Shallow Inlets & Bays

Pilot Project 2021

Project funded by Natural England

Report prepared for Natural England by Newcastle University

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Summary

The Shallow Inlets and Bays pilot project aimed to identify key habitats in the infralittoral and circalittoral areas to the north of the Farne Islands and around Lindisfarne. These habitats included subtidal biogenic reefs (Mussel beds, and *Sabellaria* spp.), stony reefs, brittlestar beds, and seagrass beds. The project was undertaken in partnership with Natural England, Northumberland Inshore Fisheries and Conservation Authority (NIFCA), and Newcastle University. Key knowledge gaps were identified using existing data, and underwater visual surveys were conducted to increase understanding of specific habitats in the survey area.

This monitoring project will aid Natural England and local partners by providing baseline data on biological community composition, presence of invasive non-natives and/or anthropogenic impacts within the Berwickshire and North Northumberland Coast SAC. Data will also feed into the Fishing in MPAs project improving advice regulators. SACs must be surveyed to inform conservation advice and condition monitoring and this work is critical to the reporting of the condition of the BNNC SAC through assessment.

The pilot project aimed to re-survey and identify the sub-feature classes in at least four locations in and around the Farne Islands and the Lindisfarne National Nature Reserve (a multi-designated site), where these sub-features are thought to be present:

- Infralittoral/ Circalittoral biogenic reefs (e.g., *Mytilus edulis* w/o encrusting coralline algae, and Sabellaria spp.,).
- Infralittoral/ Circalittoral stony reef.
- Infralittoral seagrass (i.e., fully marine seagrass in shallow water conditions
- Brittlestar beds

Underwater imagery and location data from previous projects were interrogated to identify updated survey areas using a towed Sea Spyder camera system or an ROV deployed from NIFCA's catamaran "St. Aiden," and NIFCA's RIB 'Robert Arkless' at each survey site. Video and stills were captured at each site surveyed and reviewed by a research assistant at Newcastle University.

The key findings from the fieldwork are listed below:

- Stony Reef was identified with high confidence in five survey locations with abundances of soft corals *(A. Digitatum).*
- Subtidal mussel beds (mostly juvenile) were identified in one location with high confidence.
- Brittlestar beds were identified in three locations with high confidence. All sites had a combination of *O. nigra* and *O. fragilis* on a mix of sand pebble, cobble, and boulder that may also be classified as potential stony reef. The beds were rich in associated species and may form a larger interconnected brittlestar bed between all three sites.
- Maerl was identified by ROV at 2 sites with low confidence due to image quality and identification difficulties.
- No seagrass was identified at any of the survey sites.

Further recommendations for surveys are listed below:-

1. The channel from Burrow Hole 1 towards Flats Entrance 7 for further mussel beds and South of Harbour 8 towards Burrow Hole 1, in shallow water to confirm if maerl is present, this may uncover more subtidal mussel beds (Figure 21).
2. The areas in between Longstone 1-3 to ascertain if there is any connectivity of these brittlestar beds and potential stony reef (Figure 22).

3. DUN-10-20M-MOD (and FAR-20-MOD) if feasible, to ascertain the type of *Sabellaria* spp. present, if patchy or contiguous at each site (Figure 23).
4. Resurvey North Seagrass sites, further inshore at a depth of below 5m (Figure 7)
5. Survey the west side of the Farne islands where stony reef, brittlestar beds, and potential maerl are present (Figure 19).
6. The area in between North Stony 1 and 2 to examine if the stony reef has any connectivity between sites (Figure 7).

Introduction

This pilot project looked to identify areas of key habitats of interest in the infralittoral and circalittoral areas to the north of the Farne Islands and around Lindisfarne. These habitats of interest include subtidal biogenic reef (e.g., Mytilus edulis, Sabellaria sp.,), stony reef, brittlestar beds, and seagrass beds.

The project was in partnership with Natural England, Northumberland Inshore Fisheries and Conservation Authority (NIFCA), and Newcastle University. Expert knowledge from each partner organisation was combined with a variety of extant data to identify key knowledge gaps, and subsequently, conduct underwater visual surveys to increase the understanding of specific habitats in the area.

Updated Natural England Conservation Advice has added the sub-feature stony cobble circalittoral reef to the Berwickshire and North Northumberland Coast (BNNC) SAC. Circalittoral bedrock reef sites have only been quantitatively monitored in one area (sites around the Farnes), where a pilot dive survey identified areas of infralittoral stony reef in 2019. Non-quantitative broad identification of biotopes in the site have been monitored in corridor transects based on historic data from pre-designation in 2000 over 6–10-year periods.

Anecdotal evidence and exploratory condition monitoring in 2010 has indicated that subtidal cobbly reef, subtidal seagrass, subtidal biogenic Mytilus edulis reef (and possibly *Modiolus modiolus*) are also in the BNNC SAC. Pre-designation data (MNCR) pointed to the presence of brittlestar beds in the area and it was noted that sandbanks were in the site, and the sandbanks were not formally presented as suitable for designation (Foster-Smith, 2011).

The fieldwork aims to re-survey, intending to identify the sub-feature classes:

- Infralittoral/ Circalittoral biogenic reefs (e.g., Mytilus edulis w/o encrusting coralline algae, and Sabellaria sp.,).
- Infralittoral/ Circalittoral stony reef
- Infralittoral seagrass
- Brittlestar beds

in at least four locations in the Farne Islands and Holy Island, where these sub-features are thought to be present. During the pilot survey, other features of interest may also be encountered.

This work is part of the critical reporting of the condition of SACs in the UK. This project sits within Natural England's 'Creating resilient landscapes and seas'. Sites need to be surveyed to inform conservation advice and condition monitoring. This pilot monitoring project will help Natural England and local partners understanding of the site and provide data on biological community composition for more detailed, focused condition monitoring in future years. Data will also feed into the Fishing in MPAs project improving advice for regulators e.g., NIFCA.

Project Development - Stakeholder Input

An informal workshop was held at the start of the project with representatives from Natural England (Dr Catherine Scott), NIFCA (Alex Aitken & Mark Southerton), and Newcastle University (Dr Ashleigh Tinlin-Mackenzie).

The key habitats of interest and knowledge gaps were discussed, and a reduced list created to be the focus of the project (in priority order):

- Subtidal Mussel Beds
- Subtidal Seagrass Beds
- Stony Reef
- Sabellaria Reef
- Brittlestar Beds

These key habitats were selected as the BNNC SAC is designated for its annex 1 habitats containing mudflats and sandflats not covered by seawater at low tide, large shallow inlets and bays and, subtidal rocky reefs rich in marine species and brittlestar beds are a habitat of principal importance under NERC 2006 (JNCC, 2022).

Extant data and current knowledge were discussed, with partners seeking out and supplying any available information and data to the pilot project as follows:

- Natural England supplied reports covering some subtidal elements in the area (Envision, 2011), which highlighted areas around Holy Island harbour as potential sites to scope for subtidal mussel beds and shallow stony reef.
- NIFCA supplied available single and multibeam OLEX data from St Aiden and Princess Royal research vessels, to help with targeting specific substrates during surveys.
- NIFCA interviewed five fishers around Holy Island intending to gather local expert knowledge on the distribution of key habitats – unfortunately, the fishers were unable to supply the requested information as they did not observe patterns of key habitat-forming species in their pots across the study site.
- Newcastle University explored existing data from previous underwater imagery projects in the study area (MSFD Project and Dredging Up the Past Project) to provide known locations of selected habitats/species – e.g., records of stony reef, Sabellaria sp., and detached seagrass fronds.
- Partners researched and discussed key essential variables for some habitats so that searches can be limited and targeted. For example, seagrass depth limits, exposure, and sediment preferences.

Existing Data Interrogation

Methods

Substrate Data

Images of OLEX data (e.g., Figure 1) from St Aiden and Princess Royal were georeferenced for use in ArcMap 10.6.1. OLEX data were primarily used in the assignment of possible subtidal seagrass beds, where shallow areas of muddy substrate are preferred.

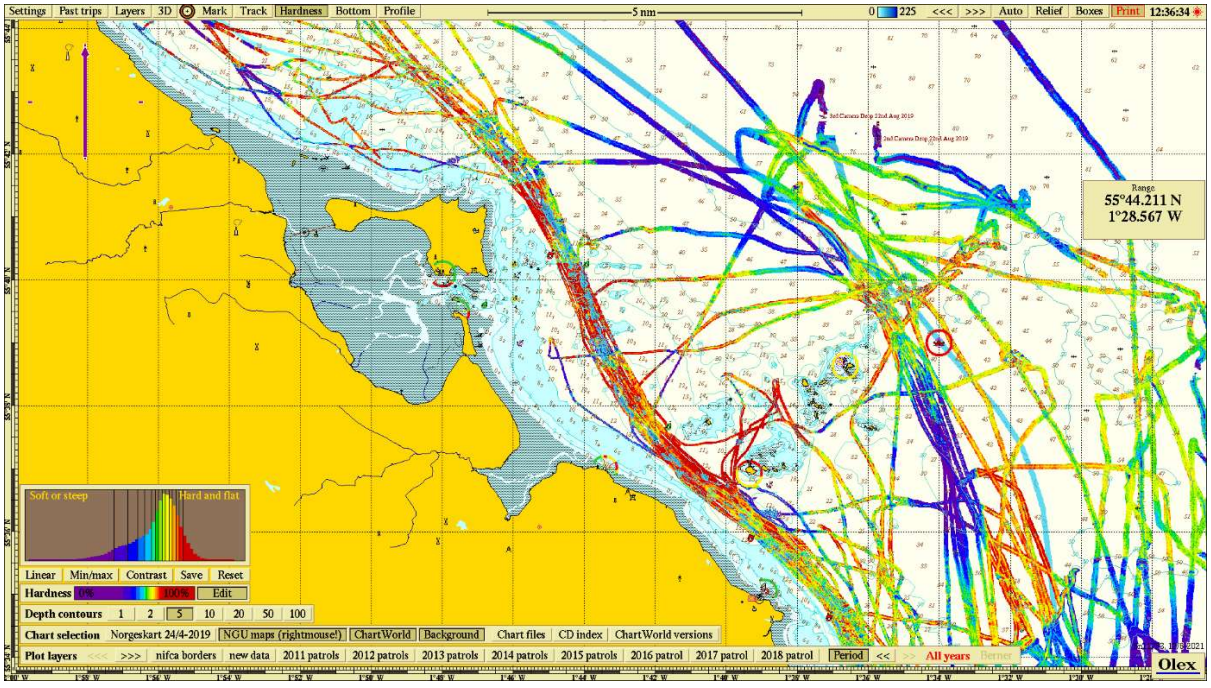

FIGURE 1: EXAMPLE OF OLEX DATA SUPPLIED BY NIFCA, SHOWING HARNESS INFORMATION FOR PATROL TRACKS IN THE STUDY AREA.

Underwater Imagery – Envision Shallow Inlets & Bays Project (2011)

The Envision report was examined for evidence of the target habitats. Much of the report focuses on intertidal areas, with a small area of subtidal habitat surveyed with underwater imagery close to Holy Island around the harbour. Findings from this discrete area were noted and included in survey planning.

Underwater Imagery – MSFD and Dredging up the Past Projects (2018-2020)

Existing underwater imagery and associated data files were reviewed to identify positive sightings of any of the target habitats within the study area. Specifically, individual images of boulder/cobble/pebble areas were interrogated in BIIGLE (https://biigle.de/) for stony reef qualifying features (e.g., >10% substrate made up of stones >64mm across, higher dominance of epifaunal species vs infaunal, and arising from the seafloor) (Irving, 2009). Area coverage was calculated for each still using the visible laser points (average 0.25 m^2 of seafloor per image). Images and associated data files were also reviewed for evidence of seagrass and other reef-forming species such as Sabellaria sp.

Key Findings

Substrate Data

OLEX data highlighted discrete areas of potential sandy mud in shallow zones which were deemed worth targeting for exploratory underwater video surveys for subtidal seagrass (locations seen in Field Data Collection section).

Underwater Imagery – Envision Shallow Inlets & Bays Project (2011)

The Envision report highlighted areas that may be potential subtidal mussel beds to the south of Holy Island Harbour (location seen in Field Data Collection section).

Underwater Imagery – MSFD and Dredging up the Past Projects (2018-2020)

There was evidence of detached seagrass fronds in sites surveyed inside the BNNC SAC during the Dredging up the Past Project in 2020. Survey sites with evidence of detached seagrass included Historic 1 (55 41.8422 N, 001 43.7929 W). Some examples of the specimens are shown in Figure 2. This site was over forty meters deep, so no seagrass could have grown here, but it raises questions about where these pieces could have drifted from, possibly subtidal beds in shallower water.

Areas of stony reef were observed in both the MSFD and Dredge projects (Table 1), hard substrate only (pebble, boulder, and bedrock) were assigned to categorise the seabed, and area coverage was calculated using visible laser points on each still.

FIGURE 2 EXAMPLES OF DETACHED SEAGRASS OBSERVED AT HISTORIC SITE 1

TABLE 1 : LOCATIONS OF STONY REEF FOUND DURING THE MSDF AND DREDGE PROJECTS FROM 2018-2020.

Site	Latitude DM	Longitude DM
Non 2	55 39.617 N	001 27.531 W
Non 1	55 40.631 N	001 35.556 W
Mod 3	55 41.0246 N	001 31.7706 W
Hist 5	55 39.7772 N	001 38.3022 W
Hist 3	55 39.6703 N	001 39.3142 W
Hist 2	55 41.2208 N	001 42.9370 W
Far-10-20	55 38.501 N	001 40.035 W

Sabellaria spp., were recorded during surveys for the MSFD project (Table 2).

TABLE 2 : LOCATION OF *SABELLARIA SPP.*, FOUND DURING THE MSDF AND DREDGE PROJECTS FROM 2018-2020 AT DEPTHS OF BETWEEN 10-46M.

Site	Latitude DM	Longitude DM
Far-20m-Mod	55 34.131 N	001 31.614 W
Sun-20m-Non (not near this study site)	54 49.879 N	001 11.075 W
Sun-10-20m-Mod (not near this study site)	54 53.293 N	001 18.287 W
Cres-10-20m-High (not near this study site)	55 11.8116 N	001 29.1838 W
Cul-10-20m-High (not near this study site)	55 04.819 N	001 26.419 W
Dun-10-20m-Mod (not near this study site)	55 29.294 N	001 33.983 W

Examples of the Sabellaria spp., are seen in Figure 3, all images were taken at a depth of 10m to 46m which indicates they are *S. spinulosa.*

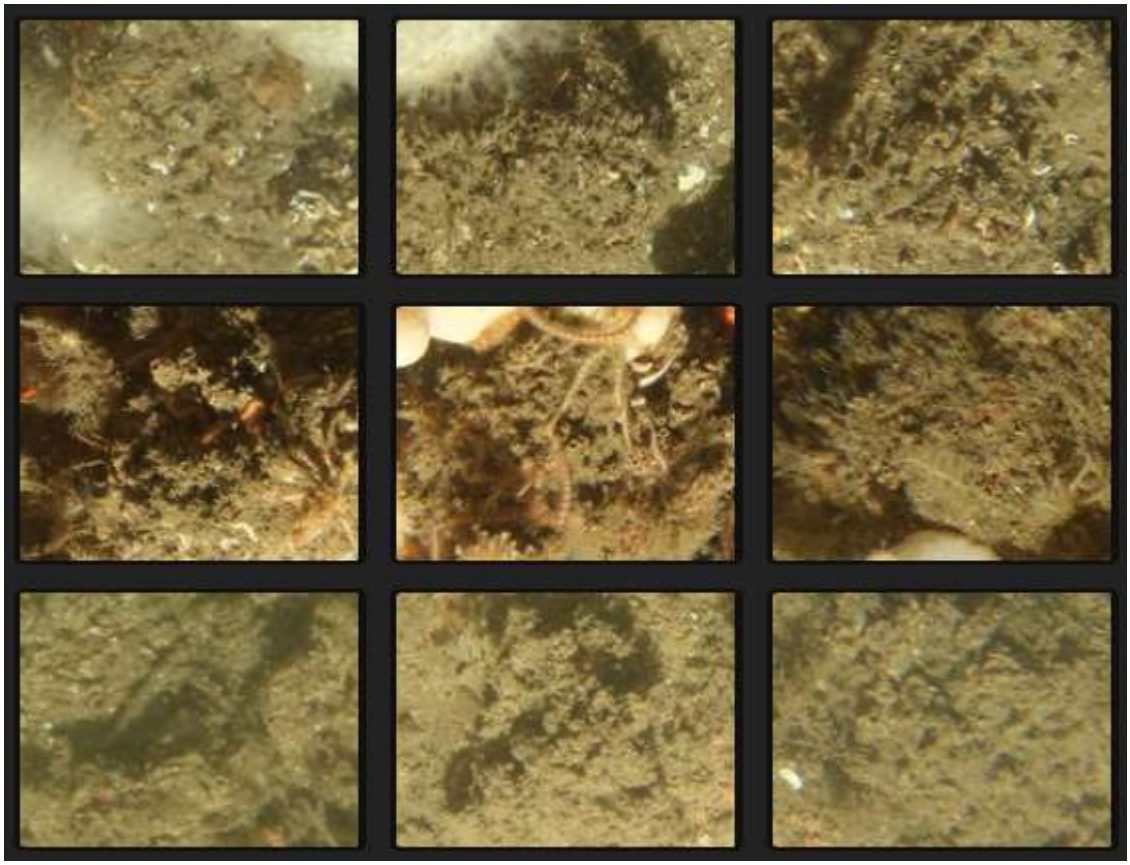

FIGURE 3: EXAMPLES OF SABELLARIA SPP., RECORDED DURING THE MSFD PROJECT.

Brittlestar., were also recorded during surveys for the MSFD project (Table 3).

TABLE 3 : LOCATION OF BRITTLESTAR BEDS FOUND DURING THE MSDF AND DREDGE PROJECTS FROM 2018-2020.

Site	Latitude DM	Longitude DM
Far-20m-Low	55 38.608 N	001 31.667 W
Far-20m-Low2	55 33.515 N	001 29.914 W
Coq-20m-High (Not near this study site)	55 16.504 N	001 29.538 W
Cres-10-20m-Low (Not near this study site)	55 16.348 N	001 31.1991 W

Examples of the Brittlestar., specimens recorded are seen in Figure 4.

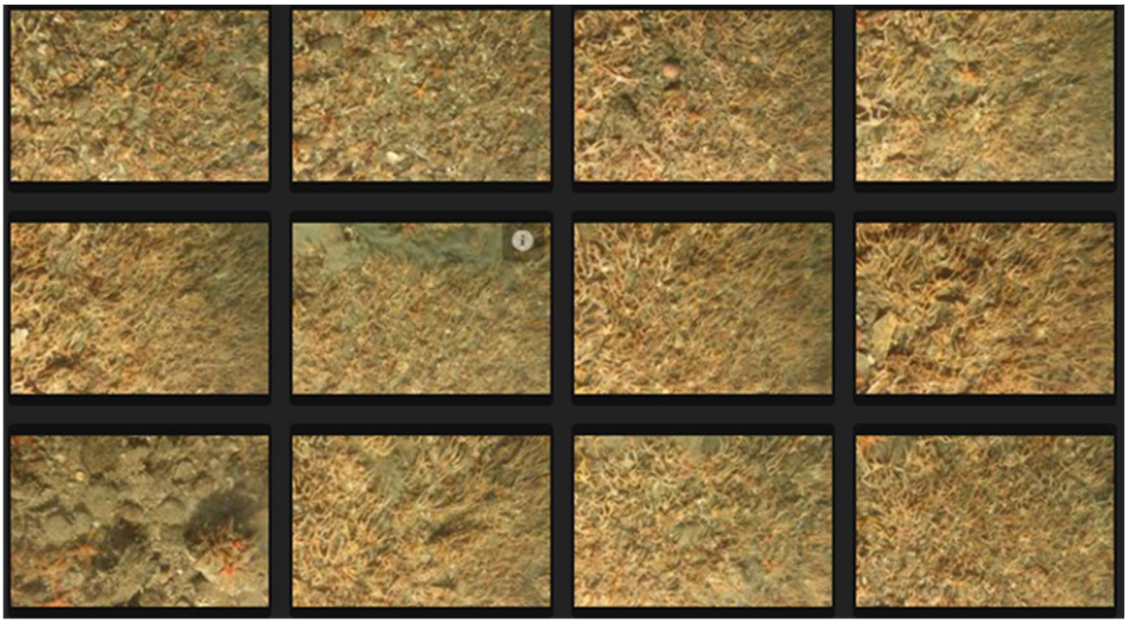

FIGURE 4: EXAMPLES OF BRITTLESTAR., RECORDED DURING THE MSFD PROJECT.

Field Data Collection

Methods

Survey Locations

Existing data and expert knowledge were combined to select target sites for exploratory surveys for each of the habitats. Points were selected where the evidence was strongest, and survey polygons were overlayed at appropriate scales (average area ~1km^2) and grouping similar conditions for underwater video surveys. Figure 5 shows the finalized survey sites for underwater video prospecting the shortlisted target habitats (stony reef, seagrass, and mussel beds). The coordinates of the polygon corners can be seen in Table 4. Transects were selected as close as possible to the target points dependent on conditions.

FIGURE 5: SURVEY SITES FOR UNDERWATER VIDEO PROSPECTING THE TARGET HABITATS (STONY REEF, SEAGRASS, AND MUSSEL BEDS).

TABLE 4: TABLE SHOWING THE EXTENT POINTS OF THE TARGET LATITUDE AND LONGITUDES FOR SURVEYS.

Polygon Name	Target Habitat	DDM Lat	DDM Long
South Stony	Stony Reef	55 38.38312419N	001 40.24013299W
South Stony	Stony Reef	55 38.51912232N	001 39.88787632W
South Stony	Stony Reef	55 37.97959592N	001 39.17225458W
South Stony	Stony Reef	55 37.92613676N	001 39.64479855W
North Stony	Stony Reef	55 40.84370437N	001 44.85459828W
North Stony	Stony Reef	55 41.12431337N	001 45.17159359W
North Stony	Stony Reef	55 41.56089393N	001 45.02045845W
North Stony	Stony Reef	55 40.95508343N	001 44.39307052W
Flats Entrance Mussel & Seagrass	Mussel & Seagrass	55 40.03332131N	001 48.20958507W
Flats Entrance Mussel & Seagrass	Mussel & Seagrass	55 39.71902697N	001 46.50820331W
Flats Entrance Mussel & Seagrass	Mussel & Seagrass	55 39.52483616N	001 46.90453803W
Flats Entrance Mussel & Seagrass	Mussel & Seagrass	55 39.87176051N	001 48.25244558W
North Seagrass	Seagrass	55 41.93865065N	001 48.90939621W
North Seagrass	Seagrass	55 42.00921266N	001 47.53738148W
North Seagrass	Seagrass	55 41.77349592N	001 47.34161391W
North Seagrass	Seagrass	55 41.57486809N	001 48.90353566W
South Seagrass	Seagrass	55 38.25536647N	001 44.27499813W
South Seagrass	Seagrass	55 38.07547267N	001 45.02671677W
South Seagrass	Seagrass	55 38.90521366N	001 45.62085551W
South Seagrass	Seagrass	55 38.99243910N	001 44.73024975W
South East Seagrass	Seagrass	55 38.92680614N	001 41.49138083W
South East Seagrass	Seagrass	55 38.64470248N	001 40.96084278W
South East Seagrass	Seagrass	55 38.00292904N	001 41.71047315W
South East Seagrass	Seagrass	55 38.53421972N	001 41.95455130W
Harbour Stony & Mussel	Stony Reef & Mussel Beds	55 40.09514725N	001 47.69114838W
Harbour Stony & Mussel	Stony Reef & Mussel Beds	55 40.04958199N	001 46.59882726W
Harbour Stony & Mussel	Stony Reef & Mussel Beds	55 39.82395386N	001 46.69682762W
Harbour Stony & Mussel	Stony Reef & Mussel Beds	55 39.94324133N	001 47.72168754W

Underwater Video Survey

Underwater video surveys were conducted by NIFCA, videos and stills were captured by a Sea Spyder camera system (ED140716), deployed from NIFCA's 16m catamaran 'St Aidan' in September 2021. The system combines an 18Mp digital still camera with high power flash, high intensity LED lights, mounted to a custom steel frame. The camera was towed slowly (<0.8 knots) just above the seabed, with a downward-facing orientation, the footage being relayed live to the surface. Stills were captured manually when the camera was stable and the lens unobstructed to ensure high-quality images.

The remotely operated underwater camera (ROV) was used on NIFCAs RIB the 'Robert Arkless MBE' The camera was towed within each target polygon at NIFCA's discretion, the boat drifted with the current determining the direction of the tow focussed in a downward facing orientation allowing video and stills to be captured.

The Sea Spyder (used for depths of over 30m) and ROV were dropped to the seabed at each location (between 2 and 11 times in each survey polygon depending on conditions), and video footage was recorded moving slowly along the seabed for four minutes on average. The ROV traversed the transect and investigated targets of interest . Final survey locations are detailed in Fig 6, Table 2.

Video surveys were analysed by two observers, and the following information was recorded in excel in the supplementary materials section.

- Substrate Description
- Mobile Fauna
- Sessile Fauna
- Flora
- Biogenic/ Interest Habitat present?
- Type of Biogenic/Interest Habitat
- Timestamp of Biogenic Example

Video footage was sped up or slowed down to manually record as many flora and fauna as possible, based on the conditions, identification was not required to be at species level due to time constraints. A species list was generated and only presence of the species along the transect was recorded (see supplementary materials). Target biogenic reef, or habitats of interest as part of the pilot project were recorded along with the timestamp, and stills were captured with a good example of the habitat type and any other pertinent information. Stills were not interrogated with BIGLE as per the historical projects.

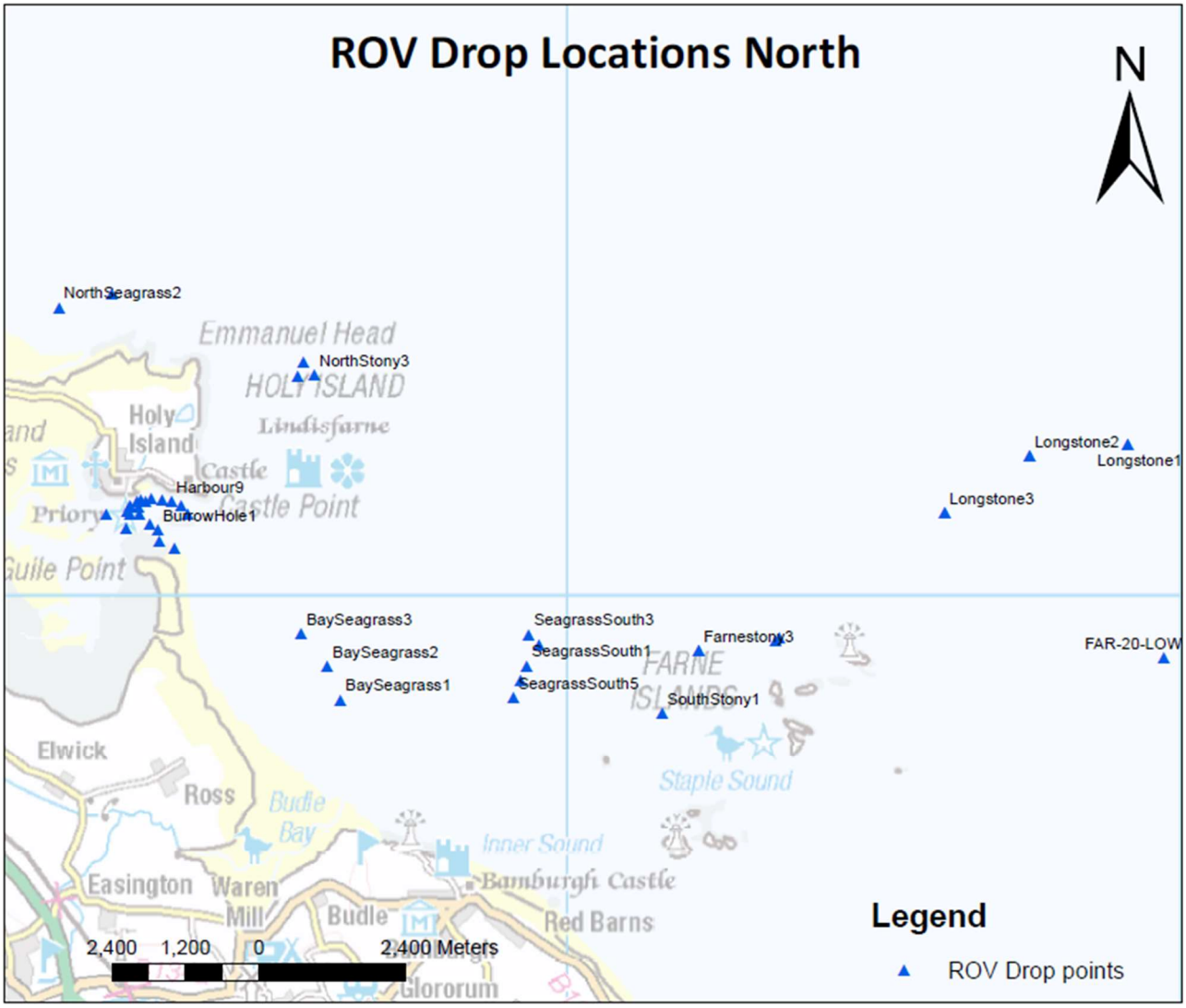

FIGURE 6: MAP SHOWING VIDEO REFERENCE AND START LOCATIONS SURVEYED BY THE ROV AND SEASPYDER (OS, 2021B).

TABLE 5: TABLE SHOWING LOCATIONS OF ROV START AND ENDPOINTS FOR SURVEYS.

Video Reference	Start Lat DM	Start Long DM	End Lat DM	End Long DM
SeagrassSouth1	55.642846	-1.692963	55.64194	-1.692671
SeagrassSouth2	55.645832	-1.689769	55.64563	-1.689627
SeagrassSouth3	55.647364	-1.692363	55.64701	-1.692194
SeagrassSouth4	55.640598	-1.694468	55.64038	-1.694371
SeagrassSouth5	55.638167	-1.696404	55.63783	-1.696467
BaySeagrass1	55.637926	-1.741223	55.63771	-1.741189
BaySeagrass2	55.642758	-1.744562	55.64254	-1.744536
BaySeagrass3	55.647634	-1.751338	55.64746	-1.751303
FlatsEntrance1	55.665123	-1.801827	55.66492	-1.801287
FlatsEntrance2	55.665254	-1.795624	55.66502	-1.795021
FlatsEntrance3	55.663095	-1.79658	55.66339	-1.796278
FlatsEntrance4	55.663852	-1.790474	55.66345	-1.789504
FlatsEntrance5	55.665309	-1.793242	55.66513	-1.79275
FlatsEntrance6	55.661205	-1.788038	55.66089	-1.788134
FlatsEntrance7	55.660278	-1.784075	55.65986	-1.783573
SouthStony1	55.63572	-1.657848	55.63629	-1.658517
NorthSeagrass1	55.69748	-1.800125	55.69745	-1.799653
NorthSeagrass2	55.695588	-1.813839	55.69554	-1.813607
NorthStony1	55.687562	-1.750553	55.68709	-1.750224
NorthStony2	55.685386	-1.752104	55.68504	-1.75186
NorthStony3	55.685583	-1.74768	55.6853	-1.74724
Harbour1	55.665662	-1.796349	55.66566	-1.797185
Harbour2	55.666434	-1.795579	55.66632	-1.796483
Harbour3	55.66628	-1.795525	55.66629	-1.795818
Harbour4	55.667001	-1.793801	55.66706	-1.793767
Harbour12	55.666273	-1.793454	55.66639	-1.793239
Harbour5	55.66727	-1.792853	55.6674	-1.792654
Harbour6	55.66714	-1.791571	55.6673	-1.79151
Harbour7	55.667458	-1.790156	55.66751	-1.789479
Harbour8	55.667348	-1.787283	55.66734	-1.78652
Harbour9	55.667065	-1.784852	55.66691	-1.784071
Harbour10	55.666462	-1.782294	55.66614	-1.781394
Harbour11	55.66518	-1.78067	55.66513	-1.78017
BurrowHole1	55.662879	-1.788424	55.66104	-1.785396
Longstone1	55.674797	-1.536832	55.66923	-1.529668
Longstone2	55.673233	-1.562256	55.67232	-1.561334
Longstone3	55.664855	-1.584443	55.66582	-1.58586
Farnestony1	55.646695	-1.627313	55.64623	-1.628331
Farnestony2	55.64623	-1.628331	55.64565	-1.629105
Farnestony3	55.644856	-1.648277	55.64646	-1.649082

Results

Interrogation of Historical Data – within BNNC SAC

Stony Reef

HIST-2, HIST-3, HIST-5, NON-1, NON-2, and MOD-3 (MSFD & Dredge projects, from seabed imagery) appear to be stony reef. Initial review of historical seabed imagery shows the presence of areas of coarse mixed sediment, this has the potential to constitute Annex 1 geogenic reef, not only near Holy Island and around the Farnes islands, but also as far east as the Farnes East Marine Conservation Zone (MCZ).

Brittlestar beds

Historic brittlestar beds (MSFD & Dredge projects, from seabed imagery) consisting of a mix of *O. nigra* and *O. fragilis* are located south of Longstone at FAR-20-LOW, and FAR-20-LOW2, these sites fall within the BNNC SAC and FAR-20-LOW2 in between Farnes East MCZ and Berwick to St Marys MCZ.

Sabellaria

Historic Sabellaria reefs (MSFD & Dredge projects, from seabed imagery) are located at FAR-20M-MOD, DUN-10-20M-MOD (in the BNNC SAC), CRES-10-20M-HIGH, CUL-10-20M-HIGH (in the MCZ), and SUN-20M-NON, SUN-10-20M-MOD outside the Berwick to St Mary's MCZ and BNNC SAC (Tinlin-Mackenzie, 2022b; Tinlin-Mackenzie, 2022a).

Mussel Beds

No evidence of mussel beds was found in the historical data from the seabed imagery.

Seagrass

No evidence of seagrass beds was found in the historical data from the seabed imagery, only one detached frond was observed at HIST-1 (Figure 2).

Locations of all historical key habitats can be seen in figures 7 and 8.

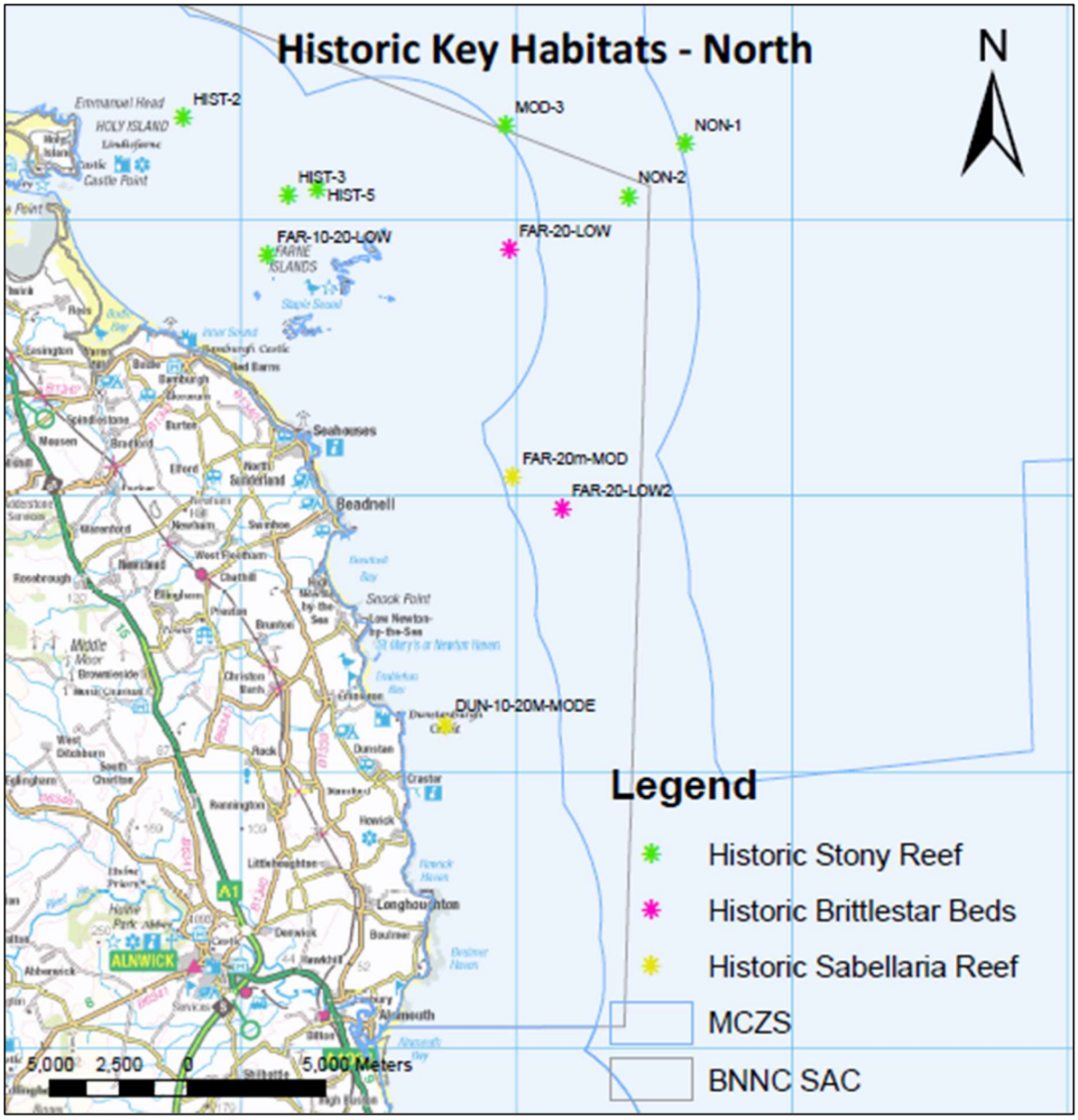

FIGURE 7 : MAP SHOWING THE LOCATIONS OF ALL HISTORIC KEY HABITATS IN THE NORTHERN AREA OF THE STUDY, INCLUDING THE BNNC SAC, BERWICKSHIRE TO ST MARYS MCZ, AND FARNES EAST MCZ.

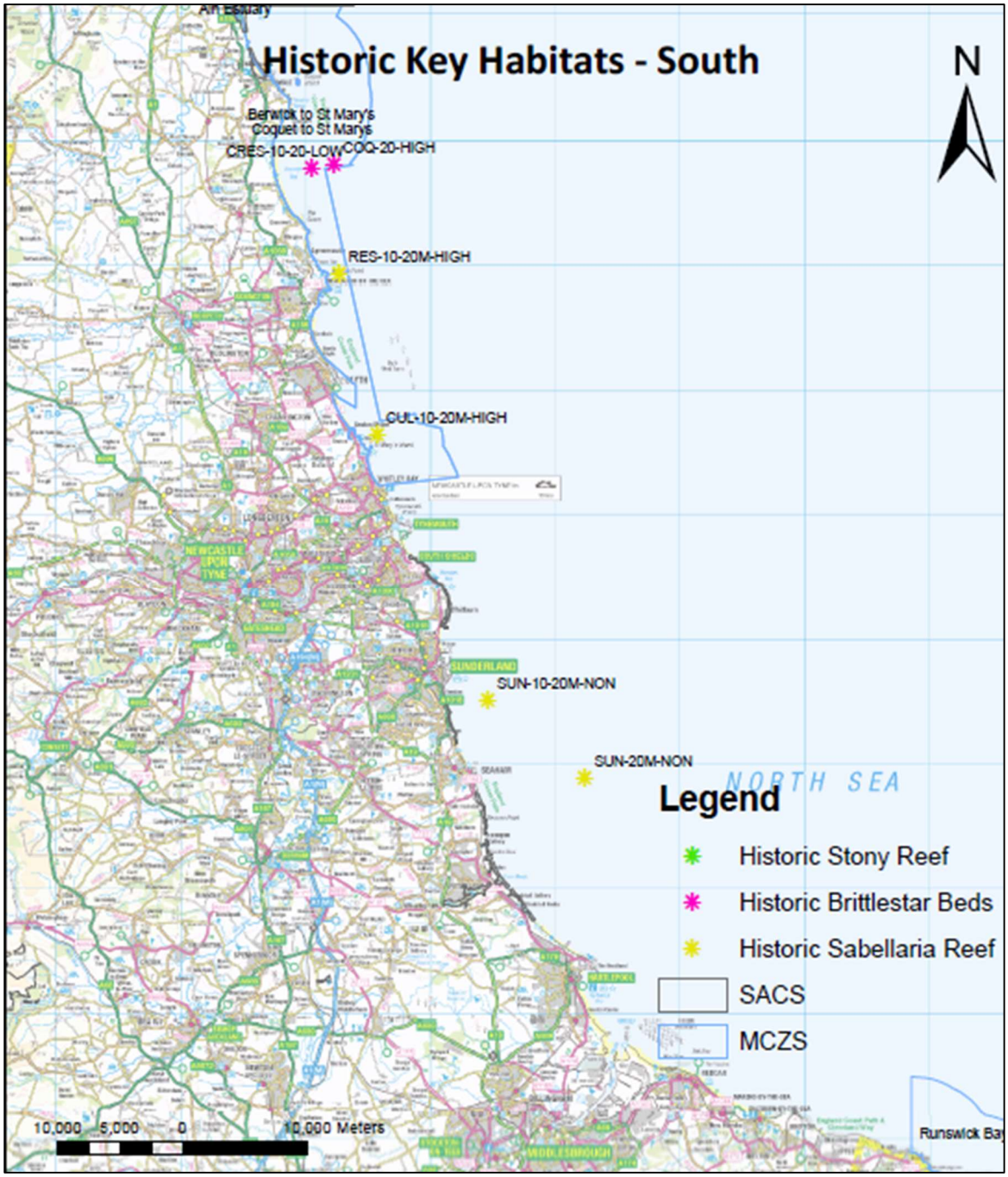

FIGURE 8 : MAP SHOWING THE LOCATIONS OF ALL HISTORIC KEY HABITATS IN THE SOUTHERN AREA OF THE STUDY, INCLUDING WITHIN THE BERWICKSHIRE TO ST MARYS MCZ AND THOSE OUTSIDE OF DESIGNATED SITES.

Interrogation of Newly collected data – ROV and Towed Camera Observations within the BNNC SAC

Stony reef, subtidal mussel beds, brittlestar beds, and possible Maerl were observed within the BNNC SAC from the ROV, and towed camera footage provided by NIFCA within the survey polygons (Figure 5). Stills captured during the analysis of the ROV video footage and towed camera stills are shown in figures 10-20. Five sites had evidence of stony reef, and seven sites with biogenic reef (not including historic data).

Confidence levels were assigned as high or low. High confidence - the observer could confidently identify the habitats of interest, videos and stills were clear and easy to observe. Low confidence - the observer could not confidently identify the habitat of interest, due to difficulty in identification or video and still quality was insufficient.

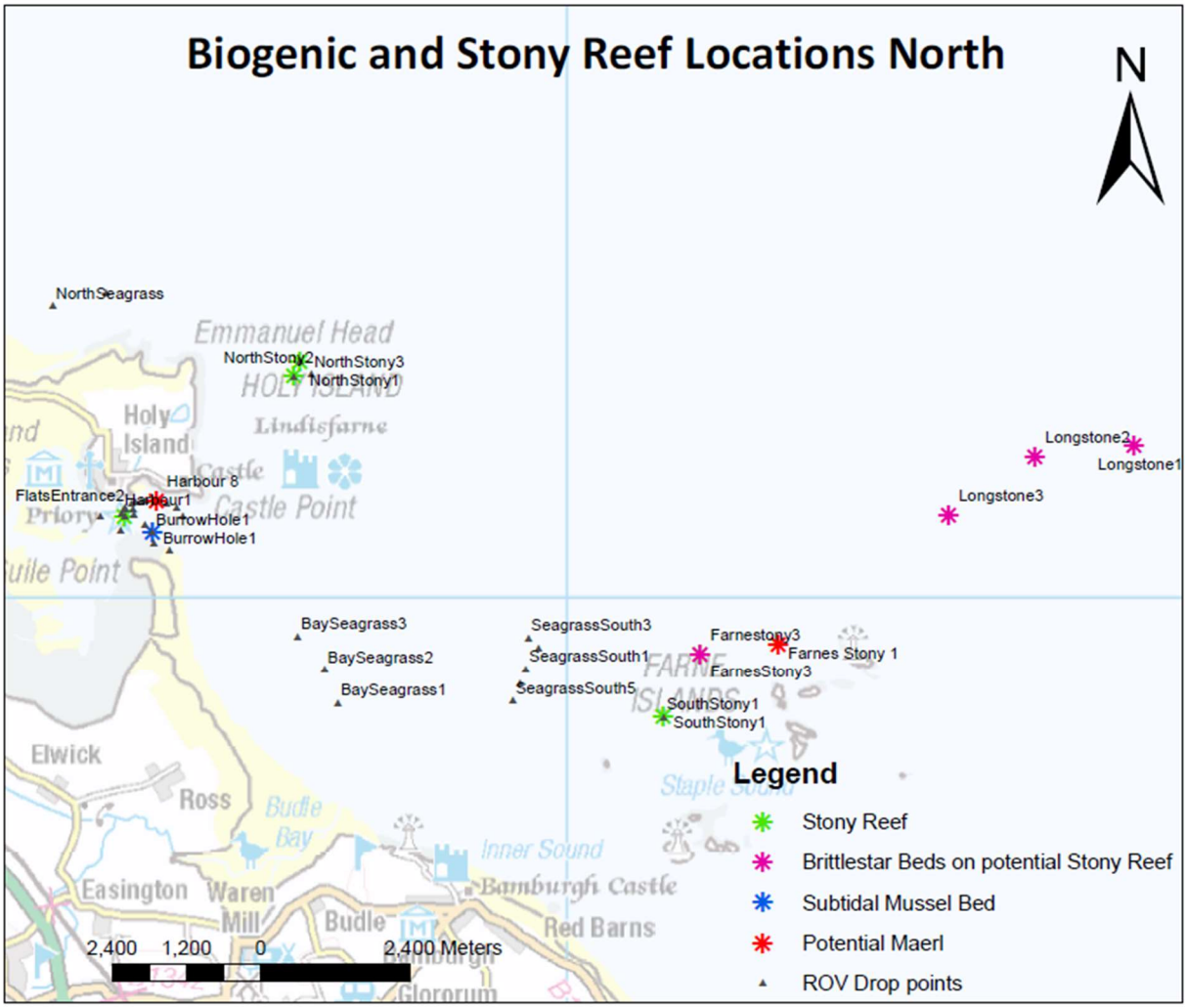

FIGURE 9: MAP SHOWING BIOGENIC AND STONY REEF HABITAT, IDENTIFIED BY THE ROV SURVEYS, IN SEPTEMBER 2021(OS, 2021B).

Brittlestar beds were identified in three locations with high confidence.

- Longstone 1 (Figure 10).
- Longstone 2 (Figure 11).
- Longstone 3 (Figure 12).

All sites had a combination of *O. nigra* and *O. fragilis* on a mix of sand pebble, cobble, and boulder. The beds were rich in associated species.

Longstone 1

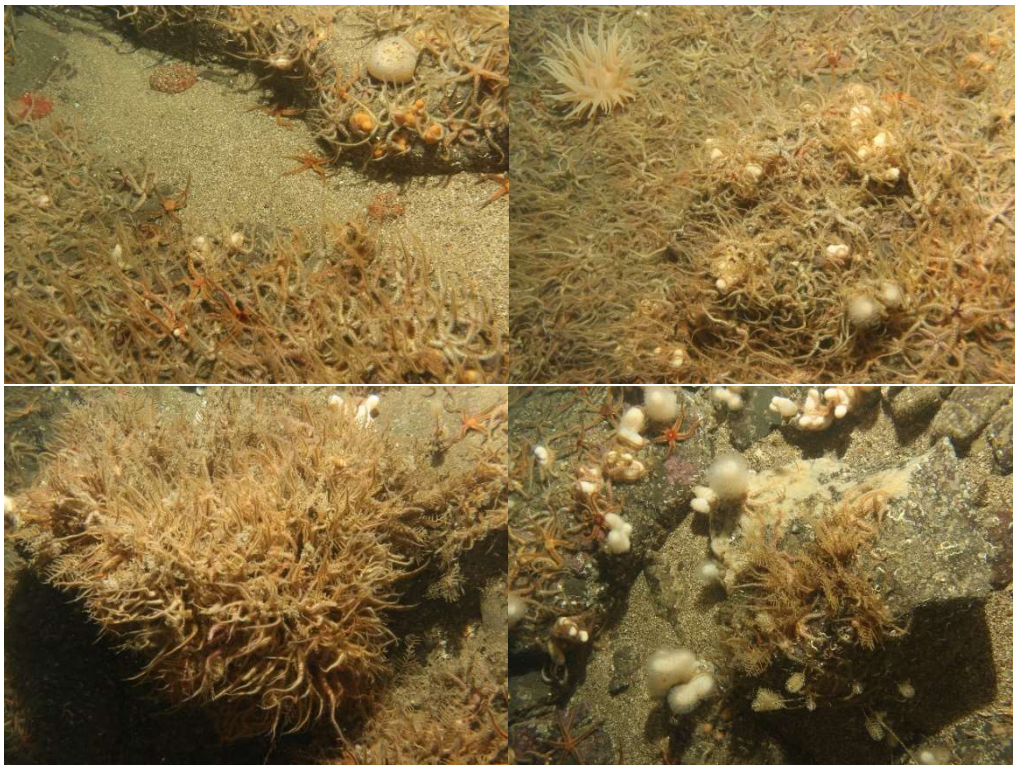

FIGURE 10: STILLS CAPTURED AT LONGSTONE 1 DURING SURVEYS BY THE SEASPYDER TOWED CAMERA IN SEPTEMBER 2021 AT A DEPTH OF 48.5M, NOTE THE PRESENCE OF DENSE BRITTLE STAR BEDS, SOFT CORALS, ANEMONES, AND HYDROIDS.

Longstone 2

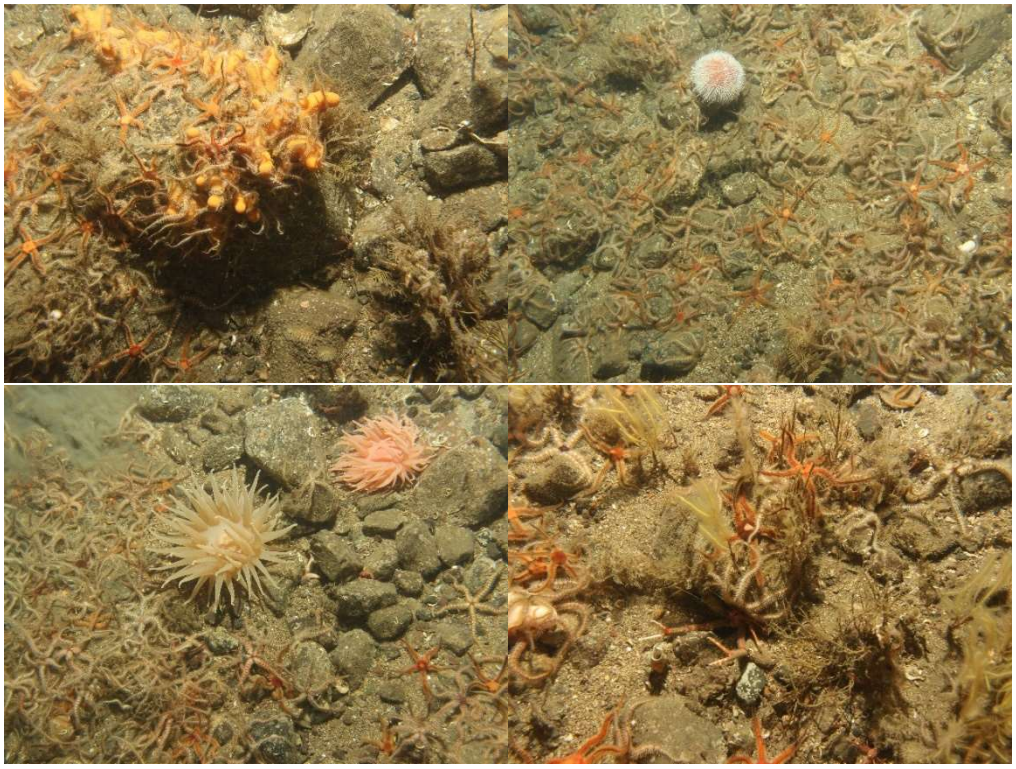

FIGURE 11: STILLS CAPTURED AT LONGSTONE 2 DURING SURVEYS BY THE SEASPYDER TOWED CAMERA IN SEPTEMBER 2021 AT A DEPTH OF 51.6M, NOTE THE PRESENCE OF DENSE BRITTLE STAR BEDS, SOFT CORALS, ANEMONES, SEA PENS, HYDROIDS, AND SEA URCHINS.

Longstone 3

FIGURE 12: STILLS CAPTURED AT LONGSTONE 3 DURING SURVEYS BY THE SEASPYDER TOWED CAMERA IN SEPTEMBER 2021 AT A DEPTH OF 51.5M, NOTE THE PRESENCE OF DENSE BRITTLE STAR BEDS, SOFT CORALS, DAHLIA ANEMONE, SEA PENS, AND HYDROIDS.

Subtidal mussel beds were identified in one location with high confidence.

- Burrow Hole 1 (Figure 13).

Sand/Pebble/Cobble and boulder were present at this site and dense areas of living juvenile *Mytilus edulis* beds at 15m depth, scattered with frequent dead adult mussels. There were some patchy areas of adult mussels present towards the end of the survey video.

BurrowHole1

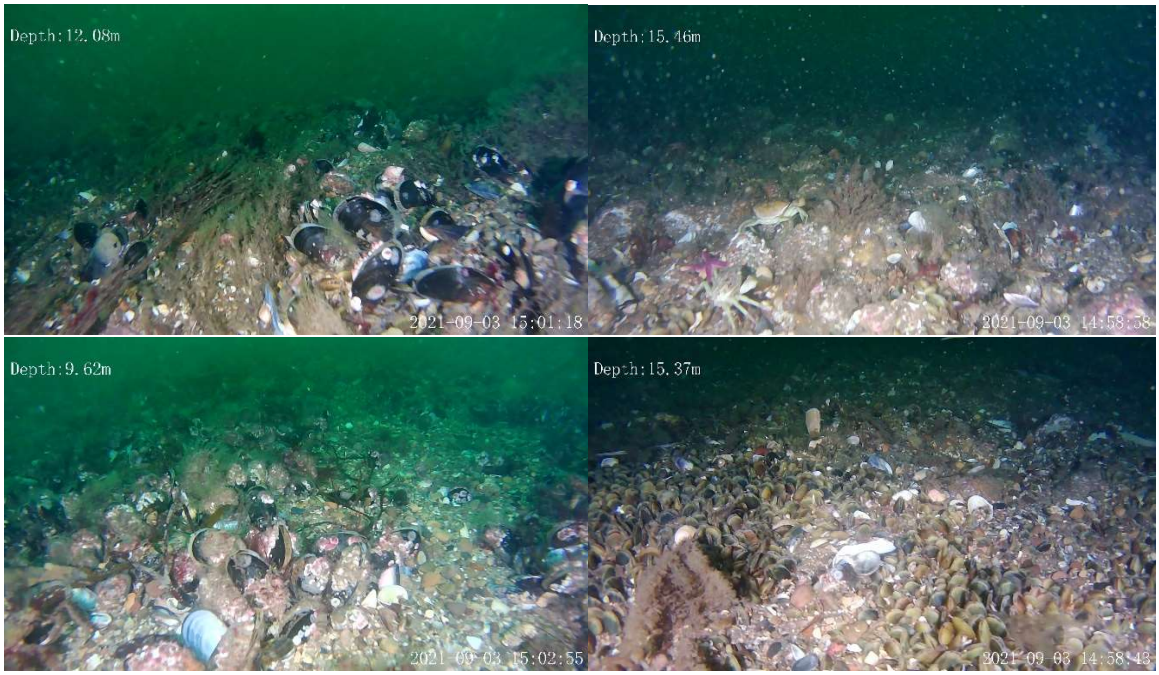

FIGURE 13: STILLS CAPTURED AT BURROW HOLE 1 DURING THE ROV SURVEYS IN SEPTEMBER 2021 AT A DEPTH OF 15.7M, NOTE THE PRESENCE OF DENSE JUVENILE MUSSEL BEDS, STARFISH, CRABS, AND ENCRUSTING CORALLINE ALGAE.

Maerl was identified at 2 sites with low confidence due to video and still quality and difficulty in identification.

- Farnes Stony 1 (Figure 14).

One large patch of potential Maerl was observed at 28m depth on a gravel substrate.

- Harbour 8 (Figure 15).

1-2 small patches potentially of Maerl were observed within the sand/pebble and cobble at 3.5m depth.

Farnes Stony 1

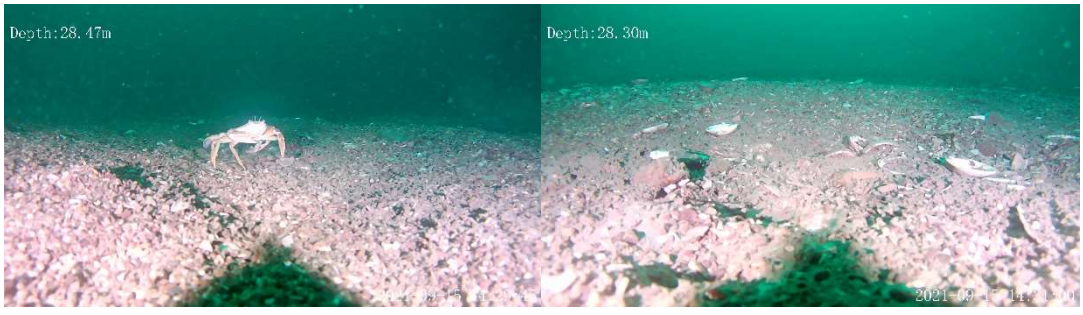

FIGURE 14: STILLS CAPTURED AT FARNES STONY 1 DURING THE ROV SURVEYS IN SEPTEMBER 2021 AT A DEPTH OF 30.5M, NOTE THE PRESENCE OF A POTENTIAL MAERL BED.

Harbour 8

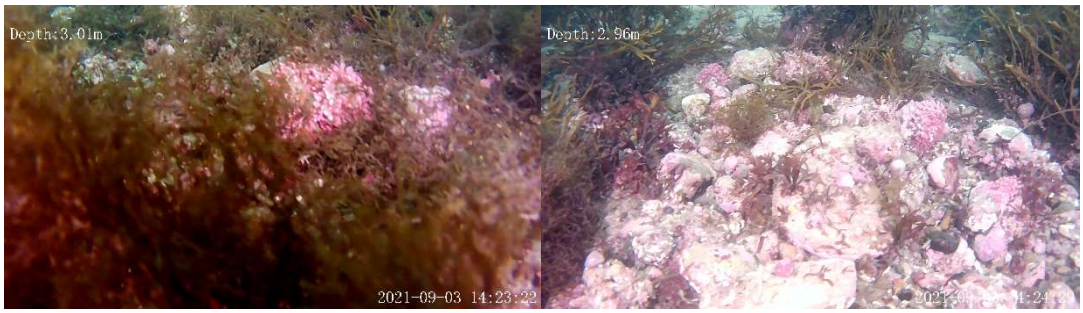

FIGURE 15: STILLS CAPTURED AT HARBOUR 8 DURING THE ROV SURVEYS IN SEPTEMBER 2021 AT A DEPTH OF 3.5M, NOTE THE PRESENCE OF A SMALL PATCH OF POTENTIAL MAERL.

Stony Reef was identified by ROV with high confidence in five survey locations and low confidence in 3 survey locations (Longstone 1-3).

- Flats Entrance 2 (Figure 16)

Pebble and cobble were dominant with an abundance of associated epifaunal species and seaweeds.

- South Stony 1 (Figure 17)

Boulders were the dominant substrate with an abundance of soft corals (*A. digitatum*) and associated epifaunal species.

- North Stony 1 (Figure 18)

Sand/pebble/cobble and boulder were dominant with an abundance of associated epifaunal species.

- North Stony 2 (Figure 19)

Sand/pebble/cobble and boulder were dominant with an abundance of associated epifaunal species.

- Farnes Stony 3 (Figure 20)

Pebble/cobble and boulder were dominant, with an abundance of soft corals (*A. digitatum*) reefs and associated epifaunal species.

Low confidence was assigned to the Longstone sites as only images were provided as the site was too deep for the ROV.

- Longstone 1 (Figure 10).
- Longstone 2 (Figure 11).
- Longstone 3 (Figure 12).

These sites had a combination of *O. nigra* and *O. fragilis* on a mix of sand pebble, cobble, and boulder. The beds were rich in associated species and have the potential to be stony reef due to their seemingly elevated position on the seabed but, the extent and composition could not be assessed fully.

Flats Entrance 2

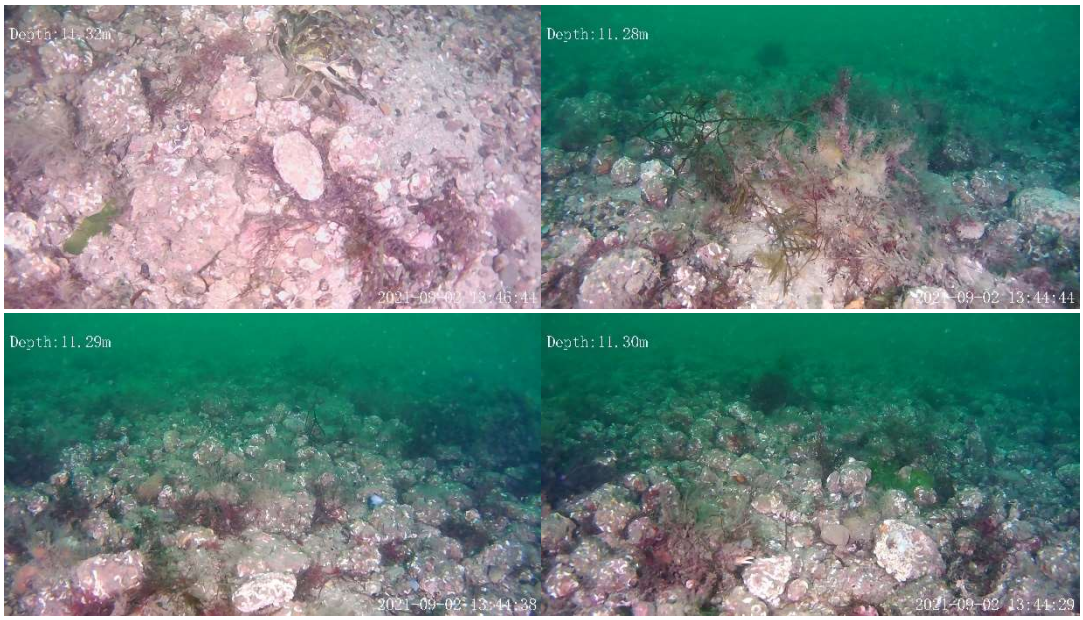

FIGURE 16: STILLS CAPTURED AT FLATS ENTRANCE 2 DURING THE ROV SURVEYS IN SEPTEMBER 2021 AT A DEPTH OF 12M, NOTE THE PRESENCE OF STONY REEF, CRABS, ENCRUSTING CORALLINE ALGAE, SEA LETTUCE, AND BROWN FILAMENTOUS ALGAE.

South Stony 1

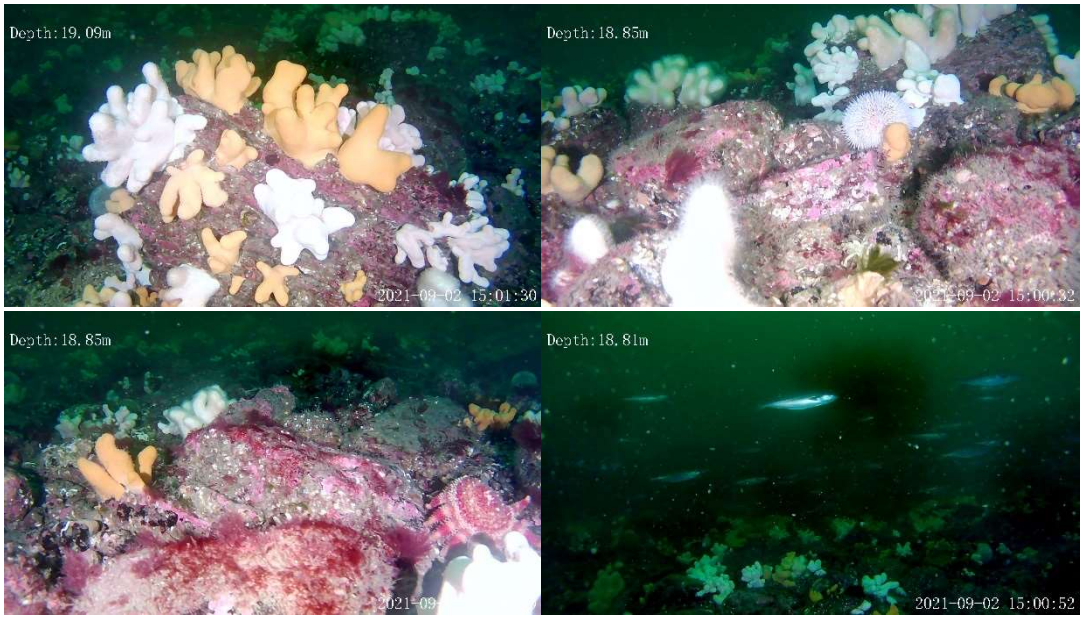

FIGURE 17: STILLS CAPTURED AT SOUTH STONY 1 DURING THE ROV SURVEYS IN SEPTEMBER 2021 AT A DEPTH OF 18M, NOTE THE PRESENCE OF STONY REEF INCLUDING SOFT CORALS, SUN STARS, SEA URCHINS, FISH, RED/BROWN TURF FORMING, AND ENCRUSTING CORALLINE ALGAE.

North Stony 1

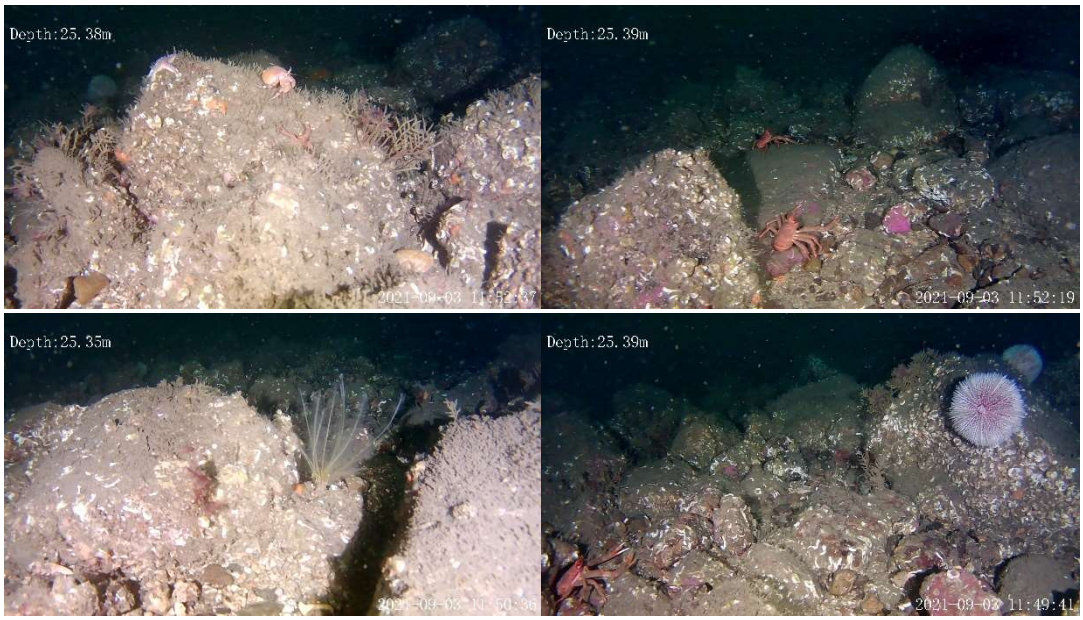

FIGURE 18: STILLS CAPTURED AT NORTH STONY 1 DURING THE ROV SURVEYS IN SEPTEMBER 2021 AT A DEPTH OF 24.9M, NOTE THE PRESENCE OF STONY REEF, SQUAT LOBSTERS, HYDROIDS, SEA URCHINS, SEA BEARD, ENCRUSTING CORALLINE ALGAE, AND BROWN BUSHY BRANCHING ALGAE.

North Stony 2

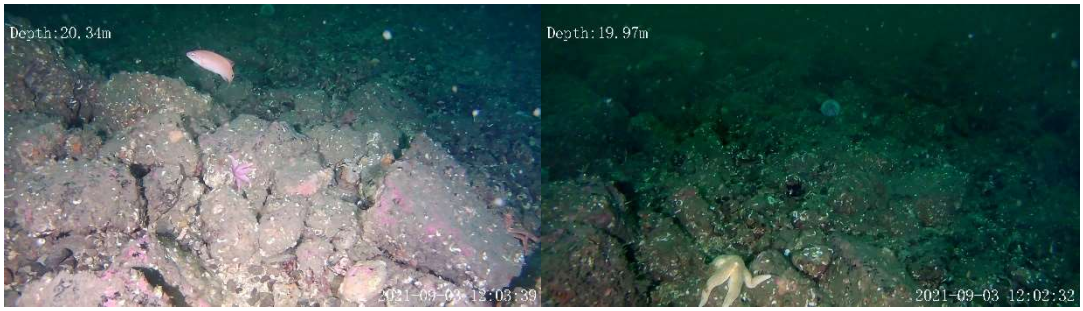

FIGURE 19: STILLS CAPTURED AT NORTH STONY 2 DURING THE ROV SURVEYS IN SEPTEMBER 2021 AT A DEPTH OF 21M, NOTE THE PRESENCE OF STONY REEF, NOTE THE PRESENCE OF STARFISH, SEA URCHINS, WRASSE, SQUAT LOBSTER, TUBE WORMS, AND RED/BROWN TURF FORMING ALGAE.

Farnes Stony 3

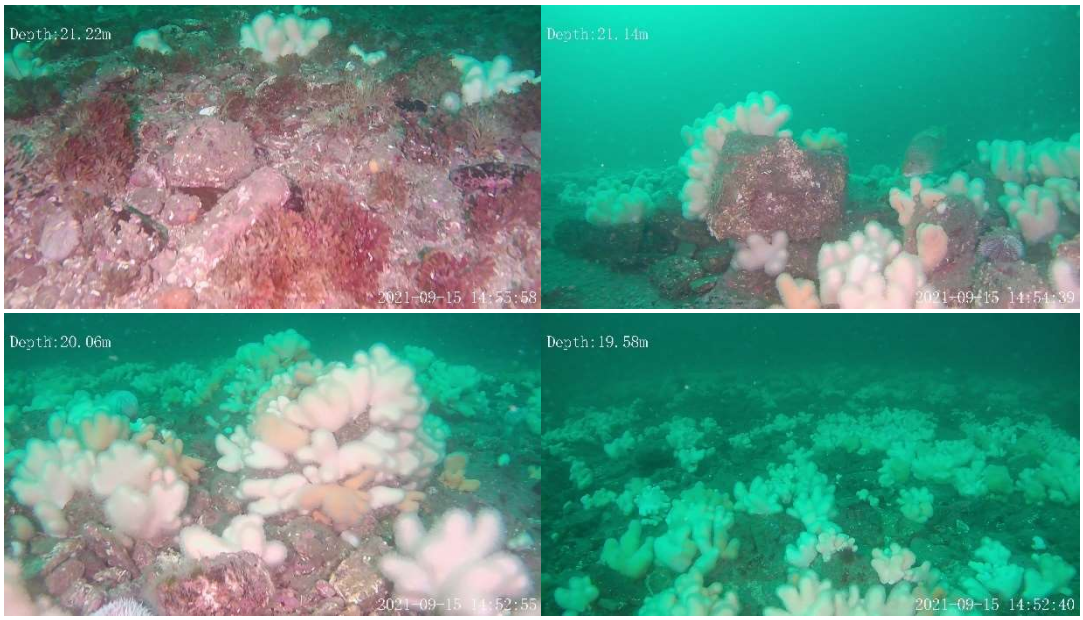

FIGURE 20: STILLS CAPTURED AT FARNES STONY 3 DURING THE ROV SURVEYS IN SEPTEMBER 2021 AT A DEPTH OF 21M, NOTE THE PRESENCE OF STONY REEF AND THE ABUNDANCE OF SOFT CORALS, CORALLINE ENCRUSTING ALGAE, WRASSE, STARFISH, AND SEA URCHINS.

Seagrass and Sabellaria were not identified in the pilot project when surveyed with the ROV or towed camera within the BNNC SAC.

TABLE 6: TABLE SHOWING THE HABITAT AND SUBSTRATE TYPE AT EACH LOCATION FROM THE ROV AND SEASPYDER CAMERA SURVEYS AS WELL AS THE HISTORICAL DATA.

Video Reference	Latitude DM	Longitude DM	Habitat Type	Substrate
FlatsEntrance2	55.665254	-1.795624	Stony Reef	Pebble/cobble
SouthStony1	55.635720	-1.657848	Stony Reef	Boulder
NorthStony1	55.687562	-1.750553	Stony Reef	Sand/Pebble/cobble
NorthStony2	55.685386	-1.752104	Stony Reef	Cobble/Boulder
Harbour8	55.667348	-1.787283	Maerl Patches	Sand/Pebble/cobble
BurrowHole1	55.662879	-1.788424	Mussel Bed	Sand/Pebble/Cobble/Boulder
Longstone1	55.674797	-1.536832	Brittlestar Bed	Sand/Boulder
Longstone 2	55.673233	-1.562256	Brittlestar Bed	Sand/Pebble/cobble
Longstone3	55.664855	-1.584443	Brittlestar Bed	Sand/Pebble
Farnestony1	55.646695	-1.627313	Maerl Bed	Gravel
Farnestony3	55.644856	-1.648277	Brittlestar bed	Pebble/Cobble/Boulder
NON-1	55.677167	-1.426000	Stony Reef	Pebble/Cobble/Boulder
NON-2	55.660283	-1.458850	Stony Reef	Pebble/Cobble/Boulder
MOD-3	55.683743	-1.529510	Stony Reef	Pebble/Cobble/Boulder
HIST-5	55.662953	-1.638370	Stony Reef	Pebble/Cobble/Boulder
HIST-3	55.661172	-1.655237	Stony Reef	Pebble/Cobble/Boulder
HIST-2	55.687013	-1.715617	Stony Reef	Pebble/Cobble/Boulder
FAR-10-20-LOW	55.641683	-1.667250	Stony Reef	Pebble/Gravel/Boulder
SUN-20M-NON	54.831317	-1.184583	Sabellaria	Sand/Gravel/Boulder/Rock

SUN-10-20M-NON	54.888217	-1.304783	Sabellaria	Sand/Gravel/Boulder/Rock
CRES-10-20M-HIGH	55.196860	-1.486397	Sabellaria	Boulder/Rock
CUL-10-20M-HIGH	55.080317	-1.440317	Sabellaria	Boulder/Rock
DUN-10-20M-MOD	55.488233	-1.566383	Sabellaria	Sand/Boulder/Rock
FAR-20m-MOD	55.568850	-1.526900	Sabellaria	Sand/Gravel/Pebble/Boulder/Rock
FAR-20-LOW	55.643467	-1.527783	Brittlestar Beds	Pebble/Boulder/Rock
FAR-20-LOW2	55.558583	-1.498567	Brittlestar Beds	Sand/Gravel/Pebble/Boulder/Rock
COQ-20-HIGH	55.275067	-1.492300	Brittlestar Beds	Sand/Boulder/Rock
CRES-10-20-LOW	55.272468	-1.519985	Brittlestar Beds	Sand/Pebble/Boulder/Rock

Synthesis of Historic and New Data

Key habitats found during the Shallow Inlets and Bays pilot project, and historical MSDF and Dredge projects can be seen in Figure 21 (within the BNNC SAC) and Figure 22 (outside the BNNC SAC), and site details can be found in Table 7. Note, Farnes Stony 3 and Longstone 1-3 may also constitute potential stony reef.

FIGURE 21: MAP SHOWING ALL CONFIRMED BIOGENIC AND STONY REEF HABITATS IN THE BNNC SAC (JNCC, 2020; NATURALENGLAND, 2021; OS, 2021B).

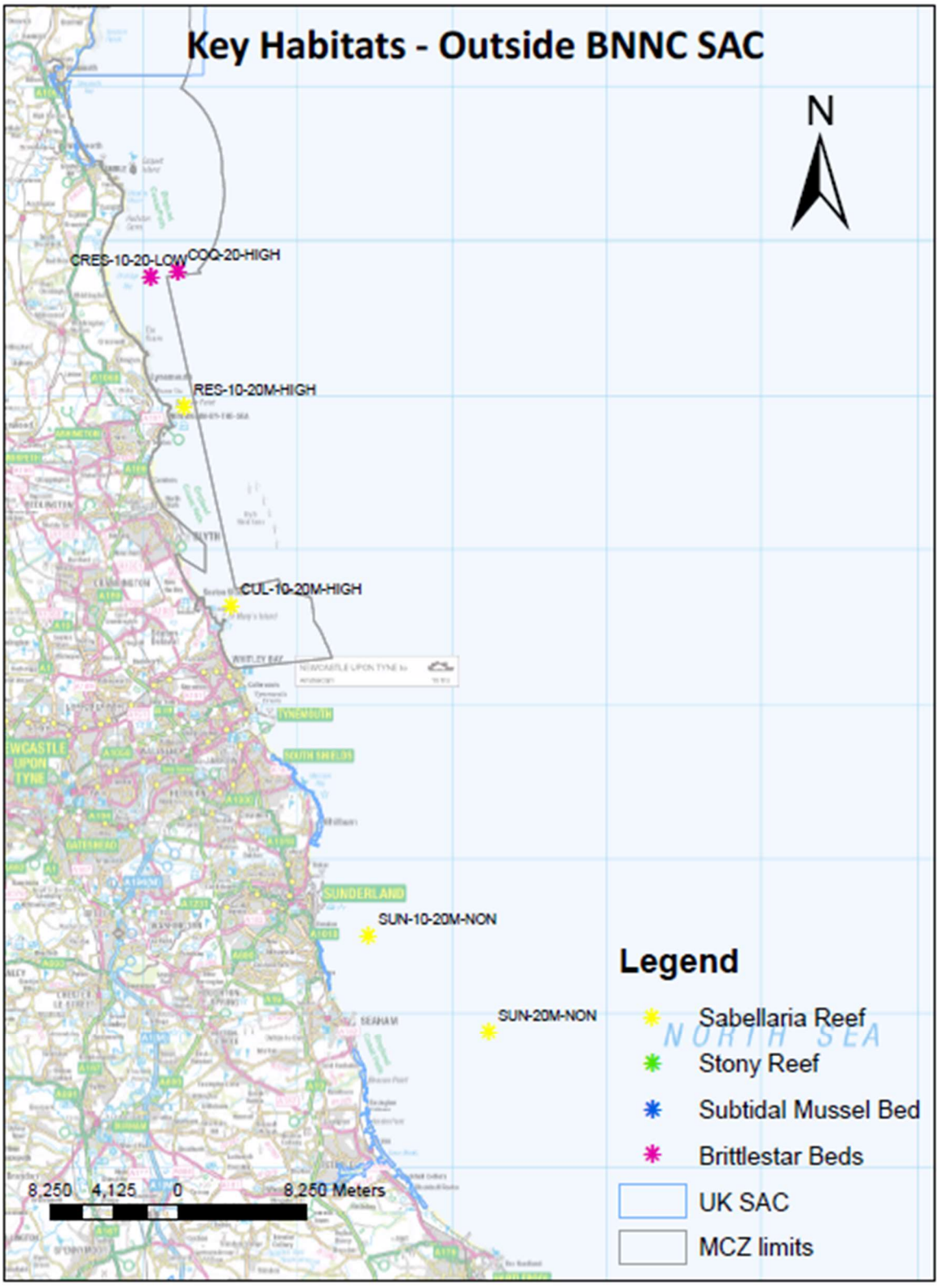

FIGURE 22: MAP SHOWING ALL CONFIRMED BIOGENIC AND STONY REEF HABITATS OUTSIDE THE BNNC SAC (JNCC, 2020; NATURALENGLAND, 2021; OS, 2021B).

TABLE 7: *TABLE OF CO-ORDINATES OF ALL TARGET HABITATS WITHIN AND OUTSIDE OF THE BNCC SAC.*

Site Reference	Latitude DM	Longitude DM	Habitat Type
FlatsEntrance2	55.66525396	-1.79562402	Stony Reef
SouthStony1	55.63571999	-1.657847995	Stony Reef
NorthStony1	55.68756198	-1.750553017	Stony Reef
NorthStony2	55.68538603	-1.752104005	Stony Reef
Harbour8	55.66734801	-1.78728302	Maerl Patches
BurrowHole1	55.66287903	-1.788423965	Mussel Bed
Longstone1	55.67479701	-1.536832005	Maerl Bed
Longstone3	55.66485498	-1.584442975	Stony Reef
Farnestony1	55.646695	-1.627312973	Brittlestar bed
Farnestony2	55.64622997	-1.628331039	Brittlestar bed
Farnestony3	55.64485601	-1.648277035	Brittlestar bed
NON-1	55.677167	-1.426	Stony Reef
NON-2	55.660283	-1.45885	Stony Reef
MOD-3	55.683743	-1.52951	Stony Reef
HIST-5	55.662953	-1.63837	Stony Reef
HIST-3	55.661172	-1.655237	Stony Reef
HIST-2	55.687013	-1.715617	Stony Reef
FAR-10-20-LOW	55.641683	-1.667250	Stony Reef
SUN-20M-NON	54.831317	-1.184583	Sabellaria
SUN-10-20M-NON	54.888217	-1.304783	Sabellaria
RES-10-20M-HIGH	55.19686	-1.486397	Sabellaria
CUL-10-20M-HIGH	55.080317	-1.440317	Sabellaria
DUN-10-20M-MODE	55.488233	-1.566383	Sabellaria
FAR-20m-MOD	55.56885	-1.5269	Sabellaria
FAR-20-LOW	55.64346667	-1.527783333	Brittlestar Beds
FAR-20-LOW2	55.55858333	-1.498566667	Brittlestar Beds
COQ-20-HIGH	55.27506667	-1.4923	Brittlestar Beds
CRES-10-20-LOW	55.27246833	-1.519985	Brittlestar Beds

Discussion and Recommendations for Future Surveys

Brittlestar beds

Brittlestar beds on sublittoral mixed sediment are a habitat of principal importance (Marlin, 2022). Longstone 1- 3, have a mixture of *O. fragilis* and *O. nigra* on mixed sediments at around 50m depth and there is a possibility that there may be larger interconnected brittlestar beds between all three sites worthy of future surveys. The beds seen in the pilot project at Longstone 1-3 are rich in epifaunal species such as *A. digitatum,* hydroids, anemones, and sea urchins and may contain potential stony reef. Historic data from FAR-20-LOW, FAR-20-LOW2 and FAR-10-20-LOW, CRES-10-20-LOW, and COQ-20-HIGH suggest that brittlestar beds are commonly found in the BNNC and Berwick to St Marys MCZ with eight sites identified as brittlestar beds in total. It should be noted that the historical data is from 2018-2020 and given the ephemeral nature of brittlestar beds, their status at the time of reporting is unknown.

Subtidal Mussel Beds

Mussel beds are a habitat of principal importance under section 41 of NERC 2006 when found on sublittoral sediment, Annex 1 under the habitats directive and listed by OSPAR as a threatened and declining habitat (OSPAR, 2014; JNCC, 2016a). Mussel beds were only observed at Burrow hole 1 in the pilot project, appear to be mostly juvenile mussels with some patches of mature mussel aggregations, the bed was rich in epifaunal species such as crab and starfish many with encrusting coralline algae and a variety of seaweeds. Future surveys of this area to identify further mussel beds would be relatively simple due to the accessible nature, and shallow depth of the site. This would complement the current yearly surveys of the intertidal mussel beds in the area at Fenham Flats and Holy Island sands and assist in further understanding the extent and distribution of the subtidal beds and their influence upon each other.

Maerl

The common maerl bed forming species *L.corallioides* and *P.calcareum* are listed under Annex V of the EC Habitats Directive and are a key habitat within some of the Annex I habitats of the directive, therefore are protected by the designation of SACs. In the UK, maerl beds on sublittoral sediments are a subject of the UK habitat action plan under the Biodiversity Action Plan (UK BAP) and listed by OSPAR as a threatened and declining habitat (OSPAR, 2008; Hall-Spencer *et al.*, 2010; JNCC, 2016b; OSPAR, 2019).

Maerl was identified from the pilot project with low confidence, it is generally not found on the northeast coast of England and is difficult to identify in the field. Given the accessibility of Harbour 8, further surveys could be conducted by ROV to confirm the presence or absence of maerl, and if identified, diver surveys could confirm species. If there are living maerl beds present within the Harbour area of Holy Island they may be at risk due to eutrophication (EA, 2020). The potential maerl identified at Farnes Stony 1 is at 28m depth and further offshore, therefore is at less risk of damage due to the current byelaws that prevent mobile fishing gear within the BNNC SAC (NIFCA, 2021).

Stony Reef

Subtidal rocky reefs rich in marine species are an Annex 1 habitat (JNCC, 2021) and stony reef is a common feature within the BNNC SAC, this study has identified 10 sites within the BNNC SAC and one in Farnes East MCZ (JNCC, 2015). Aggregation of historic data revealed that HIST-2 is located near the pilot project sites North Stony 1 & 2 suggesting further stony reef may lie between these sites. Similarly, stony reefs at South Stony 1 and Farnes Stony 3 are near each other. Flats Entrance 2 (Figure 11) shows stony reef examples along with the mussel beds at Burrow Hole 1, and the possibility of further stony reef at Longstone 1-3. Results suggest more in-depth surveys of the harbour and flats entrance area may be beneficial.

Sabellaria

Sabellaria reefs are Annex 1 reefs under the habitats directive as well as habitats of principal importance by NERC 2006 (JNCC, 2016c) with *Sabellaria spinulosa* listed as an OSPAR habitat that is under threat and declining in region II. Confirmed *Sabellaria* species, found on mixed sediments (likely *S. spinulosa* from Figure 3) are present in 6 areas off the coast of Beadnell, Craster, Newbiggin-by-the-sea, St Marys Island, Sunderland, and Seaham. *Sabellaria spinulosa* is extensive in the UK, and in BNNC SAC it may exist as ephemeral patches that may seasonal due to destruction by adverse weather. *Sabellaria spinulosa* is not classed as true reef until it forms extensive aggregations, therefore this would need confirmation by further surveys. The *S. spinulosa* at Sunderland and Seaham is not within an MCZ or SAC. Further surveys could be carried out, but these sites are not geographically close to each other. No additional *Sabellaria* was found during the pilot project.

Seagrass

Infralittoral seagrass beds found within the BNNC SAC are designated under Annex 1 mudflats and sandflats not covered by seawater at low tide, a habitat of principle of importance by NERC 2006, and a UK BAP priority habitat (JNCC, 2016d; JNCC, 2022). No subtidal seagrass beds were found in the underwater imagery at Bay Seagrass, Seagrass South and North Seagrass sites (9-18m depth) this is outside of the species depth range (<5m for *Zostera marina* and intertidal for *Zostera noltii*). The majority of the Flats Entrance and Harbour sites were all within the depth range of *Zostera marina* but none was observed (Tyler-Walters, 2008; JNCC, 2016d). Further surveys are recommended at similar locations to Bay Seagrass, and North Seagrass closer inshore within the species depth range to investigate the potential presence of seagrass in the area.

Potential future survey locations:-

1. The channel from Burrow Hole 1 towards Flats Entrance 7 for further mussel beds and South of Harbour 8 towards Burrow Hole 1, in shallow water to confirm if maerl is present, this may uncover more subtidal mussel beds (Figure 21).
2. The areas in between Longstone 1-3 to ascertain if there is any connectivity of these brittlestar beds and potential stony reef (Figure 22).
3. DUN-10-20M-MOD (and FAR-20-MOD) if feasible, to ascertain the type of *Sabellaria* spp. present, if patchy or contiguous at each site (Figure 23).
4. Resurvey North Seagrass sites, further inshore at a depth of below 5m (Figure 7)
5. Survey the west side of the Farne islands where stony reef, brittlestar beds, and potential maerl are present (Figure 19).
6. The area in between North Stony 1 and 2 to examine if the stony reef has any connectivity between sites (Figure 7).

Areas containing potential biogenic and stony reef may initially benefit from surveys using a WASSP multibeam echosounder giving high-resolution data, quickly, over large areas. This provides an accurate 3D profile of the seabed and can reveal the location of potential reefs and habitats of interest. This could be beneficial for the detection of stony reef, potentially, mussel beds and sabellaria if present as large reef structures, but unlikely to have an application for maerl and brittlestars which would require detection by ROV (dependent on depth of the site), followed by quantitative assessment using the towed camera (seaspyder) allowing assessment with image analysis software, or manually by a trained observer. Diver survey would be beneficial for the identification of maerl if samples are required (Fosså *et al.*; Russell Parrot, 2008) .

NIFCA's patrol boat 'St Aiden' and the Newcastle University research vessel 'RV Princess Royal' are equipped with multibeam systems therefore, further data could be collected from NIFCA's routine

patrols, and targeted surveys in the future allowing the collection of high-resolution seabed maps within the BNNC SAC to determine areas to target.

This future baseline data would allow targeting of key habitats before further detailed underwater surveys and ground-truthing, by towed camera or divers takes place to assess condition of the reefs within the SAC. These baseline surveys should conform to common standards as set out by the JNCC to ensure the data is suitable for assessing features and therefore forming a baseline for dedicated condition monitoring (JNCC, 2004).

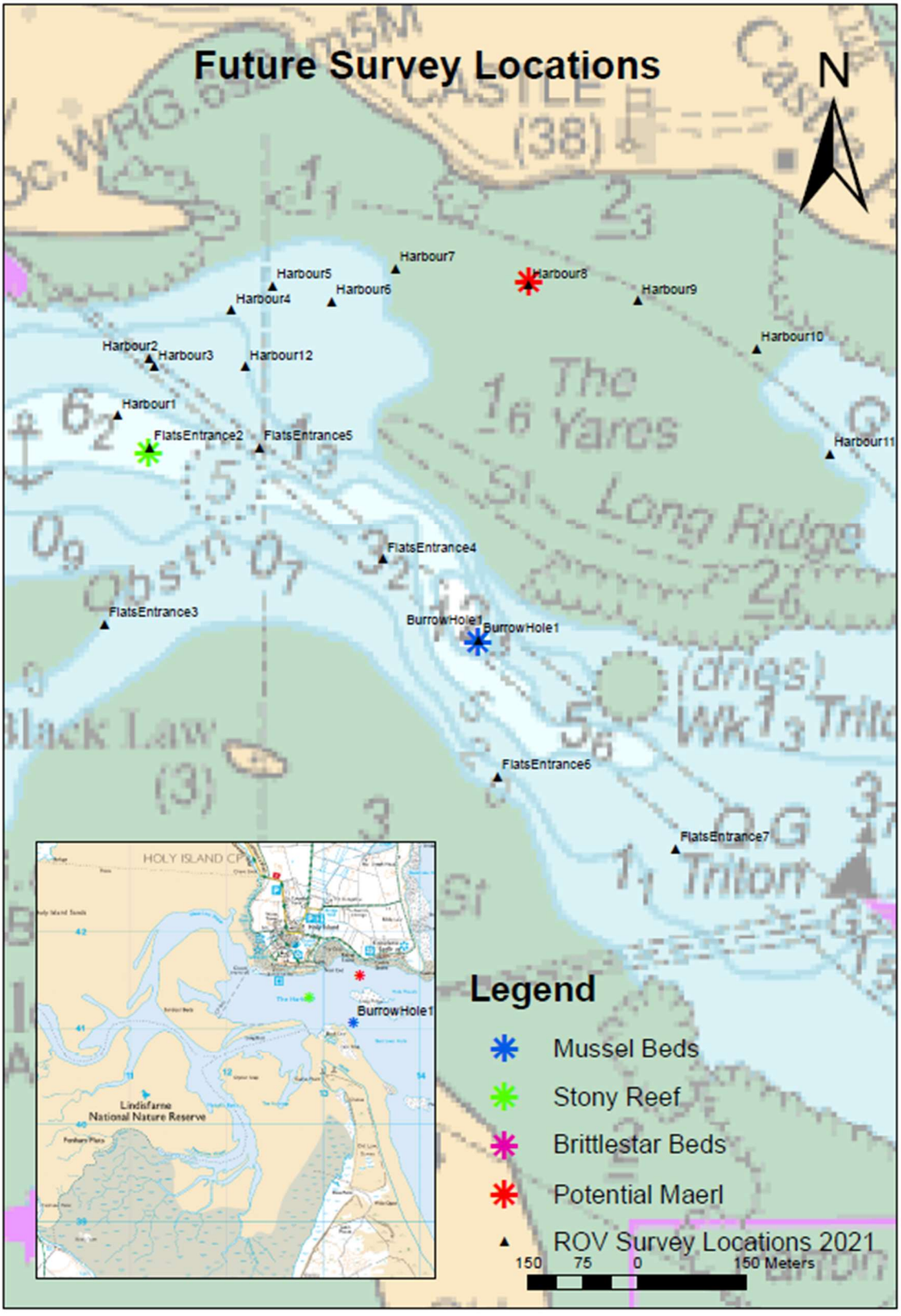

FIGURE 23: MAP SHOWING ROUGH AREAS FOR FUTURE SURVEY FOR SUBTIDAL MUSSEL BEDS AND POTENTIAL MAERL AROUND THE HARBOUR AND FLATS ENTRANCE SITES AT HOLY ISLAND (EDINA, 2021; OS, 2021A).

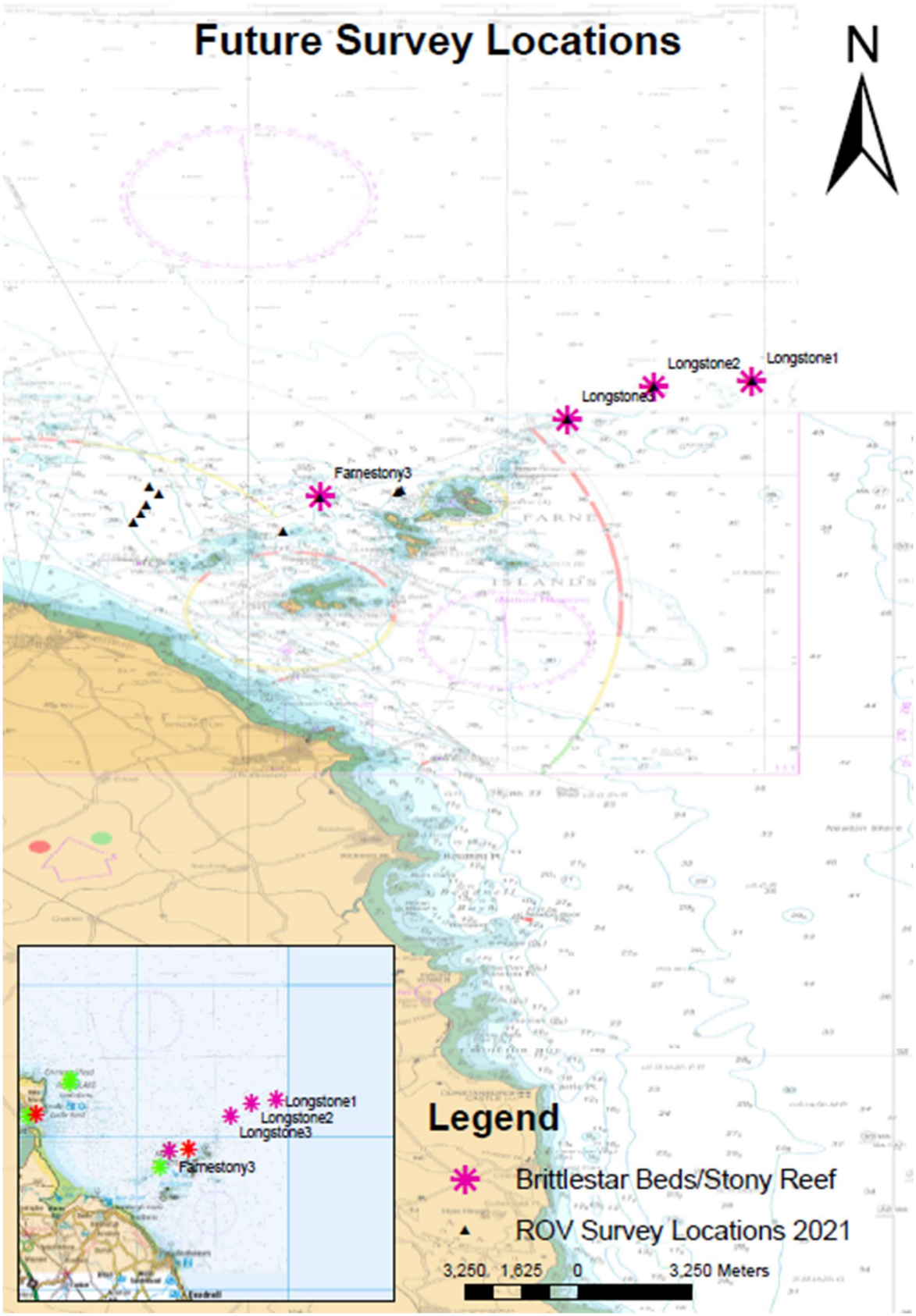

FIGURE 24: MAP SHOWING ROUGH AREAS FOR FUTURE SURVEYS OF BRITTLESTAR BEDS OFF THE NORTH EAST OF THE FARNE ISLANDS AT THE LONGSTONE SITES (EDINA, 2021; OS, 2021A).

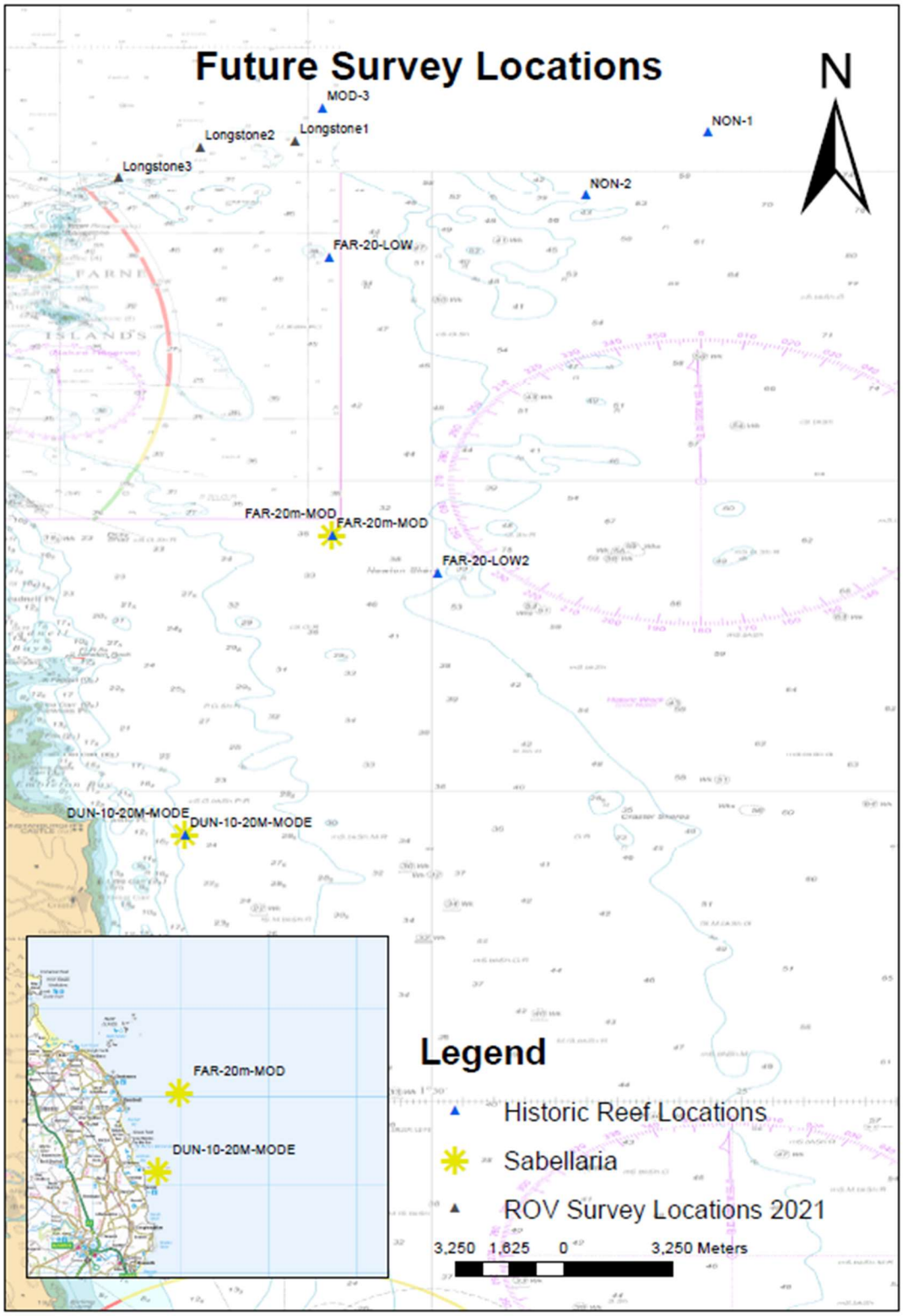

FIGURE 25: MAP SHOWING ROUGH AREAS FOR FUTURE SURVEYS IN THE SOUTHERN PART OF THE BNNC SAC NEAR DUSTANBURGH CASTLE TO INVESTIGATE POSSIBLE SABELLARIA REEFS (EDINA, 2021; OS, 2021A).

Supplementary Materials

1. NIFCA Shallow Inlets and Bays ROV footage and Photographs. https://drive.google.com/drive/folders/14x0Pp5t8tUv33ybgGGpXfiF_gbeuHVDH?usp=sharing

2. ROV Observations and metadata – Shallow Inlets and Bays Data Final.xlsx

3. ArcGIS Map files

References

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