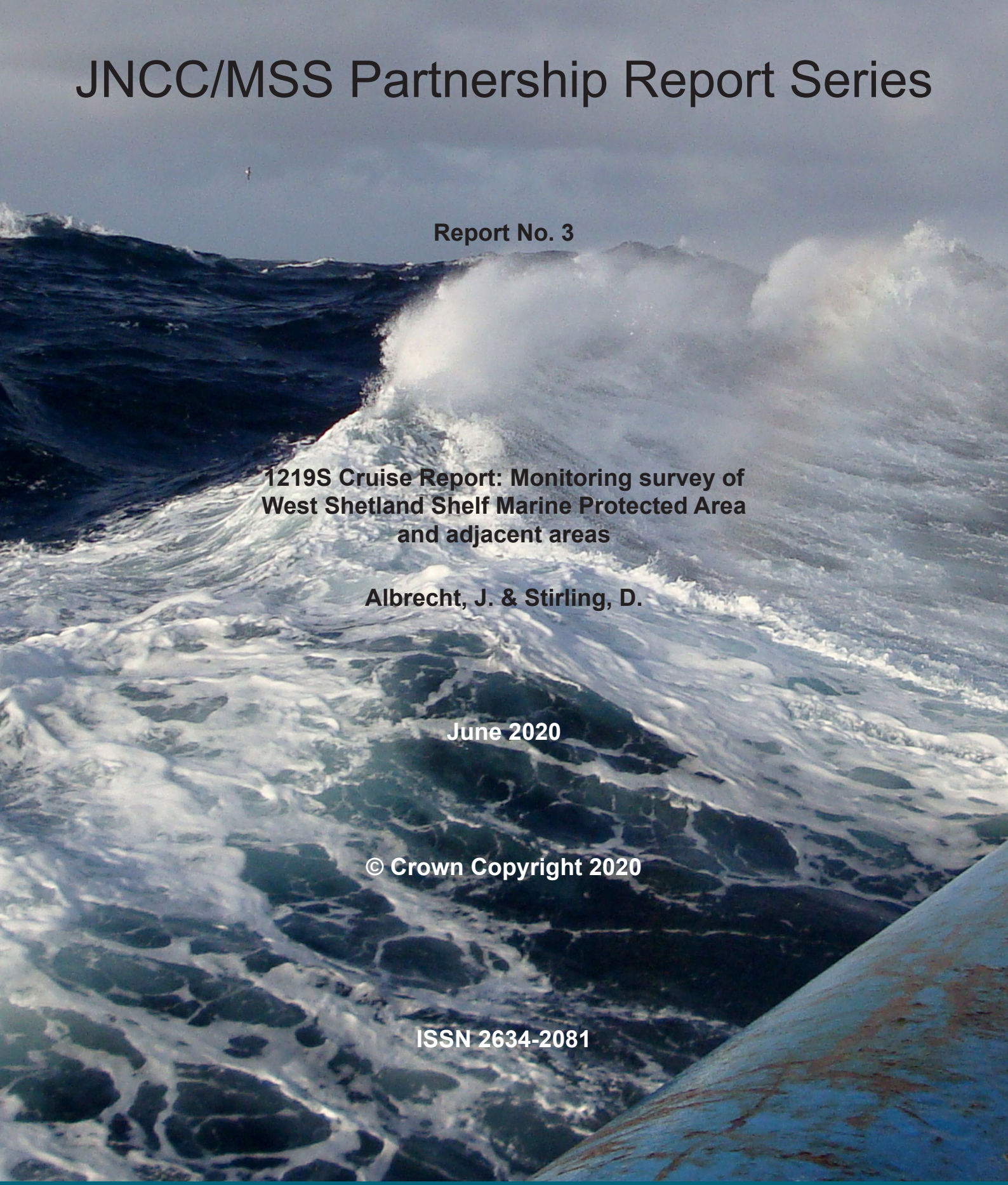

JNCC/MSS Partnership Report Series

Report No. 3

1219S Cruise Report: Monitoring survey of West Shetland Shelf Marine Protected Area and adjacent areas

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Executive summary

The Joint Nature Conservation Committee (JNCC) and Marine Scotland Science (MSS) undertook a seabed monitoring survey of West Shetland Shelf Nature Conservation Marine Protected Area (hereafter referred to as WSS) and adjacent areas between the 26 August and 11 September 2019, aboard the MRV *Scotia*.

The aim of the 1219S survey was to acquire a robust initial monitoring dataset that will contribute to the development of a monitoring time-series for WSS, against which the rate and direction of any change in the condition of the MPA features can be assessed. Repeated surveys will allow the long-term variability in any parameters measured to be quantified over time. Further, this dataset will help to determine the effectiveness of any management measures that may be implemented. Data from this survey will form part of a monitoring time series, and future repeated monitoring and evidence gathering will be required to fully investigate and understand the long-term variability in any parameters measured. By also collecting data from areas outside the WSS boundary, it may be possible to determine whether any observed change is due to management measures applied within the site, or a more widespread trend in a Before/After/Control/Impact study.

In total, 116 0.1m^2 Hamon grab samples (PSA and infauna), two 0.25m^2 Hamon grab samples (PSA and infauna), 119 drop-camera transects (still images and video footage), and 140.1km^2 of multibeam echosounder (bathymetry and backscatter) data, including areas of search for two wrecks of historical interest, were collected on the survey. Specimens were also obtained for the Natural History Museum and the National Museums of Scotland (from 18 and 14 grab samples, respectively).

Please note that observations made in this Cruise Report represent preliminary field observations. These observations have not been subject to JNCC's Evidence Quality Assurance procedures. Please refer to the Final Report for this survey for Quality Assured evidence. This disclaimer should be included when referencing this Cruise Report.

Contents

1. Introduction

The Joint Nature Conservation Committee (JNCC) and Marine Scotland Science (MSS) undertook a seabed monitoring survey of West Shetland Shelf Nature Conservation Marine Protected Area (hereafter referred to as WSS) and adjacent areas between the 26 August and 11 September 2019, aboard the Marine Research Vessel (MRV) *Scotia*. This report describes the survey activities undertaken.

In total 116 0.1m^2 Hamon grab samples (PSA and infauna), two 0.25m^2 Hamon grab samples (PSA and infauna), 119 drop-camera transects (still images and video), and 140.1km^2 of multibeam echosounder (bathymetry and backscatter) data were collected. Specimens were obtained for the Natural History Museum from 18 grab samples and for the National Museums of Scotland from 14 grab samples.

The survey team for the duration of the cruise included marine scientists, acousticians, and engineers from the Joint Nature Conservation Committee, Marine Scotland Science, and the National Museums of Scotland. Twelve-hour shift patterns were followed during the survey with a night shift (00:00-12:00) and a day shift (12:00-24:00). One TV engineer participated in this survey and camera operations were only possible during their shift.

WSS was designated as a Nature Conservation MPA in July 2014 to protect the Offshore Subtidal Sands and Gravels habitat feature (OSSG). The site has an area of 4,083km^2, a depth range of 70 - 150m, and is located to the north of Scotland in offshore waters (Figure 1). More information on WSS can be found in the JNCC site information centre[1]. WSS is encompassed by the windsock fisheries area, which prohibited bottom trawling from 1 January 2004 – 14 August 2019 as part of a recovery plan for cod in the west of Scotland (Council Regulation (EC) No 2287, 2003; Regulation (EU) 2019/1241, 2019) (Figure 1). The windsock fisheries area was also closed for a shorter period between the 8 March and 30 April 2001 (Commission Regulation (EC) No 456/2001, 2001). Subsequent to its re-opening in 2019, an agreement between trawl and creel fishers operating in the area came into effect on the 14 August 2019. This agreement divided the WSS MPA into three areas, one area where only trawl fishers would operate, one area where only creel fishers would operate, and one joint access area where both trawl fishers and creel fishers could operate (Figure 2).

[1] West Shetland Shelf MPA site information centre (accessed October 2019). http://archive.jncc.gov.uk/page-6491

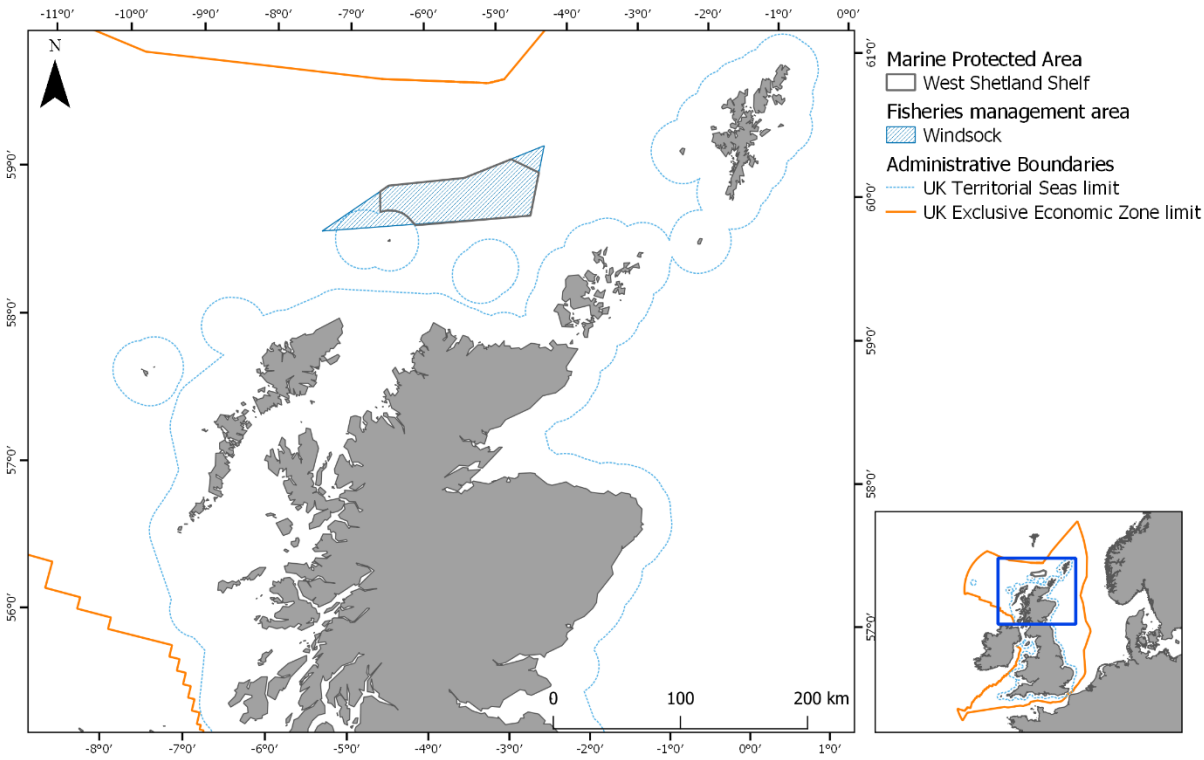


Figure 1. Map showing boundaries of West Shetland Shelf and the Windsock fisheries management area (now removed) and their location within the UK's Exclusive Economic Zone.

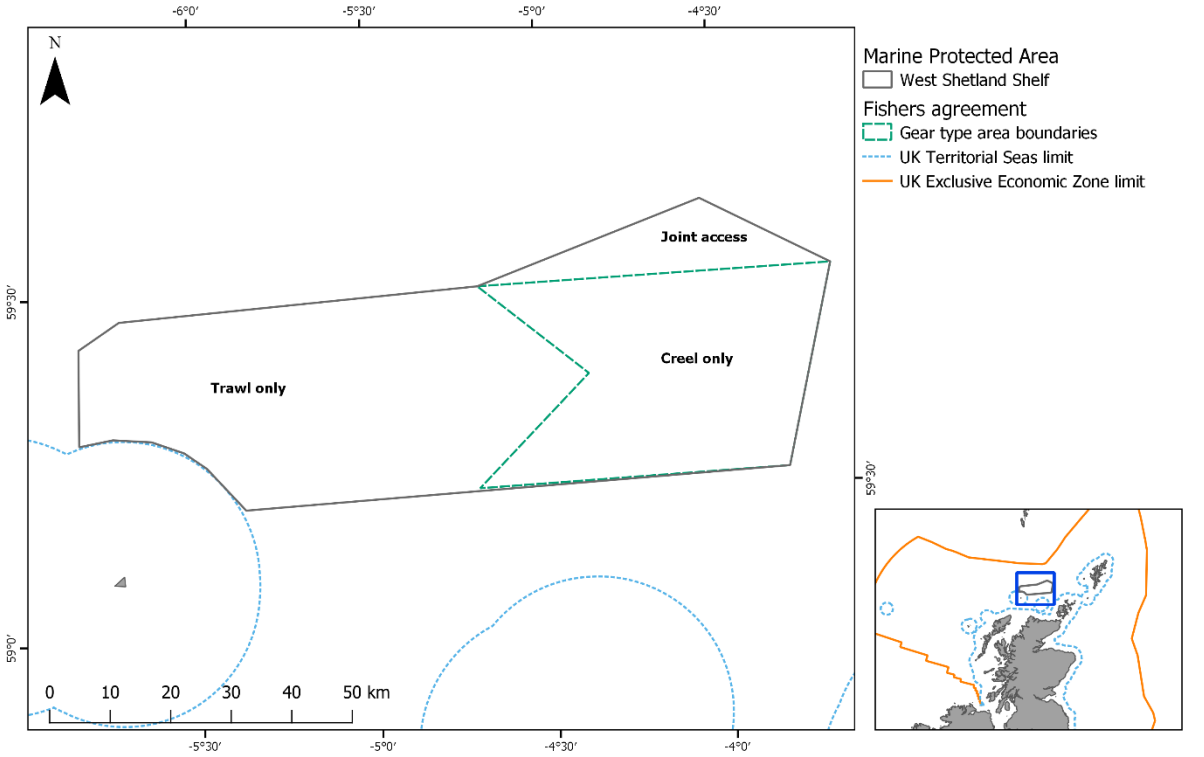


Figure 2. Map showing fishers agreement on gear use within the WSS MPA after the removal of the Windsock fisheries management area.

2. Aims and objectives

2.1. Aims

The aim of the 1219S survey was to acquire an initial, robust sentinel monitoring (Type One, Table 1) dataset within WSS to contribute to the development of a monitoring time-series for the site. The rate and direction of any change in the condition of the MPA features can be inferred against this baseline in the long term. This dataset was collected to further help detect the effectiveness of management measures that may be implemented. Data from this survey was collected to form part of a monitoring time series, and future repeated monitoring and evidence gathering will be required to fully investigate and understand the long-term variability in any parameters measured.

Data was also collected from outside WSS to investigate the feasibility of operational (Type Two) and investigative (Type Three) monitoring (Table 1). These types of monitoring require comparable seabed habitats inside and outside WSS, which was not possible to confirm with the data available before the survey. While efforts were made during the survey to select similar areas, based on remote sensing, the data will be reviewed post survey and if the areas sampled outside WSS serve as suitable control sites for the areas within WSS, then they could be used for an operational (Type Two) study or form the first point in an investigative (Type Three) monitoring timeseries (e.g. a Before/After/Control/Impact (BACI) study).

Table 1. The three monitoring types described by Kröger and Johnston (2016).

Definition of monitoring types
Sentinel monitoring of long-term trends (Type One monitoring) – Objective: to measure rate and direction of long-term change. This type of monitoring provides the context to distinguish directional trends from small-scale variability in space and time by representing variability across space at any one time and documenting changes over time. To achieve this objective efficiently, a long-term commitment to regular and consistent data collection is necessary; this means time-series must be established as their power in identifying trends is far superior to any combination of independent studies.
Operational monitoring of pressure-state relationships (Type Two monitoring) – Objective: to measure state and relate observed change to possible causes. This objective complements monitoring long-term trends and is best suited to explore the likely impacts of pressures on habitats and species and identify emerging problems. It leads to the setting of hypotheses about processes underlying observed patterns. It relies on finding relationships between observed changes in biodiversity and observed variability in pressures and environmental factors. It provides inference, but it is not proof of cause and effect. The spatial and temporal scale for this type of monitoring activity will require careful consideration of the reality on the ground to ensure inference will be reliable; for example, inference will be poor in situations where the presence of a pressure is consistently correlated to the presence of an environmental driver (e.g. a specific depth stratum).
Investigative monitoring to determine management needs and effectiveness (Type Three monitoring) – Objective: to investigate the cause of change. This monitoring type provides evidence of causality. It complements the above types by testing specific hypotheses through targeted manipulative studies. The design and statistical approach that can be used in these cases gives confidence in identifying cause and effect. It is best suited to test state/pressure relationships and the efficacy of management measures.

2.2. Monitoring objectives

Monitoring objectives for 1219S are to:

1. Collect evidence to inform the physical extent and distribution of the OSSG feature within WSS

2. Collect evidence to inform the extent and distribution of biological communities associated with the OSSG feature within WSS

3. Collect evidence to inform the physical extent and distribution of the OSSG feature outside WSS

4. Collect evidence to inform the extent and distribution of biological communities associated with the OSSG feature outside WSS

5. Collect evidence to inform on small-scale variability within the physical and biological structure of OSSG within WSS

2.3. Survey objectives

The monitoring objectives have been used to inform 12 prioritised survey objectives (Table 2). These survey objectives take into consideration the logistics of acquiring the samples as described in Section 3.

Survey objectives 1-5 have been developed to address the monitoring objectives (section 2.2). Note that because a nested box survey design has been chosen (see Section 3 for more detail), survey objectives should be considered on a survey box basis (i.e. fewer boxes with multibeam, imagery and grabs were considered preferable to more boxes with data from fewer survey methods).

In addition to the monitoring objectives, survey objectives 6 and 7 have been developed to characterise the site and specifically address the output of a habitat map as part of monitoring objective 1 and 3 (Section 2.2). These survey objectives provide useful information that could be used for the planning of future monitoring surveys.

Survey objectives 8 - 12 are opportunistic, or contingency survey activities. These survey objectives were only undertaken if there was an opportunity and enough time to do so.

All survey objectives are listed in priority order, with a description of the extent to which the objective was completed during the survey (Table 2).

Table 2. Prioritised survey objectives and description of the extent each objective was addressed during 1219S.

Survey objective code	Survey objective description	Monitoring objective being addressed	Equipment	Priority	Rationale for priority	Survey objective completed
1.	Acquire drop camera stills and imagery for monitoring	1, 2, 3, and 4	Drop-frame camera	1	Addresses monitoring objective(s) Video used to assess grab sampling suitability at each station	Completed at Boxes A, B, and D. 25 initial stations completed at Box F, however seven extra stations were only grab sampled. 17 stations completed at Box C
2.	Acquire 0.1m^2 Hamon grab samples from a subset of monitoring camera stations.	1, 2, 3, and 4	0.1m^2 Hamon grab (0.25m^2 Hamon grab)	2	Addresses monitoring objective A subset of stations identified based on assessment of video	Completed at Boxes A, B, C, D, and F Extra stations completed at Boxes C and F
3.	Acquire and process full coverage multibeam (bathymetry and backscatter) from survey Boxes B and D (predicted to be coarse sediment). If time is available also acquire multibeam from Boxes E and G	1 and 3	Multibeam	3	Addresses monitoring objective through production of habitat map outputs used to stratify imagery and grab stations	Completed at Boxes B and D (full coverage). Additional multibeam lines at Box C (not full coverage)
4.	Increase replication at three 0.1m^2 Hamon grab sampling stations for monitoring. Applies to boxes predicted to	5	0.1m^2 Hamon grab (0.25m^2	4	Addresses monitoring objective A subset of stations based on survey objective 2	Completed at all sand boxes visited (Boxes A, C, and F)

Survey objective code	Survey objective description	Monitoring objective being addressed	Equipment	Priority	Rationale for priority	Survey objective completed
	have sand substrate (Boxes A, C, and F)		Hamon grab)			
5.	Increase replication at one drop-camera stills and video stations for monitoring. Applies to boxes predicted to have coarse substrate (Boxes B, D, E and G)	5	Drop-frame camera	5	Addresses monitoring objective A subset of stations based on survey objective 1	Completed at one of the two coarse boxes visited (Box D)
6.	Acquire drop camera stills and imagery for ground-truthing	1 and 3	Drop-frame camera	6	Addresses monitoring objective Is not critical to produce habitat maps but will improve habitat map quality. Video used to assess grab sampling suitability at each station Only applicable to boxes with processed acoustic data.	Not Completed
7.	Acquire 0.1m^2 Hamon grab samples from a subset of ground-truthing camera stations.	1 and 3	0.1m^2 Hamon grab	7	Addresses monitoring objective Is not critical to produce habitat maps but will improve habitat map quality. Only applicable to boxes with processed acoustic data.	Not completed

Survey objective code	Survey objective description	Monitoring objective being addressed	Equipment	Priority	Rationale for priority	Survey objective completed
8.	Acquire DNA and museum specimen samples from Hamon grab samples	NA	0.1m^2 or 0.25m^2 Hamon grab	Opportunistic	Opportunistic DNA samples can be collected from invalid grab samples	Completed at all boxes
9.	Sample an additional survey box inside WSS	1 and 2	Drop-frame camera 0.1m^2 Hamon grab multibeam	Contingency	Contingency work if time and VMS data was available	Not completed as contingency work was not required
10.	Acquire drop-camera and 0.1m^2 Hamon grab samples from the wider WSS MPA	1 and 2	Drop-frame camera and/or 0.1m^2 Hamon grab	Contingency	Contingency work, if no multibeam data was collected and there was time available at end of survey	Not completed as contingency work was not required
11.	Acquire Van Veen grab samples from a subset of camera stations	NA	Hamon grab and Van Veen grab	Contingency	Contingency work for Hamon/Van Veen comparison study Invalid samples can be kept for DNA analysis	Completed using a 0.25m^2 Hamon grab instead of a Van Veen at two stations.
12.	Calibrate acoustic equipment using a wreck of interest to Historic Environment Scotland	NA	Multibeam	Contingency		Completed

3. Sampling strategy and methods

The sampling design and methods aim to address the survey objectives set out in Table 2.

For the duration of the cruise daily Vessel Monitoring System (VMS) updates were provided by MSS for the former Windsock area. This information was used to inform which areas of WSS had been fished at the time of sampling and to potentially update the survey plan whilst at sea accordingly.

3.1. Sampling design

3.1.1. Survey boxes

Due to the large area and depth range of WSS (4,083km^2 and 70 - 150m, respectively) the site was monitored using a nested box approach, to make the best use of the survey time available, and to increase the power to detect change within each survey box. Each box has an area of 50km^2 (5 x 10km).

Following Noble-James *et. al*. (2018) and using the best available bathymetry data (previous JNCC/MSS surveys (1111S) multibeam, EMODnet bathymetry[2], and GEBCO[3]), boxes were positioned across the site so that each box only covered a depth range of approximately 20m. Furthermore, boxes were positioned to target areas of sand or coarse sediment, as predicted by UKSeaMap 2018.

Boxes were identified inside and outside WSS. Inside boxes were also split between the areas where fishers had agreed to trawl or creel only.

Inside

Inside boxes were labelled A-B and E-G (Table 3, Figure 3). Boxes A, F, and G are within the trawl only area, while Boxes B, D, and E are within the creel only area. Although collecting imagery was the highest priority survey objective, it was decided that Box B should be visited first to acquire multibeam. This decision was made as the predicted course and potentially more topographically complex seabed at Box B, would be an opportunity to examine preliminary multibeam outputs and ensure the multibeam system was operating correctly. The drop-camera was the highest priority sampling method at all other boxes.

Outside

Two boxes (C and D) were also positioned to target similar areas of seabed outside of WSS (Table 3, Figure 3) where there was evidence of higher levels of demersal fishing. These boxes were sampled in the same way as the boxes inside WSS to assess the feasibility of a beyond BACI approach (Underwood 1992) to monitoring WSS.

Modifications were made to some boxes during the survey, as described in Section 3.1.3. The vertex coordinates for all planned and completed boxes are provided in Section 15.

[2] EMODnet Bathymetry: https://www.emodnet-bathymetry.eu
[3] GEBCO Bathymetry: https://www.gebco.net/

Table 3. Summary of planned survey boxes.

Box	Mean depth (approx. -m)	Evidence of fishing (2009 – 2016)	Inside/outside WSS	Predicted substrate based on UKSeaMap 2018	Priority	Comment
B	100	No	Inside	Coarse	1	First box to visit, in order to acquire multibeam and review outputs
A	120	No	Inside	Sand	2	
C	125	Yes	Outside	Sand	3	
D	90	Yes	Outside	Coarse	4	
E	90	No	Inside	Coarse	5	
F	135	No	inside	Sand	6	
G	125	No	Inside	Coarse	7	

3.1.2. Sampling grids and power analysis

A power analysis was conducted to guide the number of grab samples and camera transects that would be targeted.

For infauna, power analysis based on grabs collected on the 1111S and 1517S surveys indicates 207 grabs are required across the MPA to detect a 20% increase or decrease in taxa abundance, or 38 grabs are required across the MPA to detect a 20% increase or decrease in taxa richness.

For epifauna, power analysis based on video tows collected on the 1111S survey indicates 32 tows are required across the MPA to detect a 20% increase or decrease in taxa abundance, or 206 tows are required across the MPA to detect a 20% increase or decrease in taxa richness.

The large number of required samples output from the power analysis was prohibitive, and the high variation in required number of samples to detect change in richness and abundance made it unclear how accurate the results of the power analysis were likely to be.

The power analyses were also run for all seabed types previously encountered across WSS (rock habitats were not included in the grab dataset). As this survey would be targeting specific substrate types in each box and using still images rather than video for monitoring (see Section 3.2) a suitable number of sampling stations was deemed to be 175. Therefore, 25 sampling stations (each station could be used for both grabs and imagery) were assigned to each of the seven boxes using a regular grid. Stations were on average approximately 1.5km apart, but as grids were generated for each box separately using an automated process, the exact distance varies between boxes.

3.1.3. Modifications made to survey box shape and location

During the survey, modifications were made to the location and/or shape of three survey boxes (F, B, and C). This ensured boxes targeting the same substrate type had as many comparable sampling stations as possible (Box F and C), or to avoid static fishing gear (Box B). Information about the modifications made to these boxes is presented below and the data collected at each is summarised in Section 5.

Box B

Box B was modified from a 5 x 10km box to a 7 x 7.143km box (Figure 3).
This was done as creel strings had been deployed in the original Box B, obstructing the safe operation of survey equipment. Five camera stations and approximately half the multibeam had already been acquired for the original Box B before the creels had been deployed.

Therefore, the decision was made to modify Box B in order to:

a) avoid the area used by creel fishers;
b) make the best use of data already collected at Box B and;
c) maintain the desired 50km^2 survey area.

Box F

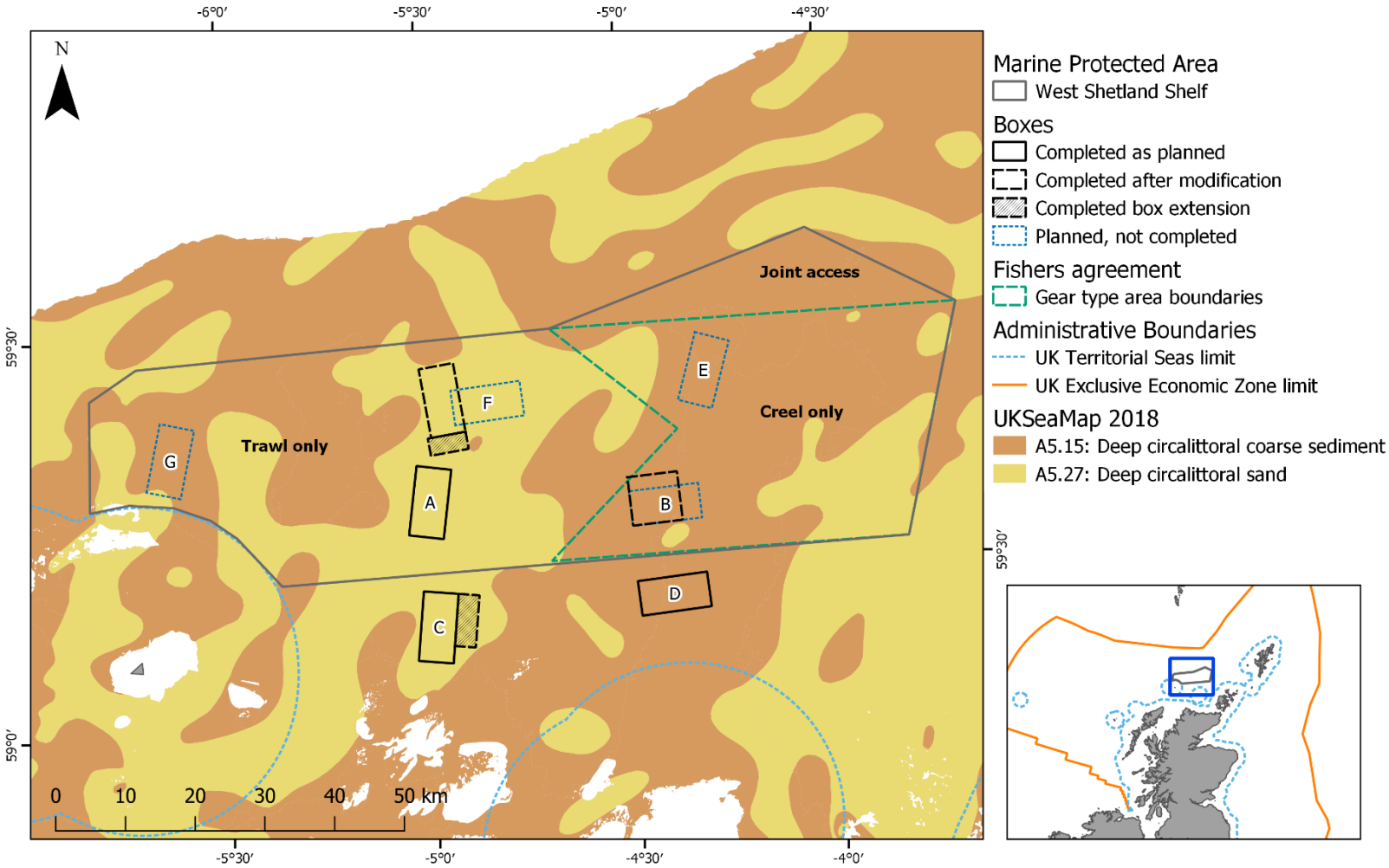
Box F was rotated approximately 90° and moved slightly to the west, a box extension was also added to the south of the new Box F (Figure 3). Box F was initially modified on 28 August after reviewing VMS data for the former Windsock Fisheries closure.

The VMS data revealed that Box A, which was chosen to represent sand substrate inside WSS, had been fished since the opening of the closure. However, areas of predicted sand to the north of Box A had not yet been targeted for fishing. Based on this information, Box F was rotated and moved west to target an area inside WSS that was predicted to have a similar depth range and substrate type as Box A but had not been fished at the time of sampling. The priority of Box F was also increased to avoid missing the opportunity to collect samples before it was fished.

Later in the survey an extension was added to the south of Box F (Figure 3). Sampling revealed that the northernmost stations of Box F contained more coarse sediments than both Box A and the southern area of Box F. The Box F extension had seven extra stations (F026 – F032) which have the same spacing as the original equidistant Box F stations. These extra stations were intended to increase the number of comparable stations between all boxes with sandy substrate.

Box C

An extension was added to the east of Box C (Figure 3). As with Box F, sampling conducted at Box C revealed that the box was not entirely comprised of sandy seabed. Stations in the south of Box C contained mainly coarser substrates. An acoustic survey of Box C and the adjacent area indicated that the seabed to the east of the box was sandy, therefore the extension was made in this area. In the Box C extension, 11 extra stations (C026 – C036) with the same spacing as the original equidistant Box C stations were added. As with changes made to Box F, these extra stations were intended to increase the number of comparable stations between all boxes with sandy substrate.



Projection: Europe Lambert Conformal Conic (EPSG: 102014); © JNCC 2019; UK Territorial Sea Limit. Contains UKHO data © Crown copyright. All rights reserved. UK Exclusive Economic Zone © Crown copyright. The exact limits of the EEZ are set out in The Exclusive Economic Zone Order 2013; Shoreline © GSHHG; UKSeaMap 2018v2: JNCC data © copyright and database right 2018 contains UKHO data © copyright and database right 2018.

Figure 3. Planned and completed 1219S survey boxes, inside and outside WSS. The map shows all seven boxes planned prior to the survey. Also shown are the three boxes which were completed as per their planned shape and location (A, C and D); the two boxes that were completed after modifications to their shape and location (B and F); and the two boxes which were not attempted or completed (E and G). Note that extensions were added to and sampled at two boxes (C and F). The three areas agreed for specific uses (trawl only, creel only, and joint access) by the trawl and creel fishers are also labelled.

3.2. Epibenthic imagery sampling method

Still and video images were captured using a seabed imagery system mounted on a drop-frame, this system is referred to as the drop-camera (see section 10.1 for details of drop-camera equipment used). The drop-camera was controlled by a winch operated by a TV engineer and images were downloaded at the end of each camera shift by the TV engineer. The drop cameras position was recorded using an Ultra Short Baseline (USBL) system. One TV engineer participated in 1219S, starting on the night shift (00:00-12:00) but changing to the day shift (12:00-24:00) on 7 September. As the camera download took approximately 2 hours, camera operations were conducted for up to 10 hours each day.

Two methods of drop-camera sampling were used during 1219S, single replicate satiations (to address survey objective 1, Table 2) and increased replication stations (to address survey objective 5, Table 2). Single replicate stations were the primary method used for collecting imagery for monitoring change at a survey box. Increased replication stations were intended to be used to assess small scale variability within a subset of grid stations and as potential repeat monitoring stations which could be sampled in the future to assess change at the station over time. However, in practice this was only completed at one station and served as a trial of the application of this method aboard the MRV *Scotia* (see Section 11 for more information on increased replication drop-camera stations).

3.2.1. Single replicate drop-camera stations

A single drop-camera transect was undertaken at each station visited for drop-camera operations. During deployments, the vessel executed a controlled drift at approximately 0.5 knots (slightly faster than the planned 0.3 knots, which was not achievable in practice) through the specified station. The height of the drop-camera off the seabed was controlled by winch (optimally 1m from seabed), with the operator having sight of the video monitor.

Drop-camera transects were at least 200m (slightly longer than the planned 150m, due to the faster speed). Still images were captured as frequently as possible, with the aim of meeting the following criteria:

1. The seabed is clearly visible (no sediment plumes or other obstructions)
2. The camera is at the correct altitude (1m above the seabed) and in focus
3. The flash has had an opportunity to charge (this took less than 10 seconds)
4. The camera's field of view does not contain any of the seabed which was visible in the last still image (to avoid pseudoreplication)

Station metadata was recorded as described in section 5.4. This included an assessment of the suitability of each station for grab sampling using one of the three categories described in Table 4. Where possible sampling stations were visited with the drop-frame camera before using the Hamon grab especially in areas predicted to have coarse sediments with cobbles or boulders.

Table 4. The three categories of a sampling stations suitability for grab sampling.

Grab suitability	Grab suitability description
Suitable to grab	Confident a valid grab sample will be acquired (few cobbles or large pieces of gravel that may prevent jaws closing)
Maybe suitable to grab	Questionable whether a valid grab sample would be achieved (occasional cobbles, potential rock under a sediment veneer)
Not suitable to grab	Very unlikely to acquire a valid grab sample (regular cobbles or bedrock visible)

3.3. Benthic sampling method

Infauna and sediment samples were collected using JNCC's deep-sea Hamon grab, this grab can function as both a 0.1m^2 or a 0.25m^2 Hamon grab through interchangeable buckets. A trial of a grab mounted camera system was also conducted on this survey (see section 10.2 for details of grab equipment used).

Two approaches to Hamon grab sampling were used during 1219S, single replicate stations and increased replication stations (three replicates). Single replicate stations were the primary method used for collecting samples for monitoring at every station where grab sampling was deemed suitable (Table 4). Increased replication was applied at nine stations to better understand small scale variability within these stations, allowing them to potentially be used as fixed stations that could be revisited to monitor change at the station over time. For both approaches a 0.1m^2 Hamon grab was used to collect samples for the purpose of monitoring WSS and the surrounding area (survey objectives 2 and 4, Table 2). Only samples with a volume ≥5L were accepted as valid for these objectives.

A 0.25m^2 Hamon grab was used to collect samples for a gear comparison (survey objective 11, Table 2). This was a contingency objective and in practise the 0.25m^2 Hamon grab bucket was only used at two stations and served more as a wet test of the equipment than a gear comparison.

Up to three attempts were made to acquire a valid sample for each replicate. Opportunistic samples were collected from grabs with a volume <5L for DNA analysis and for NMS (survey objective 8, Table 2).

All samples were first emptied into a plastic 'fish' box and had their volumes measured. For valid monitoring samples, a subsample was taken for PSA (a trowel was used to scoop sediment from each corner of the fish box). Then the sample was washed through sieves to retain everything captured on a 1mm sieve. A sieving table with a 5mm sieve that filters into a 1mm sieve was used to speed up this process. The greater than 1mm fraction of the sample was then stored in a sample container and fixed in 5% formalin solution.

Photographs were taken of labelled samples at three stages of the process:

1. Sample in fish box
2. Sample retained on 5mm sieve
3. Sample retained on 1mm sieve

Cobble analysis was conducted on any cobbles (stones with a minimum dimension of 64mm) found in valid monitoring samples. Cobble analysis was undertaken as described in Mason (in press), except the cobble volume was not estimated.

For invalid monitoring samples, no PSA sub sample or photographs were taken, but the sample was sieved in the same way as described above.

Any specimens suitable for DNA analysis, underwent the procedure described in Section 12.

Any specimens suitable for the NMS collection were narcotised using magnesium chloride and preserved in either ethanol or formalin solution.

3.4. Acoustic survey method

3.4.1. Multibeam

Survey boxes predicted to contain coarse sediment from existing habitat maps were surveyed to acquire 100% multibeam coverage. A cross line that ran across either perpendicular or at 45° to multibeam survey lines was completed for each multibeam box. Multibeam data was processed at sea to generate preliminary surfaces of bathymetry and backscatter (see section 10.3 for more detail). These surfaces were intended to be used to identify seabed features which had not been adequately sampled by the grid of sampling stations. Features could then be targeted as ground-truthing stations to improve the quality of habitat maps made using this acoustic data. However, no such features were identified and consequently no ground-truthing stations were sampled (survey objective 6 and 7, Table 2).

CTD instrumentation was deployed at each survey box visited for multibeam acquisition to generate a sound velocity profile (SVP) before the acoustic survey began.

3.4.2. Single-beam

A single-beam echosounder system was also used to provide additional acoustic information. Roxann, the single-beam signal processing system installed on MRV *Scotia*, uses two echo parameters, E1 and E2, which convey information on the roughness and hardness of the seabed respectfully. The comparatively reduced spatial coverage of single-beam acoustics necessitated significant interpolation to produce a continuous surface. The Roxann system continuously recorded data throughout the survey which was processed and interpolated while at sea to provide further, relativistic information on the seabed character and supplement the multibeam data. Roxann hardness and roughness data is also available for survey boxes where little or no multibeam was collected and can be used to help interpret seabed type.

4. Cruise narrative (all times are UTC unless stated otherwise)

26th August
We departed Aberdeen Harbour at 06:30 and began transit to WSS. On route a wet test of the new JNCC deep water Hamon grab, and the drop-camera was conducted near Peterhead (10:00 – 14:30). After the successful wet test, we continued transit to WSS. A muster and abandon ship drill followed by an induction attended by all crew was also completed.

27th August
We arrived at Box B at 03:00 and acquired a sound velocity profile (SVP) to calibrate multibeam near to Box B, then began collecting multibeam.

At 06:00, when it was light and we could be confident there were no fishing creels in the area, survey operations were changed to drop-camera and we began collecting video and stills data from Box B. Camera operations continued until 10:00, when the cameras were removed from the frame to download images. At this time survey operations changed back to multibeam acquisition which continued until 24:00, at which point six multibeam lines remained at Box B. Creel fisherman notified the bridge of fishing gear in Box B and provided coordinates.
Advice from the bridge was to avoid camera sampling in Box B until the fishing gear was removed.

28th August
We decided to transit to Box A (second priority box) until Box B was clear of fishing creels. We arrived at Box A and began collecting video and stills data at 01:00 - 09:00, when the cameras were removed from the frame to download images. At this time survey operations changed to 0.1m^2 Hamon grab sampling, which continued until 24:00.

VMS data available since the Windsock was opened to fishing was reviewed and based on this information Box F was moved and its priority increased (more information on changes made to boxes in section 3.1.3).

29th August
We finish grab and camera stations at Box A, then transit to Box F to begin 0.1m^2 Hamon grab sampling. Wind speeds started increasing throughout the afternoon and survey operations were stopped at 17:30.

30th August
Weather downtime continued until 09:00, when conditions had improved enough to deploy the 0.1m^2 Hamon grab. Grab operations continued at box F until 24:00.

The bridge was informed that more creels had been deployed in Box B so the decision was made to change the shape of Box B to avoid creels (more information on changes made to boxes in section 3.1.3).

31st August
We began camera operations at Box F and continued until 09:00. Then we began transit to Box B and acquired an SVP at 12:30, followed by multibeam. This continued until camera operations at Box B began at 23:15.

1st September
We Continued camera operations at Box B until weather conditions begin to the influence data quality and the safe deployment of the camera at 03:30.

It was considered that weather conditions may still be suitable for acoustic work, so we transited to Box D and acquired an SVP on arrival at 06:45, followed by multibeam lines. The quality of multibeam data was variable, due to poor weather and tidal conditions, and the decision was made to stop acquisition at 10:00. Multibeam lines are re-run in a north – south orientation, as this provided best data quality, until 21:30. At this time transit to Box B began, timed to arrive at the first camera station as the TV Engineer came onto shift. Camera operations at Box B started at 23:15.

2nd September
We finished all camera stations at Box B at 09:30, then began grab sampling at Box B. Once all stations, which had been deemed suitable to grab based on the imagery analysis, were revisited with the 0.1m^2 Hamon grab, the MRV *Scotia* transited to Box C. We arrived at Box C at 16:00 and began grab sampling. However, Box C was left at 21:30 in order to transit to Box F in time for the night shift and TV Engineer to have a full shift of work time at Box F (note that night shift starts at 23:00 UTC).

3rd September
We finished all camera stations at Box F, then transited back to Box C to begin camera operations there. Survey equipment was changed to the Hamon grab at midday to continue sampling grab stations at Box C.

4th September
We began transit to Stornoway so a crew member could leave the vessel due to a bereavement then transited back to Box C. This transit was timed to coincide with a forecast period of wind and swell which would prevent survey operations. Poor weather conditions meant slow progress on the return journey and Box C was not reached until midnight.

5th September
We waited on weather for most of the morning then began exploratory multibeam lines at Box C to identify where boundaries between substrate types occur. This was prompted as the grab samples from the south of Box C had been much coarser than those in the north. Extra sampling stations were plotted to the east of Box C in sandy sediment, which is more comparable to the substrate encountered at Box A. Weather improved slightly and Hamon grab sampling at the extra Box C stations began at 12:00. Four stations were visited before Hamon grab operations bought to a stop by increasing swell height.

Test lines of multibeam were run at Box C in various directions and data quality was deemed suitable to begin acoustic survey operations so MRV *Scotia* transited to Box D to resume multibeam lines, this time in an east-west orientation as this provided the best quality data.

6th September
We completed the multibeam survey of Box D but weather began to deteriorate during the transit to Box C. We waited on weather at Box C until a test deployment of the Hamon grab was conducted at 17:30, but the decision was made to wait for further improvement in weather. No samples were collected.

7th September
Shift patterns of the TV engineer are changed to the day shift (12:00-24:00 UTC+1) so they are on shift during the hours forecast to have the best weather.

We waited on weather until 05:00, then finish the remaining extra seven Hamon grab stations at Box C. We transited to Box D and collect drop-camera transects at 14 stations before changing to Hamon grab operations and visit stations which may be suitable to grab based on notes taken during camera transects. Before the end of the day we began transit to Box B.

8th September
We arrive at Box B to run a multibeam cross line diagonally across the box. Next we transited to Box F to collect samples from seven extra grab stations then transited back to Box D and collect samples from two stations using the 0.25m^2 Hamon grab. We changed survey operations to drop-camera and finish the 14 remaining stations, including one increased replication station (D022). We changed survey operations back to Hamon grab (0.1m^2) and completed the remaining grab stations at Box D.

9th September
We transited to the expected location of the wreck of the *M.V. Lagaholm* and used multibeam to identify the wreck location. Multibeam lines were run in north-south and east-west directions between 00:20 and 05:00. Next we transited to the expected location of the wreck of *U-396* and begin our search at 6:30. No sign of *U-396* was found so at 07:30 transit to Box C began. We arrive at Box C at 09:20 and collect exploratory multibeam lines to identify boundaries between substrate types in the box. We changed to camera operations at 11:00 and continue until our deadline for leaving the site (21:00). As there was not enough time to visit all camera stations, every other station was skipped in order to maximise area coverage. At 21:00 we departed the site and begin transit to Aberdeen.

10th September
We continue transit and arrive in Aberdeen Harbour at 16:30.

The amount of time spent on different survey activities in presented in Section 13.

5. Data collected

Five survey boxes (A, B, C, D, and F) were visited during 1219S (Figure 3). A total of 118 grab (0.1m^2 and 0.25m^2 Hamon grab) samples were collected from 97 stations, 119 drop-camera transects were collected from 116 stations, and 140.1km^2 of multibeam data was acquired. Additionally, grab samples invalid for monitoring purposes were used to extract specimens for the Natural History Museum and the National Museums of Scotland (Table 5). It should be noted that the majority of stations at the course boxes (B and D) were not deemed suitable for grab sampling.

Table 5. Summary of camera and grab samples and multibeam data collected during 1219S.

Sample	Quantity
Camera transect (video and still imagery)	119 transects
0.1m^2 Hamon grab (infauna and PSA)	116 samples
0.25m^2 Hamon grab (infauna and PSA)	2 samples
Multibeam from survey boxes	137.1km^2
Multibeam from wreck area of search	3.0km^2
Hamon grab (Natural History Museum samples)	Specimens from 18 samples
Hamon grab (National Museums' of Scotland samples)	Specimens from 14 samples

5.1. Epibenthic imagery, benthic samples, and multibeam data collected per survey box

5.1.1. Box A

At Box A 25 drop camera transects and 30 grab samples for monitoring were collected (Table 6).

A single camera transect was collected from each of the 25 monitoring stations.

At least one 0.1m^2 Hamon grab sample was collected from 24 of the 25 monitoring stations (there were three failed attempts at A021).

Two additional replicate 0.1m^2 Hamon grab samples were collected from three stations (A003, A011, and A019).

This information is summarised in Table 6 and Figure 4. Samples invalid for monitoring (<5L) were used to extract specimens for the Natural History Museum and National Museums of Scotland (see section 5.2).

Table 6. Summary of samples collected at Box A during 1219S, and the survey objectives they address.

Survey objective addressed	Survey equipment	Number of stations	Number of replicates	Number of samples
1	Drop-camera	25	1	25
2	0.1m^2 Hamon grab	24	1	24
4	0.1m^2 Hamon grab	3	2	6

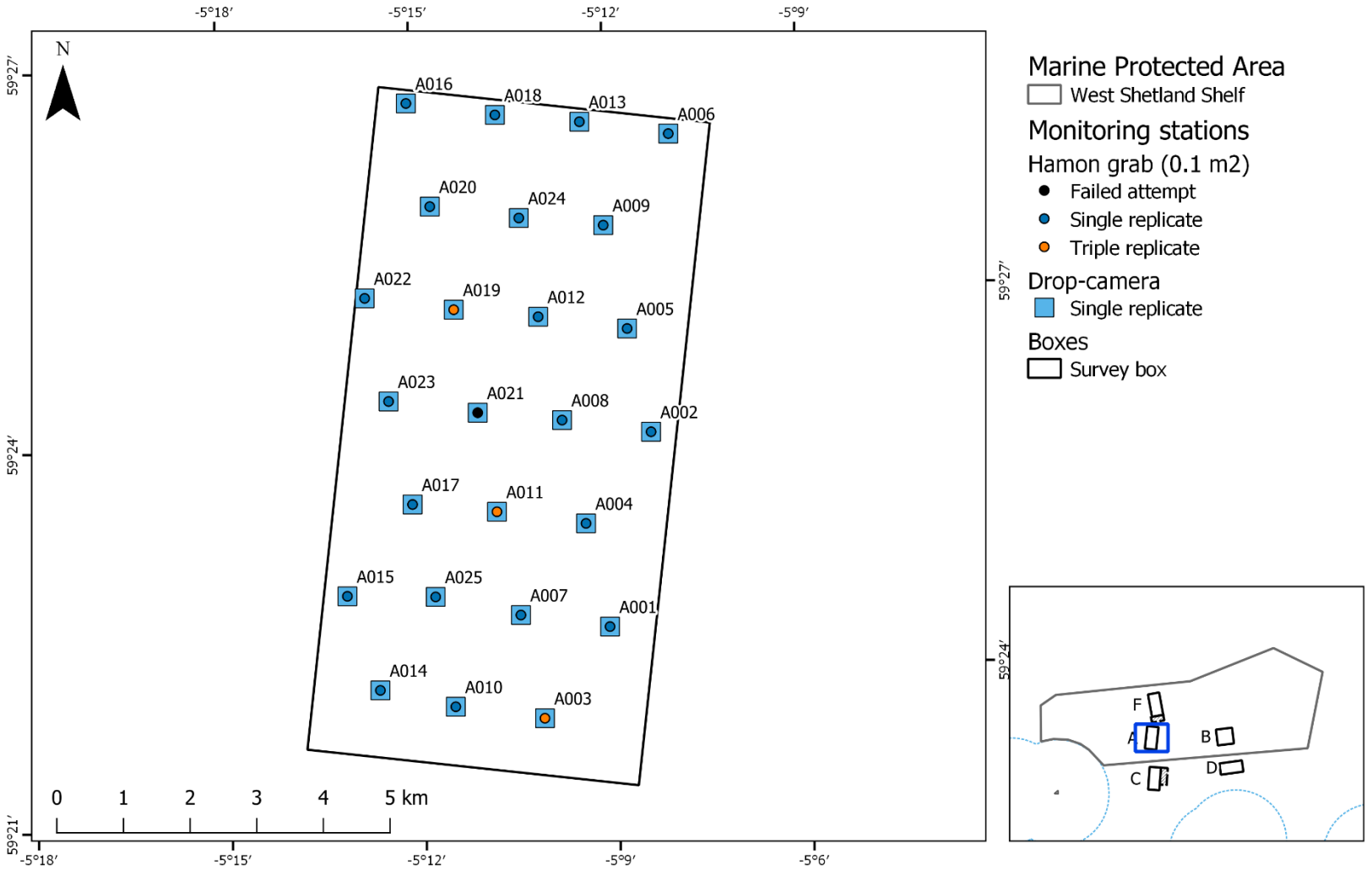


Figure 4. Map of planned and completed Hamon grab and drop-camera stations at Box A.

5.1.2. Box B

The shape and location of Box B was altered during the survey, as described in section 3.1.3.

In Box B, 24 drop camera transects and six grab samples for monitoring were collected (Table 7), together with 63.9km^2 of multibeam data were collected (Figure 5). Note that multibeam collected to the east of Box B was done so before the box shape was modified.

A single camera transect was collected from 24 of the 25 monitoring stations. B001 was the first drop-camera station visited during 1219S, some changes were made to transect length and image frequency based on this transect. B001 was revisited later in the survey to ensure it had been sampled in the same way as all other camera stations. At B005, lost fishing creels were encountered and the transect was cut short and not re-attempted. Stations B001, B002, B005, B006, and B007 were sampled before the shape of box B was changed.

Based on grab suitability scores, 0.1m^2 Hamon grab samples were attempted at seven stations. Valid samples were acquired from six of these (there were three failed attempts at B006).

This information is summarised in Table 7 and Figure 6. Samples invalid for monitoring (<5L) were used to extract specimens for the Natural History Museum and National Museums' of Scotland (see section 5.2).

Table 7. Summary of valid monitoring samples collected at Box B during 1219S, and the survey objectives they address. Additionally, 63.9km^2 of multibeam data were collected, addressing survey objective 3.

Survey objective addressed	Survey equipment	Number of stations	Number of replicates	Number of samples
1	Drop-camera	24	1	24
2	0.1m^2 Hamon grab	6	1	6

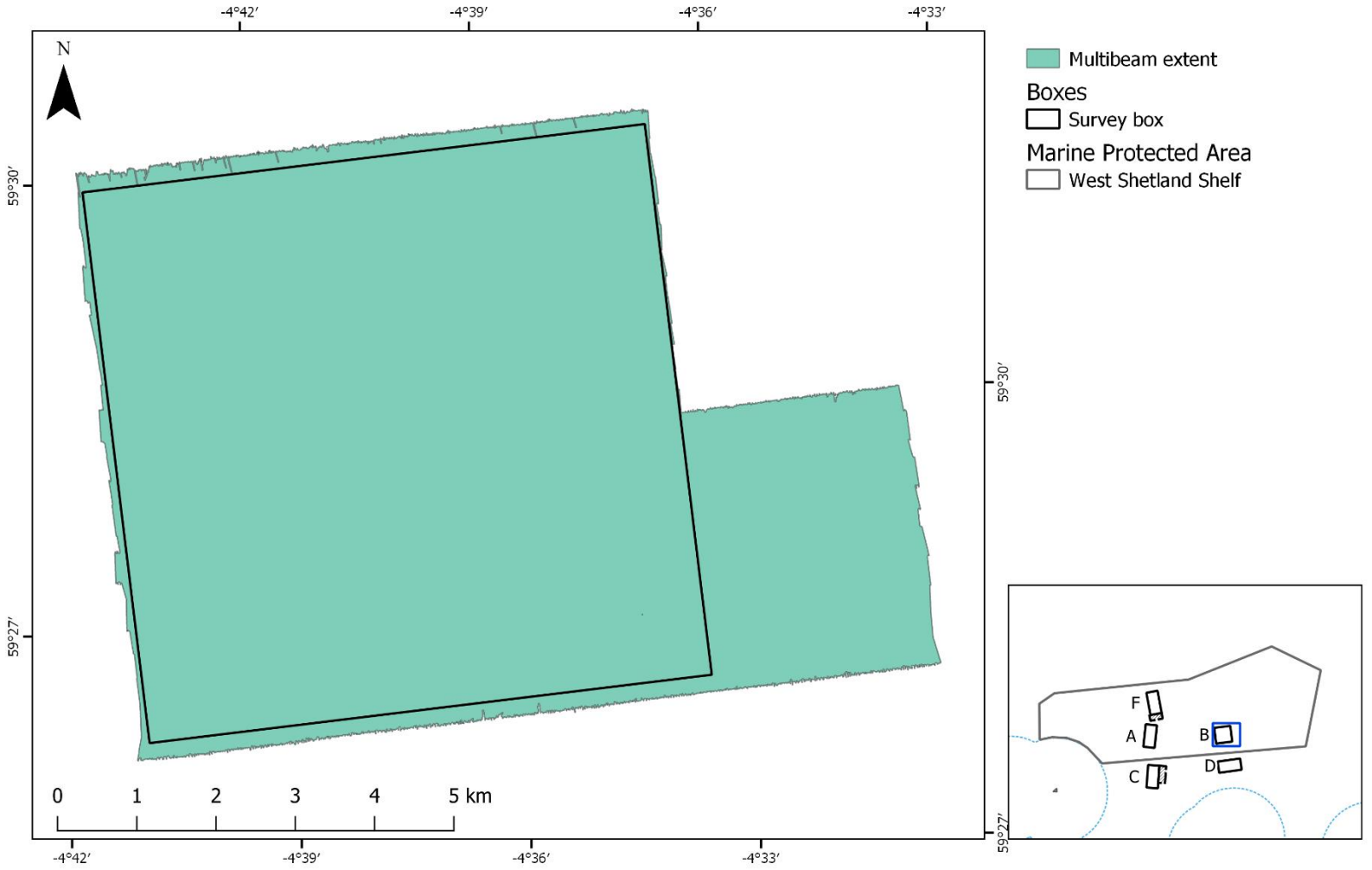


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Figure 5. Map of completed multibeam extent at Box B. Note the area of multibeam acquired to the east of Box B, which was collected before the box's shape was changed to avoid creels deployed in the area.

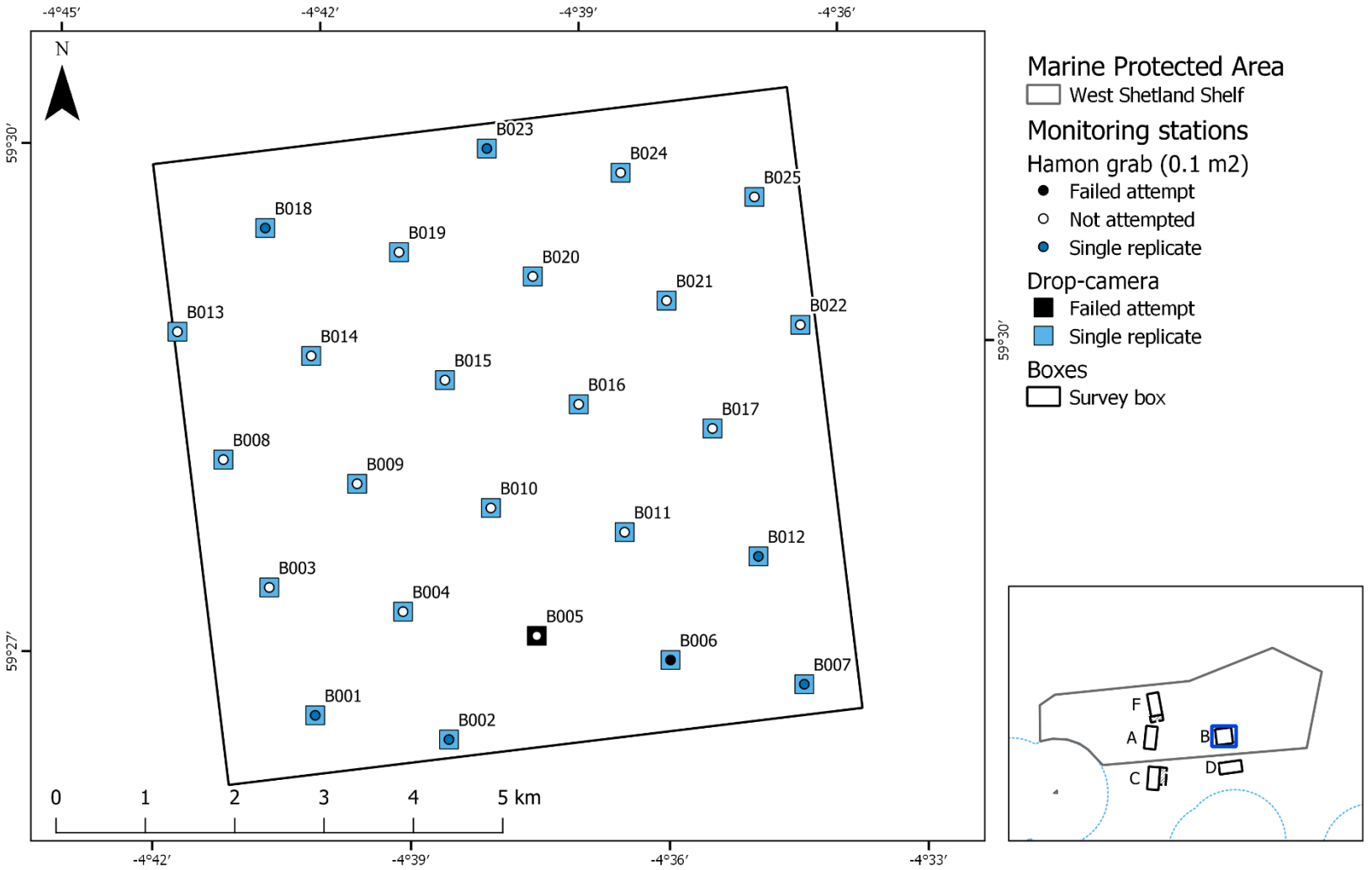

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Figure 6. Map of planned and completed Hamon grab and drop-camera stations at Box B.

5.1.3. Box C

An extension was added to Box C with 11 extra stations, as described in section 3.1.3.

In Box C, 17 drop camera transects and 35 grab samples for monitoring were collected (Table 8). Additionally, 17.9km^2 of multibeam data were collected, this data was collected to identify boundaries between different substrate types and to inform the location of the box extension (Figure 7).

A single successful camera transect was collected from 17 of the 36 monitoring stations. During the first attempted video transect at C003, there was a failure of the MRV *Scotia's* dynamic positioning thrusters. As a result, the first attempt was cut short and a second, successful, attempt was completed once the thrusters were functioning properly.

At least one 0.1m^2 Hamon grab sample was collected from 28 of the 36 monitoring stations (there were eight stations where grab sampling was attempted but all attempts failed at C004, C013, C021, C024, C025, C030, C031, C035).

Two additional replicate 0.1m^2 Hamon grab samples were collected from three stations (C007, C015, and C029). Initially two additional replicates were attempted at C003, however although the first two replicates were successful on the first attempt, the station was abandoned after three failed attempts to collect the third replicate. C029 was used as an increased replication station instead.

This information is summarised in Table 8 and Figure 8. Samples invalid for monitoring (<5L) were used to extract specimens for the Natural History Museum and National Museums of Scotland (see section 5.2).

Table 8. Summary of samples collected at Box C during 1219S, and the survey objectives they address. Additionally, 17.9km^2 of multibeam data were collected, addressing survey objective 3.

Survey objective addressed	Survey equipment	Number of stations	Number of replicates	Number of samples
1	Drop-camera	17	1	17
2	0.1m^2 Hamon grab	28	1	28
4	0.1m^2 Hamon grab	3	2	6
NA (extra grab collected from C003)	0.1m^2 Hamon grab	1	1	1

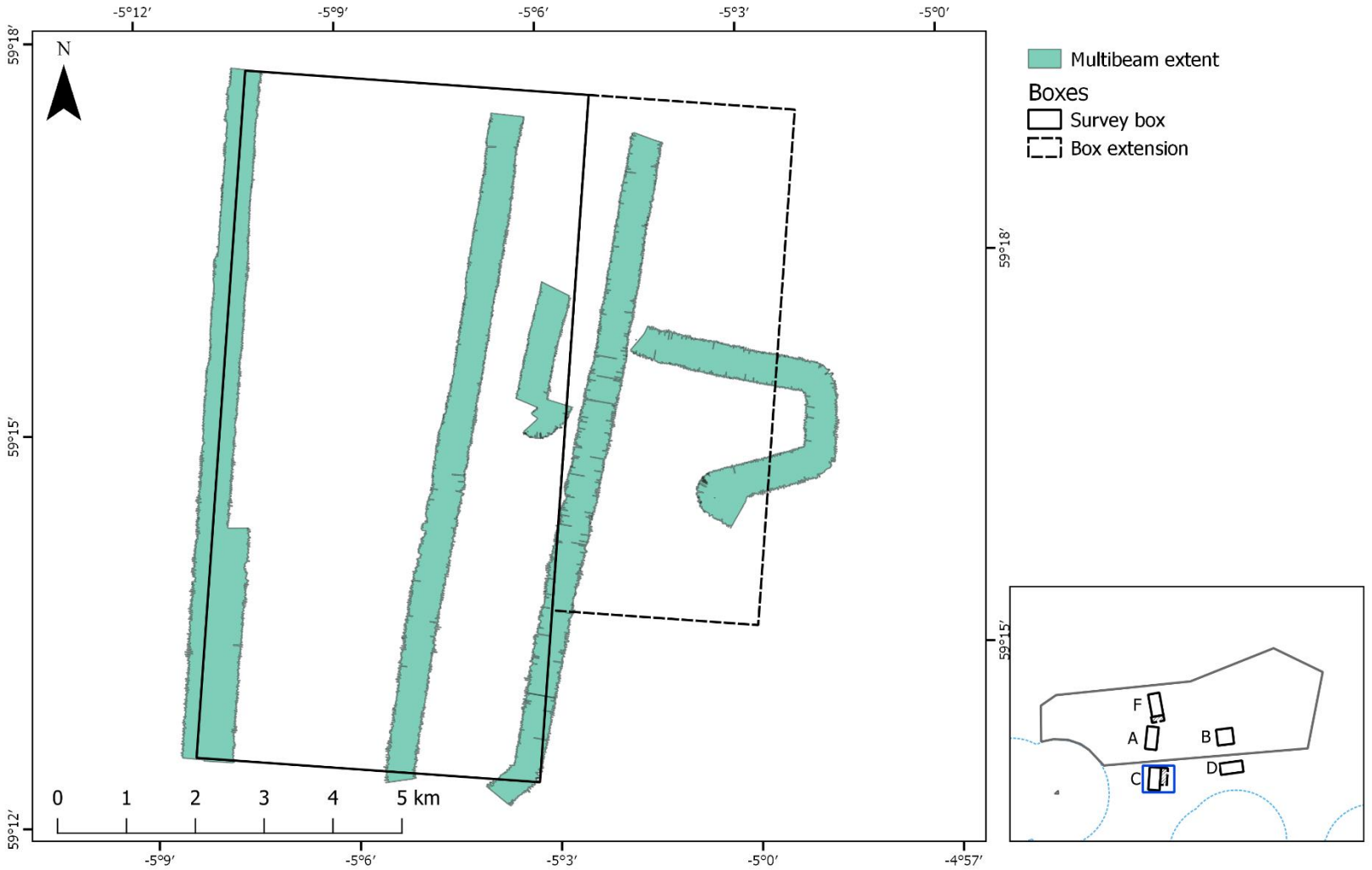

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Figure 7. Map of completed multibeam extent at Box C.

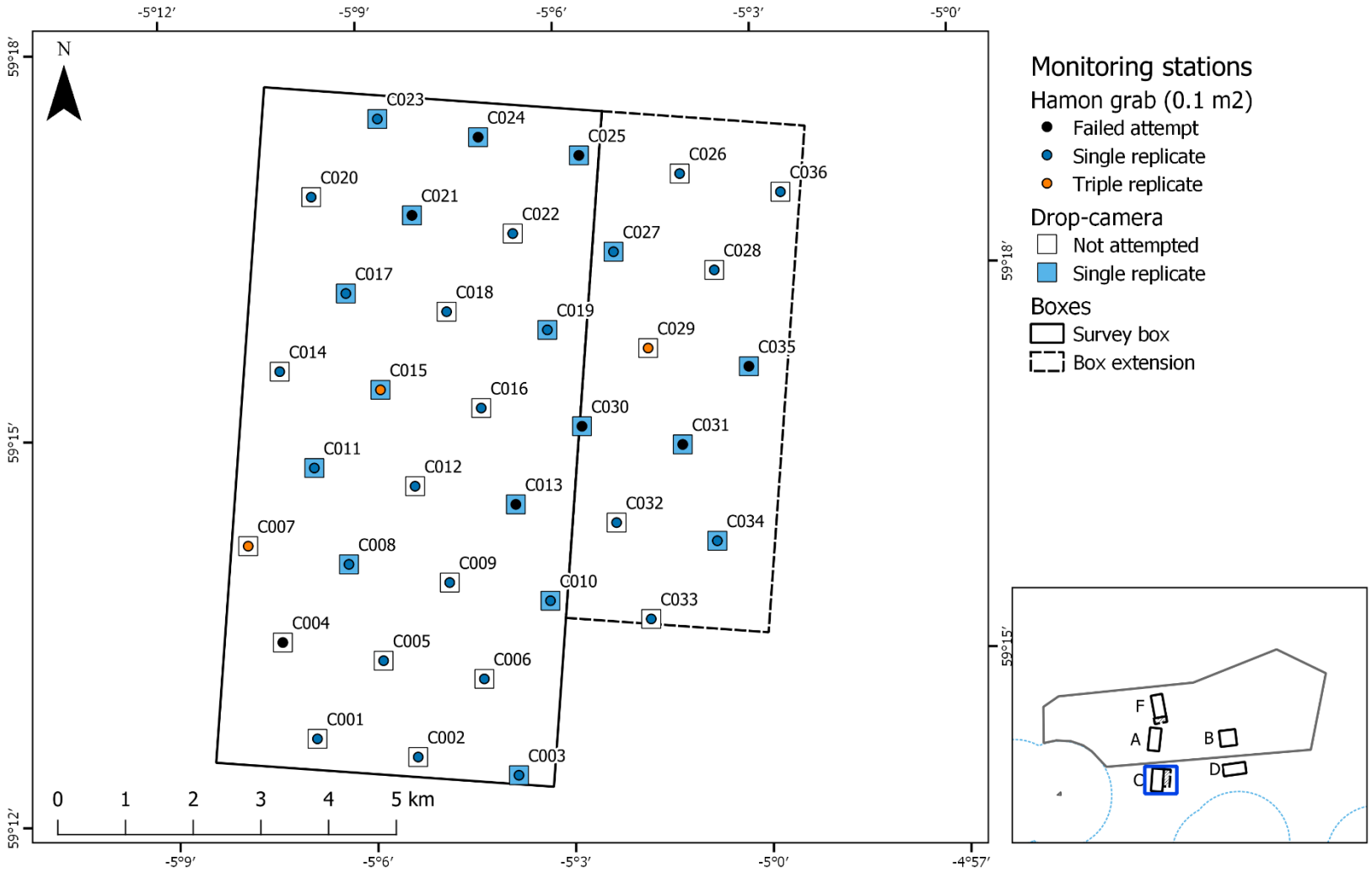

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Figure 8. Map of planned and completed Hamon grab and drop-camera stations at Box C.

5.1.4. Box D

In Box D, 28 drop camera transects, seven 0.1m^2 Hamon grab samples for monitoring, and two 0.25m^2 Hamon grab samples for gear comparison were collected (Table 9). Additionally, 55.3km^2 of multibeam data were collected (Figure 9).

A single camera transect was collected from each of the 25 monitoring stations. At D022 an additional three transects (fewer than the intended five because it was at the end of a camera shift) were collected following the method described in section 11.

Based on grab suitability scores, 0.1m^2 Hamon grab samples were attempted at nine stations. Valid samples were acquired from seven of these (there were three failed attempts at D007 and D010). 0.25m^2 Hamon grab samples were collected from D020 and D023.

This information is summarised in Table 9 and Figure 10. Samples invalid for monitoring (<5L) were used to extract specimens for the Natural History Museum and National Museums' of Scotland (see section 5.2).

Table 9. Summary of valid monitoring samples collected at Box B during 1219S, and the survey objectives they address. Additionally, 55.3km^2 of multibeam data were collected, addressing survey objective 3.

Survey objective addressed	Survey equipment	Number of stations	Number of replicates	Number of samples
1	Drop-camera	25	1	25
5	Drop-camera	1	3	3
2	0.1m^2 Hamon grab	7	1	7
11	0.2m^2 Hamon grab	2	1	2

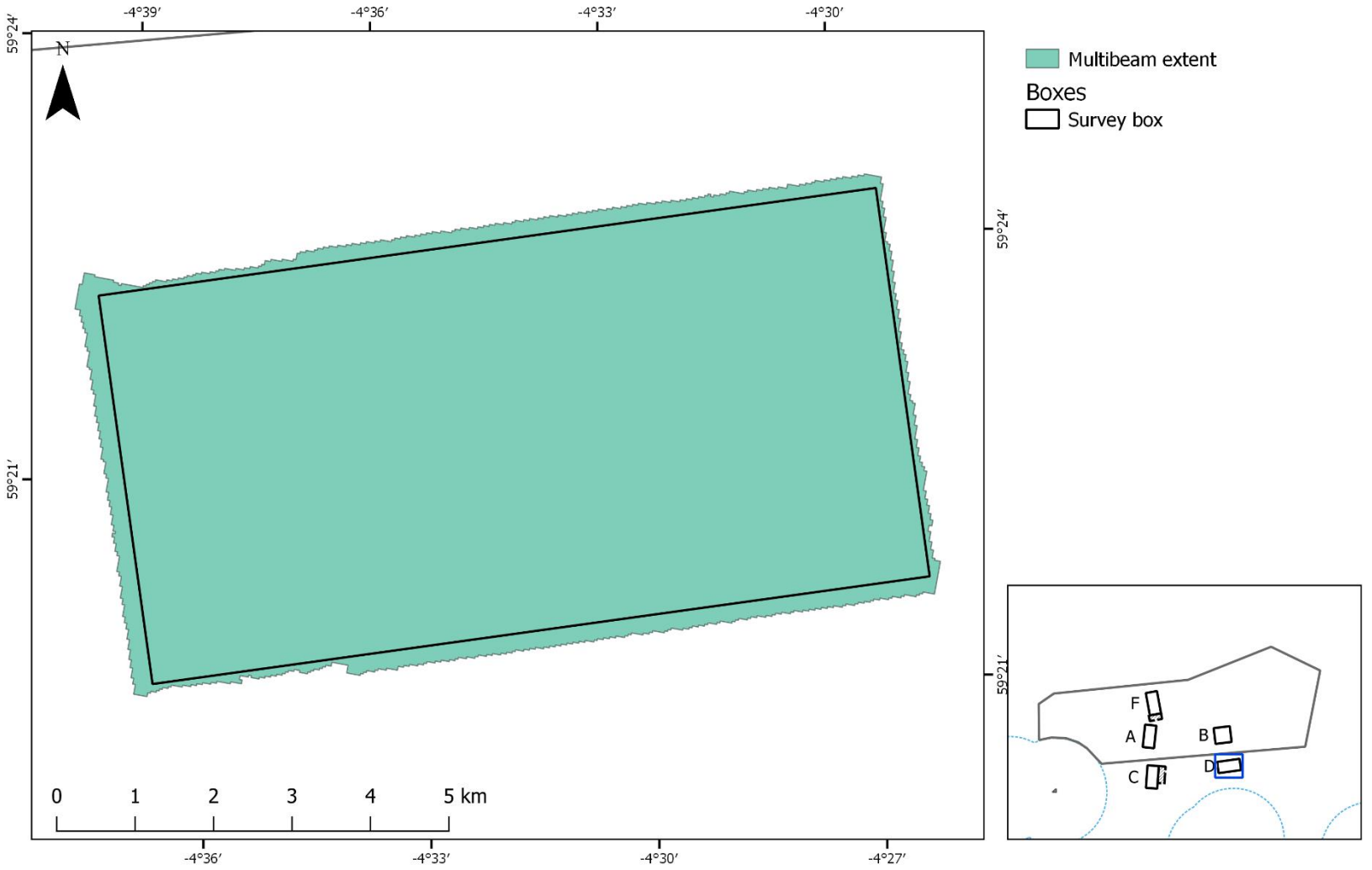

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Figure 9. Map of completed multibeam extent at Box D.

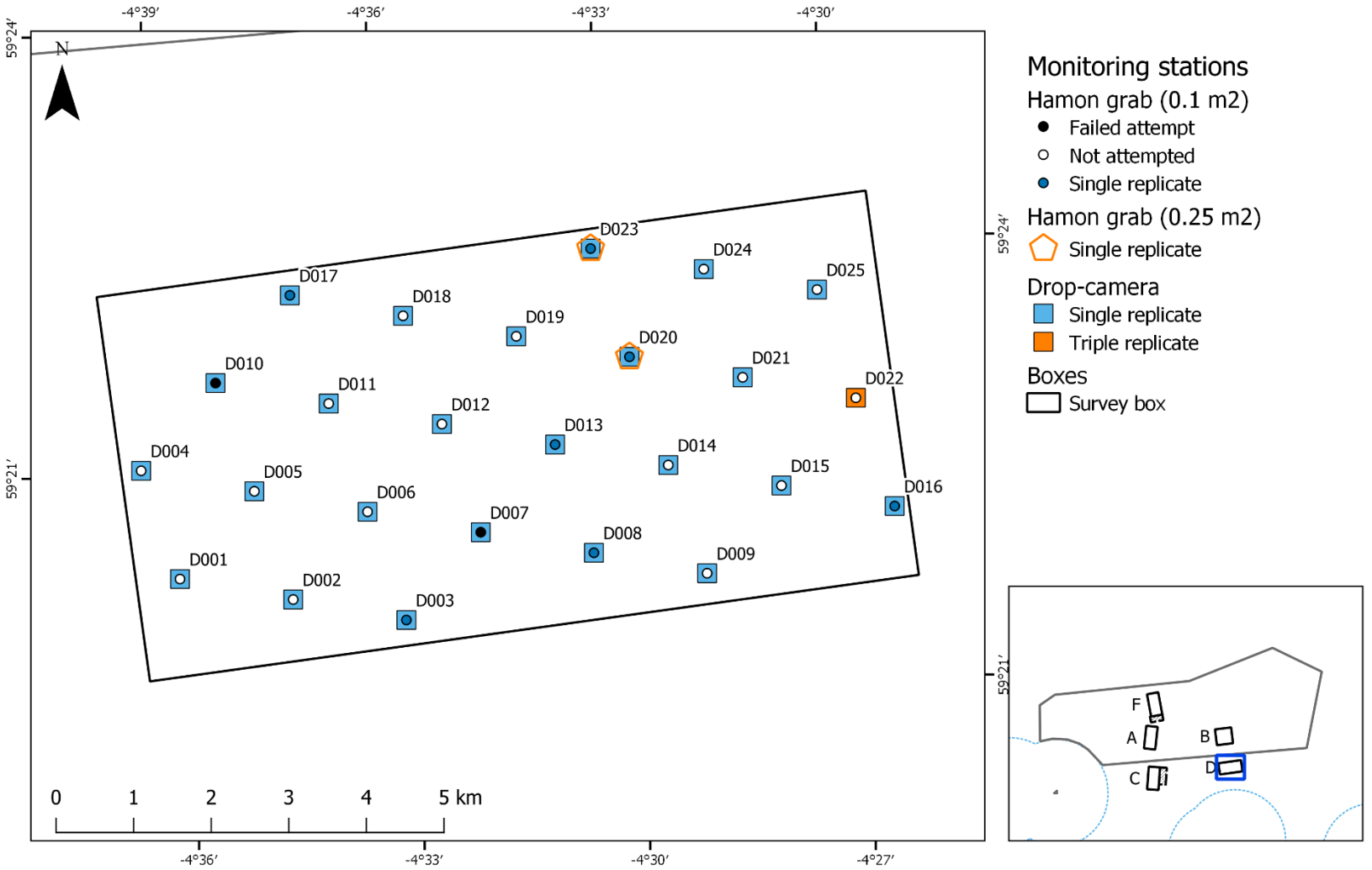

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Figure 10. Map of planned and completed Hamon grab and drop-camera stations at Box D.

5.1.5. Box F

The shape and location of Box F was altered during the survey and an extension was added with seven extra stations, as described in section 3.1.3.

In Box F, 25 drop-camera transects and 38 grab samples for monitoring were collected (Table 10).

A single camera transect was collected from each of the 25 original monitoring stations, however there was not time to visit the seven extra stations with the drop-camera.

At least one 0.1m^2 Hamon grab sample was collected from each of the 32 monitoring stations. Two additional replicate 0.1m^2 Hamon grab samples were collected from three stations (F011, F018, and F020).

This information is summarised in Table 10 and Figure 11. Samples invalid for monitoring (<5L) were used to extract specimens for the Natural History Museum and National Museums of Scotland (see section 5.2).

Table 10. Summary of samples collected at Box F during 1219S, and the survey objectives they address.

Survey objective addressed	Survey equipment	Number of stations	Number of replicates	Number of samples
1	Drop-camera	25	1	25
2	0.1m^2 Hamon grab	32	1	32
4	0.1m^2 Hamon grab	3	2	6

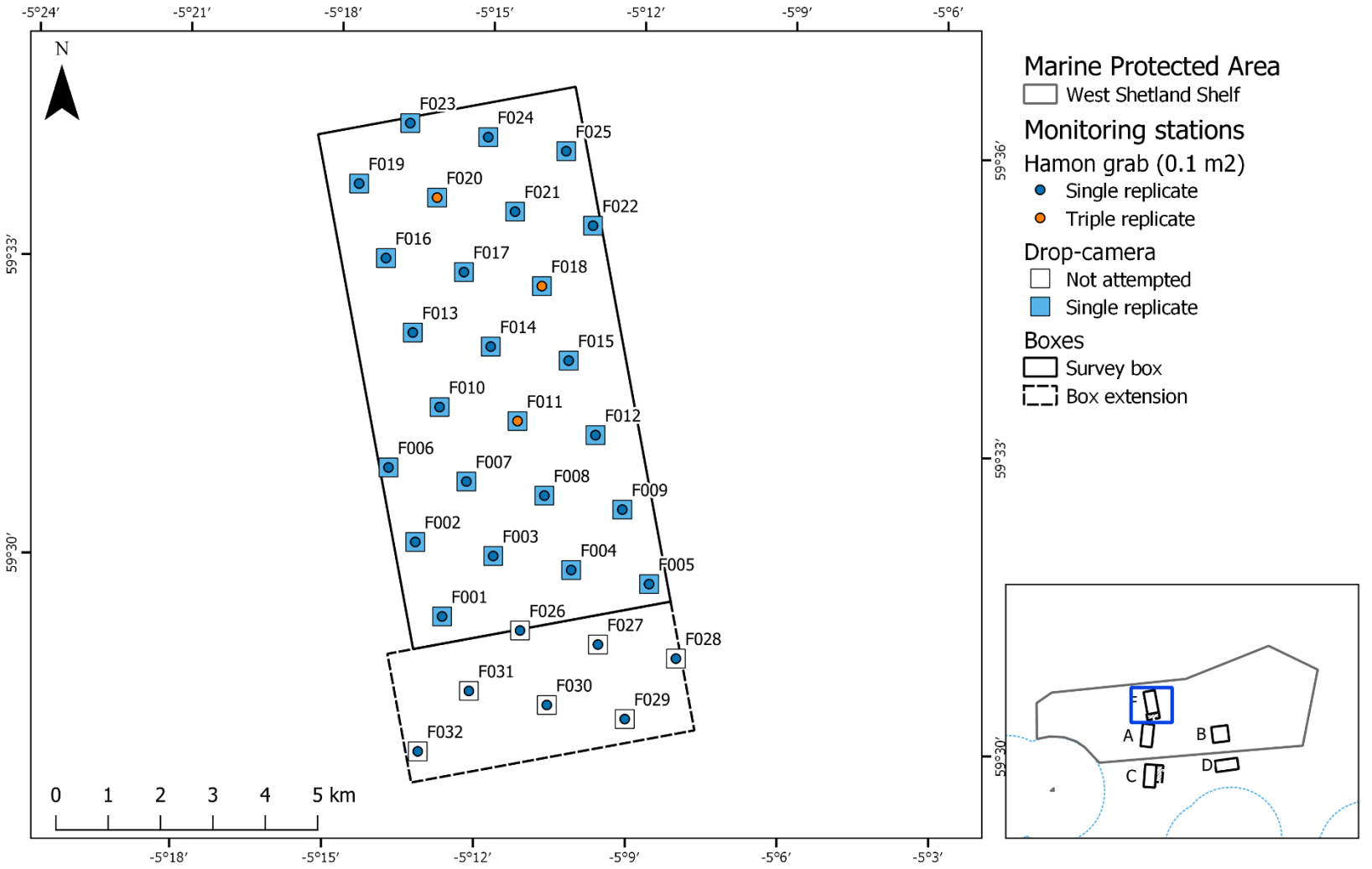

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Figure 11. Map of planned and completed Hamon grab and drop-camera stations at Box F.

5.2. Samples collected for Natural History Museum and National Museums of Scotland

During 1219S, 25 specimens were collected for Natural History Museum from 18 grab samples which were invalid for monitoring purposes (<5L sample volume) and specimens for the National Museums of Scotland were collected from 14 invalid monitoring grab samples (Table 11).

Table 11. Summary of samples collected for Natural History Museum and National Museums of Scotland.

Sample Event ID	Specimens for NHM	Specimens for NMS
1219S_WSS_A003_S055_HG_C2	2	Yes
1219S_WSS_A007_S057_HG_A1	1	Yes
1219S_WSS_A021_S031_HG_A3	2	Yes
1219S_WSS_A021_S031_HG_A1	1	No
1219S_WSS_A021_S031_HG_A2	1	No
1219S_WSS_B001_S121_HG_A1	0	Yes
1219S_WSS_B006_S123_HG_A1	0	Yes
1219S_WSS_B006_S123_HG_A2	2	Yes
1219S_WSS_B006_S123_HG_A3	0	Yes
1219S_WSS_F008_S064_HG_A1	0	Yes
1219S_WSS_C003_S166_HG_C1	1	No
1219S_WSS_C005_S162_HG_A1	3	No
1219S_WSS_C013_S154_HG_A1	1	No
1219S_WSS_C013_S154_HG_A2	2	No
1219S_WSS_C024_S129_HG_A1	1	No
1219S_WSS_C024_S129_HG_A2	0	Yes
1219S_WSS_C024_S129_HG_A3	0	Yes
1219S_WSS_C025_S128_HG_A1	0	Yes
1219S_WSS_C025_S128_HG_A2	0	Yes
1219S_WSS_C021_S132_HG_A3	1	No
1219S_WSS_C031_S173_HG_A1	1	No
1219S_WSS_C031_S173_HG_A3	1	No
1219S_WSS_D010_S196_HG_A1	1	No
1219S_WSS_D020_S204_HG_A1	2	No
1219S_WSS_F011_S068_HG_B1	1	No
1219S_WSS_F018_S075_HG_A1	1	Yes
1219S_WSS_F020_S078_HG_B1	0	Yes
1219S_WSS_F023_S080_HG_A1	0	Yes

5.3. Wrecks of historical interest

Historic Environment Scotland provided information on wrecks of historical interest. Two wrecks were targeted as part of multibeam calibration on 1219S. A 1km^2 area of search box was centred on the charted position of the wrecks. The *M.V. Lagaholm* was detected approx. 500m WNW of its charted position and was surveyed using run lines in a north-south and east-west direction, however no evidence of the wreck of *U-396* was observed. The multibeam extent for both areas of search are shown in Figure 12.

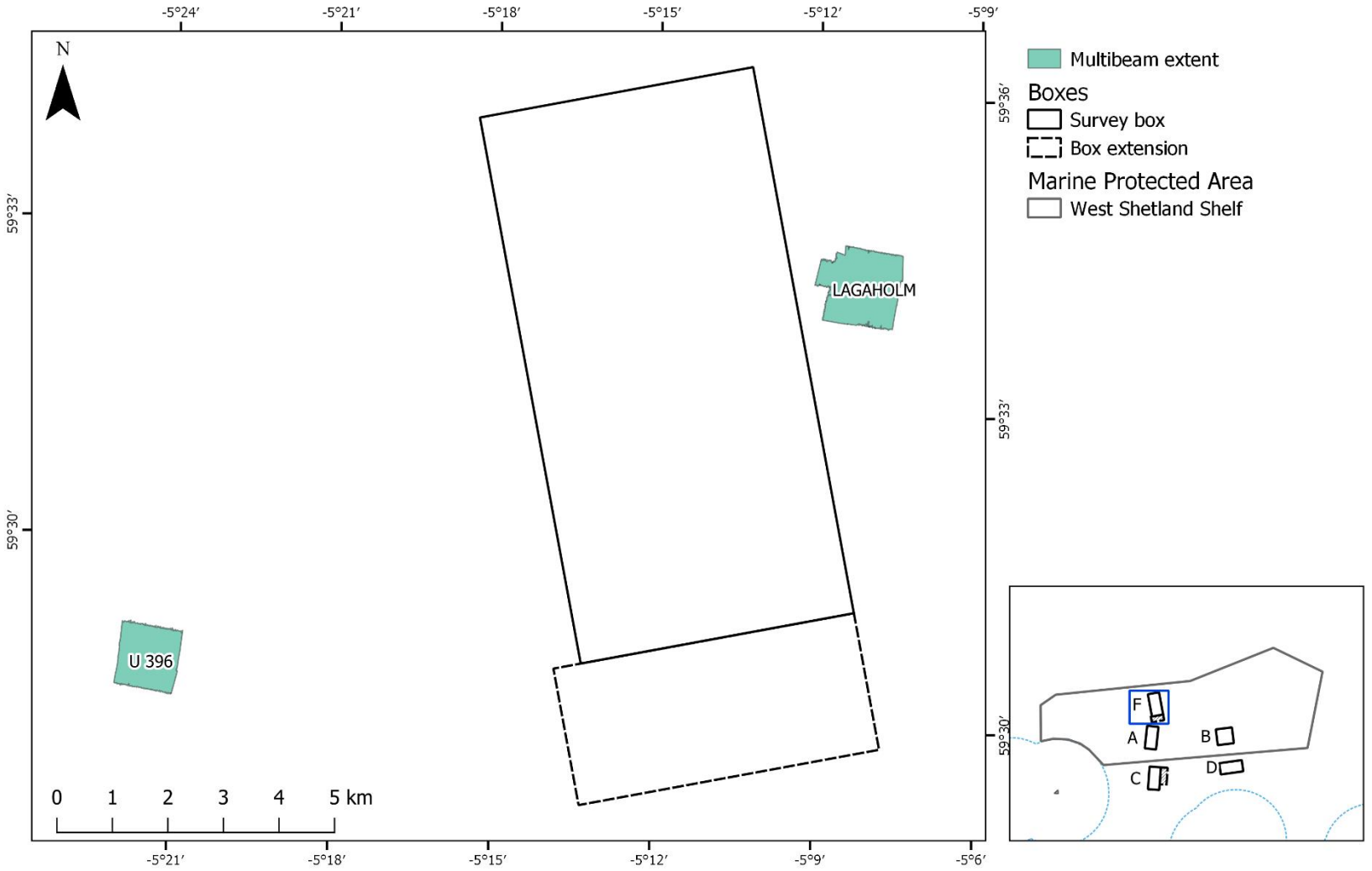

Figure 12. Map of completed multibeam extent at *M.V. Lagaholm* and *U-396* wreck areas of search.

5.4. Single-beam data (Roxann)

Single-beam echosounder data was recorded continuously during 1219S as described in section 3.4.2.

This data was not recorded to directly address a monitoring objective, but it was used during the survey to help position box extensions at Box C and F. Single-beam data is available for all areas visited by the MRV *Scotia* during 1219S (Figure 13) and interpolating this dataset may provide useful information on ground type and ground type variability at boxes where little or no multibeam data was collected.

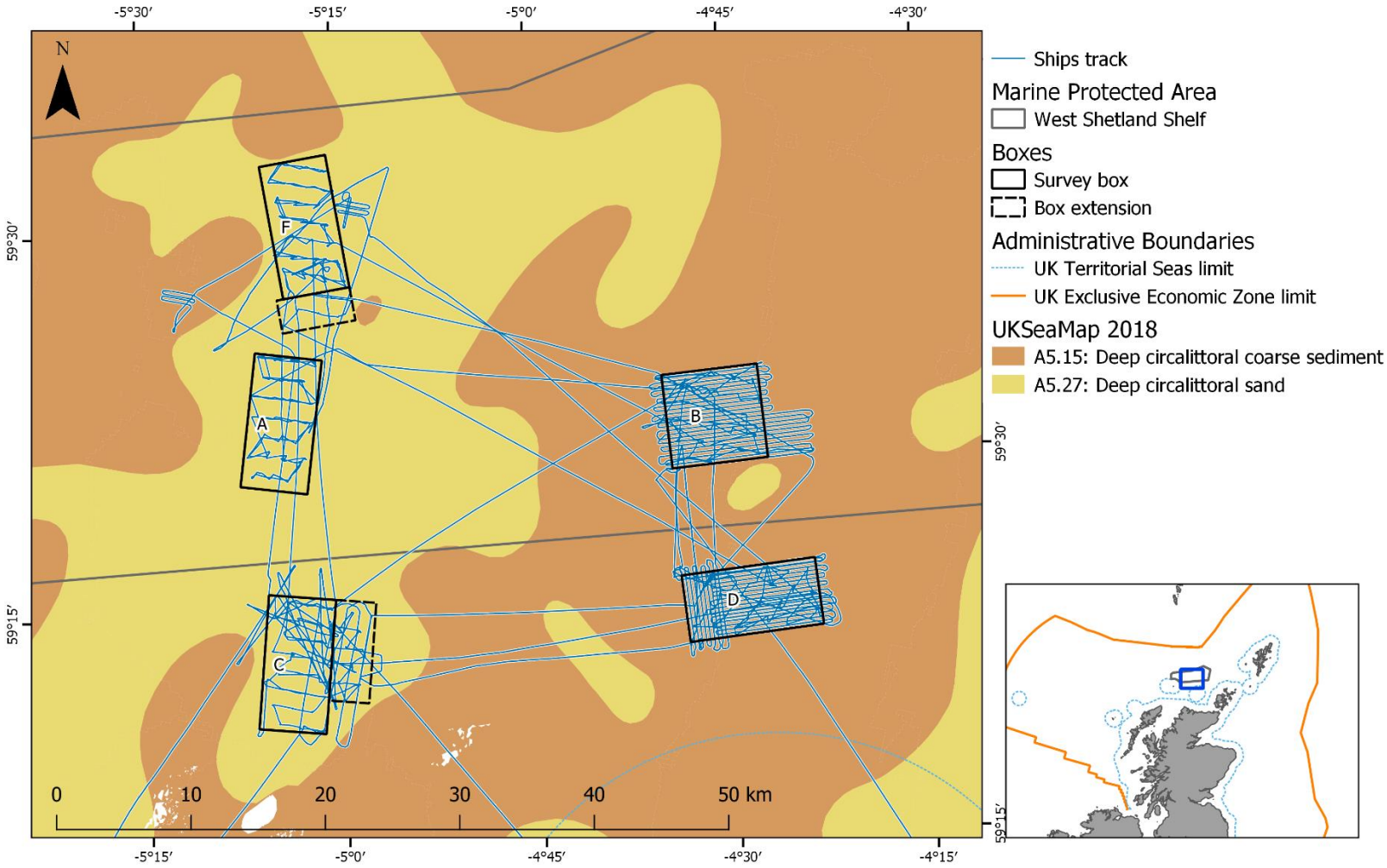

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Figure 13. *MRV Scotia's* ship tracks recorded from the vessel data management system (Davis system), showing the locations where single-beam data was recorded in relation to 1219S survey boxes and predicted BSH from UKSeaMap 2018.

6. Data management

Recording of data was standardised by using the MEDIN-compliant metadata spreadsheet and targeted deck forms. The metadata entry was checked by an additional survey scientist or the data manager to ensure consistency and accuracy.

A naming convention for all stations was adopted across the different sampling methods to include the survey code, area initials, box station, sample number and replicate ID. Replicates were planned at certain stations and recorded appropriately within the ID name.

For each still image taken, the image number and time was recorded and subsequently entered into the metadata spreadsheet. The images were downloaded via the Canon image software which retained the image number attribute. This was used to organise the images into folders based on the tow name.

Samples from the Hamon Grab were collected for site monitoring purposes and DNA analysis to be conducted by National Museums Scotland and the Natural History Museum. Metadata for these samples was collected and recorded in the whole-survey metadata spreadsheet and labelled appropriately to allow for separation post-survey.

The time of image collection was taken from the vessel data management system (Davis system). This was matched to the USBL data on time which allowed the aggregation of the USBL latitude and longitude with the metadata. To make the positional information robust, location information was recorded on the deck forms to match to the Arc GIS positions and USBL system. If there was a redundancy in any of these systems, spatial information could be pulled in from another source.

Backups of each data type were taken each day at end of shift onto the three encrypted, storage hard drives. Beyond Compare software was used to sync the hard drives and update information from the working laptop into storage.

7. Health and safety

A muster and abandon ship drill followed by an induction was attended by all crew on the 26th August.

8. Acknowledgements

Thanks to Emily Sym and Matthew Ferguson for contributing to the data management multibeam methods sections of this report respectively, and Fiona Ware for revising the DNA protocol for use during 1219S.

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Available from: http://www.legislation.gov.uk/eur/2003/2287/contents
[accessed October 2019]

Regulation (EU) 2019/1241 of the European Parliament and of the Council of 20 June 2019 on the conservation of fisheries resources and the protection of marine ecosystems through technical measures, amending Council Regulations (EC) No 1967/2006, (EC) No 1224/2009 and Regulations (EU) No 1380/2013, (EU) 2016/1139, (EU) 2018/973, (EU) 2019/472 and (EU) 2019/1022 of the European Parliament and of the Council, and repealing Council Regulations (EC) No 894/97, (EC) No 850/98, (EC) No 2549/2000, (EC) No 254/2002, (EC) No 812/2004 and (EC) No 2187/2005 (2019) Official Journal of the European Union L 198, 25 July, pp.105-201.
Available from: http://www.legislation.gov.uk/eur/2019/1241#
[accessed October 2019]

10. Appendix 1: Survey equipment

10.1. Drop-frame camera

The drop-frame system supported the following instruments (Figure 14):

- SubC 1 Alpha video camera (HD video recorded internally). SD video sent up the line and recorded on DVD
- Standard definition Kongsberg OE 14-408 digital camera (10MP) with dedicated flash unit for still images capture (camera controlled topside, images recorded internally)
- four SEALED lamps for illumination
- four reference spot lasers (green)
- two fan lasers (red)
- Ultra-short Baseline (USBL) acoustic positioning beacon
- Weight suspended 1m below stills camera
- Stabilising keel

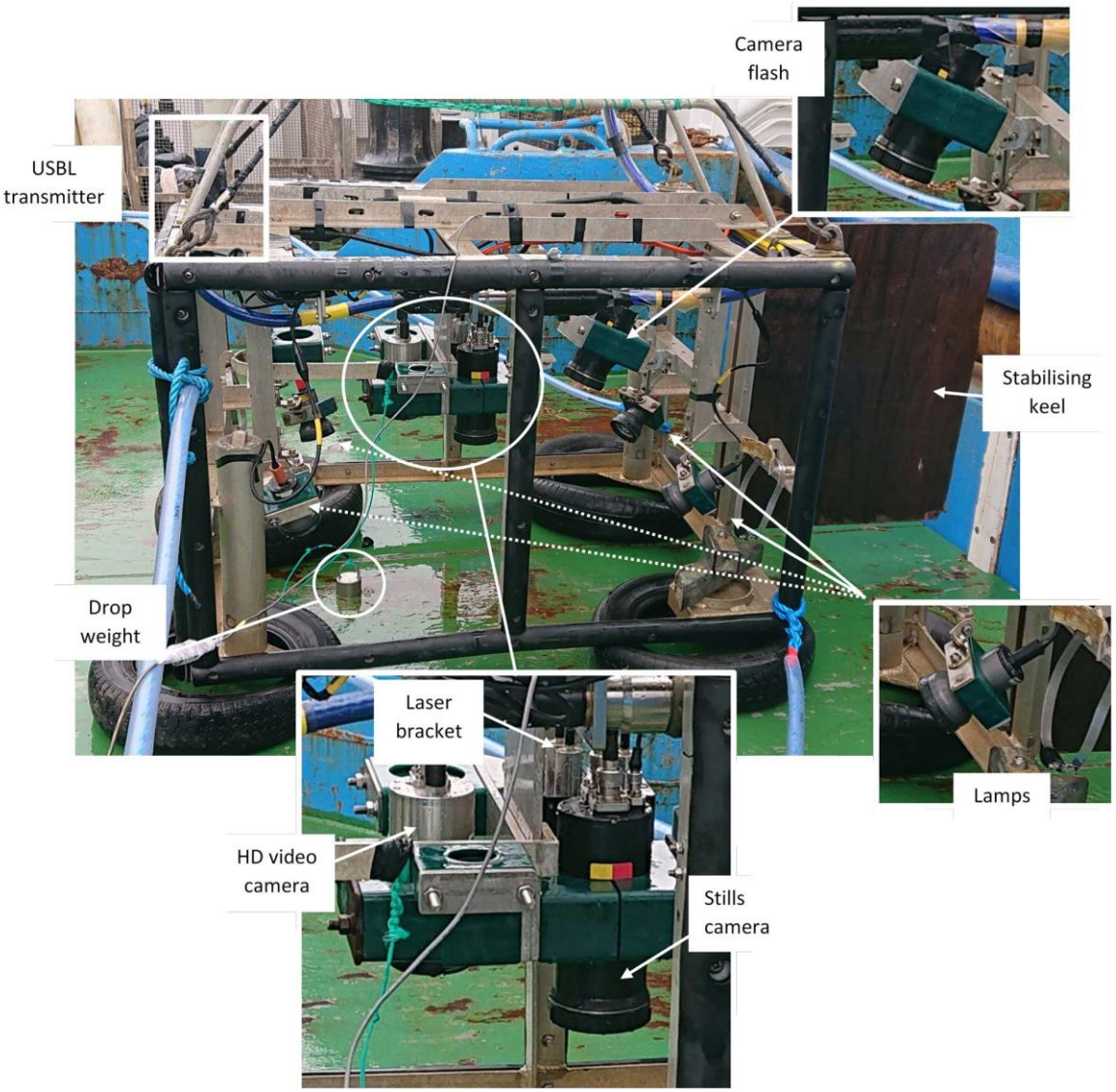

Figure 14. Labelled diagram of the drop-camera system showing the mounting locations of the; stills camera, stills camera flash, video camera, laser bracket (holding four point lasers), Lamps, USBL transmitter (partially obscured in image), drop weight, and stabilising keel (image © Tom Tangye JNCC).

The stills and video cameras were orientated in the drop-frame facing directly downwards with a video overlay displaying the time and date of recording.

Two types of scaling laser were mounted on the drop-frame; point lasers and fan lasers.

The four, green, reference point lasers were arranged so that they are visible in stills and video imagery. The point lasers are in a bracket holding them 64mm apart in a square formation. 64mm corresponds to the minimum size of a cobble stone. Imagery transects frequently had only two to three of these lasers functioning due to the electrical supply from the vessel to the drop camera.

The two, red, fan lasers were arranged so that they are visible in all video imagery. The fan lasers are mounted on the drop frame, 700mm apart, and provide a gated area that can be used for density counts (Figure 15).

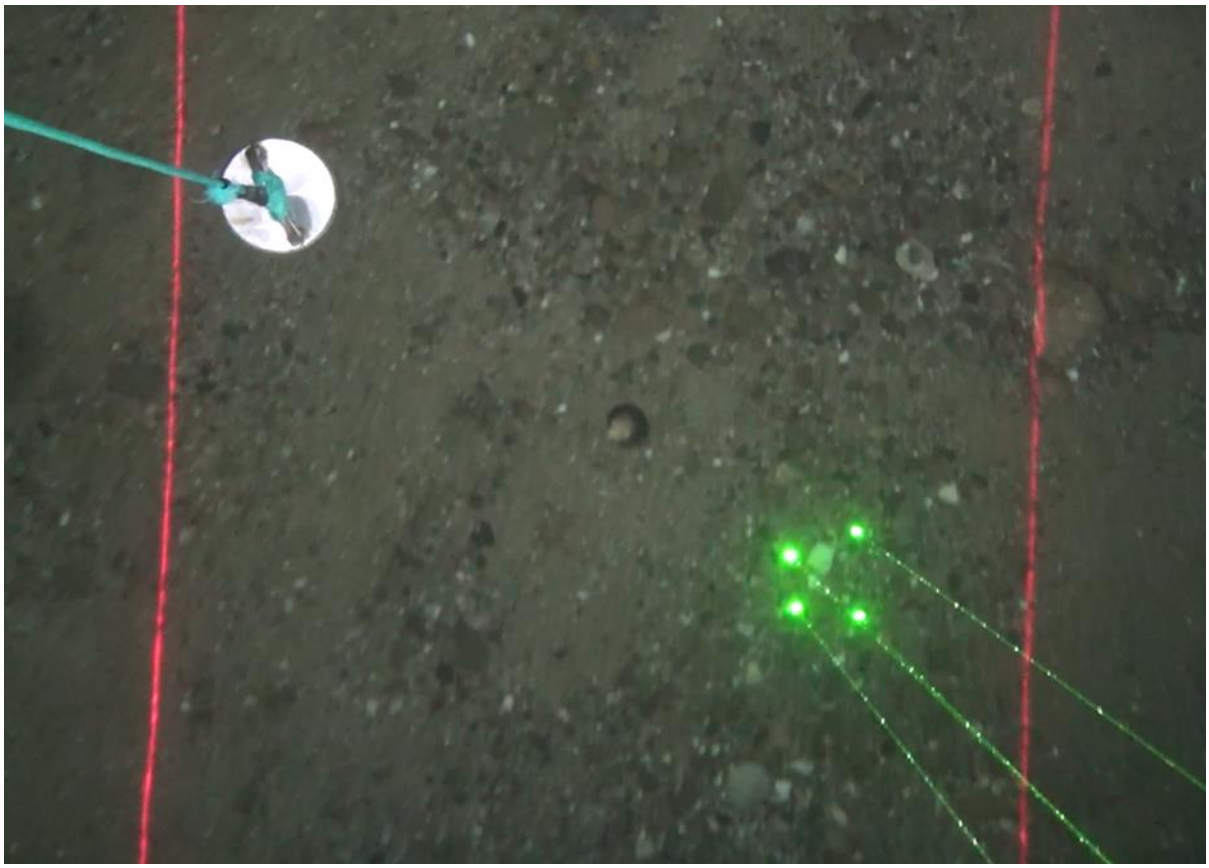

Figure 15. Example of image scaling used during 1219S. Showing four green point lasers arranged in a 64 x 64mm grid, two red fan lasers arranged in parallel lines 700mm apart, and the weight suspended 1m below camera.

10.2. Hamon grab (0.1m^2 and 0.25m^2)

JNCC's deep-sea Hamon grab was used for all benthic samples during 1219S. This grab is designed to have increased weight to improve its success rate when operating in deep water (where a long length of cable out can lead to misfires in the water column). The grab can be loaded with up to 20 weight blocks. The grab with all weight blocks and its stand was weighed at 1.16 metric tonnes before lifting onto the MRV *Scotia* with a crane. The grab also has an interchangeable 0.1m^2 and 0.25m^2 bucket. 1219S was used to test the grabs operation on coarse seabed.

Figure 16. JNCC's deep-sea Hamon grab (fitted with 0.1m^2 bucket), on its stand.

Figure 17. Hamon grab buckets side by side, 0.1m^2 bucket left and 0.25m^2 bucket right. Tape measure is extended to 60cm.

A reserve 0.1m^2 Hamon grab, 0.25m^2 Hamon grab, and 0.2m^2 Van Veen grab were also bought on survey but not used.

All samples were processed using a 5mm sieve table.

10.2.1. Deep-sea Hamon grab camera system trial

Introduction

An underwater camera system, designed to take video or still images of grab deployment, sampling and recovery and of the seabed being sampled, has been mounted and tested on the JNCC deep-sea Hamon grab.

Set-up

The camera system consists of a ‘GitUp’ camera and underwater housing (1500m depth rating) (Figure 18),two LED lamps and underwater housings (1750m depth rating) (Figure 19).

Figure 18. Waterproof camera housing (left) and camera (right).

Figure 19. Lamp housing [a)] and lamps [b)].

The camera housing is mounted by bolts to the topside of the grab seal plate with the lamp housings mounted in brackets secured to plating on either side of the trigger arm. The lamp housings are also tied to the frame using string and a jubilee clip (Figure 20).

The system is set-up by two operators, who should check each other's work (i.e. to ensure housings are sealed and mounted correctly).

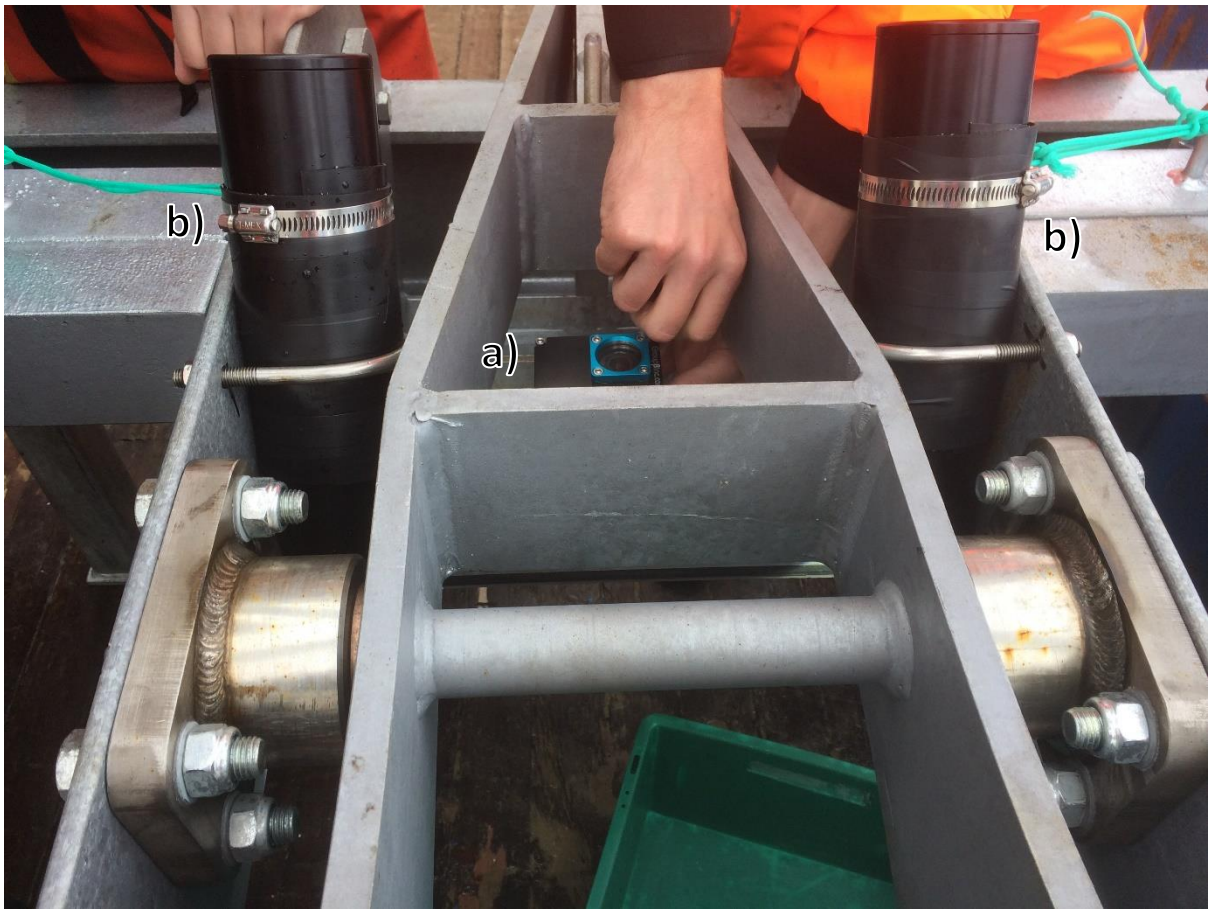

Figure 20. Underwater camera system mounted on JNCC deep-sea Hamon grab (note camera lens orientation is rotated and fixed to be downward facing before deployment [a) camera housing, b) lamp housing].

Testing

The lamp and camera housings were wet-tested on 1219S. Both were mounted to the grab and deployed to a depth of approximately 120m. No footage was recorded during 1219S but the lessons learned from these tests can be applied to future surveys.

Remote controls

Opening the camera and lamp housing takes time and could interfere with grab deployment. Each time a housing is opened care has to be taken to ensure it is closed with a watertight seal. To increase efficiency and reduce the risk of housing flooding, the set up should be altered so it is possible to turn the camera and lamps on/off without opening the housing.

Battery pack

The camera should have an external battery pack attached to extend the battery life and therefore reduce the amount of times the camera needs to be removed from its housing.

10.3. Multibeam

The MRV *Scotia* is equipped with a hull-mounted RESON Seabat 7125 dual frequency (200 or 400KHz) multibeam system. This was used to acquire bathymetry and backscatter data during the survey, set to 200KHz.

Motion and time data were collected from an Applanix Wavemaster using POSPACK software.

Multibeam data is exported in several outputs: PDS2000 (Ping data), S7K (Backscatter and log data), cleaned XYZ (ASCII output with some rough corrections) and XTF (eXtended Triton format).

Ping data were processed at sea using QGIS to generate surfaces (SAGA>Interpolate (cubic spline)), and then resample (SAGA>Resampling). This produced surfaces from which large-scale topographic features could be identified.

10.4. Single-beam (Roxann)

The MRV *Scotia* is equipped with a Sonavision Roxann acoustic ground discrimination system (AGDS) operating from the EK60 38KHz transducer. Data for each area of interest were cropped and exported in xyz format. For each echo parameter, the data were cleaned to remove outliers and interpolated using regression kriging with longitude, latitude and depth as the auxiliary variables. All processing and interpolation were undertaken within R software.

11. Appendix 2: Increased replication drop-camera stations

At stations subjected to increased replication (survey objective 5, Table 2), multiple camera transects were run in parallel lines within a radius of the sample station. This method is intended to better understand small scale variability within a sampling station and can potentially be visited in the future for monitoring change over time at the station.

1219S was the first time this sampling method has been implemented on MRV *Scotia* and some changes were made during the survey. The plan had been to have 5 parallel, 50m transects within a 50m radius of the sampling station.

In practice, transects were 100m long due to faster tow speeds and a minimum distance of 25m between transects was required. As a result, a 75m radius would be required to encompass all transects (Figure 21).

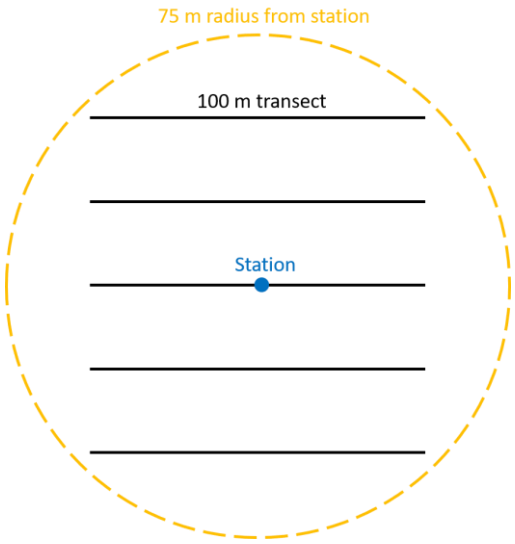

Figure 21. Diagram showing the ideal distribution of drop-camera transects at an increased replication station.

Due to time restraints on survey, only one increased replication drop-camera station was attempted (D022, see Section 5.1.4) at the end of a drop-camera shift, and only three parallel transects were achieved in this time. This does however provide a basis for developing this method on future MRV *Scotia* surveys.

In approximately 100m of water, the camera was deployed at approximately 165m (0.09 nautical miles) from the station. This allowed enough time for the camera to reach the seabed and get ready for recording by the time it was at the required start of line. At the end of the transect the drop-camera was recovered onto the deck before the ship turned. This was conducted close to slack tide, but current direction would need to be considered when deciding direction of transects.

Aside from the details described above, all other aspects of this method are the same as described for single replication stations (Section 3.2.1).

12. Appendix 3: protocol for DNA samples used on 1219S

1. If sample has failed for monitoring purposes, process through 5mm and 1mm sieves and transfer any retained target taxa to a 10 litre bucket of clean seawater. 'Mini-decant' the 1mm fraction (transfer contents of 1mm sieve to a 10 litre bucket, fill with seawater, swirl, quickly pour supernatant through sieve – repeat x 3-4, discard residue and extract target taxa (Table 12) from sieve).

2. Sterilise equipment (petri-dish, scalpel, forceps): drop into bleach solution, drain, transfer to ethanol 'bath', rinse with ethanol from wash bottle, transfer to sterile drying bucket – wear gloves and avoid contaminating subsequent stages with bleach/external DNA.

3. Remove target specimen from bucket of clean seawater with forceps, transfer to petri-dish, remove DNA sample (as per table above) using forceps/scalpel and transfer to a cryovial (pre-filled cryovials contain Absolute ethanol, empty cryovials are for Pelican foot gastropod eyes only and will need RNA later added to sample). Label the cryovial using the archival ink pen with 'Station code_Station number_Attempt' and 'Morpho #n' where n is the next available sequential number. Transfer the cryovial to the freezer.

4. Fragments of the specimen remaining in the petri-dish (which must include head & tail for polychaetes and pedal disc for starfish/brittlestars) should be transferred to a soda glass tube, labelled '1219S_WSS_ Station code_Station number_Attempt' and 'Morpho #n' where n is the same number as used for the fragment transferred to the cryovial (archival paper from the box and pencil). Add 5% formalin and transfer to the bucket labelled 'samples for Natural History Museum' in the chemical locker.

5. Repeat step 2 between each specimen.

Table 12. List of target specimen taxa, DNA sample required, and preservation medium.

TAXON	DNA Sample	Preservative
Sponges	1cm segment – any part	Absolute ethanol
Bryozoa	1cm segment – any part	Absolute ethanol
Starfish	1cm segment – tube feet tissue	Absolute ethanol
Brittlestars	1cm segment – tube feet tissue	Absolute ethanol
Worms >4cm	1cm segment – central part of worm	Absolute ethanol
Pelican foot gastropods	Eye	RNA later
	1cm section of foot or tail	Absolute ethanol

13. Appendix 4: Survey operations

Survey operations on 1219S are summarised in Figure 22.

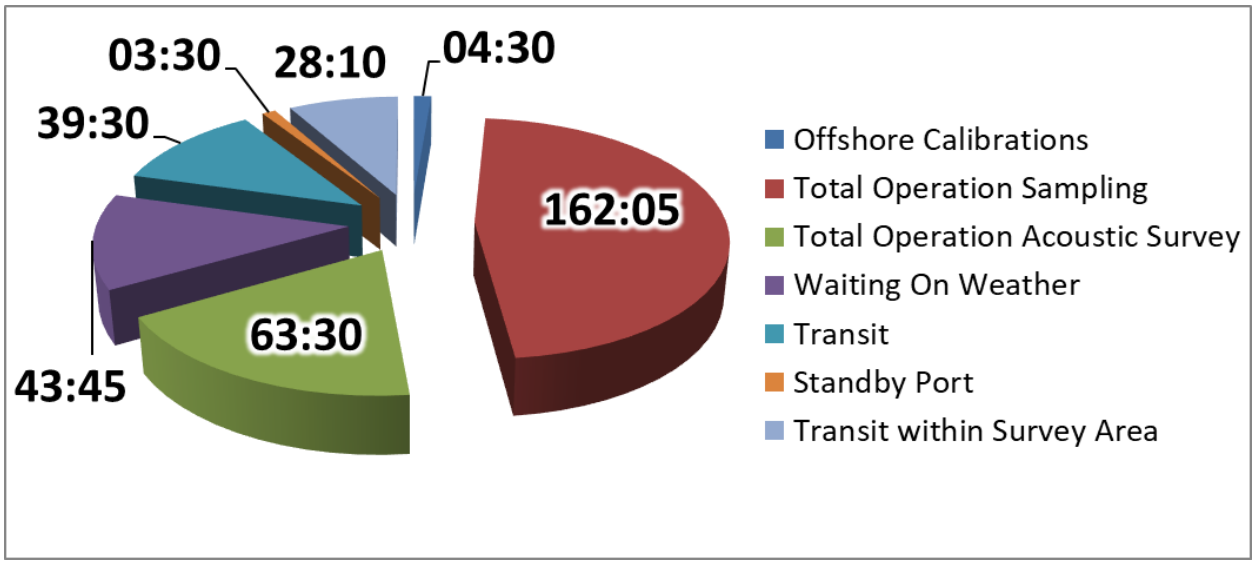

Figure 22. 1219S survey operations summary pie chart including time spent on each activity (hh:mm).

14. Appendix 5: Survey metadata

Summary metadata for camera transects and grab samples collected during 1219S are presented in Table 13 and Table 14 respectively.

Table 13. Summary metadata for drop camera transects sampled during 1219S.

Sample Event ID	Sample Accepted?	SOL Ship Latitude	SOL Ship Longitude	EOL Ship Latitude	EOL Ships Longitude	Date Sampled	Time Sampled
1219S_WSS_B001_S002_A1	No	59.44956667	4.670983333	59.44865	4.677183333	27/08/2019	06:51:00
1219S_WSS_B002_S003_A1	Yes	59.452	4.642183333	59.44983333	4.646216667	27/08/2019	07:52:32
1219S_WSS_B005_S004_A1	No	59.46348333	4.6293	59.46313333	4.630483333	27/08/2019	08:37:12
1219S_WSS_B006_S005_A1	Yes	59.46201667	4.60315	59.46208333	4.606883333	27/08/2019	09:09:00
1219S_WSS_B007_S006_A1	Yes	59.46266667	4.583866667	59.4625	4.5791	27/08/2019	09:53:00
1219S_WSS_A006_S008_A1	Yes	59.46091667	5.17955	59.45986667	5.1761	28/08/2019	01:08:00
1219S_WSS_A013_S009_A1	Yes	59.4589	5.203816667	59.45965	5.1994	28/08/2019	01:57:00
1219S_WSS_A018_S010_A1	Yes	59.45701667	5.225083333	59.45796667	5.222183333	28/08/2019	02:43:00
1219S_WSS_A016_S011_A1	Yes	59.45688333	5.248283333	59.45741667	5.24455	28/08/2019	03:26:00
1219S_WSS_A020_S012_A1	Yes	59.44353333	5.231266667	59.44363333	5.235333333	28/08/2019	04:08:00
1219S_WSS_A024_S013_A1	Yes	59.44523333	5.203333333	59.44521667	5.208533333	28/08/2019	04:48:00
1219S_WSS_A009_S014_A1	Yes	59.4468	5.1847	59.44665	5.188283333	28/08/2019	05:30:00
1219S_WSS_A005_S015_A1	Yes	59.43436667	5.164533333	59.43335	5.168083333	28/08/2019	06:47:00
1219S_WSS_A012_S016_A1	Yes	59.4331	5.196316667	59.43258333	5.200016667	28/08/2019	07:26:00
1219S_WSS_A019_S017_A1	Yes	59.4322	5.218166667	59.43113333	5.2227	28/08/2019	08:04:00
1219S_WSS_A022_S018_A1	Yes	59.43048333	5.2435	59.4299	5.247366667	28/08/2019	08:42:00
1219S_WSS_A023_S039_A1	Yes	59.41706667	5.235833333	59.41728333	5.232	28/08/2019	23:43:00
1219S_WSS_A021_S040_A1	Yes	59.4179	5.213666667	59.4184	5.209616667	29/08/2019	00:24:00
1219S_WSS_A008_S041_A1	Yes	59.41861667	5.19185	59.41981667	5.187583333	29/08/2019	01:10:00
1219S_WSS_A002_S042_A1	Yes	59.4201	5.1681	59.42088333	5.164066667	29/08/2019	01:52:00
1219S_WSS_A004_S043_A1	Yes	59.40828333	5.175816667	59.4064	5.17655	29/08/2019	02:45:00
1219S_WSS_A011_S044_A1	Yes	59.40741667	5.19765	59.40545	5.199016667	29/08/2019	03:23:00
1219S_WSS_A017_S045_A1	Yes	59.40663333	5.220116667	59.40408333	5.221233333	29/08/2019	04:01:00
1219S_WSS_A015_S046_A1	Yes	59.39211667	5.232	59.39035	5.234066667	29/08/2019	04:38:00
1219S_WSS_A025_S047_A1	Yes	59.39456667	5.2091	59.39266667	5.2103	29/08/2019	05:20:00

Sample Event ID	Sample Accepted?	SOL Ship Latitude	SOL Ship Longitude	EOL Ship Latitude	EOL Ships Longitude	Date Sampled	Time Sampled
1219S_WSS_A007_S048_A1	Yes	59.39546667	5.1858	59.39303333	5.1874	29/08/2019	05:58:00
1219S_WSS_A001_S049_A1	Yes	59.3956	5.163516667	59.39383333	5.1649	29/08/2019	06:59:00
1219S_WSS_A003_S050_A1	Yes	59.38156667	5.175	59.38003333	5.176283333	29/08/2019	07:41:00
1219S_WSS_A010_S051_A1	Yes	59.38071667	5.1985	59.37903333	5.200433333	29/08/2019	08:21:00
1219S_WSS_A014_S052_A1	Yes	59.38025	5.2195	59.3784	5.2212	29/08/2019	09:03:00
1219S_WSS_F025_S083_A1	Yes	59.58716667	5.215466667	59.58646667	5.219033333	30/08/2019	23:19:00
1219S_WSS_F024_S084_A1	Yes	59.58706667	5.241383333	59.58596667	5.2453	30/08/2019	23:59:00
1219S_WSS_F023_S085_A1	Yes	59.5862	5.267783333	59.58551667	5.2723	31/08/2019	00:44:00
1219S_WSS_F019_S086_A1	Yes	59.57545	5.283233333	59.57336667	5.284166667	31/08/2019	01:24:00
1219S_WSS_F020_S087_A1	Yes	59.57381667	5.260833333	59.57428333	5.2559	31/08/2019	02:05:00
1219S_WSS_F021_S088_A1	Yes	59.57428333	5.2335	59.57481667	5.229516667	31/08/2019	02:43:00
1219S_WSS_F022_S089_A1	Yes	59.57438333	5.206883333	59.57501667	5.203033333	31/08/2019	03:29:00
1219S_WSS_F018_S090_A1	Yes	59.56143333	5.21745	59.56353333	5.214433333	31/08/2019	04:14:00
1219S_WSS_F017_S091_A1	Yes	59.56123333	5.2441	59.56256667	5.241016667	31/08/2019	04:56:00
1219S_WSS_F016_S092_A1	Yes	59.56065	5.270066667	59.56253333	5.269383333	31/08/2019	05:34:00
1219S_WSS_F013_S093_A1	Yes	59.55015	5.252383333	59.5508	5.258266667	31/08/2019	06:46:00
1219S_WSS_F014_S094_A1	Yes	59.5509	5.225583333	59.55051667	5.22925	31/08/2019	07:34:00
1219S_WSS_F015_S095_A1	Yes	59.55173333	5.19785	59.55163333	5.20295	31/08/2019	08:19:00
1219S_WSS_F012_S096_A1	Yes	59.54105	5.186	59.53981667	5.189166667	31/08/2019	09:01:00
1219S_WSS_B023_S098_A1	Yes	59.50798333	4.659433333	59.50886667	4.663166667	31/08/2019	23:20:00
1219S_WSS_B024_S099_A1	Yes	59.50831667	4.632983333	59.50928333	4.636516667	01/09/2019	00:06:00
1219S_WSS_B025_S100_A1	Yes	59.50798333	4.607766667	59.50983333	4.60925	01/09/2019	00:52:00
1219S_WSS_B022_S101_A1	Yes	59.49598333	4.594216667	59.49803333	4.595566667	01/09/2019	01:40:00
1219S_WSS_B021_S102_A1	Yes	59.49605	4.62055	59.4978	4.622633333	01/09/2019	02:24:00
1219S_WSS_B020_S103_A1	Yes	59.4958	4.648866667	59.49746667	4.651516667	01/09/2019	03:03:00
1219S_WSS_B019_S106_A1	Yes	59.4982	4.672416667	59.49688333	4.670983333	01/09/2019	23:12:00
1219S_WSS_B018_S107_A1	Yes	59.49735	4.699383333	59.49616667	4.7026	01/09/2019	23:56:00

Sample Event ID	Sample Accepted?	SOL Ship Latitude	SOL Ship Longitude	EOL Ship Latitude	EOL Ships Longitude	Date Sampled	Time Sampled
1219S_WSS_B013_S108_A1	Yes	59.48588333	4.712966667	59.48426667	4.715333333	02/09/2019	00:34:00
1219S_WSS_B014_S109_A1	Yes	59.48561667	4.685566667	59.48468333	4.689	02/09/2019	01:24:00
1219S_WSS_B015_S110_A1	Yes	59.48541667	4.666333333	59.48513333	4.661466667	02/09/2019	02:04:00
1219S_WSS_B016_S111_A1	Yes	59.48523333	4.6386	59.4854	4.634233333	02/09/2019	02:44:00
1219S_WSS_B017_S112_A1	Yes	59.48561667	4.61305	59.48583333	4.608333333	02/09/2019	03:22:00
1219S_WSS_B012_S113_A1	Yes	59.47413333	4.598883333	59.47438333	4.593866667	02/09/2019	04:01:00
1219S_WSS_B011_S114_A1	Yes	59.47428333	4.621333333	59.47276667	4.621866667	02/09/2019	04:47:00
1219S_WSS_B010_S115_A1	Yes	59.4747	4.647116667	59.47266667	4.648233333	02/09/2019	05:22:00
1219S_WSS_B009_S116_A1	Yes	59.47426667	4.672366667	59.47253333	4.675116667	02/09/2019	05:56:47
1219S_WSS_B008_S117_A1	Yes	59.4739	4.699416667	59.47236667	4.684983333	02/09/2019	06:49:00
1219S_WSS_B003_S118_A1	Yes	59.46226667	4.68545	59.46076667	4.687883333	02/09/2019	07:27:00
1219S_WSS_B004_S119_A1	Yes	59.46281667	4.6564	59.46111667	4.661	02/09/2019	08:10:00
1219S_WSS_B001_S120_A2	Yes	59.45036667	4.67095	59.46553333	4.6744	02/09/2019	08:51:00
1219S_WSS_F001_S137_A1	Yes	59.50331667	5.2233	59.50438333	5.22695	02/09/2019	23:17:00
1219S_WSS_F002_S138_A1	Yes	59.51423333	5.237466667	59.50706667	5.515933333	02/09/2019	23:56:00
1219S_WSS_F003_S139_A1	Yes	59.51518333	5.211583333	59.51661667	5.214	03/09/2019	00:43:00
1219S_WSS_F004_S140_A1	Yes	59.5155	5.183533333	59.51693333	5.187816667	03/09/2019	01:28:00
1219S_WSS_F005_S141_A1	Yes	59.51591667	5.15785	59.51743333	5.160816667	03/09/2019	02:18:00
1219S_WSS_F009_S142_A1	Yes	59.52748333	5.1725	59.52915	5.174733333	03/09/2019	02:59:00
1219S_WSS_F008_S143_A1	Yes	59.52628333	5.203683333	59.52788333	5.200666667	03/09/2019	03:38:00
1219S_WSS_F007_S144_A1	Yes	59.526	5.2323	59.52683333	5.2289	03/09/2019	04:21:00
1219S_WSS_F006_S145_A1	Yes	59.52545	5.25565	59.52648333	5.25245	03/09/2019	05:01:00
1219S_WSS_F010_S146_A1	Yes	59.53763333	5.243866667	59.53943333	5.241366667	03/09/2019	05:37:00
1219S_WSS_F011_S147_A1	Yes	59.53821667	5.216966667	59.53986667	5.21495	03/09/2019	06:35:00
1219S_WSS_C025_S148_A1	Yes	59.30295	5.084283333	59.30195	5.08765	03/09/2019	08:38:00
1219S_WSS_C024_S149_A1	Yes	59.30243333	5.11075	59.30155	5.11405	03/09/2019	09:18:00
1219S_WSS_C023_S150_A1	Yes	59.30241667	5.135316667	59.30146667	5.139266667	03/09/2019	09:59:00

Sample Event ID	Sample Accepted?	SOL Ship Latitude	SOL Ship Longitude	EOL Ship Latitude	EOL Ships Longitude	Date Sampled	Time Sampled
1219S_WSS_C003_S167_A1	No	59.22081667	5.065083333	59.22005	5.06505	03/09/2019	23:14:00
1219S_WSS_C003_S167_A2	Yes	59.22086667	5.065866667	59.22023333	5.06905	03/09/2019	23:49:00
1219S_WSS_D004_S179_A1	Yes	59.35346667	4.630166667	59.35361667	4.6262	07/09/2019	11:52:03
1219S_WSS_D010_S180_A1	Yes	59.36406667	4.617316667	59.36611667	4.61695	07/09/2019	12:35:44
1219S_WSS_D017_S181_A1	Yes	59.37783333	4.606016667	59.37665	4.604633333	07/09/2019	13:21:40
1219S_WSS_D018_S182_A1	Yes	59.37803333	4.580316667	59.37645	4.577683333	07/09/2019	14:00:55
1219S_WSS_D011_S183_A1	Yes	59.36481667	4.587416667	59.36533333	4.591666667	07/09/2019	14:40:00
1219S_WSS_D005_S184_A1	Yes	59.3538	4.600516667	59.35333333	4.604566667	07/09/2019	15:19:12
1219S_WSS_D001_S185_A1	Yes	59.34246667	4.612783333	59.34146667	4.62905	07/09/2019	15:54:18
1219S_WSS_D002_S186_A1	Yes	59.34298333	4.587283333	59.34246667	4.591433333	07/09/2019	17:00:55
1219S_WSS_D006_S187_A1	Yes	59.35301667	4.578783333	59.35495	4.577766667	07/09/2019	17:35:13
1219S_WSS_D012_S188_A1	Yes	59.36413333	4.567316667	59.3664	4.566233333	07/09/2019	18:12:36
1219S_WSS_D019_S189_A1	Yes	59.37653333	4.555483333	59.3772	4.551833333	07/09/2019	18:48:16
1219S_WSS_D023_S190_A1	Yes	59.38898333	4.54315	59.38921667	4.539333333	07/09/2019	19:24:15
1219S_WSS_D024_S191_A1	Yes	59.38915	4.517066667	59.3895	4.5133	07/09/2019	19:58:12
1219S_WSS_D020_S192_A1	Yes	59.37763333	4.529533333	59.37783333	4.525566667	07/09/2019	20:38:05
1219S_WSS_D013_S206_A1	Yes	59.3678	4.5391	59.36585	4.5393	08/09/2019	11:27:46
1219S_WSS_D007_S207_A1	Yes	59.35615	4.55205	59.35405	4.55135	08/09/2019	12:05:48
1219S_WSS_D003_S208_A1	Yes	59.34466667	4.56525	59.34276667	4.564016667	08/09/2019	12:45:03
1219S_WSS_D008_S209_A1	Yes	59.35668333	4.526166667	59.35471667	4.525466667	08/09/2019	13:28:59
1219S_WSS_D014_S210_A1	Yes	59.36843333	4.512766667	59.36628333	4.513283333	08/09/2019	14:09:08
1219S_WSS_D021_S211_A1	Yes	59.37958333	4.500583333	59.37771667	4.5006	08/09/2019	14:49:44
1219S_WSS_D025_S212_A1	Yes	59.39165	4.487333333	59.38971667	4.487283333	08/09/2019	15:22:32
1219S_WSS_D022_S213_A1	Yes	59.37936667	4.475633333	59.37746667	4.475	08/09/2019	16:09:55
1219S_WSS_D015_S214_A1	Yes	59.36901667	4.487633333	59.36748333	4.49	08/09/2019	17:15:54
1219S_WSS_D009_S215_A1	Yes	59.35736667	4.500366667	59.35535	4.500066667	08/09/2019	17:46:29
1219S_WSS_D016_S216_A1	Yes	59.36858333	4.464533333	59.36688333	4.462166667	08/09/2019	18:26:02

Sample Event ID	Sample Accepted?	SOL Ship Latitude	SOL Ship Longitude	EOL Ship Latitude	EOL Ships Longitude	Date Sampled	Time Sampled
1219S_WSS_D022_S217_B1	Yes	59.37845	4.475933333	59.3785	4.473216667	08/09/2019	19:23:10
1219S_WSS_D022_S217_C1	Yes	59.37883333	4.471283333	59.37876667	4.47605	08/09/2019	19:54:23
1219S_WSS_D022_S217_D1	Yes	59.37898333	4.476466667	59.37896667	4.472966667	08/09/2019	20:33:25
1219S_WSS_C008_S223_A1	Yes	59.24306667	5.12535	59.24308333	5.120966667	09/09/2019	11:21:10
1219S_WSS_C010_S224_A1	Yes	59.2437	5.073883333	59.24391667	5.070216667	09/09/2019	12:06:30
1219S_WSS_C034_S225_A1	Yes	59.25573333	5.034333333	59.25633333	5.030766667	09/09/2019	12:51:01
1219S_WSS_C013_S226_A1	Yes	59.25371667	5.082966667	59.25573333	5.08375	09/09/2019	13:45:30
1219S_WSS_C011_S227_A1	Yes	59.25286667	5.136183333	59.2548	5.136533333	09/09/2019	14:35:20
1219S_WSS_C015_S228_A1	Yes	59.26445	5.124616667	59.26628333	5.125	09/09/2019	15:12:42
1219S_WSS_C030_S229_A1	Yes	59.2658	5.070816667	59.26765	5.071616667	09/09/2019	15:53:34
1219S_WSS_C031_S230_A1	Yes	59.26606667	5.043216667	59.26783333	5.044233333	09/09/2019	17:07:45
1219S_WSS_C035_S231_A1	Yes	59.2774	5.032116667	59.27915	5.034566667	09/09/2019	17:45:41
1219S_WSS_C019_S232_A1	Yes	59.2773	5.083533333	59.27878333	5.086366667	09/09/2019	18:28:11
1219S_WSS_C017_S233_A1	Yes	59.27765	5.136583333	59.27908333	5.139366667	09/09/2019	19:09:44
1219S_WSS_C021_S234_A1	Yes	59.28866667	5.1236	59.29026667	5.12565	09/09/2019	19:45:57
1219S_WSS_C027_S235_A1	Yes	59.29036667	5.070833333	59.29156667	5.07405	09/09/2019	20:29:14

Table 14. Summary metadata for samples collected during 1219S.

Sample Event ID	Sample Accepted?	Ship Latitude	Ship Longitude	Sample Date	Sample Time
1219S_WSS_A006_S019_HG_A1	No	59.46035	5.176583333	28/08/2019	09:34:57
1219S_WSS_A006_S019_HG_A2	No	59.46036667	5.1766	28/08/2019	09:44:30
1219S_WSS_A006_S019_HG_A3	Yes	59.46035	5.176583333	28/08/2019	10:26:42
1219S_WSS_A013_S020_HG_A1	Yes	59.45868333	5.200416667	28/08/2019	11:11:12
1219S_WSS_A018_S021_HG_A1	Yes	59.45778333	5.223066667	28/08/2019	12:13:00
1219S_WSS_A016_S022_HG_A1	Yes	59.4569	5.247866667	28/08/2019	12:39:00
1219S_WSS_A020_S023_HG_A1	Yes	59.44396667	5.234633333	28/08/2019	13:16:00
1219S_WSS_A024_S024_HG_A1	Yes	59.44508333	5.211033333	28/08/2019	14:05:00
1219S_WSS_A009_S025_HG_A1	Yes	59.44643333	5.1886	28/08/2019	14:33:00
1219S_WSS_A005_S026_HG_A1	Yes	59.4336	5.167316667	28/08/2019	15:04:00
1219S_WSS_A012_S027_HG_A1	No	59.43228333	5.202433333	28/08/2019	15:30:00
1219S_WSS_A012_S027_HG_A2	Yes	59.43226667	5.199283333	28/08/2019	15:52:00
1219S_WSS_A019_S028_HG_A1	Yes	59.43123333	5.22205	28/08/2019	16:17:00
1219S_WSS_A019_S028_HG_B1	Yes	59.43123333	5.222	28/08/2019	16:29:00
1219S_WSS_A019_S028_HG_C1	No	59.43121667	5.222033333	28/08/2019	16:39:00
1219S_WSS_A019_S028_HG_C2	Yes	59.43121667	5.222083333	28/08/2019	17:39:00
1219S_WSS_A022_S029_HG_A1	Yes	59.43006667	5.245733333	28/08/2019	17:57:00
1219S_WSS_A023_S030_HG_A1	Yes	59.41733333	5.233516667	28/08/2019	18:29:00
1219S_WSS_A021_S031_HG_A1	No	59.41823333	5.210033333	28/08/2019	18:53:00
1219S_WSS_A021_S031_HG_A2	No	59.41826667	5.210033333	28/08/2019	19:02:00
1219S_WSS_A021_S031_HG_A3	No	59.41826667	5.21005	28/08/2019	19:11:00
1219S_WSS_A008_S032_HG_A1	Yes	59.41953333	5.187933333	28/08/2019	19:30:00
1219S_WSS_A002_S033_HG_A1	Yes	59.4205	5.1646	28/08/2019	20:06:00
1219S_WSS_A004_S034_HG_A1	Yes	59.4068	5.175816667	28/08/2019	20:34:00
1219S_WSS_A011_S035_HG_A1	Yes	59.40578333	5.199883333	28/08/2019	21:04:00
1219S_WSS_A011_S035_HG_B1	No	59.40576667	5.1999	28/08/2019	21:12:00
1219S_WSS_A011_S035_HG_B2	Yes	59.40578333	5.199916667	28/08/2019	21:20:00
1219S_WSS_A011_S035_HG_C1	Yes	59.40578333	5.1999	28/08/2019	21:27:00
1219S_WSS_A017_S036_HG_A1	Yes	59.40441667	5.2218	28/08/2019	21:49:00
1219S_WSS_A015_SO37_HG_A1	Yes	59.3907	5.233633333	28/08/2019	22:21:00
1219S_WSS_A025_S038_HG_A1	Yes	59.39276667	5.2114	28/08/2019	22:45:00
1219S_WSS_A014_S053_HG_A1	Yes	59.37936667	5.220066667	29/08/2019	09:45:00
1219S_WSS_A010_S054_HG_A1	No	59.37925	5.1996	29/08/2019	10:04:00
1219S_WSS_A010_S054_HG_A2	Yes	59.37928333	5.1996	29/08/2019	10:12:00
1219S_WSS_A003_S055_HG_A1	Yes	59.38003333	5.1762	29/08/2019	10:43:00
1219S_WSS_A003_S055_HG_B1	Yes	59.38	5.176216667	29/08/2019	10:53:00
1219S_WSS_A003_S055_HG_C1	Yes	59.38001667	5.176266667	29/08/2019	11:02:00
1219S_WSS_A003_S055_HG_C2	No	59.38	5.1762	29/08/2019	11:13:00
1219S_WSS_A001_S056_HG_A1	Yes	59.3941	5.164466667	29/08/2019	11:58:00
1219S_WSS_A007_S057_HG_A1	No	59.39235	5.188116667	29/08/2019	12:35:00
1219S_WSS_A007_S057_HG_A2	Yes	59.39236667	5.18805	29/08/2019	12:46:00

Sample Event ID	Sample Accepted?	Ship Latitude	Ship Longitude	Sample Date	Sample Time
1219S_WSS_F001_S058_HG_A1	Yes	59.50423333	5.226066667	29/08/2019	13:50:00
1219S_WSS_F002_S059_HG_A1	Yes	59.51573333	5.24095	29/08/2019	14:18:00
1219S_WSS_F003_S060_HG_A1	Yes	59.51608333	5.214483333	29/08/2019	14:51:00
1219S_WSS_F004_S061_HG_A1	Yes	59.51675	5.1863	29/08/2019	15:23:00
1219S_WSS_F005_S062_HG_A1	Yes	59.51723333	5.159316667	29/08/2019	15:55:00
1219S_WSS_F009_S063_HG_A1	Yes	59.52866667	5.172883333	29/08/2019	17:36:00
1219S_WSS_F008_S064_HG_A1	No	59.52828333	5.200533333	30/08/2019	08:45:38
1219S_WSS_F008_S064_HG_A2	Yes	59.52826667	5.200533333	30/08/2019	08:55:23
1219S_WSS_F007_S065_HG_A1	Yes	59.52773333	5.227066667	30/08/2019	09:21:00
1219S_WSS_F006_S066_HG_A1	Yes	59.52745	5.254133333	30/08/2019	09:46:24
1219S_WSS_F010_S067_HG_A1	Yes	59.53925	5.241416667	30/08/2019	10:13:01
1219S_WSS_F011_S068_HG_A1	Yes	59.5399	5.2151	30/08/2019	10:39:47
1219S_WSS_F011_S068_HG_B1	No	59.53988333	5.215183333	30/08/2019	10:52:09
1219S_WSS_F011_S068_HG_B2	Yes	59.53991667	5.215083333	30/08/2019	11:02:00
1219S_WSS_F011_S068_HG_C1	Yes	59.5399	5.215133333	30/08/2019	11:15:00
1219S_WSS_F012_S069_HG_A1	Yes	59.54031667	5.18805	30/08/2019	11:49:00
1219S_WSS_F015_S070_HG_A1	Yes	59.55183333	5.2021	30/08/2019	12:22:00
1219S_WSS_F014_S071_HG_A1	Yes	59.55153333	5.22965	30/08/2019	12:53:00
1219S_WSS_F013_S072_HG_A1	Yes	59.55076667	5.25495	30/08/2019	13:19:00
1219S_WSS_F016_S073_HG_A1	Yes	59.56203333	5.269466667	30/08/2019	13:52:00
1219S_WSS_F017_S074_HG_A1	Yes	59.56295	5.242583333	30/08/2019	14:25:00
1219S_WSS_F018_S075_HG_A1	No	59.56348333	5.215533333	30/08/2019	14:56:00
1219S_WSS_F018_S075_HG_A2	Yes	59.56346667	5.2155	30/08/2019	15:09:00
1219S_WSS_F018_S075_HG_B1	Yes	59.56348333	5.2155	30/08/2019	15:20:00
1219S_WSS_F018_S075_HG_C1	Yes	59.56346667	5.2155	30/08/2019	15:32:00
1219S_WSS_F022_S076_HG_A1	Yes	59.57465	5.2033	30/08/2019	16:15:49
1219S_WSS_F021_S077_HG_A1	Yes	59.5747	5.2301	30/08/2019	17:48:00
1219S_WSS_F020_S078_HG_A1	Yes	59.57401667	5.25675	30/08/2019	18:10:00
1219S_WSS_F020_S078_HG_B1	No	59.574	5.256716667	30/08/2019	18:18:51
1219S_WSS_F020_S078_HG_B2	Yes	59.574	5.256733333	30/08/2019	18:26:00
1219S_WSS_F020_S078_HG_C1	Yes	59.57401667	5.25675	30/08/2019	18:48:38
1219S_WSS_F019_S079_HG_A1	Yes	59.57356667	5.2838	30/08/2019	19:29:00
1219S_WSS_F023_S080_HG_A1	No	59.5856	5.270633333	30/08/2019	19:58:00
1219S_WSS_F023_S080_HG_A2	Yes	59.58561667	5.270666667	30/08/2019	20:07:06
1219S_WSS_F024_S081_HG_A1	Yes	59.5862	5.244633333	30/08/2019	21:15:35
1219S_WSS_F025_S082_HG_A1	Yes	59.58655	5.217466667	30/08/2019	21:40:47
1219S_WSS_B001_S121_HG_A1	No	59.4503	4.6721	02/09/2019	09:39:00
1219S_WSS_B001_S121_HG_A2	Yes	59.45035	4.67205	02/09/2019	09:46:00
1219S_WSS_B002_S122_HG_A1	No	59.45001667	4.629466667	02/09/2019	10:18:00
1219S_WSS_B002_S122_HG_A2	Yes	59.45	4.646266667	02/09/2019	10:24:00
1219S_WSS_B006_S123_HG_A1	No	59.46218333	4.6069	02/09/2019	10:59:15
1219S_WSS_B006_S123_HG_A2	No	59.4622	4.6069	02/09/2019	11:09:00

Sample Event ID	Sample Accepted?	Ship Latitude	Ship Longitude	Sample Date	Sample Time
1219S_WSS_B006_S123_HG_A3	No	59.46218333	4.606883333	02/09/2019	11:19:00
1219S_WSS_B007_S124_HG_A1	Yes	59.46245	4.580233333	02/09/2019	11:54:00
1219S_WSS_B012_S125_HG_A1	Yes	59.47421667	4.5943	02/09/2019	12:25:00
1219S_WSS_B018_S126_HG_A1	Yes	59.49646667	4.70295	02/09/2019	13:16:00
1219S_WSS_B023_S127_HG_A1	Yes	59.5154	4.66295	02/09/2019	13:54:00
1219S_WSS_C025_S128_HG_A1	No	59.3022	5.086566667	02/09/2019	15:56:48
1219S_WSS_C025_S128_HG_A2	No	59.3022	5.086583333	02/09/2019	16:07:00
1219S_WSS_C025_S128_HG_A3	No	59.3022	5.086633333	02/09/2019	16:18:22
1219S_WSS_C024_S129_HG_A1	No	59.30176667	5.112833333	02/09/2019	17:32:17
1219S_WSS_C024_S129_HG_A2	No	59.30178333	5.112816667	02/09/2019	17:41:00
1219S_WSS_C024_S129_HG_A3	No	59.30223333	5.112816667	02/09/2019	17:54:00
1219S_WSS_C023_S130_HG_A1	Yes	59.30125	5.139583333	02/09/2019	18:13:00
1219S_WSS_C020_S131_HG_A1	Yes	59.28943333	5.152116667	02/09/2019	18:41:00
1219S_WSS_C021_S132_HG_A1	No	59.28995	5.12535	02/09/2019	19:09:00
1219S_WSS_C021_S132_HG_A2	No	59.28993333	5.125333333	02/09/2019	19:17:00
1219S_WSS_C021_S132_HG_A3	No	59.29038333	5.125333333	02/09/2019	19:31:00
1219S_WSS_C022_S133_HG_A1	Yes	59.29023333	5.098766667	02/09/2019	19:59:05
1219S_WSS_C019_S134_HG_A1	Yes	59.27878333	5.0848	02/09/2019	20:35:09
1219S_WSS_C018_S135_HG_A1	Yes	59.27871667	5.111366667	02/09/2019	20:58:00
1219S_WSS_C017_S136_HG_A1	Yes	59.278	5.137766667	02/09/2019	21:22:00
1219S_WSS_C014_S151_HG_A1	Yes	59.26615	5.150283333	03/09/2019	10:47:00
1219S_WSS_C015_S152_HG_A1	Yes	59.26651667	5.123816667	03/09/2019	11:31:00
1219S_WSS_C015_S152_HG_B1	Yes	59.26651667	5.123816667	03/09/2019	11:42:00
1219S_WSS_C015_S152_HG_C1	No	59.2665	5.123816667	03/09/2019	11:51:00
1219S_WSS_C015_S152_HG_C2	Yes	59.26651667	5.123816667	03/09/2019	12:01:00
1219S_WSS_C016_S153_HG_A1	Yes	59.26705	5.0973	03/09/2019	12:37:00
1219S_WSS_C013_S154_HG_A1	No	59.25543333	5.0835	03/09/2019	13:09:20
1219S_WSS_C013_S154_HG_A2	No	59.25545	5.0835	03/09/2019	13:12:17
1219S_WSS_C013_S154_HG_A3	No	59.25545	5.083516667	03/09/2019	13:31:33
1219S_WSS_C012_S155_HG_A1	Yes	59.25503333	5.11015	03/09/2019	14:03:00
1219S_WSS_C011_S156_HG_A1	Yes	59.25453333	5.1364	03/09/2019	14:41:21
1219S_WSS_C007_S157_HG_A1	Yes	59.2428	5.149133333	03/09/2019	15:14:22
1219S_WSS_C007_S157_HG_B1	Yes	59.2428	5.149133333	03/09/2019	15:24:00
1219S_WSS_C007_S157_HG_C1	Yes	59.2428	5.149133333	03/09/2019	15:34:00
1219S_WSS_C008_S158_HG_A1	Yes	59.24305	5.1232	03/09/2019	16:19:14
1219S_WSS_C009_S159_HG_A1	Yes	59.24346667	5.096316667	03/09/2019	17:26:10
1219S_WSS_C010_S160_HG_A1	Yes	59.24401667	5.06965	03/09/2019	17:49:01
1219S_WSS_C006_S161_HG_A1	Yes	59.23196667	5.0824	03/09/2019	18:14:21
1219S_WSS_C005_S162_HG_A1	No	59.23156667	5.108266667	03/09/2019	18:37:33
1219S_WSS_C005_S162_HG_A2	Yes	59.23158333	5.10825	03/09/2019	18:44:54
1219S_WSS_C004_S163_HG_A1	No	59.23111667	5.134933333	03/09/2019	19:16:38
1219S_WSS_C004_S163_HG_A2	No	59.23111667	5.134833333	03/09/2019	19:26:18

Sample Event ID	Sample Accepted?	Ship Latitude	Ship Longitude	Sample Date	Sample Time
1219S_WSS_C004_S163_HG_A3	No	59.23113333	5.135733333	03/09/2019	19:39:45
1219S_WSS_C001_S164_HG_A1	Yes	59.22043333	5.120233333	03/09/2019	20:01:29
1219S_WSS_C002_S165_HG_A1	No	59.2199	5.09435	03/09/2019	20:24:29
1219S_WSS_C002_S165_HG_A2	Yes	59.21988333	5.094383333	03/09/2019	20:31:00
1219S_WSS_C002_S165_HG_B1	No	59.2199	5.094366667	03/09/2019	20:37:00
1219S_WSS_C002_S165_HG_B2	No	59.21988333	5.0935	03/09/2019	20:51:00
1219S_WSS_C002_S165_HG_B3	No	59.2199	5.093516667	03/09/2019	20:58:00
1219S_WSS_C003_S166_HG_A1	Yes	59.22033333	5.0679	03/09/2019	21:22:00
1219S_WSS_C003_S166_HG_B1	Yes	59.22033333	5.0679	03/09/2019	21:31:09
1219S_WSS_C003_S166_HG_C1	No	59.22033333	5.067883333	03/09/2019	21:36:00
1219S_WSS_C003_S166_HG_C2	No	59.22031667	5.067933333	03/09/2019	21:42:00
1219S_WSS_C003_S166_HG_C3	No	59.22035	5.06705	03/09/2019	21:55:00
1219S_WSS_C026_S168_HG_A1	Yes	59.30283333	5.059783333	05/09/2019	12:00:59
1219S_WSS_C027_S169_HG_A1	Yes	59.29076667	5.071283333	05/09/2019	12:36:57
1219S_WSS_C028_S170_HG_A1	Yes	59.29123333	5.045816667	05/09/2019	13:13:00
1219S_WSS_C029_S171_HG_A1	Yes	59.27943333	5.058266667	05/09/2019	13:51:20
1219S_WSS_C029_S171_HG_B1	Yes	59.27948333	5.058316667	05/09/2019	14:03:00
1219S_WSS_C029_S171_HG_C1	Yes	59.27946667	5.0583	05/09/2019	14:13:27
1219S_WSS_C030_S172_HG_A1	No	59.26736667	5.071116667	06/09/2019	17:30:16
1219S_WSS_C030_S172_HG_A2	No	59.26721667	5.0708	07/09/2019	05:15:00
1219S_WSS_C030_S172_HG_A3	No	59.26738333	5.0708	07/09/2019	05:23:00
1219S_WSS_C030_S172_HG_A4	No	59.26766667	5.070716667	07/09/2019	05:37:00
1219S_WSS_C031_S173_HG_A1	No	59.26765	5.0444	07/09/2019	06:40:00
1219S_WSS_C031_S173_HG_A2	No	59.26763333	5.044433333	07/09/2019	06:49:00
1219S_WSS_C031_S173_HG_A3	No	59.2681	5.0444	07/09/2019	07:06:00
1219S_WSS_C032_S174_HG_A1	Yes	59.25578333	5.056983333	07/09/2019	07:45:00
1219S_WSS_C033_S175_HG_A1	Yes	59.24418333	5.044316667	07/09/2019	08:12:00
1219S_WSS_C034_S176_HG_A1	Yes	59.25618333	5.03035	07/09/2019	08:39:00
1219S_WSS_C035_S177_HG_A1	No	59.27975	5.031766667	07/09/2019	09:07:40
1219S_WSS_C035_S177_HG_A2	No	59.27971667	5.031833333	07/09/2019	09:15:00
1219S_WSS_C035_S177_HG_A3	No	59.28018333	5.0318	07/09/2019	09:31:16
1219S_WSS_C036_S178_HG_A1	No	59.30313333	5.033033333	07/09/2019	09:57:43
1219S_WSS_C036_S178_HG_A2	Yes	59.30316667	5.033016667	07/09/2019	10:06:05
1219S_WSS_D020_S193_HG_A1	Yes	59.3778	4.529516667	07/09/2019	21:20:57
1219S_WSS_D023_S194_HG_A1	Yes	59.38906667	4.540283333	07/09/2019	21:51:29
1219S_WSS_D017_S195_HG_A1	Yes	59.37685	4.607083333	07/09/2019	22:31:00
1219S_WSS_D010_S196_HG_A1	No	59.36411667	4.618033333	07/09/2019	22:59:05
1219S_WSS_D010_S196_HG_A2	No	59.3641	4.617466667	07/09/2019	23:11:05
1219S_WSS_D010_S196_HG_A3	No	59.36453333	4.617416667	07/09/2019	23:28:57
1219S_WSS_F026_S197_HG_A1	Yes	59.50473333	5.198883333	08/09/2019	03:37:40
1219S_WSS_F027_S198_HG_A1	Yes	59.5052	5.17245	08/09/2019	04:10:38
1219S_WSS_F028_S199_HG_A1	Yes	59.5055	5.145666667	08/09/2019	04:43:58

Sample Event ID	Sample Accepted?	Ship Latitude	Ship Longitude	Sample Date	Sample Time
1219S_WSS_F029_S200_HG_A1	Yes	59.4436	5.158216667	08/09/2019	05:11:25
1219S_WSS_F030_S201_HG_A1	Yes	59.49315	5.183466667	08/09/2019	05:39:59
1219S_WSS_F031_S202_HG_A1	Yes	59.49266667	5.211566667	08/09/2019	06:40:10
1219S_WSS_F032_S203_HG_A1	Yes	59.48065	5.224116667	08/09/2019	07:06:06
1219S_WSS_D020_S204_LHG_A1	No	59.37783333	4.526583333	08/09/2019	09:40:01
1219S_WSS_D020_S204_LHG_A2	No	59.37781667	4.526616667	08/09/2019	09:51:54
1219S_WSS_D020_S204_LHG_A3	Yes	59.37781667	4.5266	08/09/2019	10:00:06
1219S_WSS_D023_S205_LHG_A1	Yes	59.38921667	4.5399	08/09/2019	10:24:16
1219S_WSS_D013_S218_HG_A1	Yes	59.36785	4.539233333	08/09/2019	21:20:49
1219S_WSS_D007_S219_HG_A1	No	59.35426667	4.551233333	08/09/2019	21:45:59
1219S_WSS_D007_S219_HG_A2	No	59.35425	4.551266667	08/09/2019	21:51:59
1219S_WSS_D007_S219_HG_A3	No	59.35413333	4.551533333	08/09/2019	22:02:38
1219S_WSS_D003_S220_HG_A1	No	59.34488333	4.56565	08/09/2019	22:24:40
1219S_WSS_D003_S220_HG_A2	Yes	59.34488333	4.565683333	08/09/2019	22:34:00
1219S_WSS_D008_S221_HG_A1	Yes	59.35488333	4.52575	08/09/2019	23:03:55
1219S_WSS_D016_S222_HG_A1	No	59.36855	4.4642	08/09/2019	23:49:55
1219S_WSS_D016_S222_HG_A2	Yes	59.36855	4.464183333	08/09/2019	23:59:06

15. Appendix 6: Survey box coordinates

The vertex coordinates of all boxes shown in Figure 3 are provided in Table 15.

Table 15. Vertex coordinates (Decimal Degrees) of all completed and planned but not completed survey boxes.

Box	Status	Vertex order	Latitude	Longitude
A	Completed as planned	1	59.373732	-5.14838814
A	Completed as planned	2	59.3690397	-5.23586755
A	Completed as planned	3	59.4583231	-5.25442033
A	Completed as planned	4	59.4630291	-5.16671338
B	Completed after modification	1	59.5209052	-4.60741475
B	Completed after modification	2	59.4613222	-4.56806663
B	Completed after modification	3	59.4408668	-4.68745614
B	Completed after modification	4	59.5004131	-4.72698957
B	Planned, not completed	1	59.469255	-4.52097185
B	Planned, not completed	2	59.4406022	-4.68812288
B	Planned, not completed	3	59.4831289	-4.7163918
B	Planned, not completed	4	59.5118184	-4.54905554
C	Completed as planned	1	59.2135839	-5.145326
C	Completed as planned	2	59.3024893	-5.16982449
C	Completed as planned	3	59.3087417	-5.08288781
C	Completed as planned	4	59.2198188	-5.05861041
C	Completed box extension	1	59.3124654	-5.03070978
C	Completed box extension	2	59.245766	-5.0125891
C	Completed box extension	3	59.2420501	-5.0646673

C	Completed box extension	4	59.3087418	-5.08288765
D	Completed as planned	1	59.4021187	-4.48168749
D	Completed as planned	2	59.3597767	-4.45242798
D	Completed as planned	3	59.3298332	-4.61816714
D	Completed as planned	4	59.3721374	-4.64760611
E	Planned, not completed	1	59.6991071	-4.54529406
E	Planned, not completed	2	59.6093995	-4.55284675
E	Planned, not completed	3	59.6112787	-4.64136204
E	Planned, not completed	4	59.7009903	-4.63404579
F	Completed after modification	1	59.4976343	-5.23305831
F	Completed after modification	2	59.5805091	-5.30105509
F	Completed after modification	3	59.5977708	-5.21933356
F	Completed after modification	4	59.5148528	-5.15150077
F	Completed box extension	1	59.4941051	-5.13459174
F	Completed box extension	2	59.4751808	-5.22426111
F	Completed box extension	3	59.4959057	-5.24120542
F	Completed box extension	4	59.5148419	-5.15149104
F	Planned, not completed	1	59.5622058	-5.21102827
F	Planned, not completed	2	59.5932879	-5.04497259
F	Planned, not completed	3	59.5511489	-5.01446197
F	Planned, not completed	4	59.5201064	-5.1803402
G	Planned, not completed	1	59.4398702	-5.91068514
G	Planned, not completed	2	59.441114	-5.82259024
G	Planned, not completed	3	59.351374	-5.8178386
G	Planned, not completed	4	59.3501352	-5.90570117

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