Appendix F: Pioneer MAB Seabed Survey and ROV Inspections

Pioneer MAB
Seabed Survey & ROV Inspections

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Coastal and Global Scale Nodes
Ocean Observatories Initiative
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Revision History

Version	Description	ECR No.	Release Date
0-02	Updated following NSF/OOI PMO comments	--	2023-06-01
0-03	Updated with survey results for Updated Northeastern and Southeastern mooring locations	--	2023-11-06
0-04	Updated based on NSF comments to SSSEA	--	2024-01-29

Table of Contents

List of Appendices

List of Figures

List of Tables

1.0 PURPOSE

The purpose of this document is to provide the results of the seabed mapping survey and ROV inspection of the Pioneer Mid-Atlantic Bight (MAB) mooring sites. The initial surveys and ROV inspections were performed between 21 February – 1 March 2023 in conjunction with the deployment of test moorings at the Central site and Northeastern (Old) site. The surveys for updated Northeastern (NE) and updated Southeastern (SE) mooring locations were performed on the test mooring recovery cruise between 23 October – 4 November 2023.

The desktop planning performed by OOI and Tetra Tech provided a baseline for the layout and design of the proposed Pioneer MAB array. The surveys were performed to ground truth the results of the studies, including:

1. Establishing the actual water depth, seabed types, and slopes to inform the engineering of the mooring systems,
2. Confirming the avoidance of cultural and archeological resources, and
3. Assessing and avoiding any impacts to Essential Fish Habitats and Critical Habitats.

2.0 REFERENCE DOCUMENTS

Table 1: Reference Documents

Document ID / Source	Document Title
3210-00007	CGSN Site Characterization: Pioneer Mid-Atlantic Bight Array
3210-00008	CGSN Site Design: Pioneer Mid-Atlantic Bight Array
TetraTech, June 2021	Mid-Atlantic Bight Pioneer Array Regulatory Study
TetraTech, December 2022	Desktop Study: Mid-Atlantic Bight Pioneer Array
Search, November 2022	Maritime Archaeology Desktop Study

3.0 DEFINITIONS & ACRONYMS

Alt	Alternate
BOEM	Bureau of Ocean Energy Management
CGSN	Coastal & Global Scale Nodes
CN	Central Site
EA	Eastern Site
EFH	Essential Fish Habitat
IFREMER	Institut Français de Recherche pour l'Exploitation de la MER
MFN	Multi-Function Node
MAB	Mid-Atlantic Bight
NDBC	National Data Buoy Center
NE	Northeastern Site
NEPA	National Environmental Policy Act
NO	Northern Site
NOAA	National Oceanic and Atmospheric Administration
NSF	National Science Foundation
NSIF	Near Surface Instrument Frame
OOI	Ocean Observatories Initiative
PI	Principal Investigator

PM	Profiler Mooring
ROV	Remotely Operated Vehicle
SE	Southeastern Site
SEANOE	SEA scieNtific Open data Edition
SHOM	Service Hydrographique et Océanographique de la Marine
SIS	Seafloor Information System
SM	Surface Mooring
SO	Southern Site
SW	Shallow Water Mooring
VME	Vulnerable Marine Ecosystem
WE	Western Site

4.0 OVERVIEW

4.1. Site Summary

The Pioneer MAB Array is proposed to be relocated in the spring of 2024 to a region off the coast of Nags Head in North Carolina. The proposed plan is for the moored array to be constituted in a sideways “T” shape, with seven mooring sites between about 24 kilometers (km) and 84 km offshore, outside of state waters (Figure 1). The Pioneer MAB Array will consist of:

- Three surface moorings located in 30m and 100m water depths (CN, NO, SO)
- Five profiler moorings located in 100m and 300m water depths (NO, NE, EA, SE, SO)
- Two shallow-water moorings located in 30m water depths (WE, CN)
- The original NE and SE sites are shown for informational purposes (NE Old, SE Old)

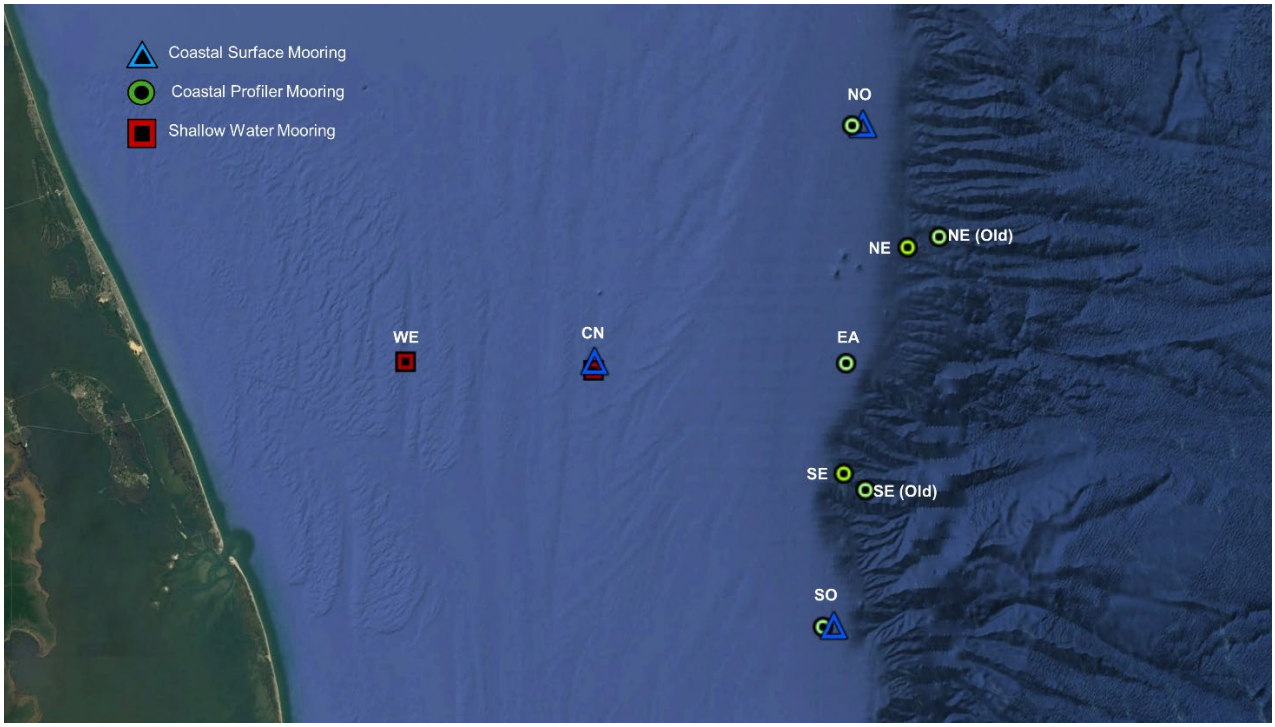

Figure 1: Pioneer MAB Proposed Array Layout

The individual site centers were initially selected during the National Science Foundation (NSF) Innovation Labs workshops based on input from the scientific community. The site centers were slightly adjusted based on information reviewed by OOI during the planning stages (*3210-00008 Site Design: Pioneer Mid-Atlantic Bight Array*) including data sourced from the Bureau of Ocean Energy Management (BOEM) and National Oceanic and Atmospheric Administration (NOAA) Marine Cadastre, as well as the desktop study (*Desktop Study, Mid-Atlantic Bight Pioneer Array, Prepared by Tetra Tech*) and regulatory study (*Mid-Atlantic Bight Pioneer Array Regulatory Study. Prepared by Tetra Tech*). A maritime archeology study (*Marine Archeology Study, Moored Buoys for Scientific Data Collection, North Carolina, Outer Continental Shelf. Prepared by SEARCH for Tetra Tech)* did not identify any documented archaeological sites, reported shipwrecks, or maritime obstructions within 1.6 km (1.0 mi) of the proposed site centers. The updated NE and SE sites were selected and surveyed based on feedback received during the 30-day public NEPA review. The original NE and SE sites (denoted as NE Old and SE Old) are shown for continuity purposes.

4.2. Vessel

The RV Neil Armstrong (Figure 2) performed the mapping and ROV inspection operations.

Figure 2: RV Neil Armstrong

- Propulsion: (x2) Siemens AC Electric Motors, 876 kW ea. (1175 hp ea.), 1752 kW total (2350 hp total)
- Bow Thruster (x1) White-Gill, 686 kW (920 hp)
- Stern Thruster: (x1) Schottel, 620 kW (831 hp)
- Main Generators: (x4) Cummings Diesels, 1044 kW ea. (1400 hp ea.), 4176 kW total (5600 hp total)
- Emergency Generator: (x1) MTU Diesel, 210 kW (282 hp)

4.3. Mapping Equipment

- Bathymetry and Backscatter: Kongsberg EM710 40-100kHz
- Subbottom: Knudsen 3260 3.5kHz
- Backup deepwater multibeam: Kongsberg EM122 12kHz (deepwater sites only)

4.4. ROV Equipment

- Saab SeaEye Falcon DR ROV with associated equipment, see Figure 3 and Table 2.

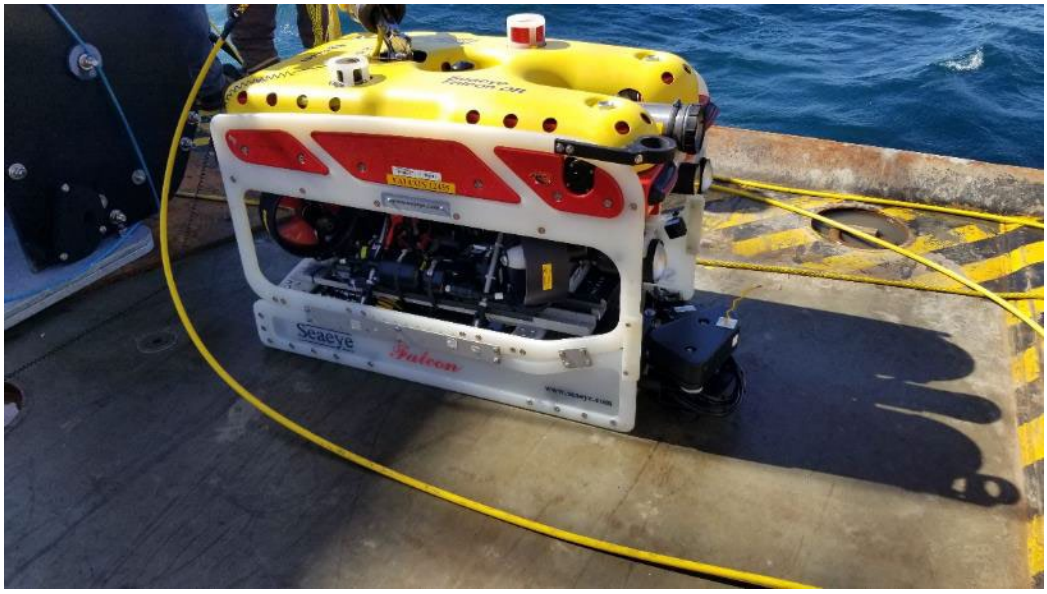

Figure 3: Saab SeaEye Falcon DR ROV

Table 2: ROV Specifications

Feature	Description
Dimensions (mm)	1055mm x 635mm x 600mm
Weight (kg)	100kg
Payload (kg)	15kg
Thrust	5 brushless (4 vectored H, 1 V); 50kgf forward, >3kts
Umbilical (m)	1100 525kg breaking strain Min dynamic bend radius 250mm Min static bend radius 165mm
Operating Depth (m)	850
Manipulator	Single function Gripstick02 plus skid mounted Hydro-Lek 5-function; cutter available as option, Gripstick02 includes soft line cutter
Navigation	PA500 altimeter Auto heading, Auto depth, Auto altitude Fluxgate compass, rate sensor
Acoustic Positioning	EasyTrak Alpha 2665 Portable USBL -1 x AAE 1310 mini-beacon (1000m rated), 1 x AAE 1015 mini-beacon (2000m rated) for use with EasyTrak -5 x Sonardyne Nano beacons (500m rating) with charger, for use with Sonardyne Mini-Ranger 2 USBL
Imaging	Imagenex gyro stabilized sonar 881A GS 310kHz 40d beam/675kHz 20d beam/1MHz 10d beam 1-4m resolution = 2mm, >5m = 10mm, 200m range
Camera	SEAEYE mini color camera, includes video recorder Kongsberg HD camera 1920 x 1080, 1080i/720p, 10x optical zoom; 1 x rear facing mini wide angle camera
Lights	2 x forward looking LEDs, 1 x rear looking LEDs

5.0 SITE MAPPING

Vessel hull-mounted multibeam and subbottom systems were used to map an approximate 2km x 2km box around each site center. Table 3 provides a list of coordinates denoting the site center for each of the nine surveyed mooring sites. Upon reviewing the survey data, the Chief Scientist selected the anchor target sites for ROV inspection. Table 4 provides the coordinates for the recommended anchor targets. During mooring service cruises, replacement moorings are typically deployed prior to recovery of the previously deployed mooring. Thus, two anchor targets are needed for a site with a single mooring. At sites where two moorings will be deployed (a surface mooring adjacent to a profiler mooring), four anchor targets are needed.

The ship's multibeam collected bathymetry and backscatter imagery. The bathymetry was used to generate digital terrain models (DTMs) and depth contour charts to assess/select anchor target locations. This data will also be used to finalize mooring designs based on improved estimates of water depth at the anchor sites. The backscatter, along with the subbottom data, was used to assess bottom types, hardness, and potential hazards. The multibeam and the subbottom frequencies do not conflict and were therefore run concurrently. Primary focus for the backscatter hazard assessment was ensuring clearance around each anchor target. Anchors are typically deployed within a 25m radius of the target.

Table 3: Site Center Coordinates

Mooring Center	Code	Lat (°N)	Lon (°W)
Western	WE	35.9500	75.3333
Central	CN	35.9500	75.1250
Eastern	EA	35.9500	74.8457
Northern	NO	36.1750	74.8267
Southern	SO	35.7250	74.853
Northeastern (Old)	NE old	36.0633	74.7427
Southeastern (Old)	SE old	35.8367	74.8242
Northeastern (Updated)	NE	36.0536	74.7776
Southeastern (Updated)	SE	35.8514	74.8482

Table 4: Anchor Target Coordinates

Anchor Target	Lat (°N)	Lon (°W)
WE N-tar	35.95442	75.3333
WE S-tar	35.94558	75.3333
CN N-tar	35.95362	75.1250
CN S-tar	35.94558	75.1250
CN E-tar	35.9503	75.1195
CN W-tar	35.9503	75.1311
NO N-tar	36.1794	74.8267
NO S-tar	36.17058	74.8267
NO E-tar	36.1750	74.8212
NO W-tar	36.1750	74.8321
EA N-tar	35.95442	74.8457

Anchor Target	Lat (°N)	Lon (°W)
EA S-tar	35.94558	74.8457
SO N-tar	35.72937	74.8530
SO S-tar	35.72062	74.8530
SO E-tar	35.7250	74.8476
SO W-tar	35.7250	74.8584
NE old N-tar	36.0675	74.7412
NE old S-tar	36.05972	74.7457
SE old N-tar	35.84083	74.8258
SE old S-tar	35.8325	74.8258
NE N-tar	36.0581	74.7773
NE S-tar	36.0492	74.7786
SE N-tar	35.8555	74.8506
SE S-tar	35.8473	74.8466

6.0 ROV INSPECTION

The ROV was tracked using the vessel Sonardyne USBL system. The position of the ROV, and ROV depressor weight, were collected in a Sonardyne log file. Targets were loaded into the USBL system to support vessel and ROV maneuvering.

The ROV performed a visual and forward looking sonar inspection of each anchor target site. Camera and sonar information were recorded to video files for each site. Forward looking sonar was set to a 50m range.

At dual mooring sites, the ROV was lowered to the initial anchor target. Once settled, the ROV performed a visual and sonar inspection surrounding the target, then transited to the next anchor target, continuing to collect camera and sonar data. Once at the next anchor target, the camera and sonar inspection was repeated. Four transects and four target inspections were completed at each dual mooring site (Figure 4).

Single mooring locations have two anchor target sites and a single survey transect. The ROV started at one anchor target and transited through the site center to the other target (Figure 4).

Procedures were in place to inspect seabed targets of interest, either visible in camera or in sonar, during the transects. However. no seabed targets were seen in the sonar during the transect lines. From camera imagery along the transect lines, away from the anchor target areas, there were some areas of benthic fauna noted. No OOI mooring deployments are planned in these areas, but they were considered areas of interest, in that they may be relevant to future, non-OOI deployments in the region. Appendix A provides an overview of these areas of interest.

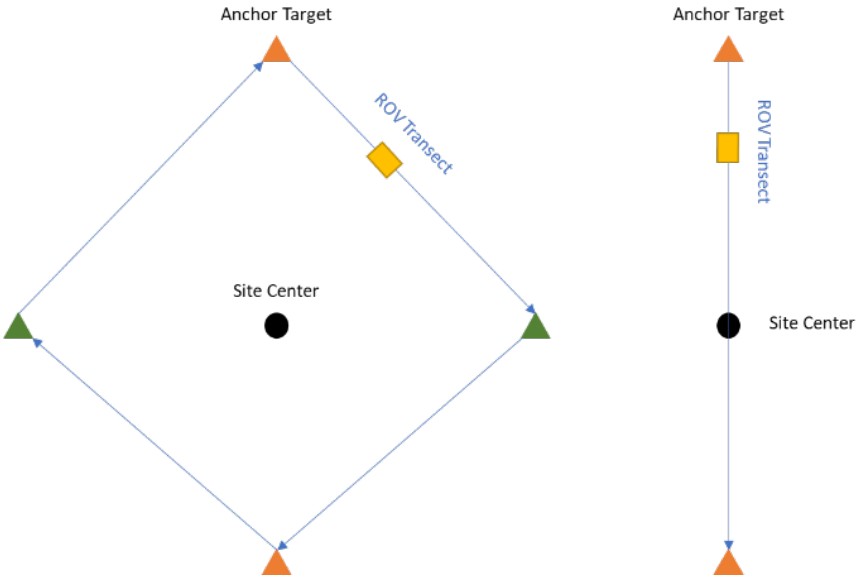

Figure 4: ROV Inspections & Transects. At sites with two moorings (left) four anchor targets are inspected with the ROV transects between targets creating a square pattern. At sites with one mooring (right) two targets are inspected with the ROV transect passing through the site center.

7.0 DATA PROCESSING

This section will provide a short introduction into the data processing and visualization performed to generate this report.

7.1. Sound Velocity

Conductivity, temperature, and depth (CTD) profiles were collected by the survey team at representative sites on the shelf and slope. These profiles were stored in *.cnv file formats. DORIS, a sound velocity visualization and processing tool, developed by IFREMER and SHOM, was used to inspect the profiles, remove duplicate soundings, and convert to *.vel files for use during the data processing step. (*Ifremer, Shom (2022). DORIS Software. SEANOE. https://doi.org/10.17882/90121*)

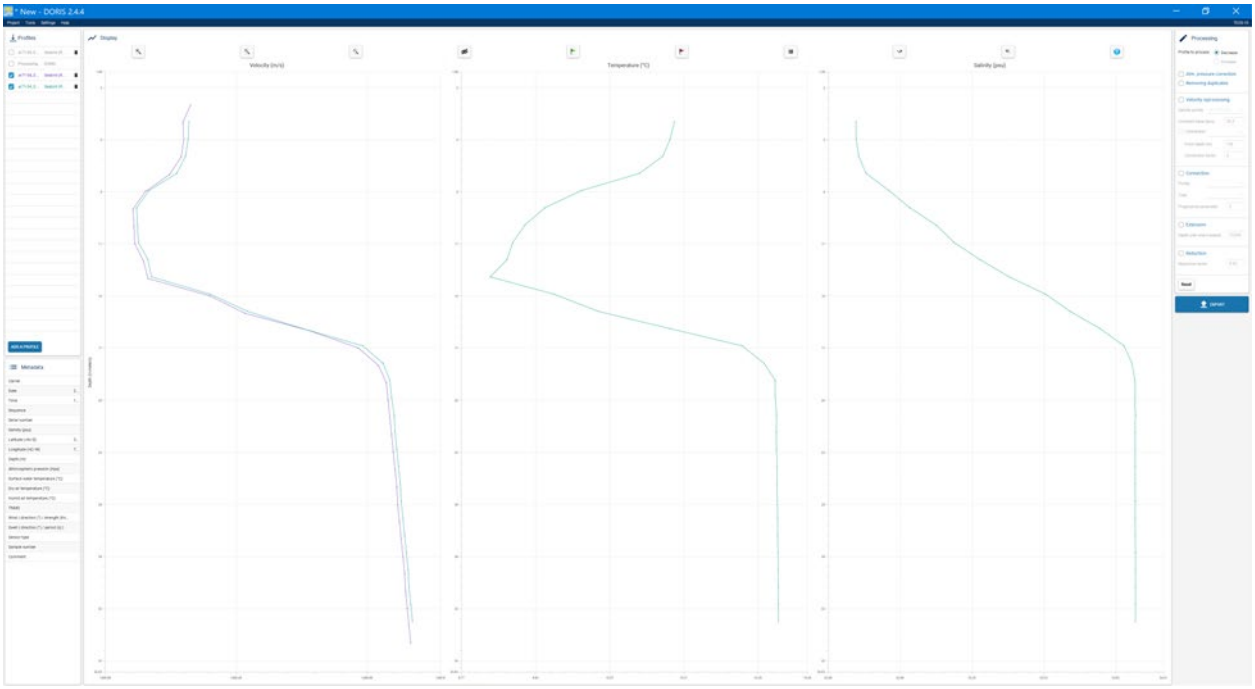

Figure 5: Example Sound Velocity Profile

7.2. Bathymetry & Backscatter

The EM710 bathymetry data was processed using the GLOBE data processing software developed by IFREMER. (*Poncelet Cyrille, Billant Gael, Corre Marie-Paule, Saunier Anthony (2023). Globe (GLobal Oceanographic Bathymetry Explorer) Software. SEANOE. https://doi.org/10.17882/70460*)

The following steps were performed:

1. Raw *.all files generated by the EM710 were loaded into the GLOBE environment.
2. Raw *.all files were then converted to *.mbg files.
3. Sound velocity profiles collected during the cruises were then loaded and applied to the sounder data.
4. A visual inspection of the soundings was performed including removal of minor errant soundings.
5. The sounding files were then filtered using the Delaunay Normal method.
6. Upon completion of the filtering, a digital terrain model (DTM) was generated using a 0.2m cell size.
7. Globe was then used to generate 1m, 2m, 10m, 20m contour files depending on location.
8. Backscatter images were also generated using GLOBE. The processed files from the bathymetry were used to generate grayscale images of the seabed strength returns.

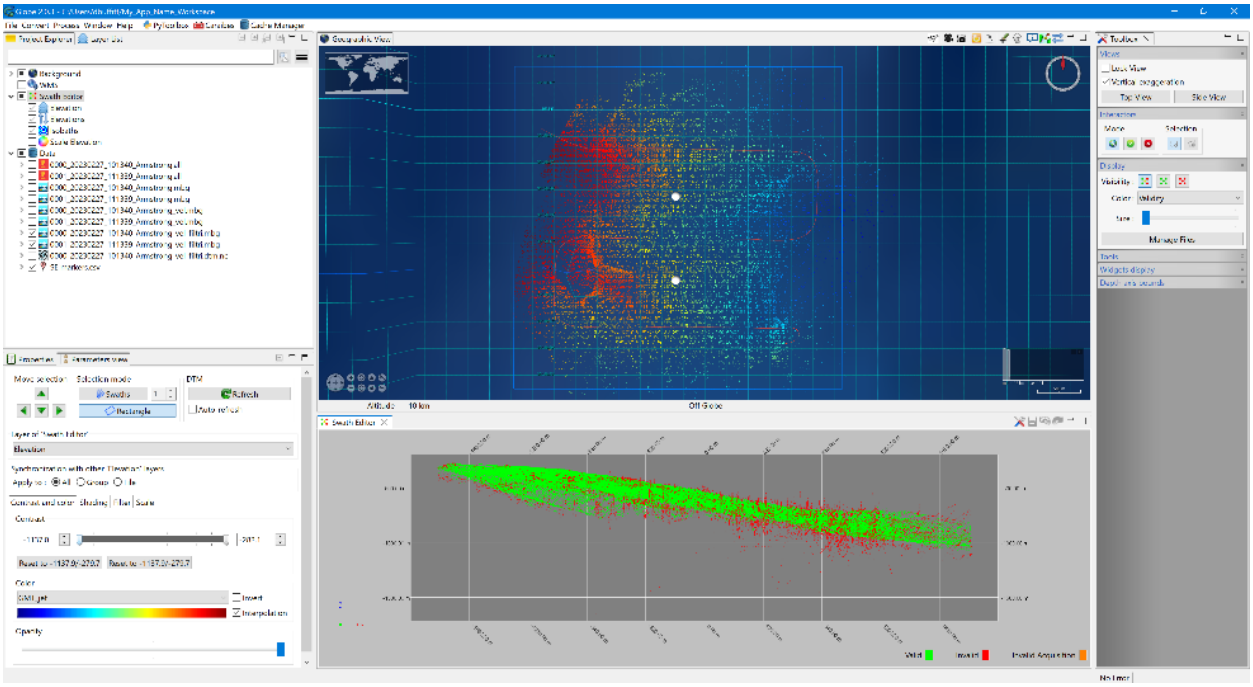

Figure 6: Example Bathymetry Processing

7.3. Subbottom

The Knudsen 3260 subbottom data (*.segy files) were loaded and visualized in the EchoPostSurvey software developed by Knudsen Engineering Limited. Visuals for each anchor target the full site survey were generated, no other processing was performed.

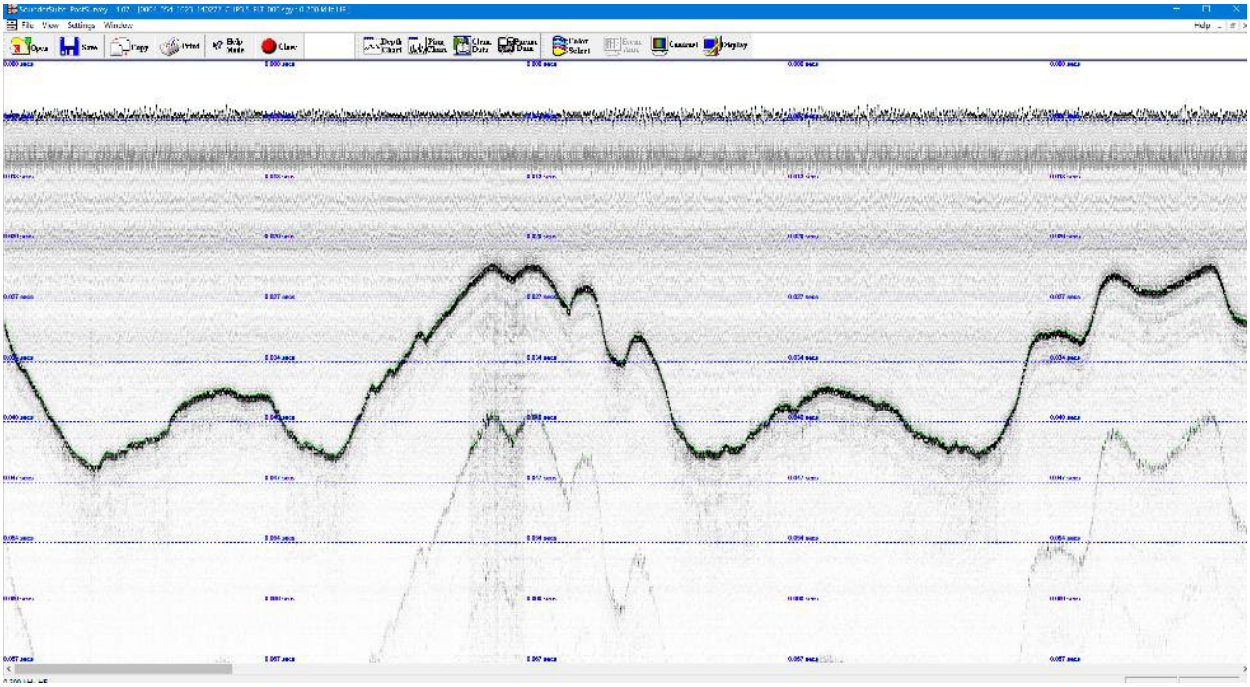

Figure 7: Example Subbottom Visualization

8.0 SURVEY RESULTS

This section provides an overview of the results of the survey and ROV inspections for each planned mooring site.

8.1. Western

Bathymetry

Moving west to east across the site (Figure 8), the water depth is at the shallowest ~17m, then deepens to ~28m in a somewhat flat north/south running channel, then rises slightly to 24m in the east. The data indicates several shallow banks to the west. As discussed in the Pioneer MAB desktop study, these shallow banks may consist of mobile sand and gravel sediments. The North and South anchor targets are at depths of ~25 m. Data collected over 2km x 2km area using 90m line spacing.

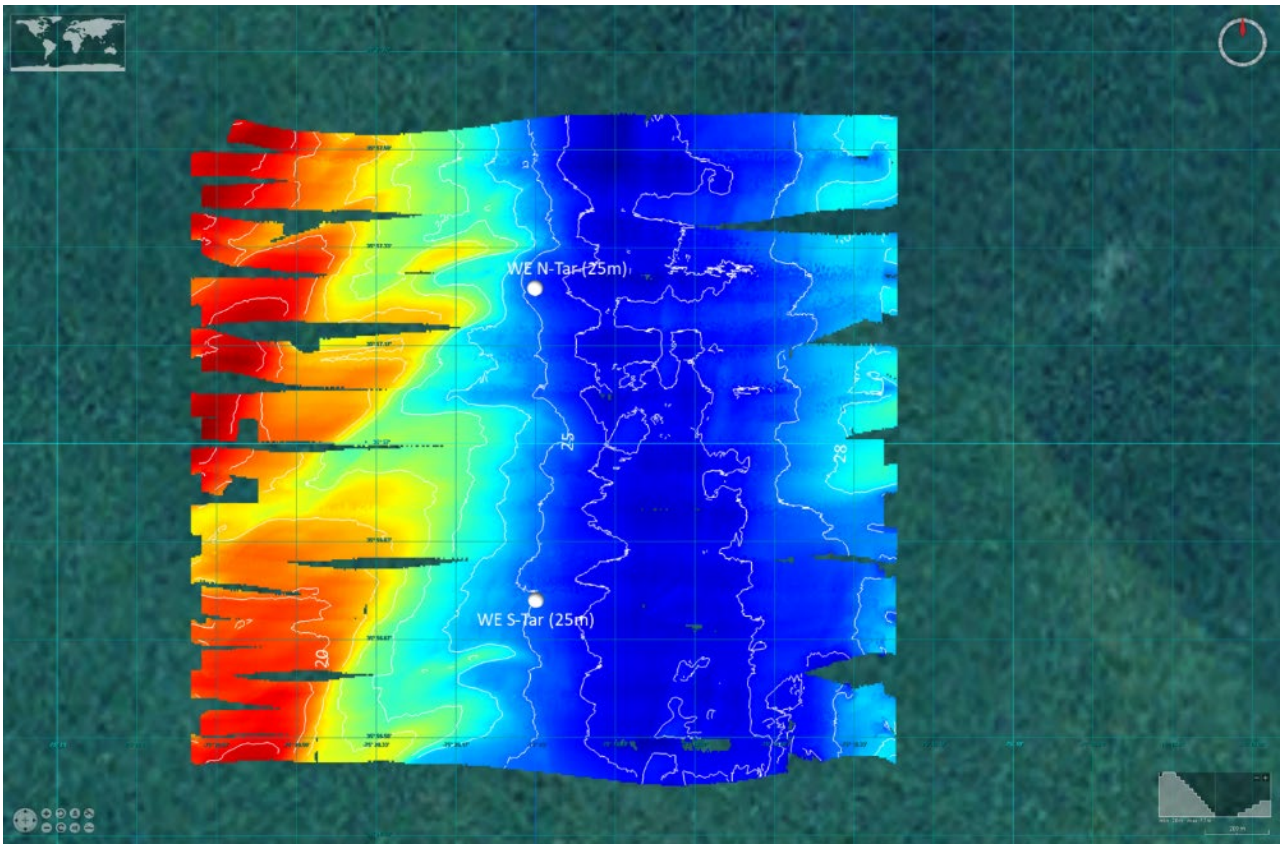

Figure 8: Western Site Digital Terrain Model (2m contours)

Backscatter

Backscatter imagery at both the north and south anchor target sites indicate a homogeneous seabed, no visible hazards such as hard bottom, cables, pipelines, wrecks, or debris (Figures 9 & 10).

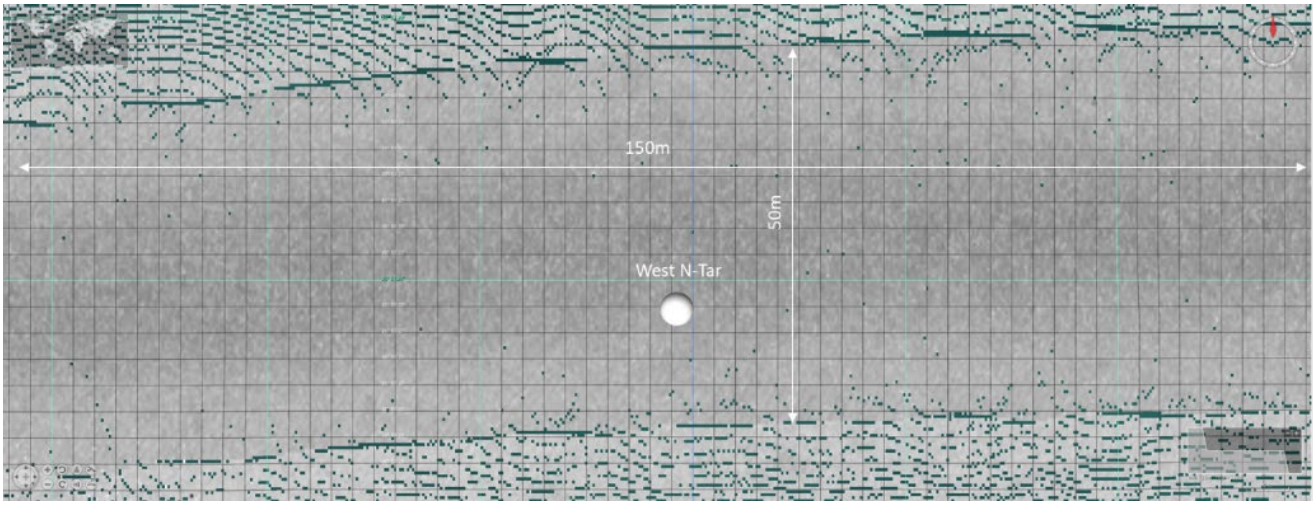

Figure 9: Western Site North Anchor Target (N-Tar) Backscatter

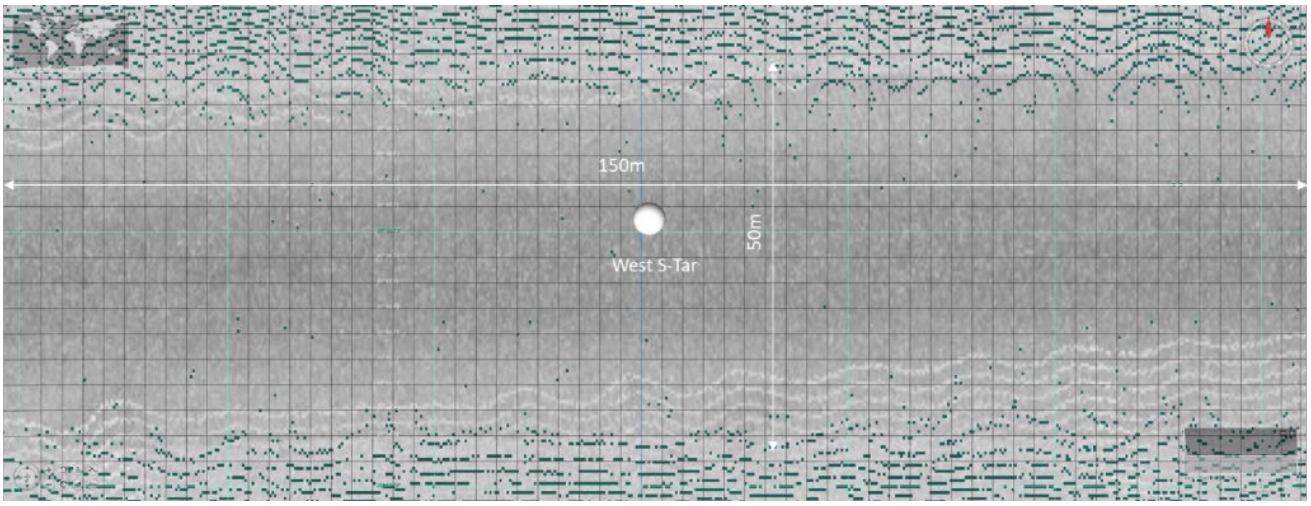

Figure 10: Western Site South Anchor Target (S-Tar) Backscatter

Subbottom

Subbottom profiles at both the north and south anchor target sites indicate a soft and homogeneous seabed with good penetration, no indication of hard bottom or hazards such as cables, pipelines, debris, or wrecks (Figures 11 & 12). Slopes are ~1.5-2°.

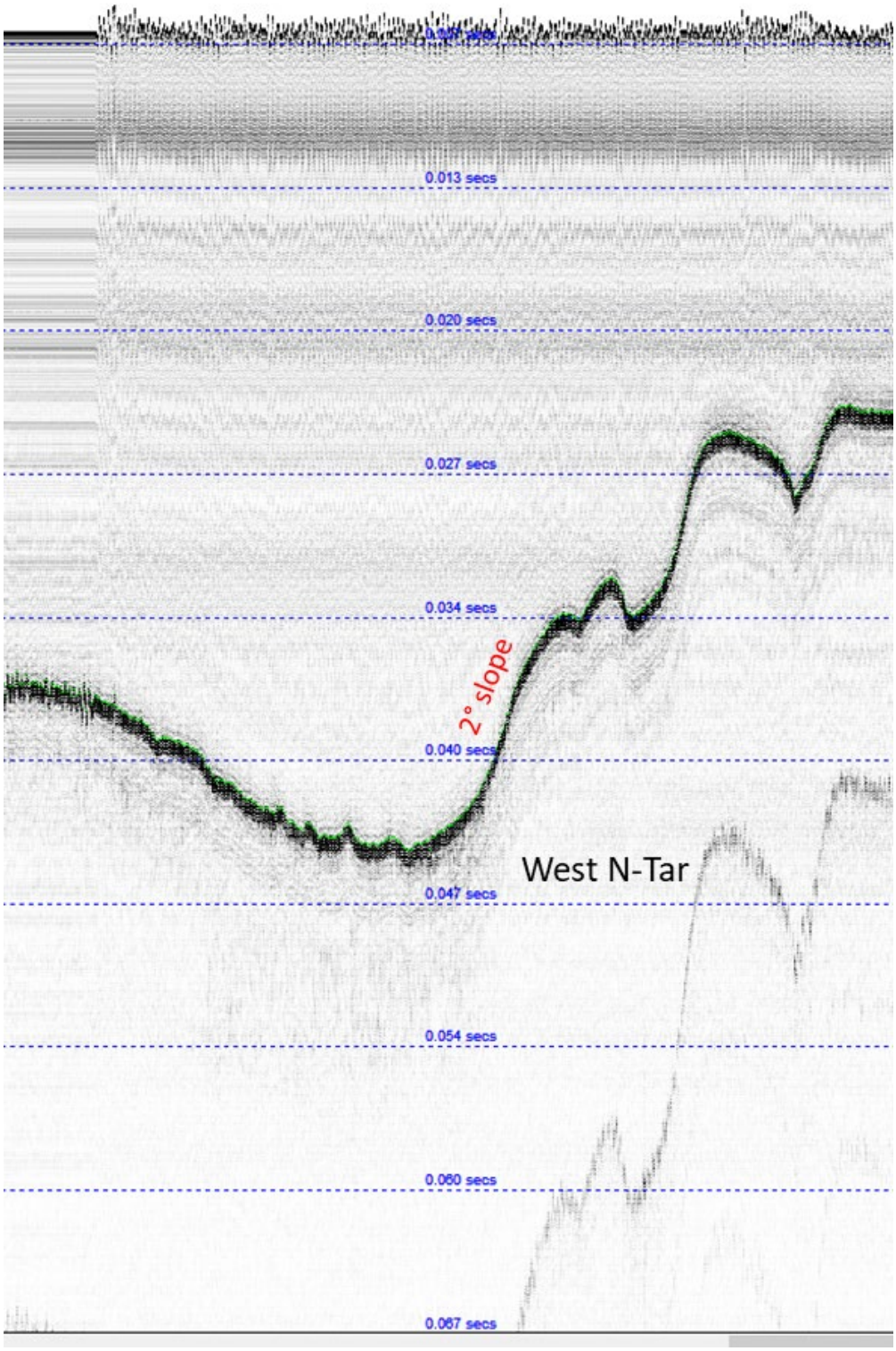

Figure 11: Western Site North Anchor Target (N-Tar) Subbottom

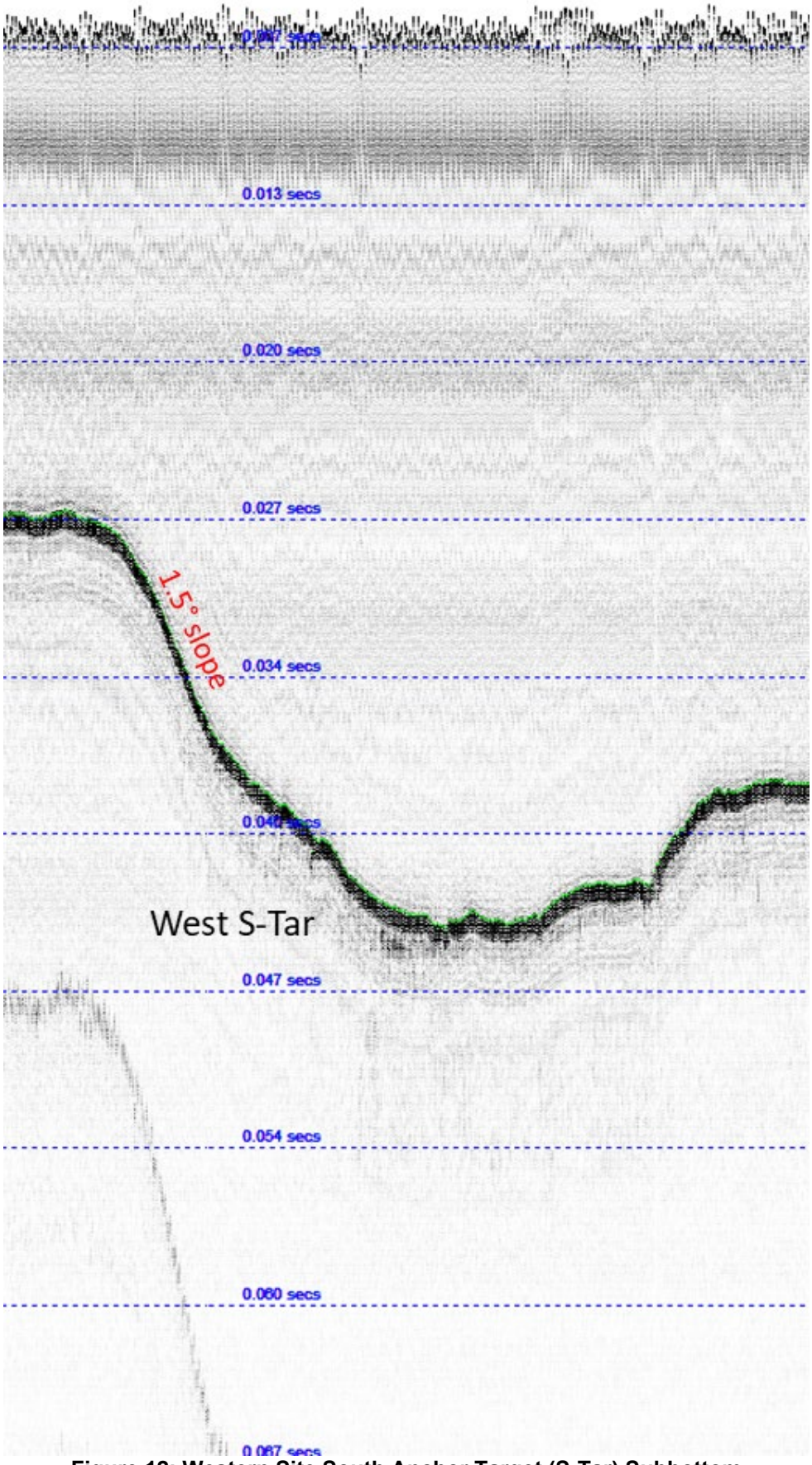

Figure 12: Western Site South Anchor Target (S-Tar) Subbottom

ROV Inspection

ROV inspection was completed at both anchor target sites, Figure 13 shows the ROV and depressor positions overlaid on the DTM. The camera data indicates a flat seabed at both sites consisting of sands and gravels (Figures 14-17). Wavy seabed also indicates some potential sediment movement. No areas or features of concern (hard bottom, debris, cables, pipelines, wrecks, artifacts, marine habitat) in ROV sonar or imagery in vicinity of anchor targets.

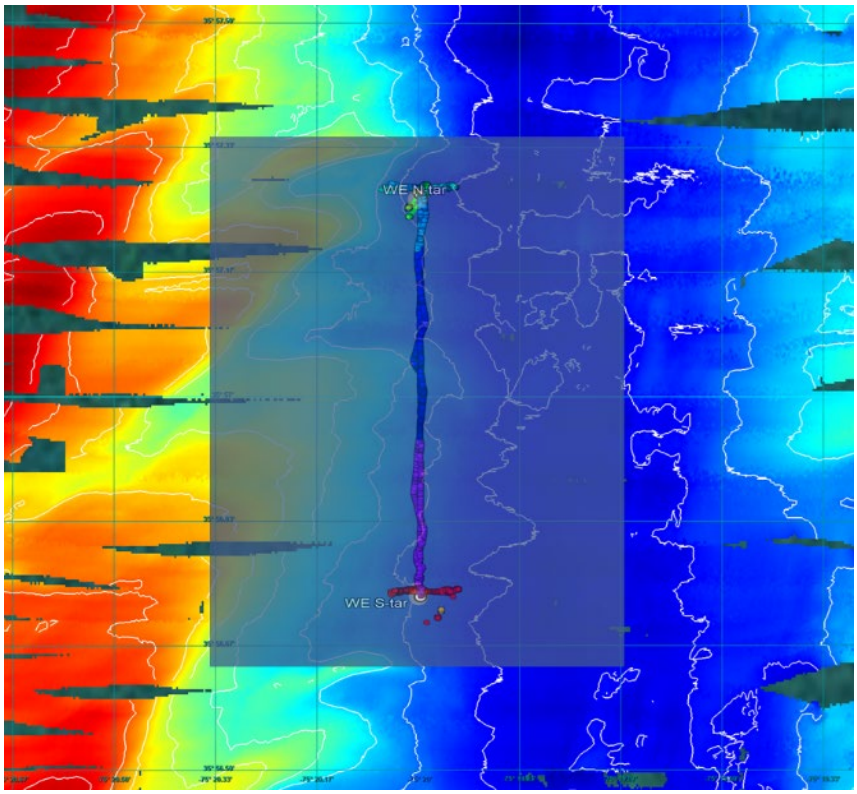

Figure 13: ROV Track at Western Site

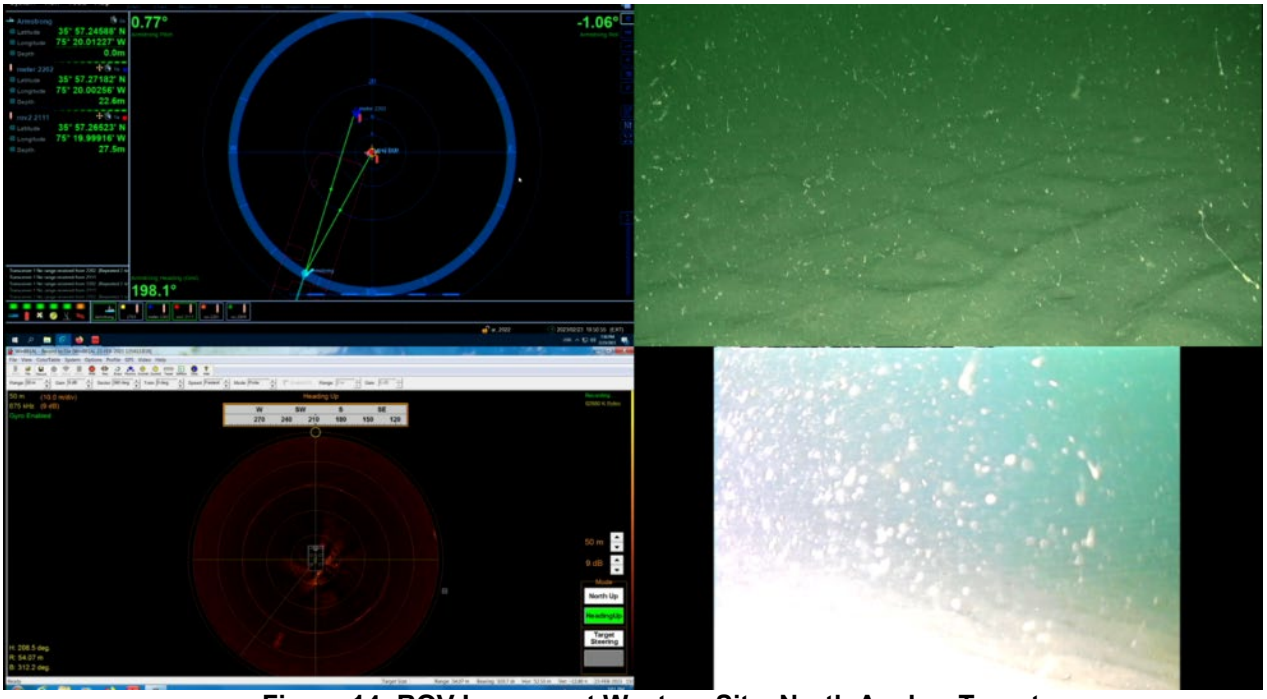

Figure 14: ROV Imagery at Western Site, North Anchor Target

Figure 15: Sandy Seabed Western Site, North Anchor Target

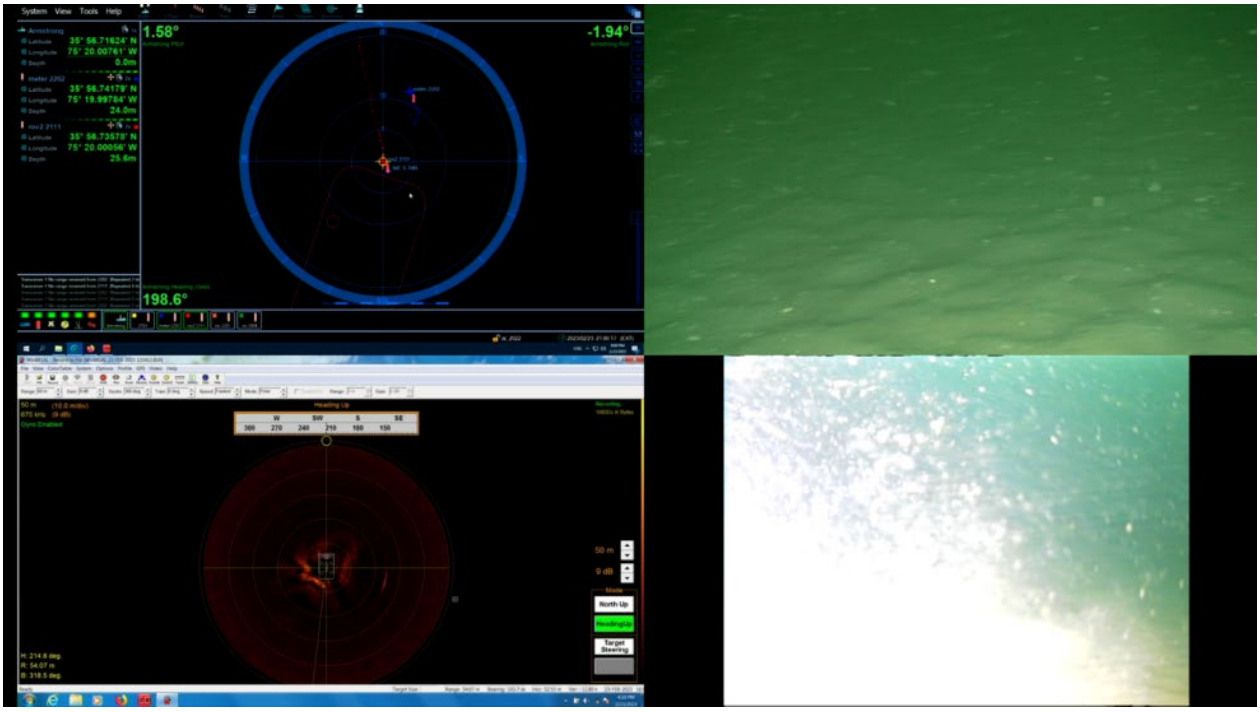

Figure 16: ROV Imagery at Western Site, South Anchor Target

Figure 17: Sandy Seabed Western Site, South Anchor Target

8.2. Central

Bathymetry

Moving west to east across Figure 18, the water depth is at the shallowest ~30m in the north and southwest corners, then deepens to ~33m in a somewhat flat north/south running channel, then rises to ~28m in the eastnortheast. The data indicates several shallow banks to the east and west. As discussed in the desktop study, these shallow banks may consist of mobile sand and gravel sediments. The North, South, East and West anchor targets are at depths of 32 m, 31 m, 28 m and 33 m, respectively. Data collected over 2km x 2km area using 90m line spacing.

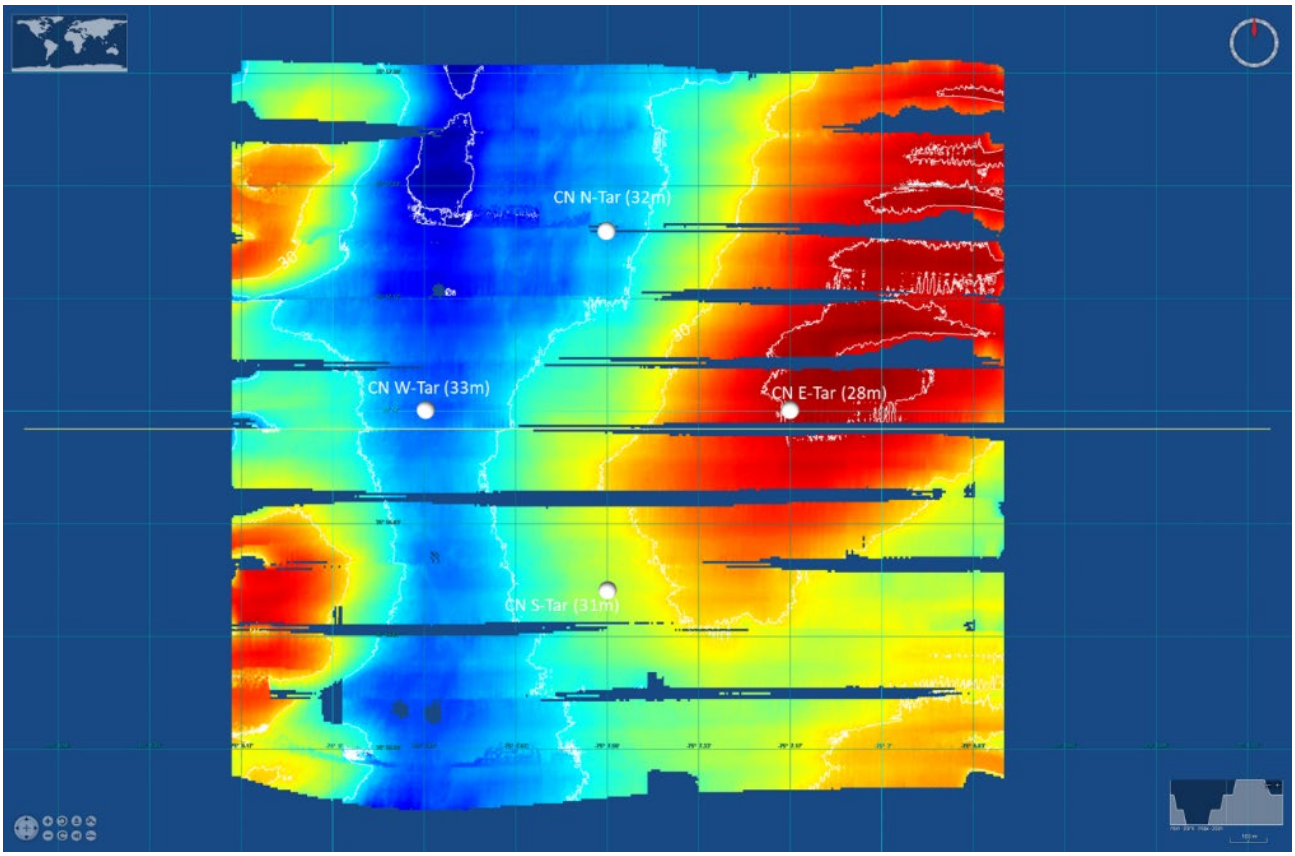

Figure 18: Central Site Digital Terrain Model (2m contours)

Backscatter

Backscatter imagery at all anchor target sites indicates a homogeneous seabed, no visible hazards such as hard bottom, cables, pipelines, wrecks, or debris (Figures 19 thru 22).

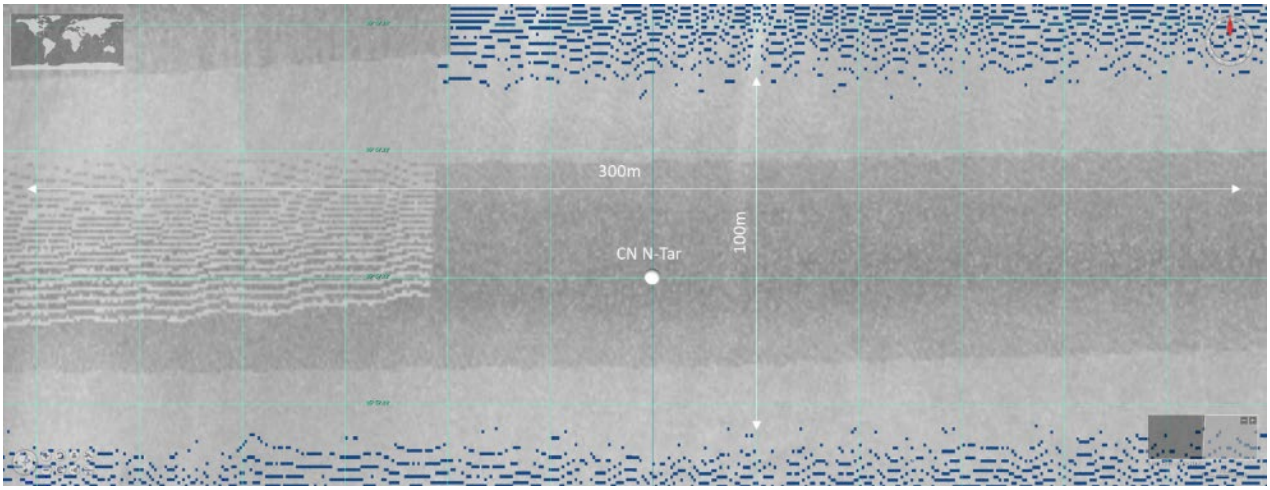

Figure 19: Central Site North Anchor Target (N-Tar) Backscatter

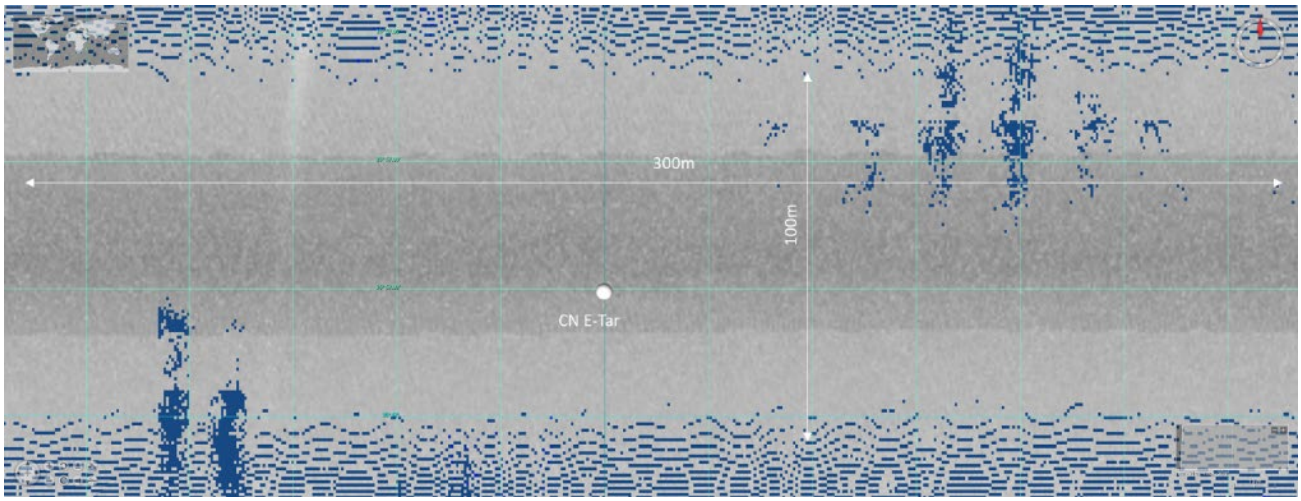

Figure 20: Central Site East Anchor Target (E-Tar) Backscatter

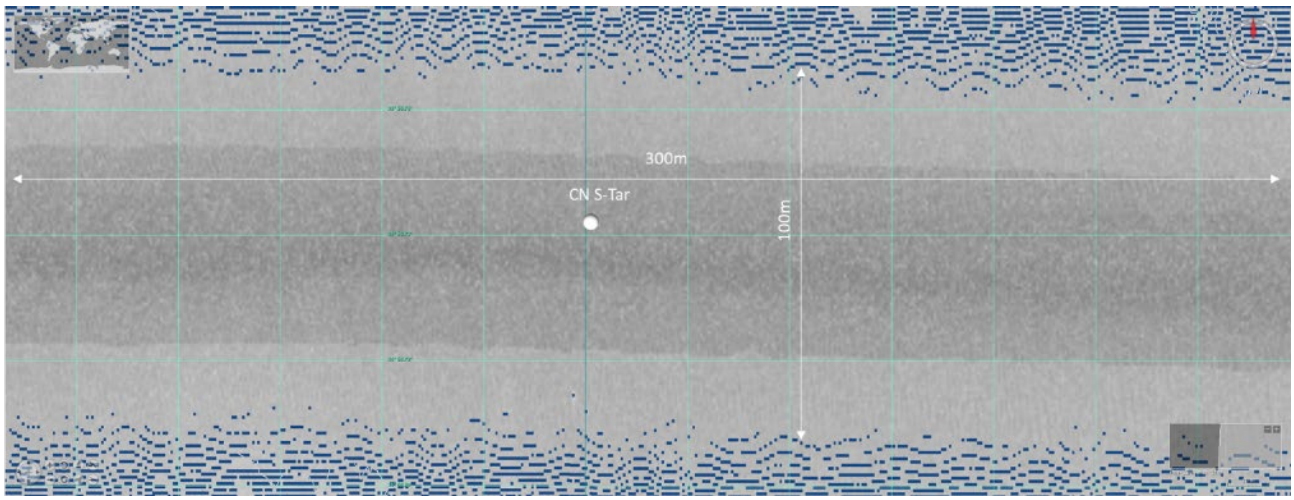

Figure 21: Central Site South Anchor Target (S-Tar) Backscatter

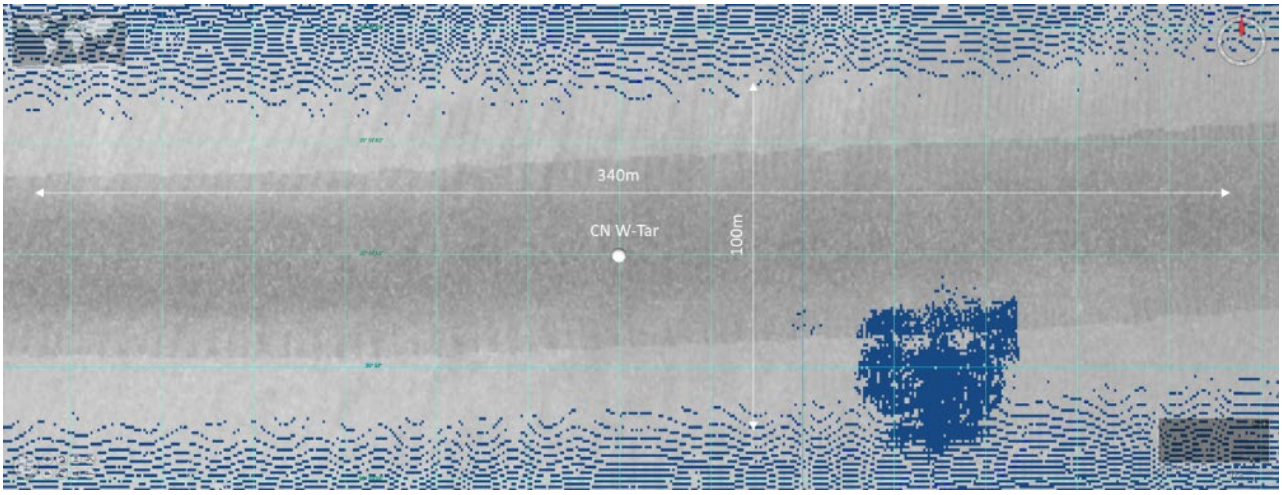

Figure 22: Central Site West Anchor Target (W-Tar) Backscatter

Subbottom

Subbottom profiles at all anchor target sites indicate a soft and homogeneous seabed with good penetration, no indication of hard bottom or hazards such as cables, pipelines, debris, or wrecks (Figures 23 thru 25). Slopes are ~0.5-1°.

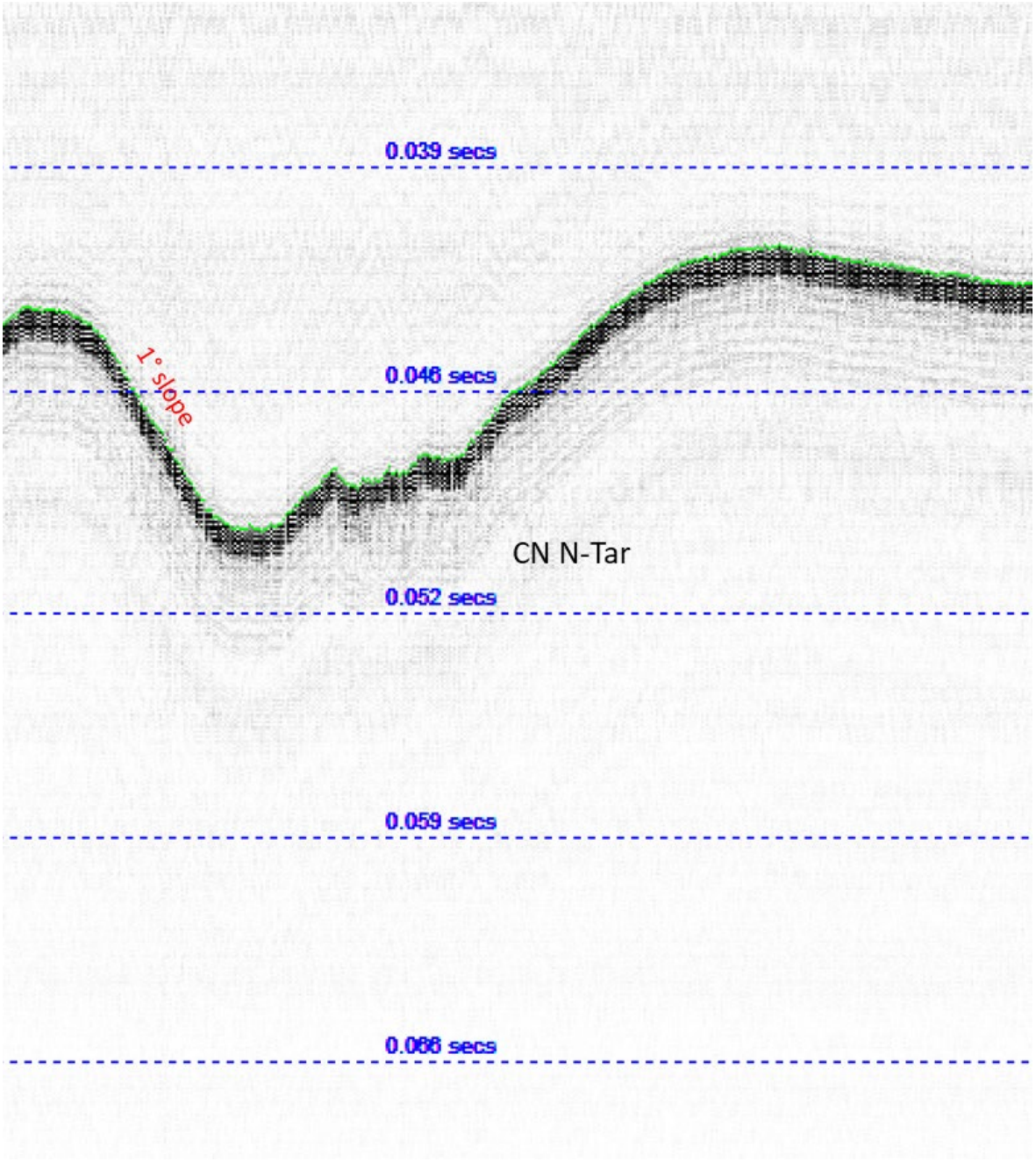

Figure 23: Central Site North Anchor Target (N-Tar) Subbottom

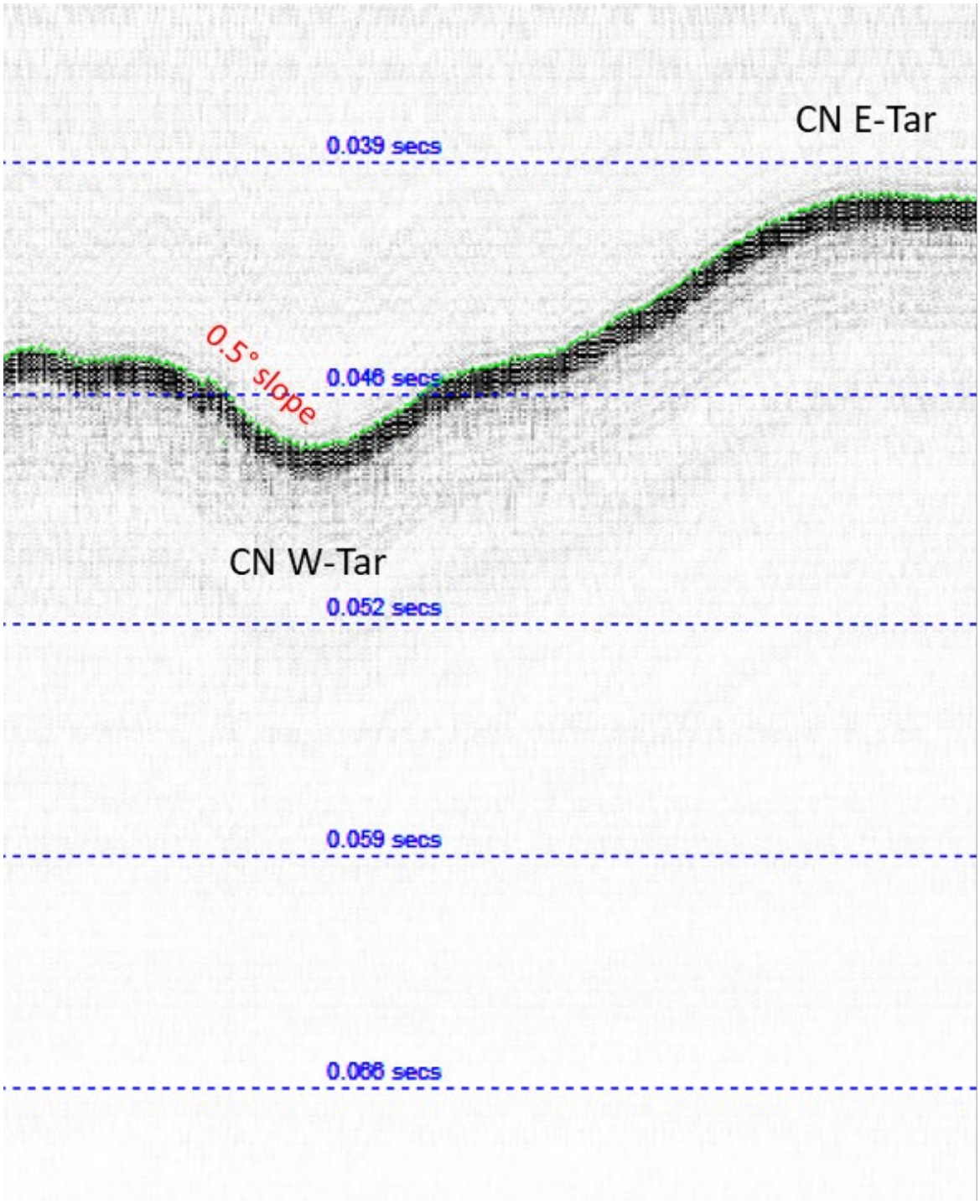

Figure 24: Central Site East & West Anchor Targets (E-Tar, W-Tar) Subbottom

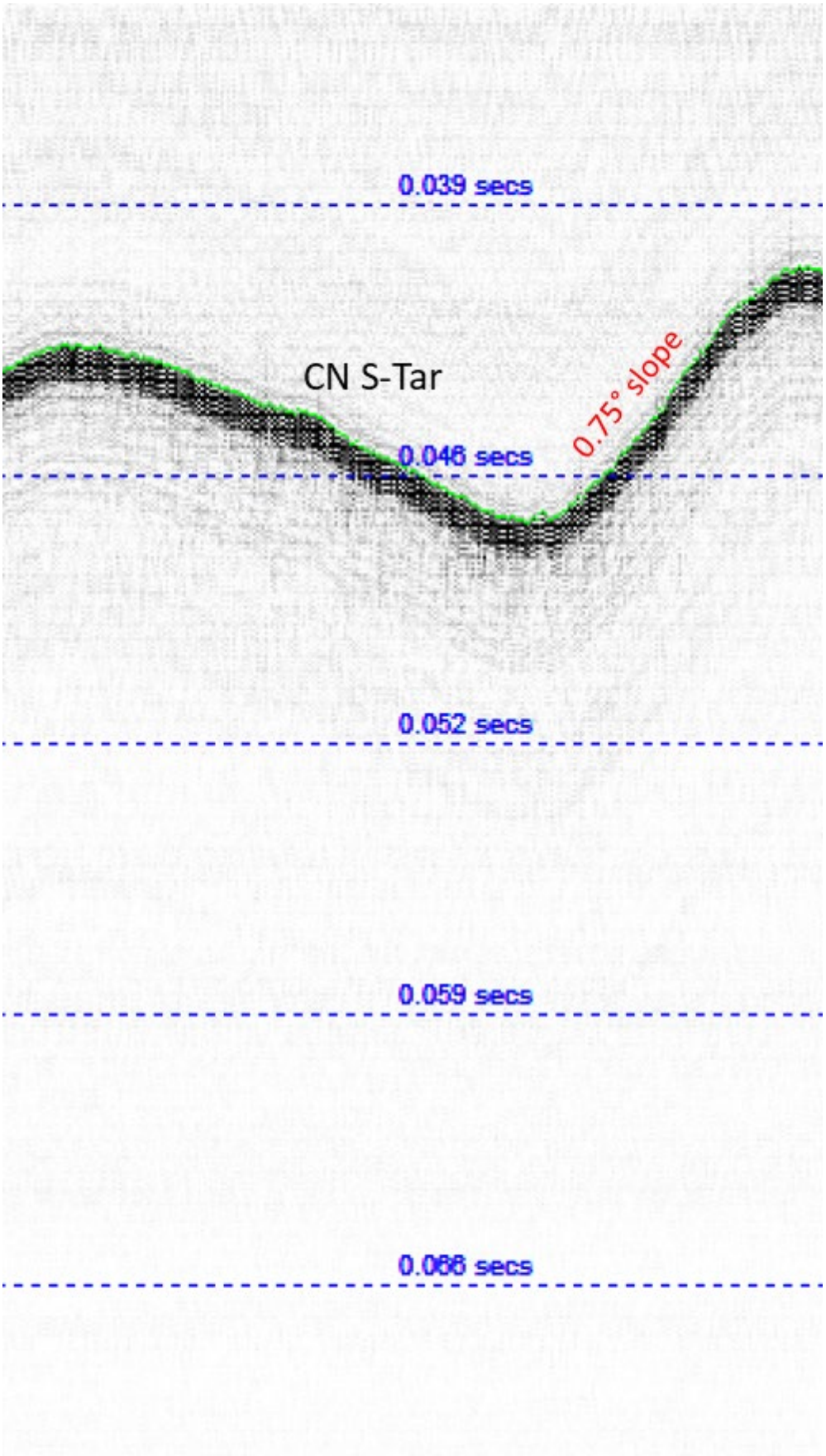

Figure 25: Central Site South Anchor Target (S-Tar) Subbottom

ROV Inspection

ROV inspection was completed at all anchor target sites, Figure 26 shows the ROV and depressor positions overlaid on the DTM. The camera data indicates a flat seabed at all sites consisting of sands, gravels, and shells (Figures 27-30). Wavy seabed also indicates some potential sediment movement. No areas or features of concern (hard bottom, debris, cables, pipelines, wrecks, artifacts, marine habitat) in ROV sonar or imagery in vicinity of anchor targets.

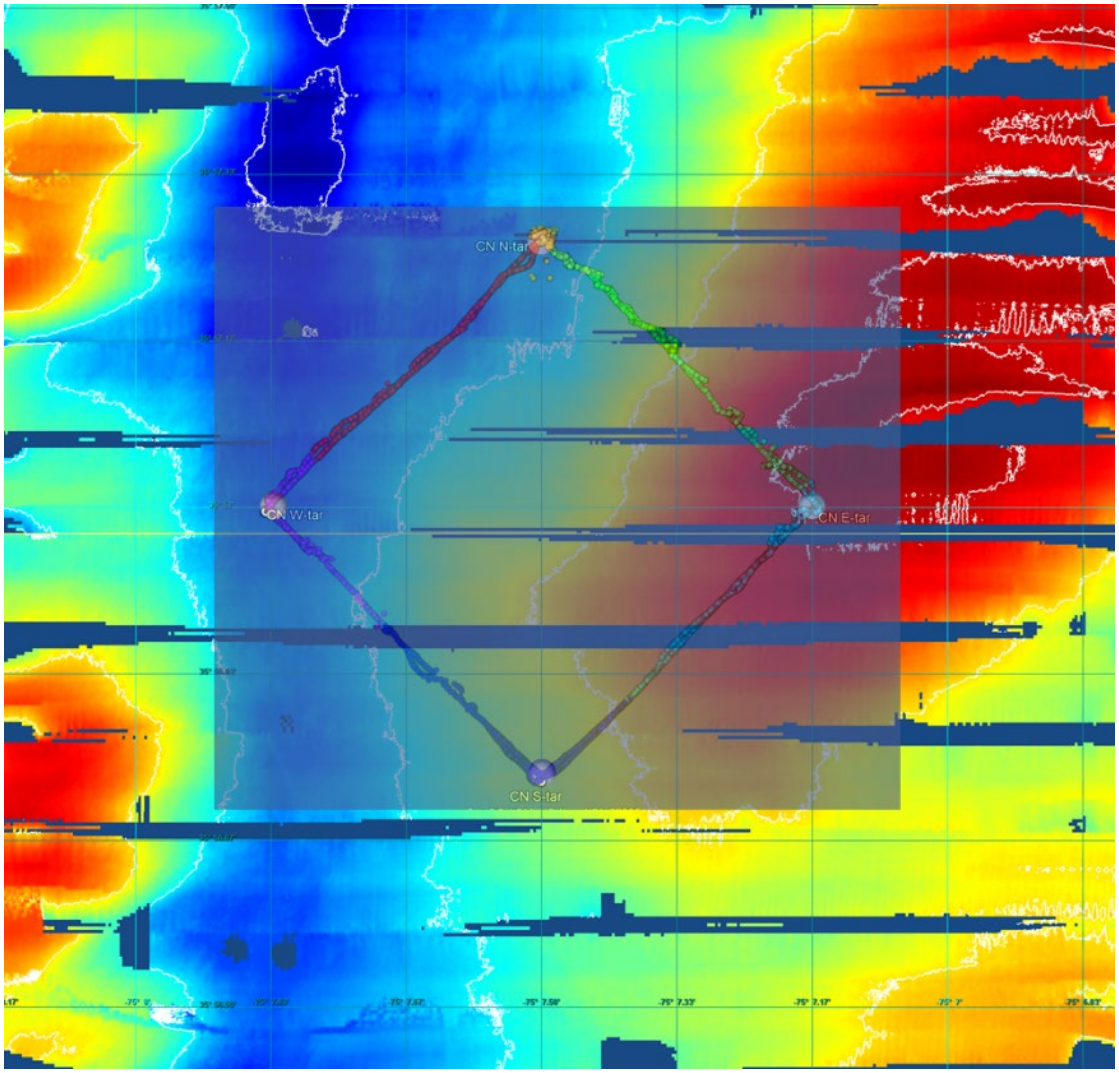

Figure 26: ROV Track at Central Site

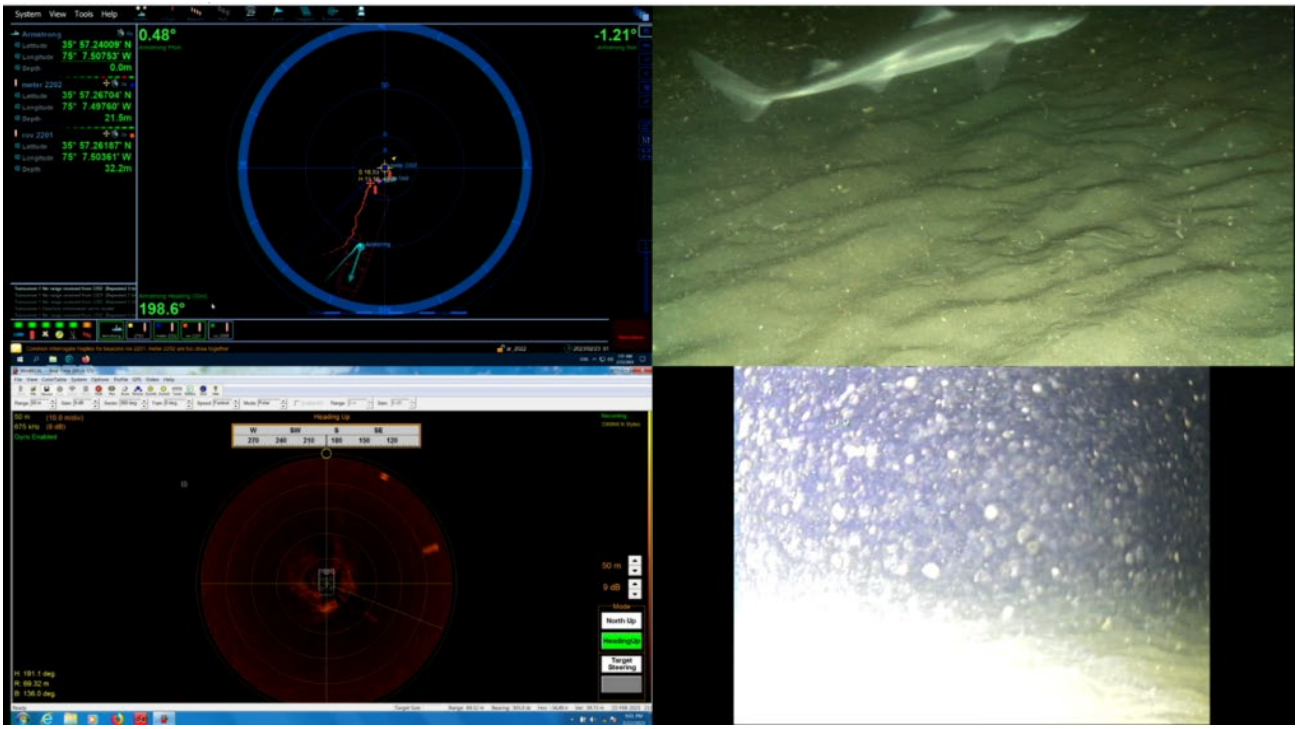

Figure 27: ROV Imagery at Central Site, North Anchor Target

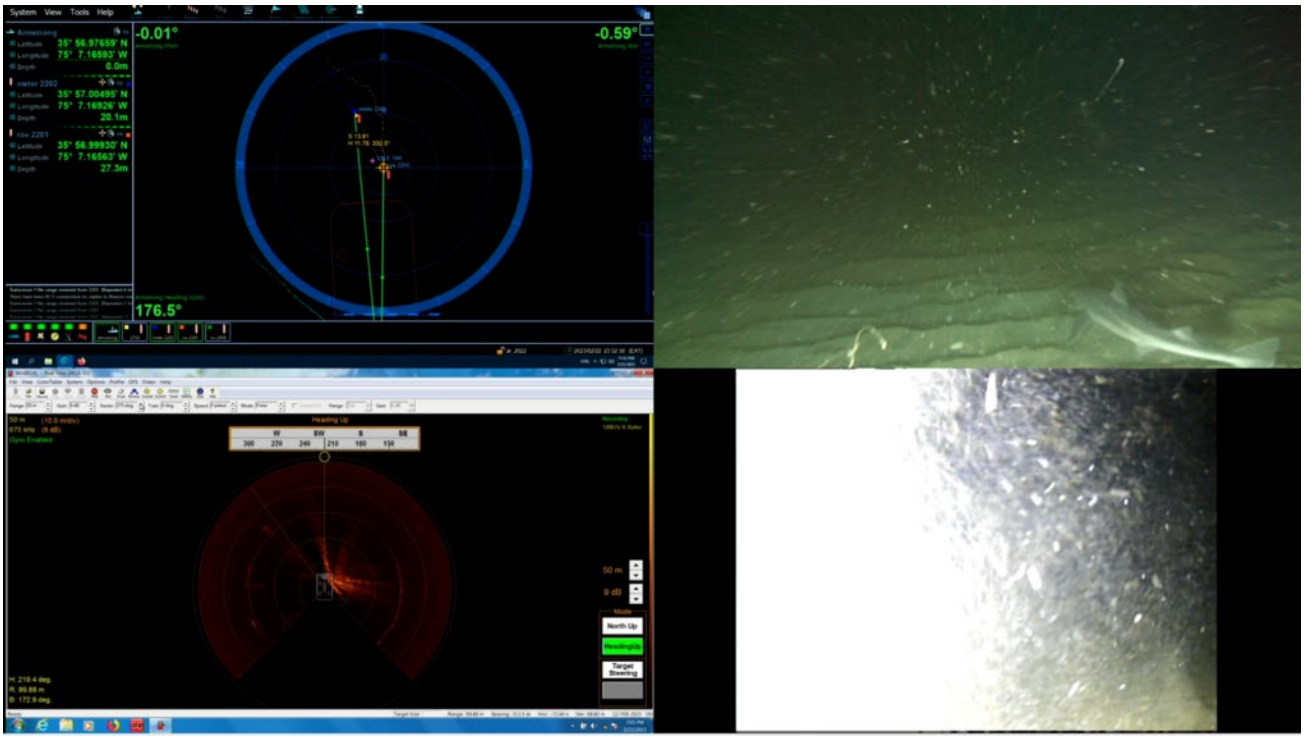

Figure 28: ROV Imagery at Central Site, East Anchor Target

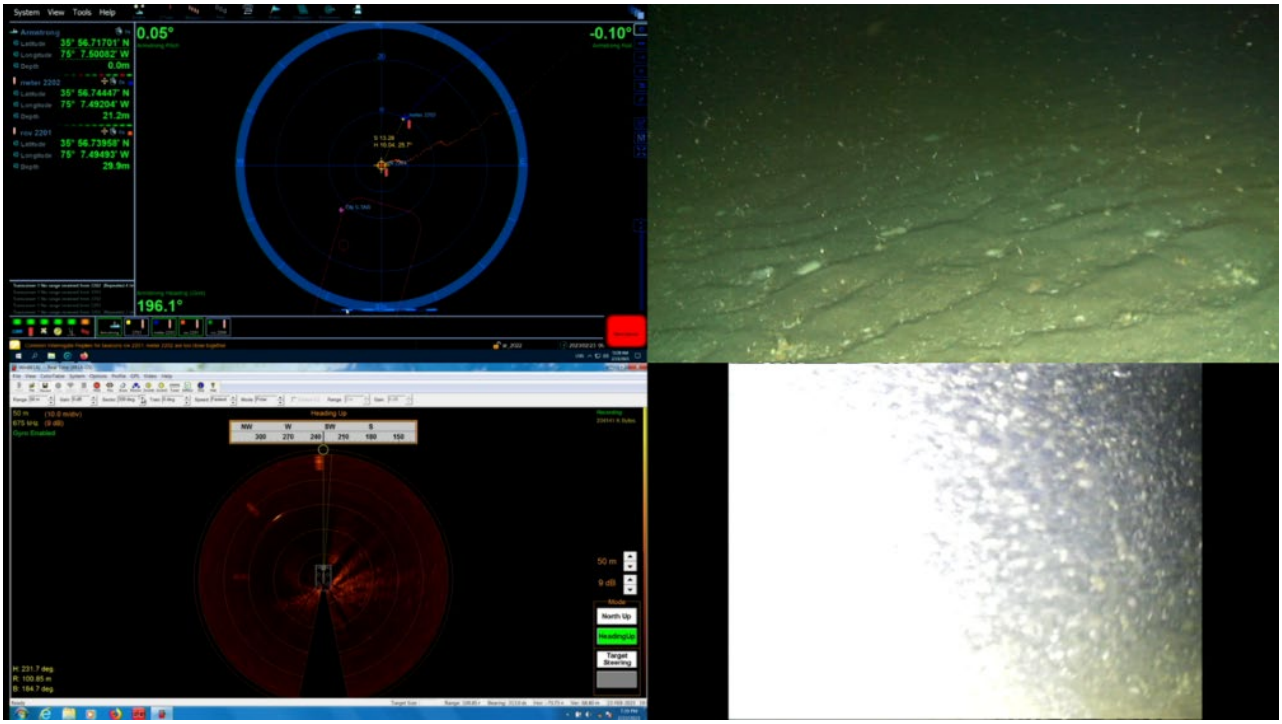

Figure 29: ROV Imagery at Central Site, South Anchor Target

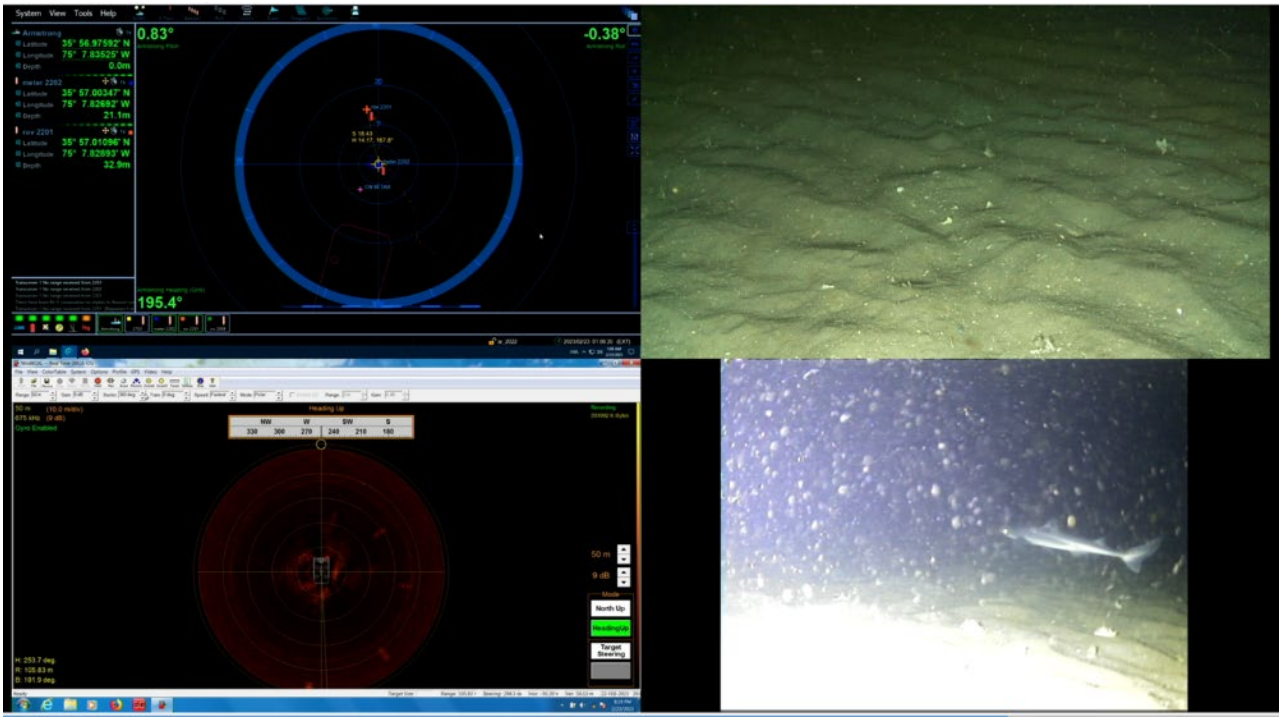

Figure 30: ROV Imagery at Central Site, West Anchor Target

8.3. Eastern

Bathymetry

Moving west to east across Figure 31, the water depth is at the shallowest ~95m, then gradually deepens to ~105m. The North and South anchor targets are at depths of 97 m and 97 m, respectively. Data collected over 2km x 2km area using 200m line spacing.

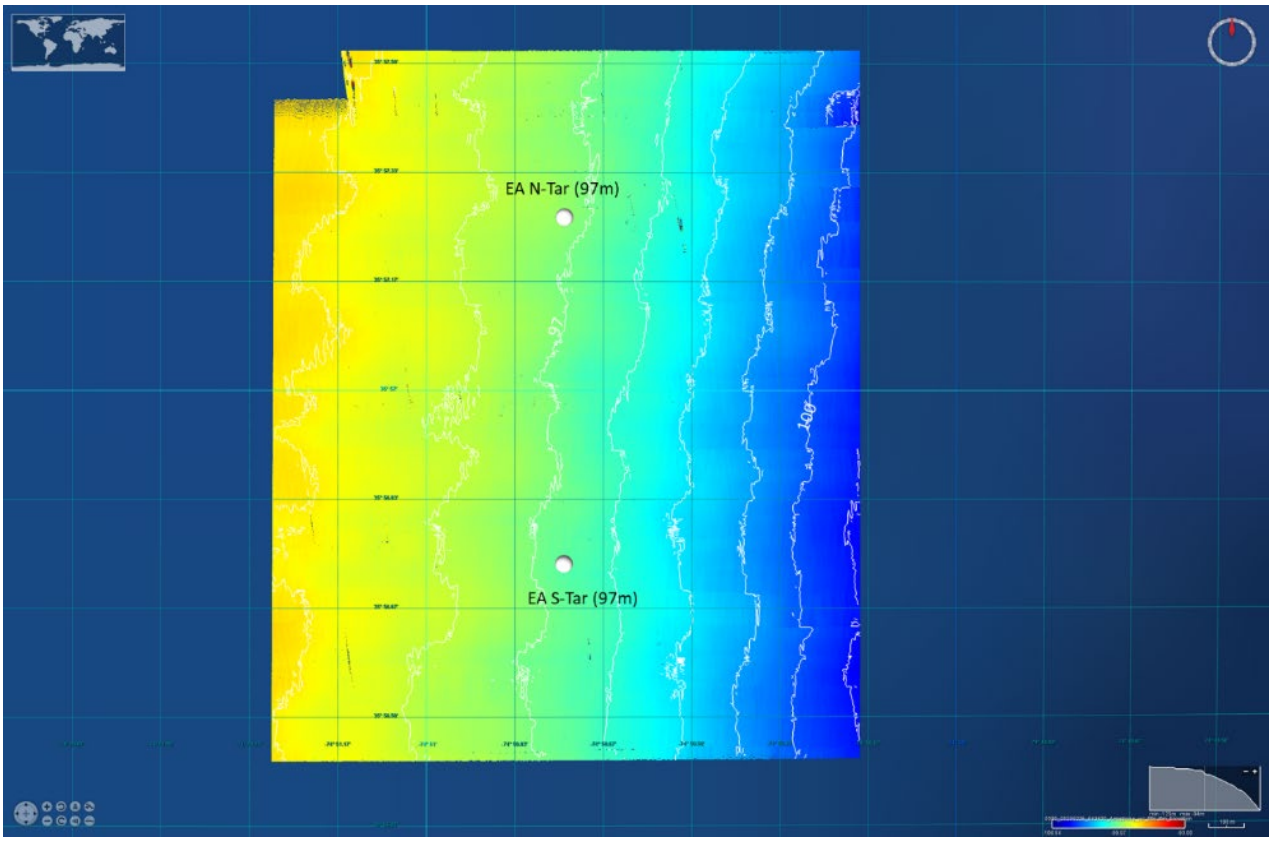

Figure 31: Eastern Site Digital Terrain Model (1m contours)

Backscatter

Backscatter imagery at both the north and south anchor target sites indicate a homogeneous seabed, no visible hazards such as hard bottom, cables, pipelines, wrecks, or debris (Figures 32 & 33).

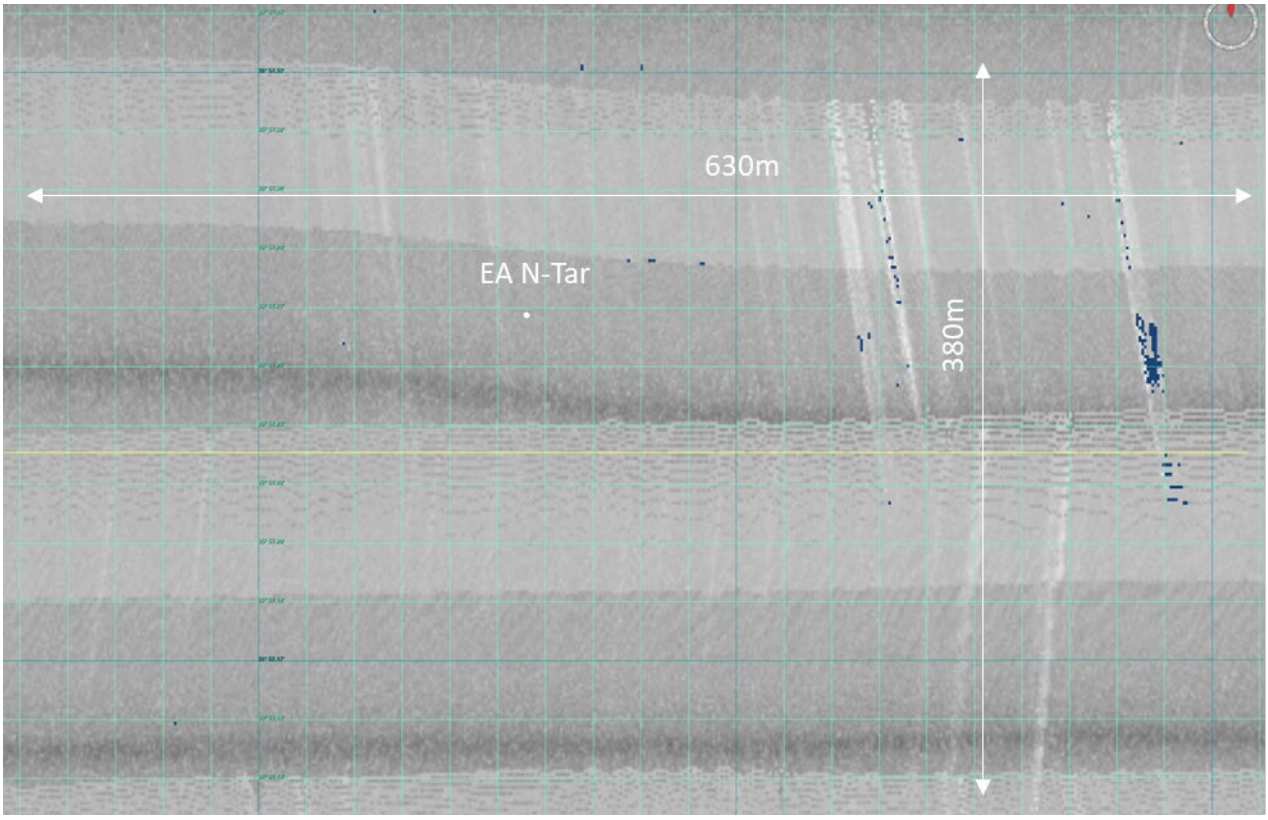

Figure 32: Eastern Site North Anchor Target (N-Tar) Backscatter

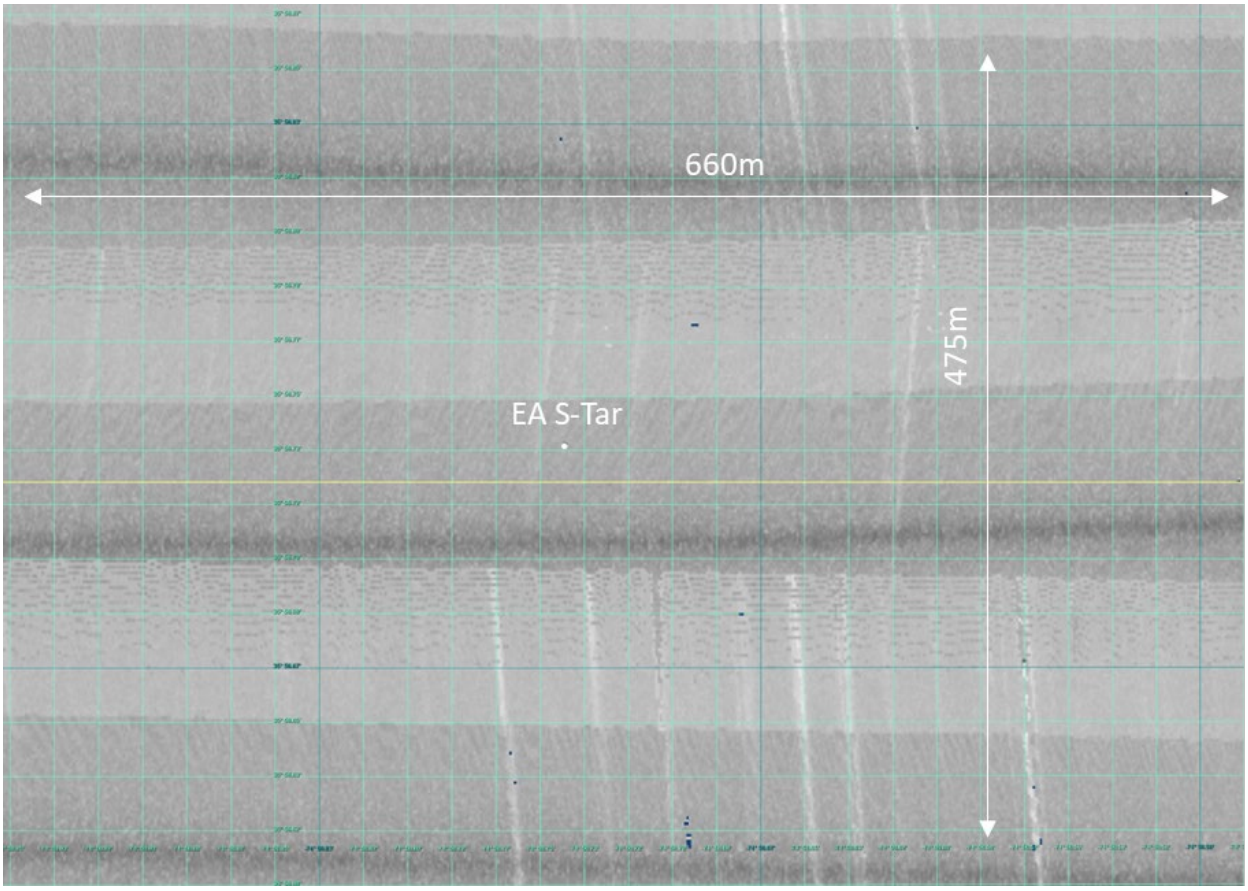

Figure 33: Eastern Site South Anchor Target (S-Tar) Backscatter

Subbottom

Subbottom profiles at both the north and south anchor target sites indicate a soft and homogeneous seabed with good penetration, no indication of hard bottom or hazards such as cables, pipelines, debris, or wrecks (Figures 34 & 35). Slopes are less than 0.5°.

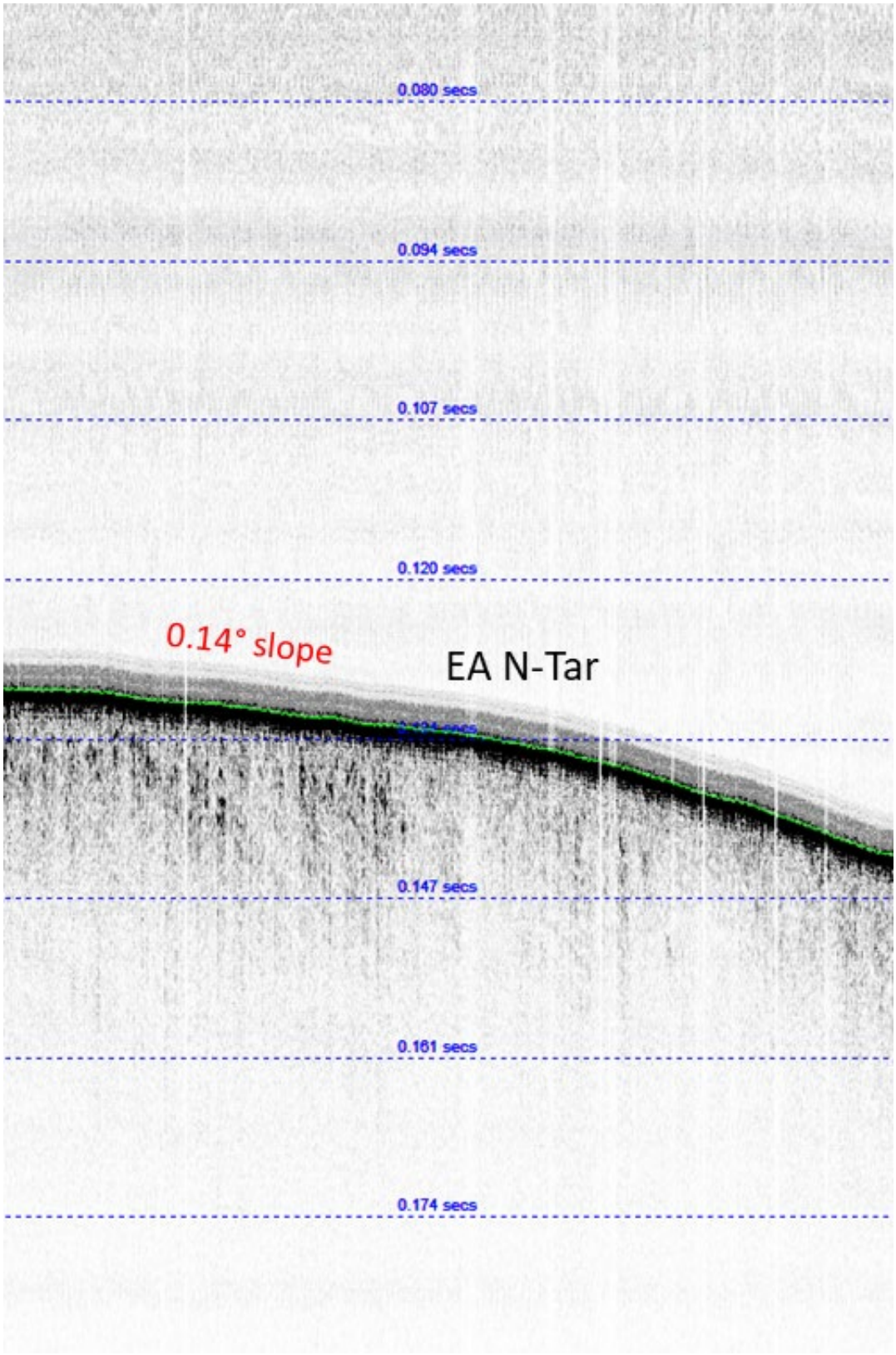

Figure 34: Eastern Site North Anchor Target (N-Tar) Subbottom

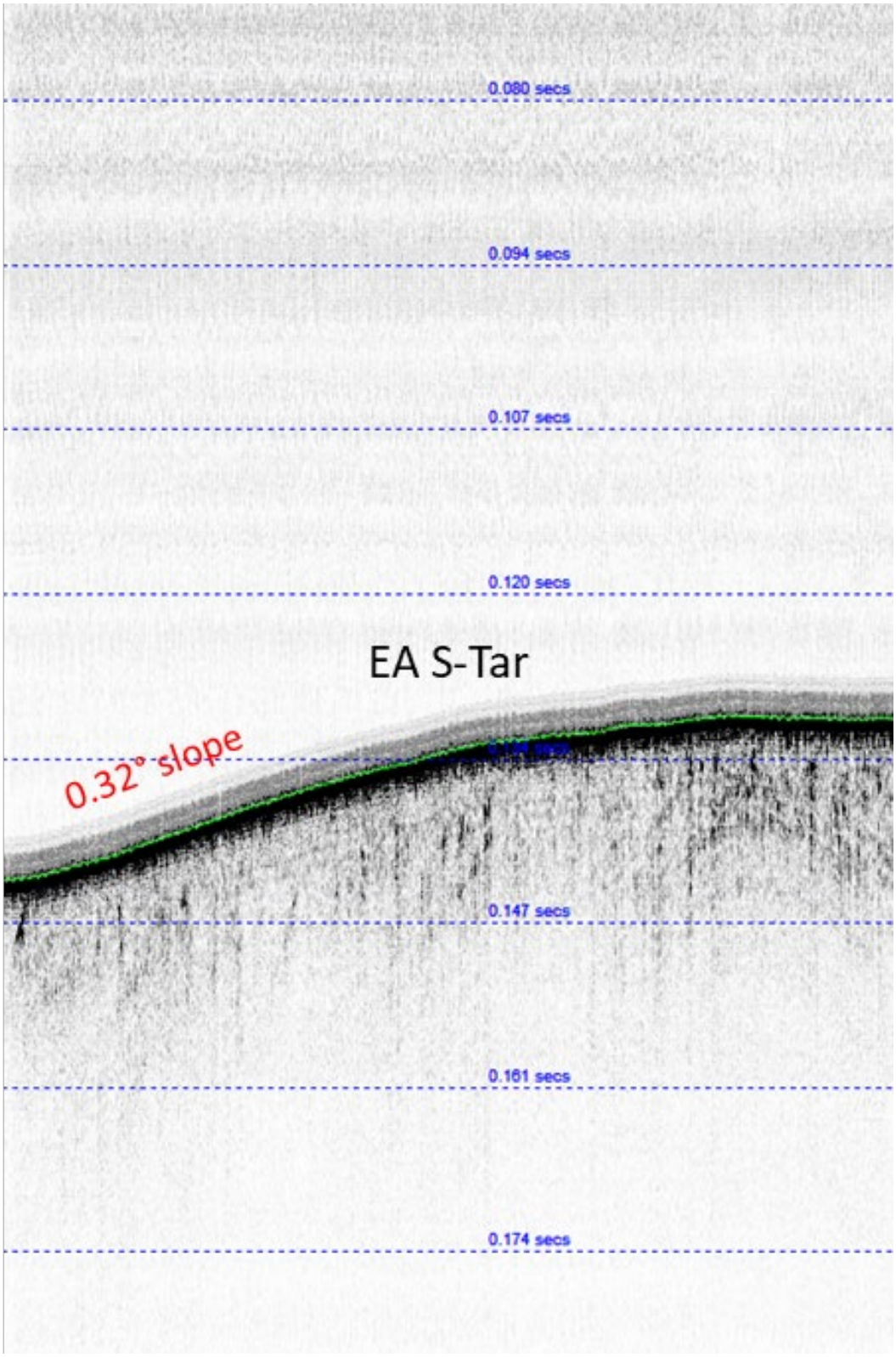

Figure 35: Eastern Site South Anchor Target (S-Tar) Subbottom

ROV Inspection

ROV inspection was completed at both anchor target sites, Figure 36 shows the ROV and depressor positions overlaid on the DTM. The camera data indicates a flat seabed at both sites consisting of sands, gravels, and shells (Figures 37 – 39). No areas or features of concern (hard bottom, debris, cables, pipelines, wrecks, artifacts, marine habitat) in ROV sonar or imagery in vicinity of anchor targets.

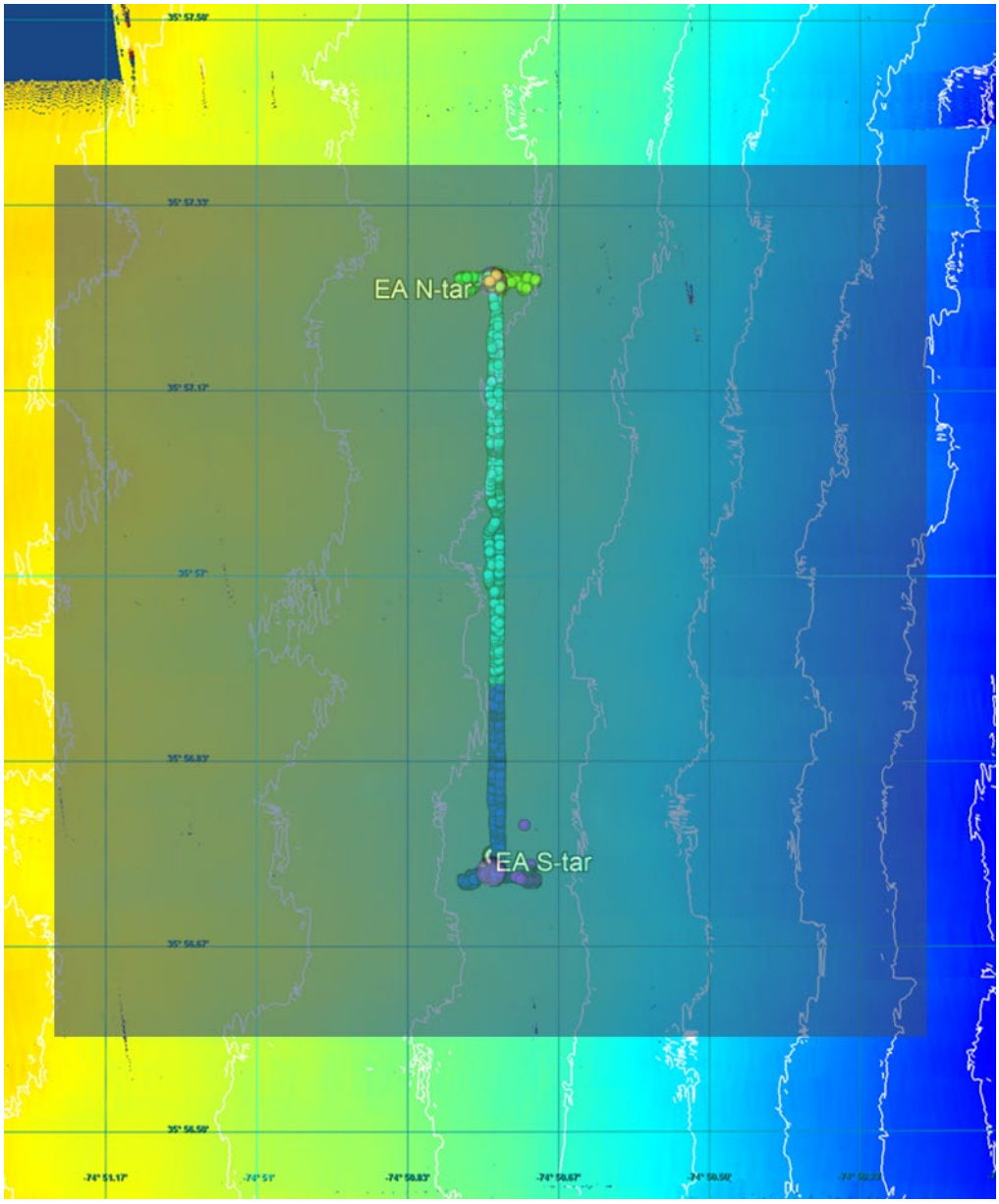

Figure 36: ROV Track at Eastern Site

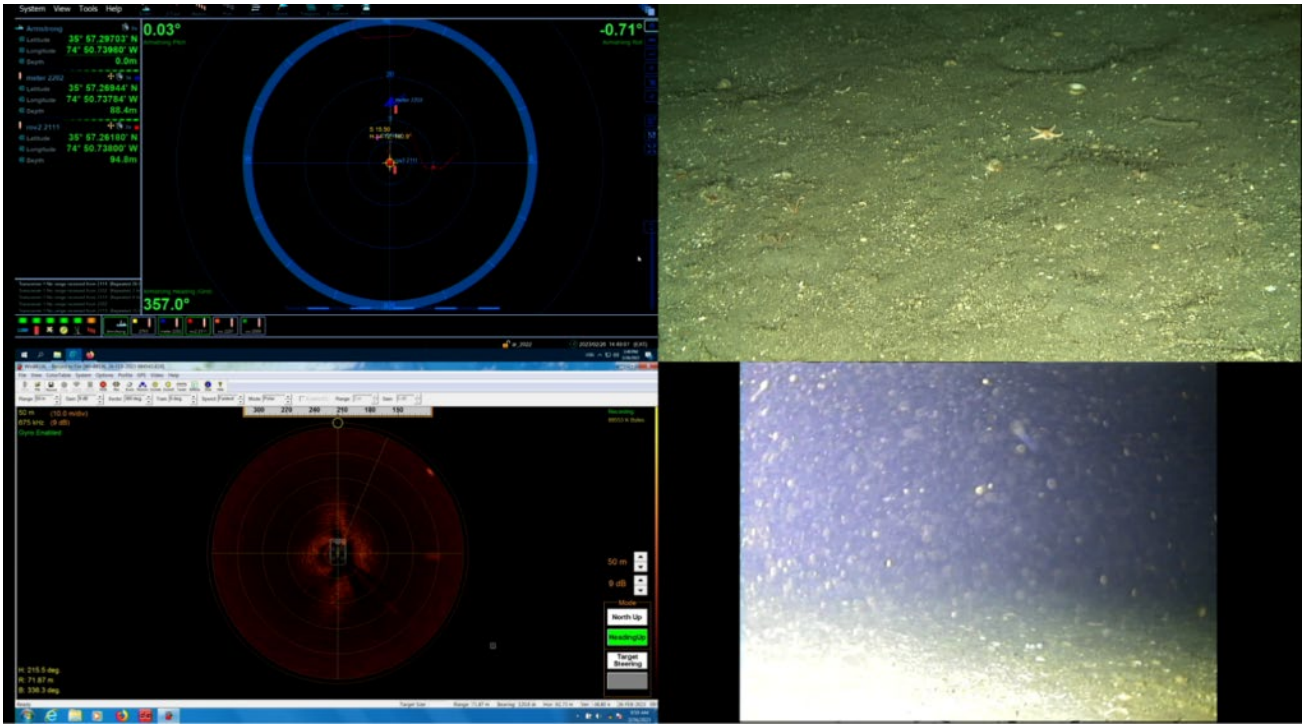

Figure 37: ROV Imagery at Eastern Site, North Anchor Target

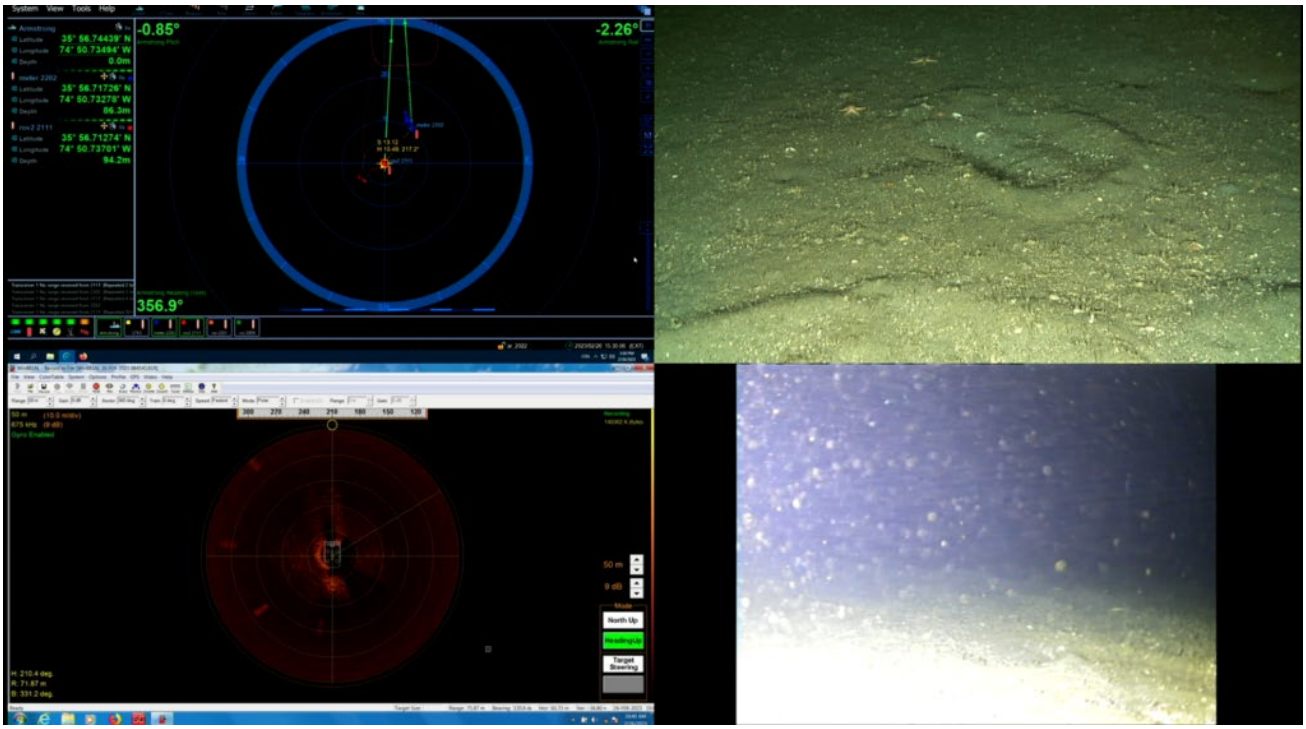

Figure 38: ROV Imagery at Eastern Site, South Anchor Target

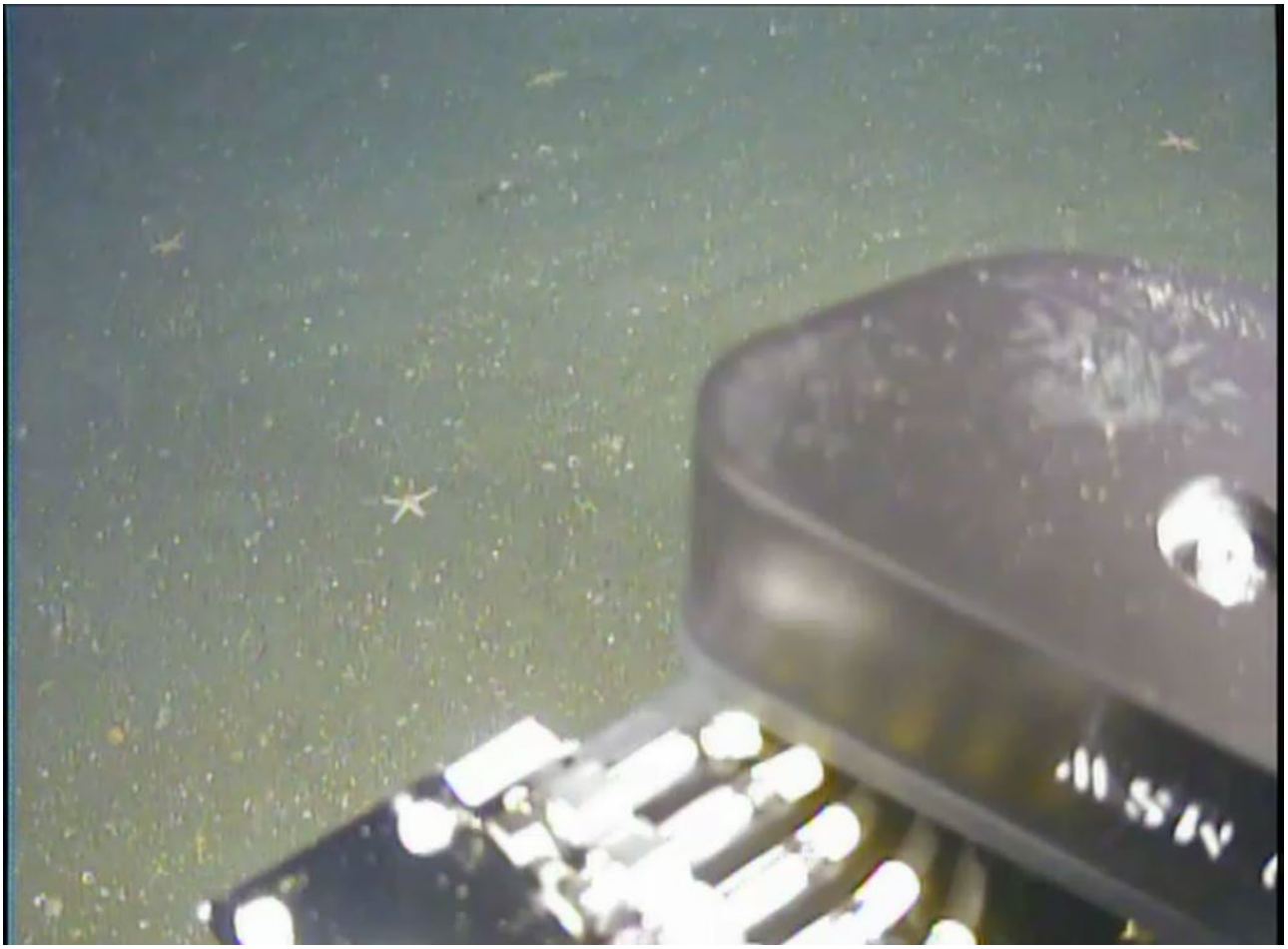

Figure 39: Sandy, Gravelly, Shelly Seabed Eastern Site, South Anchor Target

8.4. Northern

Bathymetry

Moving west to east across Figure 40, the water depth is at the shallowest ~92m, then gradually deepens to ~105m. The North, South, East and West anchor targets are at depths of 97 m, 99 m, 101 m and 95 m, respectively. Data collected over 2km x 2km area using 200m line spacing.

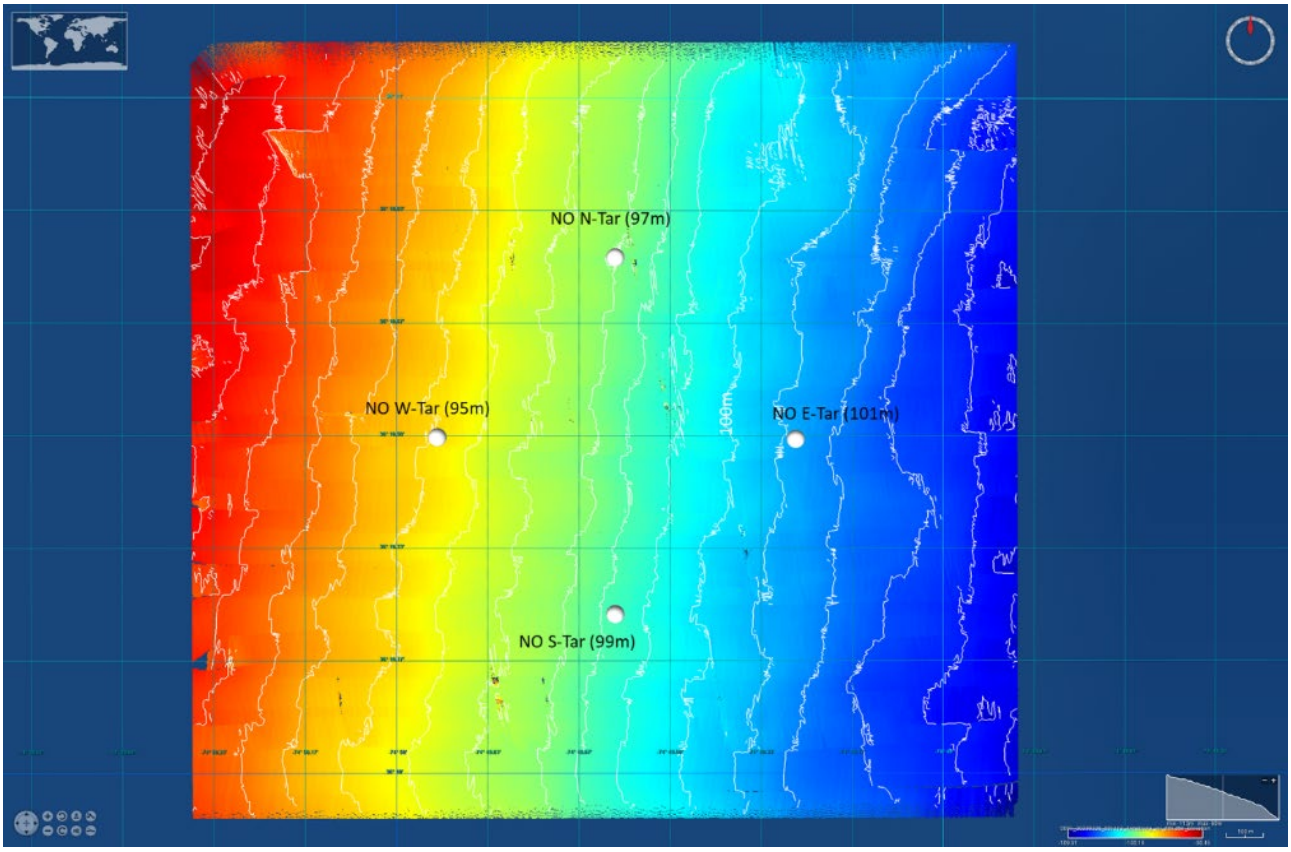

Figure 40: Northern Site Digital Terrain Model (1m contours)

Backscatter

Backscatter imagery at both the north and south anchor target sites indicate a homogeneous seabed, no visible hazards such as hard bottom, cables, pipelines, wrecks, or debris (Figures 41 thru 44).

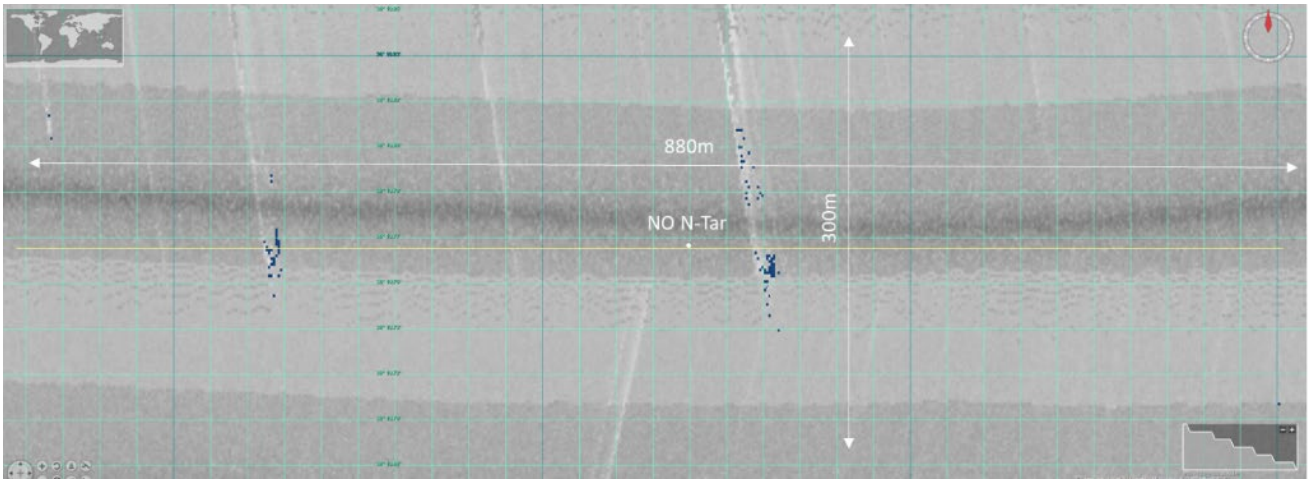

Figure 41: Northern Site North Anchor Target (N-Tar) Backscatter

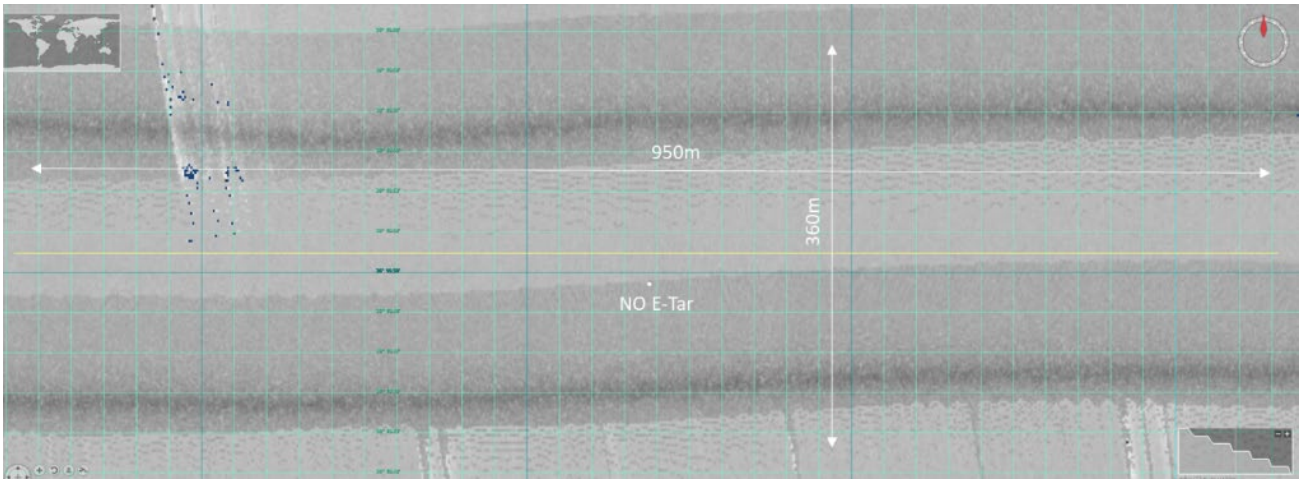

Figure 42: Northern Site East Anchor Target (E-Tar) Backscatter

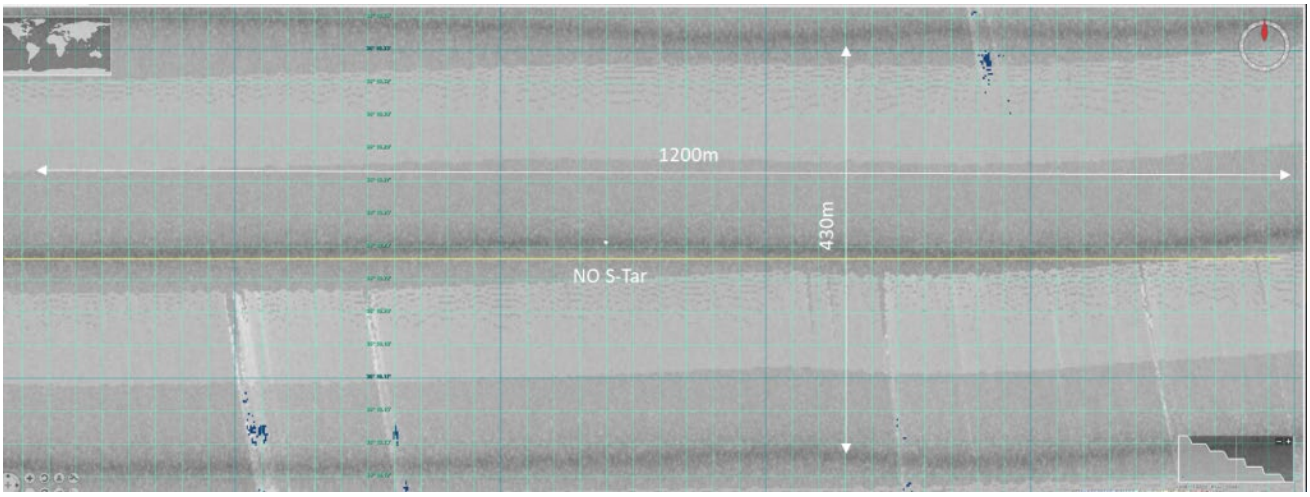

Figure 43: Northern Site South Anchor Target (S-Tar) Backscatter

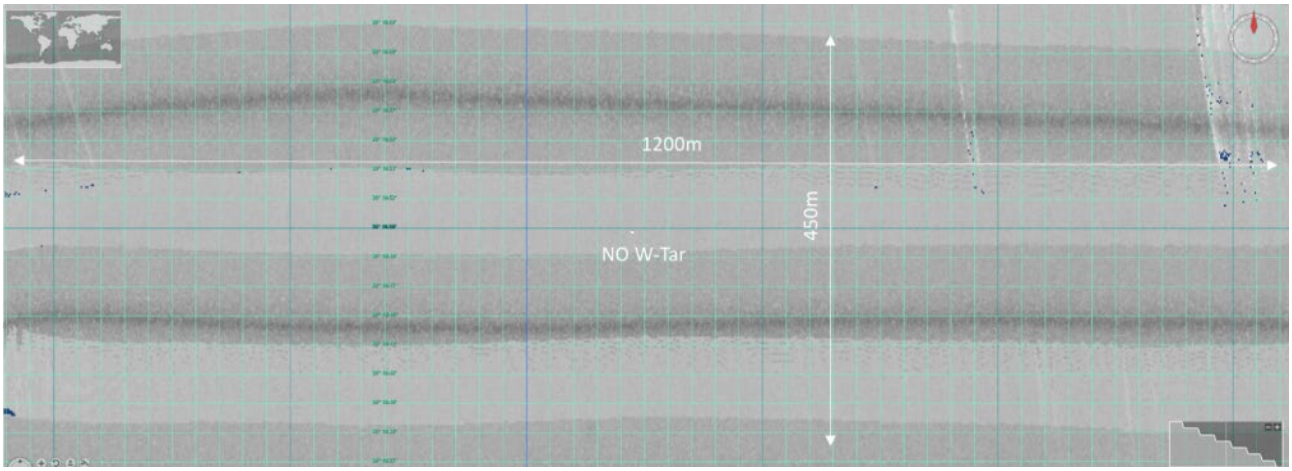

Figure 44: Northern Site West Anchor Target (W-Tar) Backscatter

Subbottom

Subbottom profiles at all anchor target sites indicate a soft and homogeneous seabed with good penetration, no indication of hard bottom or hazards such as cables, pipelines, debris, or wrecks (Figures 45 thru 47). Slopes are ~0.5°.

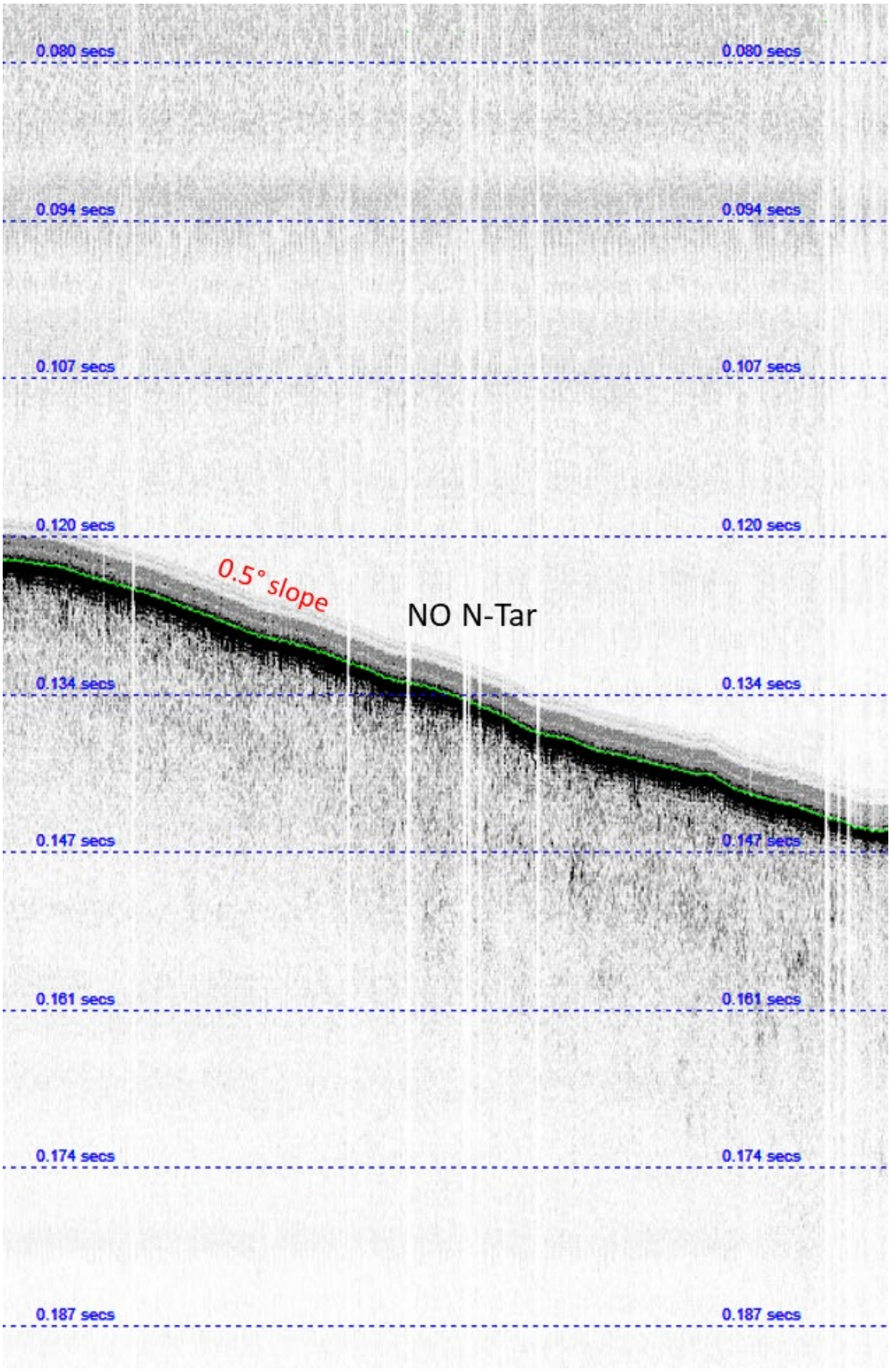

Figure 45: Northern Site North Anchor Target (N-Tar) Subbottom

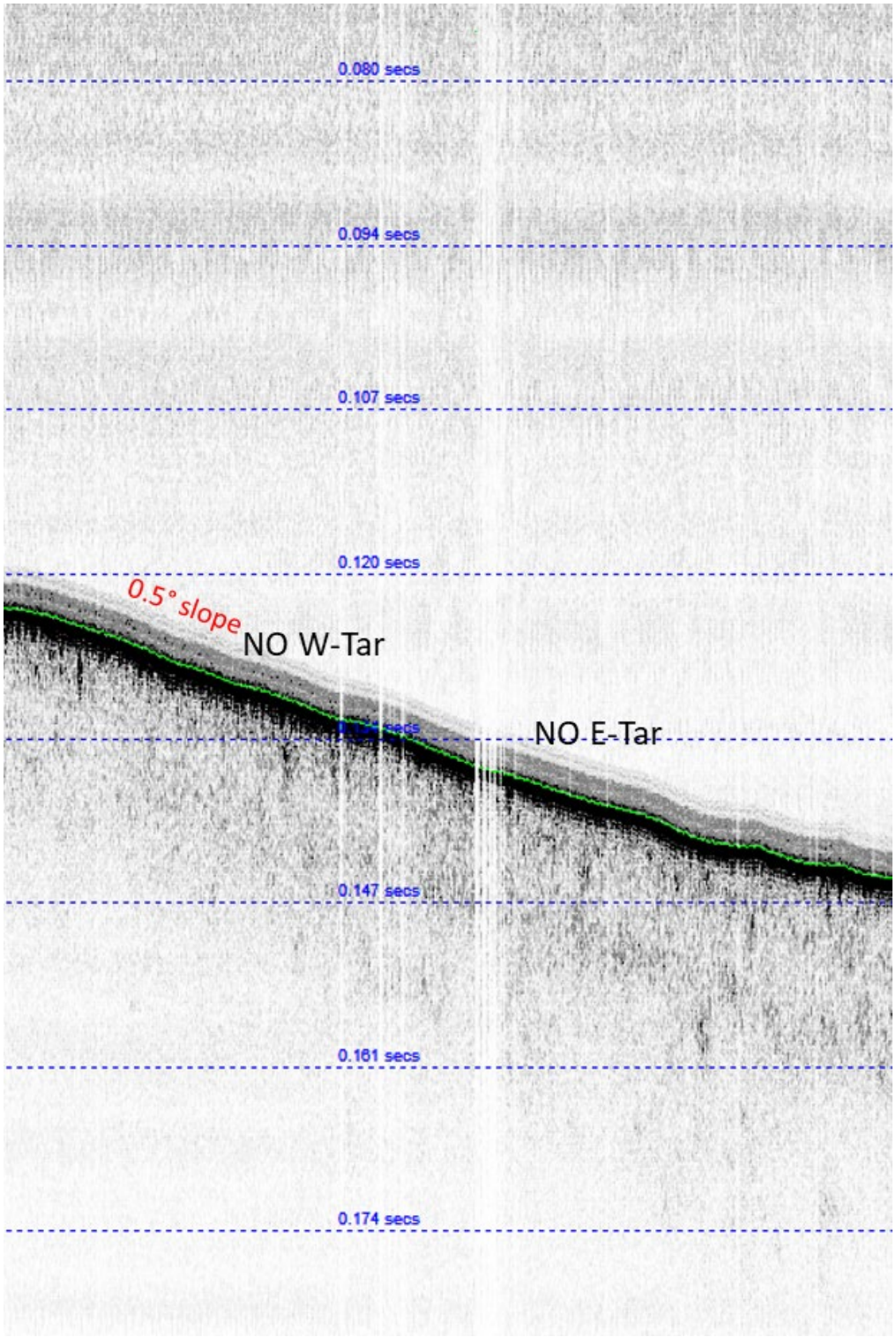

Figure 46: Northern Site East & West Anchor Targets (E-Tar, W-Tar) Subbottom

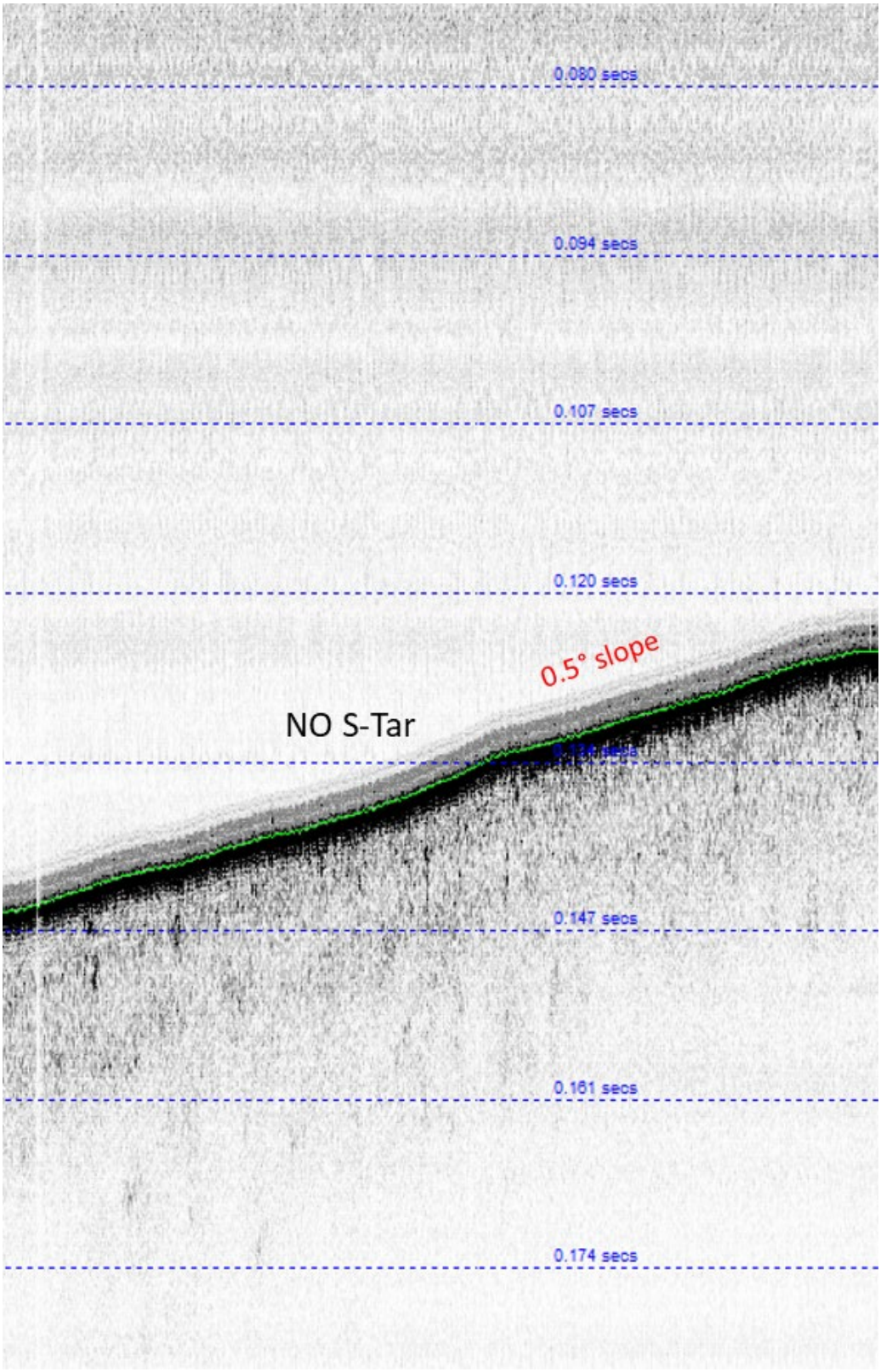

Figure 47: Northern Site South Anchor Targets (S-Tar) Subbottom

ROV Inspection

ROV inspection was completed at all anchor target sites, Figure 48 shows the ROV and depressor positions overlaid on the DTM. The camera data indicates a flat seabed at all sites consisting of sands, gravels, shells (Figures 49 thru 54). No areas or features of concern (hard bottom, debris, cables, pipelines, wrecks, artifacts, marine habitat) in ROV sonar or imagery in vicinity of anchor targets.

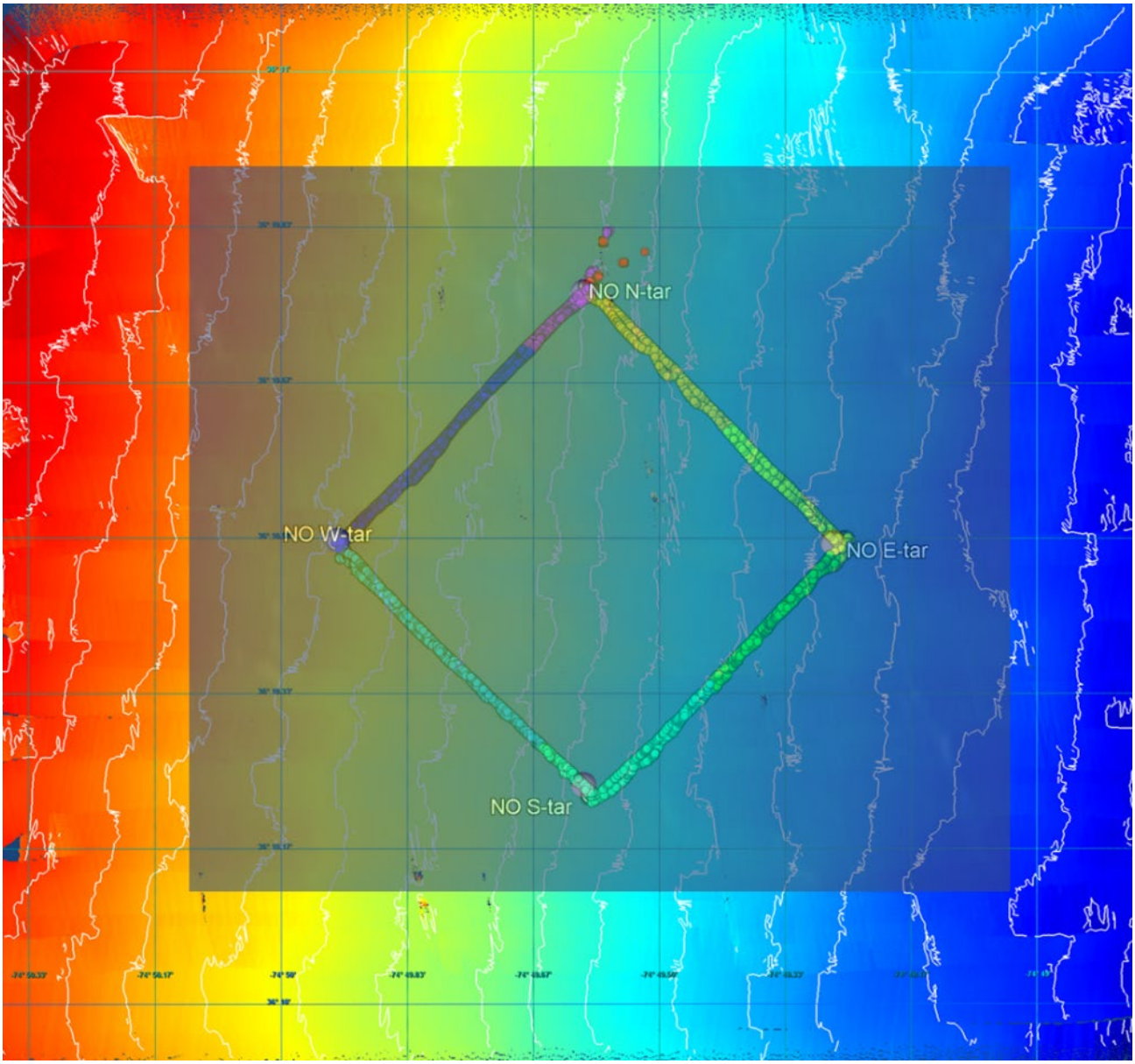

Figure 48: ROV Track at Northern Site

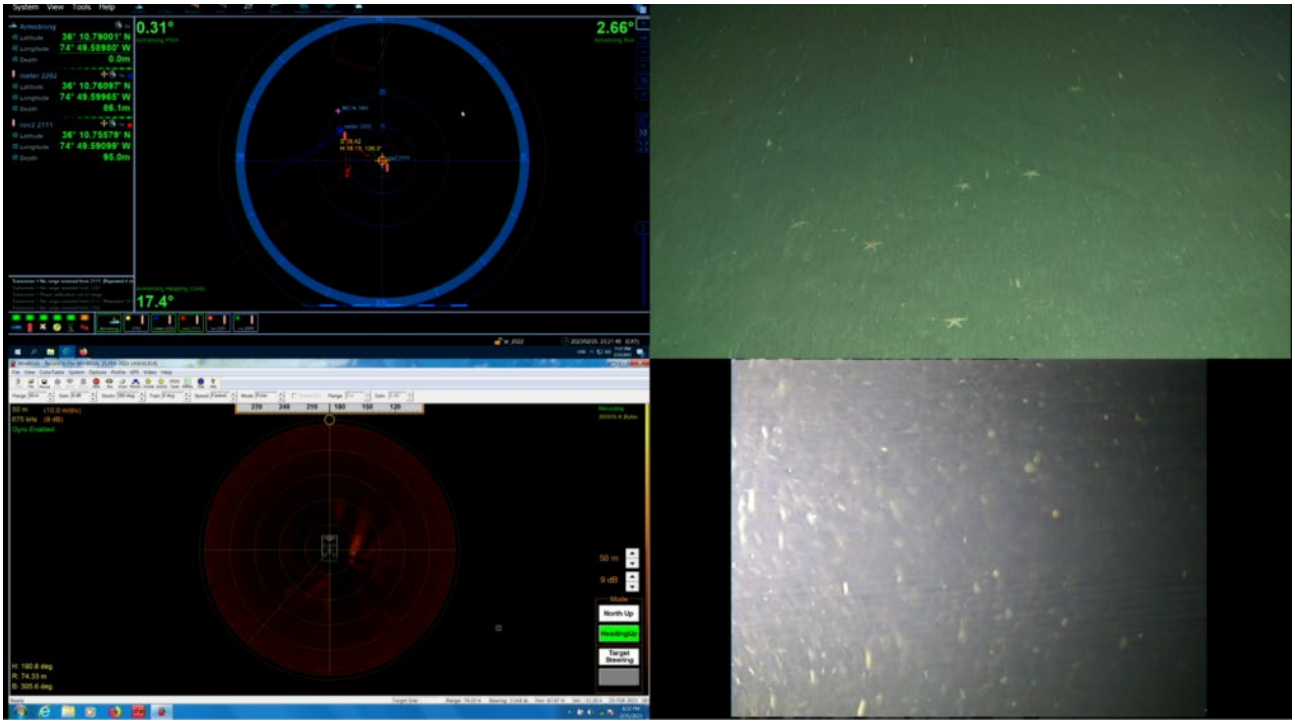

Figure 49: ROV Imagery at Northern Site, North Anchor Target

Figure 50: Sandy, Gravelly, Shelly Seabed Northern Site, North Anchor Target

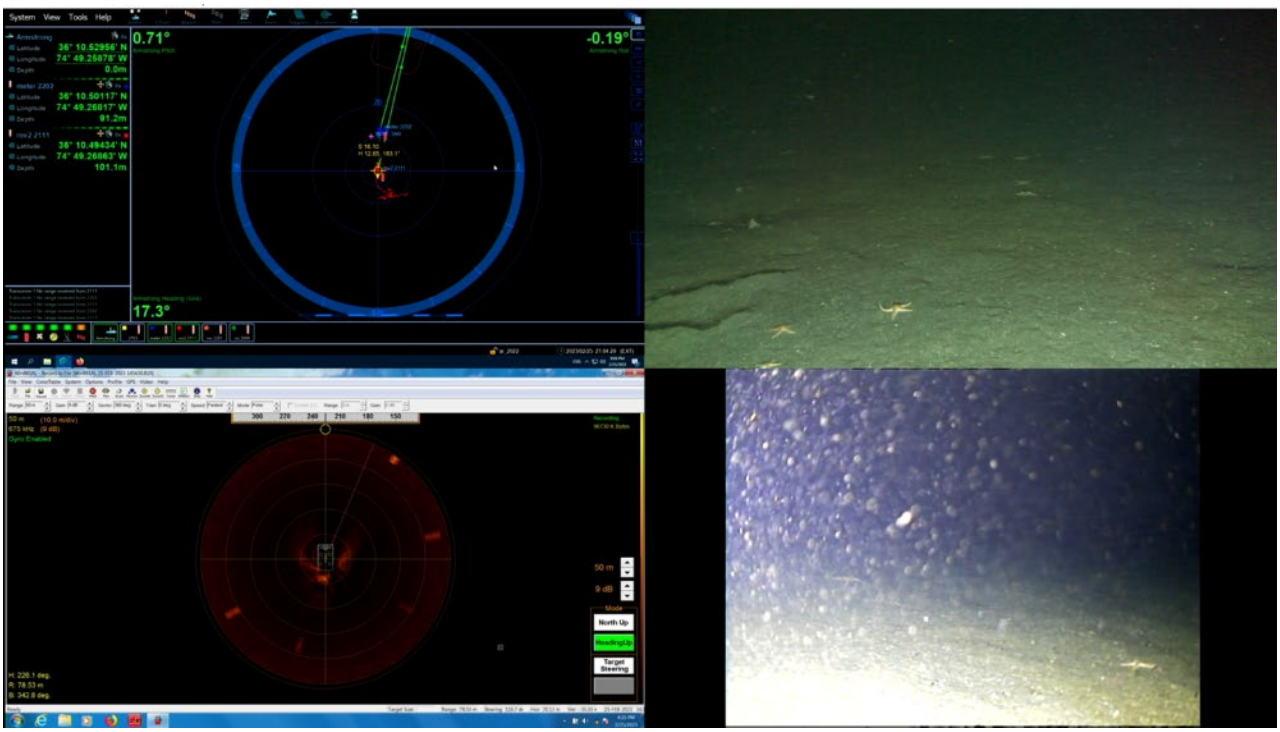

Figure 51: ROV Imagery at Northern Site, East Anchor Target

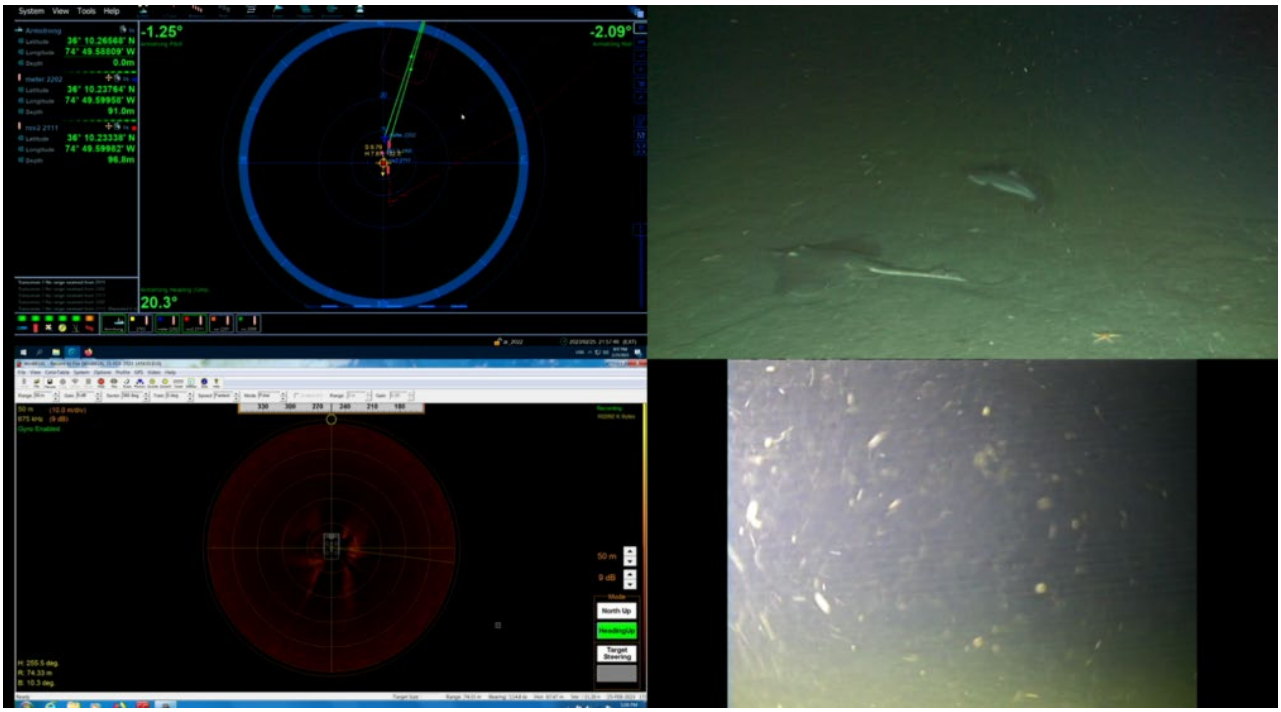

Figure 52: ROV Imagery at Northern Site, South Anchor Target

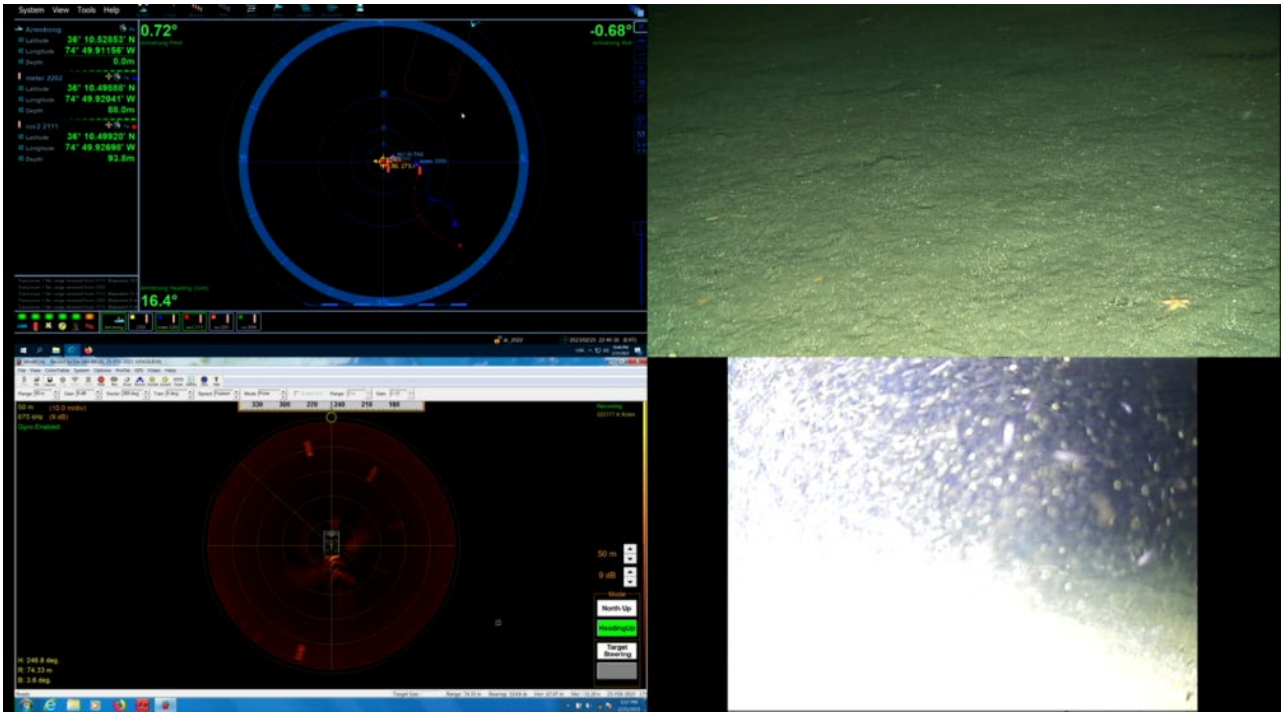

Figure 53: ROV Imagery at Northern Site, West Anchor Target

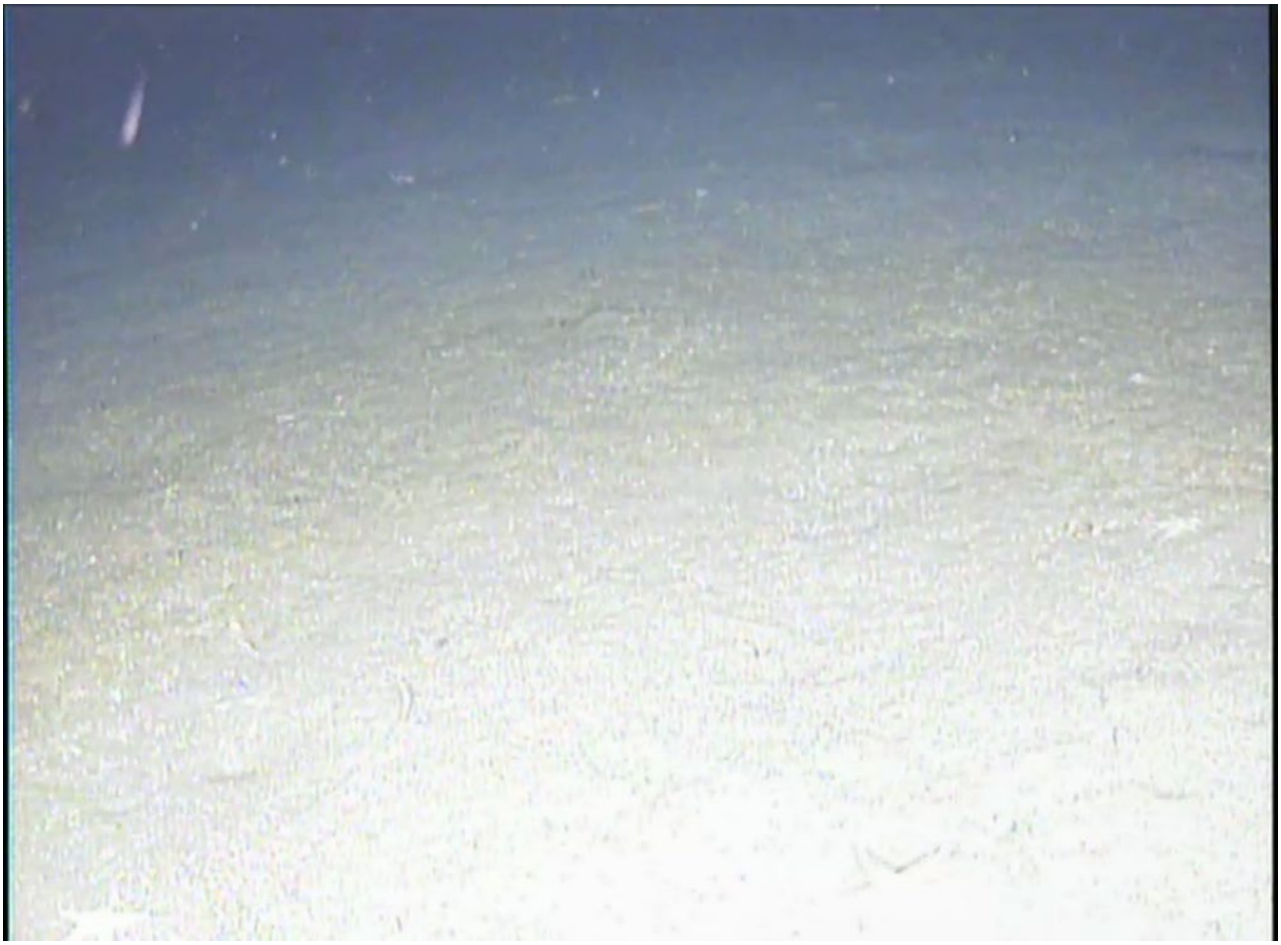

Figure 54: Sandy, Gravelly, Shelly Seabed Northern Site, West Anchor Target

8.5. Southern

Bathymetry

Moving west to east across Figure 55, the water depth is at the shallowest ~85m in the southwest corner, then deepens to the west with a steeper dropoff starting at the ~118m contour deepening again to ~140m to the west, with a steeper dropoff to ~144m in the southeast corner. The North, South, East and West anchor targets are at depths of 94 m, 92 m, 98 m and 88 m, respectively. Data collected over 2km x 2km area using 200m line spacing.

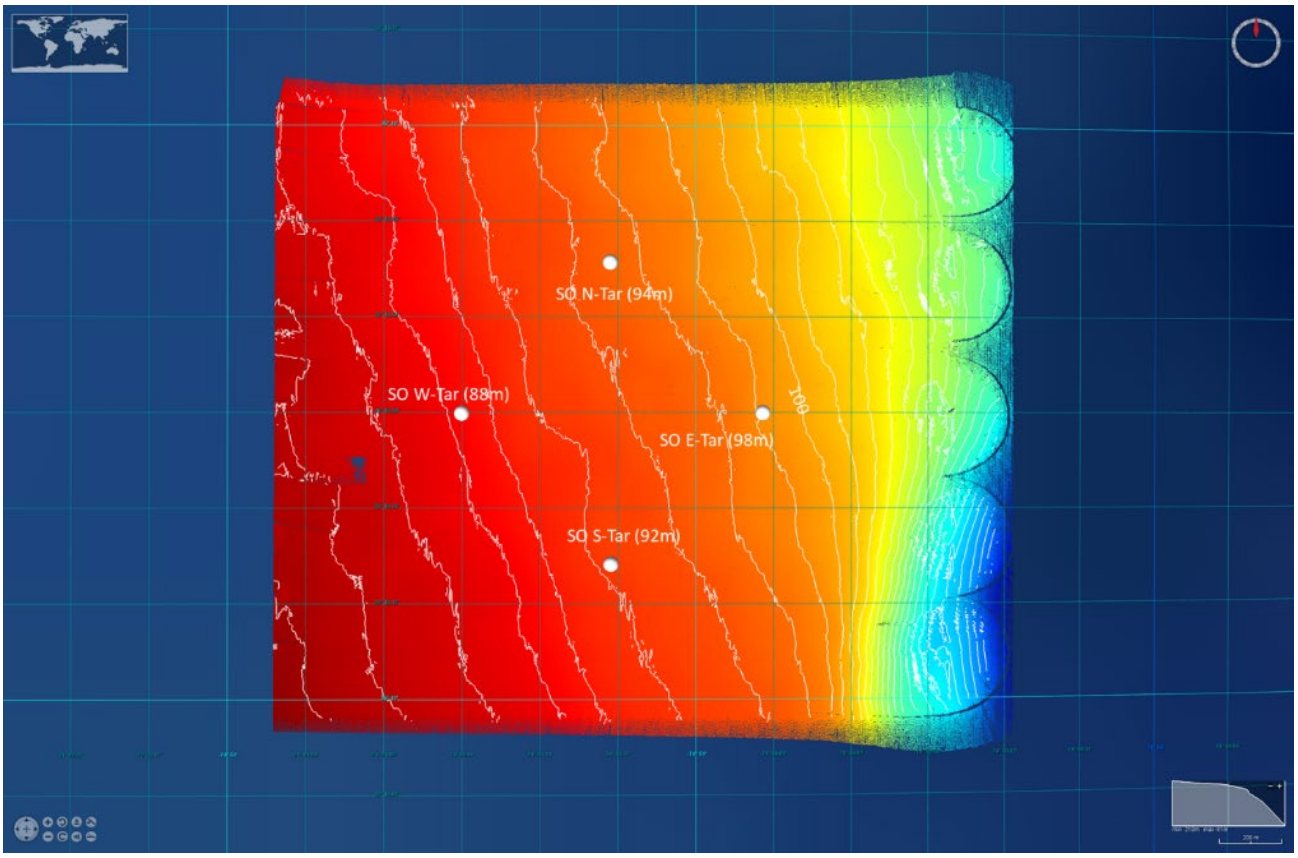

Figure 55: Southern Site Digital Terrain Model (2m contours)

Backscatter

Backscatter imagery at both the north and south anchor target sites indicate a homogeneous seabed, no visible hazards such as hard bottom, cables, pipelines, wrecks, or debris (Figures 56 thru 59).

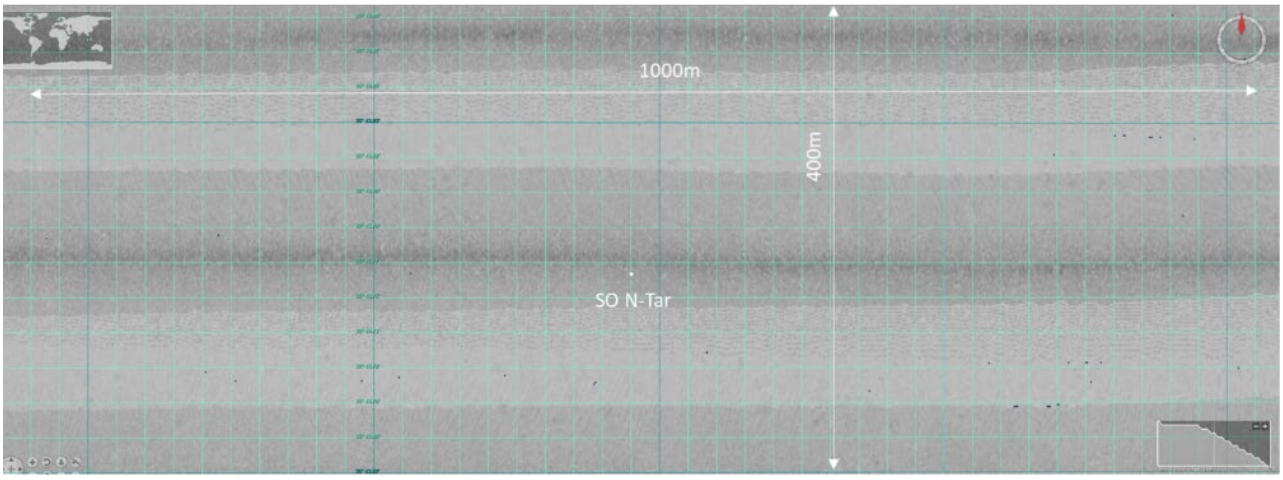

Figure 56: Southern Site North Anchor Target (N-Tar) Backscatter

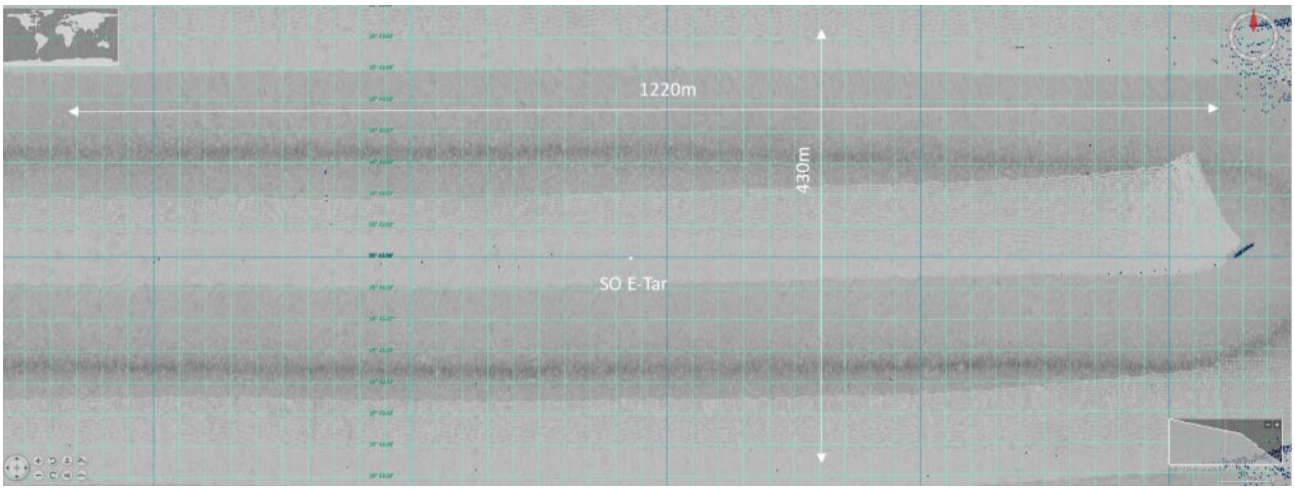

Figure 57: Southern Site East Anchor Target (E-Tar) Backscatter

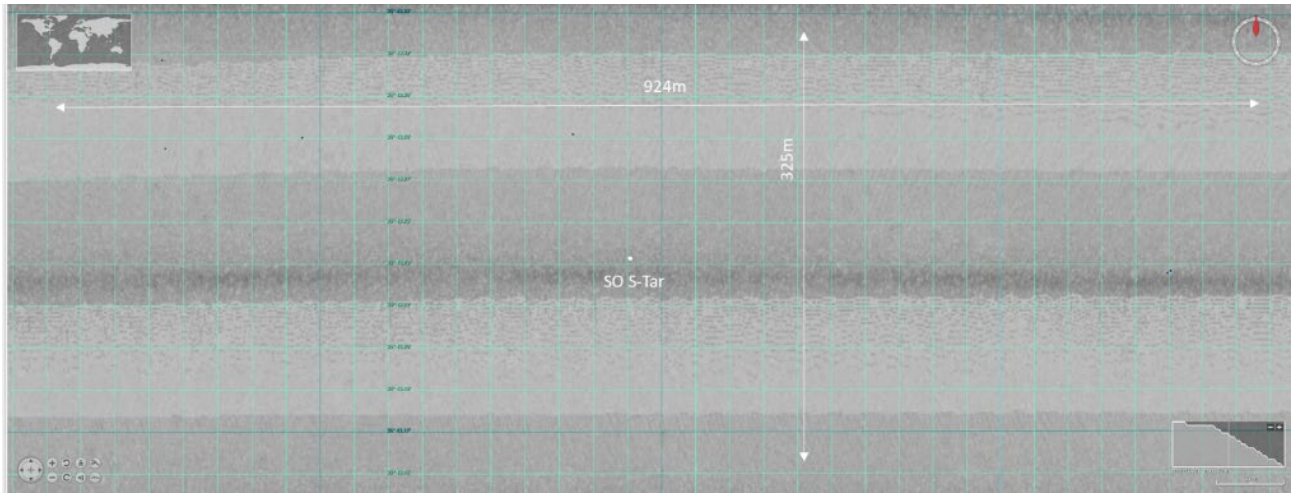

Figure 58: Southern Site South Anchor Target (S-Tar) Backscatter

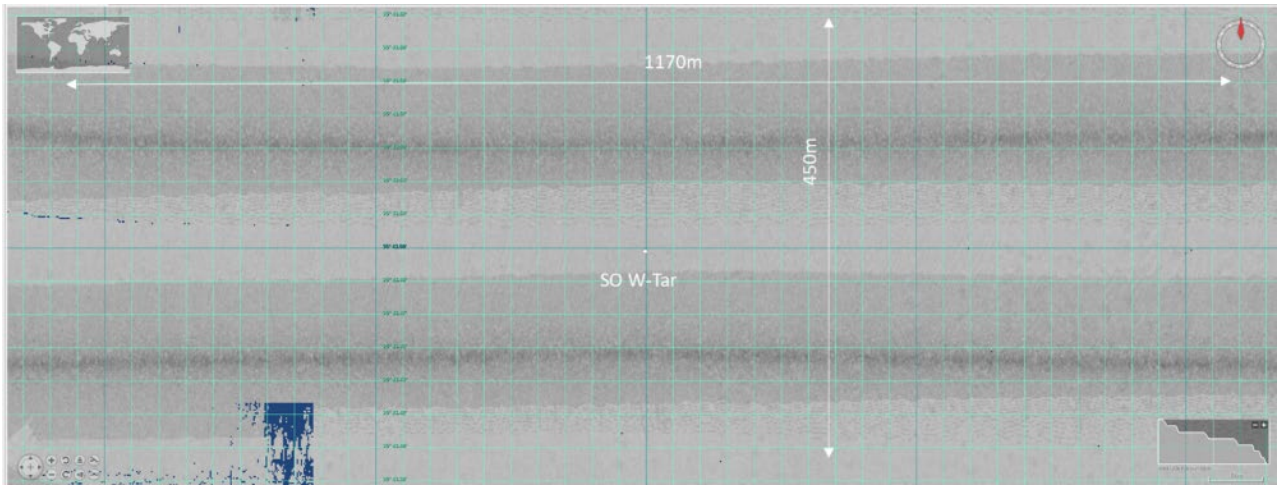

Figure 59: Southern Site West Anchor Target (W-Tar) Backscatter

Subbottom

Subbottom profiles at both the north and south anchor target sites indicate a soft and homogeneous seabed with good penetration, no indication of hard bottom or hazards such as cables, pipelines, debris, or wrecks (Figures 60 thru 62). Slopes range from 1-4°.

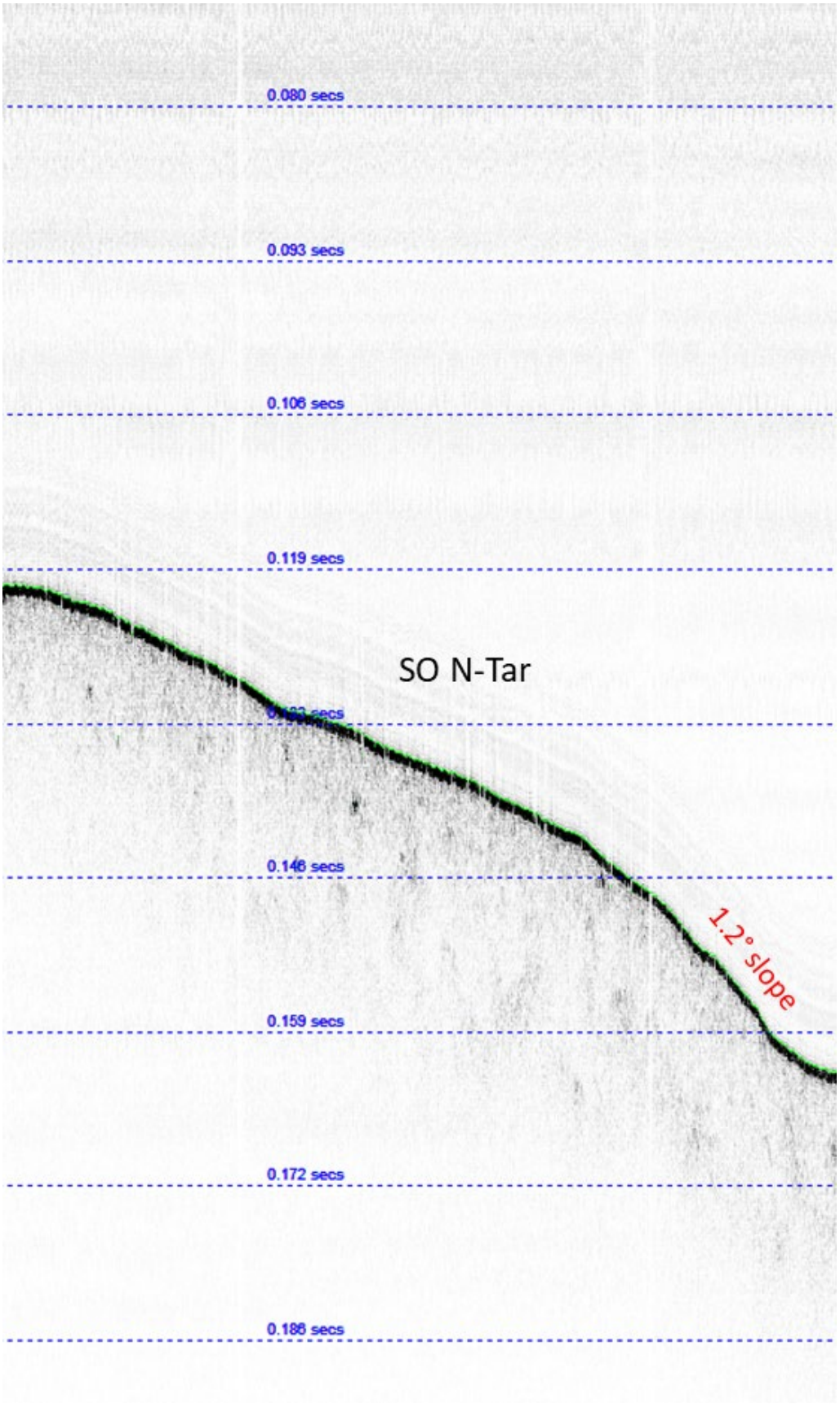

Figure 60: Southern Site North Anchor Target (N-Tar) Subbottom

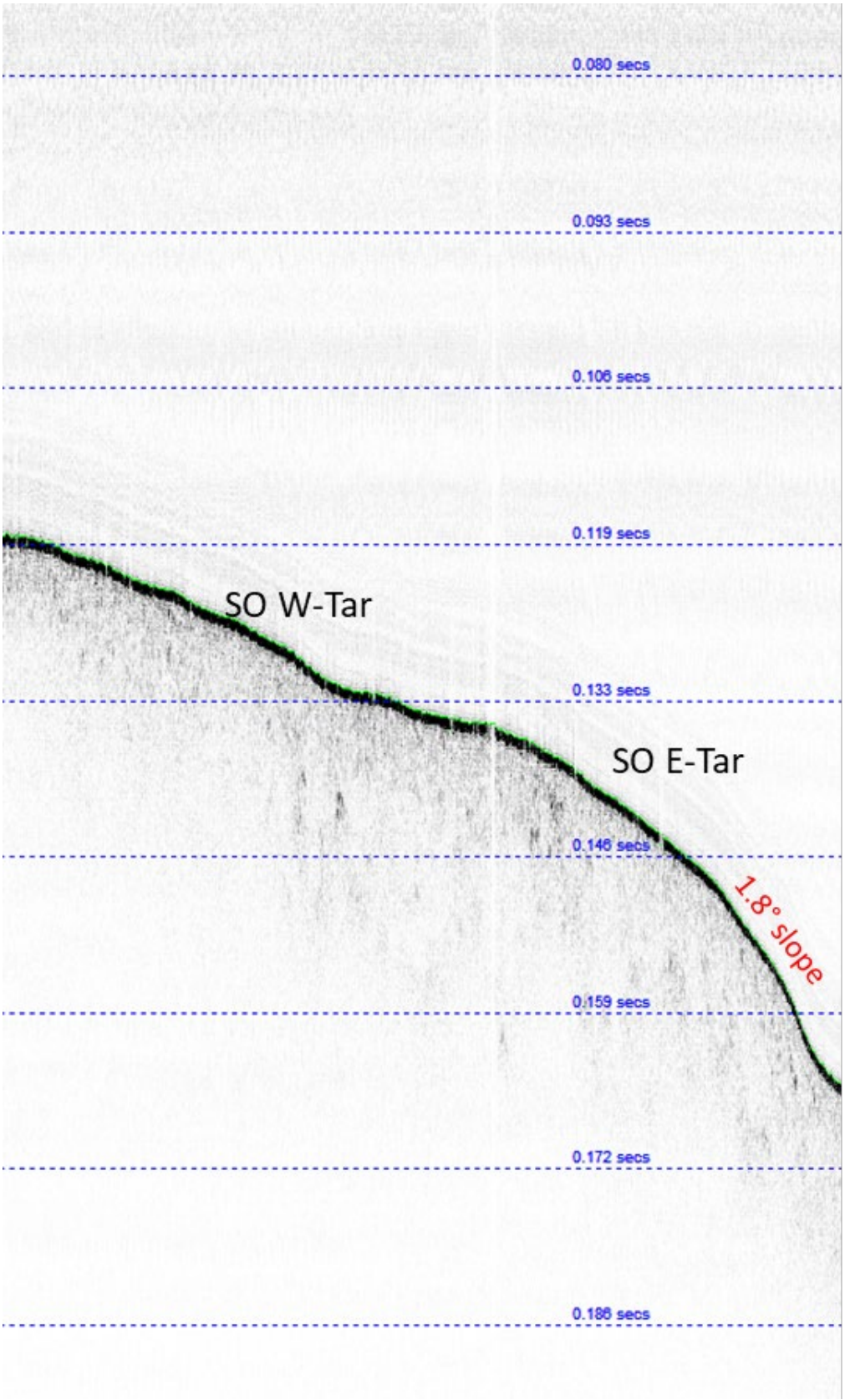

Figure 61: Southern Site East & West Anchor Targets (E-Tar, W-Tar) Subbottom

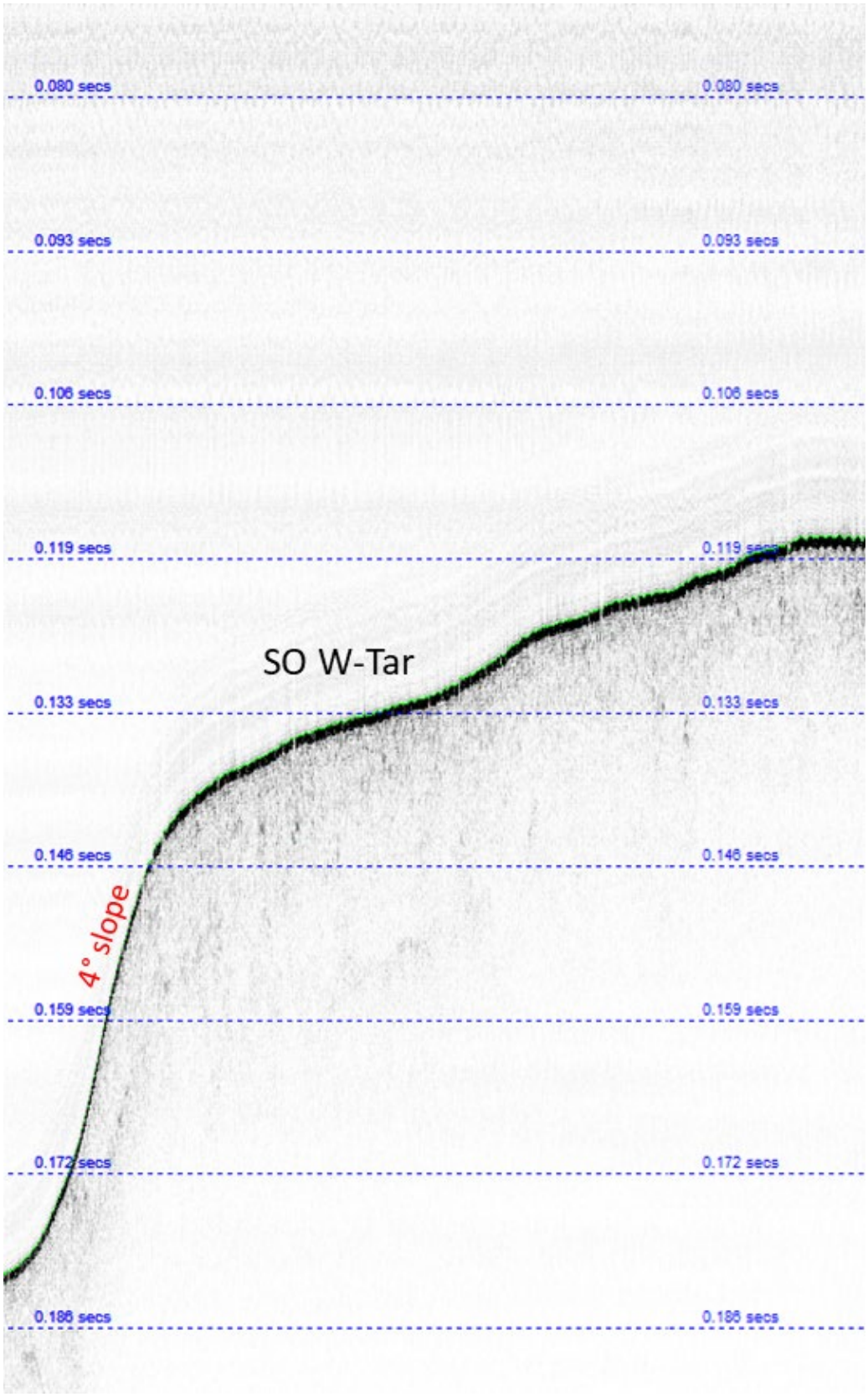

Figure 62: Southern Site West Anchor Target (W-Tar) Subbottom

ROV Inspection

ROV inspection was completed at all anchor target sites, Figure 63 shows the ROV and depressor positions overlaid on the DTM. The camera data indicates a flat seabed at both sites consisting of sands and gravels (Figures 64 thru 68). No areas or features of concern (hard bottom, debris, cables, pipelines, wrecks, artifacts, marine habitat) in ROV sonar or imagery in vicinity of anchor targets.

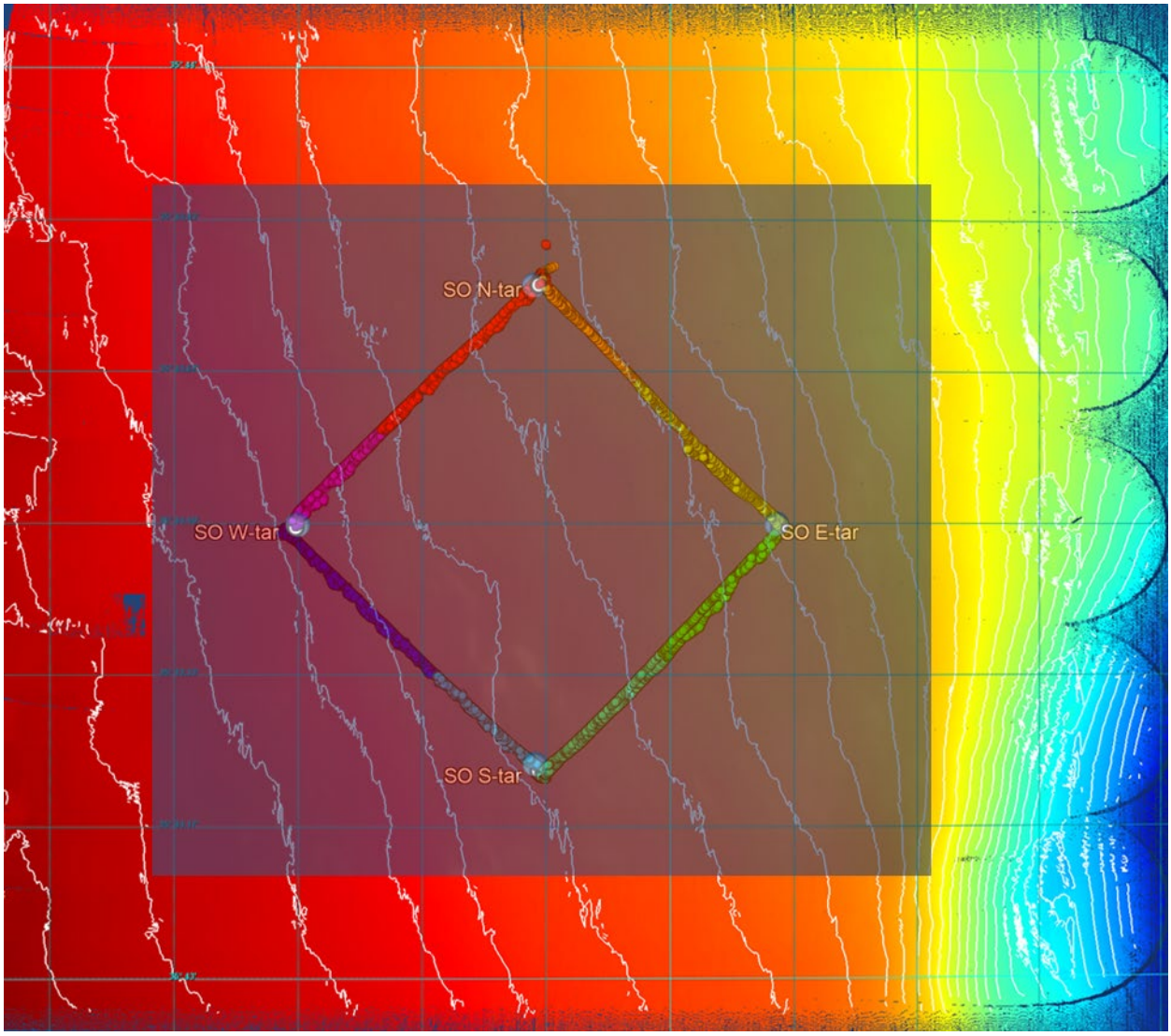

Figure 63: ROV Track at Southern Site

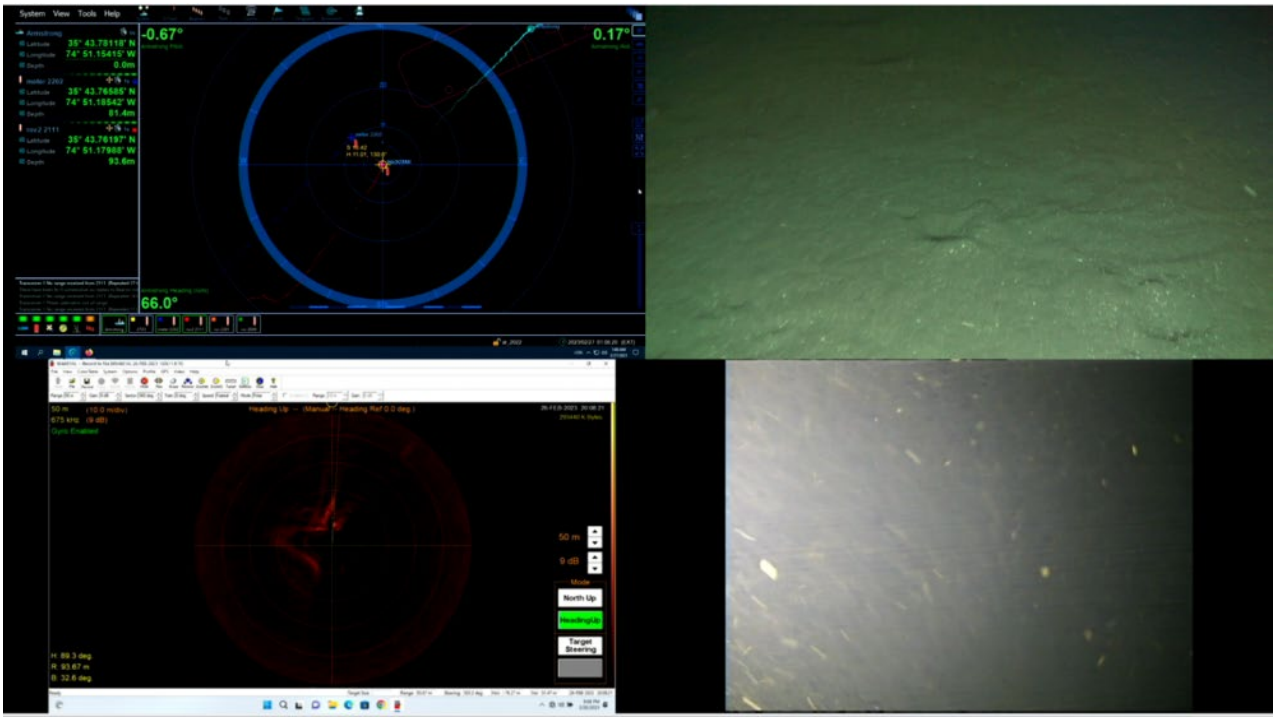

Figure 64: ROV Imagery at Southern Site, North Anchor Target

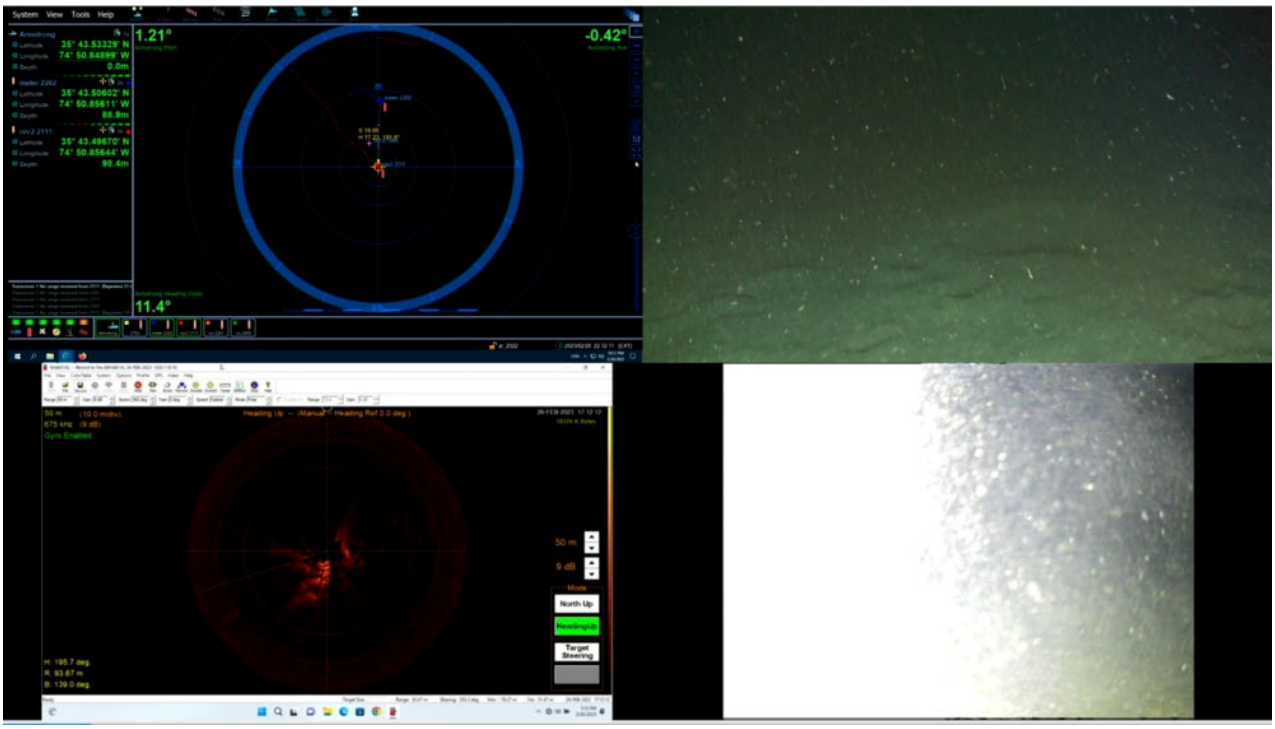

Figure 65: ROV Imagery at Southern Site, East Anchor Target

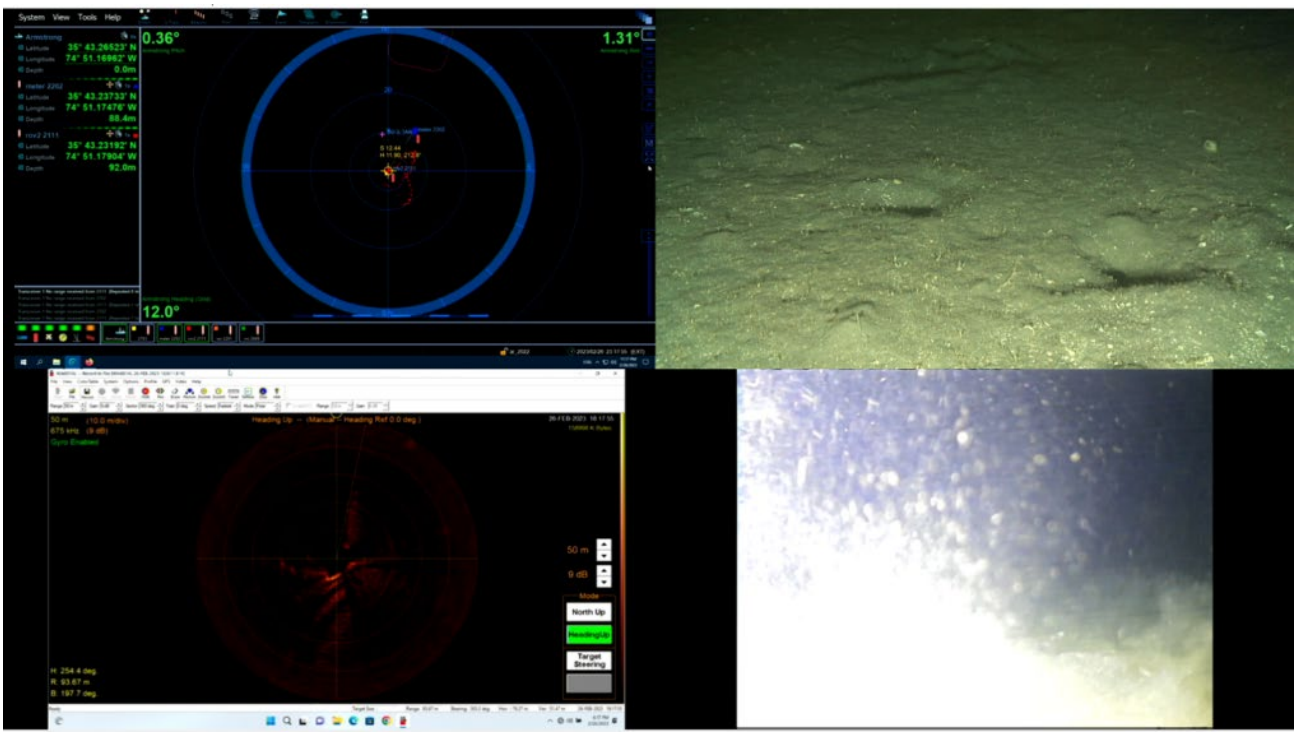

Figure 66: ROV Imagery at Southern Site, South Anchor Target

Figure 67: Sandy, Gravelly, Shelly Seabed Southern Site, South Anchor Target

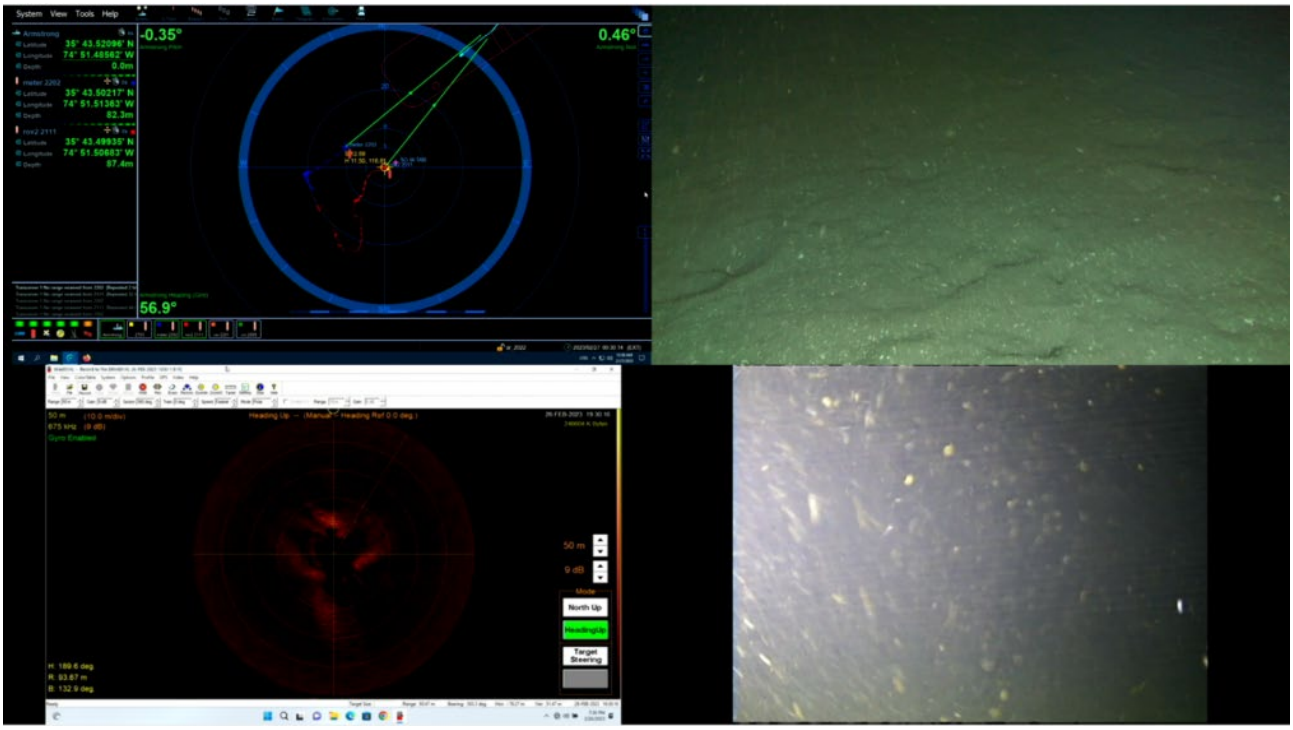

Figure 68: ROV Imagery at Southern Site, West Anchor Target

8.6. Northeastern (Old)

Bathymetry

Moving west to east across Figure 69, the water depth is at the shallowest ~450m in the northwest corner, following a ridge structure to the west, the seabed then deepens to ~930m. There is a steeper dropoff to the north of the ridge to a depth of ~950m. The slopes at the planned locations are ~11°. The North and South anchor targets are at depths of 560 m and 650 m, respectively. Data collected over ~6km x 4km area using 1km line spacing.

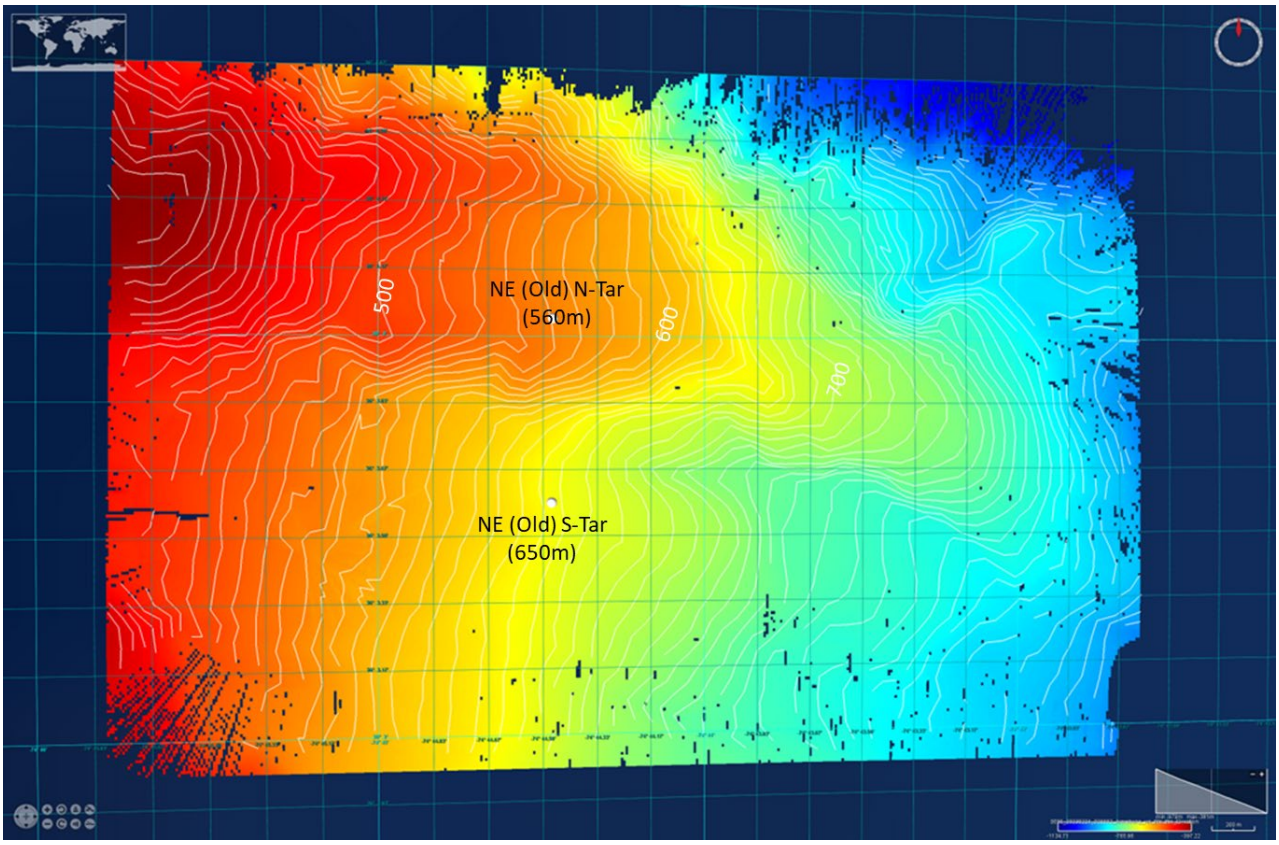

Figure 69: Northeastern (Old) Site Digital Terrain Model (10m contours)

Backscatter

Backscatter imagery at both the north and south anchor target sites indicate a homogeneous seabed, no visible hazards such as hard bottom, cables, pipelines, wrecks, or debris (Figure 70).

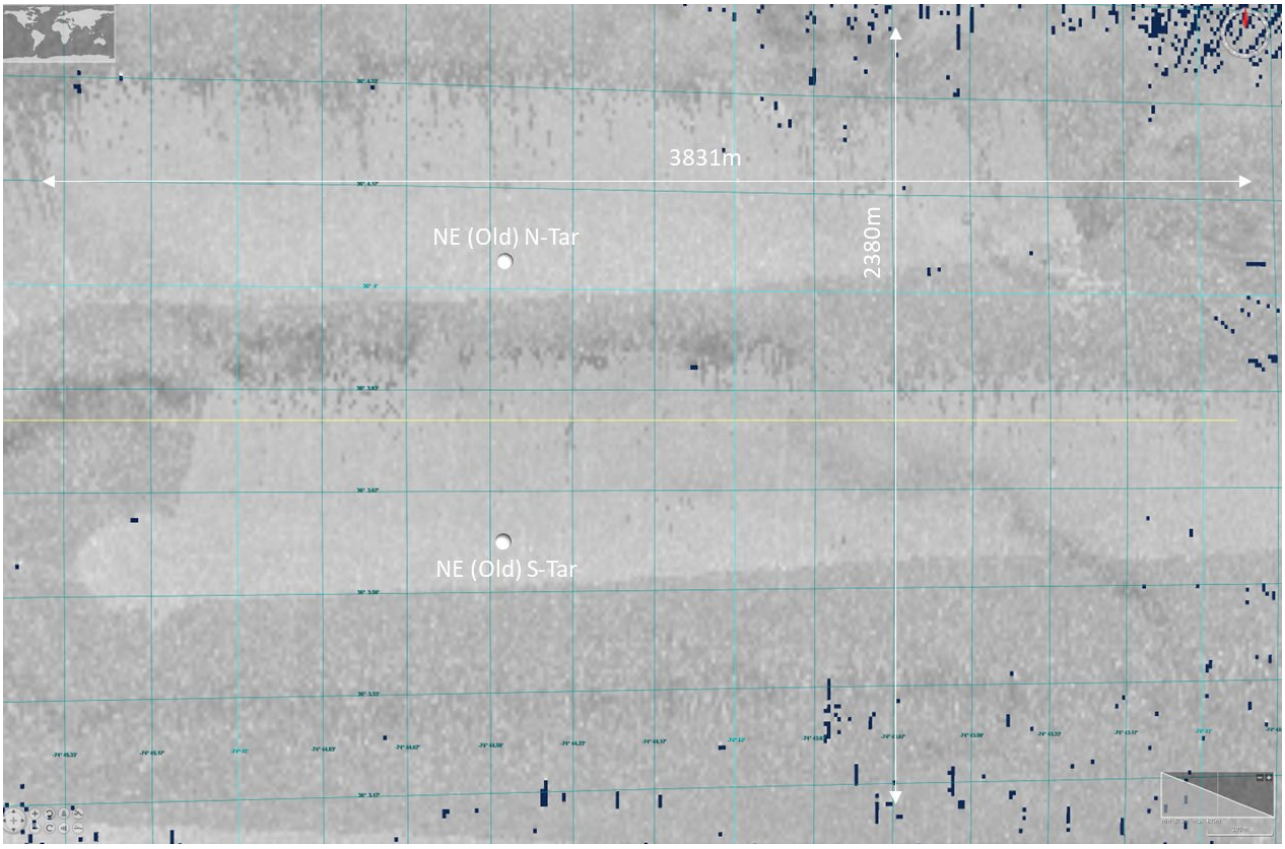

Figure 70: Northeastern (Old) Site North & South Anchor Targets (N-Tar, S-Tar) Backscatter

Subbottom

Subbottom profiles at both the north and south anchor target sites indicate a soft and homogeneous seabed with good penetration, some indication of harder sublayers that do not impact operations, no indication of hard bottom or hazards such as cables, pipelines, debris, or wrecks (Figures 71 & 72). As can be seen in the subbottom profile, this is a steeper site as the seabed crosses the shelfbreak. Slopes range from 5-15°, localized may be higher.

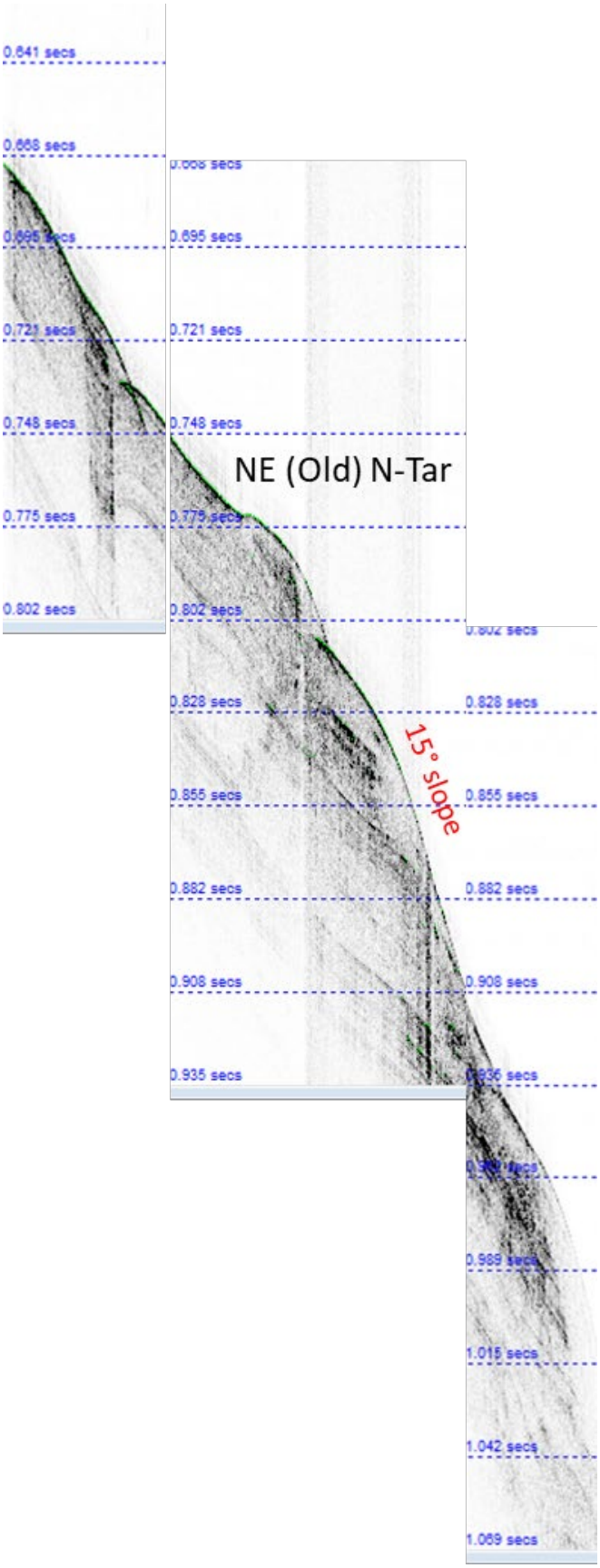

Figure 71: Northeastern (Old) Site North Anchor Target (N-Tar) Subbottom

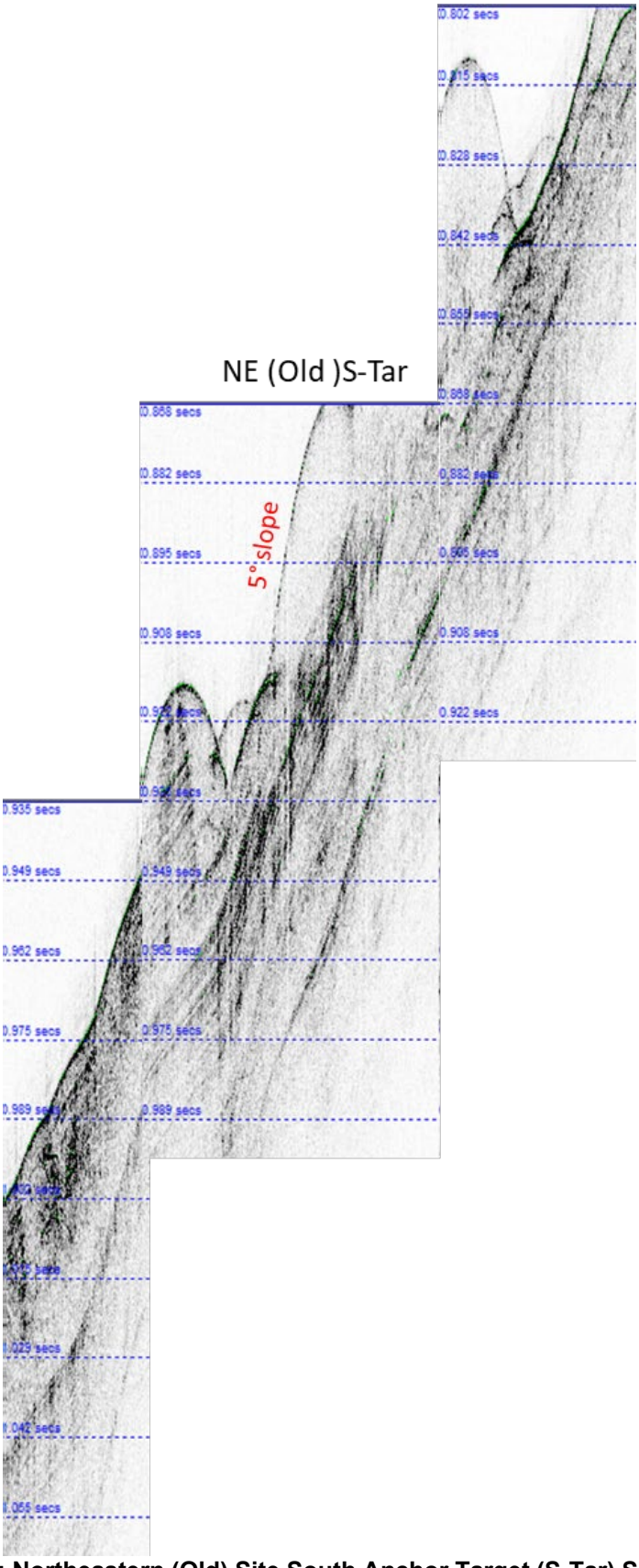

Figure 72: Northeastern (Old) Site South Anchor Target (S-Tar) Subbottom

ROV Inspection

ROV inspection was completed at the North anchor target only. Due to the risk of steep slopes and the need to maintain a constant depth, the ROV survey was halted after a depth discrepancy was found between the beacon and ROV depth sensor. Figure 73 shows the ROV and depressor positions overlaid on the DTM. The camera data indicates a flat seabed in the vicinity of the north anchor target consisting of a sandy seabed (Figures 74-75). No areas or features of concern (hard bottom, debris, cables, pipelines, wrecks, artifacts, marine habitat) in ROV sonar or imagery in vicinity of anchor targets.

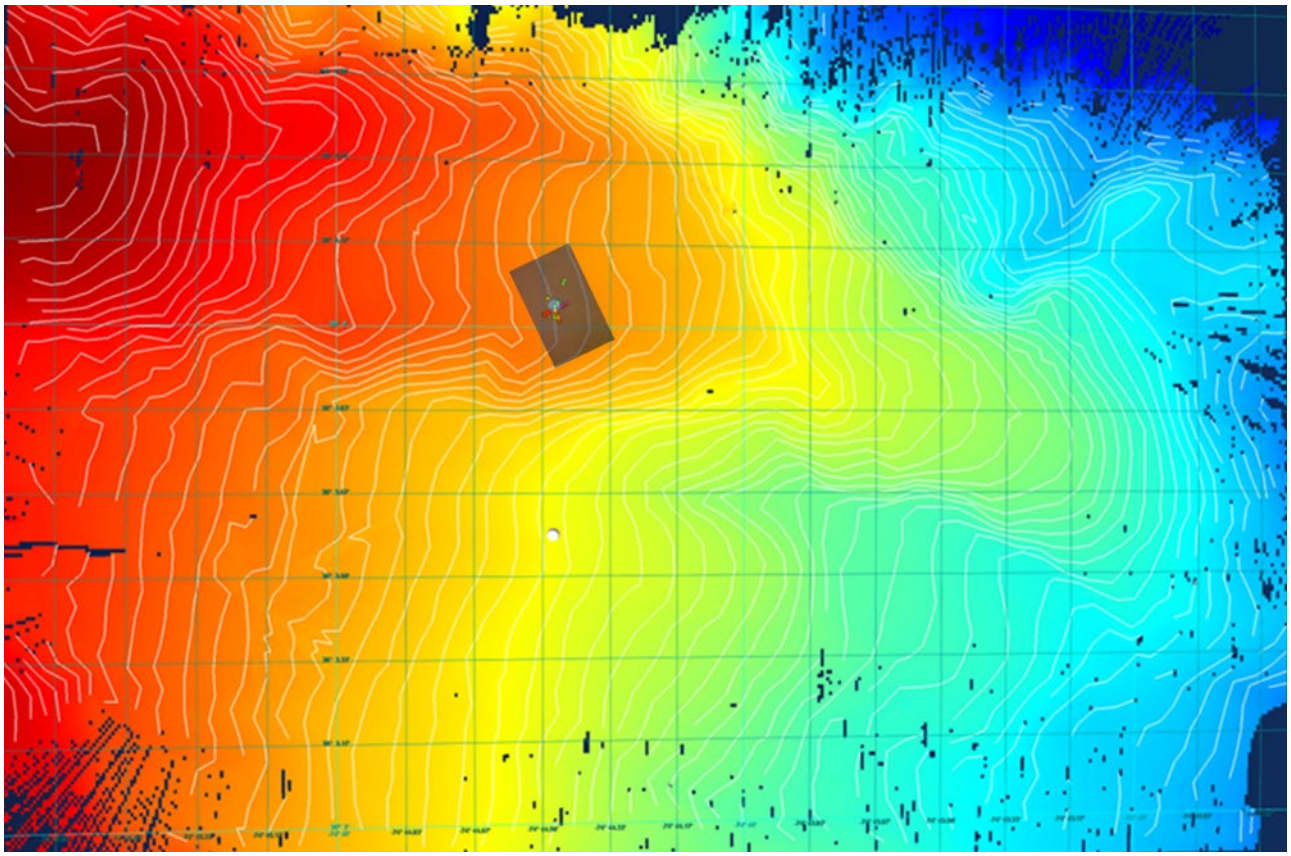

Figure 73: ROV Track at Northeastern (Old) Site

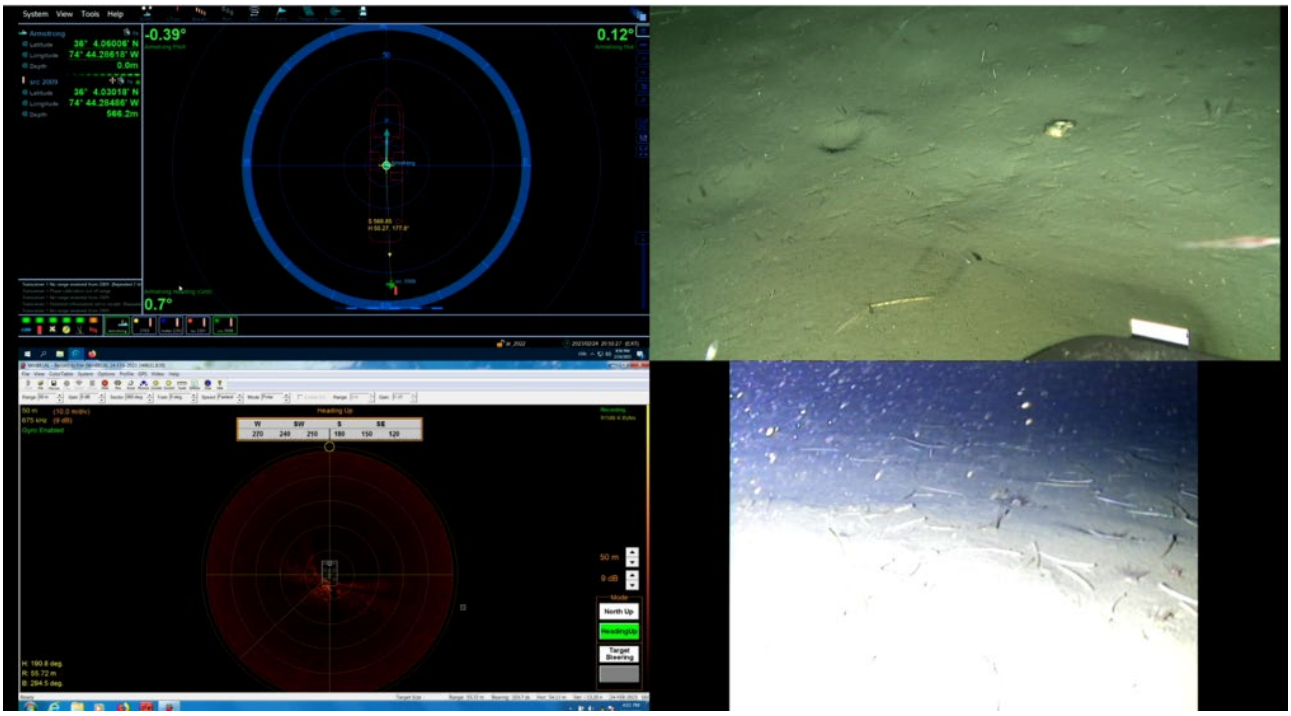

Figure 74: ROV Imagery at Northeastern (Old) Site, North Anchor Target

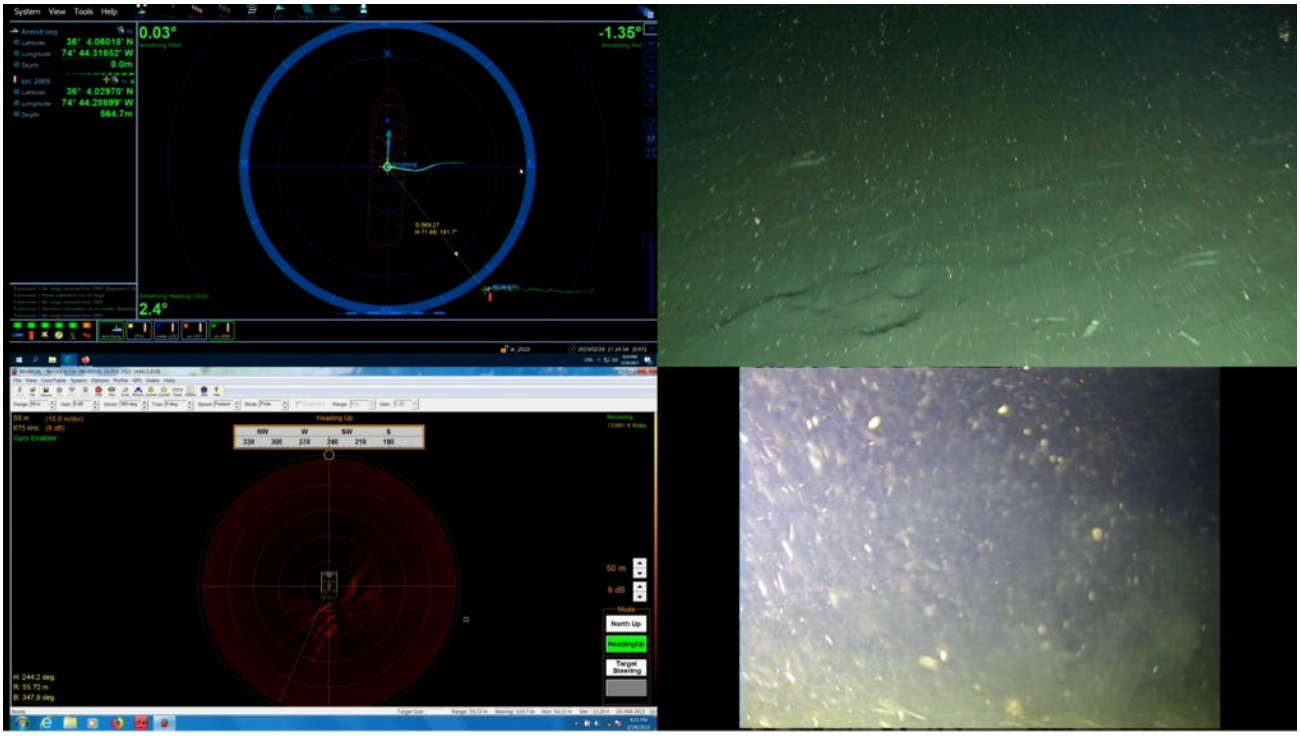

Figure 75: ROV Imagery at Northeastern (Old) Site, North Anchor Target

8.7. Southeastern (Old)

Bathymetry

Moving west to east across Figure 76, the water depth is at the shallowest ~290m, then deepens to ~1130m. There are several steep ridges and channels running west to east, the seabed is highly variable, and there is very little flat bottom. Slopes in the vicinity of the planned anchor locations can reach 15° with surrounding slopes of 30-45°. The North and South anchor targets are at depths of 570 m and 614 m, respectively. Data collected over ~5km x 4km area using 1km line spacing.

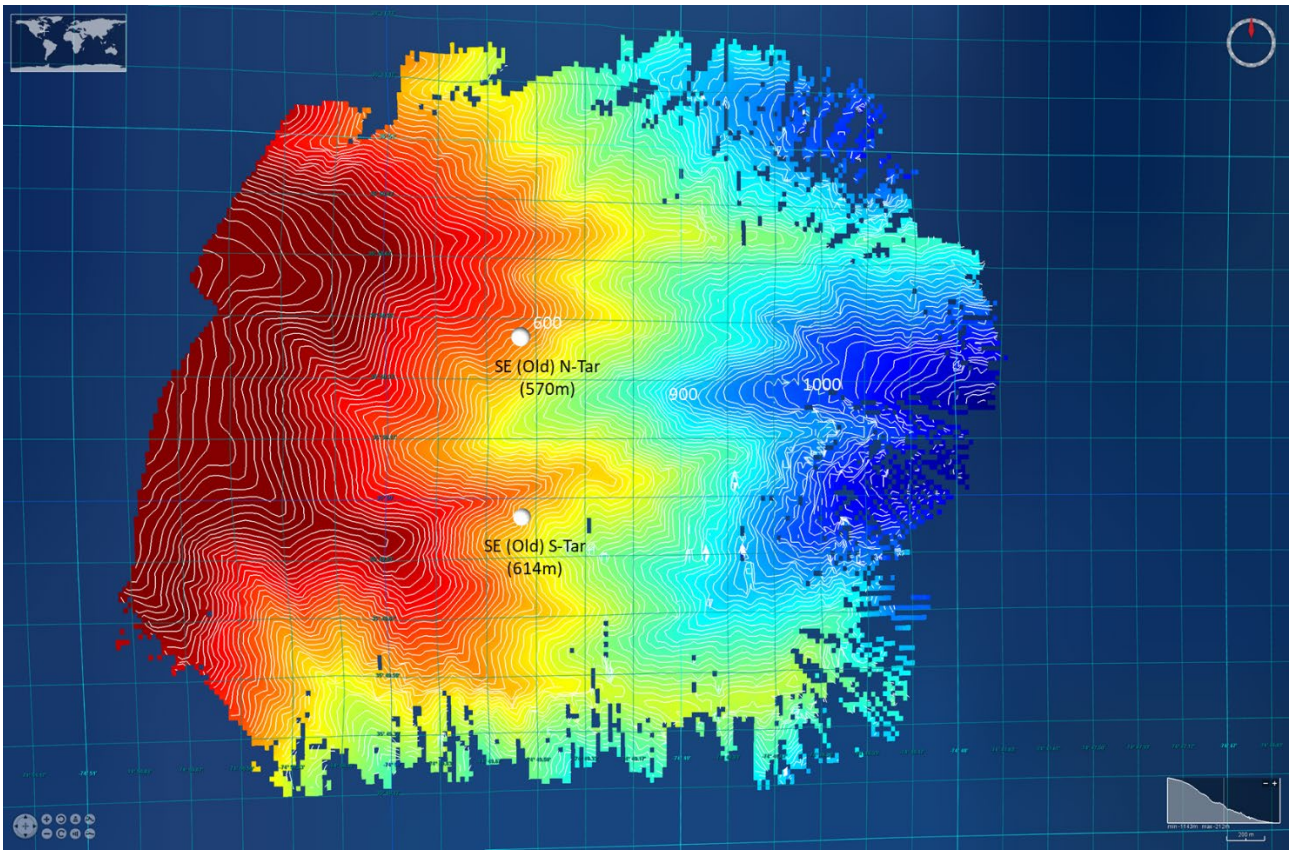

Figure 76: Southeastern (Old) Site Digital Terrain Model (10m contours)

Backscatter

Backscatter imagery at both the north and south anchor target sites indicate a homogeneous seabed, no visible hazards such as hard bottom, cables, pipelines, wrecks, or debris (Figure 77).

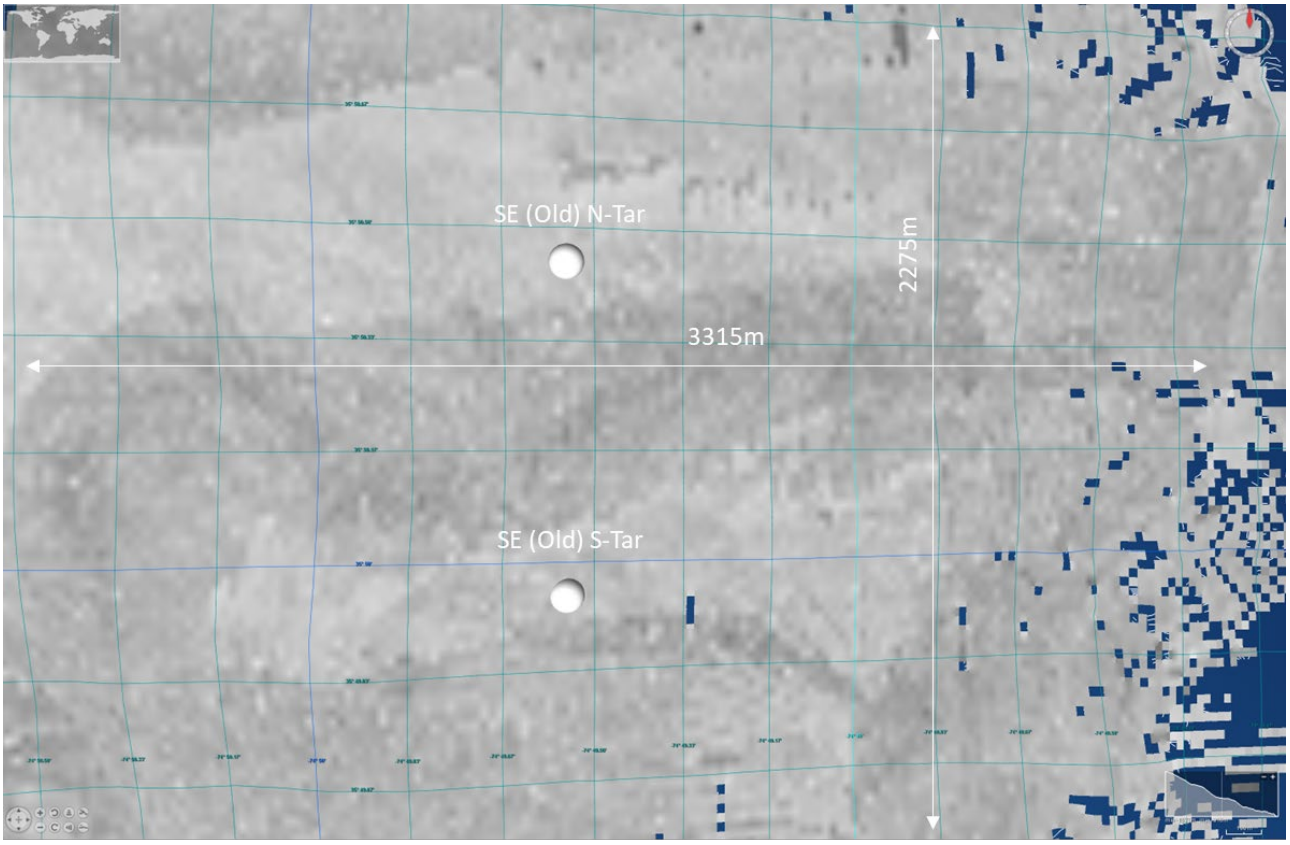

Figure 77: Southeastern (Old) Site North & South Anchor Targets (N-Tar, S-Tar) Backscatter

Subbottom

Subbottom profiles at both the north and south anchor target sites indicate a soft and homogeneous seabed with good penetration, some indication of harder sublayers that do not impact operations, no indication of hard bottom or hazards such as cables, pipelines, debris, or wrecks (Figures 78 & 79). As can be seen in the subbottom profile, this is a steeper site as the seabed crosses the shelfbreak. Slopes can range from 8-14°, localized will be higher.

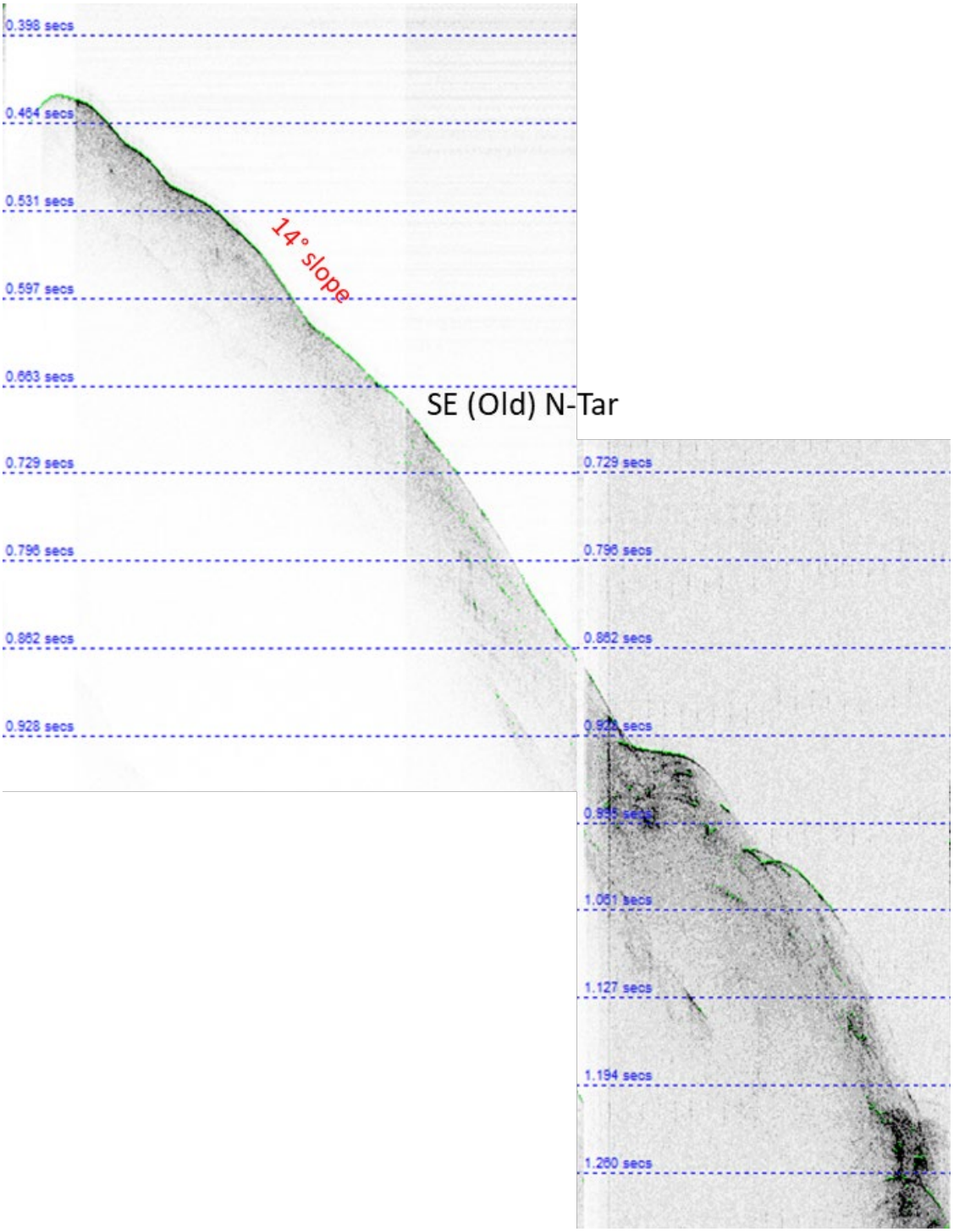

Figure 78: Southeastern (Old) Site North Anchor Target (N-Tar) Subbottom

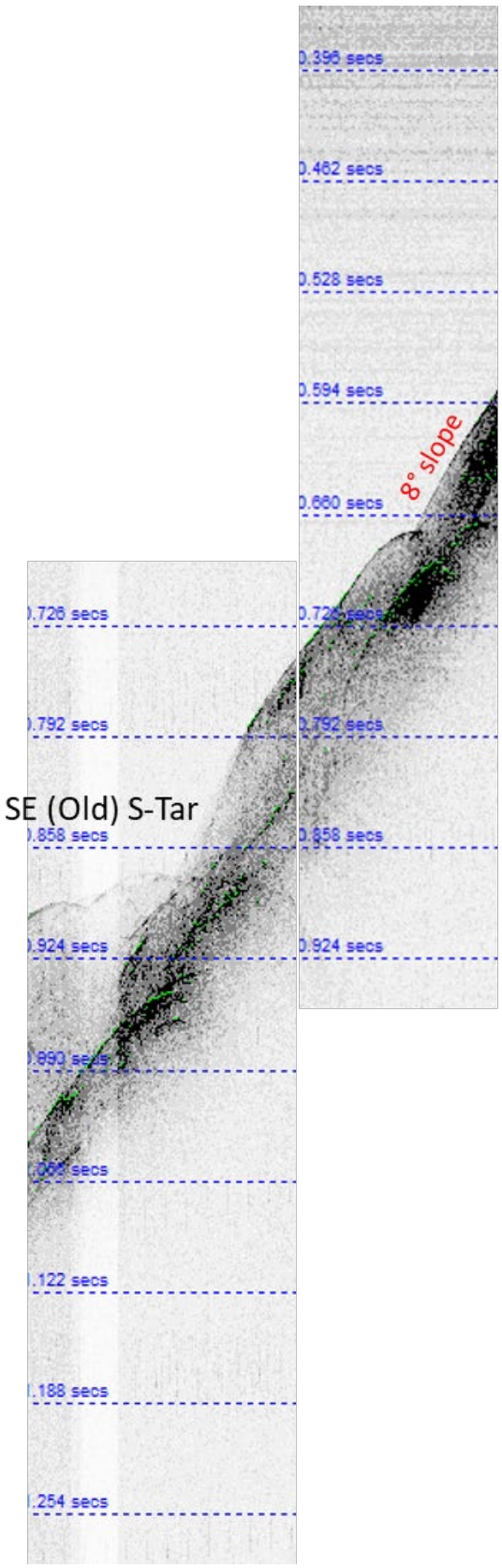

Figure 79: Southeastern (Old) Site South Anchor Target (S-Tar) Subbottom

ROV Inspection

ROV inspection was completed at the North anchor target only. Due to the risk of steep slopes and an inability to maintain a constant depth with good beacon tracking, the ROV survey was halted. Figure 80 shows the ROV and depressor positions overlaid on the DTM. The camera data indicates a flat seabed in the vicinity of the north anchor target consisting of sands and gravels (Figures 81-82). No areas or features of concern (hard bottom, debris, cables, pipelines, wrecks, artifacts, marine habitat) in ROV sonar or imagery in vicinity of anchor targets.

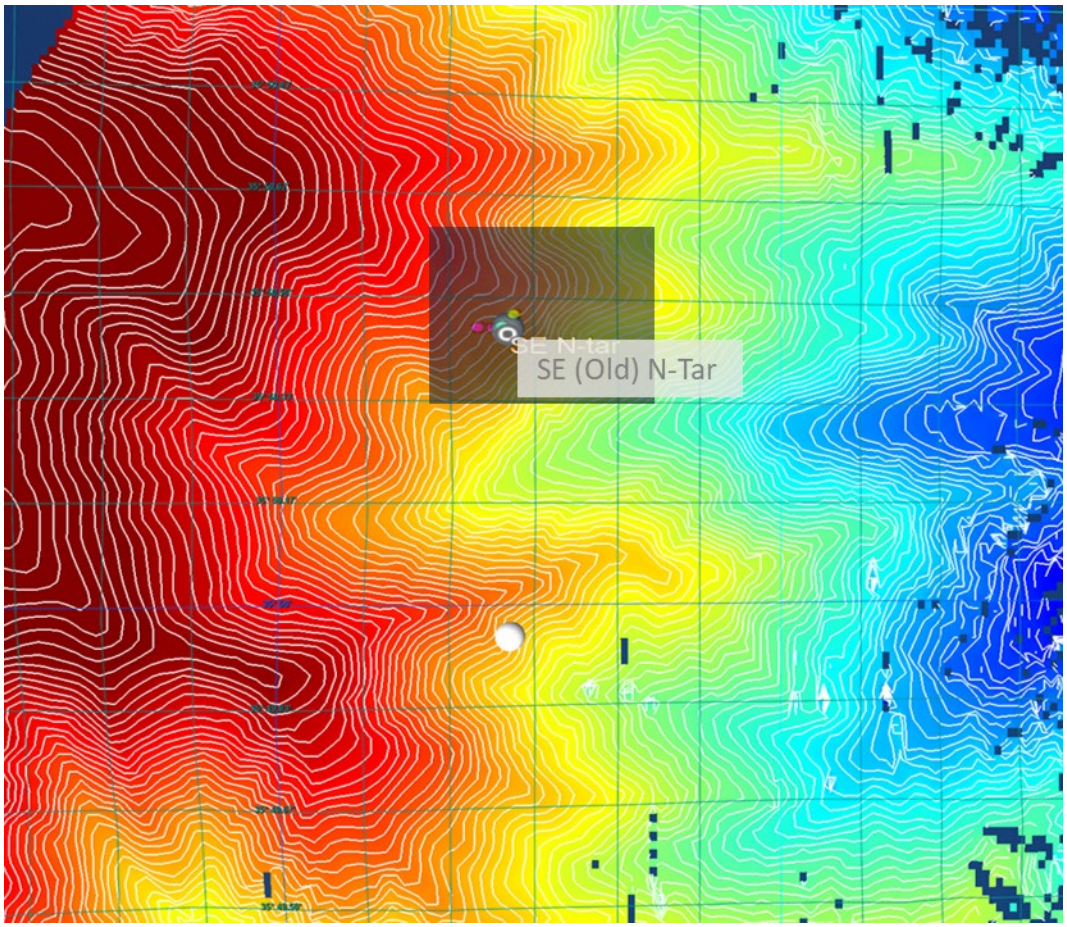

Figure 80: ROV Track at Southeastern (Old) Site

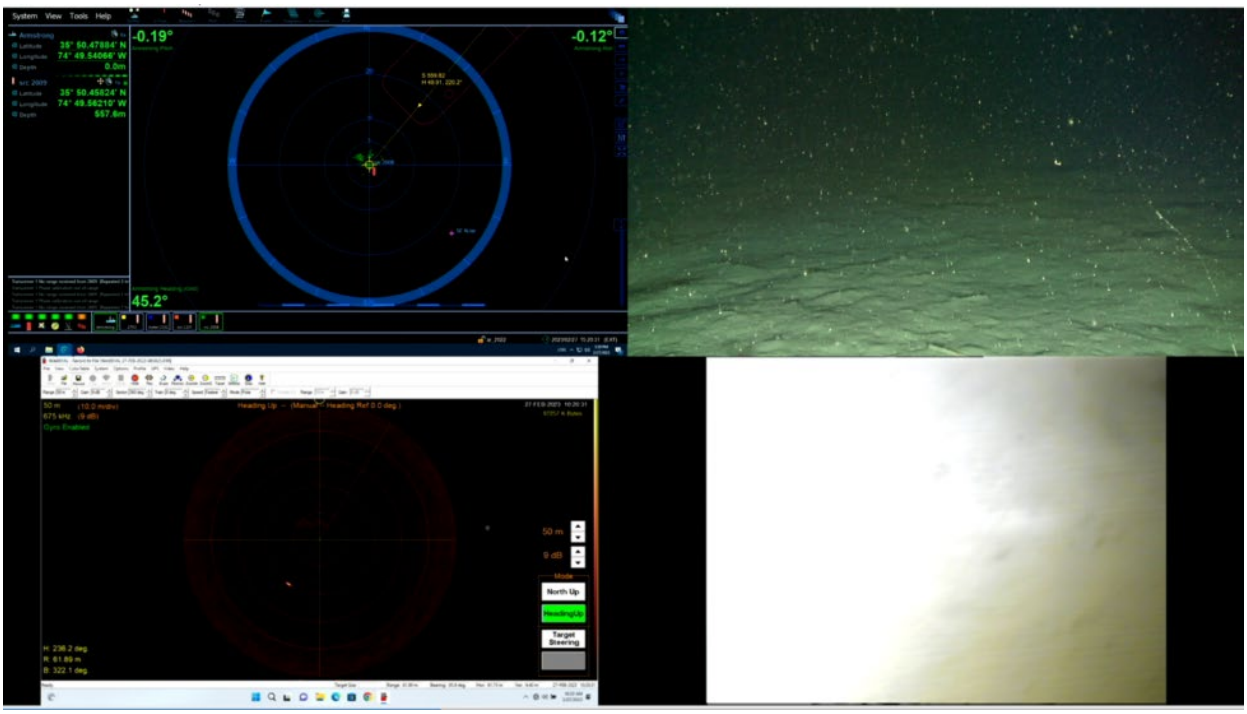

Figure 81: ROV Imagery at Southeastern (Old) Site, North Anchor Target

Figure 82: Sandy Seabed Southeastern (Old) Site, North Anchor Target

8.8. Northeastern (Updated)

Bathymetry

Moving west to east across Figure 83, the water depth is at the shallowest ~94m,moving eastward the seabed then deepens to ~500m. There is a ridge beyond the 300m depth with associated steeper slopes. The slopes at the planned locations are ~5°. The North and South anchor targets are located on the 300m contour. Data collected over ~8km x 3km area using 200m line spacing.

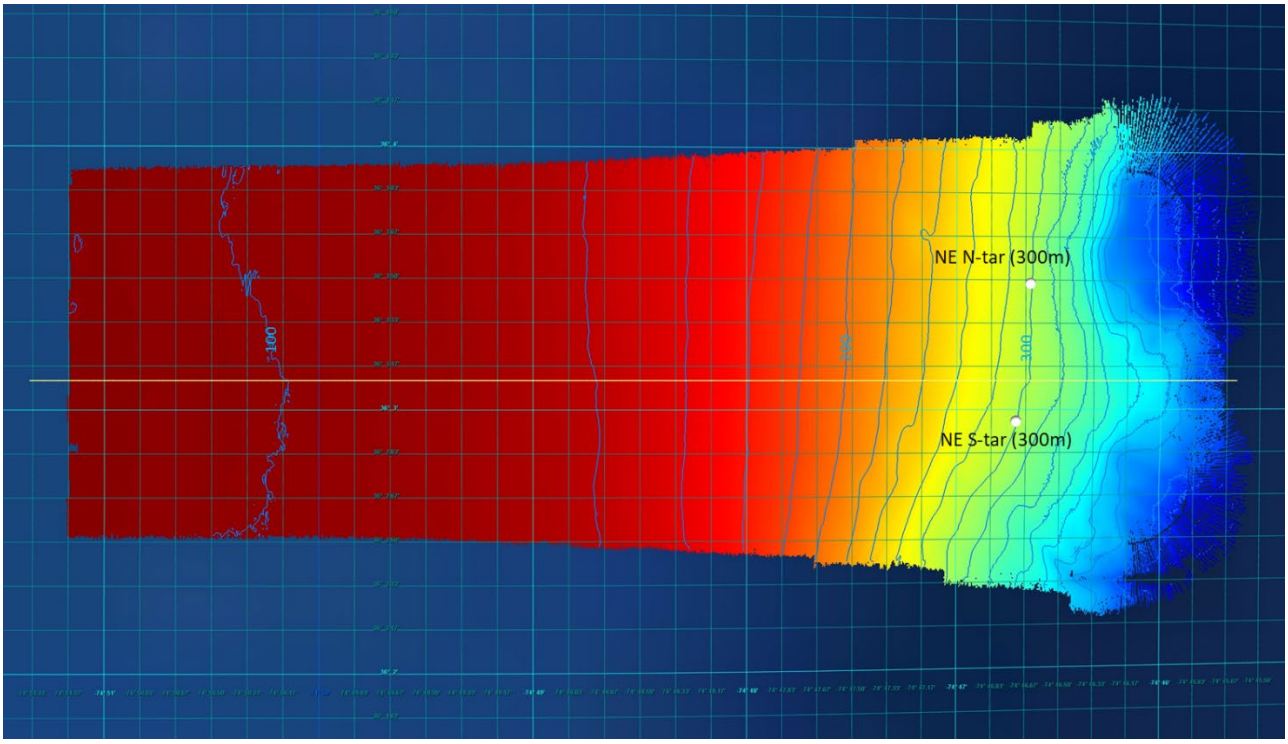

Figure 83: Northeastern (Updated) Site Digital Terrain Model (20m contours)

Backscatter

Backscatter imagery at both the north and south anchor target sites indicate a homogeneous seabed, no visible hazards such as hard bottom, cables, pipelines, wrecks, or debris (Figure 84).

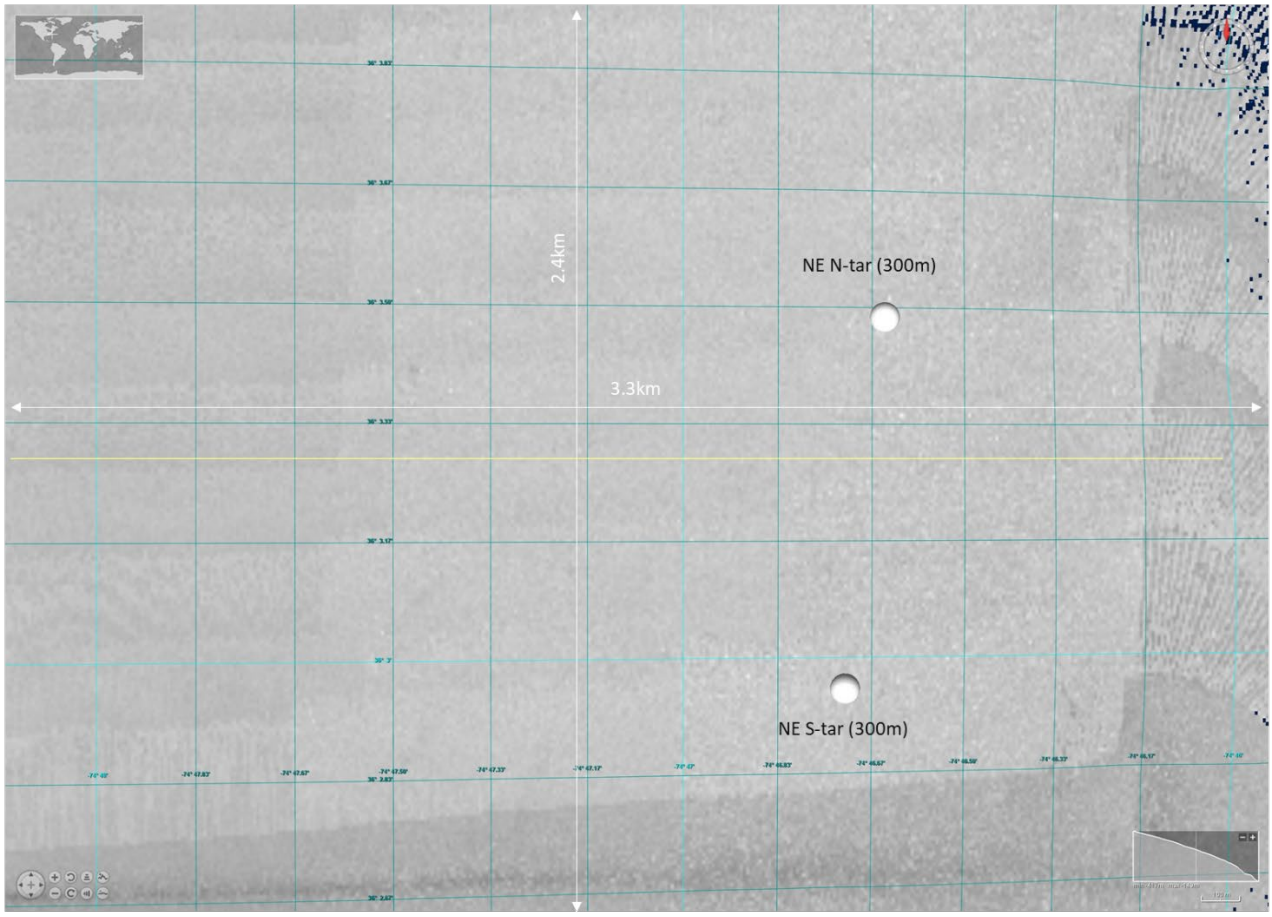

Figure 84: Northeastern (Updated) Site North & South Anchor Targets (N-Tar, S-Tar) Backscatter

Subbottom

Subbottom profiles at both the north and south anchor target sites indicate a soft and homogeneous seabed with good penetration, some indication of harder sublayers that do not impact operations, no indication of hard bottom or hazards such as cables, pipelines, debris, or wrecks (Figures 85 & 86). Slopes are approximately 5°, localized may be higher.

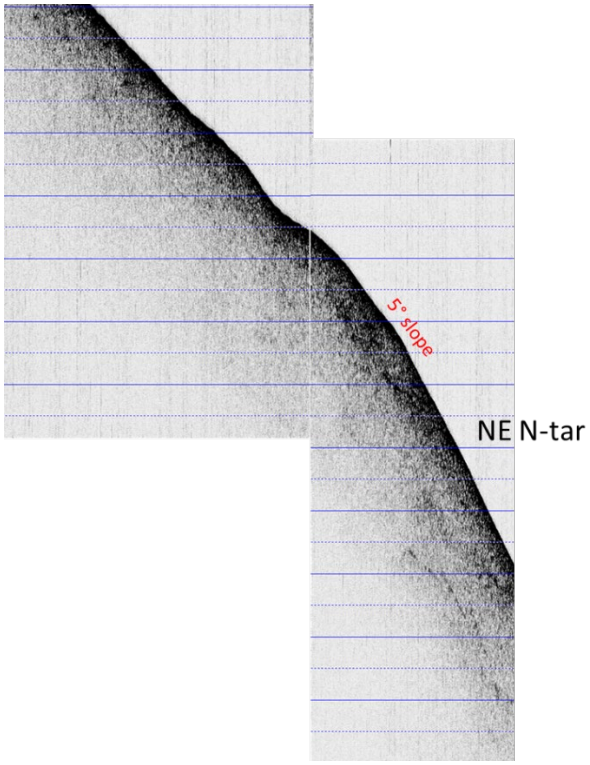

Figure 85: Northeastern (Updated) Site North Anchor Target (N-Tar) Subbottom

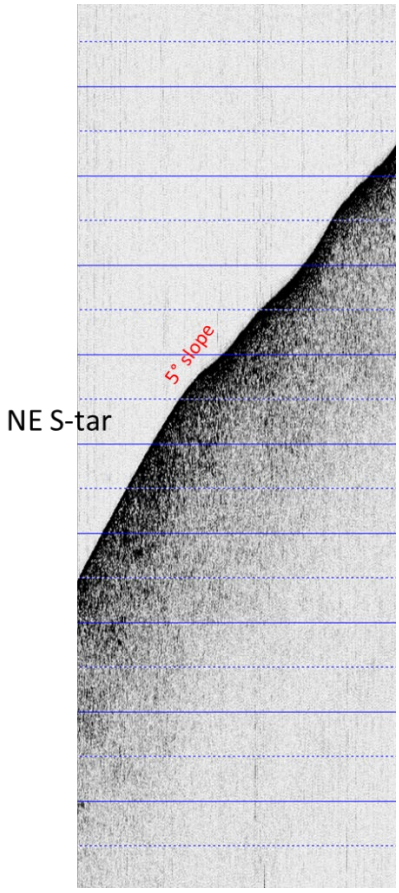

Figure 86: Northeastern (Updated) Site South Anchor Target (S-Tar) Subbottom

ROV Inspection

ROV inspection was completed at all anchor target sites, The camera data indicates a flat seabed at both sites consisting of sands and gravels (Figures 87 & 88). No areas or features of concern (hard bottom, debris, cables, pipelines, wrecks, artifacts, marine habitat) in ROV sonar or imagery in vicinity of anchor targets.

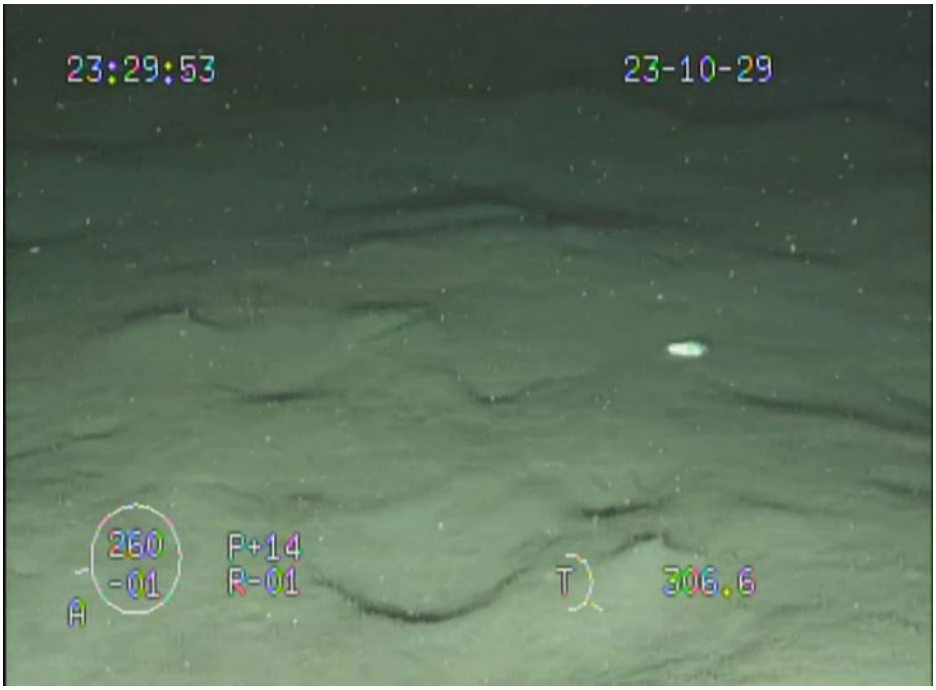

Figure 87: ROV Imagery at Northeastern (Updated) Site, North Anchor Target

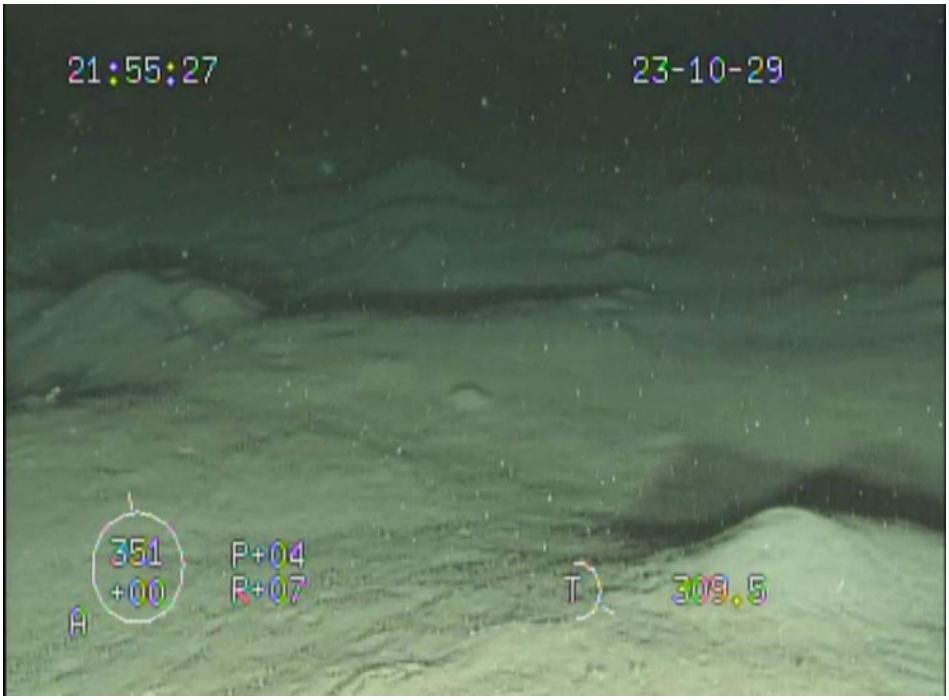

Figure 88: ROV Imagery at Northeastern (Updated) Site, South Anchor Target

8.9. Southeastern (Updated)

Bathymetry

Moving west to east across Figure 89, the water depth is at the shallowest ~84m, then deepens to ~650m. There are two channels starting at approximately the shelfbreak, running west to east. The seabed is highly variable beyond 300m water depth. Slopes in the vicinity of the planned anchor locations can reach 11° with some surrounding slopes higher. The North and South anchor targets are at the 300m depth. Data collected over ~5.5km x 3km area using 200m line spacing.

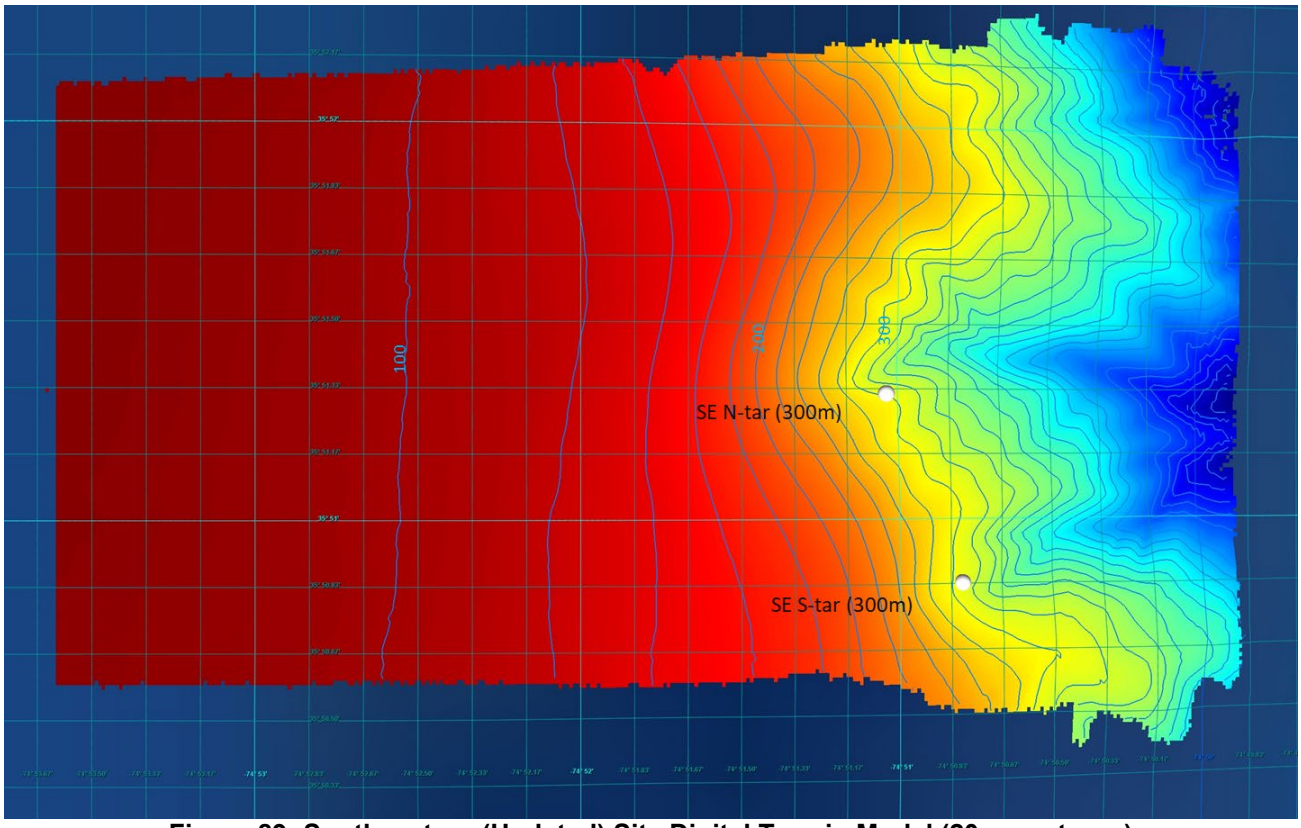

Figure 89: Southeastern (Updated) Site Digital Terrain Model (20m contours)

Backscatter

Backscatter imagery at both the north and south anchor target sites indicate a homogeneous seabed, no visible hazards such as hard bottom, cables, pipelines, wrecks, or debris (Figure 90).

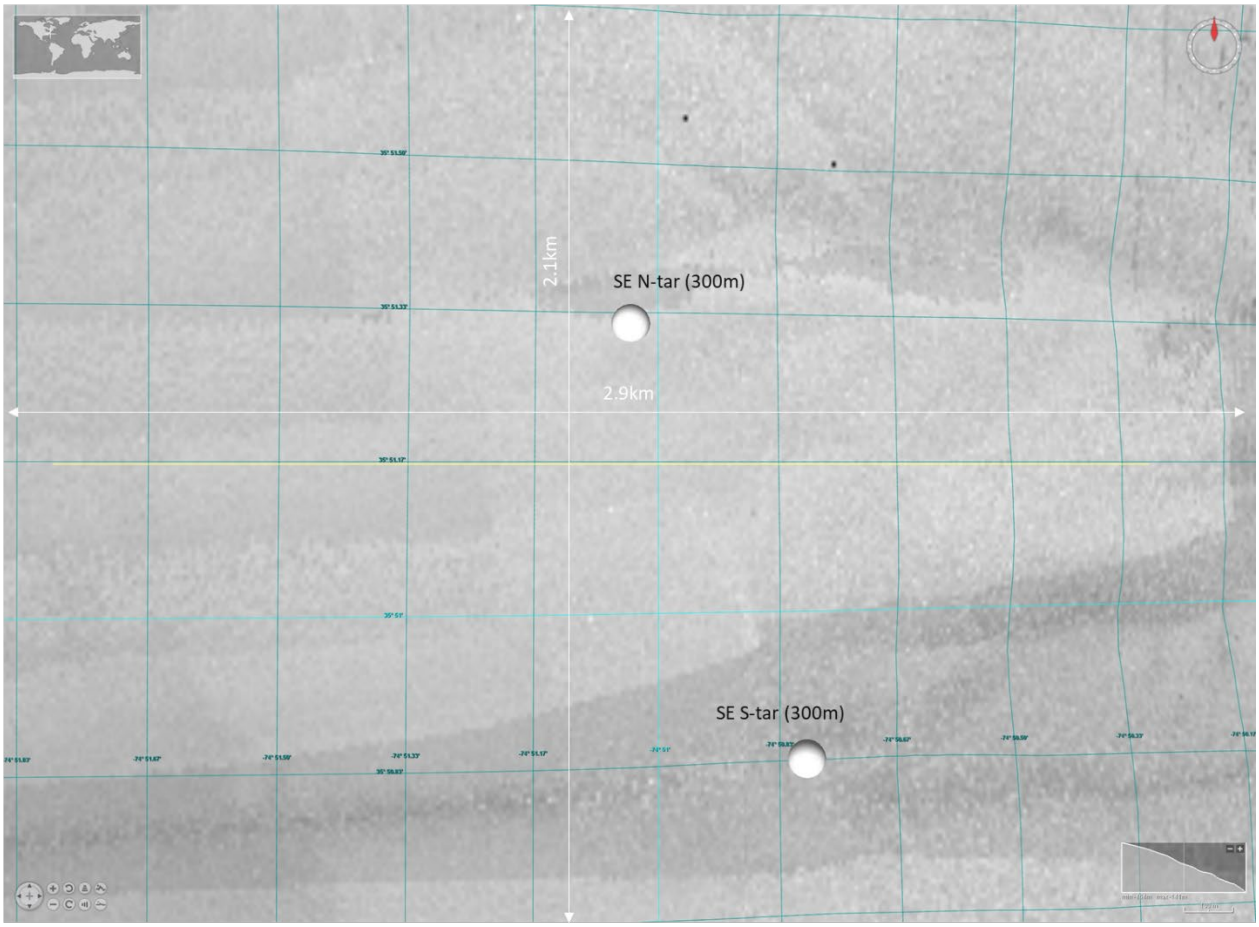

Figure 90: Southeastern (Updated) Site North & South Anchor Targets (N-Tar, S-Tar) Backscatter

Subbottom

Subbottom profiles at both the north and south anchor target sites indicate a soft and homogeneous seabed with good penetration, some indication of harder sublayers that do not impact operations, no indication of hard bottom or hazards such as cables, pipelines, debris, or wrecks (Figures 91 & 92). As can be seen in the subbottom profile, this is a steeper site as the seabed crosses the shelfbreak. Slopes are approximately 11°, localized will be higher.

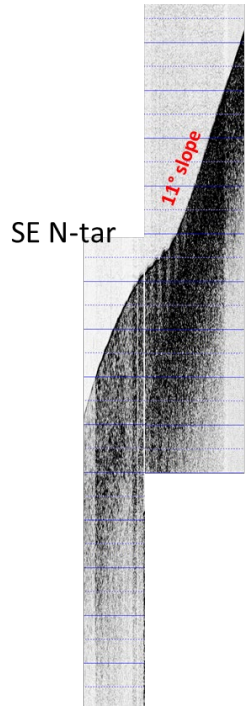

Figure 91: Southeastern (Updated) Site North Anchor Target (N-Tar) Subbottom

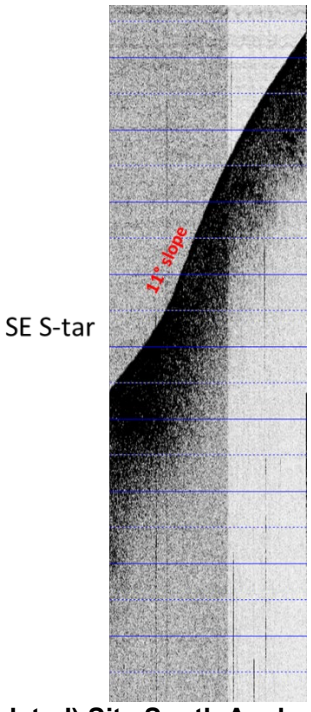

Figure 92: Southeastern (Updated) Site South Anchor Target (S-Tar) Subbottom

ROV Inspection

ROV inspection was completed at all anchor target sites, The camera data indicates a flat seabed at both sites consisting of sands and gravels (Figures 93 & 94). No areas or features of concern (hard bottom, debris, cables, pipelines, wrecks, artifacts, marine habitat) in ROV sonar or imagery in vicinity of anchor targets.

Figure 93: ROV Imagery at Southeastern (Updated) Site, North Anchor Target

Figure 94: Sandy Seabed Southeastern (Updated) Site, South Anchor Target

9.0 CONCLUSION & RECOMMENDATIONS

The survey and ROV inspection confirmed the results of the planning studies:

1. Primarily sandy seabed, suitable for anchoring and mooring deployments. Some evidence of sediment movement which should be monitored during mooring recoveries,
2. Steeper slopes at the deep mooring sites, with localized flat areas for deployment,
3. No indication of shipwrecks or cultural resources at the mooring sites, and
4. No indication of at-risk marine habitat.

The completed surveys provide sufficient information for environmental compliance at each mooring site. Additional anchor target surveys would be done as-needed to confirm seafloor characteristics prior to deployment. Table 5 and 6 provide engineering and compliance findings.

Table 5: ROV Inspection & Survey Findings

Site	Findings	Risks	Recommendations
WEST	Survey and ROV data indicate the anchor sites are suitable for the deployment of a single mooring.	Evidence of sediment mobility, risk of some burial of multifunction node (MFN)	Retain anchor targets as planned. ROV should always be available for inspection and recovery of MFN. If sediment movement impacts future recoveries, anchor targets could be moved east, further into bottom of channel.
CENTRAL	Survey and ROV data indicate the anchor sites are suitable for the deployment of dual moorings.	Minor risk of sediment mobility, and burial of MFNs.	Retain anchor targets as planned. ROV should always be available for inspection and recovery of MFN.
EAST	Survey and ROV data indicate the anchor sites are suitable for the deployment of single mooring.	Flat, sandy seabed, no minor/major risks	Retain anchor targets as planned.
NORTH	Survey and ROV data indicate the anchor sites are suitable for the deployment of dual moorings.	Flat, sandy seabed, no minor/major risks	Retain anchor targets as planned.
SOUTH	Survey and ROV data indicate the anchor sites are suitable for the deployment of dual moorings.	Flat, sandy seabed, no minor/major risks	Retain anchor targets as planned.
NORTHEASTERN (OLD)	Bathymetry and subbottom show steeper slopes, no indication of hazards in backscatter, ROV video shows sandy flat bottom in vicinity of anchor target.	South anchor target surveyed but not ROV inspected; steeper slopes greater than 30° could be found away from anchor target areas. Potential turbidity current risk. Public feedback indicates longline fishing in the area and that moorings could be a risk to longlining activities. Longlining is also a risk to mooring operations including fouling of profilers.	Assess Northeastern (Updated) site in area of less potential longlining activity. This also moves the mooring away from steep slopes and potential recovery/deployment risks.
SOUTHEASTERN (OLD)	Bathymetry and subbottom show significantly steeper slopes, no indication of hazards in backscatter, ROV video shows sandy flat bottom in vicinity of anchor target.	South anchor target surveyed but not ROV inspected; localized slopes steeper than 30° could be an anchor holding risk, slopes and channels could also be turbidity current risk leading to mooring loss. Public feedback indicates longline fishing in the area and that moorings could be a risk to longlining activities. Longlining is also a risk to mooring operations including fouling of profilers.	Assess Southeastern (Updated) site in area of less potential longlining activity. This also moves the mooring away from steep slopes and potential recovery/deployment risks.

Site	Findings	Risks	Recommendations
NORTHEASTERN (Updated)	Survey and ROV data indicate the anchor sites are suitable for the deployment of single mooring.	Flat, sandy seabed, no minor/major risks	Retain anchor targets as planned.
SOUTHEASTERN (Updated)	Survey and ROV data indicate the anchor sites are suitable for the deployment of single mooring.	Flat, sandy seabed, no minor/major risks	Retain anchor targets as planned.

Table 6: Compliance

Site	Findings	Risks	Recommendations
WEST	No indication of wrecks or cultural artifacts. No visible risks to marine habitat. No identifiable vulnerable marine ecosystems (VMEs) and no essential fish habitats (EFHs).	No identifiable risks.	Retain anchor targets as planned. If anchor targets are moved in the future due to engineering concerns, re-perform ROV inspections.
CENTRAL	No indication of wrecks or cultural artifacts. No visible risks to marine habitat. No identifiable vulnerable marine ecosystems (VMEs) and no essential fish habitats (EFHs).	No identifiable risks.	Retain anchor targets as planned.
EAST	No indication of wrecks or cultural artifacts. No visible risks to marine habitat. No identifiable vulnerable marine ecosystems (VMEs) and no essential fish habitats (EFHs).	No identifiable risks.	Retain anchor targets as planned.
NORTH	No indication of wrecks or cultural artifacts. No visible risks to marine habitat. No identifiable vulnerable marine ecosystems (VMEs) and no essential fish habitats (EFHs).	No identifiable risks.	Retain anchor targets as planned.
SOUTH	No indication of wrecks or cultural artifacts. No visible risks to marine habitat. No identifiable vulnerable marine ecosystems (VMEs) and no essential fish habitats (EFHs).	No identifiable risks.	Retain anchor targets as planned.
NORTHEASTERN (OLD)	No indication of wrecks or cultural artifacts. No visible risks to marine habitat. No identifiable vulnerable marine ecosystems (VMEs) and no essential fish habitats (EFHs).	No identifiable risks within survey data. Public feedback indicates longline fishing in the area and that moorings could be a risk to longlining activities. Longlining is also a risk to mooring operations including fouling of profilers.	Assess Northeastern (Updated) site in area of less potential longlining activity.

Site	Findings	Risks	Recommendations
SOUTHEASTERN (OLD)	No indication of wrecks or cultural artifacts. No visible risks to marine habitat. No identifiable vulnerable marine ecosystems (VMEs) and no essential fish habitats (EFHs).	No identifiable risks within survey data. Public feedback indicates longline fishing in the area and that moorings could be a risk to longlining activities. Longlining is also a risk to mooring operations including fouling of profilers.	Assess Southeastern (Updated) site in area of less potential longlining activity.
NORTHEASTERN (Updated)	No indication of wrecks or cultural artifacts. No visible risks to marine habitat. No identifiable vulnerable marine ecosystems (VMEs) and no essential fish habitats (EFHs).	No identifiable risks.	Retain anchor targets as planned.
SOUTHEASTERN (Updated)	No indication of wrecks or cultural artifacts. No visible risks to marine habitat. No identifiable vulnerable marine ecosystems (VMEs) and no essential fish habitats (EFHs).	No identifiable risks.	Retain anchor targets as planned.

APPENDIX A: Areas of Interest

AREAS OF INTEREST

The following section describes areas of interest located during the ROV transects between sites. These areas of interest are outside of the anchor target areas (anchors can typically be deployed within a 25m radius of the target) and would not be impacted by the proposed action, including Pioneer MAB anchors and operations. Benthic organisms were found within these areas; organism identification was performed by Tim Shank, a WHOI Associate Scientist in Biology. Based on the review, there are no identifiable vulnerable marine ecosystems (VMEs) and no essential fish habitats (EFHs) in these images.

Table A-1: Areas of Interest

Area	Site	Distance from Nearest Anchor Target (m)	Water Depth (m)
1	Central	300	30
2	Southern	272	85.7
3	Southern	50	93.7
4	Northeastern (Old)	230	567
5	Southeastern (Old)	50	557

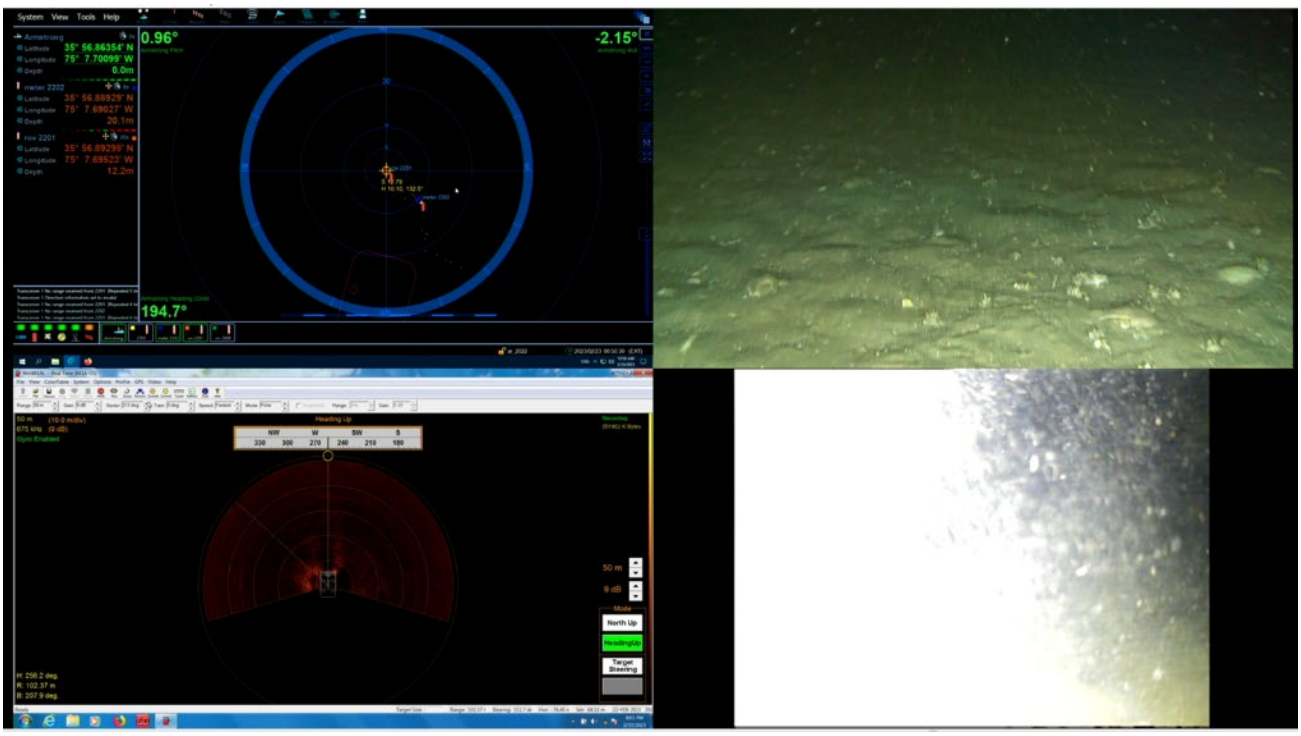

Figure A-1: Area of Interest #1, Central Site: Shell and skeleton debris, sea star, scattered vertical worm tubes

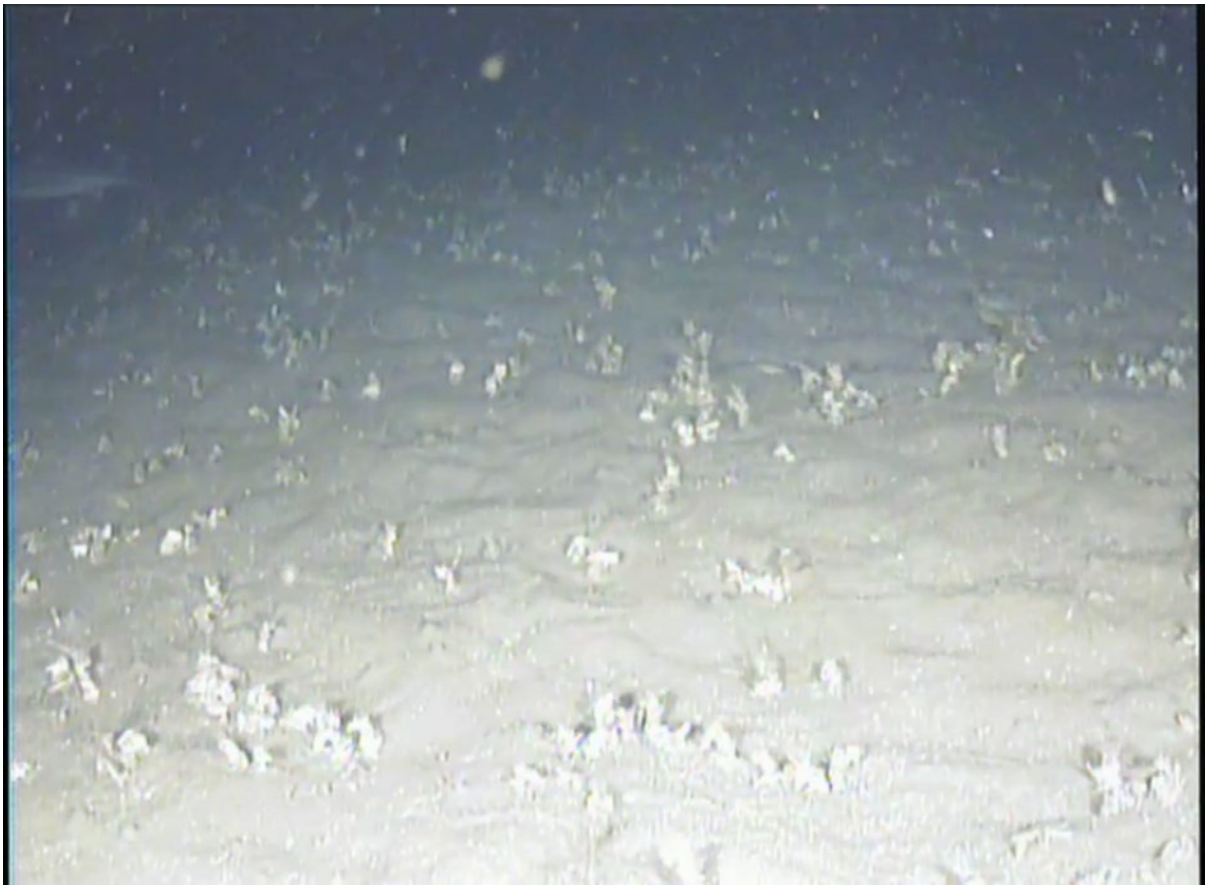

Figure A-2: Area of Interest #1, Central Site: Shell and skeleton debris, sponges

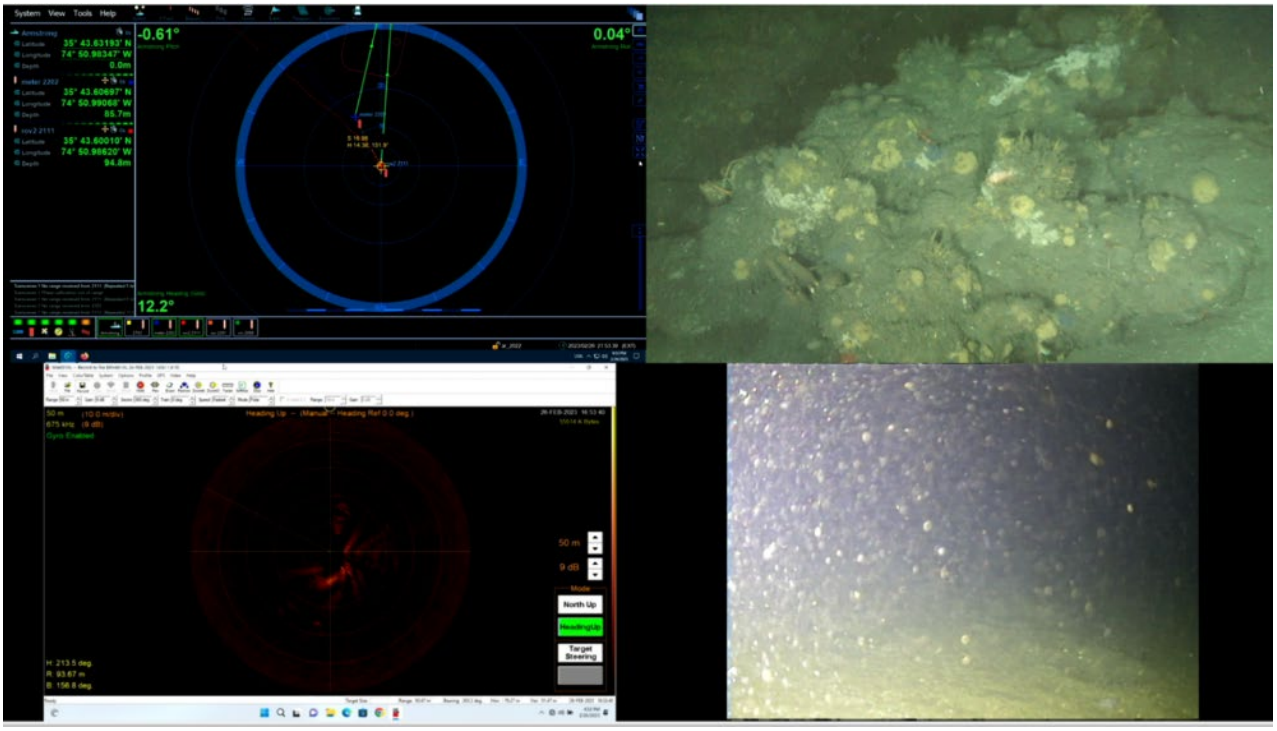

Figure A-3: Area of Interest #2, Southern Site: Lithotherm-like substrate, sponges, Galatheid crabs, Bryozoan-like animals

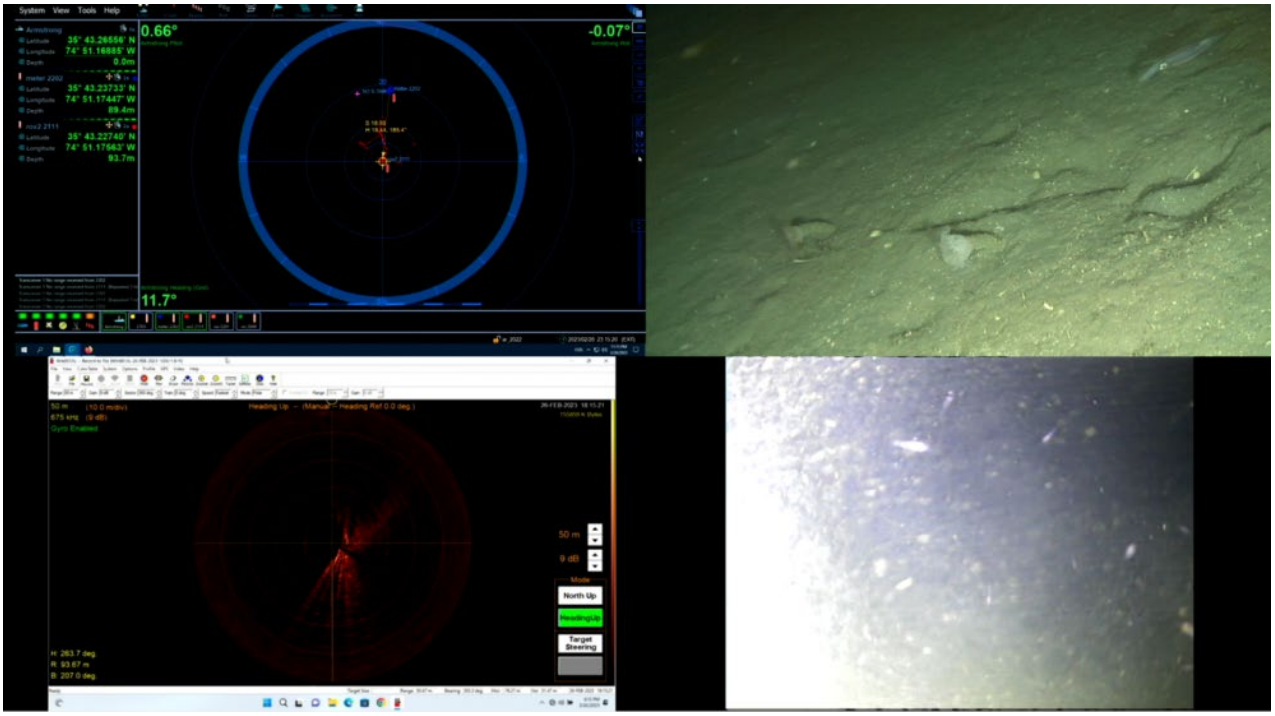

Figure A-4: Area of Interest #3, Southern Site: Anemones (solitary hydroids), shell debris, squid, small Polychaete Hyalinoecia worm tubes

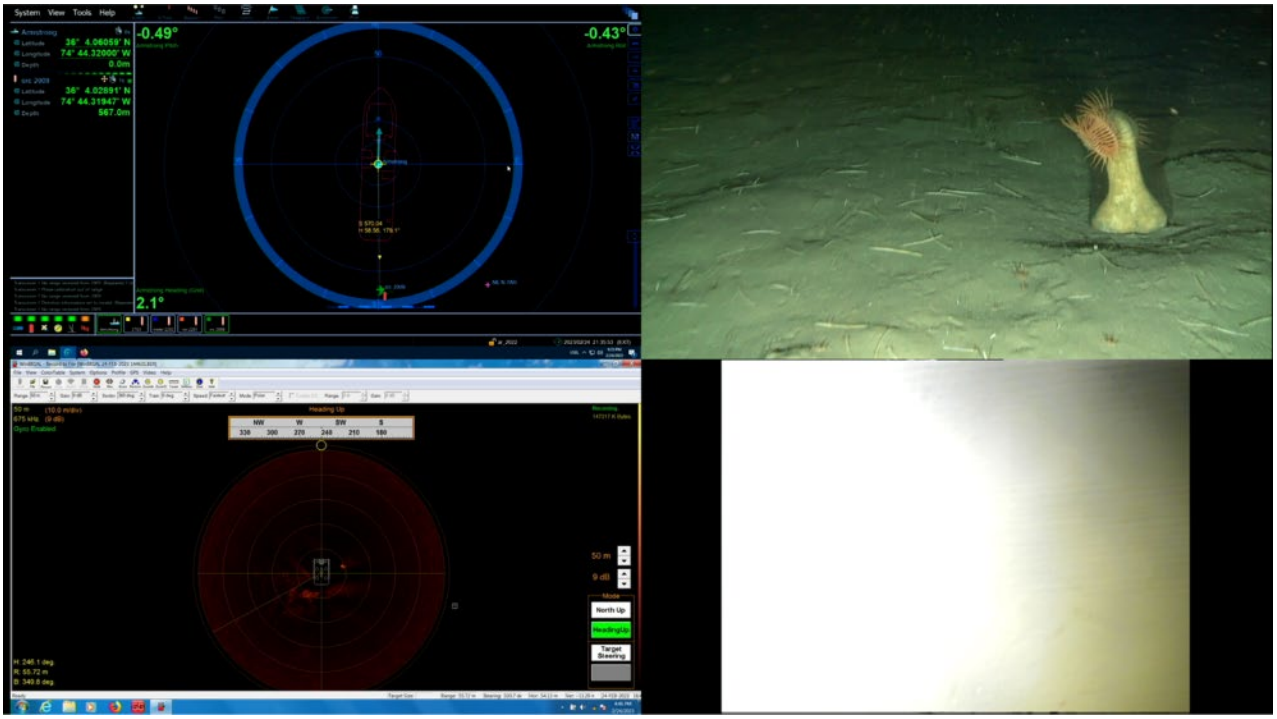

Figure A-5: Area of Interest #4, Northeastern (Old) Site: Actinoscyphia Venus Flytrab anemone, Polychaete Hyalinoecia worm tubes

Figure A-6: Area of Interest #4, Northeastern (Old) Site: Anemones, squid, Polychaete Hyalinoecia worm tubes

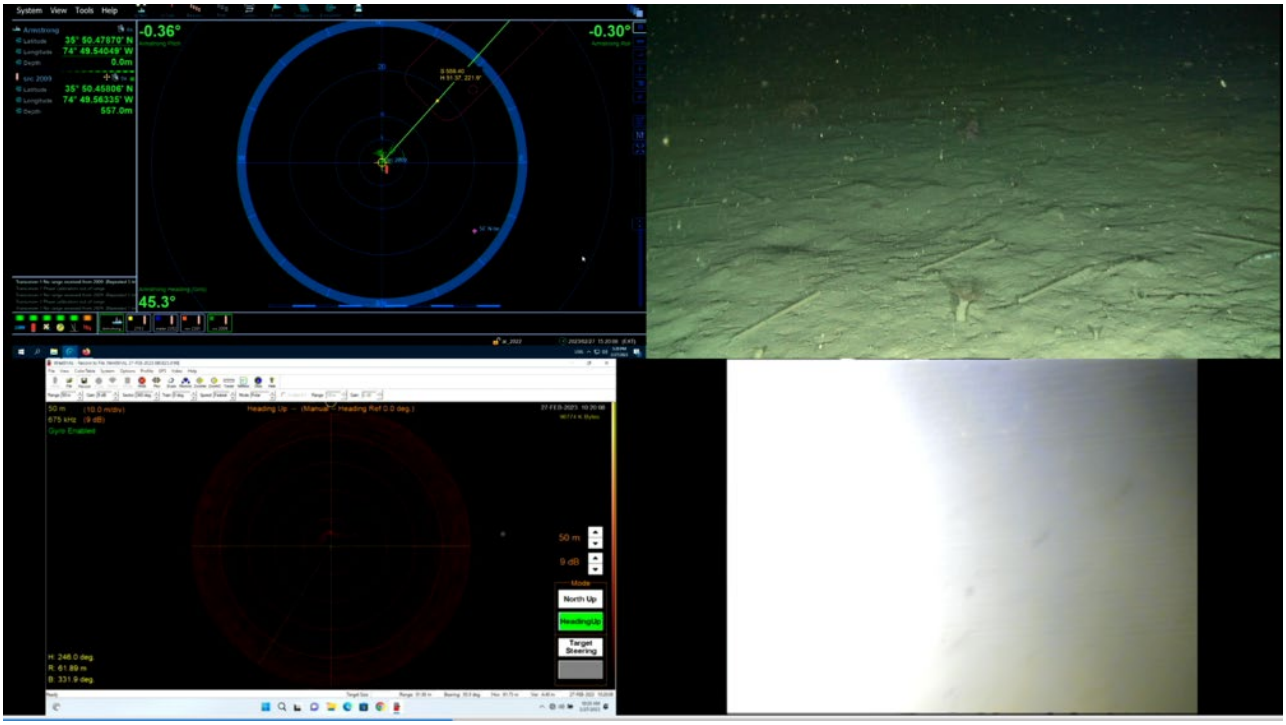

Figure A-7: Area of Interest #5, Southeastern (Old) Site: Polychaete Hyalinoecia worm tubes, tube anemones