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1016S Cruise Report: Monitoring survey of Geikie Slide and the Hebridean Slope NCMPA (Revised September 2019)

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Summary

The Joint Nature Conservation Committee (JNCC) and Marine Scotland Science (MSS) undertook an offshore seabed survey of Geikie Slide and the Hebridean Slope (GSH) Scottish Nature Conservation Marine Protected Area (NCMPA) on the Marine Research Vessel Scotia (survey code 1016S) from 18 July 2016 to 3 August 2016.

The aim of the 1016S survey was to gather the initial dataset of a site monitoring time-series for GSH. The survey focused on the monitoring of the designated features of GSH, gathering evidence which can be compared to future data collected to measure the rate and direction of change of the condition of the protected features of the site over time and to inform assessment of the effectiveness of current proposed management measures over time.

All survey objectives were met, with 56 United States Navy Electronics Laboratory (USNEL) type box corer faunal and Particle Size samples collected, and 58 drop-frame camera transects and one camera chariot transect completed within, and adjacent to, the site boundary.

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

Due to UK Government document accessibility requirements, Web Content Accessibility Guidelines (WCAG 2.1), it should be noted that some of the appendices provided as supplemental information for this report may not meet accessibility standards.

Contents

1 Introduction

The Joint Nature Conservation Committee (JNCC) and Marine Scotland Science (MSS) undertook an offshore seabed survey of Geikie Slide and the Hebridean Slope (GSH) Scottish Nature Conservation Marine Protected Area (NCMPA) on the Marine Research Vessel (MRV) Scotia (survey code 1016S).

The survey departed Aberdeen on 18 July 2016 and arrived back into Aberdeen on 3 August 2016.

1.1 Scientific staff

The survey team included scientists from Marine Scotland Science, the Joint Nature Conservation Committee (JNCC) and Benthic Solutions Ltd.

The survey team were assigned to 12 hour shifts to allow for 24-hour operations.

1.2 Survey location

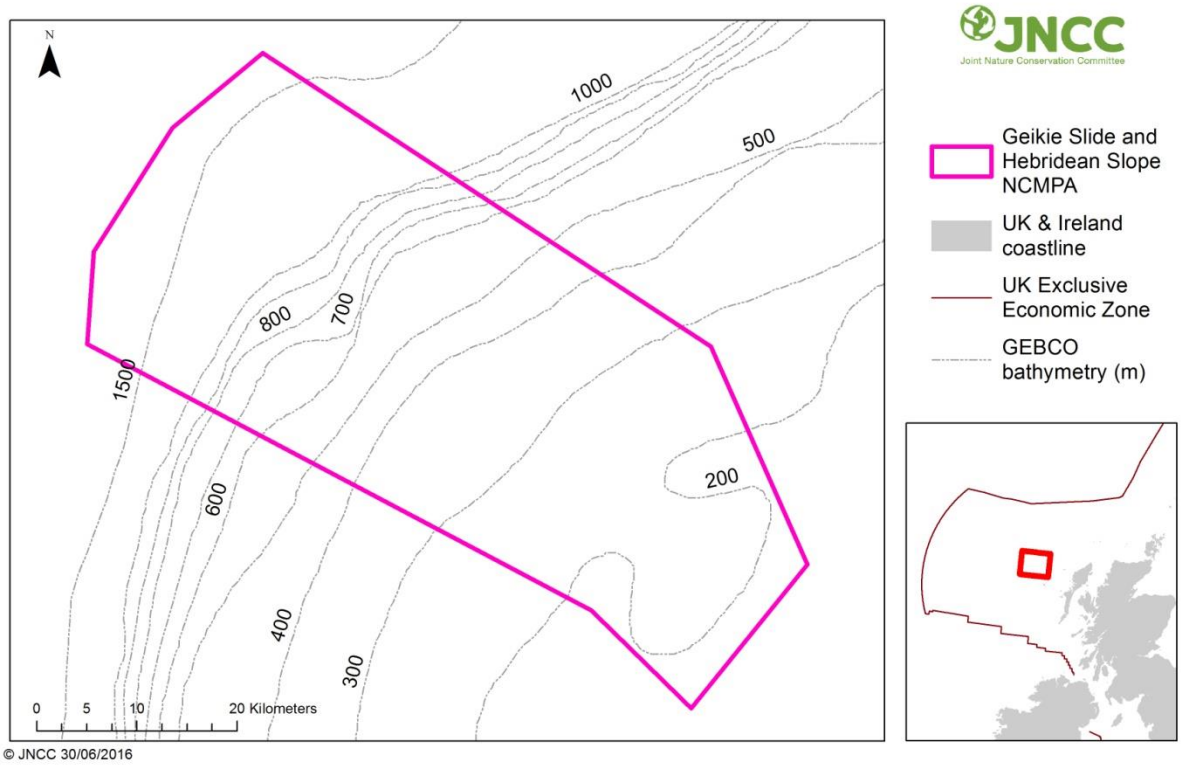

Figure 1: 1016S survey location and boundary of Geikie Slide and the Hebridean Slope NCMPA.

1.3 Geikie Slide and the Hebridean Slope NCMPA overview

Located to the north-west of Scotland, Geikie Slide and the Hebridean Slope NCMPA follows the descent of the seabed from a depth of 113m on the Hebridean continental shelf, into the deep-sea of the Rockall Trough to a depth of 1757m. Habitats within the Marine Protected Area (MPA) vary down the slope with the descent into deeper water. The MPA represents the variation in sandy, muddy and gravelly habitat types present, and the animal

communities they support. The purpose of the MPA is to conserve the features outlined in Section 1.3.1 below.

1.3.1 Protected features

Table 1: Protected Features of Geikie Slide and the Hebridean Slope NCMPA.

Features	Feature Type	Conservation Objectives
Burrowed mud	Habitat	Conserve in Favourable Condition
Offshore subtidal sands and gravels	Habitat	Conserve in Favourable Condition
Offshore deep-sea muds	Habitat	Conserve in Favourable Condition
Continental slope	Large scale feature	Conserve in Favourable Condition
Slide deposit and slide scars representative of the Geikie Slide Key Geodiversity Area	Geomorphological feature	Conserve in Favourable Condition

1.4 Anthropogenic activities known to be occurring within GSH

1.4.1 Fisheries

The primary fishing practice in the area involves the towing of **mobile demersal gear** (beam and otter). Demersal otter trawling activity occurs across the majority of the MPA. The trawl fishery is conducted by a number of the European Union (EU) member states including the UK, France and Spain. Available data suggests that beam trawling activity in the MPA is negligible.

There is some evidence of French **gill netting** vessels operating in the MPA. Danish **seine nets** and some **set gillnetting** occur within the site. **Long-lining** in the MPA is concentrated on the upper slope, predominantly between the 300 and 600m depth contours, and is conducted by vessels from the UK, Spain and France. There is also evidence of a lower intensity deep water (800-1200m) UK registered long-line fishery.

A review of available fishing activity data has been undertaken by JNCC to help inform survey planning for the 1016S monitoring survey to GSH NCMPA. The results of this review have been used to inform sampling box and station placement to allow the sampling design to account for the fishing activity patterns observed (see Section 2 Sampling Design).

No evidence was found of fishing activity occurring deeper than 1500m or shallower than 200m in 2012 or 2013. Fishing activity levels were found to decrease both inside GSH and to the south of the site boundary by 50% between 2011 and 2013. A spatial shift was observed in the distribution of fishing activity values from 2011 to 2012 and 2013, suggesting that fishing activity shifted into deeper waters moving from 200-300m water depth to 300-400m water depth. Fishing activity across the site appears consistent between these years, though UK vessel activity south of the site appears to have reduced between 2012 and 2013. For all years, the highest activity was that of non-UK vessels fishing along the 300m depth contour. UK fishing vessel activity levels were much lower than that of non-UK fishing vessels.

Areas of demersal trawling activity have been observed within the site boundary and immediately to the north of the site. Demersal trawling activity has also been observed to the south-west of the site. Purse seine and gillnet activity is considered to have negligible impact

at GSH due to the low levels of activity observed and minimal potential for seabed abrasion posed by these static gears. Higher levels of hook and line activity have been observed, though this activity is also deemed to have a minimal abrasion impact.

Please note that while fisheries management measures are not in place to protect the designated features of this site, current draft management measures[1] have been used to inform the survey design of this study (Figure 2). These draft management measures may be subject to change.

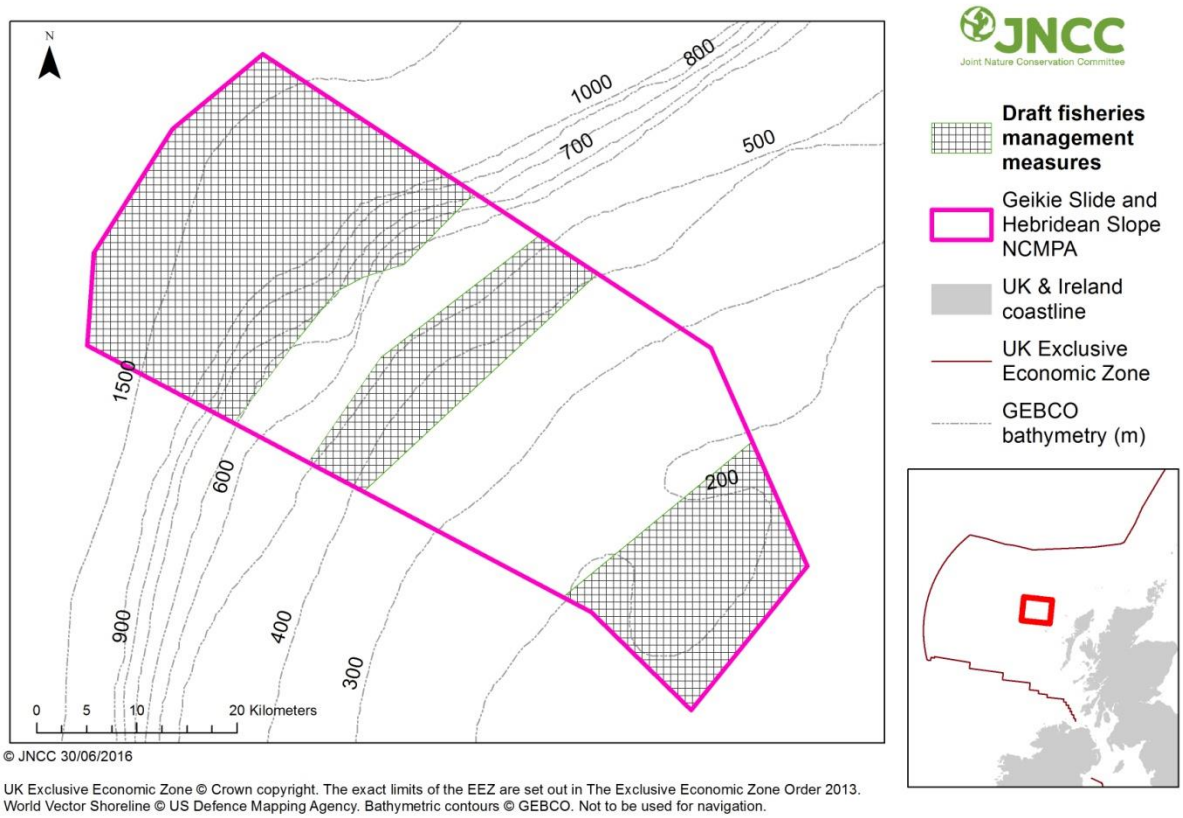

Figure 2: Draft fisheries management measures used to inform 1016S survey design.

1.4.2 Shipping

A moderate level of commercial shipping activity takes place within the MPA, which involves vessels transiting across the site. Due to the location of the MPA, it is unlikely that vessels will anchor within the site. The pressures associated with shipping activity within Geikie Slide and Hebridean Slope NCMPA are not considered likely to impact the protected features of the site.

1.4.3 Ministry of Defence activity

A small area of the south-western part of the MPA overlaps with a Ministry of Defence (MoD) practice area. This area is thought to be mostly used for sea surface activity such as vessel transiting and aerial use, and so activity is unlikely to interact with the protected features of the site. The MoD has incorporated all designated MPAs into their Environmental Protection Guidelines (Maritime) and wider Marine Environmental and Sustainability Assessment Tool.

[1] https://www2.gov.scot/Topics/marine/marine-environment/mpanetwork/SACmanagement/consult

These guidelines are used to manage MoD activity to minimise the associated risks to the environment.

1.5 Existing data used to inform survey planning

The data used to inform survey planning for GSH is presented in Figure 3 below, and includes existing survey data sourced from the Geodatabase for Marine Habitats and Species in Scotland (GeMS)[2] and the British Geological Survey (BGS), and data products which have been generated through JNCC commissioned analysis of existing survey data (Allen *et al* 2014; Allen *et al* 2014; Hughes *et al* 2014). These data provide direct evidence confirming the presence of the protected features within the site.

In addition to these data, multibeam bathymetry and backscatter data shown in Figure 4 was collected from GSH by the RRS James Cook in 2016 during the JC136 Deeplinks[3] survey, which JNCC was a partner organisation of.

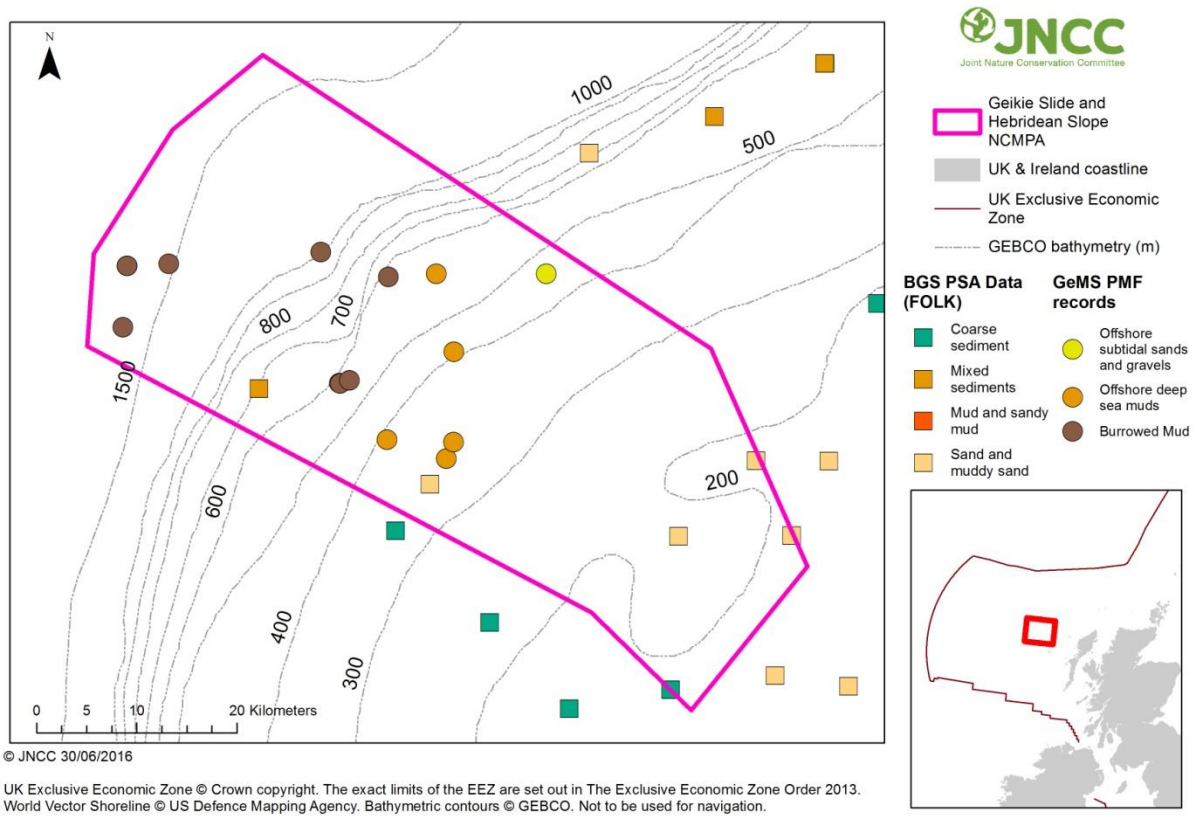

Figure 3: Existing survey data for Geikie Slide and Hebridean Slope NCMPA comprising Priority Marine Feature (PMF) records from GeMS and Particle Size Analysis (PSA) data from BGS.

[2] GeMS Version 2 Iteration 14.
[3] https://deeplinksproject.wordpress.com/.

Figure 4: Multibeam bathymetry and backscatter data collected from GSH in 2016, processed to 50m resolution (Bathymetry © NOC & BGS, 2016, do not use for navigation).

Biotope analysis has been used to characterise the biological diversity of the wider Hebridean slope region based on archive stills data from 1988-1998 (Hughes *et al* 2014, see Figure 5). The findings predict five distinct biological zones with associated communities that change with depth on the slope, and the MPA represents examples of each:

- **Outer shelf and shelf break zone (135-227m)** – characterised by coarse sediments ranging from strongly rippled sand and gravel plains to dense fields of cobbles and small boulders. Visible fauna is sparse in this zone and predominantly comprises echinoderms such as the pencil urchin *Cidaris cidaris* and asteroids.
- **Upper slope zone (279-470m)** – generally characterised by coarser sediments with sand and gravel patches and predominantly includes echinoderms as visible fauna.
- ***Ophiocten gracialis* zone (600-1020m)** – a biological zone dominated by large numbers of the small brittlestar *Ophiocten gracialis* on fine sandy, muddy sand or sandy mud, with some areas of gravel or cobbles.
- **Xenophyophore zone (1088-1180m)** – a biological zone characterised by the Xenophyophore *Syringammina fragilissima* in rippled muddy sand or sandy mud.
- **Decapod burrowing zone (1293-1595m)** – a biological zone characterised by the burrows of large decapods such as *Munida tenuimania* in fine muds.

Please note the analysis was carried out on a wider geographic scale than GSH, and that the analysis has been informed by data collected from outside of GSH (i.e. limited information from within GSH was available to inform the analysis).

The modelled biological community zones put forward by Hughes *et al* (2014) are represented in Figure 5 below.

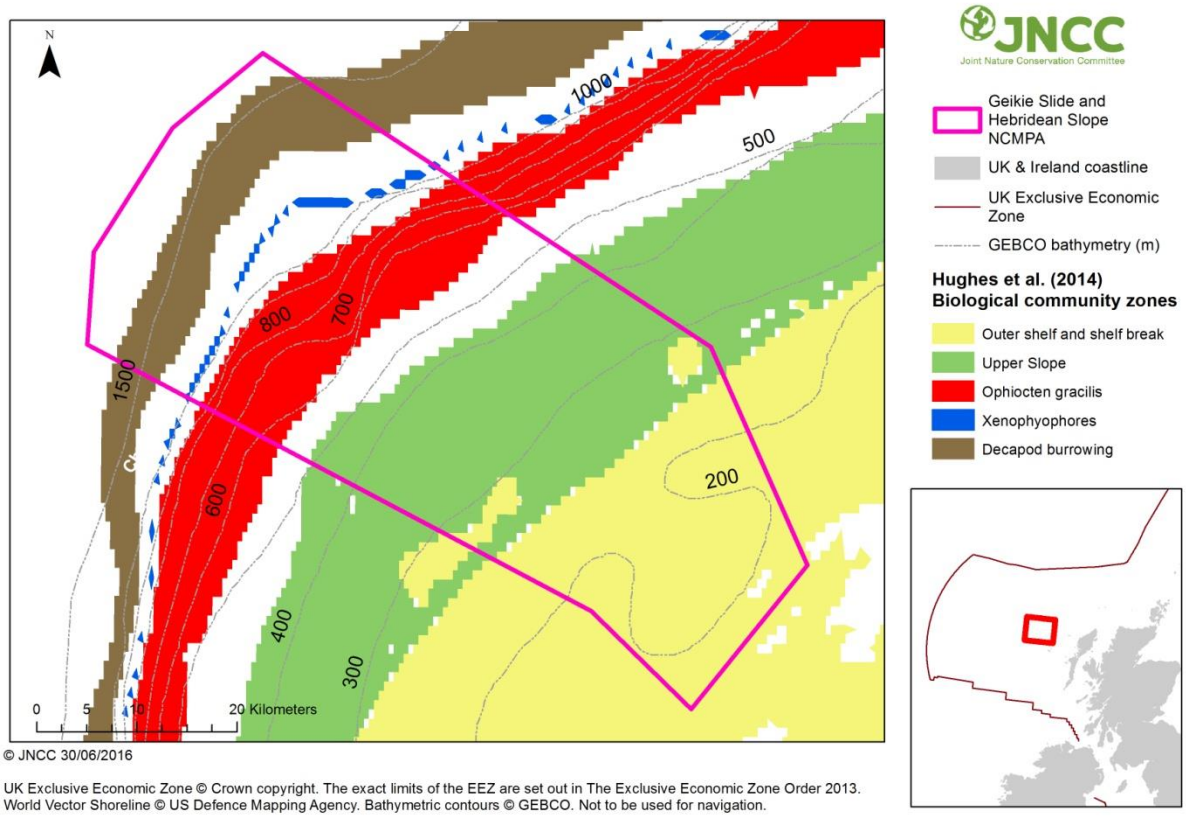

Figure 5: Hughes *et al* (2014) biological community zones for Geikie Slide and Hebridean Slope NCMPA.

2 Survey rationale

Geikie Slide and the Hebridean Slope NCMPA was selected by JNCC for a monitoring survey in 2016-17, following application of the prioritisation process described in the JNCC document 'Prioritisation for seabed habitat surveys of offshore MPAs in 2016-17 and beyond' (Jesus 2015*).*

Three types of monitoring have been described as part of the UK Marine Biodiversity Monitoring Strategy (Kröger & Johnston 2016). These monitoring types are described in Table 2, and the suitability of each monitoring type for application to the 1016S GSH survey has been assessed below.

Table 2: The three monitoring types (Kröger & Johnston 2016).

Definition of monitoring types
Sentinel monitoring of long-term trends (Type 1 monitoring) – Objective: to measure rate and direction of long-term change. This type of monitoring provides the context to distinguish directional trends from short-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 2 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 3 monitoring) – Objective: to investigate the cause of change. This monitoring type provides evidence of causality. It complements the above types by testing specific hypothesis 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.

1. Sentinel monitoring of long-term trends (Type 1 monitoring)

As limited existing survey data was available for this site prior to the 1016S survey (see Section 1.3 above) it was determined that Type 1 monitoring study should be conducted. The Type 1 monitoring study will form the initial data point in a sentinel monitoring time-series to measure the rate and direction of change in condition of the designated habitats within the site.

2. Operational monitoring of pressure-state relationships (Type 2 monitoring)

Following review of demersal fisheries data, it was determined that surface abrasion within the site was likely to be of insufficient intensity and variability to conduct a Type 2 gradient study for this pressure (i.e. the level of abrasion was considered too low and the data did not demonstrate a sufficient range of pressure intensity).

3. Investigative monitoring to determine management needs and effectiveness (Type 3 monitoring)

Fisheries management measures for the site were under development when the 1016S survey was planned and closures had not been defined, however draft management measures available before the survey were used to inform a Type 3 monitoring survey to investigate the effects of a potential future closure. The Type 3 monitoring study will ensure a sufficient “before” dataset is present, which can be used to assess the effectiveness of these proposed management measures.

2.1 Survey rationale summary

The following monitoring types were therefore determined to be appropriate for this survey (**listed in order of priority**):

- Sentinel monitoring of long-term trends (Type 1 monitoring).
- Investigative monitoring to determine management needs and effectiveness (Type 3 monitoring).

Additional information on the distribution of broad-scale habitats present within the site was also collected to augment the limited existing survey data available for this site.

3 Aim and objectives

3.1 Aim

The aim of the 1016S survey was to gather the initial dataset of a site monitoring time-series for GSH.

The survey focused on Type 1 and Type 3 monitoring (see Table 3 above) of the designated habitat features of GSH, to measure the rate and direction of change of the condition of these features over time and to determine effectiveness of current proposed management measures over time.

3.2 Objectives

The objectives of the survey were as follows (**listed in order of priority**):

1. Conduct a Type 1 monitoring survey of GSH focusing sampling within nested boxes, positioned to allow for sampling to occur across the range of depths, biological zones (as proposed by Hughes *et al* 2014) and proposed management measures at the site.
2. Conduct Type 3 sampling within a nested box outside of GSH at the same depth and of similar current fishing pressure as a nested box within a proposed management measures area in GSH.
3. Conduct a camera chariot transect survey within GSH (including within the area of existing MBES bathymetry and backscatter data) to gather further information on the distribution of broadscale habitats present within the site.

3.2.1 Contingency objectives

In the event of a prolonged period of poor weather necessitating the ship to transit to a more sheltered location, inshore contingency survey locations were identified following discussion with Scottish Natural Heritage (SNH). These contingency locations were not visited.

3.3 Outputs

The outputs the 1016S survey aimed to deliver include:

- The first dataset of a time-series against which to monitor change in condition of the designated habitat features of GSH (‘Burrowed mud’, ‘Offshore subtidal sands and gravels’ and ‘Offshore deep-sea muds’).
- A sufficient “before” dataset (including control stations outside of GSH) forming the first monitoring event in a Before-After-Control-Impact (BACI) study to allow future evaluation of the effectiveness of proposed management measures.
- A robust dataset to improve understanding of the distribution of the designated habitat features of GSH (‘Burrowed mud, ‘Offshore subtidal sands and gravels’ and ‘Offshore deep-sea muds’) within the site.

These datasets will be used to inform monitoring of this site (i.e. to enable assessment of change in features over time).

4 Sampling design

4.1 Overview

The number of survey boxes and stations per box to be visited, identified during survey planning, were informed by JNCC and MSS expert judgement, taking into account the time available for the survey and estimations of the length of time required to complete each sampling station visited with the respective gear type(s) used.

Please note that at the time of planning the survey, insufficient existing biological data were available to undertake a statistical power analysis to inform development of the sampling design used.

The sampling design employed to achieve each objective is described in Sections 4.2 to 4.4.

4.2 Objective 1: Conduct a Type 1 monitoring survey of GSH focusing sampling within nested boxes

The following null hypotheses were proposed for this objective:

- Current hypotheses (to be evaluated from current dataset)
    - H_0 There is no difference *(in infaunal or epifaunal metric/trait or community composition)* between sampling boxes.
    - H_0 There is no difference *(in infaunal or epifaunal metric/trait or community composition)* within sampling boxes.

- Future hypothesis (enabled by collection of a second dataset)
    - H_0 There is no difference *(in infaunal or epifaunal metric/trait or community composition)* in each sampling box between two different sampling events.

To achieve Objective 1, benthic samples and drop-frame camera data were acquired at stations positioned within nested sampling boxes across GSH.

4.2.1 Nested sampling box and station positioning

Nested sampling boxes were positioned to allow for sampling to occur across the range of depth zones, predicted biological zones (as proposed by Hughes *et al* 2014), and draft management measure zones at the site (Table 4).

Consideration of available fisheries data also informed the positioning of the nested sampling boxes (see Section 1.2.1), with sampling boxes positioned where the effects of a closure are more likely to be detectable due to the presence of relatively higher levels of fishing activity; in areas which are not proposed to be closed, boxes were positioned where abrasion pressure was thought to be at a similar intensity to potentially closed areas of the same habitat feature (i.e. offshore subtidal sands and gravels).

4.2.2 Nested sampling box and station numbers

Four nested sampling boxes were identified to achieve this objective. A fifth, Box B, was identified as a contingency box though was not visited.
Eighteen sampling stations were allocated within each box using a 3km triangular grid in ArcGIS 10.1.

4.2.3 Further considerations

Hughes *et al* (2014) report that epifauna are sparse in the outer shelf and upper slope; therefore, box core sampling effort (which focuses on sampling infaunal communities) was prioritised in this area over camera transect work (which focuses on sampling epifaunal communities).

Conversely, as epifauna and burrows made by burrowing fauna such as decapods are associated with the mud habitats that Hughes *et al* (2014) predict dominate the deeper areas, drop-frame camera transect effort was prioritised here. Characterisation of associated infauna (e.g. burrowing decapods) from box core samples will help inform biotope assessment.

Table 4: Proposed Objective 1 nested sampling boxes.

Priority	Sampling box	Feature	Hughes *et al* 2014 zone	Inside proposed management area?	Placement justification	Target parameters	Proposed sampling strategy options
1	**D**	Offshore subtidal sands & gravels / Offshore deep sea muds	Upper slope	Yes	Positioned inside the site boundary at same depth range and at area with similar level of fishing pressure as **F (see Section 4.3)**, providing the greatest chance of identifying a difference following potential closure.	Infaunal metrics and drop camera (sparse epifauna)	If sand & epifauna are very sparse, prioritise box coring & acquire extra box core samples
2	**C**	Offshore deep sea muds	*Ophiocten gracilis* zone	No	Positioned to cover area of reasonably dense demersal trawl activity outside closure, to enable comparison between closure & non-closure areas within offshore deep-sea muds. Reasonably close to Box **B**.	Infauna & epifauna	Drop camera & box coring
3	**E**	Offshore subtidal sands & gravels	Outer shelf and shelf break	No	There are low levels of demersal trawl activity within the proposed closure area in this zone, therefore sampling box is positioned outside of it. Positioned to cover area of repeated trawling at a similar intensity to Box **D** (proposed management area for Offshore subtidal sands & gravel)	Infaunal metrics (sparse epifauna)	If sand & epifauna is very sparse, prioritise box coring & acquire extra box core samples
4	**A**	Burrowed mud	Decapod burrowing zone	Yes	Positioned in deepest section of survey site (note potential EU-wide trawling ban in waters deeper than 800m), covers area of modelled burrowed mud. No evidence of demersal trawling here.	Burrows, sea pens, megafauna	Potential focus on drop camera, with lower effort box coring
5 (N.B. Contingency; box <u>not</u> visited)	**B**	Offshore deep sea muds	*Ophiocten gracilis* zone	Yes	Positioned to cover area of higher VMS ping density <800m. Lowest priority box.	Infauna & epifauna	Drop camera & grab sampling/box coring

4.3 Objective 2: Conduct sampling within a nested box outside of GSH

The following null hypotheses have been proposed for this objective (please note the null hypotheses will be further developed according to the analysis outcomes following this initial survey):

- Current hypotheses (to be evaluated from current dataset)
  - H_0 There is no difference (*in infaunal or epifaunal metric/trait or community composition*) between control and impact boxes.
  - H_0 There is no difference (*in environmental parameter i.e. sediment type/organic content/depth/other*) between control and impact boxes (i.e. are the boxes comparable for purpose of a future BACI?).

- Future hypothesis (enabled by collection of a second dataset)
  - H_0 There is no interaction between the 'Time' factor (Before/After) and the 'Box' treatment factor (Control/Impact) (where *infaunal or epifaunal metric/trait* is the response variable).

Data were acquired to comprise the 'Before' monitoring event in a BACI study to investigate the effectiveness of possible fisheries management measures.

The 'Before-After' site sample box (**D**, see Section 4.2 above) was positioned in an area of GSH which is currently fished and may be closed to fishing. The 'Control' site sample box (**F**) was positioned to include the same depth range and similar levels of fishing pressure as box **D** to maximise chances of detecting a change not related to either depth or fishing pressure (see Table 5). Sampling effort was allocated to Box **F** as is outlined in Section 4.2 above.

Completing Objective 2 was considered to be of higher priority than completing contingency sampling Box B (see 4.2.2 above).

Table 5: Proposed Objective 2 nested sampling box.

Sampling box	Feature	Hughes *et al* 2014 Zone	Inside proposed management area?	Placement justification	Target parameters	Proposed sampling strategy options
F	Note box is outside of site boundary	Upper slope	No, but at same depth range as a proposed management area	Positioned outside the site boundary at same depth range and at area with similar level of fishing pressure as **D** to act as a control site to identify a difference in target parameters following closure with the highest likelihood.	Infaunal metrics (sparse epifauna)	If sand & epifauna is very sparse, prioritise grab sampling & acquire extra box core samples

4.4 Objective 3: Conduct a camera chariot transect survey to gather further information on the distribution of broad-scale habitats present within the site

Three 3.8km long camera chariot transects were planned within GSH to achieve this objective. Owing to limited time available on survey and the lower priority of this objective relative to Objectives 1 and 2, one 3.8km long camera chariot transect was collected.

Completing Objective 3 was considered to be of higher priority than completing contingency sampling Box B (see 4.2.2 above).

4.4.1 Chariot transect positioning

The camera chariot transect was positioned to include a range of depth zones and predicted habitats present within the site not otherwise visited in order to meet Objectives 1 and 2, and to coincide with an area of MBES bathymetry and backscatter data coverage to provide a ground truthing dataset for this data.

5 Methods used

5.1 Benthic sampling

5.1.1 USNEL box corer

A 0.25m^2 (sampling surface area) United States Navy Electronics Laboratory (USNEL) box corer, hired from Benthic Solutions Ltd. (BSL), was used as the primary equipment for collecting benthic infaunal and PSA samples on the 1016S survey (Figure 6).

Figure 6: 0.25m^2 sampling surface area BSL USNEL box corer (image © Ellen Last/JNCC, 2016).

A BSL-developed camera system was mounted on the USNEL box corer, which allowed for acquisition of HD video footage of the seabed prior to landing the box corer.

The system consisted of a self-contained 1080 pixel HD 60 frames per second video camera with separate 2000 lumens LED light. The system was capable of being triggered automatically by a pre-set on-board pressure sensor, so that video recording commenced prior to reaching the seabed, or set to record continuously immediately prior to deployment (both methods were employed during the 1016S survey).

Sampling operations, including gear deployment and recovery and preliminary sample processing, were conducted according to Appendix 7 (Box Corer Operating Guidelines).

5.1.2 Contingency grab samplers

The following contingency sampling devices were brought for collection of benthic infaunal and PSA samples (i.e. in case of failure of the box corer), but were not used:

- Double 0.1m^2 (sampling surface area) Van Veen grab.

- 0.1m^2 Hamon grab.
- Day grab.

5.2 Epibenthic imagery

5.2.1 Drop-frame camera system

Underwater photographs and video data were captured using a seabed imagery system mounted on a drop-frame (Figure 7).

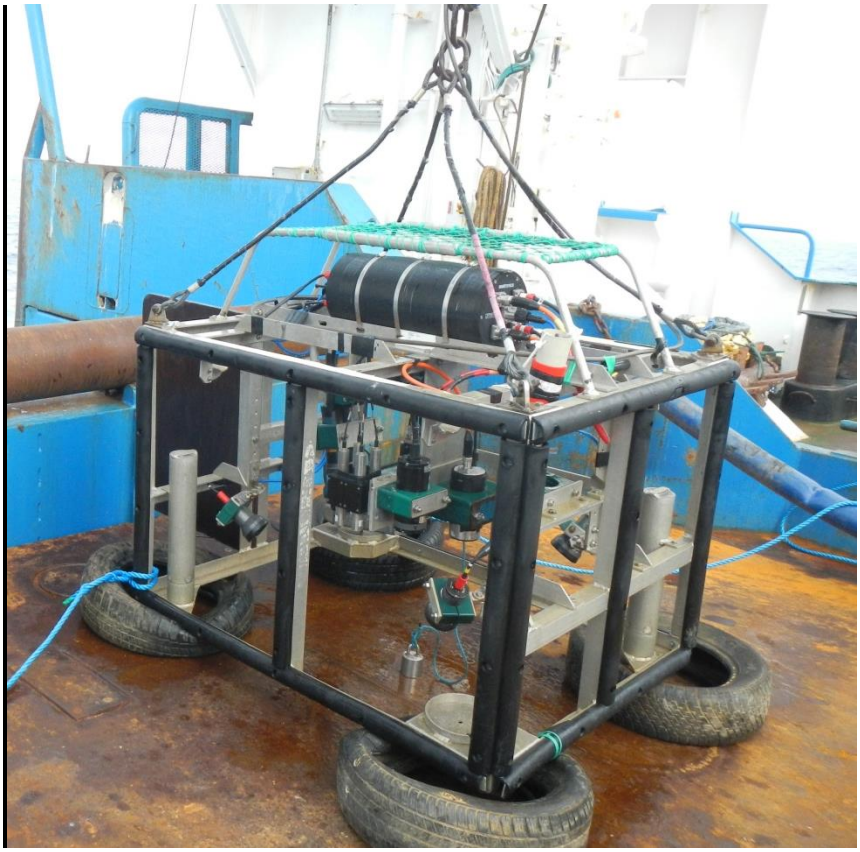

Figure 7: MSS drop-frame camera system (image © JNCC, 2016).

The drop-frame system supported the following instruments:

- SubC 1 Alpha video camera for primary TV observation and topside recording to mini-DV tape and DVD (HD video recorded internally).
- Standard definition Kongsberg OE 14-408 digital camera (10MP) with dedicated flash unit for still images capture (camera controlled topside, images recorded internally).
- 4 SEALED lamps for illumination.
- Two reference spot lasers (green).

Set-up and operation followed the MESH 'Recommended Operating Guidelines (ROG) for underwater video and photographic imaging techniques'[4].

Field notes were made during each camera deployment, with station and sample metadata and real-time observations of substrate and taxa recorded.

[4] Coggan, R., Mitchell, A., White, J. & Golding, N. (2007) Recommended operating guidelines (ROG) for underwater video and photographic imaging techniques. MESH Project guideline document. Online: http://www.searchmesh.net/pdf/GMHM3_Video_ROG.pdf.

The station locations assigned represented the midpoints of each transect. During deployments, the vessel executed a controlled drift at ~ 0.2 knots through the specified station. The height of the drop-frame off the seabed was controlled by winch; the operator had sight of the video monitor.

Short (150m) transects were carried out, with HD video recorded continuously and stills captured every minute. A positional fix was recorded for every still image captured.

Two green point lasers, with laser points 100mm apart, were used to provide scaling for video and stills captured. Note that, owing to a power supply issue with the cable which supported the drop-frame camera, for a subset of video transects red SubC 1 Alpha video camera internal point lasers, with laser points 62.4mm apart, were used to provide scaling for video and stills captured.

5.2.2 Towed camera chariot system

Underwater video data were also captured using a camera chariot system.

The chariot system supported the following instruments:

- SubC 1 Alpha video camera for primary TV observation and topside recording to mini-DV tape and DVD (HD video recorded internally).
- 4 SEALED lamps for illumination.
- Two reference spot lasers (green).

Set-up and operation followed MSS standard operating procedures.

During deployment, the vessel transited at ~2 knots along the specified transects. The height of the chariot off the seabed was controlled by winch; the operator had sight of the video monitor.

A long (3.8km) transect was carried out, with HD video recorded continuously. A positional fix was recorded every five minutes.

Field notes were made during each camera deployment, with station and sample metadata and real-time observations of substrate and taxa recorded.

Two green point lasers, with laser points 100mm apart, were used to provide scaling for video and stills captured.

5.3 Metadata

Ship's position and a time-stamp for each survey event were acquired by using a USB-Comms adaptor to input the ship's GPS feed to a laptop with ArcGIS 10.1 to allow 'fixes' of the ship's position be recorded.

Positional data for the drop-frame camera, camera chariot and box corer were acquired using a Sonardyne Ranger 2 Ultra Short Baseline (USBL) system. The system comprised a hull-mounted Sonardyne transceiver and equipment-mounted Sonardyne transponders (both directional and omni-directional transponders were used); the resulting positions were then linked to respective survey events using the time stamp of each event.

Ship's position has been used where USBL positions were not available (see Appendix 1).

JNCC log sheets (i.e. SamplingMetadata spreadsheet) were completed for each sampling event.

Video and still images were downloaded from the cameras and backed up to multiple hard drives at appropriate intervals.

5.4 Davis System

The following vessel navigational and metocean measurements were recorded throughout the 1016S survey using the Scotia Davis system (note positions and measurements are available at a temporal resolution of one minute):

- Latitude
- Longitude
- Heading
- Depth
- Speed
- Wind direction
- Wind speed
- Conductivity
- Density
- Salinity
- Sound velocity
- Temperature
- Air pressure
- Air temperature
- Relative humidity

6 Cruise Narrative

The Marine Research Vessel (MRV) Scotia (hereafter “Scotia”) mobilised for the 1016S offshore seabed survey from Aberdeen Harbour from 15 - 17 July 2016.

JNCC scientists joined Scotia on Sunday 17 July 2016.

A ship’s induction was carried out at 07:00 UTM on Monday 18 July 2016. Scotia departed Aberdeen Harbour for GSH at 08:30 on Monday 18 July 2016, with a safety drill (general muster) following at 09:30. The box corer and drop-frame camera system, and associated operational and data processing procedures, were successfully “wet tested” from 14:00 to 16:30 on Monday 18 July 2016. A toolbox talk, led by Scientist-in-Charge (SIC) Iain Gibb, was held between JNCC and MSS scientists and the captain (Mario Styles) at 18:00 on Monday 18 July 2016.

Scotia arrived on the first station in Box C (C18) at GSH at 17:30 on Tuesday 19 July 2016 and began drop-frame camera sampling operations.

Daily survey effort was divided equally between box corer operations, which were carried out between 23:00 and 11:00 each day, and camera operations, which were carried out between 11:00 to 23:00 each day; as such camera operations were ceased and box corer sampling operations began in Box C at 23:00 on Tuesday 19 July 2016.

Drop-frame camera operations were resumed at 11:00 on Wednesday 20 July 2016.

Camera operations were suspended from 12:30 to 15:00 on Wednesday 20 July 2016 due to a warped Netsonde cable (warping was caused by heating of the cable). Camera operations resumed from 15:00 to 16:00 on Wednesday 20 July 2016 and were suspended from 16:00 to 20:15 on Wednesday 20 July 2016 due to a recurrence of the cable issue. Camera operations resumed from 20:15 to 21:00 on Wednesday 20 July 2016 and were suspended from 21:00 to 23:00 due to a fault with the still image camera (MSS Kongsberg 14-408). Box corer sampling operations resumed in Box C at 23:00 on Wednesday 20 July 2016.

Drop-frame camera operations were resumed at 11:00 on Thursday 21 July 2016. Camera operations were suspended on Thursday 21 July 2016 from 11:30 to 14:00 to resolve a connection failure in the cable connecting the topside power supply unit to the drop-frame camera system. Drop-frame camera operations in Box C were completed at 19:30 on Thursday 21 July 2016. Scotia transited to Box D, where drop-frame camera operations began at 20:00 on Thursday 21 July 2016.

Scotia transited to Box C at 22:30 on Thursday 21 July 2016, and box corer sampling operations resumed in Box C at 23:00 on Thursday 21 July 2016.

Scotia transited to Box D at 11:00 on Friday 22 July 2016, where drop-frame camera operations continued at 11:30 on Friday 22 July 2016. Scotia transited to Box C when drop-frame camera operations were completed in Box D at 22:30 on Friday 22 July 2016, and continued box corer sampling operations in Box C at 23:00 on Friday 22 July 2016.

Scotia completed box coring operations in Box C at 10:00 on Saturday 23 July 2016 and transited to Box F to begin drop frame camera operations, collecting a box core sample from Box D station D10 in transit. Scotia arrived at Box F at 11:00 on Saturday 23 July 2016, where unfavourable weather suspended drop-frame camera operations until 19:30 on Saturday 23 July 2016. Scotia then transited to Box D at 22:00 on Saturday 23 July 2016, and continued box corer sampling operations in Box D at 23:00 on Saturday 23 July 2016.

Scotia transited to Box F, while processing a box core sample collected from D15, at 10:00 on Sunday 24 July 2016, where drop-frame camera operations continued at 11:00 on Sunday 24 July 2016. Scotia transited to Box D when drop-frame camera operations were completed in Box F at 22:00 on Sunday 24 July 2016, and continued box corer sampling operations in Box D at 23:00 on Sunday 24 July 2016.

Scotia transited to Box A, while processing a box core sample collected from D08, at 10:00 on Monday 25 July 2016. Drop-frame camera operations were continued in Box A at 11:00 on Monday 25 July 2016. Scotia transited to Box D at 22:00 on Monday 25 July 2016, and continued box corer sampling operations in Box D at 23:00 on Monday 25 July 2016.

Box coring operations were suspended at 10:00 on Tuesday 26 July 2016 as the box corer was damaged by a large cobble. Scotia transited to Box A, while processing a box core sample collected from D07, at 10:00 on Tuesday 26 July 2016. Drop-frame camera operations were continued in Box A at 12:00 on Tuesday 26 July 2016. Camera operations were suspended from 17:30 to 20:00 on Tuesday 26 July 2016 due to a warped Netsonde cable (warping caused by heating of the cable), which was resolved by re-terminating and streaming cable. Scotia began transiting to Stornaway for a scheduled half-landing at 20:00 on Tuesday 26 July 2016.

Scotia arrived alongside in Stornaway at 10:00 on Wednesday 27 July 2016. As had been scheduled, Iain Gibb was replaced by Eric Armstrong as Scientist-in-Charge in Stornaway, and a replacement box corer was delivered to Scotia at 20:00 on Wednesday 27 July 2016. Scotia departed Stornaway at 22:00 on Wednesday 27 July 2016 to return to GSH.

Scotia arrived back on site and began collection of box core samples from Box F with the replacement box corer at 09:00 on Thursday 28 July 2016. Scotia transited to Box A, while processing a box core sample collected from F16, at 11:00 on Thursday 28 July 2016. Drop-frame camera operations were continued in Box A at 14:00 on Thursday 28 July 2016. Scotia transited to Box D when drop-frame camera operations were completed in Box A at 22:00 on Thursday 28 July 2016, and continued box corer sampling operations in Box D at 23:00 on Thursday 28 July 2016.

Box coring operations were suspended from 14:00 to 15:30 on Friday 29 July 2016 to reboot the ship's Dynamic Positioning system. Scotia completed box coring operations in Box D and transited to Box F while processing a box core sample collected from D07 at 16:30 on Friday 29 July 2016, and continued box corer sampling operations in Box F at 17:30 on Friday 29 July 2016.

Box coring operations in Box F were completed and Scotia transited to Box E while processing a box core sample collected from F18 at 11:00 on Sunday 31 July 2016. Drop-frame camera operations began in Box E at 12:00 on Sunday 31 July 2016. Drop-frame camera operations were suspended from 16:00 to 17:00 on Sunday 31 July 2016 as a cruise ship transited across the planned camera transect. Drop-frame camera operations were completed in Box E, and box core operations begun, at 21:30 on Sunday 31 July 2016.

Box coring operations in Box E were completed and Scotia transited to chariot station TOW_2 while processing a box core sample collected from E15 at 13:00 on Monday 1 August 2016. Chariot camera operations began at 14:00 and were completed at 16:00 on Monday 1 August 2016, and Scotia departed GSH for Aberdeen Harbour.

Scotia arrived alongside in Aberdeen Harbour at 01:00 on Wednesday 03 August 2016.

7 Variations to survey plan

7.1 Adaptations to sampling order

The sampling order presented in Table 6 was proposed in the Survey Plan.

Table 6: Proposed sampling order and timings.

Order	Sampling	Objective	Time Required
1	Complete Boxes C[5], D, F, E and A	1 & 2	~ 9 days
2	Complete additional sampling at Boxes D and F	2	~ 1.5 days
3	Complete chariot transects	3	~ 1.5 days
4	Complete Box B	1 (Contingency)	~ 2 days

This proposed sampling order was revised 'on the fly' by the JNCC Lead and SIC as is outlined below, with the revised sampling order agreed at sea with the captain and by email with representatives of JNCC's Monitoring and Evidence Teams. The actual sampling order followed and timings are presented in Table 7.

Table 7: Actual sampling order and timings.

Order	Sampling	Objective	Time Spent
1	Completed Boxes C, D, F, A and E	1 & 2	10 days
2	Completed chariot transect	3	0.25 days

7.1.1 Box core sampling

The sampling order was revised primarily as box core sampling operations required more time per sample than was estimated in the survey planning stages; the proposed sampling order estimated that 10 box core samples could be collected and processed during each 12 hour box coring shift whereas on survey it was found that 4-6 box core samples were achievable per 12 hour box coring shift.

Box core sample processing was the most time-intensive part of the sampling operations. This was due to:

- The large sample volume processed (the entire 0.25m^2 surface area of each box core was processed to a depth of 15cm);
- Dividing samples into two grain size fractions using fine sieve mesh sizes (0.25mm and 0.5mm) and;
- The consolidated nature of the sediment encountered (field notes suggest box core samples predominantly consisted of clay, mud and sandy mud).

It is worth noting that, as the 1016S survey was the first dedicated seabed monitoring survey of GSH, sampling timings were estimated using expert judgement relating to deployment and recovery of the equipment used. The pre-survey estimates made did not consider the

[5] Box C was planned to be visited first as this Box is predicted to contain muddier substrate than Box D, which may be more suitable for box corer operations than the coarser substrate predicted to be present in Box D.

effect sediment grain size would have on sample processing time due to the limited availability of existing data regarding the types and distribution of sediments in the site.

The following steps were taken to increase sample processing efficiency:

- The Wilson Autosiever was used with a 0.25mm mesh sieve, with two additional sieving tables with 0.25mm (bottom) and 0.5mm (top) stacked sieves respectively.
- Drop-frame camera transects were collected at box core sampling stations before box core sampling to visually determine whether the seabed was suitable for box core sampling.
- Box core samples were processed on transit to camera operations stations (i.e. increasing the amount of time available for box coring work whilst continuing to complete camera operations).
- 24-hour box corer operations were undertaken on two occasions.

7.1.2 Stations numbers and sampling effort by gear type

All planned box core (18 per box) and drop-frame camera (12 per box) stations were attempted in two of the highest priority boxes (Boxes D and F).

In Box C, 15 box core stations out of the 18 planned stations were completed, and 12 drop-frame camera stations were completed.

Sampling was carried out with the drop-frame camera only in Box A, with transects completed at 13 of the 18 planned stations. Collection of imagery data was prioritised over collection of box core samples in this box to capture information regarding the epifaunal communities predicted to be present in this section of the site (see Section 4.2.3).

Sampling was carried out with the box corer (5 stations) and drop-frame camera (9 stations) in the northern section of Box E; the southern section of Box E was not sampled as Navy exercises were scheduled to begin here on Monday 01 August 2016.

8 Data collected

Please note that observations made in the Cruise Report represent preliminary field observations. These observations have not been subject to Quality Assurance procedures.

150m (approximately 10-minute duration) drop-frame camera transects were successfully completed at 58 stations; representative images of each camera transect are shown in Appendix 2.

56 stations were successfully sampled for infauna and PSA using the 0.25m^2 USNEL box corer; representative images of each grab sample are shown in Appendix 3.

One 3.8km (approximately one-hour duration) camera chariot transect was successfully completed; please note that representative images of this transect are not available as video only was collected during the camera chariot transect.

Locations of completed stations are shown in Figure 8. Sections 8.1 to 8.5 outline the number of stations successfully completed in each box.

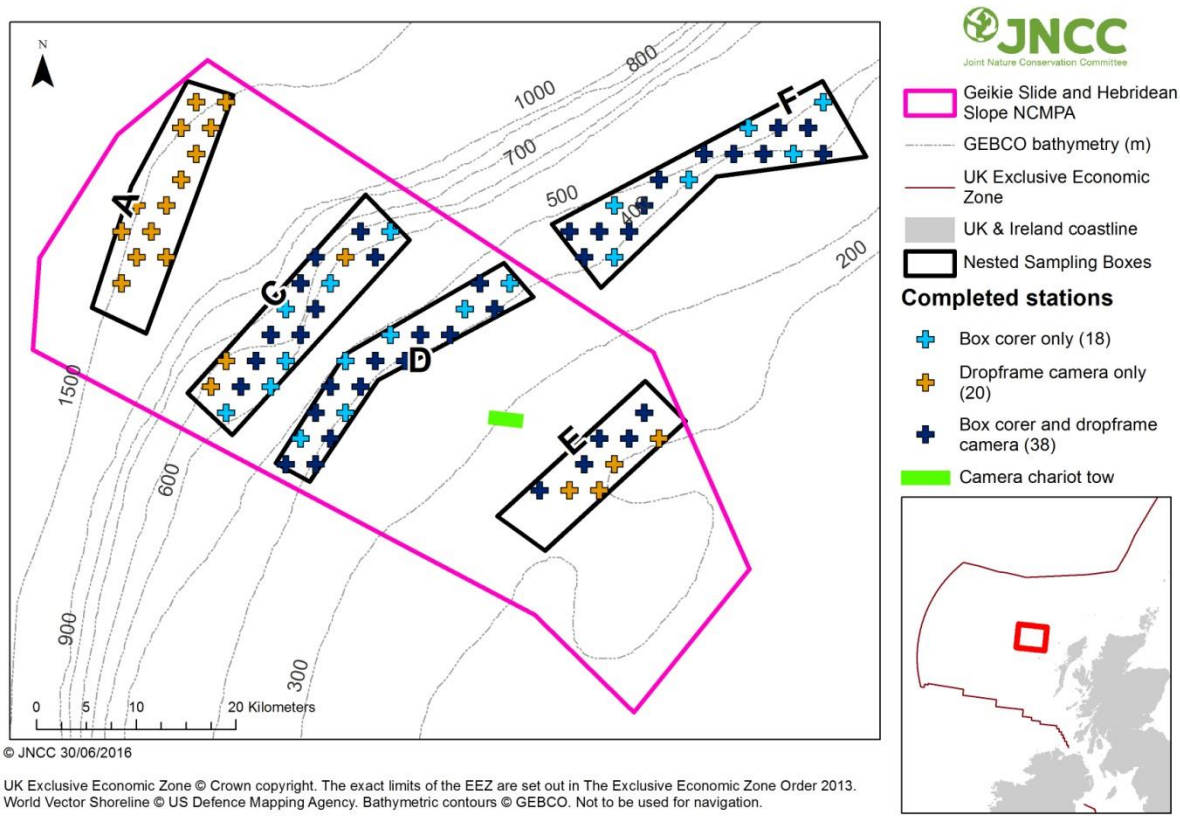

Figure 8: Completed box corer and drop-frame camera transect stations at GSH.

8.1 Box A

13 drop-frame camera transects, collecting video and stills data, were successfully completed in Box A.

8.2 Box C

15 0.25m^2 USNEL box corer infaunal and PSA samples were successfully collected in Box C.

12 drop-frame camera transects, collecting video and stills data, were successfully completed in Box C.

8.3 Box D

18 0.25m^2 USNEL box corer infaunal and PSA samples were successfully collected in Box D.

12 drop-frame camera transects, collecting video and stills data, were successfully completed in Box D.

8.4 Box E

5 0.25m^2 USNEL box corer infaunal and PSA samples were successfully collected in Box E.

9 drop-frame camera transects, collecting video and stills data, were successfully completed in Box E.

8.5 Box F

18 0.25m^2 USNEL box corer infaunal and PSA samples were successfully collected in Box F.

12 drop-frame camera transects, collecting video and stills data, were successfully completed in Box F.

9 Data formats

The 1016S survey collected data in the formats described in Table 8.

Table 8: 1016S data formats.

Data Type	Raw Format	Converted To	Saved
High Definition video	.m2ts	n/a	Electronically
Standard Definition video	.vob	n/a	DVD, mini DV tape
Stills	.cr2	.jpeg	Electronically
Grab sample images	.jpeg	n/a	Electronically
USBL	.csv	.xls	Electronically
Davis system	.txt	n/a	Electronically

10 Quality control (QC)

10.1 Data management

A Data manager was assigned to ensure relevant survey metadata was recorded, stored and catalogued appropriately (according to JNCC data management protocols). For details of on-board data management procedures please refer to the Data Management Plan (O'Connor 2016; available on request from JNCC).

11 Human activity

Potential anthropogenic impacts were observed at **2** box core stations and during the camera chariot transect (Table 10 and Figure 9).

Table 10: Potential anthropogenic impacts observed at GSH survey stations.

Station name	Date	Time	Potential anthropogenic impact	Image
C06	23/07/2016	05:49:30	**Pottery** found in box core sample	
F17	31/07/2016	06:02:22	Box core with 0.5m **monofilament** (fishing wire) buried in sample	
TOW_02	01/08/2016	14:25:00	Discarded **rope** attached to chariot frame	

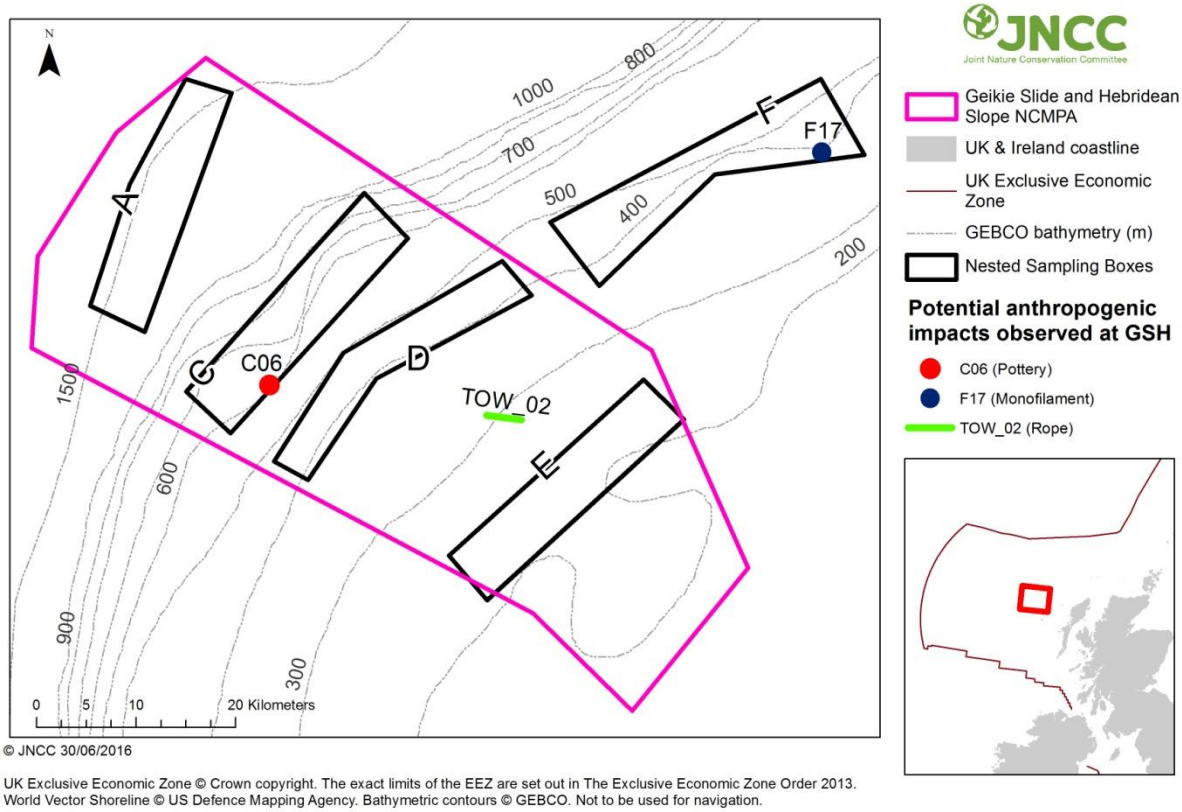

Figure 9: Potential anthropogenic impacts observed at GSH survey stations.

12 Health and safety events

No unplanned health and safety (H&S) events occurred.

Two safety drills were undertaken:

- A ‘general muster’ was held at 09:30 on 18 July 2016.
- A fire-fighting drill, including a general muster, was held at 09:30 on Monday 25 July 2016.

13 Intellectual property rights and confidentiality

Rights to all knowledge (including, but not limited to, data, information, know-how, designs, drawings and specifications) brought to the project by either party (JNCC or MSS) will remain with that party, and such knowledge is to be used solely for the purposes of conducting this project.

Rights to knowledge jointly generated within the project will be jointly owned by JNCC and MSS.

The project is publically funded and all knowledge generated within the project will be made publically available under Open Government Licence (http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/).

Data must be accompanied by the following statement:

“Contains Joint Nature Conservation Committee and Marine Scotland Science materials ©JNCC/MSS 2016/2017.”

14 References

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15 Appendices

Please note that a number of the appendices are provided as separate documents to the main report.

Appendix 1: Survey metadata (summary version; full electronic spreadsheet available on request)

Comprising:

Table 1: Summary metadata for 1016S USNEL box corer sampling events. Latitudes and longitudes are USBL derived unless otherwise stated.

Table 2: Summary metadata for 1016S drop-frame camera transects, including Start of Line (SOL) and End of Line (EOL) information. Latitudes and longitudes are USBL derived unless otherwise stated.

Table 3: Summary metadata for 1016S camera chariot transect. Latitudes and longitudes are USBL derived.

Appendix 2: Representative images of each camera transect

Comprising a description and three images of each Box station, for:

Box C

Box D

Box F

Box A

Box E

Also, three images from a **Chariot Tow**.

Appendix 3: Representative images of each grab sample

Comprising the Station name and four images of each Box station – Sample, Core profile, 0.5mm sieve, 0.25mm sieve - for:

Box C

Box D

Box F

Box E

Appendix 4: Vessel and equipment used (additional information)

Vessel

For more information on MRV Scotia, please see:
http://www.scotland.gov.uk/Topics/marine/science/scienceops/vessels-technology/vessels/scotia

Sonar Ranger 2 Ultra-Short Base Line (USBL) acoustic transponder

For information on USBL system used, please see:
http://www.sonardyne.com/products/positioning/ranger2.html

USNEL box corer

For more information on the USNEL box corer used, please see:
http://benthicsolutions.com/brochures/BSL_Brochure_Box_Corer.pdf

Equipment configuration and calibration:

Camera

Camera	Viewing angle (nominal) deg	Viewing angle horizontal (deg)	Viewing angle vertical (deg)	Aspect ratio	Field width (mm) at range 1.25m	Field height (mm) at range 1.25m
Kongsberg OE-14-366 (TV)	61 (diagonal)	50	41	4:3	975	750
Kongsberg OE-14-408 (Digital Stills)	62 (diagonal)	50	38	4:3	1125	870
SubC Control HD 1Cam Alpha	60 (horizontal)	60	34	16:9	1100	625

Digital stills camera configuration	
Focus	1m (fixed)
Aperture	f5.6
Mode/Shutter	Manual (1/250)
ISO	200
Flash	1/8 +2
Resolution	RAW and JPEG
HD camera configuration	
File format	.M2TS

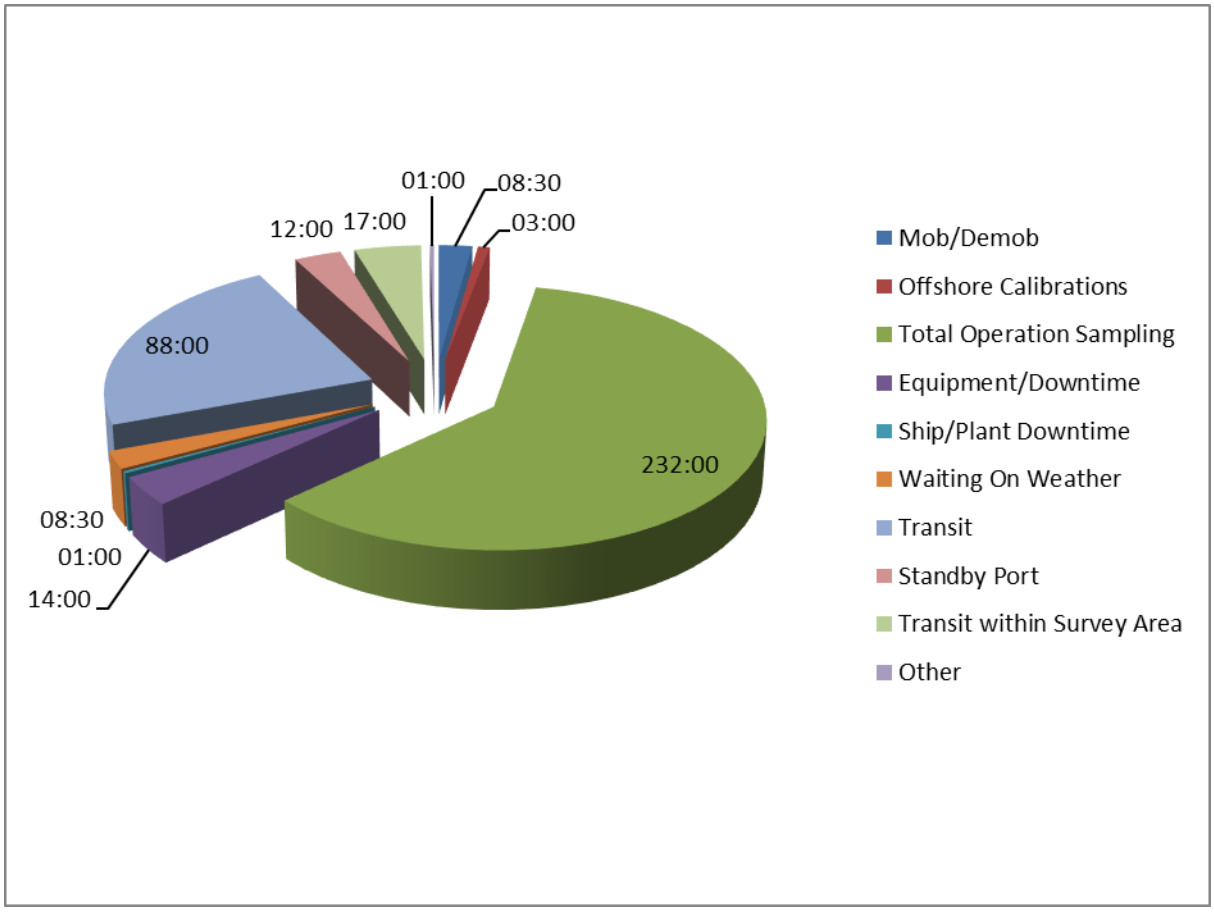
Image quality	HD-FH
Filename = recording start date and time	YYMMDDHHMMSS (eg 30/08/13 00:21:21)
Recording capacity	96GB (available time approx 7h 50m)
Frame rate	50 p (progressive)
Laser projectors	4 spot, 100mm apart

Other

- USBL system did not require calibration.
- Navigation data (ship's position) is from the vessels main system (i.e. GPS aerial). Offsets were not applied.
- Positional data for the USBL was supplied from the ship's multibeam system and is corrected (to within 1m) for the drop keel, where the USBL transceiver is located; therefore, the USBL is corrected for its location. Vessel heading was supplied from the same source, and the motion reference for the USBL was supplied from the USBL unit.

Appendix 5: Breakdown of survey operation time

Activity	Hours Spent
Mob/demob	**08:30**
Offshore calibrations	**03:00**
Total operation sampling	**232:00**
Equipment/downtime	**14:00**
Ship/plant downtime	**01:00**
Waiting on weather	**08:30**
Transit	**88:00**
Standby port	**12:00**
Transit within survey area	**17:00**
Other: Camera operations suspended while cruise ship transited across planned transect	**01:00**
Total:	**385:00**



Appendix 6: Daily progress reports

The Daily Log of operations on the MRV Scotia, for the 1016S Geikie Slide and the Hebridean Slope NCMPA offshore monitoring survey, covering the period - Monday 18 July to Wednesday 3 August 2016.

Appendix 7: Box corer protocol

Guidance on the deployment and recovery of a box corer, with further instruction on processing of samples.

Appendix 8: Fishing activity review

A review of available fishing activity data has been undertaken by JNCC to help inform survey planning for the 1016S monitoring survey to Geikie Slide and the Hebridean Slope NCMPA. The results of this review have been used to inform sampling box and station placement to allow the sampling design to account for the fishing activity patterns observed.