Natural England

Shell Flat and Lune Deep Site of Community Importance (SCI) Drop-Down Video Survey

Final Report

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Seastar Survey Ltd. Project Number - J/15/465

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EXECUTIVE SUMMARY

Background

Lune Deep is a feature of the Shell Flat and Lune Deep Site of Community Importance (SCI), located at the entrance to Morecambe Bay. It is a glacially-incised feature – a 'kettlehole' – which has not been infilled by Holocene sediments (Doody, 1996). It has a maximum charted depth of over 86 m and is subject to tidal streams of up to 1.9 knots (Irving *et al*., 1996; Admiralty Charts). The primary reason for selection of this site is the presence of the Annex I feature 'reefs.'

In order to help inform site condition monitoring, Seastar Survey Ltd. were contracted by Natural England to undertake a drop-down video (DDV) survey of the Lune Deep reefs feature with the aim of defining the distribution and extent of any subtidal boulder and/or bedrock reef communities and establishing a baseline for the site against which future condition of these reef sub-features can be assessed.

Main findings

- A total of 39 transects were attempted throughout the survey areas using Seastar Survey's own high definition Freshwater Lens Camera System (FLCS), with a total of 258 approximately 1 minute discrete video clips achieved, 252 of which yielded usable data.
- The survey area can be broadly divided into two main areas; the deep channel, composed of sands and muds with sparse epifauna, and the relatively shallow and flat northern 'shelf' with the two areas separated by a relatively steep slope.
- While no bedrock was observed during the survey, potential stony reef habitat, composed of cobbles and boulders, was observed on 37 of the 39 achieved transects.
- Areas of potential Annex I reef habitat were found throughout the survey area, both on the 'shelf' and slope.
- Polygons to delineate the extent of potential Annex I reef sub-features were created at four confidence levels. The total area covered by potential Annex I stony reef habitat (at a minimum of 50 - 70 % confidence) was found to be ~4.752 km^2, equivalent to approximately 52 % of the total area surveyed.
- Where potential cobble and boulder reef habitats were observed, epifauna was dominated by the non-native, cryptogenic colonial ascidian *Molgula manhattensis*. These areas were assigned the biotope **CR.HCR.XFa.Mol**. Other fauna commonly observed included silt- and scour-resistant species such as the bryozoans *Flustra foliacea* and *Eucratea loricata*, the hydroids *Nemertesia spp.* and *Hydrallmania falcata* and the sponge *Haliclona oculata*.
- A preliminary assessment of condition has been made for the potential Annex I reef communities observed.
- It is recommended that future monitoring incorporate camera deployments and sediment sampling with broad-scale acoustic techniques to enable changes in substrate, including areas of Annex I reef, to be readily identified.

Table of Contents

1 INTRODUCTION 1

1.1 Project background 1

1.2 Survey aims 1

1.3 Survey area 2

1.4 The environment 3

1.4.1 Geological and sedimentary environment 3

1.4.2 Biological environment 8

2 METHODOLOGY 14

2.1 Overall approach to sampling design 14

2.2 Survey Strategy 15

2.2.1 Survey equipment 15

2.2.2 Horizontal control 15

2.2.3 Vertical Control 15

2.2.4 Drop Down Video Methodology 17

2.3 Video analysis and habitat mapping 18

2.3.1 Analysis of the HD video records 18

2.3.2 Biotope and feature mapping 20

3 RESULTS 22

3.1 Video analysis – ground-truthing 22

3.1.1 General description of the biological communities observed 22

3.1.2 The general biological community of potential Annex I reef habitat 22

3.2 Biotope mapping of the survey area 30

3.3 Distribution, extent and composition of Annex I reef habitat 35

3.3.1 Delineation of potential Annex I reef sub-features 35

3.3.2 Distribution and extent of Annex I reef sub-features 35

4 DISCUSSION 42

4.1 Survey methodology 42

4.2 Survey Limitations 42

4.2.1 Visibility and coverage 43

4.2.2 Weather conditions 43

4.2.3 Limitations in analysis 43

4.2.4 Discrepancies between the geophysical data and survey results 44

4.3 Confidence assessment 45

4.3.1 Confidence in biotope assignment 45

4.3.2 Confidence in mapping stony reef habitat 45

4.4 Comparisons with previous studies ... 45
4.5 Condition monitoring – subtidal reef sub-features ... 49
4.6 Recommendations for future monitoring ... 49
5 REFERENCES ... 53
6 APPENDICES ... 56

List of Figures

Figure 1.1: Location of the Shell Flat and Lune Deep Site of Community Importance (SCI) . **2**

Figure 1.2: Superficial sediments in and around the Shell Flat and Lune Deep SCI (SeaMap, 2010) **4**

Figure 1.3: Multibeam bathymetry acquired by the Maritime and Coastguard Agency in 2008 and 2009 in and around the Lune Deep **6**

Figure 1.4: Backscatter dataset acquired by the Maritime and Coastguard Agency in 2008 and 2009 in and around the Lune Deep **7**

Figure 1.5: Location of data sampling points surveyed and MNCR biotopes (Connor et al., 2004) assigned to data points in the Lune Deep area by Envision (2008) overlying backscatter data.......... **10**

Figure 1.6: MNCR biotopes (Connor et al., 2004) assigned during Seastar Survey Ltd.'s reanalysis of data collected in the Lune Deep area by CMACS in November 2011 overlying backscatter data **11**

Figure 2.1: Location of planned camera transects for the 2015 Lune Deep drop-down video survey overlying multibeam bathymetry data supplied by Natural England **16**

Figure 3.1: Locations of camera transects achieved in both phases of the 2015 drop-down video survey of the Lune Deep survey **25**

Figure 3.2: Locations of seabed landings in both phases of the 2015 drop-down video survey of the Lune Deep survey.......... **26**

Figure 3.3: Example images of the variety of habitats and fauna observed during the Lune Deep drop-down video survey 2015.......... **27**

Figure 3.4: Distribution of observed MNCR biotopes (Connor *et al*., 2004) in the Lune Deep 2015. Each data point represents a single video clip. **28**

Figure 3.5: Example images of the variety of identified biotopes and features of interest observed during the Lune Deep drop-down video survey 2015.......... **29**

Figure 3.6: Distribution of observed Broadscale Habitat types in the Lune Deep 2015. ...... **32**

Figure 3.7: Example of biotope mapping of the Lune Deep area using backscatter data in conjunction with drop-down video data **33**

Figure 3.8: Biotope complex map of the Lune Deep survey area **34**

Figure 3.9: Percentage cover of cobbles and boulders observed in each video clip captured in the Lune Deep survey area 2015 .... **37**

Figure 3.10: The distribution of confidence level one (point source) Annex I cobble and boulder stony reef habitats identified in the Lune Deep DDV survey 2015 .... **38**

Figure 3.11: The distribution of confidence level two Annex I cobble and boulder stony reef habitats identified in the Lune Deep DDV survey 2015 .... **39**

Figure 3.12: The distribution of confidence level three Annex I cobble and boulder stony reef habitats identified in the Lune Deep DDV survey 2015 .... **40**
Figure 3.13: The distribution of confidence level four Annex I cobble and boulder stony reef habitats identified in the Lune Deep DDV survey 2015 .... **41**
Figure 4.1: MNCR biotopes (Conner *et al*., 2004) assigned to two drop-down video datasets collected by CMACS in 2011 and Seastar Survey Ltd in 2015 overlying backscatter data collected by Maritime and Coastguard Agency in 2008-09... **48**

List of Tables

Table 1.1: Attributes to be used to define the condition of the Shell Flat and Lune Deep SCI sub-feature of interest 'reefs' (after Natural England, 2012) **12**

Table 2.1: The main characterising features of a stony reef, after Irving (2009). **19**

Table 2.2: Threshold ranges proposed by workshop participants for reef characteristics which may be used to determine whether an area of *Sabellaria* spp. aggregations might qualify as a biogenic reef. From Gubbay (2007). **19**

Table 3.1: Total area in square kilometres of each biotope complex assigned during the creation of the broadscale biotope map of the survey area **31**

Table 3.2: Total area covered by deliniated areas of potetnial stony reef habitat **36**

Table 4.1: Favourable condition assessment table with recommended measures and attributes for the Lune Deep feature of the Shell Flat and Lune Deep SCI post-2015 survey (based on Natural England, 2012) **50**

List of Appendices

Appendix I: Details of planned camera transects for the Lune Deep drop-down video survey 2015.

Appendix II: Survey logs detailing achieved ‘seabed contacts’ in the 2015 Lune Deep drop-down video survey

Appendix III: Biotopes complexes and biotopes identified using video data collected from the 2015 Lune Deep drop-down video survey

Appendix IV: Full list of taxa identified in the video data collected during the Lune Deep drop-down video survey

Appendix V: MESH Confidence Assessment Score Sheet for Lune Deep 2015 potential stony reef polygons

1 INTRODUCTION

1.1 Project background

The EU Habitats Directive aims to promote the maintenance of biodiversity, taking account of economic, social, cultural and regional requirements and sets out measures to maintain or restore natural habitats and species of European Union interest at favourable conservation status. Under the Habitats Directive, Natural England has statutory responsibility to advise relevant authorities as to the conservation objectives for European marine sites in England and to advise relevant authorities as to any operations which may cause deterioration of natural habitats or the habitats of species or disturbance of species for which these sites have been designated. This information is a key component of any management schemes which may be developed for these sites.

Lune Deep is a feature of the Shell Flat and Lune Deep Site of Community Importance (SCI), located at the entrance to Morecambe Bay. It is a glacially-incised feature – a 'kettlehole' – which has not been infilled by Holocene sediments (Doody, 1996). It has a maximum charted depth of over 86 m and is subject to strong tidal streams, (Irving *et al*., 1996) with Admiralty charts indicating up to 1.9 knots on springs. The primary reason for selection of this site is the presence of the Annex I feature 'reefs.'

In order to help inform site condition monitoring, Seastar Survey Ltd. (Seastar) were contracted by Natural England to undertake a drop-down video (DDV) survey of the Lune Deep feature with the aim of defining the distribution and extent of any subtidal boulder and/or bedrock reef communities and establishing a baseline for the site against which future condition of these reef sub-features can be assessed.

1.2 Survey aims

The overall aim of this contract was to undertake a drop-down video survey in order to inform condition monitoring of the subtidal bedrock and boulder reef communities within the Lune Deep. The attributes to be assessed during the survey were as follows;

- Biotope composition of subtidal boulder and bedrock reef
- Extent and distribution of characterising biotopes
- Species composition of characterising biotopes

The data acquired were to be of sufficient quality to allow for a preliminary condition assessment of Annex I sub-features, enabling the creation of a robust baseline against which future change can be measured, as well as comparison with previous data to assess any change in feature condition (see Table 1.1). In addition, the results of this survey will be used by Natural England in combination with information from additional sources to undertake a condition assessment of the reef feature at a later date. A limited quantity of previously collected data were made available to Seastar prior to the survey taking place to assist creation of a survey plan, including multibeam echosounder (MBES) bathymetric data and associated backscatter data acquired by the Maritime and Coastguard Agency in 2008 and 2009. In addition, some drop-down video data collected by CMACS in 2011 were provided to Seastar for analysis, including the identification of taxa and assignment of biotopes, to allow direct comparisons with current data to be made.

1.3 Survey area

The Lune Deep is a feature of the Shell Flat and Lune Deep SCI, located at the entrance to Morecambe Bay. The general location and outline of the Shell Flat and Lune Deep SCI is shown in Figure 1.1.

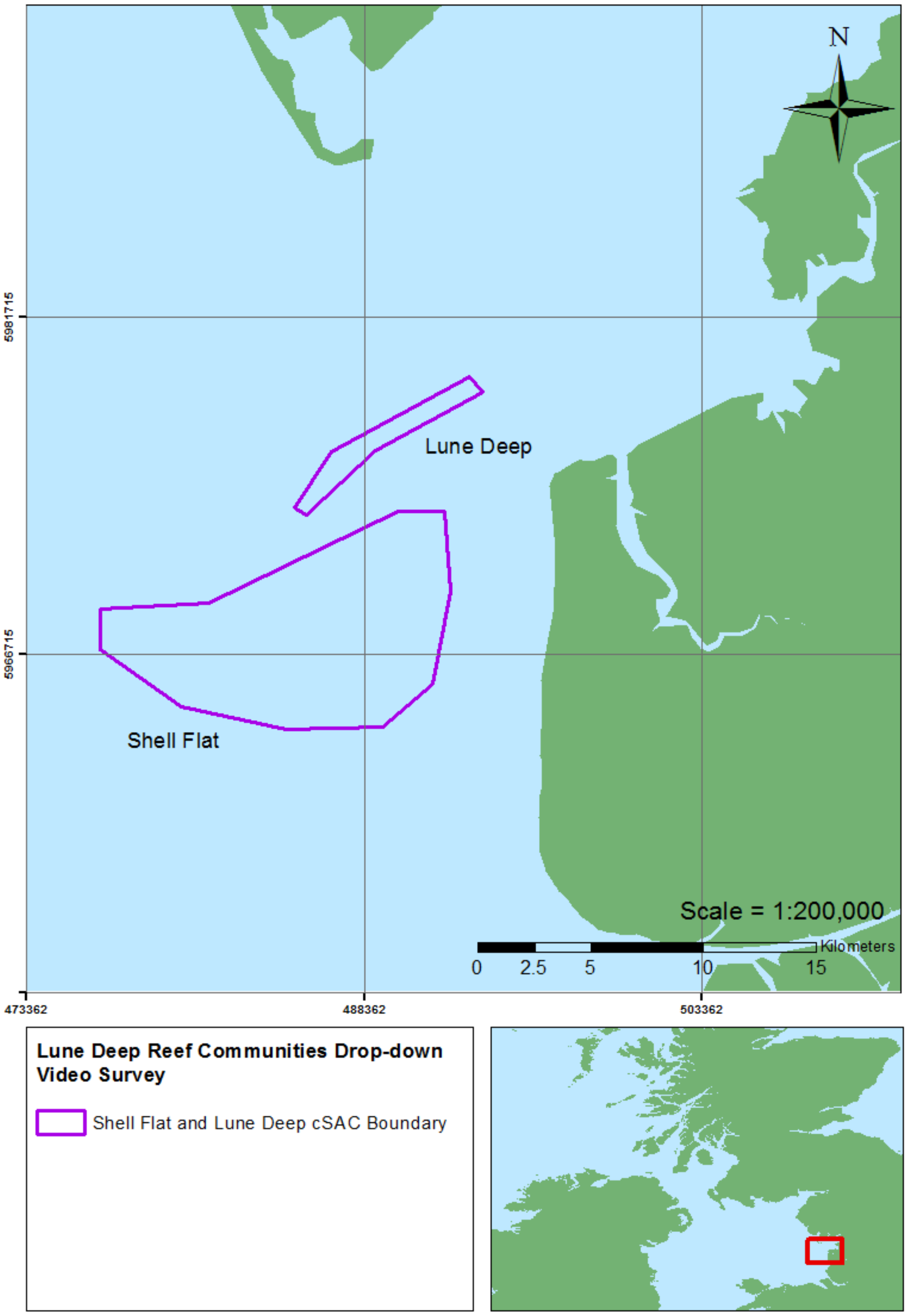

Figure 1.1: Location of the Shell Flat and Lune Deep Site of Community Importance (SCI)

1.4 The environment

1.4.1 Geological and sedimentary environment

The majority of coast surrounding the Lune Deep is low lying, with the only major cliff outcrop occurring at St Bees Head. The solid geology of the underlying bedrock of the northern Irish Sea, including Shell Flat and Lune Deep SCI, is Permo-Triassic in origin (248-286 Ma) (Doody, 1996). The Lancashire coast geology is mainly composed of sandstone, whereas the Cumbrian coast comprises extensive limestone pavement. However, both within the bay and onshore, these underlie thick glacial drift deposit and Holocene alluvial deposition (Doody, 1996). The continued movement of post glacial sediments by longshore drift is a major feature within the region, although these natural systems have been greatly modified by human intervention in the last 2000 years (Doody, 1996).

Water depths in the northern Irish Sea seldom reach more than 40 m. The exception is the Lune Deep, where depths of up to 86 m occur (Doody, 1996).

The general seabed substrata offshore of the entrance to Morecambe Bay is dominated by muddy sand due to the generally lower speed of tidal currents in this northern area (British Geological Society, 1996). Sedimentary substrata predominate throughout the northern Irish Sea region, being mixtures of coarse, fine and muddy sand with pebbles and occasional cobbles (Irving *et al*., 1996). 2010 UK SeaMap charts indicate that the region surrounding Shell Flat and Lune Deep SCI is primarily composed of mixed, sandy and muddy sediments, though areas of rock are recorded along the edge of the Lune Channel and in the centre of the Morecambe Bay (Figure 1.2).

The Shell Flat area (see Figure 1.1) is primarily composed of a sandbank which runs northeast from the southern corner of the area in a blunt crescent to the south west, forming a continuous structure approximately 15 km in length (Natural England, 2012; JNCC, 2016a). Shell Flat is considered to be an excellent example of the Annex I habitat ‘sandbanks which are slightly covered by sea water all the time’ (JNCC, 2016a). The bank is an example of a Banner Bank, which are up to a few kilometres in length, located in water depths less than 20 m below chart datum (Natural England, 2012). They are generally an elongated pear or sickle shape and take the form of single long banks of sand protruding seawards from headlands with one end almost touching the shore and are thought to be formed by differences in tidal ebb and flood flows (Envision, 2014).

By contrast, the Lune Deep, which formed as a result of a large block of ice becoming buried during the last ice age and melting after the retreat of the glaciers, is characterised by hard substrate, having not been infilled by the more recent Holocene sediments (Doody, 1996). This unique enclosed ‘kettlehole’ feature provides a contrasting habitat to the surrounding soft sediment communities, with steep sides from which boulders and cobbles outcrop (Irving *et al*., 1996). The northern flanks of the Lune Deep are primarily composed of exposed bedrock with a rugged seabed physiography. By contrast, the southern section consists of a smooth seabed which acts as a sink for muds and sands (Natural England, 2012).

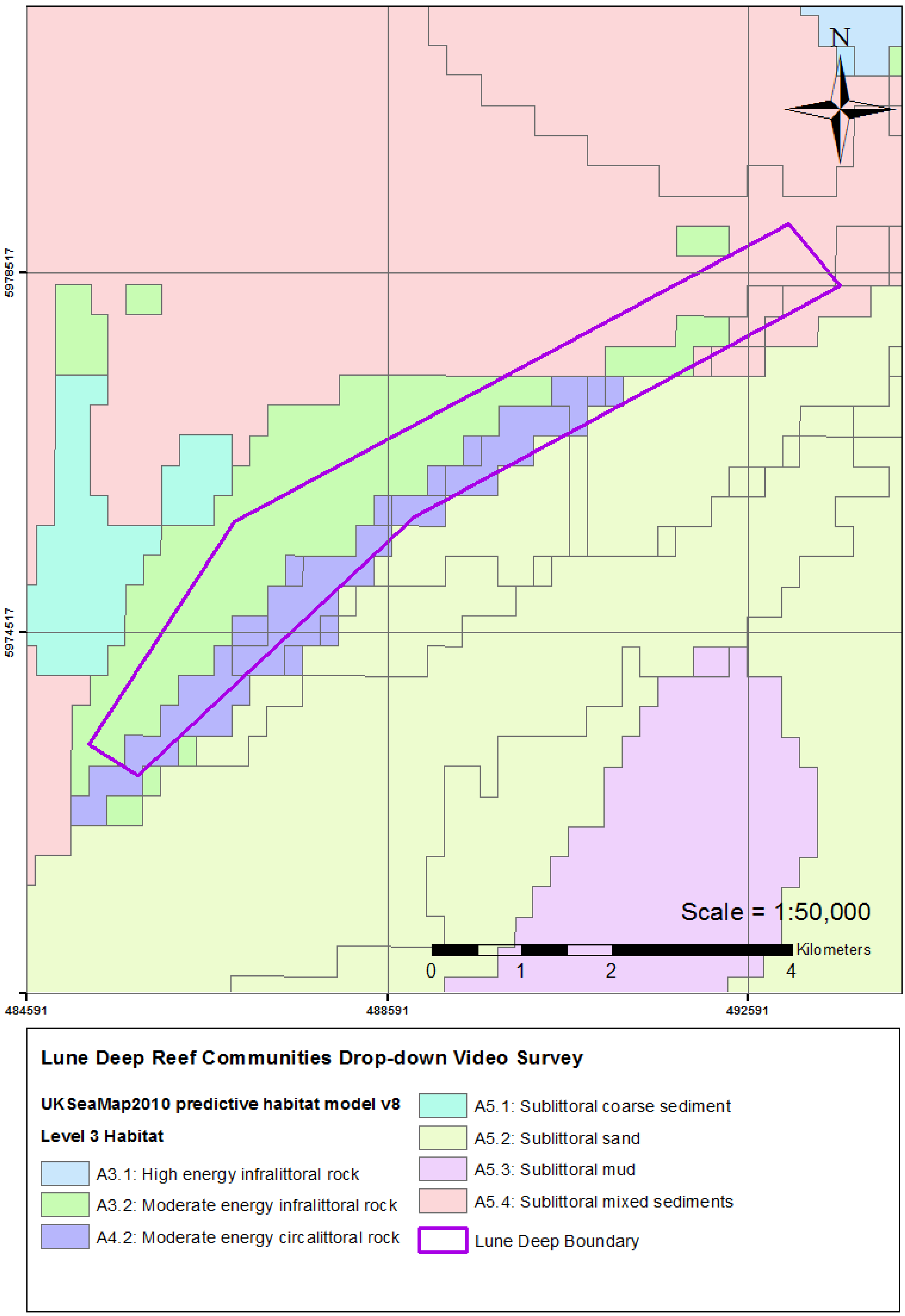

Figure 1.2: Superficial sediments in and around the Shell Flat and Lune Deep SCI (SeaMap, 2010)

1.4.1.1 Bathymetry

Bathymetric data and associated backscatter data for the survey area were acquired by the Maritime and Coastguard Agency in 2008 and 2009. These data are displayed in Figures 1.3 and 1.4.

The bathymetry data indicate a large variation in depth within the Lune Deep, with the northern section of the survey area as shallow as 2 m and the channel reaching a deepest point of more than 80 m, with a steep slope separating the upper 'shelf' and the channel. There are also several areas of variable bathymetry in the southern part of the survey area and along the upper edge of the slope.

The backscatter data show a uniform low return in the channel, suggesting the presence of soft sediment, while the upper 'shelf' is characterised by mottled high return, indicating hard substrata. The slope meanwhile is more variable, potentially indicating a variety of substrate types, or perhaps hard substrata overlain by soft sediments. The area of variable bathymetry in the south of the survey area is also characterised by alternating high and low reflectivity, possibly indicting changes in sediment associated with wave-like bedforms.

Backscatter data derived from multibeam bathymetry systems can be useful in determining seabed composition, however there is a lack of resolution when compared with sidescan sonar data (Collier and McGonigle, 2011). The various parameters associated with the collection and processing of the backscatter dataset, such as gain variations, were not provided; the confidence in the constancy of the reflectivity types shown is therefore reduced.

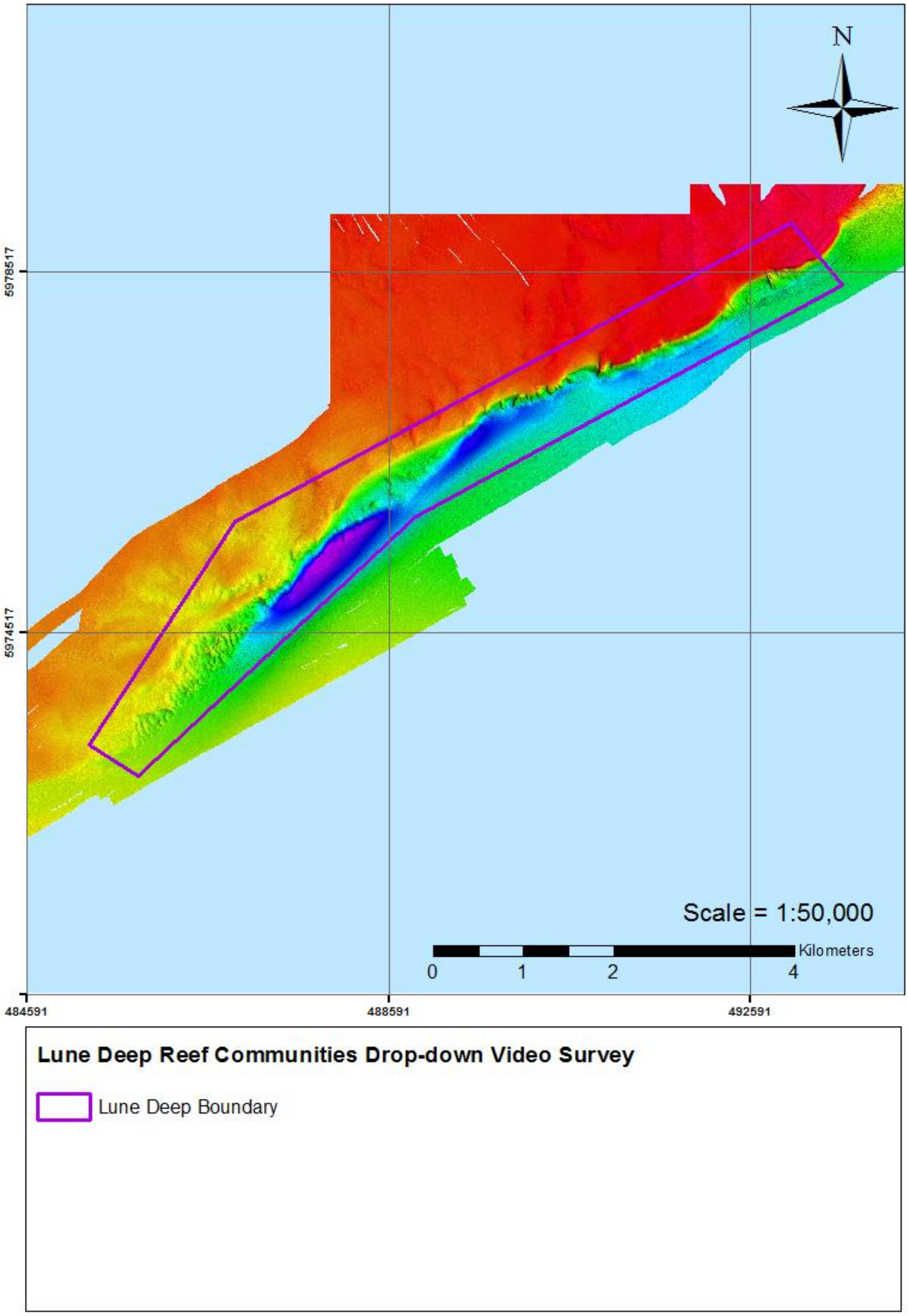

Figure 1.3: Multibeam bathymetry acquired by the Maritime and Coastguard Agency in 2008 and 2009 in and around the Lune Deep

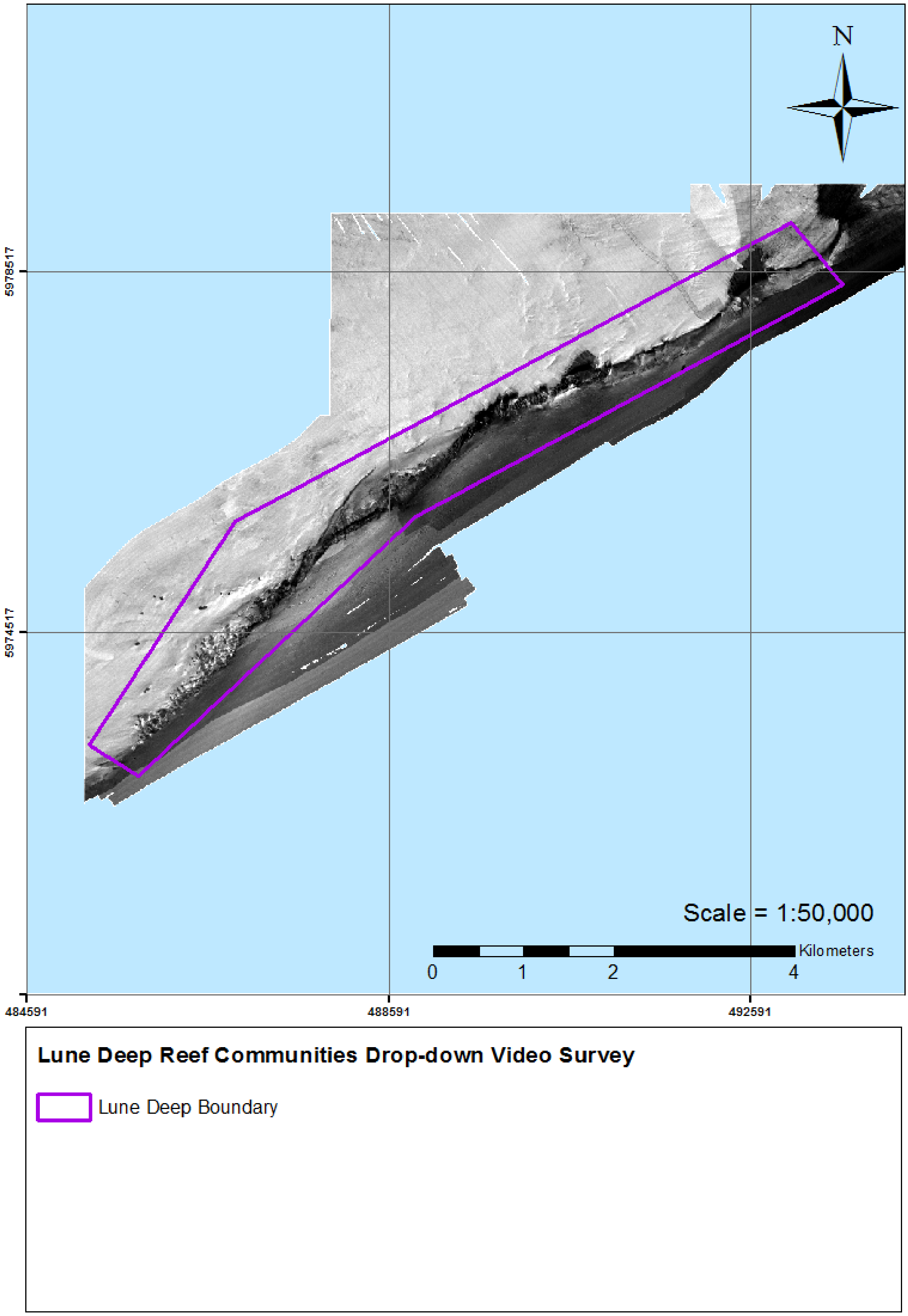

Figure 1.4: Backscatter dataset acquired by the Maritime and Coastguard Agency in 2008 and 2009 in and around the Lune Deep

1.4.2 Biological environment

Previous studies of the subtidal communities within the Lune Deep area have generally been limited in success or extent. The soft sediment communities present in the Lune Deep are typical of those found in the wider Irish Sea region, with low species diversity and high biomass (Irving *et al.*, 1996). Patches of sediment have been evident in much of Lune Deep, particularly in the deeper areas of the channel. Despite the presence of sediment, much of this area and the biota associated with this habitat is likely to be dependent on the hard substratum rather than the overlying sediment (Emblow, 1992). The central and southern areas of the Lune Deep, in the deeper channel, have been described previously either as being dominated by gravelly sand and gravelly mud (Envision, 2014) or as predominantly muddy sands and sandy muds with populations of the brittlestar *Ophiura* spp. (Envision, 2008).

While hard substrata are limited in extent in northern Irish Sea, the Annex I habitat 'reefs' are a primary reason for the selection of the Lune Deep area as an SCI (JNCC, 2016a). Reefs are defined by the JNCC (2016b) as;

Rocky marine habitats or biological concretions that rise from the seabed. They are generally subtidal but may extend as an unbroken transition into the intertidal zone, where they are exposed to the air at low tide. Intertidal areas are only included within this Annex I type where they are connected to subtidal reefs. Reefs are very variable in form and in the communities that they support. Two main types of reef can be recognised: those where animal and plant communities develop on rock or stable boulders and cobbles, and those where structure is created by the animals themselves (biogenic reefs).

Ecological subdivisions for Annex I Reef include rocky (bedrock and boulder), stony and biogenic reefs. The reef habitat present in the Lune Deep represents a good example of boulder and bedrock reef (Natural England, 2012). The northern edges of the Lune Deep are characterised by heavily silted cobble and boulder slopes which are subject to strong tidal currents and which support a dense hydroid and bryozoan turf, with some areas characterised by erect sponges such as *Haliclona oculata* and the bryozoan *Flustra foliacea* with a rich faunal turf on tide-swept circalittoral mixed substrata (Emblow, 1992; Envision, 2014). Similar findings were reported by Envision (2008), who, using a combination of Acoustic Ground Discrimination System (AGDS), grab and video data, found that hard substrate in the Lune Deep – predominantly stable cobbles and boulders – tended to be heavily influenced by sediment, with the dominant fauna consisting of silt- and scour-tolerant species such as *F. foliacea*, *Nemertesia antennina*, *Hydrallmania falcata*, and *Alcyonidium diaphanum* with occasional populations of *Haliclona oculata*.

The most common biotopes associated with the areas of hard substrate in the Lune Deep belong to the mixed faunal turf communities biotope complex (**CR.HCR.XFa**) although those identified were mainly impoverished compared with the Marine Nature Conservation Review (MNCR) descriptions, particularly those areas described as the biotope **CR.HCR.XFa.FluCoAs** (*Flustra foliacea* and colonial ascidians on tide-swept moderately wave-exposed circalittoral rock) (Envision, 2008; Envision, 2014). Where *H. oculata* and *F. foliacea* were observed, primarily to the north of the Lune Deep, the biotope **CR.HCR.XFa.FluHocu** (*Flustra foliacea* and *Haliclona oculata* with a rich faunal turf on tide-swept circalittoral mixed substrata) was assigned. Biotopes assigned to samples from the Envision (2008) survey are shown in Figure 1.5.

Seastar's analysis of the drop-down video data collected in 2011 by CMACS suggested similar findings, with the video drops on the slope and flat area to the north of the channel primarily characterised by faunal turf biotopes (**CR.HCR.XFa**), particularly **CR.HCR.XFa.Mol** (*Molgula manhattensis* with a hydroid and bryozoan turf on tide-swept moderately wave-exposed circalittoral rock) and **CR.HCR.XFa.FluCoAs.X** (*Flustra foliacea* and colonial ascidians on tide-swept exposed circalittoral mixed substrata) on heavily silt-influenced pebbles and cobbles. In line with previous surveys, the deep channel was found to be characterised by mixed sediments and sandy muds with sparse fauna. Results of the analysis of the CMACS data are shown in Figure 1.6.

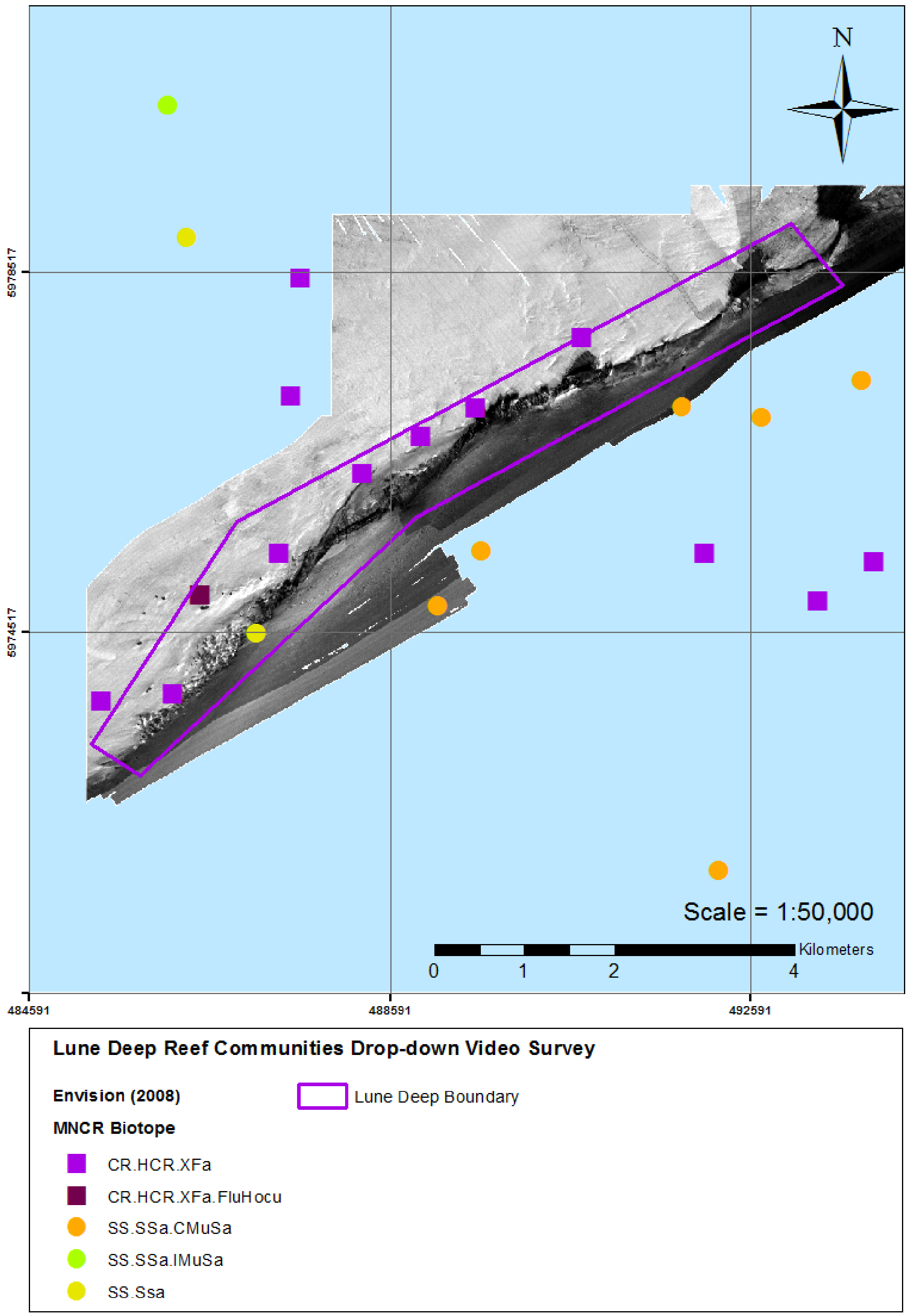

Figure 1.5: Location of data sampling points surveyed and MNCR biotopes (Connor et al., 2004) assigned to data points in the Lune Deep area by Envision (2008) overlying backscatter data

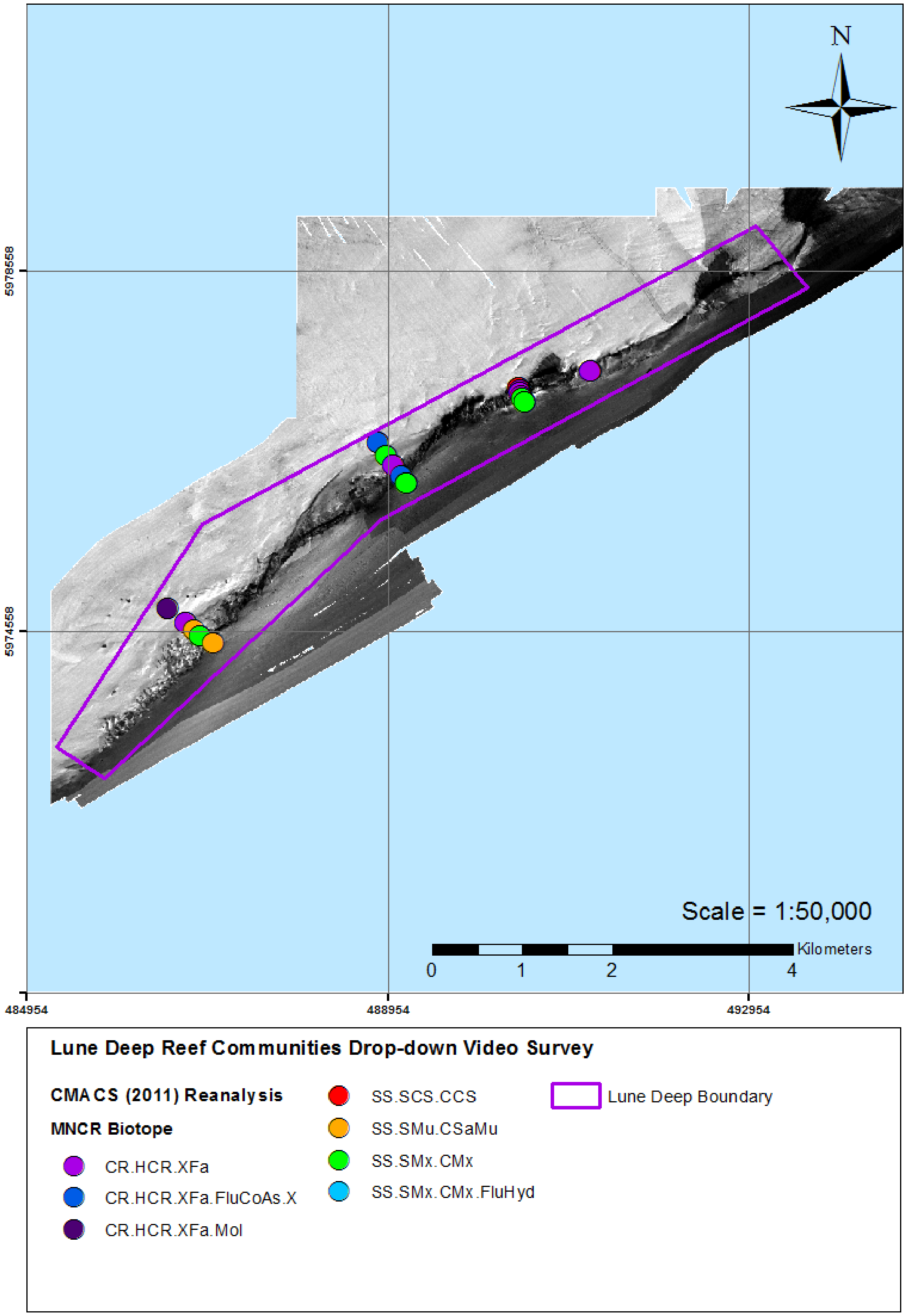

Figure 1.6: MNCR biotopes (Connor et al., 2004) assigned during Seastar Survey Ltd.'s reanalysis of data collected in the Lune Deep area by CMACS in November 2011 overlying backscatter data

Table 1.1: Attributes to be used to define the condition of the Shell Flat and Lune Deep SCI sub-feature of interest 'reefs' (after Natural England, 2012).

Attribute	Measure	Target	Baseline
Extent of reefs	Overall area (ha) of reef measured periodically throughout the reporting cycle	No decrease in extent from established baseline, subject to natural change.	Royal Haskoning (2008) and MCA acoustic data, with reference to additional survey data collected by CMACS in 2011
Biotope composition of reefs	Presence and/or abundance of a variety of reef biotopes at specified locations throughout the site.	Maintain the full variety of biotopes identified for the site to an established baseline, subject to natural change.	Baseline from Royal Haskoning (2008), with reference to additional survey data collected by CMACS in 2011
Distribution and spatial pattern of reef biotopes	Distribution and spatial arrangement of reef biotopes at specified locations. Measure during summer, once during reporting cycle.	Maintain the distribution and spatial pattern of reef biotopes identified for the site, to an established baseline, allowing for natural change.	Baseline from Royal Haskoning (2008), with reference to additional survey data collected by CMACS in 2011
Presence of representative /notable reef biotopes	Presence and/or abundance of representative/notable reef biotopes including; **CR.HCR.XFa** **CR.HCR.XFa.FluCoAs** **CR.HCR.XFa.FluHocu** **SS.SMx.CMx.FluHyd**; measured once during summer, within the reporting cycle.	Presence of biotopes at specified locations should not deviate significantly from an established baseline, allowing for natural change.	Baseline from Royal Haskoning (2008), with reference to additional survey data collected by CMACS in 2011

Attribute	Measure	Target	Baseline
Extent of representative /notable reef biotopes	Extent of representative/notable reef biotopes, including; **CR.HCR.XFa** **CR.HCR.XFa.FluCoAs** **CR.HCR.XFa.FluHocu** **SS.SMx.CMx.FluHyd**; measured once during summer, within the reporting cycle.	No change in the extent of representative / notable reef biotopes, from an established baseline, allowing for natural change.	Baseline from Royal Haskoning (2008), with reference to additional survey data collected by CMACS in 2011
Species composition of representative or notable reef biotopes	Frequency and occurrence of component species of representative or notable reef biotopes including; **CR.HCR.XFa** **CR.HCR.XFa.FluCoAs** **CR.HCR.XFa.FluHocu** **SS.SMx.CMx.FluHyd**; measured once during summer, within the reporting cycle.	No decline in reef biotope quality due to change in species composition or loss of notable species, from an established baseline, allowing for natural change.	Baseline from Royal Haskoning (2008), with reference to additional survey data collected by CMACS in 2011
Presence and/or abundance of specified reef species	Species may include: *Alcyonium digitatum, Cancer pagurus, Flustra foliacea, Asterias rubens, Nemertesia* spp.*, antennina* spp.*, Pomatoceros* spp.*, Ammodytes* spp.*, Hyas araneus, Urticina eques*. Measured once, during summer, within the reporting cycle.	Maintain presence and/or abundance of species from an established baseline, allowing for natural change	Baseline from Royal Haskoning (2008), with reference to additional survey data collected by CMACS in 2011

2 METHODOLOGY

The survey was conducted on board Seastar's own vessel; SV '*Mariner'* in two phases. The first phase was mobilised based on an excellent weather forecast and in consultation with Natural England. The survey team travelled to site and mobilised the equipment on the Thursday 20th August 2015. Work was carried out on Saturday 22nd August 2015 and Monday 24th August 2015 and the survey was demobilised on Tuesday 25th August 2015.

Survey operations were conducted over two days during this survey period. There were a total of two weather days during the survey period; Friday 21st August 2015 and Sunday 23rd August 2015.

The second phase was also mobilised based an excellent weather forecast and in consultation with Natural England. The survey team travelled to site and mobilised the equipment on Sunday 20th September with work conducted over three days on Tuesday 22nd, Wednesday 23rd September and Saturday 26th September. The survey vessel and equipment were demobilised and the survey team left site on Sunday 27th September.

2.1 Overall approach to sampling design

The survey plan was designed to assess the extent and distribution of subtidal rocky and stony reef communities within the Lune Deep survey area using high resolution video footage.

Sampling locations for the Lune Deep survey area were selected following a review of the literature and existing multibeam and backscatter data supplied to Seastar by Natural England. The aim was to target areas of potential rocky and stony reef, to revisit sites previously surveyed by CMACS in 2011 and Envision (2008) in order to allow for direct comparison and assessment of change, and to fill in gaps in the existing data in order to create a robust baseline against which future change could be measured. Camera transects were selected to investigate priority areas specified by the client, to revisit previous survey locations, and to achieve coverage of other identified potential areas of subtidal reef communities. Seastar utilised a stratified systematic approach to sampling design, aiming to sample at a range of water depths and predicted sediment types whilst targeting areas of potential rocky scar ground.

Following a review of the available data, it was ascertained that the largest areas of potential rocky and/or stony reef were likely to be associated with the northern slope and 'flats' area, with the deep areas of channel likely to be primarily composed of soft sediments. These northern areas were therefore assigned as the priority areas for survey. A total of 43 video transects were planned within the survey area, generally orientated in the direction of the expected predominant tidal currents except where features of interest dictated otherwise. Transects were of various lengths, depending on the feature to be investigated; for example, it was ensured that transects running across the slope were of sufficient length to sample at the full range of depths. The planned stations are shown in Figure 2.1 and full details of each planned transect, including rationales, are provided in Appendix I.

2.2 Survey Strategy

2.2.1 Survey equipment

The equipment used during the survey included:

- Hemisphere Crescent A100 differential global positioning system (DGPS)
- Hypack 2011 survey management software
- Sony MiniDV recorder
- Seastar Survey Freshwater Camera System including:
    - Bowtech Surveyor HD Pro video camera
    - 4 x Seatronics SubSea LED Lights
    - 2 x 100 m soft umbilicals
- Simrad CA42 hull mounted echosounder
- Roberts Fluxgate Compass

2.2.2 Horizontal control

Positioning of the vessel was achieved using a Hemisphere Crescent A100 DGPS smart antenna. This system fed raw WGS84 positions into Hypack 2011 survey management software. The WGS84 positions were then converted by Hypack 2011 into Universal Transverse Mercator (WGS84 UTM North Zone 30 (6°W - 0°) grid co-ordinates.

2.2.3 Vertical Control

SV *'Mariner'* was equipped with a Simrad CA42 chart plotter echosounder transducer. The raw depth under the keel was monitored and a correction added to account for the draught of the vessel. Non-tidally corrected depths were manually recorded at each fix location.

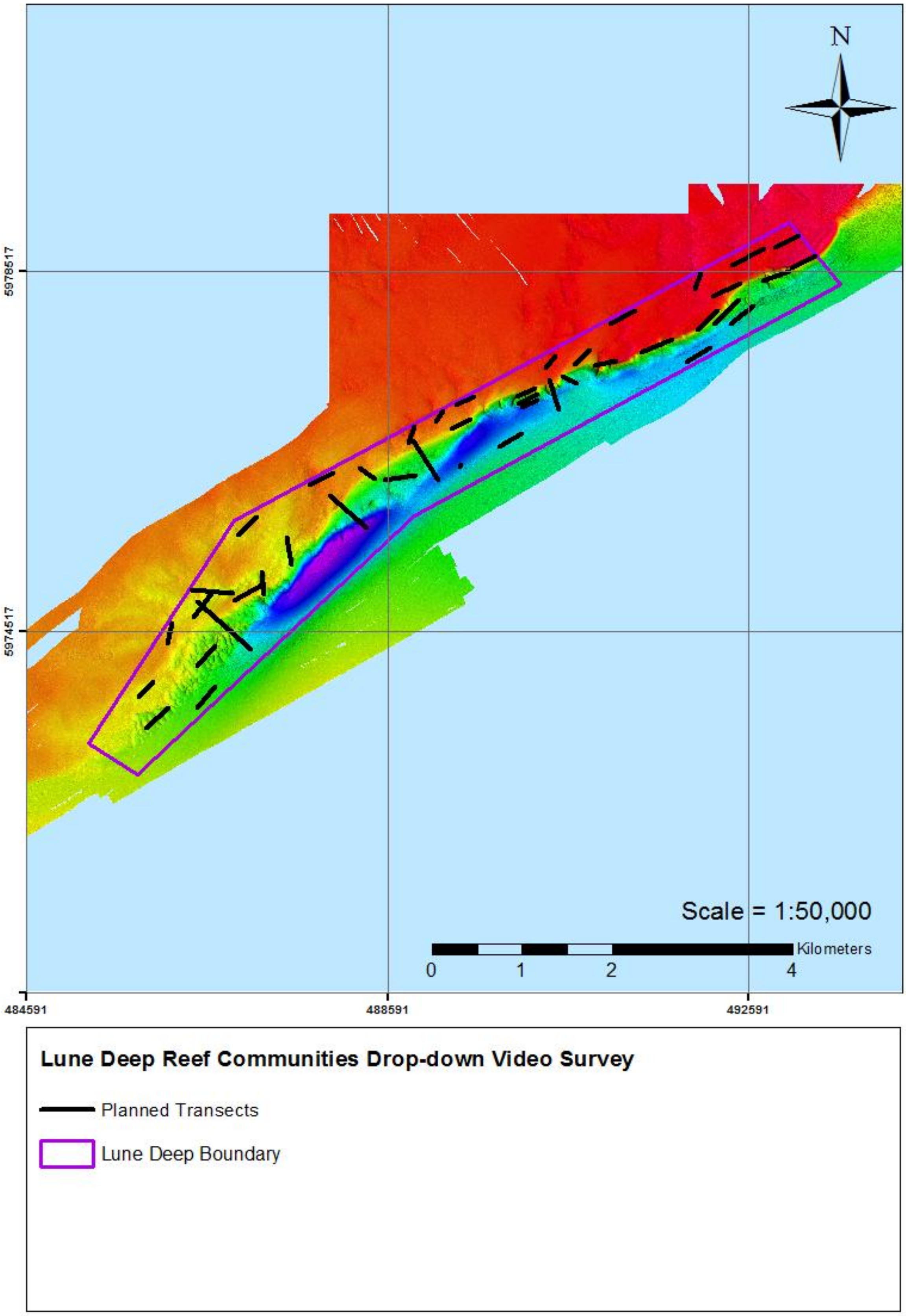

Figure 2.1: Location of planned camera transects for the 2015 Lune Deep drop-down video survey overlying multibeam bathymetry data supplied by Natural England

2.2.4 Drop Down Video Methodology

2.2.4.1 Freshwater Lens Camera System

Due to the nature of the survey environment, Natural England specified that a freshwater lens was to be used. The term 'freshwater lens' refers to a system comprising an underwater video camera housed within a sealed container filled with fresh or distilled water, mounted vertically over a clear lens at the base of the housing. This system enables useable seabed video data to be collected in highly turbid conditions by reducing the path length of light through the turbid water whilst still allowing the camera to be mounted far enough from the seabed to capture an appropriate field of view.

The camera system used was Seastar's own freshwater lens camera system (FLCS). This system was designed in-house and custom-built to prioritise flexibility and reliability in challenging sea conditions. The system can house a variety of High Definition (HD) (1080p) subsea video cameras and allow these cameras to acquire a minimum seabed field of view of 40 x 29 cm in waters with a visibility of <10 cm. For this survey a Bowtech Surveyor HD Pro digital video camera was mounted within the FLCS, recording HD (1080p) video with a field of view of approximately 50 x 45 cm at a frame height of 10 cm. The camera was controlled using a surface command unit (SCU) enabling direct recording of HD video to a Hard Disk Drive (HDD) recorder. Secondary recording was achieved using a high resolution Sony MiniDV digital tape recording system. The SCU enabled real time control of optical zoom, focal length and iris diameter. Four sub-sea LED lights were mounted on the frame in order to illuminate the seabed. These were also controlled from the surface. This is a proven system configuration which provides excellent and versatile imagery even in challenging low visibility conditions.

Two 100 m soft umbilicals were used to transmit data from and power to the system.

2.2.4.2 Deployment methodology

The Seastar FLCS was designed to capture video footage in challenging tidal conditions (i.e. high current flows) and in areas of poor underwater visibility where traditional flown camera systems would prove of little to no use. As a result the camera system has been optimised to capture footage whilst landed (to reduce the visibility problems caused by suspended matter) rather than to provide footage along an entire transect. The camera is landed at intervals along each transect and video recorded at each discrete position. For the majority of the planned sampling locations these drops were spaced at approximately 50 m intervals along each transect, or at specific positions if features of interest had been identified or if repeat stations were to be attempted. These landings had minimal impact on the seabed, particularly when compared with methods such as camera sledges, as the frame is not dragged along the seabed (which would be impractical on areas of potential reef) but held in a single position while video data are recorded. Each of these seabed landings is referred to as a "seabed contact".

The clear lens of the system was fixed at 10 cm above the seabed and a scale cord was attached across the field of view in order to aid the focusing of the camera and to assist sediment and species identification.

The camera was deployed over the stern of the vessel using the vessel's A-frame and winch. Two members of crew guided the frame over the stern of the vessel and the soft umbilical cable was taped to the winch wire at suitable intervals to prevent excess drag and entanglement. Once the camera system was in the water and approximately 1 m above the seabed the on-board surveyor began to log navigation data. The skipper then positioned the vessel into the tide and approached the first drop location at the start of the transect. The vessel then came to a stop and the camera was slowly lowered to the seabed. A manual fix was then taken to record the time (UTC) and the exact position of the frame on the seabed. The stationary nature of the vessel resulted in minimal horizontal layback of the FLCS from the vessel reference point when the fix was taken. Once the camera was landed the umbilical and winch wire were paid out at the same speed as the vessel's drift, allowing the camera to remain undisturbed on the seabed for sufficient time to allow for sediment to clear and high quality imagery to be acquired. This methodology meant that operations could take place throughout the survey day, regardless of current speeds. While the camera was stationary on the seabed, the camera operator took time to optimise zoom, lighting and focus levels in order to better identify the biota present. Where visibility was very poor (<5 cm) the camera was still deployed in order to gain an indication of seabed type.

The camera sent a continuous video feed to the surface, where the deployment was monitored and the camera was controlled by the camera operator using the surface control system. The HDD system was set to record discrete seabed landings only, and each track on the HDD system was associated with a separate seabed landing. The entirety of the transect was recorded using MiniDV tapes.

Where potential reef features were observed, all stations on each transect were investigated. On some planned transects it was expected, based on examination of backscatter and bathymetric data, that only soft muds would be found. When the video feed proved that this was the case the number of drops on each transect was reduced.

Raw navigation data were recorded throughout the drop-down camera deployment. All camera deployment logs were synchronised to the navigation data from the GPS system. The camera operator recorded the time in UTC from the GPS at the start and end of each deployment and the time of each landing. The position of each seabed landing was then extracted from the navigation data and backed up on a separate system.

2.3 Video analysis and habitat mapping

2.3.1 Analysis of the HD video records

The nature of the highly turbid environment within the survey area, and the resultant required deployment methodology, resulted in a dataset comprised of discrete seabed HD video 'clips.' These video clips record a static 0.225 m^2 patch of the seabed for a period of between 30 and 60 seconds. The camera system remained stationary during this time, however the entire video clip was analysed in each case in order to record any mobile fauna present and to view all changes in zoom, lighting and focus levels made by the onboard camera operator in order to better identify any biota.

Video clip analysis consisted of a description of the seabed and the identification of flora and fauna to the lowest practical taxonomic level. The abundance data were recorded using the semi-quantitative SACFOR scale, however counts or percentage cover of taxa were also recorded where it was deemed useful (e.g. reef forming species etc.). Sediment categories were assigned based on the Folk Trigon and Wentworth scale (see Leeder, 1982), with boulders and cobbles being described within ‘gravel’, and ‘rock’ referring to bedrock. A broadscale habitat (BSH) type was subsequently assigned to each video segment. If applicable a Habitat Features of Conservation Importance (FOCI) category was also assigned. The presence of any Annex I habitats and associated sub-features, including reef sub-features, were recorded. In addition, where potential stony or biogenic reef was recorded, an assessment of ‘reefiness’ was made based on elevation, percentage cover and, where possible, extent (Tables 2.1 and 2.2), as according to Irving (2009) and Gubbay (2007) respectively. However, without a grab survey, the fourth criterion of stony reefs (i.e. the ratio of infauna to epifauna) could not be assessed.

Table 2.1: The main characterising features of a stony reef, after Irving (2009).

Characteristic	Not a reef	Resemblance to being a stony reef		
		Low	Medium	High
Composition (% cobble cover)	< 10 %	10 - 40 %	40 - 95 %	> 95 %
Elevation	Flat seabed	< 64 mm	64 mm - 5 m	> 5 m
Extent	< 25 m^2	> 25 m^2		
Biota	Dominated by infaunal species			> 80 % of species epifauna

Table 2.2: Threshold ranges proposed by workshop participants for reef characteristics which may be used to determine whether an area of *Sabellaria* spp. aggregations might qualify as a biogenic reef. From Gubbay (2007).

Characteristic	Not a reef	"Reefiness"		
		Low	Medium	High
Elevation (cm)	< 2	2 - 5	5 - 10	> 10
Extent (m^2)	< 25	25 - 10,000	10,000 - 1,000,000	> 1,000,000
Patchiness (% cover)	< 10	10 - 20	20 - 30	> 30

Any other features of interest, including anthropogenic impacts such as trawl marks or litter, were also noted. A list of the encountered fauna was produced for each site using species reference numbers as cited in the Marine Conservation Society Species Directory (Howson and Picton, 1997) with additional reference to the World Register of Marine Species (WoRMS Editorial Board, 2016) to avoid problems in species nomenclature. Video clips were assigned a biotope according to Connor *et al.* (2004) and a European Nature Information System (EUNIS) habitat classification code. The results were analysed using GIS which enabled a high level of processing, interpretation and display of substrata types, biotopes and HD video data.

The Quality Control (QC) process for the video analysis involved ongoing and post-analysis elements, as well as continuous collaboration with other Seastar staff to check species identification, sediment classification and biotope classifications during the process of analysis. A senior member of staff also checked any uncertain identifications to ensure the highest possible level of data quality. The post-analysis QC process involved a re-assessment of 10 % of the data, checking the identification of the biota, habitat/biotope classification and data entry. Any discrepancies were discussed between analysts and agreed on prior to finalisation of the results.

2.3.2 Biotope and feature mapping

The assigned biotopes for each discrete HD video clip were incorporated into the GIS and the relevant positions checked against the proposed locations for positional quality control. The data were then superimposed over the acoustic data (both MBES and backscatter). The principal of habitat mapping is based on the acquisition of video (or sediment sampling) data which enables areas of consistent reflectivity, areas of consistent depths or bathymetric features to be ground-truthed. The ground-truthing of the acoustic data enables a substrate type or biotope to be assigned to areas of consistent reflectivity (principally using sidescan sonar data) or bathymetry with varying levels of confidence. This assignment is illustrated by creating a layer of polygon shape files within the GIS to create habitat maps.

2.3.2.1 Biotope mapping

The first stage of biotope mapping involved the delineation of biotope complexes / biotopes. The biotope mapping process would usually be achieved by ground-truthing areas of consistent reflectivity identified from sidescan sonar acoustic data, however the acoustic dataset provided by Natural England consisted of multibeam bathymetry and associated backscatter data. Due to the inherent uncertainty associated with backscatter data and the lack of associated metadata these data were used in conjunction with the bathymetric dataset to delineate areas dominated by a single biotope or biotope complex.

2.3.2.2 Mapping of potential Annex I reef features

Once the biotopes had been mapped the next stage of analysis involved the mapping of areas of potential Annex I reef habitat. Areas of potential reef were delineated based on substrate composition, including percentage cobble composition, assigned biotope and reflectivity and/or bathymetric features.

Four levels of confidence were assigned to the potential stony reef polygons, in order to provide levels of accuracy in prediction of these habitats of interest. Confidence scores were determined using MESH confidence scoresheets. Habitat polygons at point source (i.e. a single video clip) are estimated >90 % accurate (confidence level 1). Confidence level 2 (areas immediately surrounding point source data) was assigned with ~80 % confidence. These polygons were generated by extending a 50 m radius from any point source at which the seabed was shown to be composed of greater than 10 % cobbles, or from seabed contacts at which cobble coverage was recorded as <10 % but which were located within 50 m of a contact with >50 % cobbles. Level three polygons were assigned a confidence level of approximately 70 %, and have been delineated by extending areas of level two polygons along bathymetric features and areas of similar reflectivity. However, areas of similar bathymetric features and/or reflectivity with limited or no ground-truthing, or areas of highly variable depth and/or backscatter return were treated separately, and assigned a confidence score of approximately 50 %.

3 RESULTS

3.1 Video analysis – ground-truthing

During the survey 39 of the planned 43 transects were completed, with a total of 258 discrete seabed video clips recorded, 252 of which yielded usable data. Figures 3.1 and 3.2 show the locations of all the achieved transects and seabed landings and the full logs with all locations are given in Appendix II.

Underwater visibility was poor throughout the survey, estimated by the survey team as approximately 15 cm on average. Despite this, the use of a FLCS coupled with the high quality camera system achieved excellent data on the majority of transects.

3.1.1 General description of the biological communities observed

The Lune Deep survey area can be broadly split into two sections; the relatively flat and shallow northern 'shelf' and the deep channel. The 'shelf' was found to be generally characterised by heavily silt-influenced cobbles, while the deep channel was dominated by slightly shelly sands and muds.

A total of eight biotope complexes and biotopes (EUNIS level 4/5) were identified (a glossary of the identified habitat types is found in Appendix III, and a full list of the taxa identified is shown in Appendix IV). Example screenshots of video data from the survey are given in Figure 3.3 and the distribution of the identified biotopes is shown in Figure 3.4. It should be noted that several biotope assignments have been left at the 'biotope complex' level (level 3 in the MNCR classification). This is due primarily to a lack of information; soft sediment biotopes are classified largely based on infaunal data rather than sediment characteristics alone. Furthermore, the assignment of mixed sediment and sandy or muddy biotopes was based solely on the assessment of the person undertaking the analysis. Without supporting data from sediment sample analysis there can be some uncertainty in the assessment of the quantities of sand and mud present. As a result some biotopes may be subject to change.

In the deep channel three biotopes complexes were identified; **SS.SMx.CMx** (circalittoral mixed sediment), **SS.SSa.CMuSa** (circalittoral muddy sand) and **SS.SMu.CSaMu** (circalittoral sandy mud). Very little epifauna was recorded on those lines undertaken in the deep sections of the channel, with populations of the brittlestar *Ophiura* spp. present on the sediment surface. Closer to the slope, however, on line LNDP 09, where sediment was more coarse (pebbles on muddy sand and shell), fauna was slightly more diverse, with sparse hydroid turf attached to the larger pebbles and dense juvenile *Asterias rubens*. Example screenshots of video data from the deep channel are provided in Figure 3.5a and 3.5b.

3.1.2 The general biological community of potential Annex I reef habitat

In contrast to the channel itself, the northern, relatively flat, shallow 'shelf' of the Lune Deep was dominated by silt-influenced cobbles on soft sediment. Cobble (and, less frequently, boulder) potential reef features were observed throughout the shelf area, with potential reef features recorded on 37 of the 39 achieved transects.

Fauna were generally sparse on these areas of cobbles, being characterised by sparse faunal turf. These areas were categorised as the biotope complex **CR.HCR.XFa** (mixed faunal turf communities). Dense aggregations of the non-native ascidian *Molgula manhattensis* were observed at 71 seabed contacts (on a total of 26 transects). Where *M. manhattensis* was recorded, the high energy circalittoral rock biotope **CR.HCR.XFa.Mol** (*Molgula manhattensis* with a hydroid and bryozoan turf on tide-swept moderately wave-exposed circalittoral rock) was assigned (Figure 3.5c). Where the bryozoan *Flustra foliacea* was also observed, the biotope **CR.HCR.XFa.FluCoAs.X** (*Flustra foliacea* and colonial ascidians on tide-swept exposed circalittoral mixed substrata) was recorded (Figure 3.5d). *Flustra foliacea* was generally observed at greater densities on areas of higher percentage cobble coverage, occasionally alongside the sponge *Haliclona oculata*. In these cases (a total of four seabed contacts) the biotope **CR.HCR.XFa.FluHocu** (*Flustra foliacea* and *Haliclona oculata* with a rich faunal turf on tide-swept circalittoral mixed substrata) was assigned, although the fauna identified indicates that the communities observed represent an impoverished version of this biotope (Figure 3.5e). Where *F. foliacea* was recorded on more mixed sediment (i.e. higher proportion of muds, sands and shell) alongside the hydroid *Hydrallmania falcata* the biotope **SS.SMx.CMx.FluHyd** (*Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment) was assigned, although in reality, both the substrate and fauna present were very similar to that observed elsewhere on the ‘shelf’ section of the survey area (Figure 3.5f).

In some cases, due to a paucity of fauna, the biotope complex **SS.SMx.CMx** was assigned even where potential stony reef features were observed. It should be noted however that the substrata present was not drastically different to those areas assigned to high energy rock biotopes.

3.1.2.1 Representative and notable species on potential Annex I reef habitats

The most common species observed on areas of hard substrate was the colonial ascidian *M. manhattensis*. It was observed in very high abundances throughout the survey area.

Species diversity on area of potential stony (cobble) reef was generally low, with *M. manhattensis* dominating most areas of hard substrate, although unidentified hydroid and bryozoan turf was also commonly recorded alongside silt-tolerant species such as *F. foliacea*, the hydroids *Nemertesia spp.* and *H. falcata* and the sponge *H. oculata.*

The seastar *Asterias rubens* was frequently recorded at very high densities (Figure 3.5g) throughout the survey area on all observed substrata. Most of the individuals recorded were less than 5 cm across, indicating a recent potential population explosion or spawning event. Possibly related to this was the presence of aggregations of very small (1 – 2 mm) bivalves, likely *Mytilus* sp., observed at five seabed contacts on lines LNDP 02 and LNDP 03.

Other commonly identified fauna included; the hydroid *Tubularia indivisa*; the soft coral *Alcyonium digitatum*; anemones such as *Urticina* spp., *Metridium dianthus* and *Sagartia troglodytes*; polychaetes, primarily serpulid worms and the peacock worm *Sabella pavonina*, although in the majority of cases only the tubes of this species were observed; and the bryozoan *Eucratea loricata*, which was tentatively identified at 48 seabed contacts. Frequently recorded crustaceans included the commercial species *Cancer pagurus*, recorded at four seabed contacts, as well as hermit crabs (Paguridae), spider crabs (Majidae) and swimming crabs (Portunidae) including *Liocarcinus depurator* and *Necora puber*.

The tube-building polychaete *Sabellaria spinulosa* was tentatively identified at two seabed contacts on lines LNDP 36 and 37, however only at low abundances (Figure 3.5h). The simplest definition of *S. spinulosa* reef, as given by Gubbay (2007), is “an area of *S. spinulosa* which is elevated from the seabed and has a large spatial extent.” Using the criteria outlined in Table 2.2 the ‘reefiness’ of aggregations of *S. spinulosa* were assessed. It is unlikely that either of the *S. spinulosa* aggregations observed in this survey constitute a reef, primarily due to the apparent low extent, but also to the low to medium percentage cover and elevation.

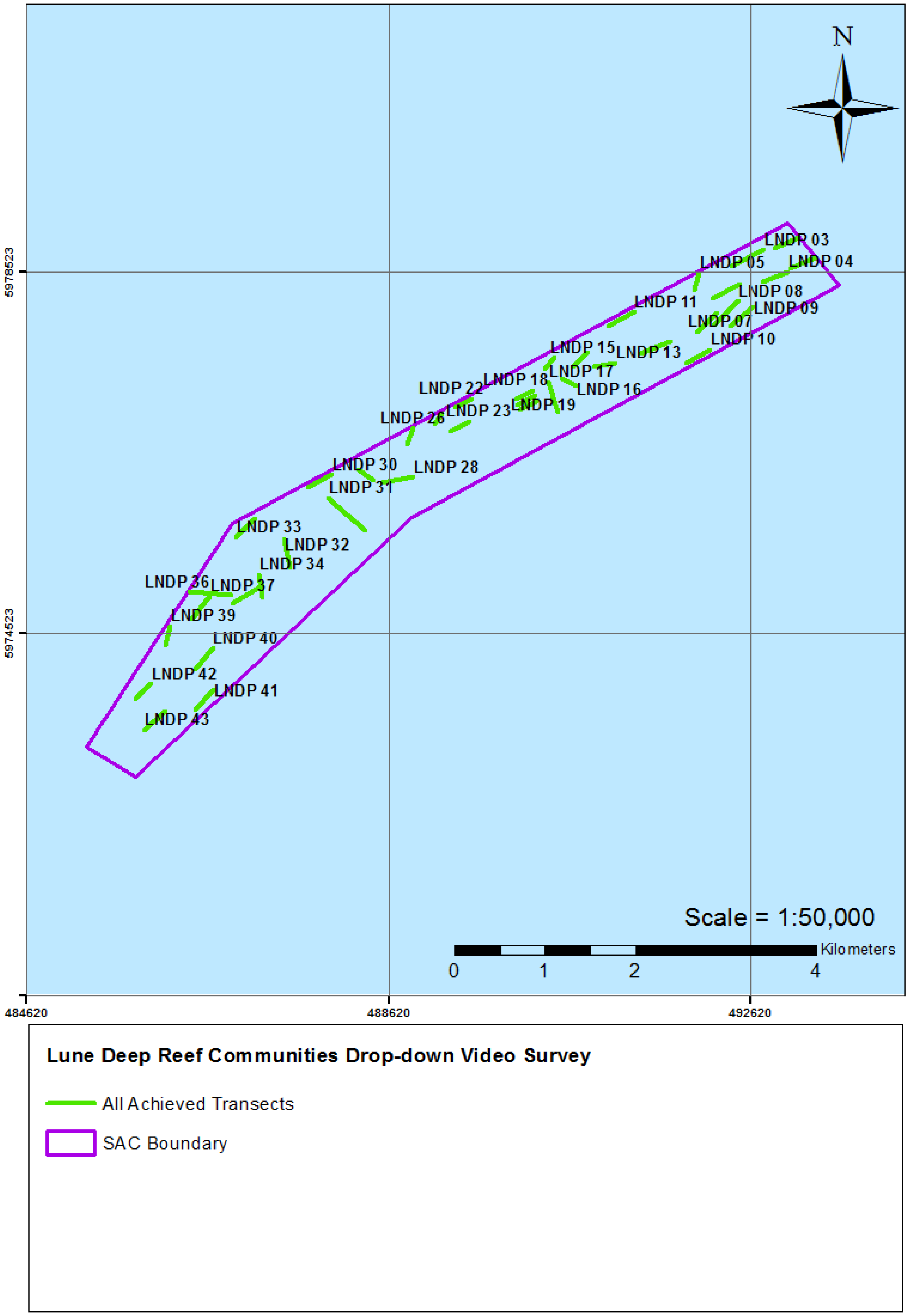

Figure 3.1: Locations of camera transects achieved in both phases of the 2015 drop-down video survey of the Lune Deep survey

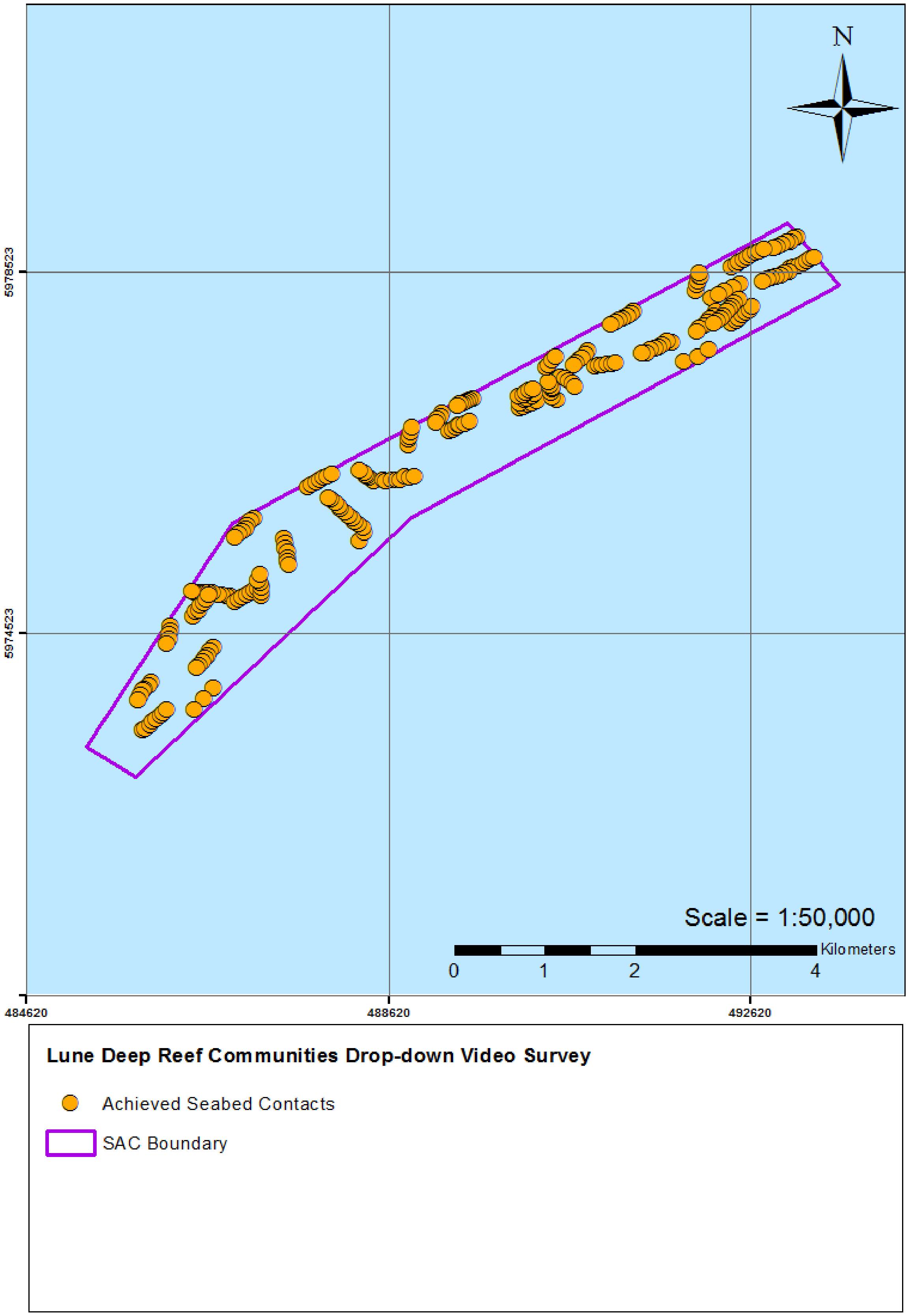

Figure 3.2: Locations of seabed landings in both phases of the 2015 drop-down video survey of the Lune Deep survey

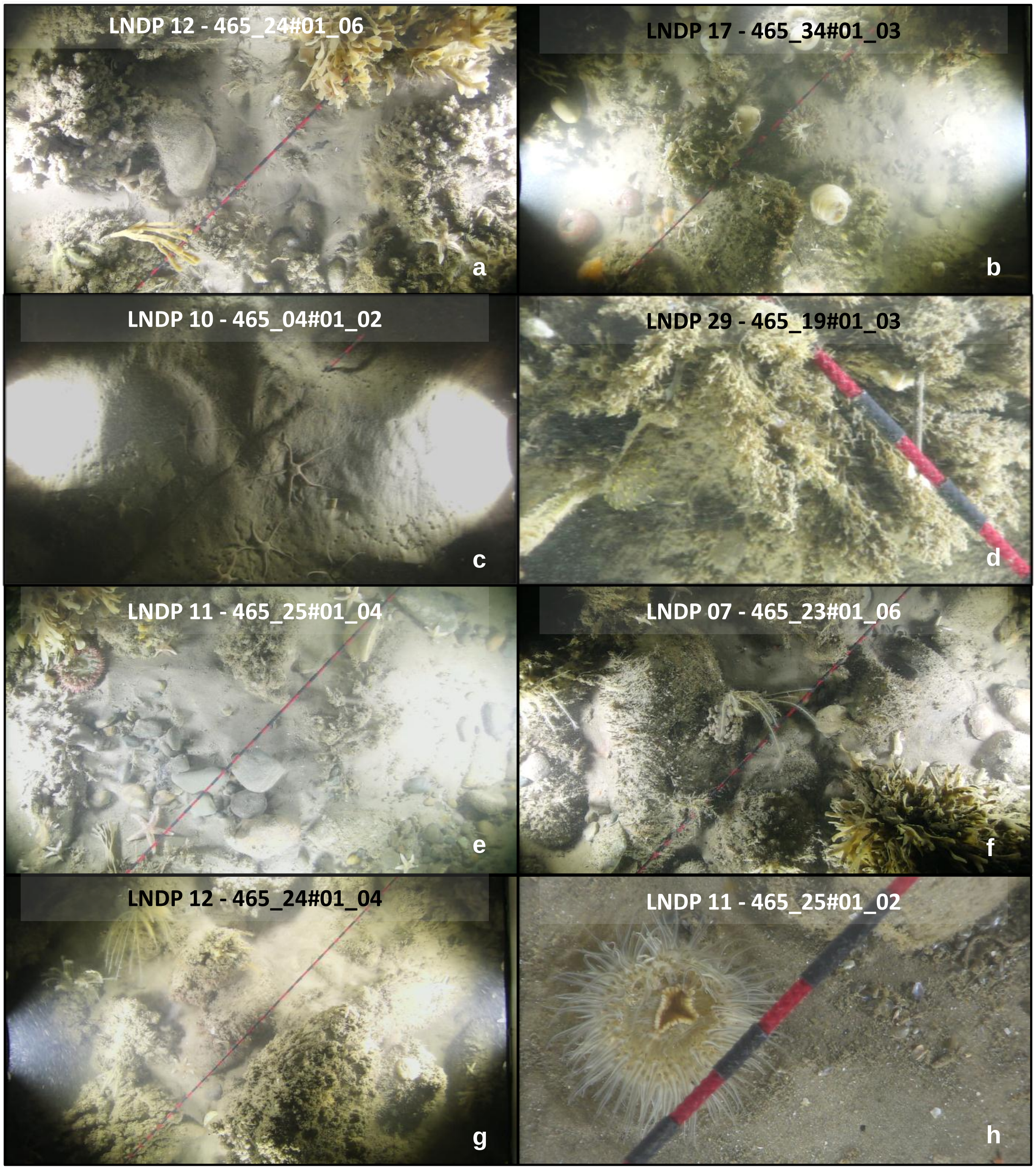

Figure 3.3: Example images of the variety of habitats and fauna observed during the Lune Deep drop-down video survey 2015; (a) *Flustra foliacea*, *Haliclona oculata*, *Molgula manhattensis* and faunal turf on silt-influenced cobbles; (b) *Metridium dianthus* and *Urticina felina* on cobbles with sparse faunal turf; (c) *Ophiura* spp. on burrowed muddy sand; (d) zoomed-in image showing the bryozoan *Eucratea loricata* and the nudibranch *Eubranchus tricolor*; (e) sparse faunal turf, *F. foliacea* and encrusting sponges on silt-influenced cobbles and pebbles; (f) *F. foliacea*, *Nemertesia antennina* and faunal turf on silt-influenced cobbles; (g) *M. manhattensis* and *N. antennina* on silt-influenced cobbles on muddy fine sand; (h) zoomed-in image showing the anemone *Sagartiogeton undatus* on mixed sediment.

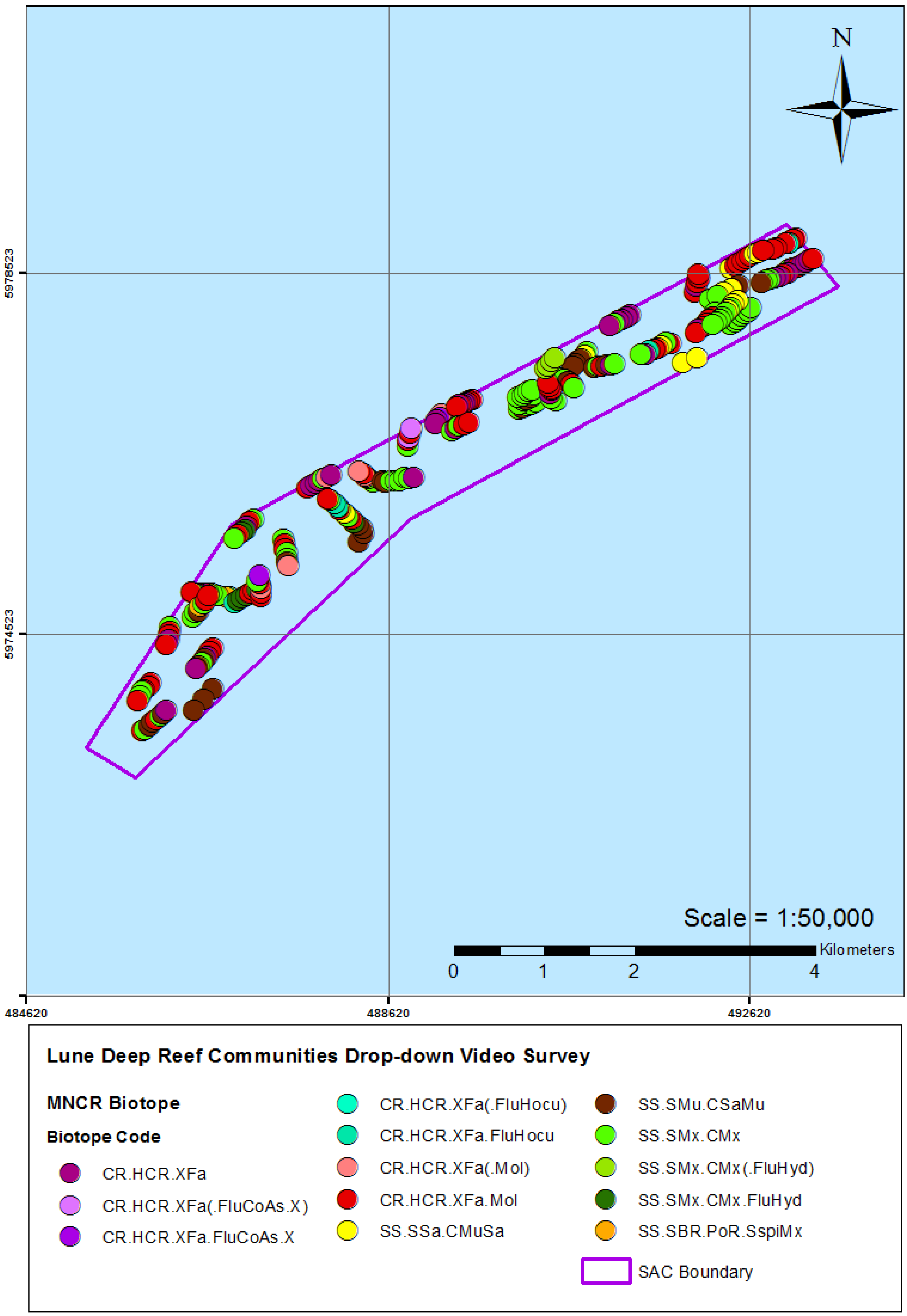

Figure 3.4: Distribution of observed MNCR biotopes (Connor *et al*., 2004) in the Lune Deep 2015. Each data point represents a single video clip.

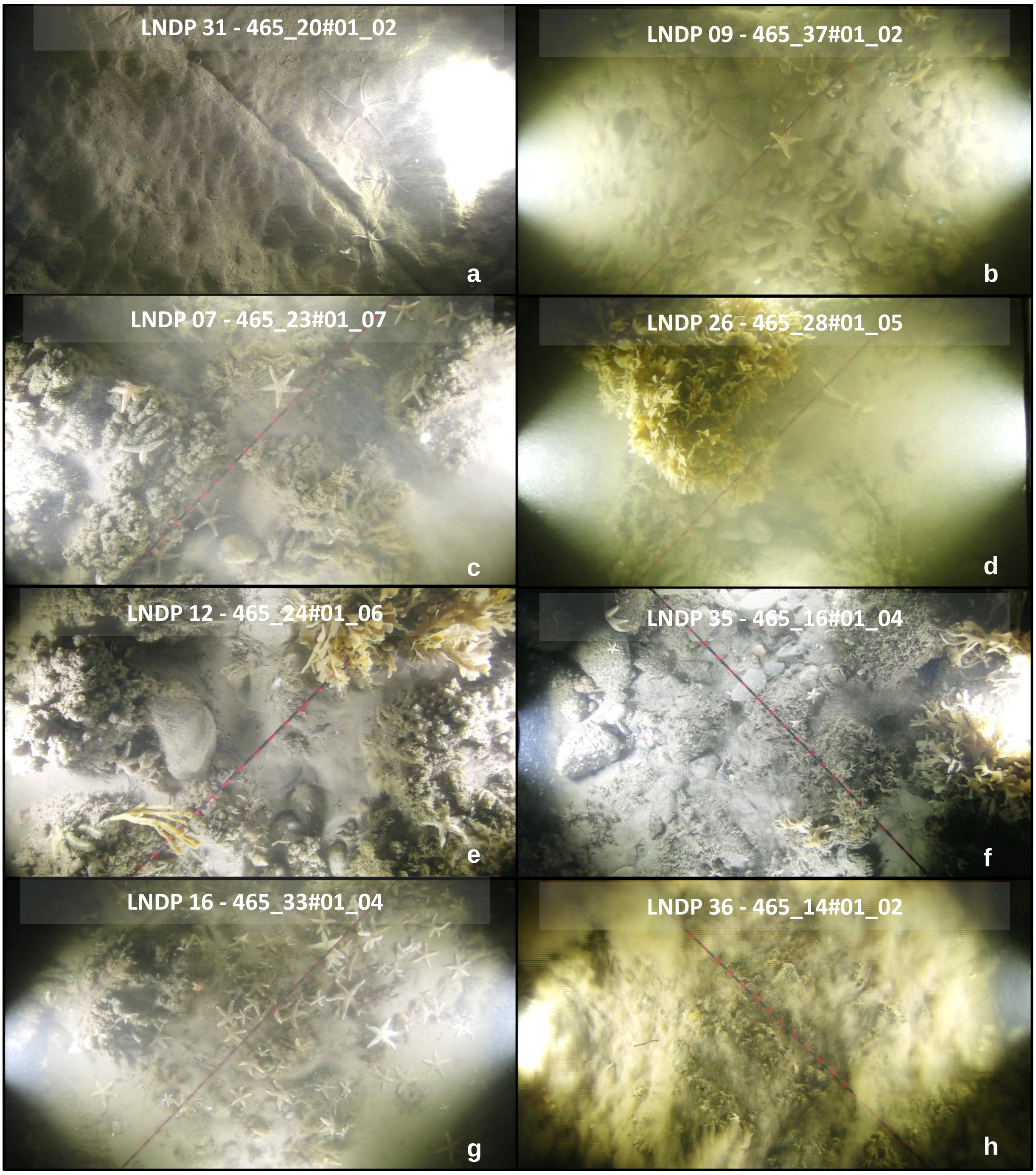

Figure 3.5: Example images of the variety of identified biotopes and features of interest observed during the Lune Deep drop-down video survey 2015; (a) *Ophiura* spp. on burrowed muddy sand (**SS.SSa.CMuSa**); (b) pebbles on mixed muddy sand and shell with *Asterias rubens* (**SS.SMx.CMx**); (c) Dense *Molgula manhattensis* and faunal turf on silt-influenced cobbles with *A. rubens* (**CR.HCR.XFa.Mol**); (d) *Flustra foliacea*, robust hydroids and ascidians on silt-influenced cobbles and pebbles (**CR.HCR.XFa.FluCoAs.X**); (e) *F. foliacea*, *Haliclona oculata*, *Molgula manhattensis* and faunal turf on silt-influenced cobbles (**CR.HCR.XFa.FluHocu**); (f) *F. foliacea*, *Hydrallmania falcata* and other hydroids on silt-influenced cobbles (**SS.SMx.CMx.FluHyd**); (g) dense juvenile *A. rubens* on silt-influenced cobbles and pebbles with *M. manhattensis*; (h) Mixed sediment with sparse fauna and patchy *Sabellaria spinulosa*.

3.2 Biotope mapping of the survey area

In order to create a biotope map of the Lune Deep survey area it was necessary to use both the bathymetry and backscatter datasets in conjunction with the ground-truthing survey data. The incorporation of the geophysical datasets and the ground-truthing data into ArcGIS v.10.2.1 allowed for a more detailed assessment of the habitats in the survey area. The interpretation of all the available data revealed a heterogeneous seabed environment which was difficult to accurately delineate, not least due to apparent gain changes (changes in the amplification of the return signal) with depth in the backscatter data.

Initially areas of similar backscatter reflectivity were identified. The BSH types of video clips were then displayed on top of the acoustic data in ArcGIS in order to allow interpretation of the sediment types associated with each kind of reflectivity in order to provide a low resolution overview of the superficial geology within the survey area. This information is displayed in Figure 3.6, which illustrates the somewhat heterogeneous nature of the substrates observed within the survey area.

Subtidal sands and muds (**A5.2** and **A5.3** respectively) were found to dominate within the deep channel of the survey area. These BSH types correspond with low seabed reflectivity. The shallow 'shelf' area of the survey area was more heterogeneous, with high energy circalittoral rock (**A4.1**) and subtidal mixed sediments (**A5.4**) found throughout the area. It should be noted however that in this case 'high energy circalittoral rock' corresponds to areas of cobble and boulder hard substrate, rather than bedrock; as such, there is no discernible correlation between BSH types and changes in reflectivity in this area.

The region of bedforms in the south of the survey area, identified from both the bathymetry and backscatter data, was also found to be heterogeneous, with a mixture of high energy circalittoral rock, subtidal mixed sediments and subtidal muds present. It is possible that the alternating pattern of low and high backscatter represents changes in sediment type associated with the peaks and troughs of these bedforms, however no pattern could be discerned using the ground-truthing data.

The slope between the northern 'shelf' and the deep channel was similarly variable, with subtidal mixed sediments predominating together with scattered patches of subtidal sands, subtidal muds and cobbles (assigned as high energy circalittoral rock). Several 'slump-like' features were identified using the bathymetry data, particularly in the north of the survey area, however video data indicate that these features are not markedly different to the surrounding slope.

Due to the patchy nature of the seabed, habitat polygons were created using both the BSH and the biotopes assigned to the individual video clips in conjunction with the acoustic data, with boundaries created around areas dominated by a single biotope complex (EUNIS level 4).

The exact positions of the boundaries between different biotope complexes were often difficult to determine, as the boundaries observed were frequently transitional in nature. The patchiness of some of the biotopes identified in the analysis also resulted in difficulties in determining the exact location of boundaries, with patchy biotopes occasionally being incorporated into the more dominant surrounding biotope complex. In addition, changes in observed biotope or biotope complex were not always mirrored by changes in reflectivity (for example, areas of mixed sediment and areas of cobbles and boulders appeared to be very similar), further hampering the assignment of boundaries. In these cases, “best estimates” of the biotope boundary positions were made based solely on the distribution of biotopes assigned to video data. Due to the heterogeneous nature of the seabed within the survey area, some polygons were assigned a ‘matrix’ of two biotope complexes; this was also the case for regions where changes in reflectivity did not reflect observed habitat types.

An example of the mapping process is illustrated in Figure 3.7, which shows an area of raised seabed with a distinct sediment boundary (inferred from the change in reflectivity, although backscatter changes may also be a reflection of changing depth). The biotopes assigned to the video clips crossing this boundary match well with the change in reflectivity, with the higher reflectivity area being composed of the biotope complex **CR.HCR.XFa** and the lower reflectivity area characterised by soft sediments.

The resultant biotope complex map is shown in Figure 3.8. Table 3.1 lists the total area covered by each identified biotope complex or habitat type.

Table 3.1: Total area in square kilometres of each biotope complex assigned during the creation of the broadscale biotope map of the survey area

Biotope Complex Polygons	Total Area (km^2)
CR.HCR.XFa	3.782
SS.SMx.CMx	1.539
SS.SSa.CMuSa / SS.SMu.CSaMu	3.076
Heterogeneous bedform features	0.594
Total area mapped	**8.999**

It was determined that the deep channel was a matrix of the soft sediment biotope complexes **SS.SSa.CMuSa** and **SS.SMu.CSaMu**. Two areas at the top of the slope associated with potential slump features were also determined to fall into this matrix.

The dominant biotope observed in the northern ‘shelf’ section was **CR.HCR.XFa.Mol**, however due to the presence of several other faunal turf biotopes (e.g. **CR.HCR.XFa.FluCoAs.X**; **CR.HCR.XFa.FluHocu**) the region was designated at the biotope complex level (**CR.HCR.XFa**).

While the slope between these two areas was found to be fairly heterogeneous, it was deemed appropriate to designate large areas of the slope as **SS.SMx.CMx** as this was the most common biotope complex observed. The area of bedforms associated with alternating high and low reflectivity in the southern part of the survey area were more problematic, due to the large number of changes identified in the acoustic data and to the fact that the ground-truthing data did not always align with the changes in reflectivity. As a result, while this area was delineated, no habitat was assigned to the polygons.

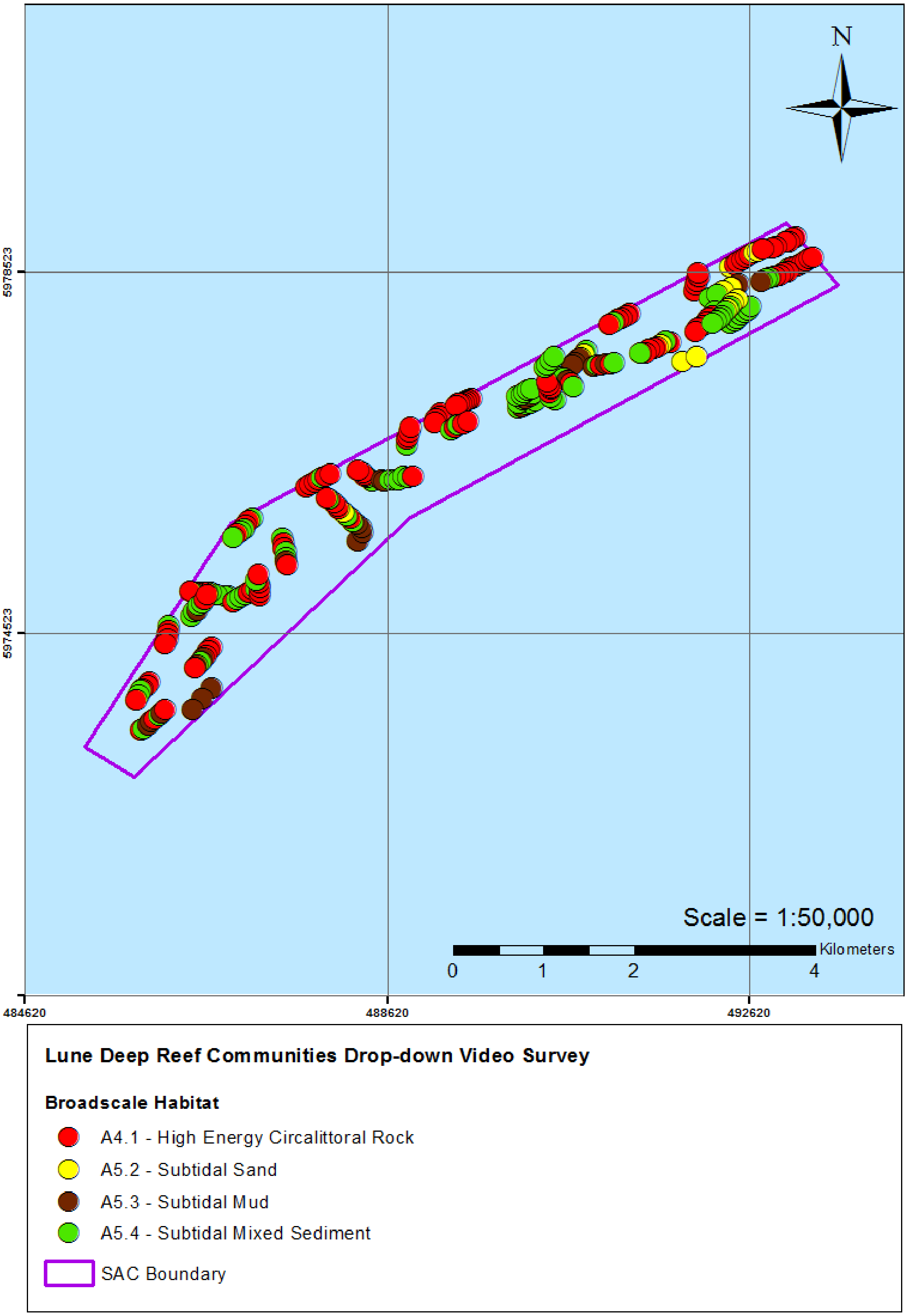

Figure 3.6: Distribution of observed Broadscale Habitat (BSH) types in the Lune Deep 2015. Each data point represents a single video clip. BSH types were selected based on the MNCR biotopes assigned; 'High Energy Circalittoral Rock' may therefore include cobbles as well as bedrock

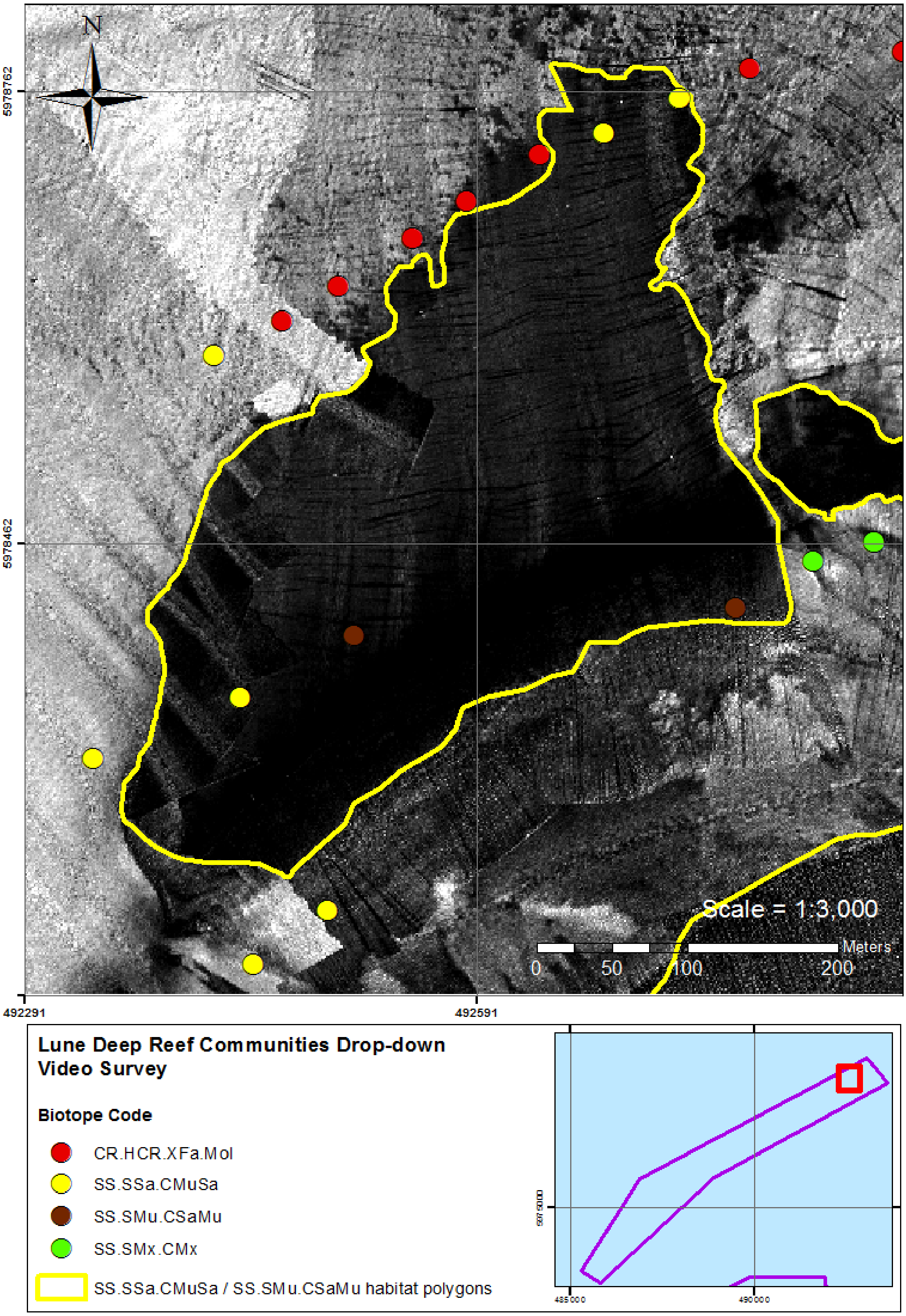

Figure 3.7: Example of biotope mapping of the Lune Deep area using backscatter data in conjunction with drop-down video data; area of lower reflectivity coincident with a change in observed substrata

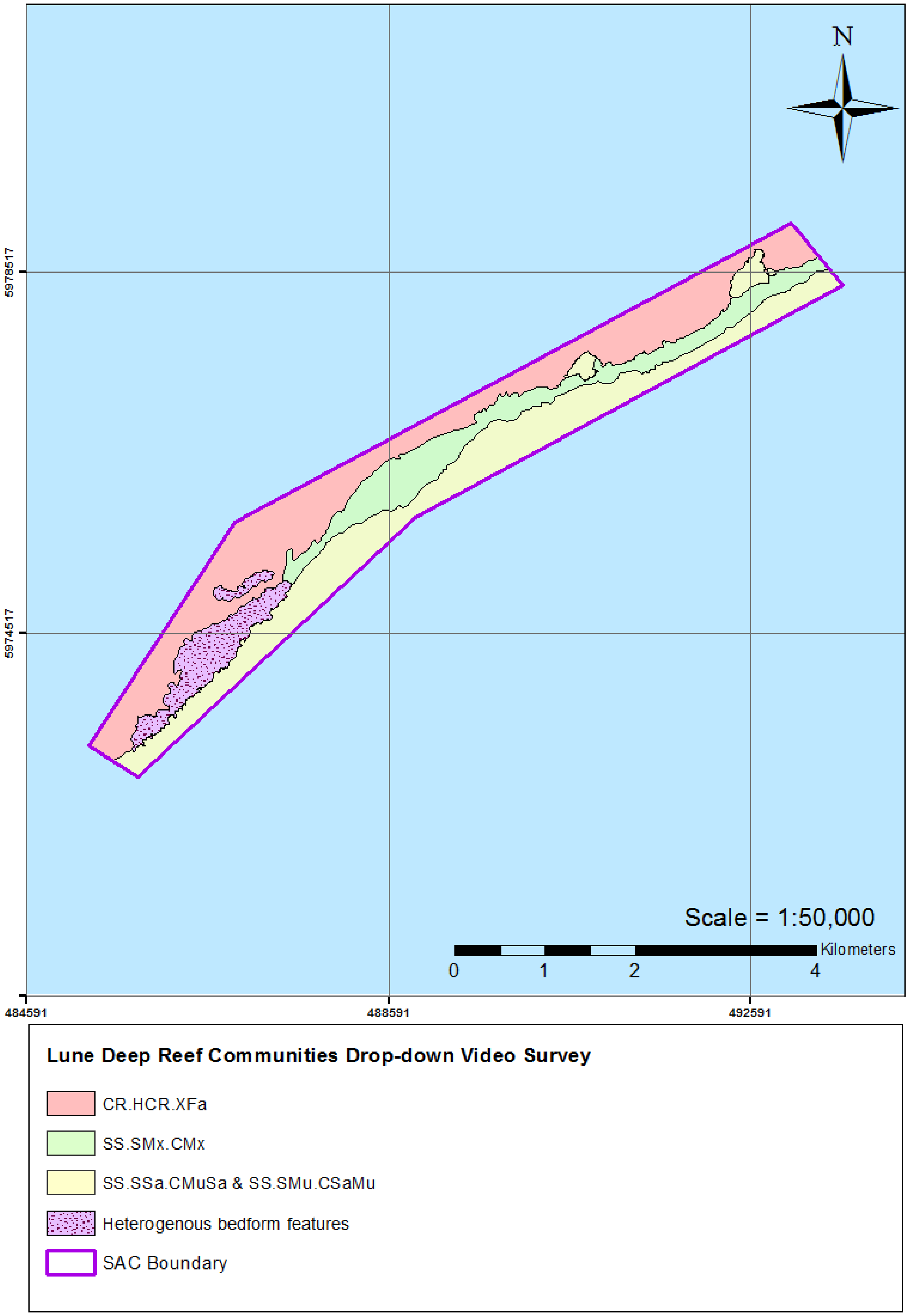

Figure 3.8: Biotope complex map of the Lune Deep survey area based on interpretation of acoustic data acquired by the Maritime and Coastguard Agency in 2008 and 2009 and ground-truthing data collected by Seastar Survey in 2015.

3.3 Distribution, extent and composition of Annex I reef habitat

Potential reef features were observed throughout the survey area. All potential reef features observed consisted of stony reef; areas of cobbles and boulders on otherwise soft sediment.

3.3.1 Delineation of potential Annex I reef sub-features

In order to fully define and map the extent of potential Annex I reef sub-features within the survey area it was necessary to establish the density of cobble and boulder substrata at each of the seabed contacts. The percentage of the seabed covered by cobbles at each seabed contact is shown in Figure 3.9.

Areas of potential Annex I reef sub-features were delineated to four levels of confidence, assigned using MESH confidence scoresheets, which are provided in Appendix V. Point source records (i.e. discrete seabed contacts) with over 10 % cobble or boulder coverage are regarded as confidence level one (assigned >90 % confidence). The minimum 10 % coverage was based on the guidelines for assessment of stony reefs by Irving (2009). The distribution of these confidence level one locations are shown in Figure 3.10.

Level two polygons (~80 % confidence) were created by extending a 50 m radius from any level one point source at which the seabed was shown to be composed of greater than 10 % cobbles, or from seabed contacts at which cobble coverage was recorded as <10 % but which were located within 50 m of a contact with >50 % cobbles (Figure 3.11).

The next stage of potential Annex I reef sub-feature mapping involved examination of the level two polygons over the acoustic and biotope complex map data, in a similar manner to the mapping of biotope polygons. Areas of potential reef were delineated based on substrate composition, including percentage cobble composition, assigned biotope and reflectivity and/or bathymetric features and were created by extending areas of level two polygons along bathymetric features and areas of similar reflectivity. The area designated as the biotope complex **CR.HCR.XFa** in the habitat mapping process was also interpreted as being composed of potential reef features, as were other areas of high backscatter return, particularly when associated with bathymetric ridges. The resulting potential stony reef habitat level 3 polygons (~70 % confidence) are shown in Figure 3.12.

Analysis of the acquired video data indicate that areas of heterogeneous bedform features identified during the biotope mapping, which were associated with highly variable depths and alternating high and low backscatter return, are at least partially composed of potential stony reef features interspersed with mixed and muddy sediments with very sparse epifauna. However, as the changes in reflectivity did not align with the changes observed in the video analysis these areas were treated separately, and assigned a low confidence score of approximately 50 %. These confidence level four polygons are shown in Figure 3.13.

3.3.2 Distribution and extent of Annex I reef sub-features

A total of 159 seabed contacts were identified as potential Annex I reef habitat. The areas covered by the Annex I reef polygons shown in Figures 3.11 – 3.13 are given in Table 3.2.

Identified areas of potential Annex I reef habitat were generally associated with the relatively flat and shallow areas on the 'shelf' section of the survey area, though potential stony reef features were also identified on the slope and in the area of bedforms in the south of the survey area.

Table 3.2: Total area covered by delineated areas of potential stony reef habitat

Annex I Reef Habitat Confidence Level	Total No. / Area (km^2)
Level 1 (no. of seabed contacts)	159
Level 2	0.893
Level 3	3.983
Level 4	0.771

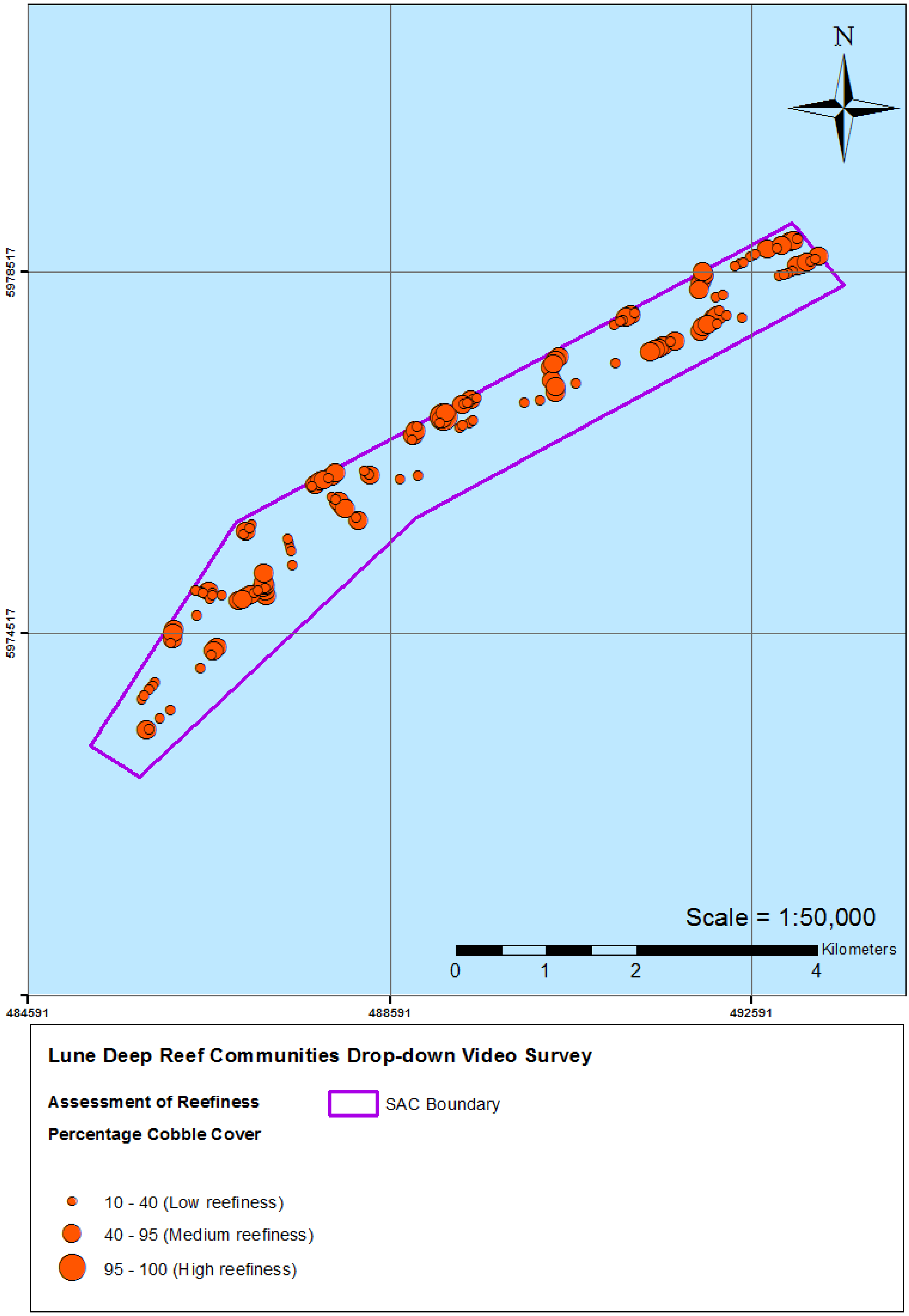

Figure 3.9: Percentage cover of cobbles and boulders observed in each video clip captured in the Lune Deep survey area 2015

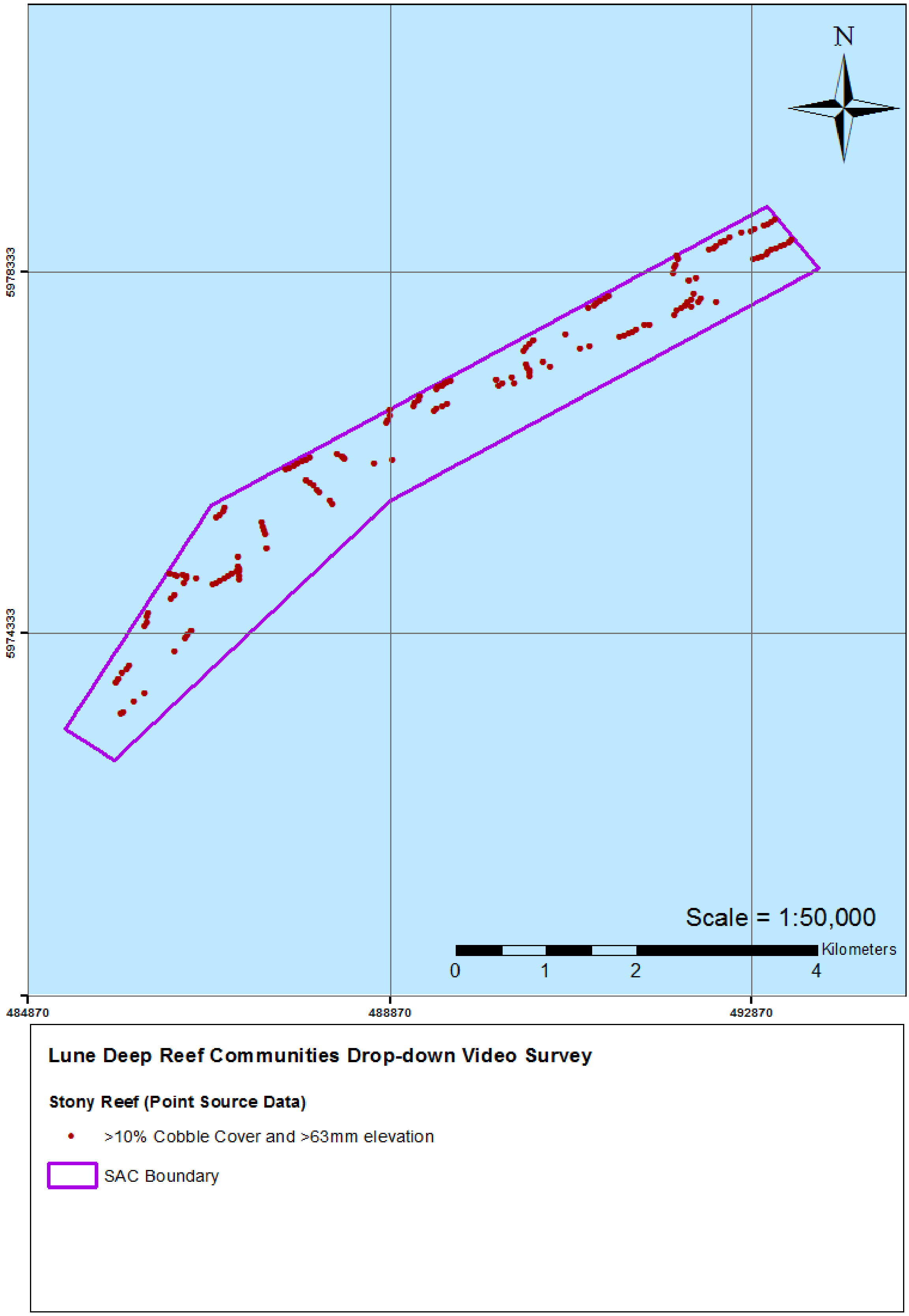

Figure 3.10: The distribution of confidence level one (point source) Annex I cobble and boulder stony reef habitats identified in the Lune Deep drop-down video survey 2015

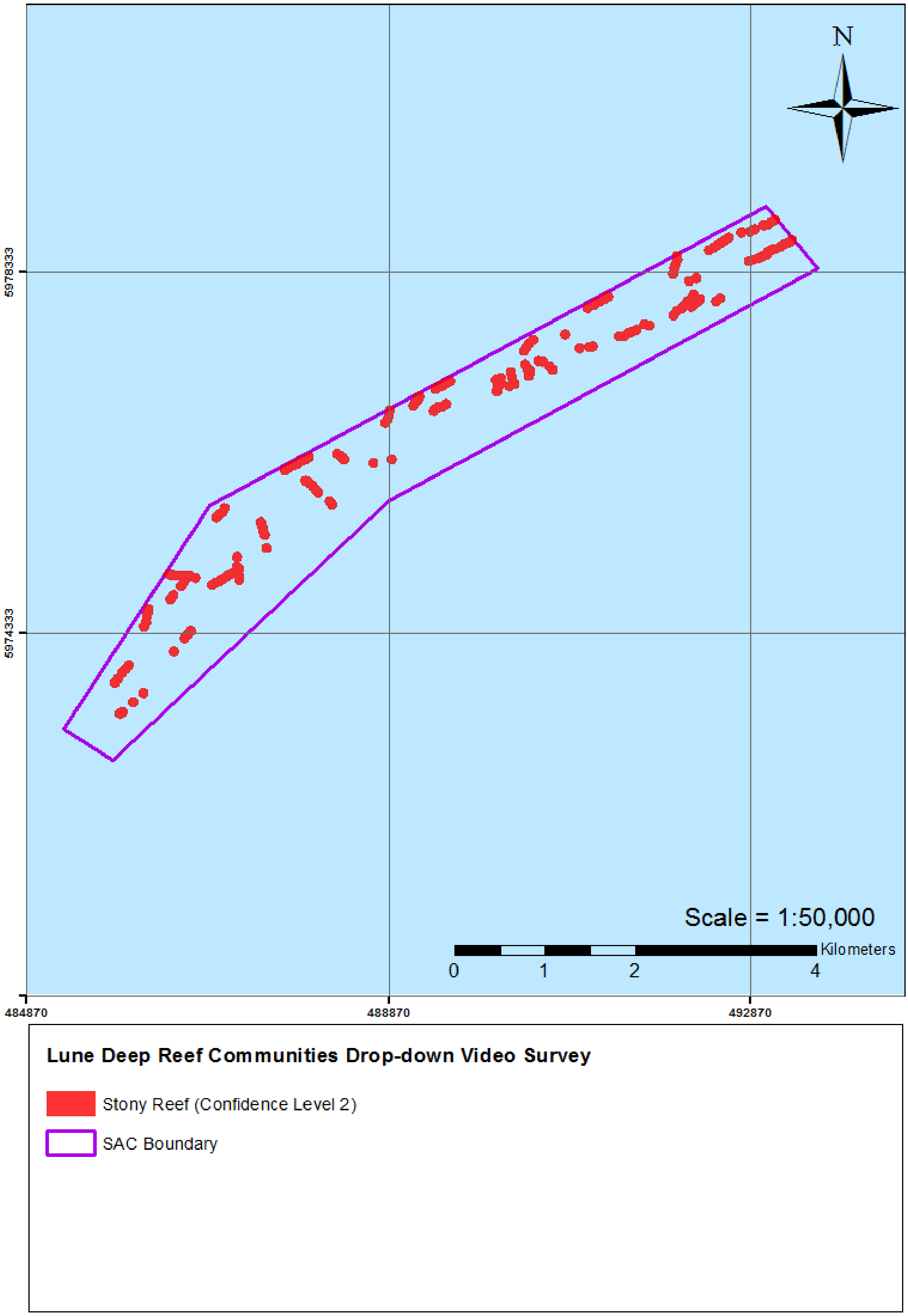

Figure 3.11: The distribution of confidence level two (50 m radius ellipsoids) Annex I cobble and boulder stony reef habitats identified in the Lune Deep drop-down video survey 2015

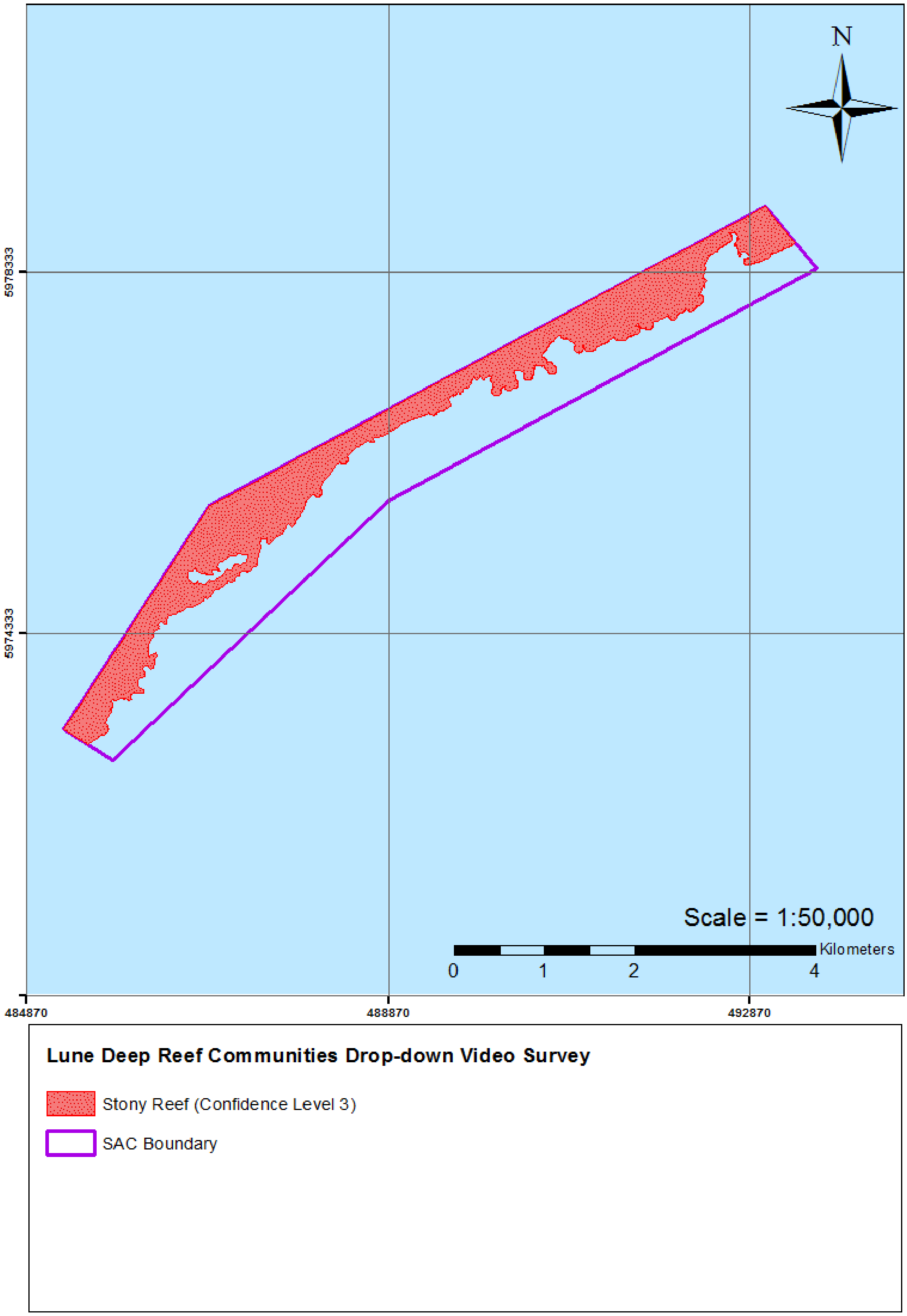

Figure 3.12: The distribution of confidence level three (extension along seabed feature or areas of common reflectivity) Annex I cobble and boulder stony reef habitats identified in the Lune Deep drop-down video survey 2015

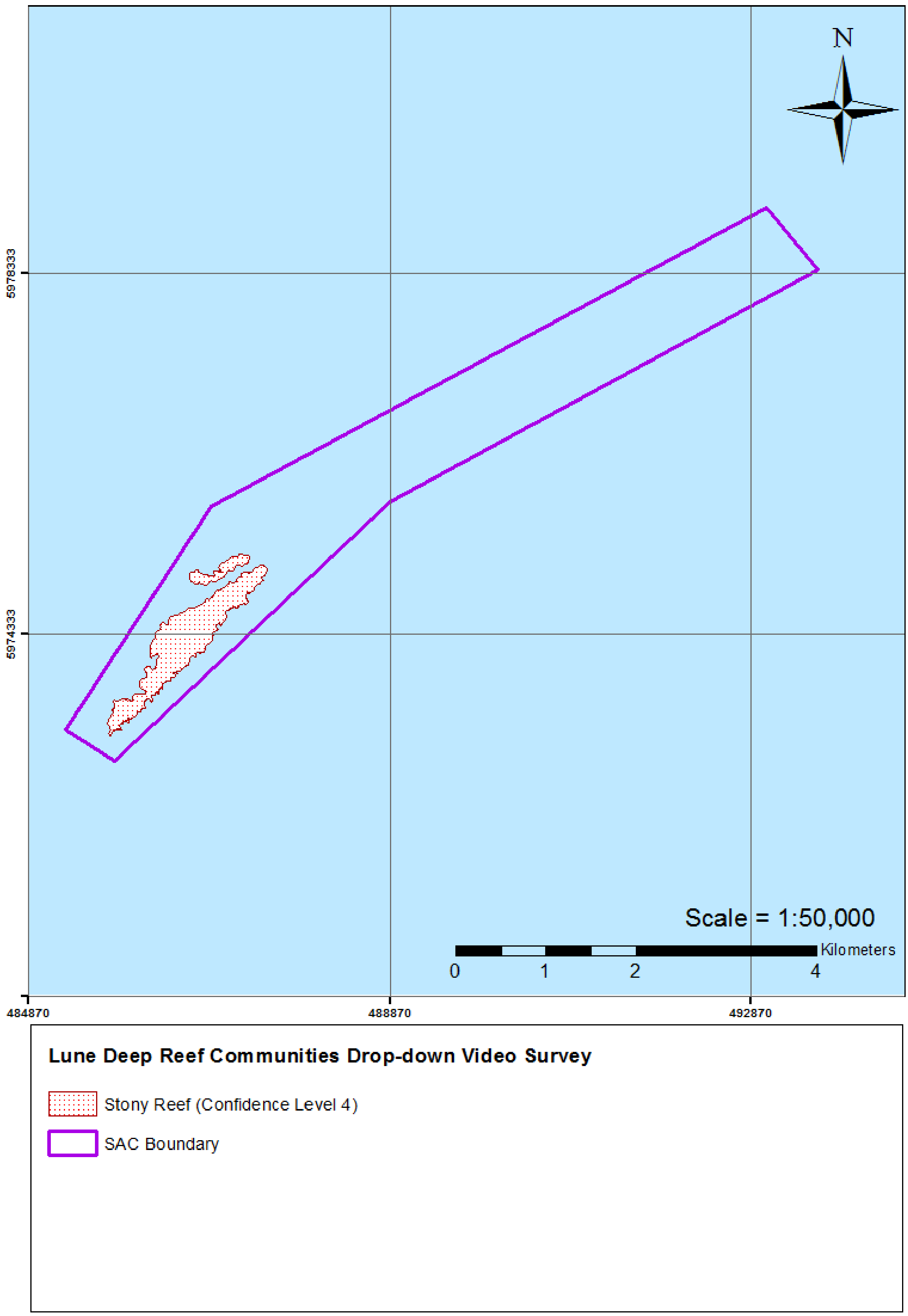

Figure 3.13: The distribution of confidence level four (low confidence / patchy reef features associated with the heterogeneous bedform features identified in the habitat mapping process) Annex I cobble and boulder stony reef habitats identified in the Lune Deep drop-down video survey 2015

4 DISCUSSION

4.1 Survey methodology

The use of an integrated approach – for example using acoustic and ground-truthing data in combination – to study an area of seabed has been shown to be successful in many studies (e.g. Bett and Masson, 1998; Axelsson, 2003; Masson *et al.*, 2003; Brown *et al.*, 2004; Axelsson *et al.*, 2006; O'Dell *et al.*, 2013). The use of underwater video data in surveys has been shown to be cost-effective with large areas being covered in a relatively short time (Brown *et al.*, 2004; Stevens and Connolly, 2005). A number of studies have concluded that video data are appropriate for the assessment of the presence and extent of biotopes (Service and Golding, 2001) as well as ground-truthing of acoustic images (Brown *et al.*, 2002; Brown *et al.*, 2004). There is, however, some loss in taxonomic resolution when using photography rather than biological sampling techniques (e.g. Stevens and Connolly, 2005) and some video records are not of sufficient quality to allow biotope classifications to be carried out. Still photography and sediment sampling should be carried out simultaneously to supply meaningful data (Hiscock and Seeley, 2006) but in the current survey this was not possible due to the poor underwater visibility and to the focus of the survey being hard substrata, namely rocky reef features. In addition, diver-based surveys would not be appropriate in this survey area as the depths and local conditions (very low underwater visibility, strong currents) are prohibitive.

The utilisation of a FLCS in the current survey was found to be a successful and cost-effective method of surveying potential reef features, and has proved to be an appropriate method of sampling in challenging tidal conditions and low underwater visibility. The system configuration and survey methodology resulted in the data acquired being of a high enough quality to identify fauna to a good taxonomic level and allow the assignment of biotopes to at least EUNIS level 4 or 5. However, additional sampling effort may be required in the survey area in order to increase coverage, to improve understanding of the habitats and species and to improve the confidence in the maps illustrating the extent of the observed features. Ideally camera deployments and infaunal sampling (a Hamon grab would be suitable for sampling areas of cobbles and pebbles on otherwise soft sediment, though not for areas dominated by cobbles and/or boulders) should be carried out in the survey area in conjunction with broadscale acoustic techniques in order to allow very conspicuous changes in habitat distribution to become apparent and to confirm species identifications. Due to the limitations of the backscatter data provided (e.g. the lack of resolution when compared with sidescan sonar data (Collier and McGonigle, 2011), the lack of associated metadata, such as information regarding variations in gain and the age of the data, and the data being collected at least six years prior to the ground-truthing survey), it is particularly recommended that sidescan sonar data be acquired in the survey area in order to enable changes in sediment composition, including areas of bedrock, boulder and stony reef, to be identified with more certainty, a significant limitation in the current analysis.

4.2 Survey Limitations

Due to the very strong tidal conditions and limited underwater visibility expected in the survey area, the survey methodology and equipment employed were selected specifically to allow for collection of high quality data, a goal which was successfully achieved. The poor underwater visibility encountered did slightly hamper species identification and biotope assignment, however the use of the FLCS in combination with a market leading HD video camera meant that these problems were minimised and enabled the production of biotope maps to EUNIS level 4 and the delineation of potential reef features.

4.2.1 Visibility and coverage

The major limitation was the lack of continuous seabed footage over the proposed transects. Due to the poor underwater visibility in the Lune Deep survey area the camera had to be within a maximum of 15 - 20 cm from the seabed in order for the seabed to be visible. As a result the Seastar FLCS has been optimised to capture footage whilst landed rather than to provide footage along an entire transect. The methodology employed therefore focused on the landing of the camera frame on the seabed at a series of discrete locations along each transect to enable the collection of a series of approximately one minute high quality video clips to allow analysts to identify fauna to a good taxonomic level and subsequent assignment of biotopes to at least EUNIS level 4 or 5. While this was the most appropriate and cost-effective method given the conditions, this was a time-consuming process and as such meant that, given the number of days allocated, less of the seabed in the survey area could be sampled. In addition, this methodology has made estimates of extent of seabed features more problematic.

Coverage of the survey area was tailored to locate areas of possible bedrock, boulder and stony reef habitat. If a type of acoustic return had been ground-truthed and found to be of a muddy, sandy or mixed substrate the area was not investigated further. In addition, as the requirements of the project specified that high quality images were to be collected, HD video was used, which in turn meant that the umbilical length was restricted to less than 100 m, coupled with the strong and non-uniform tidal currents in the deep channel it was not possible to survey the very deep ‘hole’ evident on the bathymetry data (approx. 86 m depth). However, as all other seabed landings in the channel revealed soft substrate (primarily sandy mud) with populations of *Ophiura* spp. it is a reasonable assumption that this deep region displays similar characteristics.

4.2.2 Weather conditions

The survey area is very susceptible to north-westerly, westerly and south-westerly winds and swells. The survey area was deemed unworkable in such winds of Force 4 or greater, or a swell of greater than 0.5 m significant. The Met Office Inshore Waters Forecast was used to monitor weather forecasts and the decision to work was based on these forecasts.

On the two survey days conducted during Phase I of the survey sea conditions in the early part of the day were marginal resulting in reduced video quality. During Phase II two survey days (22nd and 23rd September) were cut short by the poor sea conditions experienced on site.

4.2.3 Limitations in analysis

The acoustic data provided were acquired in 2008 and 2009, several years prior to the DDV ground-truthing undertaken during the current survey. As Morecambe Bay and the surrounding area are known to have high levels of sediment transport (Doody, 1996) it is likely that there have been significant alterations in the distribution of soft sediments in the survey area since the acoustic data were collected. While the position and depths of the channel are unlikely to have changed, during analysis of the bathymetry data several ‘slump’ like features were identified on the slope of the channel. It is possible that these have undergone substantial changes in the years between the acoustic and video surveys. It should therefore be noted that confidence levels for the acoustic data are relatively low compared to those assigned to the video data. If a conflict in sediment type (i.e. predicted rocky outcrop shown by more than one video clip to be sand or mud) occurred then the habitat was mapped according to the video clip biotope.

Backscatter data are acquired simultaneously from modern MBES systems, providing an indication of seabed roughness dependent on a number of factors including frequency and source level of the acoustic instrument as well as substrate composition (Collier and McGonigle, 2011). Backscatter data derived from multibeam bathymetry systems are useful in determining seabed composition, however they have a lack of resolution when compared with sidescan sonar data (Collier and McGonigle, 2011). The various parameters associated with the collection and processing of the backscatter dataset, such as gain variations, were not provided; the confidence in the constancy of the reflectivity types shown was therefore reduced.

4.2.4 Discrepancies between the geophysical data and survey results

The interpretation of the multibeam and backscatter data and the subsequent ground-truthing resulted in some discrepancies in the boundaries between different habitats and/or biotopes. This discrepancy has a number of possible explanations including: (i) positioning of camera frame relative to navigation data; (ii) positioning of the boundaries of biotope and habitat classifications; and (iii) changes in the seabed of the survey area in the time between acoustic data collection and acquisition of the ground-truthing data (see above).

(i) Positioning of camera frame relative to navigation data
During survey operations, no lay-back error was calculated for the camera frame position in relation to the vessel as the deployment methodology required that the camera frame be deployed vertically from the A-frame. It was on occasion difficult to determine the exact moment of contact with the seabed due to e.g. strong tidal currents or poor underwater visibility. Slight inaccuracies (up to ~10 m) in the position of the video clips were therefore likely.

(ii) Biotope and habitat classifications
The exact positions of the boundaries between different biotopes were often difficult to determine as some boundaries are transitional in nature. The patchiness and change in observed sediment types, combined with the discrete nature of the data acquired, resulted in some difficulties in determining the exact boundary between biotopes. Some of the boundaries identified using the video data therefore did not correspond exactly with those identified using the acoustic data. Overall, however, the results were good.

4.3 Confidence assessment

In this study, attempts have been made to minimise interpolation of the data as much as possible. However, as with many similar studies, ground-truth coverage is not as extensive as perhaps desired. In order to illustrate the quality and interpretation of the data, confidence ratings were assigned to the figures.

4.3.1 Confidence in biotope assignment

Underwater video photography has been demonstrated to be appropriate for the assessment of the presence and extent of marine biotopes, however the classification of biotopes is also somewhat subjective and not all seabed environments 'fit' the biotope classification scheme resulting in some biotopes being classified to 'best fit' the communities present. While individual video clips were assigned to either biotope complex (EUNIS level 4), biotope (level 5) or sub-biotope (level 6), all at a confidence level of >90 %, the habitat maps produced were left at the biotope complex level. Areas of soft sediments could only be mapped at the biotope complex level (**SS.SMx.CMx** and **SS.SSa.CMuSa** / **SS.SMu.CSaMu**) primarily due to lack of infaunal data. Without infaunal sampling these areas cannot be assigned at a higher level. While the dominant biotope recorded in the northern 'shelf' section was **CR.HCR.XFa.Mol**, the polygon was left at the biotope complex level (**CR.HCR.XFa**). This was due to the patchy nature of the biotopes observed in the area, with several other faunal turf biotopes (e.g. **CR.HCR.XFa.FluCoAs.X**; **CR.HCR.XFa.FluHocu**) recorded. It was therefore deemed more appropriate to assign the polygons at the biotope complex level.

4.3.2 Confidence in mapping stony reef habitat

The confidence assessment for the different levels of potential stony reef habitat has been generated using the MESH confidence assessment score sheet, taking into account attributes of the acoustic data, the ground-truthing data and the mapping techniques.

The level of certainty of the interpretation of the seabed environment and habitat polygons at point source (i.e. a single video clip) is estimated at 90 – 100 % accurate (level 1). Confidence level 2 (areas immediately surrounding point source data) have been assigned with 83 % confidence, and were generated by extending a 50 m radius from any point source data at which the seabed has been shown to be composed of greater than 10 % cobbles (or < 10 % if within 50 m of a data point with more than 50 % cobbles).

Confidence level three polygons were assigned a confidence level of 78 %, and have been delineated by extending areas of level two polygons along bathymetric features and areas of similar reflectivity. The areas of bedform features in the south of the survey area however were designated at confidence level 4 (approximately 50 %) due to the heterogeneous nature of both the acoustic and ground-truthing data.

4.4 Comparisons with previous studies

The usefulness of comparisons with previous studies is limited by various factors. For example, the methods employed and the distributions of sampling points are not the same between surveys. Furthermore, the quality of the data obtained (e.g. quality of video recording) varies between studies, as does the compatibility of the biotopes listed in Connor *et al.* (2004). As such any findings or trends from comparisons with previous surveys must be treated with caution. Such comparisons may however be useful in attempting to assess feature condition.

There is very little published information regarding the epifaunal communities in the Lune Deep. The baseline study for the general Morecambe Bay area, including the Shell Flat and Lune Deep SCI (Envision, 2008 in a report to Royal Haskoning) utilised a RoxAnn single beam Acoustic Ground Discrimination System (AGDS) in conjunction with towed video footage. Just eight sampling locations fell within the Lune Deep feature boundary, with seven of those situated on the upper 'shelf' feature and the eighth located in the deep channel. The biology in the northern section of the Lune Deep area was described as faunal turf with erect hydroids and bryozoans. Six of the video drops were assigned the biotope complex **CR.HCR.XFa**, with one designated **CR.HCR.XFa.FluHocu** due to the presence of erect sponges. While the study describes the sediment in this area as 'rock and boulders with occasional sand patches' it is also stated that the only potential Annex I reef features observed consisted of stable cobble and boulder stony reef. The sample in the channel, as well as samples to the south of the Lune Deep feature, indicated muddy sands with *Ophiura* spp..

The video footage collected by CMACS in 2011 and analysed by Seastar in 2015 indicated a similar trend, with faunal turf biotopes (particularly **CR.HCR.XFa.FluCoAs.X**) present on the upper slope and 'shelf' areas, interspersed with mixed sediments and finer sediments in the deep channel.

The findings of the current study were broadly very similar to those of the baseline survey and the analysis by Seastar of data collected by CMACS in 2011; the northern 'shelf' section was found to be characterised by cobbles and boulders on soft sediment with patchy faunal turf dominated by robust species such as the bryozoans *Flustra foliacea* and *Eucratea loricata*, the hydroids *Nemertesia spp.* and *Hydrallmania falcata* and the erect sponge *Haliclona oculata*, while the channel was found to be composed of sands and muds with *Ophiura* spp.. These similarities are particularly noticeable where repeat transects were undertaken. Figure 4.1 shows a series of drop-down video locations from both the 2011 survey and from line LNDP 17 in the 2015 survey. The biotopes assigned to video clips at the bottom and middle of the slope were the same in both datasets. At the top of the slope however there appears to be a deviation, with the biotope complex **SS.SCS.CCS** (circalittoral coarse sediment) in the 2011 data while the biotope **CR.HCR.XFa.Mol** was recorded in 2015. The substrate is the same in both datasets (gravel, pebbles and cobbles on mixed sediments), however the biota present appears to have changed notably. Faunal turf with robust hydroids were recorded in both datasets, however in the 2015 *Molgula manhattensis* was present in high abundance.

This was a pattern observed throughout the survey area. While faunal turf biotopes identified in previous years, such as **CR.HCR.XFa.FluHocu** and **CR.HCR.XFa.FluCoAs.X** were also identified in 2015, the *M. manhattensis* dominated **CR.HCR.XFa.Mol** was by far the most commonly recorded hard-substrate biotope in the current study, identified at 71 of the 258 seabed contacts. The prevalence of the non-native, cryptogenic ascidian *M. manhattensis*, which is known to be tolerant of varying salinities, high turbidity and high levels of organics (Zvyagintsev *et al*., 2003; Haydar *et al.*, 2011), on areas of hard substrate has also been observed in Morecambe Bay in recent years (Hawes *et al*., 2015), particularly in areas of silt-influenced cobble and boulder stony reef. Without further study, however, it cannot be determined whether this change is part of a periodic cycle or is indicative of a more prevalent trend.

One possible example of periodicity in the communities of the Lune Deep area was identified, however. Dense juvenile bivalves (likely *Mytilus* sp.) were observed at five seabed contacts on lines LNDP 02 and LNDP 03, while the common starfish *Asterias rubens* was recorded at very high densities throughout the survey area. The majority of the individuals recorded were less than 5 cm across, possibly indicating a recent potential population explosion or spawning event. Irving *et al.* (1996) report that throughout the greater Morecambe Bay area periodic explosions of the population of *A. rubens* are recorded, generally connected with heavy deposition of mussel spat in the spring.

The aim of the current survey was to inform condition monitoring of the subtidal bedrock and boulder reef communities within the Lune Deep. While previous studies of acoustic data identify the presence of bedrock in the northern part of the Lune Deep area, this is often qualified as 'rock/hard substrate' (Envision, 2014) or 'rock/cobble' (Envision, 2008). This is possibly due to the reliance on acoustic techniques with very little in the way of ground-truthing. Certainly, despite the high backscatter present in the northern sections of the survey area, no bedrock was identified in the 2015 survey. Instead, the predominant substrate consisted of cobbles and, to a lesser extent, boulders on mixed or sandy sediments.

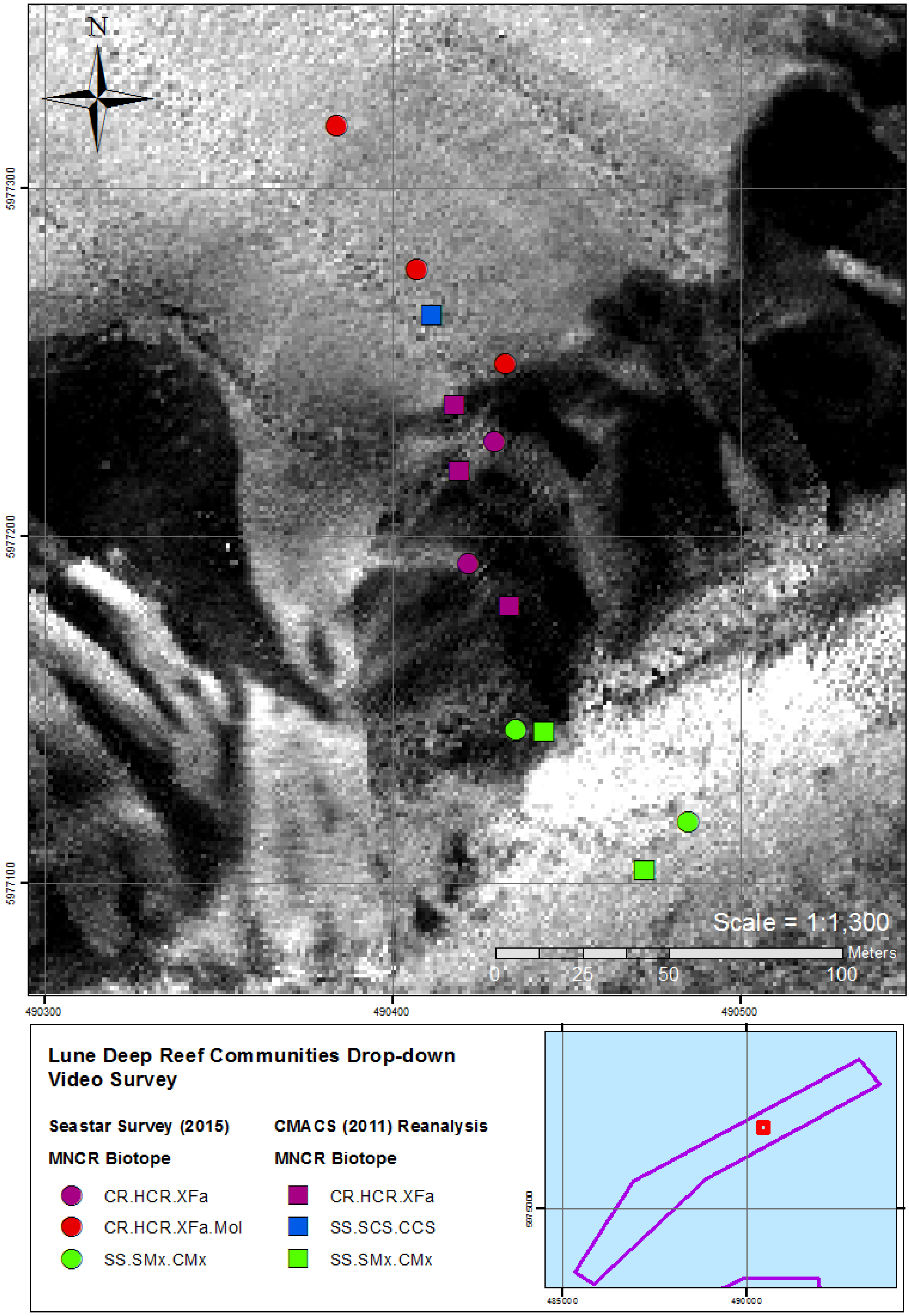

Figure 4.1: MNCR biotopes (Conner *et al*., 2004) assigned to two drop-down video datasets collected by CMACS in 2011 and Seastar Survey Ltd in 2015 overlying backscatter data collected by Maritime and Coastguard Agency in 2008-09. Each data point represents a single video clip. All data analysed by Seastar Survey Ltd.

4.5 Condition monitoring – subtidal reef sub-features

The 2015 survey of the Lune Deep feature of the Shell Flat and Lune Deep SCI collected data for the re-establishment of a baseline of the extent of Annex I reef habitat, including bedrock, boulder and stony reef sub-features, in order to aid condition monitoring. In addition, the data enabled an assessment of change against previously collected datasets and thereby an initial assessment of feature condition. The results of the current survey, including a preliminary condition assessment, are given in Table 4.1, together with recommendations for future monitoring.

4.6 Recommendations for future monitoring

While the current survey collected considerable amounts of baseline data, additional baseline data may be required in order to enable future monitoring of all the habitats and species present in the survey area. It is recommended that additional ground-truthing survey work using a freshwater lens camera system is completed in order to acquire more data and achieve increased coverage of the seabed environment, therefore allowing a higher confidence in the detail of the habitat maps. Areas to be targeted further include the identified habitat boundaries, the extents of areas of potential reef features and the area of heterogeneous sediments in the south of the survey area. Any further survey work should be conducted during and following periods of calm weather conditions and on neap tides so that poor underwater visibility does not hamper survey effort, as was done in the current study. Any further camera work should be conducted during and following periods of calm weather and on neap tides so that poor underwater visibility does not hamper survey effort, as was done in the current survey.

Camera deployments and sediment sampling using a Hamon grab (which may be used in areas of cobbles on otherwise soft sediment) should be carried out in conjunction with broadscale acoustic techniques to allow very conspicuous changes in habitat distribution to become apparent and to confirm the identity of taxa. It is particularly recommended that sidescan sonar survey work be conducted. This would enable changes in sediment composition, including areas of rocky and stony reef features, to be more readily identified. Future subtidal surveys of the Lune Deep should see ‘permanent’ transects established in order to enable repeat monitoring to take place. While this may be difficult to achieve, due in part to the small area sampled at each seabed contact by the FLCS, it would allow direct and robust comparisons to be made between years, resulting in a more accurate assessment of change. In 2015, repeat transects were attempted based on the transects conducted by CMACS in 2011. In all cases seabed contacts were no more than 20 m from the target, meaning that direct comparisons were possible. Furthermore, given that reef feature confidence level 2 polygons in the current study were set at 50 m from point source, slight discrepancies in the positions of repeated seabed contacts should not adversely affect delineation of reef features in future years.

Additionally, it is recommended that the biotope **CR.HCR.XFa.Mol** is incorporated into the favourable condition assessment criteria as an attribute to be monitored, as this appears to have replaced other faunal turf biotopes as the dominant community associated with potential cobble reef features within the survey area.

Table 4.1: Favourable condition assessment table with recommended measures and attributes for the Lune Deep feature of the Shell Flat and Lune Deep SCI post-2015 survey (based on Natural England, 2012)

Attribute	Measure	Target	2015 Survey Results	Recommendations
Extent of reefs	Overall area (ha) of reef measured periodically throughout the reporting cycle	No decrease in extent from established baseline, subject to natural change.	- 39 transects were successfully surveyed in the Lune Deep survey area with good coverage geographically and at a range of depths - No bedrock observed, but boulder and cobble potential reef features observed on a total of 37 transects - Stony reef found estimated to cover a total of 4.752 km^2	- Sidescan sonar data should be acquired in the survey area and further coverage achieved using a freshwater lens camera system in order to further investigate instances of this attribute
Biotope composition of reefs	Presence and/or abundance of a variety of reef biotopes at specified locations throughout the site.	Maintain the full variety of biotopes identified for the site to an established baseline, subject to natural change.	- A total of six biotopes / biotope complexes associated with cobble and boulder reef identified - The most common biotope identified associated with reef sub-features was **CR.HCR.XFa.Mol**	
Distribution and spatial pattern of reef biotopes	Distribution and spatial arrangement of reef biotopes at specified locations. Measure during summer, once during reporting cycle.	Maintain the distribution and spatial pattern of reef biotopes identified for the site, to an established baseline, allowing for natural change.	- Reef sub-features found to be predominately limited to the northern, relatively shallow 'shelf' and slope, as previously reported (Royal Haskoning, 2008)	- Sidescan sonar data should be acquired in the survey area and further coverage achieved using a freshwater lens camera system in order to further investigate instances of this attribute
Presence of representative /notable reef biotopes	Presence / abundance of representative / notable reef biotopes including; **CR.HCR.XFa** **CR.HCR.XFa.FluCoAs** **CR.HCR.XFa.FluHocu**	Presence of biotopes at specified locations should not deviate significantly from an established baseline, allowing for natural change.	All representative/notable reef biotopes identified in the survey area; - **CR.HCR.XFa** (36 seabed contacts) - **CR.HCR.XFa.FluCoAs** (4) - **CR.HCR.XFa.FluHocu** (5)	- Presence and/or abundance of representative/notable reef biotopes should continue to be regularly monitored

Attribute	Measure	Target	2015 Survey Results	Recommendations
	SS.SMx.CMx.FluHyd; measured once during summer, within the reporting cycle.		**- SS.SMx.CMx.FluHyd** (11) However, the most commonly identified biotopes associated with reef sub-features in 2015 were; - **CR.HCR.XFa.Mol** - **SS.SMx.CMx**	- It is recommended that the **CR.HCR.XFa.Mol** biotope be included as a representative /notable biotope for this attribute
Extent of representative /notable reef biotopes	Extent of representative / notable reef biotopes, including; **CR.HCR.XFa** **CR.HCR.XFa.FluCoAs** **CR.HCR.XFa.FluHocu** **SS.SMx.CMx.FluHyd**; measured once during summer, within the reporting cycle.	No change in the extent of representative/notable reef biotopes, from an established baseline, allowing for natural change.	- While still present, representative biotopes appear to have reduced in area, giving way to the *Molgula manhattensis* dominated **CR.HCR.XFa.Mol**	- Extent of representative /notable reef biotopes should continue to be regularly monitored - It is recommended that the **CR.HCR.XFa.Mol** biotope be included as a representative / notable biotope for this attribute
Species composition of representative or notable reef biotopes	Frequency and occurrence of component species of representative or notable reef biotopes including; **CR.HCR.XFa** **CR.HCR.XFa.FluCoAs** **CR.HCR.XFa.FluHocu** **SS.SMx.CMx.FluHyd**; measured once during summer, within the reporting cycle.	No decline in reef biotope quality due to change in species composition or loss of notable species, from an established baseline, allowing for natural change.	- Fauna generally sparse with impoverished versions of MNCR biotopes observed, as previously reported (Royal Haskoning, 2008) - Dominant fauna according to MNCR biotope descriptions present and similar to those previously reported, including *Flustra foliacea*, *Haliclona oculata* and *Hydrallmania falcata*. - However, there appears to have been an increase in the presence of the non-native ascidian *Molgula manhattensis* and the associated biotope **CR.HCR.XFa.Mol**	- It is recommended that *Molgula manhattensis* be included as a representative/notable reef species for this attribute - Future surveys should aim to use a Hamon grab at camera locations in order to acquire specimens to confirm identification of *Molgula manhattensis* and other species.

Attribute	Measure	Target	2015 Survey Results	Recommendations
Presence and/or abundance of specified reef species	Species may include: *Alcyonium digitatum, Cancer pagurus, Flustra foliacea, Asterias rubens, Nemertesia antennina, Pomatoceros* spp., *Ammodytes* spp., *Hyas araneus, Urticina eques*. Measured once, during summer, within the reporting cycle.	Maintain presence and/or abundance of species from an established baseline, allowing for natural change	- Most commonly identified species associated with reef features was the non-native ascidian *Molgula manhattensis*. - Other commonly identified fauna included *Asterias rubens* (primarily small/juvenile individuals), *Flustra foliacea*, *Nemertesia antennina*, *Alcyonium digitatum* and *Sabella pavonina*. - With regard to the other specified taxa; *Cancer pagurus* was identified at 4 seabed contacts and *Urticina* spp. was identified at 19 seabed contacts. - Serpulid worms, such as *Spirobranchus* (formerly *Pomatoceros*) sp., were recorded at 41 contacts; spider crabs (Majidae, potentially including *Hyas araneus*) were recorded at 17 contacts. No sandeels were observed.	- It is recommended that *Molgula manhattensis* be included as a representative/notable reef species for this attribute - Future surveys should aim to use a Hamon grab at camera locations in order to acquire specimens to confirm identification of *Molgula manhattensis* and other species.

5 REFERENCES

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6 APPENDICES

6.1 Appendix I

Details of planned camera transects for the Lune Deep drop-down video survey 2015.

Line No.	SOL Easting	SOL Northing	EOL Easting	EOL Northing	Rationale
LNDP 01	493158.8	5978916.9	492890.1	5978792.1	Small bathymetric features
LNDP 02	493342.8	5978693.0	493067.7	5978568.2	Ridge at upper edge of slope / likely reef area (Hawes *et al.*, 2015)
LNDP 03	492773.3	5978779.3	492416.6	5978592.2	Change in reflectivity
LNDP 04	493042.1	5978529.8	492760.5	5978422.6	Bathymetric features on slope
LNDP 05	492063.2	5978516.7	492008.6	5978332.0	Small bathymetric features
LNDP 06	492504.6	5978397.0	492197.4	5978240.2	Change in reflectivity
LNDP 07	492251.8	5978081.9	492024.6	5977873.9	Ridge at upper edge of slope
LNDP 08	492490.2	5978211.4	492216.6	5977942.7	Bathymetric features mid-slope
LNDP 09	492652.1	5978142.0	492397.6	5977939.8	Bathymetric features lower-slope
LNDP 10	492175.1	5977672.2	491915.3	5977522.2	Ground-truthing of flat area in channel (low priority)
LNDP 11	491343.4	5978088.5	491056.6	5977938.9	Change in bathymetric / mottled reflectivity
LNDP 12	491403.9	5977625.9	491746.3	5977765.1	Bathymetric features at upper edge of slope
LNDP 13	491130.7	5977525.2	490888.4	5977482.5	Bathymetric features at upper edge of slope
LNDP 14	490833.2	5977644.1	490664.0	5977489.4	Change in reflectivity/striations
LNDP 15	490457.2	5977584.8	490348.7	5977451.3	Small bathymetric feature associated with mottled reflectivity
LNDP 16	490694.4	5977278.7	490537.8	5977356.1	Bathymetric feature orientated with the slope
LNDP 17	490388.7	5977315.6	490495.1	5976985.0	Investigation of series of sites sampled by CMACS (2011) for comparison purposes
LNDP 18	490222.8	5977225.9	490029.2	5977132.7	Ridge at upper edge of slope - for comparison with lines 19 & 20
LNDP 19	490249.2	5977160.8	490045.0	5977058.7	Bathymetric features mid-slope - for comparison with lines 18 & 20

Line No.	SOL Easting	SOL Northing	EOL Easting	EOL Northing	Rationale
LNDP 20	490261.5	5977095.7	490078.5	5977011.2	Bathymetric features lower-slope for comparison with lines 18 & 19
LNDP 21	490088.9	5976729.6	489829.1	5976579.6	Ground-truthing of flat area in channel (low priority)
LNDP 22	489548.8	5977132.7	489355.2	5977035.9	Bathymetric feature associated with mottled reflectivity
LNDP 23	489511.9	5976879.3	489302.4	5976771.9	Bathymetric feature associated with mottled reflectivity
LNDP 24	489207.4	5976969.0	489133.5	5976854.6	Bathymetric feature associated with mottled reflectivity
LNDP 25	489412.2	5976374.6	489391.9	5976351.9	Small feature in channel
LNDP 26	488892.4	5976808.9	488830.8	5976620.6	Bathymetric feature associated with mottled reflectivity in vicinity of previous sampling sites indicating hard substrata (CMACS, 2011; Envision, 2008)
LNDP 27	488873.4	5976641.5	489161.3	5976204.8	Investigation of series of sites sampled by CMACS (2011) for comparison purposes
LNDP 28	488899.0	5976264.0	488556.6	5976203.2	Series of bathymetric features associated with mottled reflectivity
LNDP 29	488456.3	5976221.4	488281.7	5976343.0	Low ridge feature associated with change in reflectivity
LNDP 30	487991.8	5976290.0	487726.8	5976149.7	Bathymetric feature associated with mottled reflectivity
LNDP 31	487951.2	5976031.3	488359.6	5975672.8	Down-slope transect to investigate changes with depth and reflectivity
LNDP 32	487470.5	5975573.4	487531.3	5975264.0	Bathymetric feature associated with change in reflectivity
LNDP 33	486934.5	5975593.4	487141.1	5975799.0	Bathymetric feature associated with mottled reflectivity
LNDP 34	487193.7	5975187.1	487222.5	5974935.8	Series of bathymetric features associated with mottled reflectivity
LNDP 35	486899.6	5974870.2	487222.5	5975057.9	Bathymetric feature associated with change in reflectivity
LNDP 36	486418.5	5974994.5	486884.4	5974952.5	Features indicted by change in reflectivity
LNDP 37	486643.4	5974944.2	486446.2	5974689.6	Feature indicated by change in reflectivity

Line No.	SOL Easting	SOL Northing	EOL Easting	EOL Northing	Rationale
LNDP 38	486480.2	5974859.4	487080.0	5974332.7	Investigation of series of sites sampled by CMACS (2011) for comparison purposes & reflectivity feature
LNDP 39	486210.3	5974616.9	486158.6	5974394.4	Ground-truthing of flat area on 'shelf'
LNDP 40	486679.6	5974370.2	486486.8	5974140.4	Series of bathymetric features associated with mottled reflectivity
LNDP 41	486681.0	5973913.7	486488.1	5973683.9	Ground-truthing of flat area in channel (low priority)
LNDP 42	485992.3	5973976.4	485829.1	5973798.8	Feature indicated by change in reflectivity
LNDP 43	485920.9	5973461.5	486160.6	5973679.2	Series of bathymetric features associated with mottled reflectivity

6.2 Appendix II

Survey logs detailing achieved 'seabed contacts' in the 2015 Lune Deep drop-down video survey.

Seastar Survey Ltd			
Shell Flat and Lune Deep cSAC DDV Survey			
Seabed Contact Log			
WGS 1984			
Client	Natural England	**Job No**	J/15/465
Location	Shell Flat and Lune Deep cSAC	**Vessel**	SV Mariner

Date	Sample #	Station	Time (UTC)	Easting (m)	Northing (m)	Lat_WGS84 (dd.ddddd)	Lon_WGS84 (dd.ddddd)	Depth (m)	Tape #	Quality
22/08/2015	465_01#01	1								
22/08/2015	465_01#01_01	1	05:40:39	493143.6	5978920.0	53.95860	-3.10450	10	1	Good
22/08/2015	465_01#01_02	1	05:46:59	493101.6	5978896.0	53.95838	-3.10513	10	1	Adequate
22/08/2015	465_01#01_03	1	05:51:06	493063.7	5978864.0	53.95809	-3.10571	10	1	Good
22/08/2015	465_01#01_04	1	05:56:56	493017.3	5978856.0	53.95801	-3.10642	10	1	Good
22/08/2015	465_01#01_05	1	06:03:16	492975.9	5978832.0	53.95780	-3.10705	10	1	Good
22/08/2015	465_01#01_06	1	06:07:22	492922.4	5978813.0	53.95763	-3.10786	10	1	Good
22/08/2015	465_01#01_07	1	06:12:53	492874.3	5978789.0	53.95741	-3.10860	10	1	Good
22/08/2015	465_02#01	3								
22/08/2015	465_02#01_01	3	06:42:34	492416.5	5978587.0	53.95559	-3.11557	10	1	Good
22/08/2015	465_02#01_02	3	06:45:39	492461.9	5978610.0	53.95580	-3.11488	10	1	Good
22/08/2015	465_02#01_03	3	06:48:00	492499.4	5978633.0	53.95601	-3.11431	9.5	1	Good
22/08/2015	465_02#01_04	3	06:50:12	492548.4	5978665.0	53.95630	-3.11356	10	1	Good
22/08/2015	465_02#01_05	3	06:52:56	492583.9	5978690.0	53.95652	-3.11302	10	1	Good
22/08/2015	465_02#01_06	3	06:55:19	492632.6	5978721.0	53.95680	-3.11228	10	1	Good
22/08/2015	465_02#01_07	3	06:57:32	492675.4	5978735.0	53.95693	-3.11163	10	1	Good

Date	Sample #	Station	Time (UTC)	Easting (m)	Northing (m)	Lat_WGS84 (dd.ddddd)	Lon_WGS84 (dd.ddddd)	Depth (m)	Tape #	Quality
22/08/2015	465_02#01_08	3	06:59:35	492725.3	5978758.0	53.95714	-3.11087	10	1	Good
22/08/2015	465_02#01_09	3	07:01:40	492772.6	5978778.0	53.95731	-3.11015	10	1	Good
22/08/2015	465_03#01	2								
22/08/2015	465_03#01_01	2	07:18:46	493060.9	5978565.0	53.95541	-3.10575	12.5	2	Good
22/08/2015	465_03#01_02	2	07:25:57	493105.1	5978588.0	53.95561	-3.10507	7.5	2	Good
22/08/2015	465_03#01_03	2	07:29:14	493150.2	5978599.0	53.95571	-3.10439	7.5	2	Good
22/08/2015	465_03#01_04	2	07:32:05	493208.4	5978625.0	53.95595	-3.10350	12	2	Good
22/08/2015	465_03#01_05	2	07:35:41	493249.6	5978649.0	53.95616	-3.10287	11	2	Adequate
22/08/2015	465_03#01_06	2	07:40:07	493294.8	5978669.0	53.95634	-3.10218	7	2	
22/08/2015	465_03#01_07	2	07:43:08	493333.0	5978694.0	53.95657	-3.10160	10	2	Good
22/08/2015	465_04#01	10								
22/08/2015	465_04#01_01	10	08:50:29	491888.8	5977531.0	53.94609	-3.12358	44	2	Good
22/08/2015	465_04#01_02	10	08:55:59	492043.9	5977596.0	53.94668	-3.12122	44.5	2	
22/08/2015	465_04#01_03	10	09:00:07	492165.9	5977675.0	53.94739	-3.11936	44.5	2	
22/08/2015	465_05#01	43								
22/08/2015	465_05#01_01	43	10:05:30	485897.5	5973458.0	53.90936	-3.21468	23	3	Good
22/08/2015	465_05#01_02	43	10:08:43	485930.5	5973472.0	53.90948	-3.21417	25	3	Good
22/08/2015	465_05#01_03	43	10:11:54	485976.5	5973510.0	53.90983	-3.21348	24	3	Poor
22/08/2015	465_05#01_04	43	10:15:04	486009.5	5973550.0	53.91018	-3.21298	26	3	Poor
22/08/2015	465_05#01_05	43	10:17:28	486048.2	5973583.0	53.91048	-3.21239	26	3	Good
22/08/2015	465_05#01_06	43	10:20:28	486101.1	5973617.0	53.91079	-3.21158	27	3	Adequate
22/08/2015	465_05#01_07	43	10:23:02	486123.1	5973650.0	53.91109	-3.21125	27	3	Adequate
22/08/2015	465_05#01_08	43	10:25:31	486162.1	5973683.0	53.91139	-3.21066	21.5	3	Adequate
22/08/2015	465_06#01	42								
22/08/2015	465_06#01_01	42	11:38:37	485997.6	5973988.0	53.91412	-3.21318	19.5	3	Good
22/08/2015	465_06#01_02	42	11:40:54	485965.7	5973950.0	53.91378	-3.21366	20	3	Good

Date	Sample #	Station	Time (UTC)	Easting (m)	Northing (m)	Lat_WGS84 (dd.ddddd)	Lon_WGS84 (dd.ddddd)	Depth (m)	Tape #	Quality
22/08/2015	465_06#01_03	42	11:44:01	485921.9	5973907.0	53.91340	-3.21433	22	3	Good
22/08/2015	465_06#01_04	42	11:46:06	485904.6	5973894.0	53.91327	-3.21459	23	3	Good
22/08/2015	465_06#01_05	42	11:48:46	485876.1	5973841.0	53.91280	-3.21502	22	3	Adequate
22/08/2015	465_06#01_06	42	11:51:53	485844.1	5973797.0	53.91240	-3.21551	22	3	Good
22/08/2015	465_07#01	41								
22/08/2015	465_07#01_01	41	12:02:07	486684.9	5973930.0	53.91362	-3.20271	30	3	Poor
22/08/2015	465_07#01_02	41	12:07:13	486583.6	5973799.0	53.91244	-3.20425	29	3	Adequate
22/08/2015	465_07#01_03	41	12:11:28	486473.7	5973687.0	53.91143	-3.20592	28	3	Adequate
22/08/2015	465_08#01	40								
22/08/2015	465_08#01_01	40	12:36:58	486682.3	5974369.0	53.91757	-3.20277	28	4	Good
22/08/2015	465_08#01_02	40	12:41:35	486648.1	5974329.0	53.91721	-3.20329	24	4	Good
22/08/2015	465_08#01_03	40	12:45:04	486617.8	5974288.0	53.91684	-3.20375	27	4	Good
22/08/2015	465_08#01_04	40	12:50:03	486585.6	5974254.0	53.91653	-3.20424	28	4	Poor
22/08/2015	465_08#01_05	40	12:52:35	486561.8	5974220.0	53.91622	-3.20460	28	4	Adequate
22/08/2015	465_08#01_06	40	12:57:09	486529.1	5974178.0	53.91585	-3.20509	28	4	Poor
22/08/2015	465_08#01_07	40	12:59:39	486497.9	5974146.0	53.91556	-3.20557	26	4	Good
22/08/2015	465_09#01	39								
22/08/2015	465_09#01_01	39	13:13:55	486211.8	5974615.0	53.91977	-3.20994	21	4	Adequate
22/08/2015	465_09#01_02	39	13:17:25	486206.5	5974565.0	53.91932	-3.21002	21	4	Adequate
22/08/2015	465_09#01_03	39	13:21:21	486197.5	5974525.0	53.91895	-3.21016	21	4	Adequate
22/08/2015	465_09#01_04	39	13:25:31	486191.3	5974464.0	53.91841	-3.21025	20	4	Good
22/08/2015	465_09#01_05	39	13:29:13	486168.0	5974419.0	53.91800	-3.21060	20	4	Good
22/08/2015	465_10#01	24								
22/08/2015	465_10#01_01	24	14:05:42	489209.6	5976965.0	53.94096	-3.16438	16	4	Good
22/08/2015	465_10#01_02	24	14:08:48	489193.5	5976926.0	53.94061	-3.16463	16	4	Adequate
22/08/2015	465_10#01_03	24	14:11:03	489163.6	5976898.0	53.94036	-3.16508	16	4	Adequate

Date	Sample #	Station	Time (UTC)	Easting (m)	Northing (m)	Lat_WGS84 (dd.ddddd)	Lon_WGS84 (dd.ddddd)	Depth (m)	Tape #	Quality
22/08/2015	465_10#01_04	24	14:13:20	489147.0	5976863.0	53.94004	-3.16533	17	4	Good
22/08/2015	465_11#01	22								
22/08/2015	465_11#01_01	22	14:21:03	489553.0	5977133.0	53.94248	-3.15916	17	5	Good
22/08/2015	465_11#01_02	22	14:23:27	489520.2	5977120.0	53.94236	-3.15966	17	5	Good
22/08/2015	465_11#01_03	22	14:25:49	489489.3	5977105.0	53.94222	-3.16013	16	5	Adequate
22/08/2015	465_11#01_04	22	14:27:44	489466.9	5977084.0	53.94203	-3.16047	16	5	Good
22/08/2015	465_11#01_05	22	14:29:54	489442.4	5977077.0	53.94197	-3.16084	16	5	Good
22/08/2015	465_11#01_06	22	14:32:10	489413.6	5977069.0	53.94190	-3.16128	16	5	Good
22/08/2015	465_11#01_07	22	14:34:06	489390.0	5977049.0	53.94171	-3.16164	16	5	Good
24/08/2015	465_12#01	33								
24/08/2015	465_12#01_01	33	06:13:23	487139.8	5975803.0	53.93046	-3.19586	22	5	Good
24/08/2015	465_12#01_02	33	06:15:48	487099.8	5975776.0	53.93022	-3.19647	21	5	Adequate
24/08/2015	465_12#01_03	33	06:18:04	487059.5	5975729.0	53.92980	-3.19708	2	5	Adequate
24/08/2015	465_12#01_04	33	06:20:21	487038.2	5975688.0	53.92943	-3.19741	12	5	Adequate
24/08/2015	465_12#01_05	33	06:22:02	486997.0	5975658.0	53.92916	-3.19803	12	5	Adequate
24/08/2015	465_12#01_06	33	06:24:35	486966.8	5975628.0	53.92889	-3.19849	22	5	Adequate
24/08/2015	465_12#01_07	33	06:26:48	486926.4	5975590.0	53.92855	-3.19911	23	5	
24/08/2015	465_13#01	32								
24/08/2015	465_13#01_01	32	06:38:08	487461.9	5975573.0	53.92840	-3.19095	24	5	Good
24/08/2015	465_13#01_02	32	06:40:43	487474.2	5975527.0	53.92799	-3.19076	24	5	Adequate
24/08/2015	465_13#01_03	32	06:43:46	487484.3	5975477.0	53.92754	-3.19060	24	5	Good
24/08/2015	465_13#01_04	32	06:46:44	487500.5	5975435.0	53.92717	-3.19036	24	5	Good
24/08/2015	465_13#01_05	32	06:49:24	487499.0	5975372.0	53.92660	-3.19038	28	5	Good
24/08/2015	465_13#01_06	32	06:52:17	487510.7	5975333.0	53.92625	-3.19020	28	5	Adequate
24/08/2015	465_13#01_07	32	06:54:44	487521.6	5975288.0	53.92584	-3.19003	30	5	
24/08/2015	465_14#01	36								

Date	Sample #	Station	Time (UTC)	Easting (m)	Northing (m)	Lat_WGS84 (dd.ddddd)	Lon_WGS84 (dd.ddddd)	Depth (m)	Tape #	Quality
24/08/2015	465_14#01_01	36	07:07:17	486872.4	5974945.0	53.92274	-3.19990	25	6	Adequate
24/08/2015	465_14#01_02	36	07:08:29	486834.5	5974946.0	53.92275	-3.20048	26	6	Adequate
24/08/2015	465_14#01_03	36	07:09:58	486781.2	5974962.0	53.92290	-3.20129	26	6	Poor
24/08/2015	465_14#01_04	36	07:13:18	486733.4	5974955.0	53.92283	-3.20202	25	6	Good
24/08/2015	465_14#01_05	36	07:14:56	486675.8	5974980.0	53.92306	-3.20290	24	6	Poor
24/08/2015	465_14#01_06	36	07:19:19	486629.9	5974980.0	53.92306	-3.20359	24	6	Good
24/08/2015	465_14#01_07	36	07:21:56	486587.7	5974985.0	53.92310	-3.20424	23	6	Adequate
24/08/2015	465_14#01_08	36	07:23:34	486529.4	5974982.0	53.92307	-3.20512	22	6	Poor
24/08/2015	465_14#01_09	36	07:24:38	486494.9	5974989.0	53.92313	-3.20565	22	6	Poor
24/08/2015	465_14#01_10	36	07:29:14	486475.0	5974986.0	53.92311	-3.20595	23	6	Adequate
24/08/2015	465_14#01_11	36	07:30:22	486443.7	5974999.0	53.92322	-3.20643	22	6	Adequate
24/08/2015	465_15#01	37								
24/08/2015	465_15#01_01	37	07:49:48	486459.6	5974724.0	53.92075	-3.20618	23	6	Adequate
24/08/2015	465_15#01_02	37	07:52:25	486492.1	5974765.0	53.92112	-3.20568	24	6	Adequate
24/08/2015	465_15#01_03	37	07:57:15	486525.5	5974786.0	53.92131	-3.20517	25	6	Good
24/08/2015	465_15#01_04	37	08:00:40	486543.1	5974834.0	53.92174	-3.20491	25	6	Good
24/08/2015	465_15#02	37								
24/08/2015	465_15#02_01	37	08:17:51	486576.7	5974867.0	53.92204	-3.20440	24	6	Good
24/08/2015	465_15#02_02	37	08:20:38	486606.3	5974905.0	53.92238	-3.20395	24	6	Good
24/08/2015	465_15#02_03	37	08:23:22	486635.3	5974950.0	53.92279	-3.20351	24	6	Adequate
24/08/2015	465_16#01	35								
24/08/2015	465_16#01_01	35	09:22:32	486918.7	5974881.0	53.92217	-3.19919	18	7	Good
24/08/2015	465_16#01_02	35	09:26:14	486958.1	5974903.0	53.92237	-3.19859	18	7	Good
24/08/2015	465_16#01_03	35	09:29:14	487004.6	5974924.0	53.92256	-3.19789	18	7	Good
24/08/2015	465_16#01_04	35	09:31:45	487050.2	5974951.0	53.92281	-3.19719	18	7	Good
24/08/2015	465_16#01_05	35	09:35:06	487088.1	5974980.0	53.92306	-3.19662	19	7	Good

Date	Sample #	Station	Time (UTC)	Easting (m)	Northing (m)	Lat_WGS84 (dd.ddddd)	Lon_WGS84 (dd.ddddd)	Depth (m)	Tape #	Quality
24/08/2015	465_16#01_06	35	09:38:35	487135.4	5975007.0	53.92331	-3.19590	19	7	Good
24/08/2015	465_16#01_07	35	09:42:33	487180.5	5975026.0	53.92348	-3.19521	20	7	Good
24/08/2015	465_16#01_08	35	09:45:59	487215.7	5975057.0	53.92376	-3.19468	19	7	Good
24/08/2015	465_17#01	34								
24/08/2015	465_17#01_01	34	09:56:05	487218.4	5974938.0	53.92269	-3.19463	24	7	Good
24/08/2015	465_17#01_02	34	09:59:05	487215.0	5974984.0	53.92310	-3.19469	20	7	Good
24/08/2015	465_17#01_03	34	10:01:29	487208.9	5975030.0	53.92352	-3.19478	18	7	Good
24/08/2015	465_17#01_04	34	10:04:39	487194.5	5975085.0	53.92401	-3.19500	22	7	Good
24/08/2015	465_17#01_05	34	10:07:42	487170.2	5975115.0	53.92428	-3.19537	25	7	Adequate
24/08/2015	465_17#01_06	34	10:11:30	487195.7	5975188.0	53.92494	-3.19499	21	7	Good
24/08/2015	465_18#01	30								
24/08/2015	465_18#01_01	30	10:30:08	487724.3	5976150.0	53.93360	-3.18698	16	8	Good
24/08/2015	465_18#01_02	30	10:32:47	487768.8	5976174.0	53.93381	-3.18630	15	8	Good
24/08/2015	465_18#01_03	30	10:35:23	487816.3	5976202.0	53.93407	-3.18558	13	8	Adequate
24/08/2015	465_18#01_04	30	10:37:37	487862.7	5976221.0	53.93424	-3.18487	15	8	Adequate
24/08/2015	465_18#01_05	30	10:40:26	487907.2	5976252.0	53.93452	-3.18419	15	8	Good
24/08/2015	465_18#01_06	30	10:43:28	487947.0	5976266.0	53.93464	-3.18359	16	8	Adequate
24/08/2015	465_18#01_07	30	10:47:38	487988.9	5976294.0	53.93490	-3.18295	17	8	
24/08/2015	465_19#01	29								
24/08/2015	465_19#01_01	29	11:05:46	488452.2	5976218.0	53.93423	-3.17589	28	8	Good
24/08/2015	465_19#01_02	29	11:08:33	488407.8	5976256.0	53.93457	-3.17657	23	8	Good
24/08/2015	465_19#01_03	29	11:13:13	488377.1	5976270.0	53.93470	-3.17704	20	8	Good
24/08/2015	465_19#01_04	29	11:16:58	488362.7	5976286.0	53.93484	-3.17726	17	8	Good
24/08/2015	465_19#01_05	29	11:21:11	488347.2	5976300.0	53.93496	-3.17749	16	8	Good
24/08/2015	465_19#01_06	29	11:24:21	488304.1	5976331.0	53.93524	-3.17815	15	8	
24/08/2015	465_20#01	31								

Date	Sample #	Station	Time (UTC)	Easting (m)	Northing (m)	Lat_WGS84 (dd.ddddd)	Lon_WGS84 (dd.ddddd)	Depth (m)	Tape #	Quality
24/08/2015	465_20#01_01	31	12:25:56	488293.1	5975547.0	53.92819	-3.17829	60	9	Adequate
24/08/2015	465_20#01_02	31	12:29:25	488356.8	5975649.0	53.92911	-3.17732	62	9	Adequate
24/08/2015	465_20#01_03	31	12:33:06	488338.0	5975698.0	53.92955	-3.17761	64	9	Adequate
24/08/2015	465_20#01_04	31	12:36:53	488291.8	5975733.0	53.92986	-3.17832	54	9	Adequate
24/08/2015	465_20#01_05	31	12:40:49	488246.8	5975769.0	53.93019	-3.17900	40	9	Adequate
24/08/2015	465_20#01_06	31	12:45:29	488219.8	5975807.0	53.93053	-3.17942	38	9	Adequate
24/08/2015	465_20#01_07	31	12:49:19	488173.6	5975829.0	53.93072	-3.18012	37	9	Adequate
24/08/2015	465_20#01_08	31	12:52:23	488136.3	5975868.0	53.93107	-3.18069	32	9	Adequate
24/08/2015	465_20#01_09	31	12:56:28	488092.6	5975904.0	53.93139	-3.18136	21	9	Adequate
24/08/2015	465_20#01_10	31	12:59:37	488069.9	5975930.0	53.93163	-3.18170	16	9	Adequate
24/08/2015	465_20#01_11	31	13:04:33	488027.7	5975978.0	53.93206	-3.18235	17	9	Good
24/08/2015	465_20#01_12	31	13:08:27	487987.4	5976009.0	53.93234	-3.18296	17	9	Adequate
24/08/2015	465_20#01_13	31	13:11:19	487953.5	5976034.0	53.93256	-3.18348	16	9	Good
24/08/2015	465_21#01	5								
24/08/2015	465_21#01_01	5	14:14:11	492017.6	5978321.0	53.95320	-3.12164	9	10	Adequate
24/08/2015	465_21#01_02	5	14:18:44	492032.2	5978387.0	53.95379	-3.12142	8	10	Adequate
24/08/2015	465_21#01_03	5	14:20:46	492041.8	5978421.0	53.95409	-3.12127	8	10	Adequate
24/08/2015	465_21#01_04	5	14:22:50	492063.6	5978481.0	53.95463	-3.12094	8	10	Adequate
24/08/2015	465_21#01_05	5	14:25:59	492067.2	5978481.0	53.95463	-3.12089	8	10	Good
24/08/2015	465_21#01_06	5	14:29:08	492059.8	5978521.0	53.95499	-3.12100	8	10	
22/09/2015	465_22#01	6								
22/09/2015	465_22#01_01	6	07:24:27	492509.6	5978401.3	53.95392	-3.11414	16	11	Good
22/09/2015	465_22#01_02	6	07:28:29	492433.8	5978359.8	53.95355	-3.11530	15	11	Good
22/09/2015	465_22#01_03	6	07:32:35	492336.6	5978319.3	53.95318	-3.11678	12	11	Good
22/09/2015	465_22#01_04	6	07:42:45	492194.6	5978241.1	53.95248	-3.11894	11	11	Good
22/09/2015	465_22#01_05	6	07:48:19	492273.8	5978276.1	53.95280	-3.11773	12	11	Good

Date	Sample #	Station	Time (UTC)	Easting (m)	Northing (m)	Lat_WGS84 (dd.ddddd)	Lon_WGS84 (dd.ddddd)	Depth (m)	Tape #	Quality
22/09/2015	465_23#01	7								
22/09/2015	465_23#01_01	7	07:58:11	492243.8	5978096.5	53.95118	-3.11819	13	11	Good
22/09/2015	465_23#01_02	7	08:01:53	492211.7	5978037.0	53.95065	-3.11868	12	11	Good
22/09/2015	465_23#01_03	7	08:05:44	492177.3	5978011.8	53.95042	-3.11920	11	11	Good
22/09/2015	465_23#01_04	7	08:11:33	492144.3	5977974.0	53.95008	-3.11970	12	11	Good
22/09/2015	465_23#01_05	7	08:15:25	492108.6	5977938.1	53.94976	-3.12024	13	11	Good
22/09/2015	465_23#01_06	7	08:25:19	492057.7	5977912.4	53.94952	-3.12102	12	11	Good
22/09/2015	465_23#01_07	7	08:30:11	492026.6	5977863.1	53.94908	-3.12149	23	11	Adequate
23/09/2015	465_24#01	12								
23/09/2015	465_24#01_01	12	08:41:50	491754.3	5977752.8	53.94808	-3.12564	24	11	Adequate
23/09/2015	465_24#01_02	12	08:46:26	491701.3	5977762.4	53.94817	-3.12644	15	11	Good
23/09/2015	465_24#01_03	12	08:53:27	491652.6	5977719.9	53.94779	-3.12719	23	11	Good
23/09/2015	465_24#01_04	12	09:00:03	491612.6	5977701.5	53.94762	-3.12779	16	11	Good
23/09/2015	465_24#01_05	12	09:06:00	491561.4	5977681.3	53.94744	-3.12857	21	11	Adequate
23/09/2015	465_24#01_06	12	09:11:23	491521.1	5977668.0	53.94732	-3.12919	17	11	Good
23/09/2015	465_24#01_07	12	09:18:34	491478.4	5977633.1	53.94700	-3.12984	21	11	Adequate
23/09/2015	465_24#01_08	12	09:25:07	491420.0	5977630.1	53.94698	-3.13073	20	11	Good
23/09/2015	465_25#01	11								
23/09/2015	465_25#01_01	11	09:58:28	491335.2	5978089.9	53.95111	-3.13203	11	12	Good
23/09/2015	465_25#01_02	11	10:03:55	491300.4	5978071.6	53.95094	-3.13256	10	12	Good
23/09/2015	465_25#01_03	11	10:09:49	491257.0	5978042.4	53.95068	-3.13322	9	12	Adequate
23/09/2015	465_25#01_04	11	10:13:48	491209.6	5978016.1	53.95044	-3.13394	9	12	Good
23/09/2015	465_25#01_05	11	10:17:26	491166.9	5978000.4	53.95030	-3.13459	10	12	Good
23/09/2015	465_25#01_06	11	10:28:54	491137.2	5977974.9	53.95007	-3.13505	10	12	Good
23/09/2015	465_25#01_07	11	10:38:28	491072.1	5977943.4	53.94979	-3.13604	11	12	Good
23/09/2015	465_26#01	14								

Date	Sample #	Station	Time (UTC)	Easting (m)	Northing (m)	Lat_WGS84 (dd.ddddd)	Lon_WGS84 (dd.ddddd)	Depth (m)	Tape #	Quality
23/09/2015	465_26#01_01	14	10:51:49	490825.7	5977652.9	53.94717	-3.13978	13	12	Good
23/09/2015	465_26#01_02	14	10:55:00	490799.1	5977618.8	53.94686	-3.14019	14	12	Good
23/09/2015	465_26#01_03	14	10:58:58	490738.7	5977559.0	53.94633	-3.14111	14	12	Adequate
23/09/2015	465_26#01_04	14	11:00:14	490762.9	5977570.9	53.94643	-3.14074	15	12	Good
23/09/2015	465_26#01_05	14							12	
23/09/2015	465_26#01_06	14	11:08:35	490699.4	5977529.2	53.94606	-3.14170	14	12	Good
23/09/2015	465_26#01_07	14	11:15:31	490670.2	5977495.1	53.94575	-3.14215	14	12	Good
26/09/2015	465_27#01	28								
26/09/2015	465_27#01_01	28	09:36:28	488559.0	5976230.9	53.93434	-3.17427	31	13	Good
26/09/2015	465_27#01_02	28	09:40:01	488594.9	5976213.2	53.93419	-3.17372	32	13	Adequate
26/09/2015	465_27#01_03	28	09:45:21	488660.8	5976222.4	53.93427	-3.17271	34	13	Good
26/09/2015	465_27#01_04	28	09:52:38	488704.1	5976228.1	53.93432	-3.17206	35	13	Good
26/09/2015	465_27#01_05	28	09:57:13	488749.0	5976233.2	53.93437	-3.17137	35	13	Good
26/09/2015	465_27#01_06	28	10:00:56	488803.2	5976270.8	53.93471	-3.17055	33	13	Adequate
26/09/2015	465_27#01_07	28	10:04:42	488848.8	5976259.5	53.93461	-3.16985	31	13	Good
26/09/2015	465_27#01_08	28	10:08:52	488903.1	5976268.2	53.93469	-3.16903	32	13	Good
26/09/2015	465_28#01	26								
26/09/2015	465_28#01_01	26	10:18:14	488838.3	5976613.0	53.93778	-3.17003	20	13	Good
26/09/2015	465_28#01_02	26	10:20:28	488835.2	5976674.6	53.93834	-3.17007	18	13	Good
26/09/2015	465_28#01_03	26	10:24:11	488856.9	5976704.7	53.93861	-3.16975	16	13	Good
26/09/2015	465_28#01_04	26	10:27:25	488874.0	5976757.5	53.93908	-3.16949	16	13	Adequate
26/09/2015	465_28#01_05	26	10:30:36	488892.5	5976807.8	53.93954	-3.16921	16	13	Poor
26/09/2015	465_28#01_06	26	10:31:01	488885.7	5976811.8	53.93957	-3.16931	16	13	Good
26/09/2015	465_29#01	23								
26/09/2015	465_29#01_01	23	10:41:56	489296.3	5976768.9	53.93920	-3.16306	23	13	Adequate
26/09/2015	465_29#01_02	23	10:46:19	489334.0	5976786.4	53.93935	-3.16248	22	13	Adequate

Date	Sample #	Station	Time (UTC)	Easting (m)	Northing (m)	Lat_WGS84 (dd.ddddd)	Lon_WGS84 (dd.ddddd)	Depth (m)	Tape #	Quality
26/09/2015	465_29#01_03	23	10:51:04	489369.9	5976807.4	53.93954	-3.16193	22	13	Adequate
26/09/2015	465_29#01_04	23	10:57:51	489395.3	5976831.5	53.93976	-3.16155	22	13	Adequate
26/09/2015	465_29#01_05	23	11:03:49	489414.9	5976842.2	53.93986	-3.16125	20	13	Adequate
26/09/2015	465_29#01_06	23	11:09:09	489468.7	5976854.7	53.93997	-3.16043	21	13	Adequate
26/09/2015	465_29#01_07	23	11:14:30	489511.8	5976881.4	53.94021	-3.15978	23	13	Adequate
26/09/2015	465_030#01	20								
26/09/2015	465_30#01_01	20	11:39:31	490070.4	5977021.0	53.94148	-3.15127	50	13	Adequate
26/09/2015	465_30#01_02	20	11:46:14	490111.8	5977036.7	53.94162	-3.15064	48	13	Adequate
26/09/2015	465_30#01_03	20	11:52:39	490166.0	5977064.0	53.94187	-3.14982	43	13	Good
26/09/2015	465_30#01_04	20	12:07:07	490207.6	5977077.0	53.94198	-3.14918	43	13	Adequate
26/09/2015	465_30#01_05	20	12:15:33	490261.7	5977102.5	53.94221	-3.14836	42	13	Adequate
26/09/2015	465_31#01	19								
26/09/2015	465_31#01_01	19	12:23:55	490077.6	5977079.2	53.94200	-3.15116	38	13	Good
26/09/2015	465_31#01_02	19	12:30:44	490118.7	5977108.8	53.94227	-3.15054	34	13	Adequate
26/09/2015	465_31#01_03	19	12:39:20	490147.6	5977128.1	53.94244	-3.15010	30	13	Adequate
26/09/2015	465_31#01_04	19	12:44:45	490210.4	5977147.1	53.94261	-3.14914	29	13	Adequate
26/09/2015	465_31#01_05	19	12:50:34	490235.8	5977177.0	53.94288	-3.14875	24	13	Good
26/09/2015	465_32#01	18								
26/09/2015	465_32#01_01	18	13:46:21	490059.1	5977149.7	53.94263	-3.15145	20	13	Adequate
26/09/2015	465_32#01_02	18	13:49:32	490110.9	5977171.1	53.94283	-3.15066	20	13	Good
26/09/2015	465_32#01_03	18	13:51:41	490140.7	5977192.8	53.94302	-3.15020	15	13	Good
26/09/2015	465_32#01_04	18	13:54:23	490177.6	5977215.3	53.94323	-3.14964	14	13	Good
26/09/2015	465_32#01_05	18	13:57:31	490221.5	5977236.6	53.94342	-3.14898	14	13	Adequate
26/09/2015	465_33#01	16								
26/09/2015	465_33#01_01	16	14:04:56	490528.1	5977359.2	53.94453	-3.14431	16	13	Adequate
26/09/2015	465_33#01_02	16	14:07:28	490575.3	5977350.5	53.94445	-3.14359	24	13	Good

Date	Sample #	Station	Time (UTC)	Easting (m)	Northing (m)	Lat_WGS84 (dd.ddddd)	Lon_WGS84 (dd.ddddd)	Depth (m)	Tape #	Quality
26/09/2015	465_33#01_03	16	14:10:26	490611.9	5977329.8	53.94426	-3.14303	28	13	Good
26/09/2015	465_33#01_04	16	14:15:17	490652.6	5977297.7	53.94398	-3.14241	39	13	Good
26/09/2015	465_33#01_05	16	14:20:44	490684.6	5977261.3	53.94365	-3.14192	43	13	Good
26/09/2015	465_34#01	17								
26/09/2015	465_34#01_01	17	14:44:42	490485.2	5977117.8	53.94236	-3.14495	45	14	Good
26/09/2015	465_34#01_02	17	14:50:48	490435.5	5977144.4	53.94259	-3.14571	45	14	Good
26/09/2015	465_34#01_03	17	14:57:54	490421.8	5977192.1	53.94302	-3.14592	28	14	Good
26/09/2015	465_34#01_04	17	15:01:08	490429.4	5977227.3	53.94334	-3.14581	22	14	Good
26/09/2015	465_34#01_05	17	15:10:40	490432.4	5977249.7	53.94354	-3.14576	17	14	Good
26/09/2015	465_34#01_06	17	15:13:37	490406.9	5977277.0	53.94378	-3.14615	13	14	Good
26/09/2015	465_34#01_07	17	15:17:32	490384.1	5977318.0	53.94415	-3.14650	10	14	Good
26/09/2015	465_35#01	15								
26/09/2015	465_35#01_01	15	15:28:33	490377.8	5977465.9	53.94548	-3.14660	8	14	Poor
26/09/2015	465_35#01_02	15	15:31:45	490368.6	5977470.3	53.94552	-3.14674	8	14	Adequate
26/09/2015	465_35#01_03	15	15:35:02	490394.7	5977503.0	53.94582	-3.14635	7	14	Good
26/09/2015	465_35#01_04	15	15:39:30	490426.8	5977549.7	53.94624	-3.14586	7	14	Good
26/09/2015	465_35#01_05	15	15:42:36	490469.4	5977590.4	53.94660	-3.14521	7	14	Good
26/09/2015	465_36#01	13								
26/09/2015	465_36#01_01	13	15:56:00	490906.9	5977478.4	53.94560	-3.13854	24	14	Good
26/09/2015	465_36#01_02	13	15:59:39	490940.7	5977500.3	53.94580	-3.13803	15	14	Good
26/09/2015	465_36#01_03	13	16:03:36	490982.5	5977496.1	53.94576	-3.13739	10	14	Good
26/09/2015	465_36#01_04	13	16:06:40	491040.4	5977510.4	53.94589	-3.13651	16	14	Poor
26/09/2015	465_36#01_05	13	16:08:36	491087.4	5977512.9	53.94592	-3.13579	9	14	Good
26/09/2015	465_36#01_06	13	16:11:26	491130.7	5977520.0	53.94598	-3.13513	7	14	Good
26/09/2015	465_37#01	9								
26/09/2015	465_37#01_01	9	16:39:51	492421.4	5977963.6	53.94999	-3.11548	42	14	Good

Date	Sample #	Station	Time (UTC)	Easting (m)	Northing (m)	Lat_WGS84 (dd.ddddd)	Lon_WGS84 (dd.ddddd)	Depth (m)	Tape #	Quality
26/09/2015	465_37#01_02	9	16:42:49	492462.6	5977988.1	53.95021	-3.11485	42	14	Good
26/09/2015	465_37#01_03	9	16:45:10	492495.7	5978014.7	53.95045	-3.11435	39	14	Good
26/09/2015	465_37#01_04	9	16:47:40	492535.9	5978049.2	53.95076	-3.11374	38	14	Good
26/09/2015	465_37#01_05	9	16:50:26	492574.6	5978083.3	53.95107	-3.11315	36	14	Good
26/09/2015	465_37#01_06	9	16:52:45	492609.5	5978108.4	53.95129	-3.11261	35	14	Adequate
26/09/2015	465_37#01_07	9	16:54:23	492646.2	5978142.2	53.95160	-3.11206	35	14	Good
26/09/2015	465_38#01	8								
26/09/2015	465_38#01_01	8	16:59:39	492491.9	5978219.1	53.95229	-3.11441	31	14	Good
26/09/2015	465_38#01_02	8	17:02:48	492442.8	5978182.8	53.95196	-3.11516	24	14	Adequate
26/09/2015	465_38#01_03	8	17:06:06	492415.4	5978149.4	53.95166	-3.11557	24	14	Good
26/09/2015	465_38#01_04	8	17:11:26	492391.1	5978122.5	53.95142	-3.11594	24	14	Good
26/09/2015	465_38#01_05	8	17:13:59	492356.3	5978093.0	53.95115	-3.11647	27	14	Good
26/09/2015	465_38#01_06	8	17:18:23	492315.9	5978044.1	53.95071	-3.11709	24	14	Adequate
26/09/2015	465_38#01_07	8	17:22:11	492297.2	5978014.5	53.95044	-3.11737	31	14	Adequate
26/09/2015	465_38#01_08	8	17:26:34	492249.6	5977989.6	53.95022	-3.11810	30	14	Good
26/09/2015	465_38#01_09	8	17:31:24	492218.0	5977957.1	53.94993	-3.11858	31	14	Adequate
26/09/2015	465_39#01	4								
26/09/2015	465_39#01_01	4	17:50:33	493053.0	5978533.3	53.95512	-3.10587	25	14	Good
26/09/2015	465_39#01_02	4	17:56:57	493001.2	5978512.5	53.95493	-3.10666	25	14	Adequate
26/09/2015	465_39#01_03	4	18:01:38	492957.3	5978495.5	53.95478	-3.10732	24	14	Adequate
26/09/2015	465_39#01_04	4	18:06:08	492905.6	5978480.1	53.95464	-3.10811	27	14	Adequate
26/09/2015	465_39#01_05	4	18:10:30	492854.6	5978463.0	53.95448	-3.10889	22	14	Good
26/09/2015	465_39#01_06	4	18:14:56	492814.4	5978450.9	53.95437	-3.10950	27	14	Good
26/09/2015	465_39#01_07	4	18:21:02	492763.1	5978419.8	53.95409	-3.11028	35	14	Good

6.3 Appendix III

Biotopes complexes and biotopes identified using video data collected from the 2015 Lune Deep drop-down video survey.

CR.HCR.XFa	Mixed faunal turf communities
CR.HCR.XFa.FluCoAs.X	*Flustra foliacea* and colonial ascidians on tide-swept moderately wave-exposed circalittoral rock
CR.HCR.XFa.FluHocu	*Flustra foliacea* and *Haliclona oculata* with a rich faunal turf on tide-swept circalittoral mixed substrata
CR.HCR.XFa.Mol	*Molgula manhattensis* with a hydroid and bryozoan turf on tide-swept moderately wave-exposed circalittoral rock
SS.SSa.CMuSa	Circalittoral muddy sand
SS.SMu.CSaMu	Circalittoral sandy mud
SS.SMx.CMx	Circalittoral mixed sediment
SS.SMx.CMx.FluHyd	*Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment
SS.SBR.PoR.SspiMx	*Sabellaria spinulosa* on stable circalittoral mixed sediment

6.4 Appendix IV

Full list of taxa identified in the video data collected during the Lune Deep drop-down video survey.

MCS alpha	MCS num	Taxon	Qualifier
C	1	Porifera	arborescent
C	1	Porifera	encrusting
C	1	Porifera	repent
C	414	*Suberites*	sp; globular
C	480	*Cliona celata*	
C	758	*Amphilectus fucorum*	repent
C	1427	*Haliclona (Haliclona) oculata*	
D	58	Hydrozoa	turf
D	58	Hydrozoa	
D	166	*Tubularia indivisa*	
D	407	Sertulariidae	
D	424	*Hydrallmania falcata*	
D	433	Sertularia	argentea/cupressina
D	433	Sertularia	sp
D	462	*Nemertesia*	sp
D	463	*Nemertesia antennina*	
D	466	*Nemertesia ramosa*	
D	597	*Alcyonium digitatum*	
D	662	Actiniaria	
D	682	*Urticina*	sp
D	684	*Urticina felina*	
D	710	*Metridium dianthus*	
D	711	Sagartiidae	
D	712	*Sagartia*	
D	713	*Sagartia elegans*	
D	715	*Sagartia troglodytes*	
D	722	*Sagartiogeton undatus*	
G	1	Nemertea	
G	28	*Tubulanus annulatus*	
P	2	Polychaeta	cast
P	2	Polychaeta	tube
P	1117	*Sabellaria spinulosa*	
P	1320	*Sabella pavonina*	tube only
P	1320	*Sabella pavonina*	

MCS alpha	MCS num	Taxon	Qualifier
P	1324	Serpulidae	
R	15	Thoracica	
S	1293	Caridea	
S	1385	*Crangon crangon*	
S	1445	Paguridae	
S	1485	Brachyura	
S	1512	Majidae	
S	1529	*Macropodia*	sp
S	1566	*Cancer pagurus*	
S	1568	Portunoidea	
S	1577	*Liocarcinus*	sp
S	1580	*Liocarcinus depurator*	
S	1589	*Necora puber*	
W	88	Gastropoda	
W	140	Trochidae	
W	1243	Nudibranchia	
W	1450	*Eubranchus tricolor*	
W	1560	Bivalvia	juv.
Y	1	Bryozoa	erect
Y	1	Bryozoa	encrusting
Y	1	Bryozoa	turf
Y	76	*Alcyonidium diaphanum*	
Y	131	*Vesicularia spinosa*	
Y	165	*Eucratea loricata*	tent.
Y	185	Flustridae	
Y	187	*Flustra foliacea*	
ZB	75	*Crossaster papposus*	
ZB	100	*Asterias rubens*	juv.
ZB	100	*Asterias rubens*	
ZB	105	Ophiuroidea	
ZB	167	*Ophiura*	sp
ZB	168	*Ophiura albida*	
ZB	170	*Ophiura ophiura*	
ZD	2	ASCIDIACEA	colonial
ZD	2	ASCIDIACEA	small solitary
ZD	151	*Molgula manhattensis*	colonial
ZB	28	*Scyliorhinus canicula*	
ZG	7	Teleostei	

MCS alpha	MCS num	Taxon	Qualifier
ZG	262	*Chelidonichthys cuculus*	
ZG	291	*Agonus cataphractus*	
ZG	440	*Pholis gunnellus*	
ZG	455	Gobiidae	
ZG	545	Pleuronectiformes	
ZM	1	Rhodophyta	filamentous

6.5 Appendix V

MESH Confidence Assessment Score Sheet for Lune Deep 2015 potential stony reef polygons.

	RemoteTechnique	RemoteCoverage	RemotePositioning	RemoteStdsApplied	RemoteVintage	BGTTechnique	PGTTechnique	GTPositioning	GTDensity	GTStdsApplied	GTVintage	GTInterpretation	RemoteInterpretation	DetailLevel	MapAccuracy	Remote score	GT score	Interpretation score	**Overall score**
Level 1 - Point Source Data	2	3	3	2	2	2	2	3	3	3	3	3	3	3	2	80.00	86.67	91.67	**86**
Level 2 - Immediately surrounding 50 m Radius	2	3	3	2	2	2	2	3	3	3	3	3	3	2	2	80.00	86.67	83.33	**83**
Level 3 - Areas of similar bathymetric features / backscatter with ground-truthing	2	3	3	2	2	2	2	3	3	3	3	3	3	1	1	80.00	86.67	66.67	**78**
Level 4 - Areas of similar bathymetric features / backscatter with limited or no ground-truthing	2	3	3	2	2							3	3	1	1	80.00	0.00	66.67	**49**

Further information

Natural England evidence can be downloaded from our **Access to Evidence Catalogue**. For more information about Natural England and our work see **Gov.UK**. For any queries contact the Natural England Enquiry Service on 0300 060 3900 or e-mail **enquiries@naturalengland.org.uk**.

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