.5585395	0.9992263	50.5593028	1.0011979	1
BSSS_CEND0617_BSSS012_STN_009_B1	19/04/2017	50.5584251	0.9994758	50.5591403	1.0014574	1

BSSS_CEND0617_BSSS018_STN_010_A1	19/04/2017	50.5650794	0.9808246	50.5655963	0.9828907	1
BSSS_CEND0617_BSSS018_STN_010_B1	19/04/2017	50.5648225	0.9807246	50.565369	0.9829229	1
BSSS_CEND0617_BSSS038_STN_011_A1	20/04/2017	50.5788585	1.005008	50.578956	1.0073076	1
BSSS_CEND0617_BSSS038_STN_011_B2	20/04/2017	50.5791856	1.0054966	50.5790886	1.0034918	1
BSSS_CEND0617_BSSS058_STN_012_A1	20/04/2017	50.5929752	1.0171068	50.5919492	1.0157269	1
BSSS_CEND0617_BSSS058_STN_012_B1	20/04/2017	50.5928249	1.0173286	50.5918301	1.0158249	1
BSSS_CEND0617_BSSS073_STN_013_A1	20/04/2017	50.6070423	1.0294397	50.6060247	1.0274856	1
BSSS_CEND0617_BSSS073_STN_013_B1	20/04/2017	50.6070565	1.0300273	50.606106	1.0282434	1
BSSS_CEND0617_BSSS066_STN_014_A1	20/04/2017	50.5992512	0.997989	50.5983239	0.9963416	1
BSSS_CEND0617_BSSS066_STN_014_B1	20/04/2017	50.5991131	0.9984101	50.5981547	0.9966838	1
BSSS_CEND0617_BSSS064_STN_015_A1	20/04/2017	50.5988831	0.9731843	50.5996066	0.9707431	1
BSSS_CEND0617_BSSS064_STN_015_B1	20/04/2017	50.599149	0.9736327	50.5982459	0.9765555	1
BSSS_CEND0617_BSSS053_STN_016_A1	20/04/2017	50.5917891	0.9549139	50.5921098	0.9568217	1
BSSS_CEND0617_BSSS053_STN_016_B1	20/04/2017	50.591504	0.9551085	50.5917982	0.957187	1
BSSS_CEND0617_BSSS061_STN_017_A1	20/04/2017	50.5982802	0.9360986	50.5988657	0.9380846	1
BSSS_CEND0617_BSSS061_STN_017_B1	20/04/2017	50.5981088	0.936507	50.5987242	0.9385939	1
BSSS_CEND0617_BSSS042_STN_129_A1	22/04/2017	50.5843295	0.9368464	50.5852701	0.9379813	1
BSSS_CEND0617_BSSS042_STN_129_B1	22/04/2017	50.5843491	0.9372264	50.5855248	0.9386604	1
BSSS_CEND0617_BSSS032_STN_130_A1	22/04/2017	50.577774	0.9314996	50.5791892	0.9324094	1
BSSS_CEND0617_BSSS032_STN_130_B1	22/04/2017	50.5775696	0.9311998	50.5787422	0.9319241	1
BSSS_CEND0617_BSSS021_STN_131_A1	22/04/2017	50.5703736	0.9135601	50.5706068	0.9113712	1
BSSS_CEND0617_BSSS021_STN_131_B1	22/04/2017	50.570564	0.9135819	50.5707834	0.9115769	1
BSSS_CEND0617_BSSS006_STN_132_A1	22/04/2017	50.55732	0.9264513	50.5573054	0.9244293	1
BSSS_CEND0617_BSSS006_STN_132_B1	22/04/2017	50.5571281	0.9270578	50.5570745	0.9247136	1
BSSS_CEND0617_BSSS003_STN_133_A1	22/04/2017	50.5508027	0.9448033	50.5507891	0.9428239	1
BSSS_CEND0617_BSSS003_STN_133_B1	22/04/2017	50.550659	0.9448931	50.5506202	0.942801	1
BSSS_CEND0617_BSSS015_STN_134_A1	22/04/2017	50.5641575	0.9443691	50.5631608	0.9427263	1
BSSS_CEND0617_BSSS015_STN_134_B1	22/04/2017	50.5643413	0.9437632	50.5632686	0.9420712	1
BSSS_CEND0617_BSSS035_STN_135_A1	22/04/2017	50.5786192	0.9682437	50.5773804	0.9672044	1
BSSS_CEND0617_BSSS035_STN_135_B1	22/04/2017	50.5787416	0.9685668	50.5775364	0.9674396	1

BSSS_CEND0617_BSSS046_STN_136_A1	22/04/2017	50.501	0.9860439	50.5845214	0.9854049	1
BSSS_CEND0617_BSSS046_STN_136_B1	22/04/2017	50.5856719	0.9863326	50.584349	0.9856718	1

Table 10. 0.1m^2 Hamon Grab stations at Bassurelle Sandbank, showing the coordinates of each sample in WGS1984.

Event ID	Date	Latitude	Longitude
BSSS_CEND0617_BSSS099_STN_019_A1	20/04/2017	50.6555507	1.1310443
BSSS_CEND0617_BSSS098_STN_020_A1	20/04/2017	50.655373	1.1187874
BSSS_CEND0617_BSSS097_STN_021_A1	20/04/2017	50.6487361	1.1251217
BSSS_CEND0617_BSSS096_STN_022_A1	20/04/2017	50.6489499	1.1128646
BSSS_CEND0617_BSSS095_STN_023_A1	20/04/2017	50.6484784	1.1007707
BSSS_CEND0617_BSSS094_STN_024_A1	20/04/2017	50.6418012	1.1067205
BSSS_CEND0617_BSSS093_STN_025_A1	20/04/2017	50.6415488	1.0947213
BSSS_CEND0617_BSSS092_STN_026_A1	20/04/2017	50.6412501	1.0824524
BSSS_CEND0617_BSSS089_STN_027_A1	20/04/2017	50.6343916	1.0767516
BSSS_CEND0617_BSSS090_STN_028_A1	20/04/2017	50.6349712	1.0886393
BSSS_CEND0617_BSSS091_STN_029_A1	20/04/2017	50.634903	1.1013823
BSSS_CEND0617_BSSS088_STN_030_A1	20/04/2017	50.6281647	1.0950592
BSSS_CEND0617_BSSS087_STN_031_A1	20/04/2017	50.627722	1.083046
BSSS_CEND0617_BSSS086_STN_032_A1	20/04/2017	50.6275994	1.0707229
BSSS_CEND0617_BSSS086_STN_033_A1	20/04/2017	50.627188	1.0581902
BSSS_CEND0617_BSSS081_STN_034_A1	20/04/2017	50.6203273	1.052679
BSSS_CEND0617_BSSS082_STN_035_A1	20/04/2017	50.6207161	1.065061
BSSS_CEND0617_BSSS083_STN_036_A1	20/04/2017	50.6209047	1.0774261
BSSS_CEND0617_BSSS084_STN_037_A1	20/04/2017	50.6211034	1.0896449
BSSS_CEND0617_BSSS080_STN_038_A1	20/04/2017	50.6138137	1.0711956
BSSS_CEND0617_BSSS079_STN_039_A1	20/04/2017	50.6135468	1.058487
BSSS_CEND0617_BSSS078_STN_040_A1	20/04/2017	50.6136372	1.0461171
BSSS_CEND0617_BSSS077_STN_041_A1	20/04/2017	50.6132387	1.033988
BSSS_CEND0617_BSSS072_STN_042_A1	20/04/2017	50.6060961	1.0161411
BSSS_CEND0617_BSSS073_STN_043_A1	20/04/2017	50.6066282	1.0289696
BSSS_CEND0617_BSSS074_STN_044_A1	20/04/2017	50.6067935	1.0406024
BSSS_CEND0617_BSSS075_STN_045_A1	21/04/2017	50.6069783	1.0533143
BSSS_CEND0617_BSSS076_STN_046_A1	21/04/2017	50.6072378	1.0653022
BSSS_CEND0617_BSSS071_STN_047_A1	21/04/2017	50.6001664	1.0596242
BSSS_CEND0617_BSSS070_STN_048_A1	21/04/2017	50.5999722	1.0470667
BSSS_CEND0617_BSSS069_STN_049_A1	21/04/2017	50.5997075	1.0348495
BSSS_CEND0617_BSSS068_STN_050_A1	21/04/2017	50.5994331	1.0225068
BSSS_CEND0617_BSSS067_STN_051_A1	21/04/2017	50.5994493	1.0102879
BSSS_CEND0617_BSSS066_STN_052_A1	21/04/2017	50.5991572	0.998045
BSSS_CEND0617_BSSS065_STN_053_A1	21/04/2017	50.5989182	0.9857708
BSSS_CEND0617_BSSS064_STN_054_A1	21/04/2017	50.598651	0.9734998
BSSS_CEND0617_BSSS063_STN_055_A1	21/04/2017	50.5985041	0.9610861
BSSS_CEND0617_BSSS062_STN_056_A1	21/04/2017	50.5982642	0.9487794
BSSS_CEND0617_BSSS061_STN_057_A1	21/04/2017	50.5980408	0.9365241
BSSS_CEND0617_BSSS051_STN_058_A1	21/04/2017	50.5913821	0.9310025
BSSS_CEND0617_BSSS052_STN_059_A1	21/04/2017	50.5915048	0.9431121
BSSS_CEND0617_BSSS053_STN_060_A1	21/04/2017	50.5916776	0.955428
BSSS_CEND0617_BSSS054_STN_061_A1	21/04/2017	50.5919513	0.9677552
BSSS_CEND0617_BSSS055_STN_062_A1	21/04/2017	50.5923016	0.9800136

BSSS_CEND0617_BSSS056_STN_063_A1	21/04/2017	50.5927237	0.9926114
BSSS_CEND0617_BSSS057_STN_064_A1	21/04/2017	50.5926589	1.0046575
BSSS_CEND0617_BSSS058_STN_065_A1	21/04/2017	50.5927765	1.0170191
BSSS_CEND0617_BSSS059_STN_066_A1	21/04/2017	50.5931944	1.0295317
BSSS_CEND0617_BSSS060_STN_067_A1	21/04/2017	50.5933033	1.0418637
BSSS_CEND0617_BSSS061_STN_068_A1	21/04/2017	50.5861752	1.035473
BSSS_CEND0617_BSSS049 _STN_069_A1	21/04/2017	50.5859888	1.0230578
BSSS_CEND0617_BSSS048_STN_070_A1	21/04/2017	50.585935	1.01069
BSSS_CEND0617_BSSS047_STN_071_A1	21/04/2017	50.585628	0.9984867
BSSS_CEND0617_BSSS046_STN_072_A1	21/04/2017	50.5853663	0.9862932
BSSS_CEND0617_BSSS045_STN_073_A1	21/04/2017	50.5851144	0.9739376
BSSS_CEND0617_BSSS044_STN_074_A1	21/04/2017	50.5847782	0.9619095
BSSS_CEND0617_BSSS043_STN_075_A1	21/04/2017	50.5847756	0.9488067
BSSS_CEND0617_BSSS042_STN_076_A1	21/04/2017	50.584543	0.9369371
BSSS_CEND0617_BSSS041_STN_077_A1	21/04/2017	50.5841815	0.9246143
BSSS_CEND0617_BSSS031_STN_078_A1	21/04/2017	50.5773812	0.9185908
BSSS_CEND0617_BSSS032_STN_079_A1	21/04/2017	50.5776437	0.9312368
BSSS_CEND0617_BSSS033_STN_080_A1	21/04/2017	50.5778405	0.9431211
BSSS_CEND0617_BSSS034_STN_081_A1	21/04/2017	50.5779059	0.9555646
BSSS_CEND0617_BSSS035_STN_082_A1	21/04/2017	50.5783376	0.9680981
BSSS_CEND0617_BSSS036_STN_083_A1	21/04/2017	50.5786491	0.9806579
BSSS_CEND0617_BSSS037_STN_084_A1	21/04/2017	50.5787805	0.9926992
BSSS_CEND0617_BSSS038_STN_085_A1	21/04/2017	50.5789341	1.0051068
BSSS_CEND0617_BSSS039_STN_086_A1	21/04/2017	50.5792807	1.0173675
BSSS_CEND0617_BSSS040_STN_087_A1	21/04/2017	50.5794224	1.0296909
BSSS_CEND0617_BSSS030_STN_088_A1	21/04/2017	50.5721064	1.02344
BSSS_CEND0617_BSSS029_STN_089_A1	21/04/2017	50.5722444	1.011239
BSSS_CEND0617_BSSS028_STN_090_A1	21/04/2017	50.5720559	0.9990309
BSSS_CEND0617_BSSS027_STN_091_A1	21/04/2017	50.5718989	0.9866469
BSSS_CEND0617_BSSS026_STN_092_A1	21/04/2017	50.571679	0.9747026
BSSS_CEND0617_BSSS025_STN_093_A1	21/04/2017	50.5714762	0.9621067
BSSS_CEND0617_BSSS024_STN_094_A1	21/04/2017	50.5712694	0.9497846
BSSS_CEND0617_BSSS023_STN_095_A1	21/04/2017	50.571101	0.9374814
BSSS_CEND0617_BSSS022_STN_096_A1	21/04/2017	50.5708966	0.9254372
BSSS_CEND0617_BSSS021_STN_097_A1	21/04/2017	50.5707417	0.9132281
BSSS_CEND0617_BSSS013_STN_098_A1	21/04/2017	50.5639496	0.9196104
BSSS_CEND0617_BSSS014_STN_099_A1	21/04/2017	50.5641265	0.9319488
BSSS_CEND0617_BSSS015_STN_100_A1	21/04/2017	50.5645232	0.9442059
BSSS_CEND0617_BSSS016_STN_101_A1	21/04/2017	50.5646695	0.9567255
BSSS_CEND0617_BSSS017_STN_102_A1	21/04/2017	50.564837	0.9688947
BSSS_CEND0617_BSSS018_STN_103_A1	21/04/2017	50.5651146	0.9812554
BSSS_CEND0617_BSSS019_STN_104_A1	21/04/2017	50.5652746	0.9936683
BSSS_CEND0617_BSSS020_STN_105_A1	21/04/2017	50.5655415	1.0058077
BSSS_CEND0617_BSSS012_STN_106_A1	21/04/2017	50.5585093	0.999635
BSSS_CEND0617_BSSS011_STN_107_A1	21/04/2017	50.5582879	0.9874118
BSSS_CEND0617_BSSS010_STN_108_A1	21/04/2017	50.5580533	0.9752692

BSSS_CEND0617_BSSS009_STN_109_A1	21/04/2017	50.5578416	0.9628159
BSSS_CEND0617_BSSS008_STN_110_A1	21/04/2017	50.5576192	0.9505388
BSSS_CEND0617_BSSS007_STN_111_A1	21/04/2017	50.557411	0.9382766
BSSS_CEND0617_BSSS006_STN_112_A1	21/04/2017	50.5571754	0.9259898
BSSS_CEND0617_BSSS005_STN_113_A1	21/04/2017	50.5569522	0.9136794
BSSS_CEND0617_BSSS001_STN_114_A1	21/04/2017	50.5505445	0.9205973
BSSS_CEND0617_BSSS002_STN_115_A1	21/04/2017	50.5506232	0.9326917
BSSS_CEND0617_BSSS003_STN_116_A1	21/04/2017	50.5509018	0.945038
BSSS_CEND0617_BSSS004_STN_117_A1	21/04/2017	50.5509343	0.9571685
BSSS_CEND0617_BSSS010_STN_118_B1	21/04/2017	50.5580882	0.9750486
BSSS_CEND0617_BSSS010_STN_118_C1	21/04/2017	50.5580534	0.9750872
BSSS_CEND0617_BSSS010_STN_118_D1	21/04/2017	50.558091	0.9752232
BSSS_CEND0617_BSSS010_STN_118_E1	21/04/2017	50.5580718	0.9753721
BSSS_CEND0617_BSSS018_STN_119_B1	21/04/2017	50.565276	0.9811837
BSSS_CEND0617_BSSS018_STN_119_C1	21/04/2017	50.5651766	0.9810822
BSSS_CEND0617_BSSS018_STN_119_D1	21/04/2017	50.5651091	0.9810027
BSSS_CEND0617_BSSS018_STN_119_E1	21/04/2017	50.5650366	0.9809078
BSSS_CEND0617_BSSS019_STN_120_B1	21/04/2017	50.5652158	0.993943
BSSS_CEND0617_BSSS019_STN_120_C1	21/04/2017	50.5652556	0.9938027
BSSS_CEND0617_BSSS019_STN_120_D1	21/04/2017	50.5653073	0.9936866
BSSS_CEND0617_BSSS019_STN_120_E1	21/04/2017	50.5653389	0.9935406
BSSS_CEND0617_BSSS012_STN_121_B1	21/04/2017	50.558706	0.9993797
BSSS_CEND0617_BSSS012_STN_121_C1	21/04/2017	50.5586349	0.9994573
BSSS_CEND0617_BSSS012_STN_121_D1	21/04/2017	50.5585562	0.9995722
BSSS_CEND0617_BSSS012_STN_121_E1	21/04/2017	50.5584868	0.9996449
BSSS_CEND0617_BSSS029_STN_122_B1	21/04/2017	50.5722552	1.0107648
BSSS_CEND0617_BSSS029_STN_122_C1	21/04/2017	50.5722372	1.0109023
BSSS_CEND0617_BSSS029_STN_122_D1	21/04/2017	50.57222	1.011039
BSSS_CEND0617_BSSS029_STN_122_E1	21/04/2017	50.5722057	1.0111766
BSSS_CEND0617_BSSS079_STN_123_B1	21/04/2017	50.6625286	1.1369647
BSSS_CEND0617_BSSS079_STN_123_C1	21/04/2017	50.613772	1.0586717
BSSS_CEND0617_BSSS079_STN_123_D1	21/04/2017	50.6137648	1.0587884
BSSS_CEND0617_BSSS079_STN_123_E1	21/04/2017	50.6137449	1.0589339
BSSS_CEND0617_BSSS081_STN_124_B1	21/04/2017	50.6205314	1.0521334
BSSS_CEND0617_BSSS081_STN_124_C1	21/04/2017	50.6205009	1.0522805
BSSS_CEND0617_BSSS081_STN_124_D1	21/04/2017	50.6204767	1.0524237
BSSS_CEND0617_BSSS081_STN_124_E1	21/04/2017	50.6203871	1.0524235
BSSS_CEND0617_BSSS083_STN_125_B1	21/04/2017	50.6209333	1.0764247
BSSS_CEND0617_BSSS083_STN_125_C1	21/04/2017	50.6209382	1.0765745
BSSS_CEND0617_BSSS083_STN_125_D1	21/04/2017	50.6209152	1.0766953
BSSS_CEND0617_BSSS083_STN_125_E1	21/04/2017	50.6209288	1.0768364
BSSS_CEND0617_BSSS084_STN_126_B1	21/04/2017	50.6212225	1.0890034
BSSS_CEND0617_BSSS084_STN_126_C1	21/04/2017	50.6212025	1.0891327
BSSS_CEND0617_BSSS084_STN_126_D1	21/04/2017	50.6211962	1.0892762
BSSS_CEND0617_BSSS084_STN_126_E1	21/04/2017	50.6211694	1.0894153
BSSS_CEND0617_BSSS089_STN_127_B1	22/04/2017	50.6341896	1.076364

BSSS_CEND0617_BSSS089_STN_127_C1	22/04/2017	50.6342603	1.0762422
BSSS_CEND0617_BSSS089_STN_127_D1	22/04/2017	50.6343163	1.0761372
BSSS_CEND0617_BSSS089_STN_127_E1	22/04/2017	50.6343745	1.076033
BSSS_CEND0617_BSSS100_STN_128_B1	22/04/2017	50.6624316	1.1365167

Table 11. Drop camera sampling stations at Wight-Barfleur Reef, showing the coordinates of start and end of line (SOL and EOL) in WGS1984 as well as vessel speed and number of still images taken on each tow.

Event ID	Date	Latitude SOL	Longitude SOL	Latitude EOL	Longitude EOL	Vessel Speed Knots	Number Of Stills
WBRF_CEND0617_F12_STN_143_A1	24/04/2017	50.2486126	-1.4540161	50.2487331	-1.4525356	0.3	13
WBRF_CEND0617_F06_STN_144_A1	24/04/2017	50.2635019	-1.4387822	50.262657	-1.4392119	0.3	20
WBRF_CEND0617_F10_STN_145_A1	24/04/2017	50.2595604	-1.441528	50.2582543	-1.4424479	0.3	44
WBRF_CEND0617_F05_STN_147_A1	24/04/2017	50.2711437	-1.4472852	50.2720587	-1.4466378	0.3	25
WBRF_CEND0617_F14_STN_148_A1	24/04/2017	50.260351	-1.4541433	50.2602872	-1.4563281	0.3	30
WBRF_CEND0617_F04_STN_149_A1	24/04/2017	50.2572471	-1.4605393	50.2565817	-1.4614485	0.3	18
WBRF_CEND0617_F03_STN_150_A1	24/04/2017	50.2559478	-1.4876433	50.2559773	-1.4891819	0.3	20
WBRF_CEND0617_F01_STN_151_A1	24/04/2017	50.2564009	-1.5023531	50.2561194	-1.5039676	0.3	19
WBRF_CEND0617_F02_STN_152_A1	24/04/2017	50.2616359	-1.5090131	50.261758	-1.5076857	0.3	19
WBRF_CEND0617_F13_STN_153_A1	24/04/2017	50.2676406	-1.511384	50.2685222	-1.5111383	0.3	18
WBRF_CEND0617_F07_STN_154_A1	24/04/2017	50.2707834	-1.4998378	50.2699354	-1.4983555	0.3	24
WBRF_CEND0617_F08_STN_155_A1	24/04/2017	50.2708507	-1.4915371	50.2706518	-1.4899343	0.3	18
WBRF_CEND0617_F09_STN_156_A1	24/04/2017	50.2646214	-1.4894715	50.2637217	-1.4902204	0.3	18
WBRF_CEND0617_F11_STN_157_A1	24/04/2017	50.2710785	-1.4712976	50.2703568	-1.4719942	0.3	16
WBRF_CEND0617_E06_STN_164_A1	26/04/2017	50.2347135	-1.1810435	50.2339201	-1.1805126	0.3	16
WBRF_CEND0617_E04_STN_165_A1	26/04/2017	50.2378498	-1.168376	50.2369237	-1.1687796	0.3	18
WBRF_CEND0617_E05_STN_166_A1	26/04/2017	50.2275881	-1.1634153	50.2278165	-1.1646537	0.3	14
WBRF_CEND0617_E02_STN_167_A1	26/04/2017	50.2200019	-1.1688004	50.2208974	-1.1685235	0.3	13
WBRF_CEND0617_E07_STN_168_A2	26/04/2017	50.2196002	-1.1771873	50.2194963	-1.178509	0.3	12
WBRF_CEND0617_E01_STN_169_A1	26/04/2017	50.218026	-1.1813011	50.2171973	-1.1811402	0.3	15
WBRF_CEND0617_E08_STN_170_A1	26/04/2017	50.2122069	-1.1671413	50.2119887	-1.1658538	0.3	13
WBRF_CEND0617_E13_STN_171_A1	26/04/2017	50.2263465	-1.1489558	50.2267064	-1.1500761	0.3	22
WBRF_CEND0617_E03_STN_172_A1	26/04/2017	50.223875	-1.1433041	50.2234587	-1.1420518	0.3	17
WBRF_CEND0617_E12_STN_173_A1	26/04/2017	50.2332279	-1.1335366	50.2324675	-1.1326358	0.3	24
WBRF_CEND0617_E15_STN_174_A1	26/04/2017	50.2266002	-1.127496	50.226111	-1.1286636	0.3	24
WBRF_CEND0617_E10_STN_175_A1	26/04/2017	50.2319879	-1.1092846	50.2311012	-1.1086293	0.3	16
WBRF_CEND0617_E11_STN_176_A1	26/04/2017	50.2252156	-1.113077	50.2252522	-1.11433	0.3	12

WBRF_CEND0617_E09_STN_177_A1	27/04/2017	50.216828	-1.1138034	50.2174746	-1.1127806	0.3	17
WBRF_CEND0617_D04_STN_180_A1	27/04/2017	50.3258015	-1.2156573	50.324799	-1.2152462	0.3	26
WBRF_CEND0617_D13_STN_181_A1	27/04/2017	50.3182957	-1.2117498	50.3173847	-1.2109744	0.3	28
WBRF_CEND0617_D03_STN_182_A1	27/04/2017	50.3147496	-1.2090827	50.3140785	-1.2082199	0.3	22
WBRF_CEND0617_D06_STN_183_A1	27/04/2017	50.3036101	-1.2017039	50.3036432	-1.2002115	0.3	31
WBRF_CEND0617_D12_STN_184_A1	27/04/2017	50.3074847	-1.2178106	50.3066923	-1.2170545	0.3	28
WBRF_CEND0617_D05_STN_185_A2	27/04/2017	50.3067475	-1.2300831	50.3059723	-1.2291778	0.3	17
WBRF_CEND0617_D07_STN_186_A1	27/04/2017	50.3159852	-1.2276243	50.3157104	-1.228954	0.3	20
WBRF_CEND0617_D15_STN_187_A1	27/04/2017	50.3196206	-1.2310667	50.319624	-1.2296397	0.3	15
WBRF_CEND0617_D02_STN_188_A1	27/04/2017	50.32616	-1.2413087	50.3261582	-1.2427314	0.3	12
WBRF_CEND0617_D11_STN_189_A1	27/04/2017	50.3276596	-1.2651716	50.3276709	-1.2666493	0.3	16
WBRF_CEND0617_D10_STN_190_A2	27/04/2017	50.3267646	-1.2702557	50.3262621	-1.2691636	0.3	25
WBRF_CEND0617_D09_STN_191_A1	27/04/2017	50.3072952	-1.2643626	50.3074209	-1.2628105	0.3	30
WBRF_CEND0617_D01_STN_192_A1	27/04/2017	50.3101618	-1.2494029	50.3099133	-1.2482155	0.3	12
WBRF_CEND0617_D08_STN_193_A1	27/04/2017	50.31669	-1.2528135	50.3167556	-1.2542908	0.3	15
WBRF_CEND0617_D14_STN_194_A1	27/04/2017	50.319376	-1.2581158	50.3201946	-1.2576549	0.3	14
WBRF_CEND0617_A01_STN_205_A1	30/04/2017	50.3076513	-1.8136664	50.3076929	-1.8150894	0.3	32
WBRF_CEND0617_A04_STN_206_A1	30/04/2017	50.3134239	-1.8303664	50.3144664	-1.830363	0.3	34
WBRF_CEND0617_A10_STN_207_A1	30/04/2017	50.3310773	-1.8280762	50.3311278	-1.8263517	0.3	22
WBRF_CEND0617_A05_STN_208_A1	30/04/2017	50.3196331	-1.8316579	50.320801	-1.8313456	0.3	23
WBRF_CEND0617_A06_STN_209_A1	30/04/2017	50.3196239	-1.8081181	50.3205576	-1.8078843	0.3	17
WBRF_CEND0617_A07_STN_210_A1	30/04/2017	50.3301737	-1.791083	50.3295073	-1.7901773	0.3	15
WBRF_CEND0617_A12_STN_211_A1	30/04/2017	50.329954	-1.7825501	50.330785	-1.7825035	0.3	14
WBRF_CEND0617_A03_STN_212_A1	30/04/2017	50.3162584	-1.7854987	50.3170983	-1.7852866	0.3	15
WBRF_CEND0617_A02_STN_213_A1	30/04/2017	50.3092057	-1.788379	50.3092513	-1.7897564	0.3	12
WBRF_CEND0617_A11_STN_214_A1	30/04/2017	50.3131801	-1.7702671	50.3128101	-1.7690889	0.3	17
WBRF_CEND0617_A09_STN_215_A1	30/04/2017	50.3208546	-1.7717911	50.3202766	-1.7706209	0.3	20
WBRF_CEND0617_A13_STN_216_A1	30/04/2017	50.3198531	-1.7573903	50.3198475	-1.7559436	0.3	20
WBRF_CEND0617_A08_STN_217_A1	30/04/2017	50.3131087	-1.7604541	50.3132336	-1.7587691	0.3	36
WBRF_CEND0617_B09_STN_218_A1	01/05/2017	50.232288	-1.7255569	50.2312642	-1.7255375	0.3	28

WBRF_CEND0617_B01_STN_219_A1	01/05/2017	50.2189097	-1.7185261	50.2189058	-1.717078	0.3	15
WBRF_CEND0617_B12_STN_220_A1	01/05/2017	50.2218031	-1.7127711	50.2206135	-1.7128438	0.3	18
WBRF_CEND0617_B02_STN_221_A1	01/05/2017	50.2183784	-1.7067424	50.2184151	-1.7052279	0.3	12
WBRF_CEND0617_B06_STN_222_A1	01/05/2017	50.223602	-1.6949816	50.2237829	-1.6935399	0.3	12
WBRF_CEND0617_B03_STN_223_A1	01/05/2017	50.2311698	-1.6953994	50.2310942	-1.6939531	0.3	11
WBRF_CEND0617_B11_STN_224_A2	01/05/2017	50.2333227	-1.6798449	50.2341992	-1.6790472	0.3	19
WBRF_CEND0617_B07_STN_225_A1	01/05/2017	50.2373113	-1.6739491	50.2365123	-1.6741922	0.3	25
WBRF_CEND0617_B10_STN_226_A1	01/05/2017	50.2371313	-1.6591644	50.2363062	-1.659461	0.3	16
WBRF_CEND0617_B04_STN_227_A1	01/05/2017	50.2301114	-1.6609462	50.2304975	-1.6623999	0.3	26
WBRF_CEND0617_B05_STN_228_A1	01/05/2017	50.2283573	-1.6638671	50.2285187	-1.6651354	0.3	16
WBRF_CEND0617_B08_STN_229_A1	01/05/2017	50.2179991	-1.6674712	50.2182276	-1.6694444	0.3	32
WBRF_CEND0617_B13_STN_230_A1	01/05/2017	50.2136782	-1.6803518	50.212554	-1.6799626	0.3	30
WBRF_CEND0617_C01_STN_231_A2	01/05/2017	50.1879471	-1.5803753	50.1872943	-1.5796198	0.3	11
WBRF_CEND0617_C11_STN_232_A1	01/05/2017	50.1750738	-1.5862244	50.1747495	-1.5850286	0.3	15
WBRF_CEND0617_C10_STN_233_A1	01/05/2017	50.1678942	-1.5811619	50.1673682	-1.5824523	0.3	18
WBRF_CEND0617_C04_STN_234_A1	01/05/2017	50.1793521	-1.5688866	50.1801686	-1.5693082	0.3	16
WBRF_CEND0617_C06_STN_235_A1	01/05/2017	50.1823807	-1.5604694	50.1814988	-1.5602118	0.3	20
WBRF_CEND0617_C08_STN_236_A1	01/05/2017	50.180559	-1.5493728	50.1796786	-1.5493849	0.3	22
WBRF_CEND0617_C07_STN_237_A1	01/05/2017	50.1753797	-1.5498175	50.1753086	-1.5484533	0.3	22
WBRF_CEND0617_C03_STN_238_A1	01/05/2017	50.1846149	-1.5394545	50.1837307	-1.5394855	0.3	19
WBRF_CEND0617_C02_STN_239_A1	01/05/2017	50.1873623	-1.5336917	50.1880374	-1.5347784	0.3	23
WBRF_CEND0617_C12_STN_240_A1	01/05/2017	50.1716745	-1.5173072	50.1713343	-1.5186246	0.3	17
WBRF_CEND0617_C05_STN_241_A1	01/05/2017	50.1751843	-1.5140466	50.1758838	-1.514727	0.3	16
WBRF_CEND0617_C09_STN_242_A1	01/05/2017	50.1813779	-1.5150267	50.1805349	-1.5160577	0.3	25
WBRF_CEND0617_C13_STN_243_A1	01/05/2017	50.1946893	-1.5224841	50.1950914	-1.5238012	0.3	17

Appendix 4. Power analysis

Power analyses were conducted on sample data previously collected at Wight-Barfleur Reef and Bassurelle Sandbank in 2013 on the cruise CEND0313 (Barrio-Frojan *et al.,* in press; Barrio-Frojan *et al.* 2017) to help determine the number of samples that would be required from each site to form a Type 1 monitoring dataset. The existing infaunal data at Bassurelle Sandbank was collected using a mini Hamon Grab in 2013. Epifaunal data at Wight-Barfleur Reef was collected from dropdown SD video tows in 2013. Analyses were conducted in R using the EMON package to determine the number of samples required to detect 20% change in taxonomic richness with a power of 0.8, in accordance with guidance on statistical significance and power (Noble-James *et al*. 2017).

Bassurelle Sandbank

Initial results of the power analyses at 20% and 30% change suggested that the number of samples required for both abundance and taxa richness would be impractically high for the scope of the present survey due to high levels of variability. It should be noted that these biodiversity metrics were used in lieu of more fully validated indicators for habitat monitoring and the power analysis is therefore intended as a guide. Guidance by Noble-James *et al.* (2017) suggests reducing power or level of change if the originally desired levels require an unachievable number of samples to detect.

Power analysis was re-run at 40% change, which recommended collecting 100 samples (Table 12). A triangular sample grid of 100 stations was created within the site, using a 50m buffer from the site boundary (Figure 4).

Table 12. Power analysis results using infaunal data from the CEN0313 to Bassurelle Sandbank SAC**.**

	All sediments		**All sediments**
No. Samples	**Power (40% change) – taxa richness**	**No. Samples**	**Power (40% change) – taxa richness**
20	0.265	90	0.779
25	0.335	95	0.787
30	0.363	**100**	**0.828**
35	0.423	105	0.821
40	0.433	110	0.853
45	0.478	115	0.881
50	0.566	120	0.878
55	0.538	125	0.897
60	0.585	130	0.901
65	0.607	135	0.93
70	0.633	140	0.919
75	0.71	145	0.927
80	0.727	150	0.939
85	0.752		

Few epifaunal trawl data are available for Bassurelle Sandbank, with the 2013 JNCC/Cefas survey sampling three trawl stations for qualitative purposes in 2013. To carry out power analyses for this element of the survey, data from another sandbank site, Dogger Bank cSAC\SCI 2014 survey CEND1014 (Ware & McIlwaine 2015), were used as a proxy. This analysis proposes that 25 trawl stations are required to detect a 40% change in taxa richness (Table 13). A higher amount of change would have required an unfeasible number of samples.

Table 13. Power analysis results using epifaunal trawl data from the CEND1014 survey to Dogger Bank cSAC/SCI as a proxy for Bassurelle Sandbank SAC.

	Predicted number of camera transects required to detect change with a power of 0.8 and significance of 0.05							
	Richness				Abundance			
	20% change	30% change	40% change	50% change	20% change	30% change	40% change	50% change
All habitats combined	80	40	**25**	20	195	90	50	35

Wight-Barfleur Reef

The number of stations required to detect a 20% level of change in taxa richness with a power of 0.8 or higher at Wight-Barfleur Reef is presented in Table 14. An assessment of the available Broadscale Habitat map (
Figure **3**) suggested that reliably stratifying sampling to target the designated feature would be difficult to achieve due to the apparent heterogeneity in substrata across the site. The analysis therefore combined data from across the habitats present. Seventy 100m video tows were suggested as a suitable number of camera tows required to detect a 20% change in species richness with a power of 0.8. Due to the large size of the site, these samples will be allocated within a series of six nested boxes (Figure 5). As the number of proposed tows is not neatly divisible by the number of boxes, the number was rounded up to 78 (13 tows per box).

Table 14. Power analysis results using epifaunal data from the CEND0313 survey to Wight-Barfleur Reef SAC.

Sediment Type	Predicted number of camera transects required to detect change with a power of 0.8 and significance of 0.05	
	Taxa Richness	
	20% change	30% change
Circalittoral Rock (A4.1 & A4.2)	55	25
Coarse Sediment (A5.1)	95	45
All habitats combined (including A5.6 biogenic reef)	**70**	25

McIlwaine, P., Albrecht, J. & Nelson, M. (2020). CEND0617 Cruise Report: Monitoring Survey of Bassurelle Sandbank SAC and Wight-Barfleur Reef SAC. JNCC/Cefas Partnership Report No. 27. JNCC, Peterborough, ISSN 2051-6711.