

Appendix F: Pioneer MAB Seabed Survey and ROV Inspections



Pioneer MAB Seabed Survey & ROV Inspections

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Table of Contents

List of Figures	iii
List of Tables	v
1.0 PURPOSE.....	1
2.0 REFERENCE DOCUMENTS	1
3.0 DEFINITIONS & ACRONYMS	1
4.0 OVERVIEW.....	3
4.1. Site Summary.....	3
4.2. Vessel	4
4.3. Mapping Equipment.....	4
4.4. ROV Equipment	4
5.0 SITE MAPPING.....	6
6.0 ROV INSPECTION.....	7
7.0 DATA PROCESSING.....	8
7.1. Sound Velocity	8
7.2. Bathymetry & Backscatter	8
7.3. Subbottom	9
8.0 SURVEY RESULTS	10
8.1. West.....	10
8.2. Central.....	17
8.3. East.....	26
8.4. North	34
8.5. South.....	44
8.6. Northeast.....	54
8.7. Southeast.....	60
9.0 CONCLUSION & RECOMMENDATIONS	66
APPENDIX A: Areas of Interest.....	68

List of Figures

Figure 1: Pioneer MAB Proposed Array Layout.....	3
Figure 2: RV Neil Armstrong	4
Figure 3: Saab SeaEye Falcon DR ROV.....	5
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
Figure 5: Example Sound Velocity Profile	8
Figure 6: Example Bathymetry Processing.....	9
Figure 7: Example Subbottom Visualization	9
Figure 8: West Site Digital Terrain Model (2m contours)	10
Figure 9: West Site North Anchor Target (N-Tar) Backscatter.....	11
Figure 10: West Site South Anchor Target (S-Tar) Backscatter	11
Figure 11: West Site North Anchor Target (N-Tar) Subbottom	12
Figure 12: West Site South Anchor Target (S-Tar) Subbottom.....	13
Figure 13: ROV Track at West Site	14
Figure 14: ROV Imagery at West Site, North Anchor Target	15
Figure 15: Sandy Seabed West Site, North Anchor Target	15
Figure 16: ROV Imagery at West Site, South Anchor Target.....	16
Figure 17: Sandy Seabed West Site, South Anchor Target.....	16
Figure 18: Central Site Digital Terrain Model (2m contours).....	17
Figure 19: Central Site North Anchor Target (N-Tar) Backscatter.....	18
Figure 20: Central Site East Anchor Target (E-Tar) Backscatter	18
Figure 21: Central Site South Anchor Target (S-Tar) Backscatter	18
Figure 22: Central Site West Anchor Target (W-Tar) Backscatter	19
Figure 23: Central Site North Anchor Target (N-Tar) Subbottom.....	20
Figure 24: Central Site East & West Anchor Targets (E-Tar, W-Tar) Subbottom.....	21
Figure 25: Central Site South Anchor Target (S-Tar) Subbottom	22
Figure 26: ROV Track at Central Site.....	23
Figure 27: ROV Imagery at Central Site, North Anchor Target.....	24
Figure 28: ROV Imagery at Central Site, East Anchor Target.....	24
Figure 29: ROV Imagery at Central Site, South Anchor Target	25
Figure 30: ROV Imagery at Central Site, West Anchor Target.....	25
Figure 31: East Site Digital Terrain Model (1m contours)	26
Figure 32: East Site North Anchor Target (N-Tar) Backscatter.....	27
Figure 33: East Site South Anchor Target (S-Tar) Backscatter	28

Figure 34: East Site North Anchor Target (N-Tar) Subbottom	29
Figure 35: West Site South Anchor Target (S-Tar) Subbottom	30
Figure 36: ROV Track at East Site	31
Figure 37: ROV Imagery at East Site, North Anchor Target	32
Figure 38: ROV Imagery at West Site, South Anchor Target.....	32
Figure 39: Sandy, Gravelly, Shelly Seabed East Site, South Anchor Target	33
Figure 40: West Site Digital Terrain Model (1m contours)	34
Figure 41: North Site North Anchor Target (N-Tar) Backscatter	35
Figure 42: North Site East Anchor Target (E-Tar) Backscatter	35
Figure 43: North Site South Anchor Target (S-Tar) Backscatter	35
Figure 44: North Site West Anchor Target (W-Tar) Backscatter	36
Figure 45: North Site North Anchor Target (N-Tar) Subbottom.....	37
Figure 46: North Site East & West Anchor Targets (E-Tar, W-Tar) Subbottom.....	38
Figure 47: North Site South Anchor Targets (S-Tar) Subbottom	39
Figure 48: ROV Track at North Site.....	40
Figure 49: ROV Imagery at North Site, North Anchor Target.....	41
Figure 50: Sandy, Gravelly, Shelly Seabed North Site, North Anchor Target	41
Figure 51: ROV Imagery at North Site, East Anchor Target	42
Figure 52: ROV Imagery at North Site, South Anchor Target	42
Figure 53: ROV Imagery at North Site, West Anchor Target	43
Figure 54: Sandy, Gravelly, Shelly Seabed North Site, West Anchor Target	43
Figure 55: South Site Digital Terrain Model (2m contours)	44
Figure 56: South Site North Anchor Target (N-Tar) Backscatter.....	45
Figure 57: South Site East Anchor Target (E-Tar) Backscatter	45
Figure 58: South Site South Anchor Target (S-Tar) Backscatter	45
Figure 59: South Site West Anchor Target (W-Tar) Backscatter	46
Figure 60: South Site North Anchor Target (N-Tar) Subbottom	47
Figure 61: South Site East & West Anchor Targets (E-Tar, W-Tar) Subbottom.....	48
Figure 62: South Site West Anchor Target (W-Tar) Subbottom.....	49
Figure 63: ROV Track at South Site	50
Figure 64: ROV Imagery at South Site, North Anchor Target	51
Figure 65: ROV Imagery at South Site, East Anchor Target.....	51
Figure 66: ROV Imagery at South Site, South Anchor Target.....	52
Figure 67: Sandy, Gravelly, Shelly Seabed South Site, South Anchor Target	52
Figure 68: ROV Imagery at South Site, West Anchor Target.....	53

Figure 69: Northeast Site Digital Terrain Model (10m contours)	54
Figure 70: Northeast Site North & South Anchor Targets (N-Tar, S-Tar) Backscatter.....	55
Figure 71: Northeast Site North Anchor Target (N-Tar) Subbottom	56
Figure 72: Northeast Site South Anchor Target (S-Tar) Subbottom.....	57
Figure 73: ROV Track at Northeast Site	58
Figure 74: ROV Imagery at Northeast Site, North Anchor Target	59
Figure 75: ROV Imagery at Northeast Site, North Anchor Target	59
Figure 76: Southeast Site Digital Terrain Model (10m contours)	60
Figure 77: Southeast Site North & South Anchor Targets (N-Tar, S-Tar) Backscatter	61
Figure 78: Southeast Site North Anchor Target (N-Tar) Subbottom	62
Figure 79: Southeast Site South Anchor Target (S-Tar) Subbottom	63
Figure 80: ROV Track at Southeast Site	64
Figure 81: ROV Imagery at Southeast Site, North Anchor Target	65
Figure 82: Sandy Seabed Southeast Site, North Anchor Target.....	65
Figure 83: Area of Interest #1, Central Site: Shell and skeleton debris, sea star, scattered vertical worm tubes	69
Figure 84: Area of Interest #1, Central Site: Shell and skeleton debris, sponges.....	70
Figure 85: Area of Interest #2, South Site: Lithotherm-like substrate, sponges, Galatheid crabs, Bryozoan-like animals	70
Figure 86: Area of Interest #3, South Site: Anemones (solitary hydroids), shell debris, squid, small Polychaete Hyalinoecia worm tubes.....	71
Figure 87: Area of Interest #4, Northeast Site: Actinoscyphia Venus Flytrab anemone, Polychaete Hyalinoecia worm tubes	71
Figure 88: Area of Interest #4, Northeast Site: Anemones, squid, Polychaete Hyalinoecia worm tubes.....	72
Figure 89: Area of Interest #5, Southeast Site: Polychaete Hyalinoecia worm tubes, tube anemones	72

List of Tables

Table 1: Reference Documents.....	1
Table 2: ROV Specifications	5
Table 3: Site Center Coordinates	6
Table 4: Anchor Target Coordinates	6
Table 5: Engineering Findings.....	66
Table 6: Compliance	67
Table 7: Areas of Interest.....	69

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 surveys and ROV inspections were performed between 21 February – 1 March 2023 in conjunction with the deployment of test moorings at the Central and Northeast sites.

The desktop planning performed by OOI and TetraTech 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 avoid 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

BOEM	Bureau of Ocean Energy Management
CGSN	Coastal & Global Scale Nodes
CN	Central Site
EA	East 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	Northeast Site
NO	North 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	Southeast Site
SEANOE	SEA scieNtific Open data Edition
SHOM	Service Hydrographique et Océanographique de la Marine
SIS	Seafloor Information System
SM	Surface Mooring
SO	South Site
SW	Shallow Water Mooring
VME	Vulnerable Marine Ecosystem
WE	West 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 preliminary 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
- Five profiler moorings located in 100m and 600m water depths
- Two shallow-water moorings located in 30m water depths

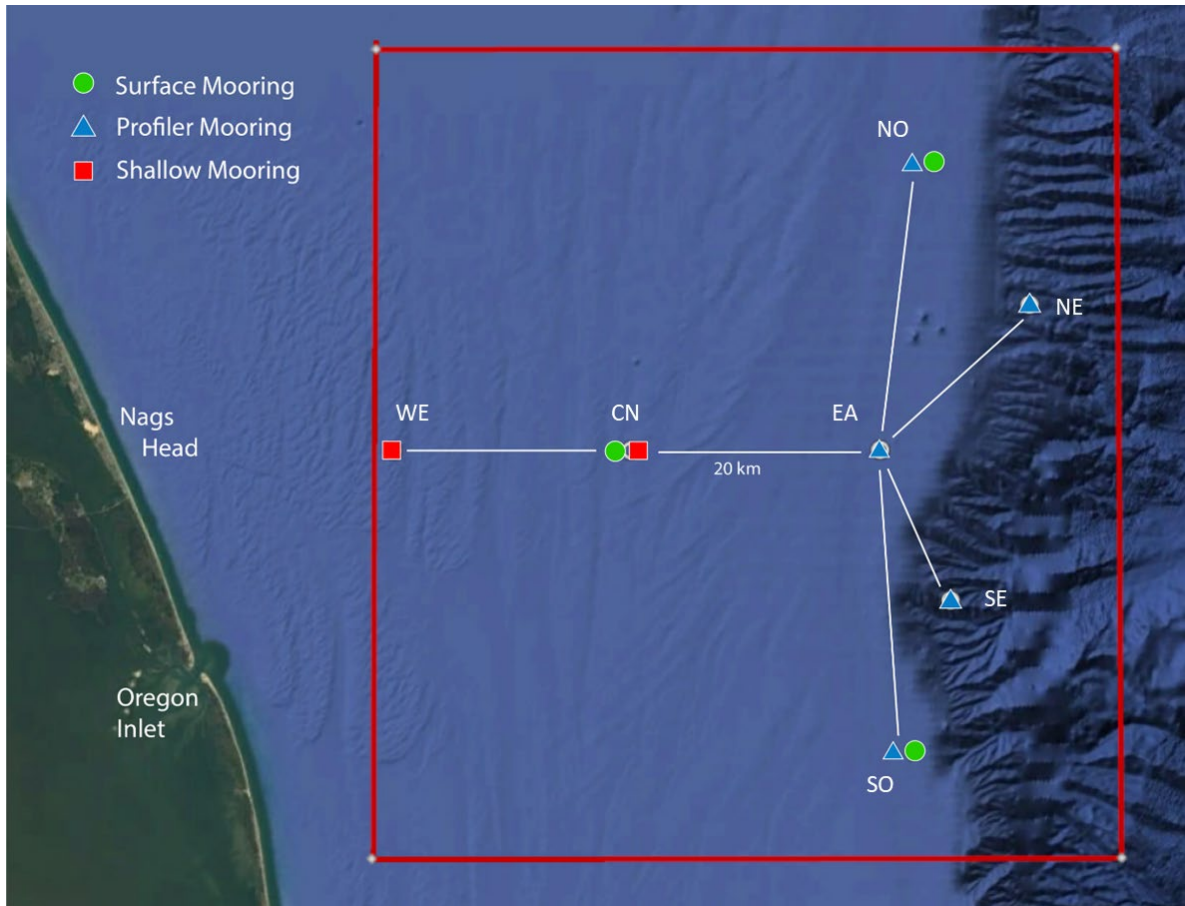


Figure 1: Pioneer MAB Proposed Array Layout

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 TetraTech*) and regulatory study (*Mid-Atlantic Bight Pioneer Array Regulatory Study, Prepared by TetraTech*). A maritime archeology study (*Marine Archeology Study, Moored Buoys for Scientific Data Collection, North Carolina, Outer Continental Shelf. Prepared by SEARCH for TetraTech*) did not identify any documented archaeological sites, reported shipwrecks, or maritime obstructions within 1.6 km (1.0 mi) of the proposed site centers.

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

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 Griptstick02 plus skid mounted Hydro-Lek 5-function; cutter available as option, Griptstick02 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 seven 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	35.95	75.3333
Central	CN	35.95	75.125
Eastern	EA	35.95	74.8457
North	NO	36.175	74.8267
Southern	SO	35.725	74.853
Northeast	NE	36.0633	74.7427
Southeast	SE	35.8367	74.8242

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	75.125
CN S-tar	35.94558	75.125
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	36.175	74.8212
NO W-tar	36.175	74.8321
EA N-tar	35.95442	74.8457
EA S-tar	35.94558	74.8457

SO N-tar	35.72937	74.853
SO S-tar	35.72062	74.853
SO E-tar	35.725	74.8476
SO W-tar	35.725	74.8584
NE N-tar	36.0675	74.7412
NE S-tar	36.05972	74.7457
SE N-tar	35.84083	74.8258
SE S-tar	35.8325	74.8258

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 an 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.

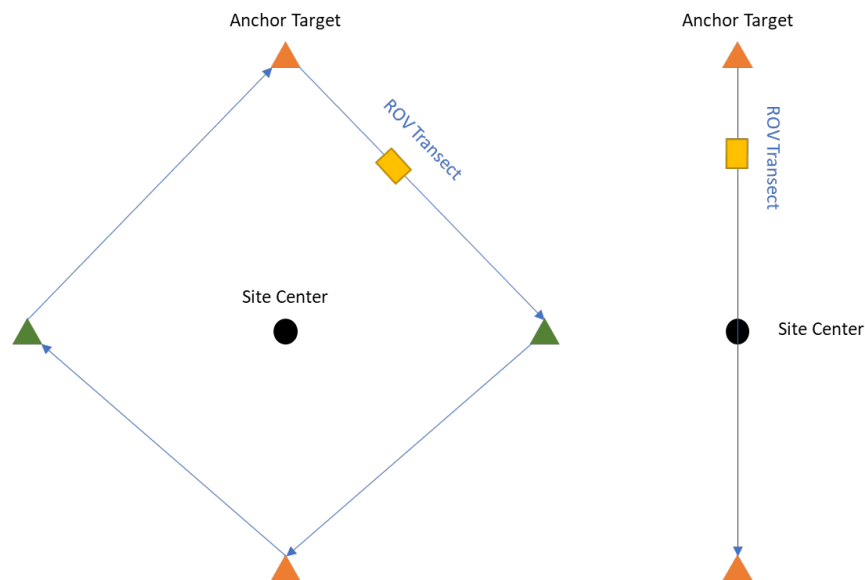


Figure 4: ROV Inspections & Transects. At sites with two moorings (left) four anchor targets are inspected with the ROV transects between targets creating a square pattern. At sites with one mooring (right) two targets are inspected with the ROV transect passing through the site center.

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>)

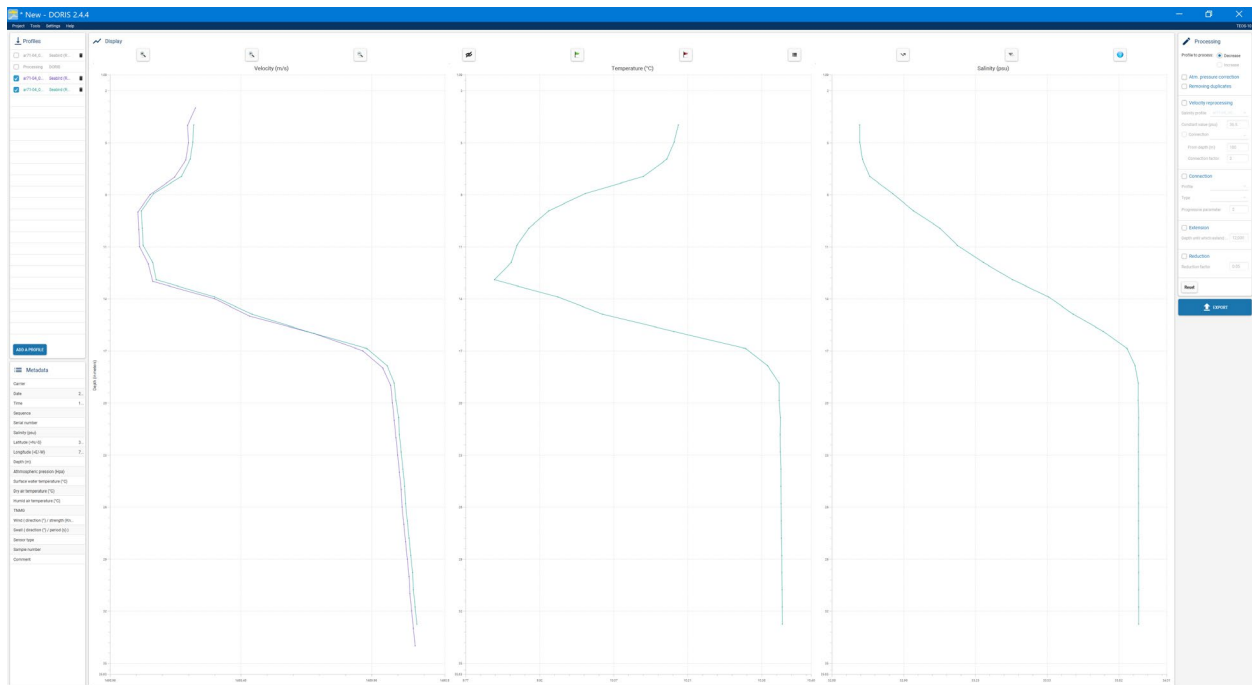


Figure 5: Example Sound Velocity Profile

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 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.

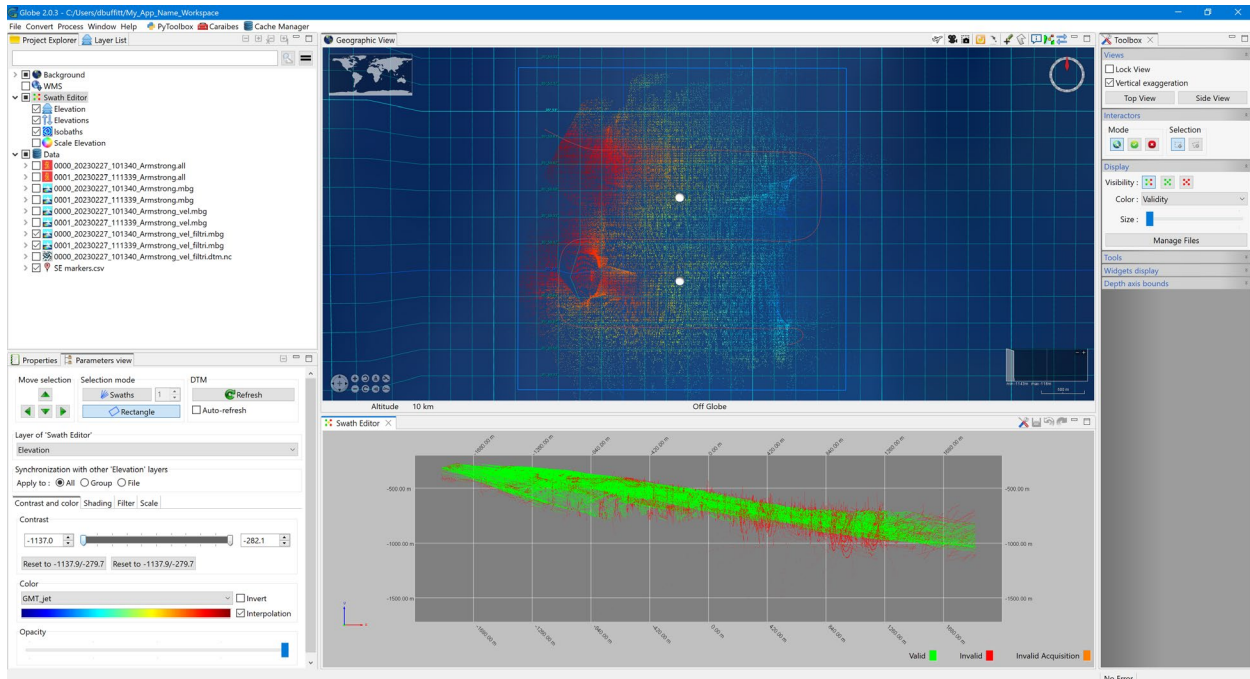


Figure 6: Example Bathymetry Processing

7.3. Subbottom

The Knudsen 3260 subbottom data (*.seggy 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.

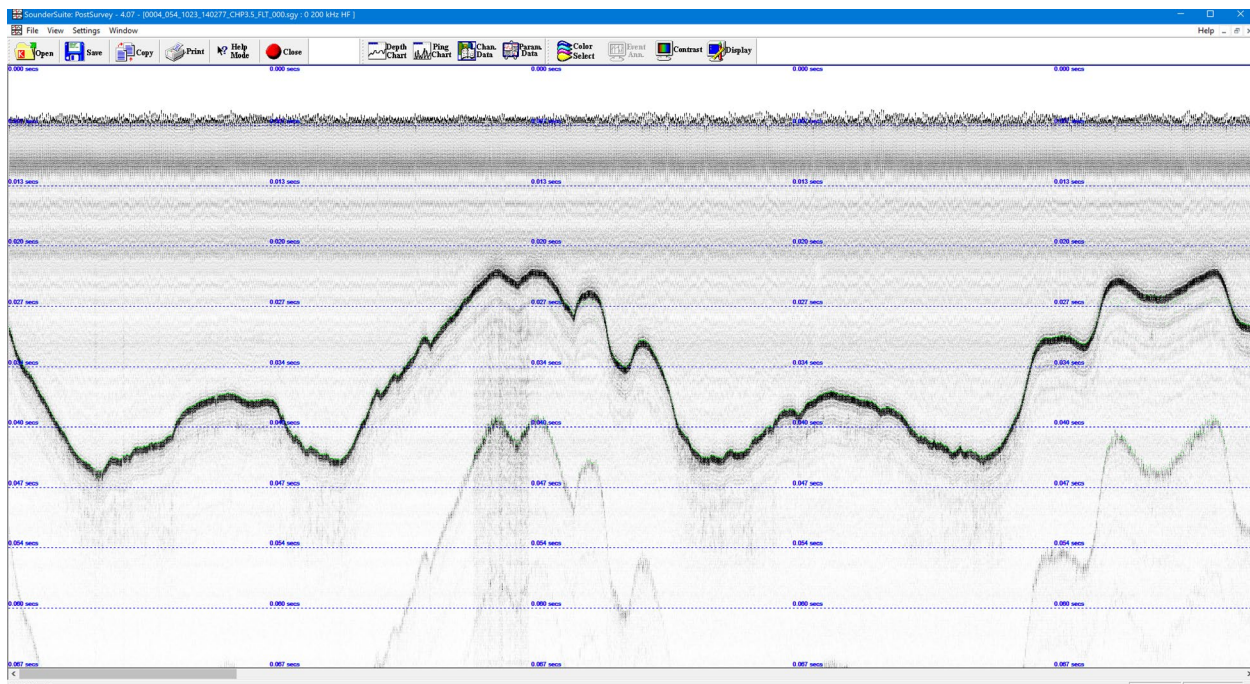


Figure 7: Example Subbottom Visualization

8.0 SURVEY RESULTS

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

8.1. West

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.

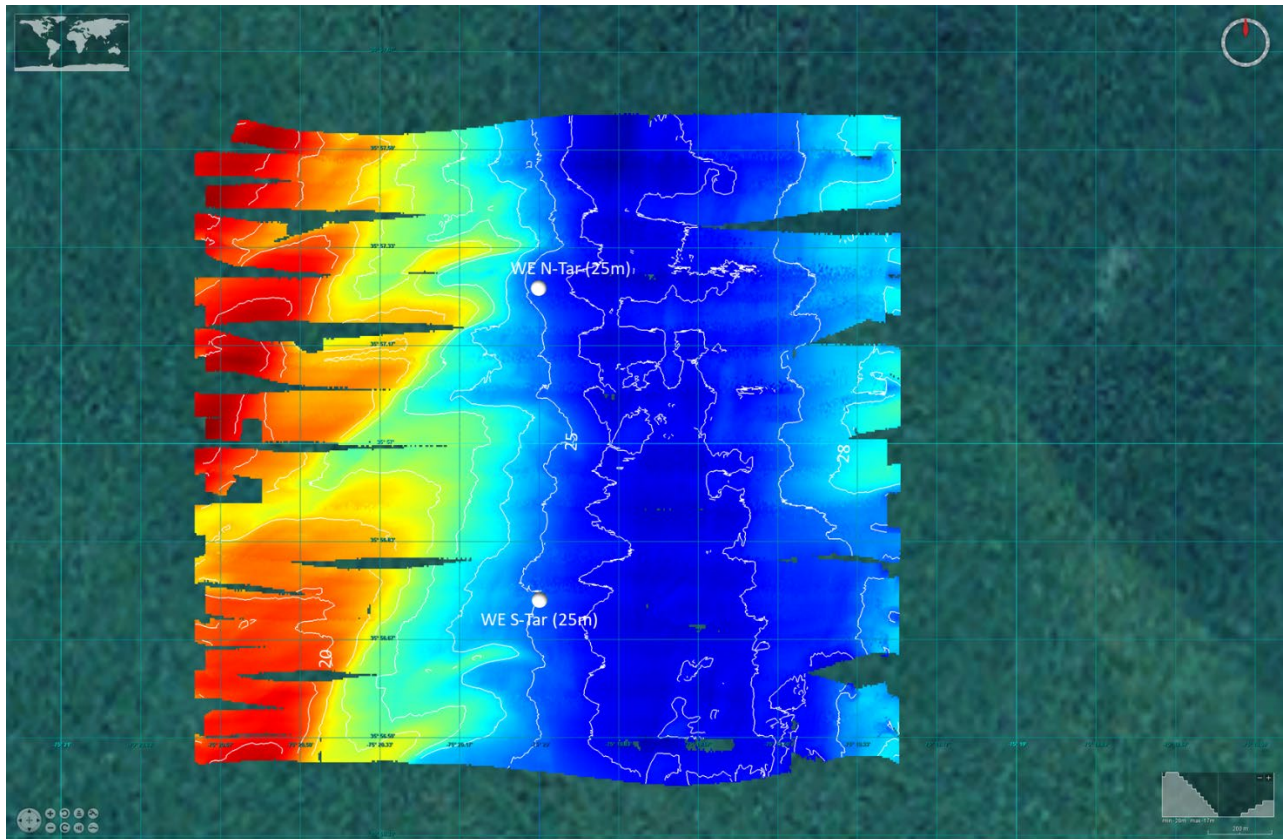


Figure 8: West Site Digital Terrain Model (2m contours)

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).

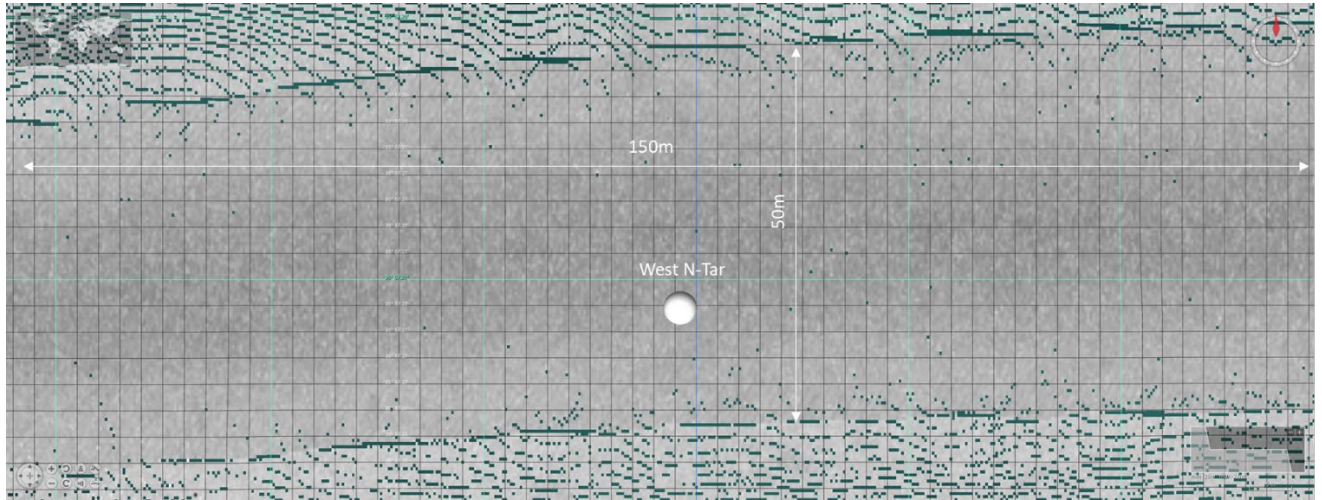


Figure 9: West Site North Anchor Target (N-Tar) Backscatter

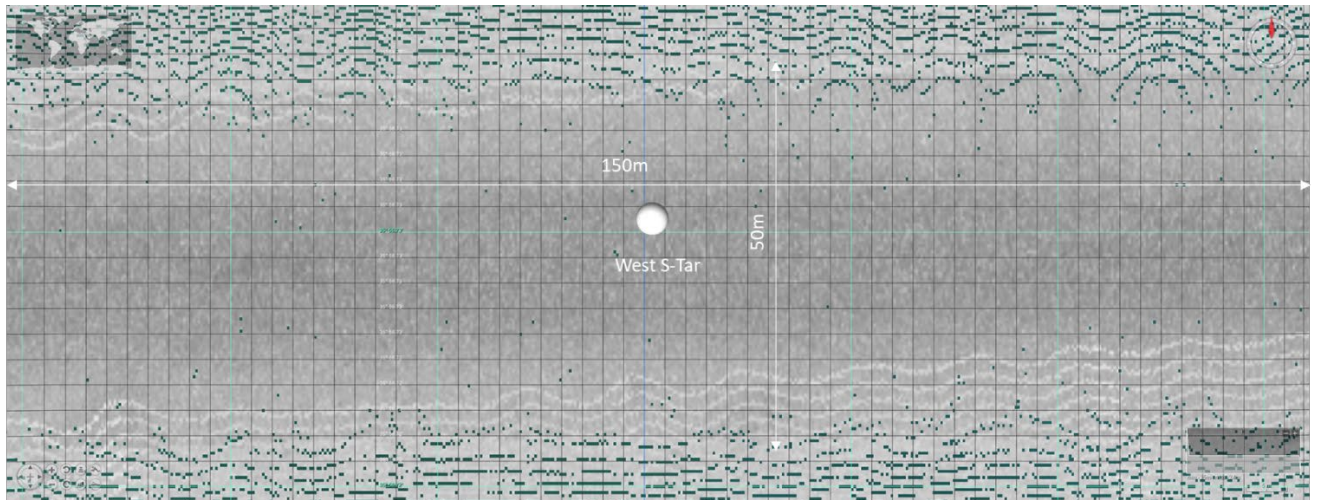


Figure 10: West Site South Anchor Target (S-Tar) Backscatter

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° .

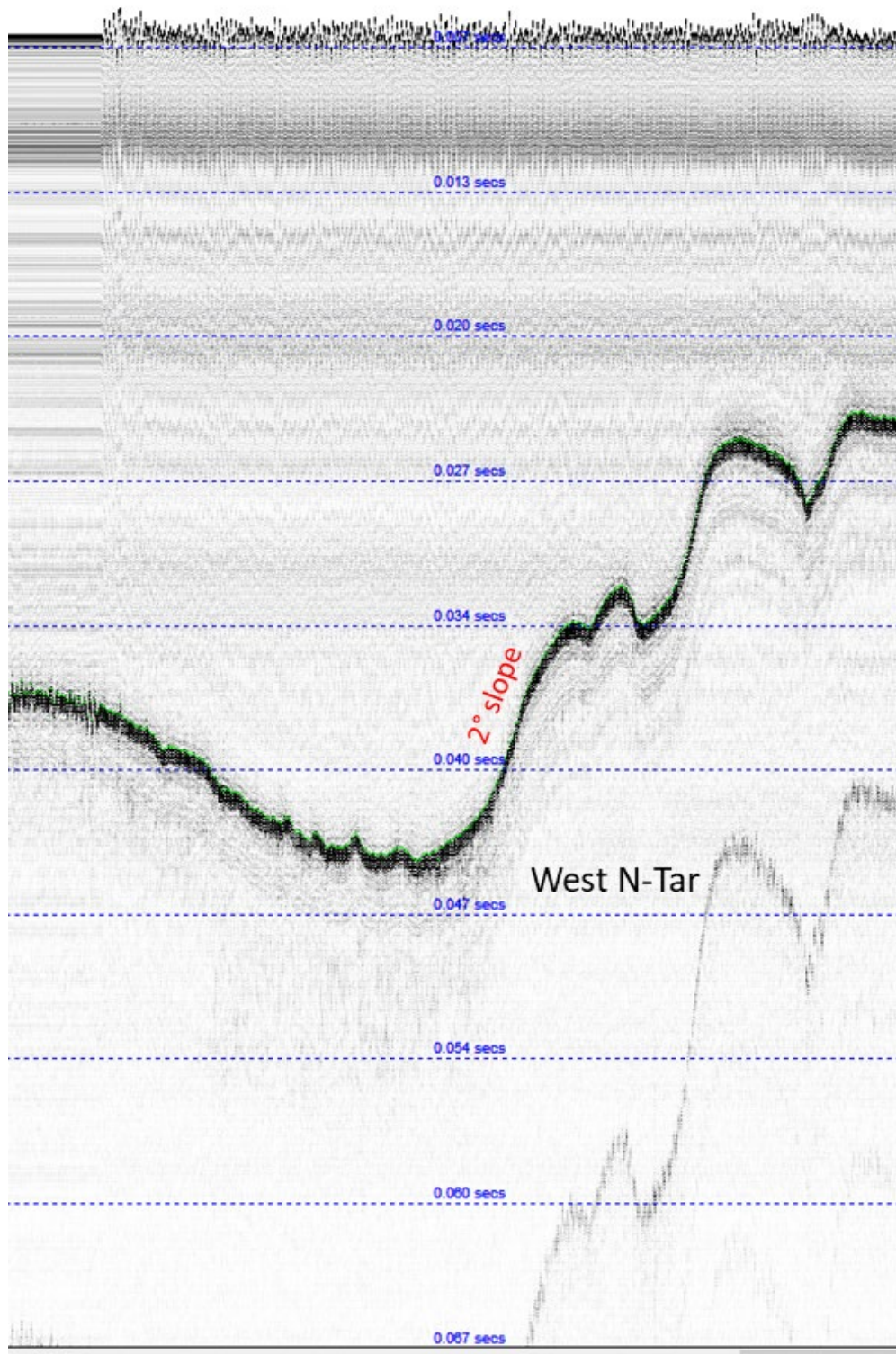


Figure 11: West Site North Anchor Target (N-Tar) Subbottom

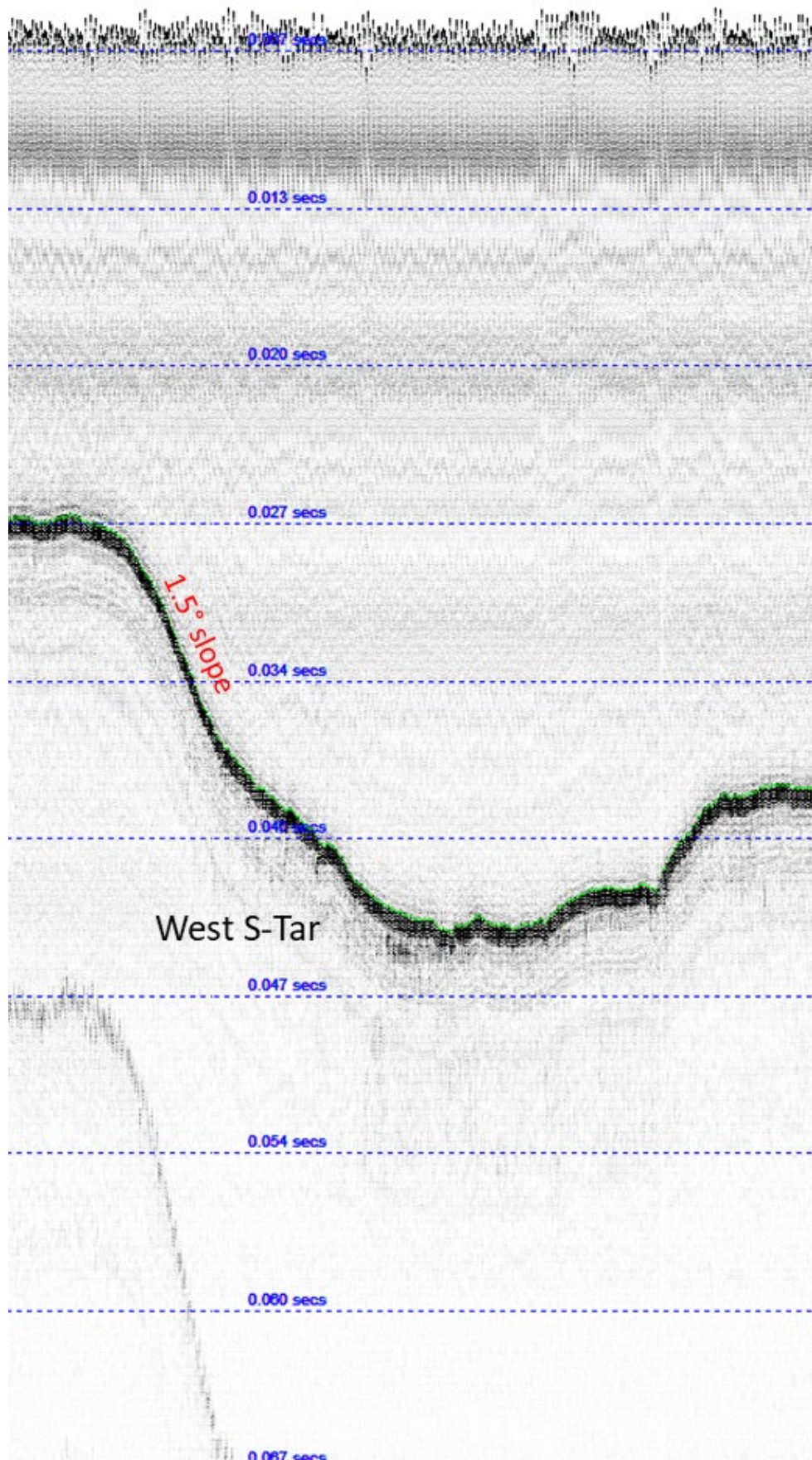


Figure 12: West Site South Anchor Target (S-Tar) Subbottom

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.

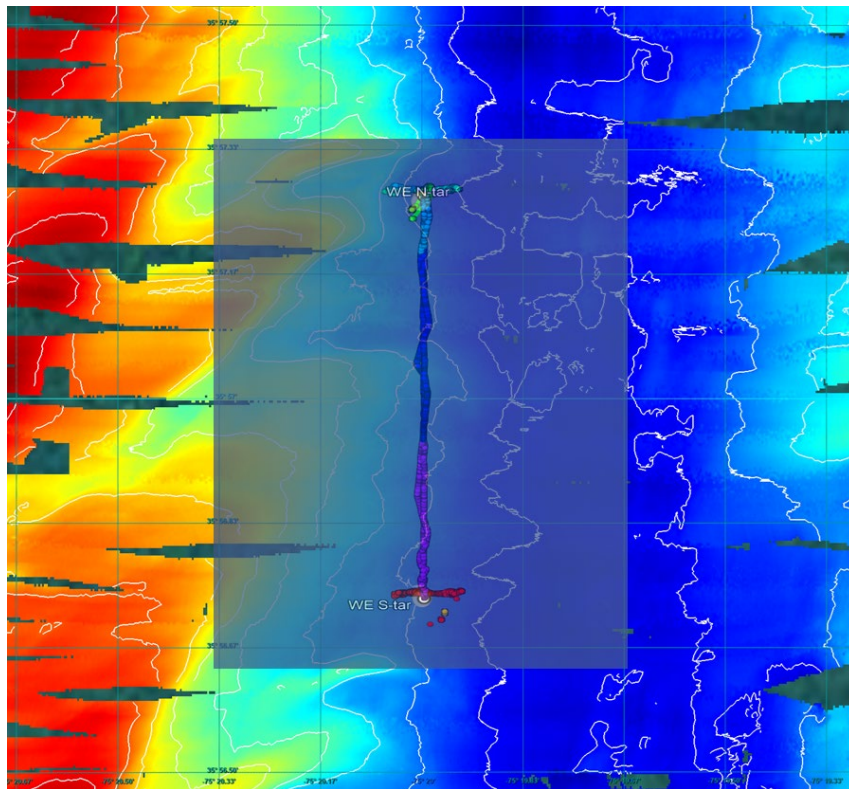


Figure 13: ROV Track at West Site

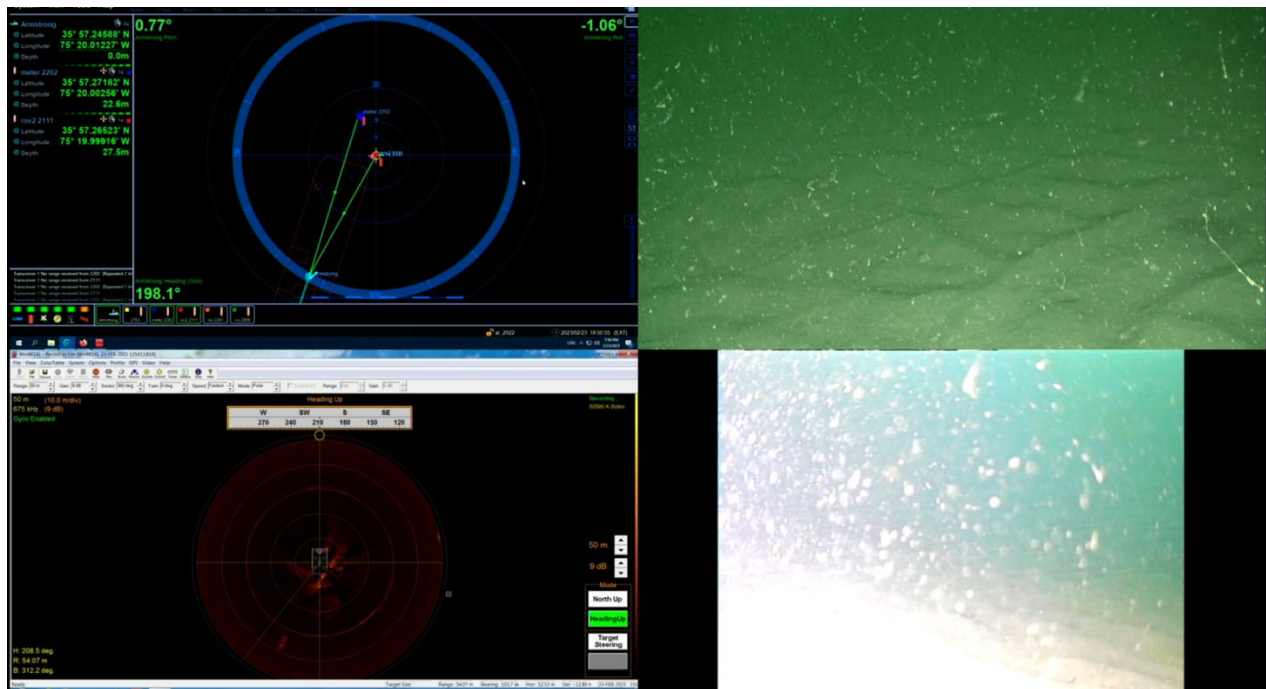


Figure 14: ROV Imagery at West Site, North Anchor Target



Figure 15: Sandy Seabed West Site, North Anchor Target

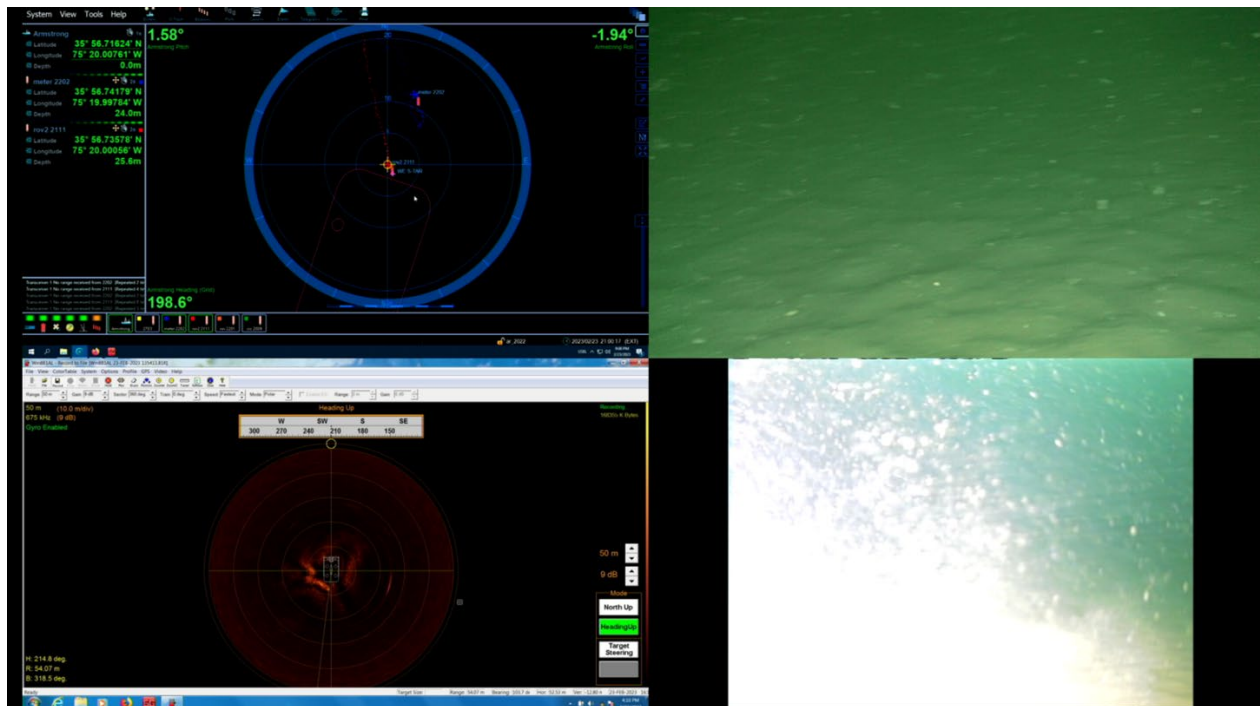


Figure 16: ROV Imagery at West Site, South Anchor Target



Figure 17: Sandy Seabed West 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.

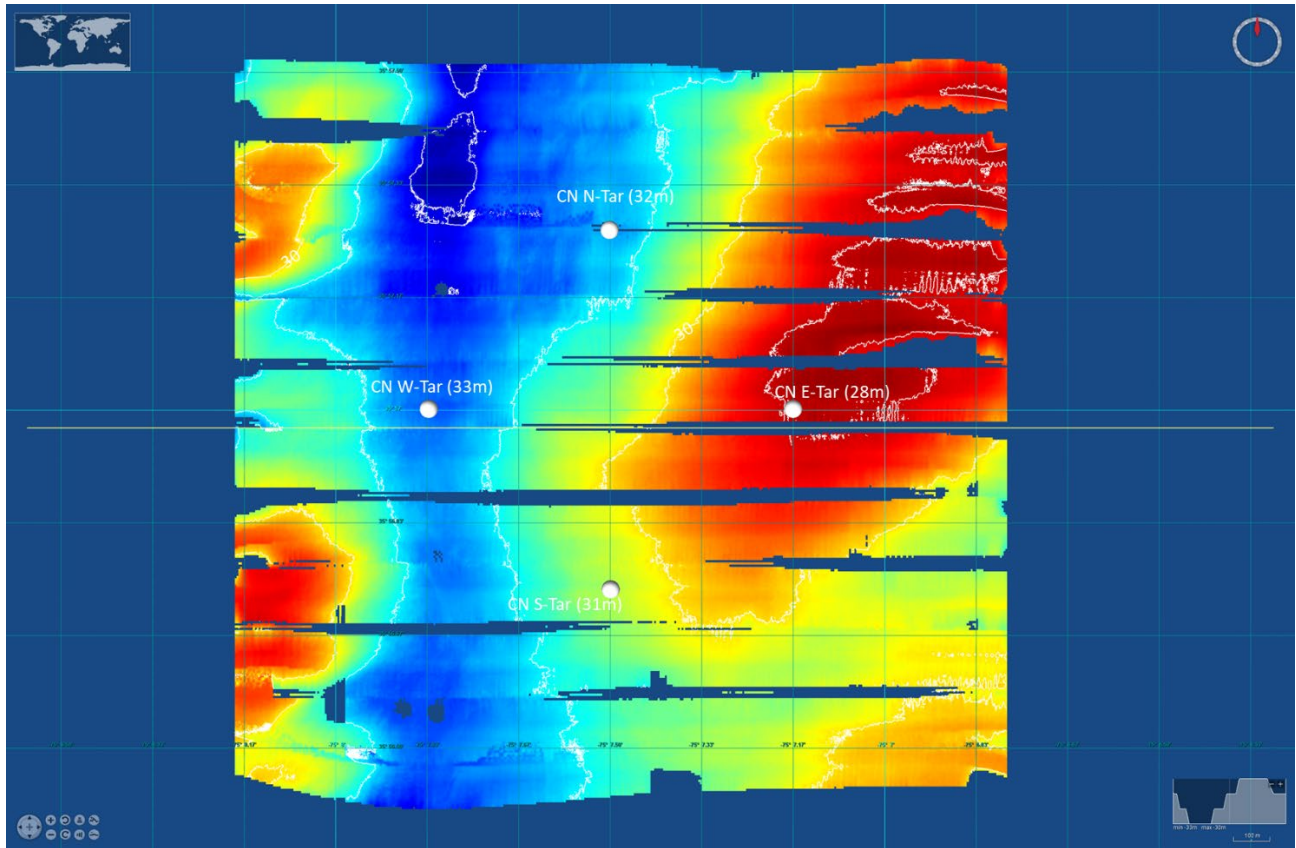


Figure 18: Central Site Digital Terrain Model (2m contours)

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).

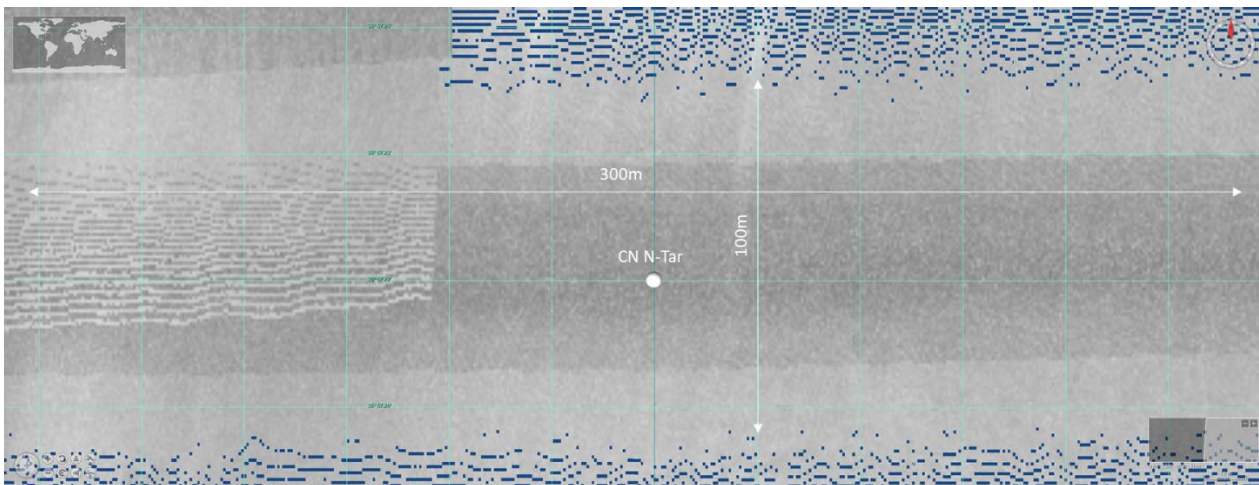


Figure 19: Central Site North Anchor Target (N-Tar) Backscatter

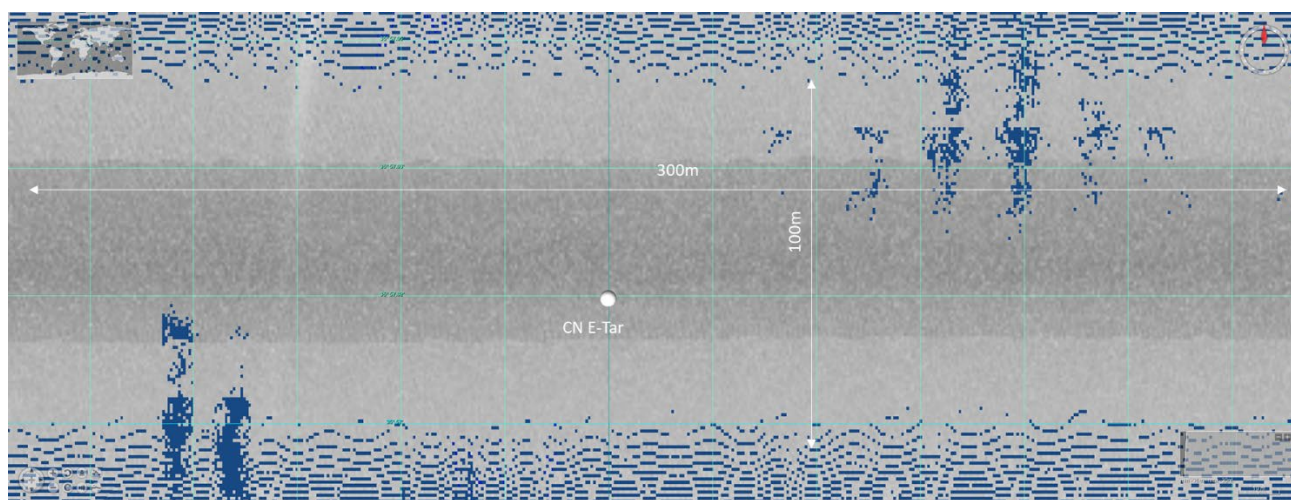


Figure 20: Central Site East Anchor Target (E-Tar) Backscatter

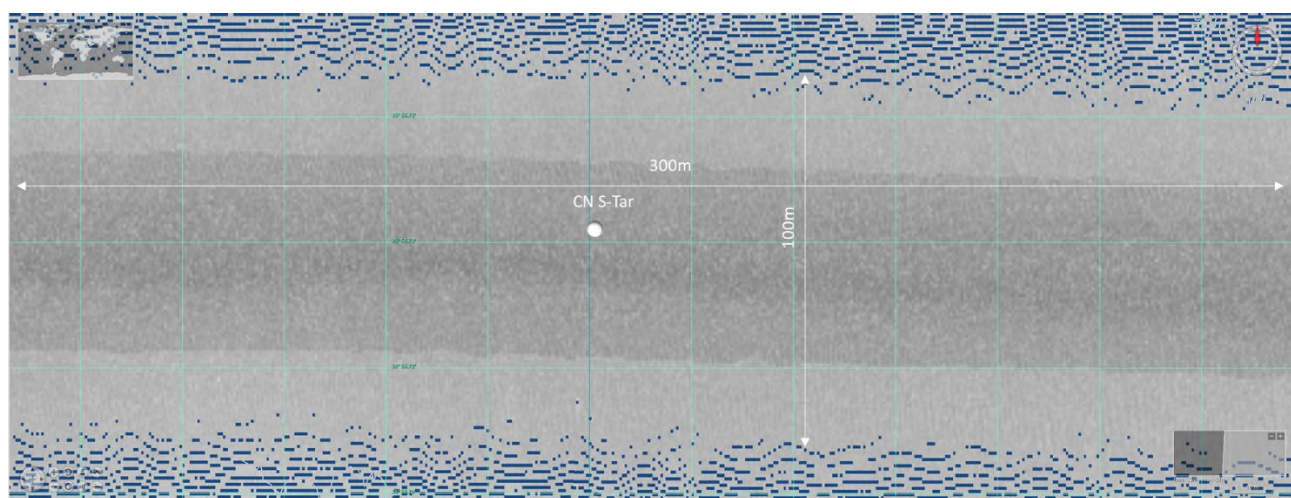


Figure 21: Central Site South Anchor Target (S-Tar) Backscatter

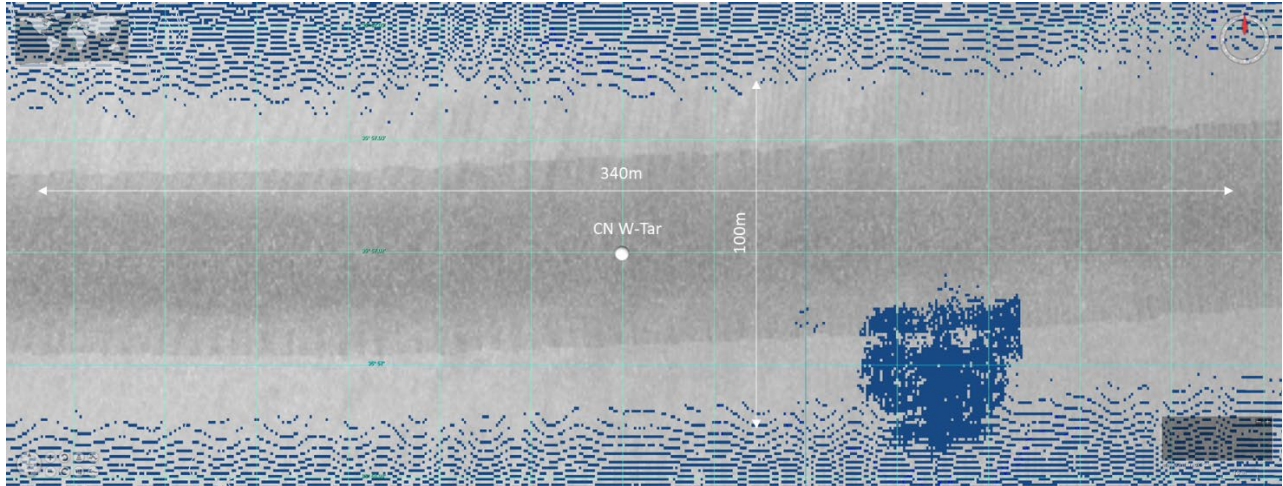


Figure 22: Central Site West Anchor Target (W-Tar) Backscatter

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 $\sim 0.5\text{-}1^\circ$.

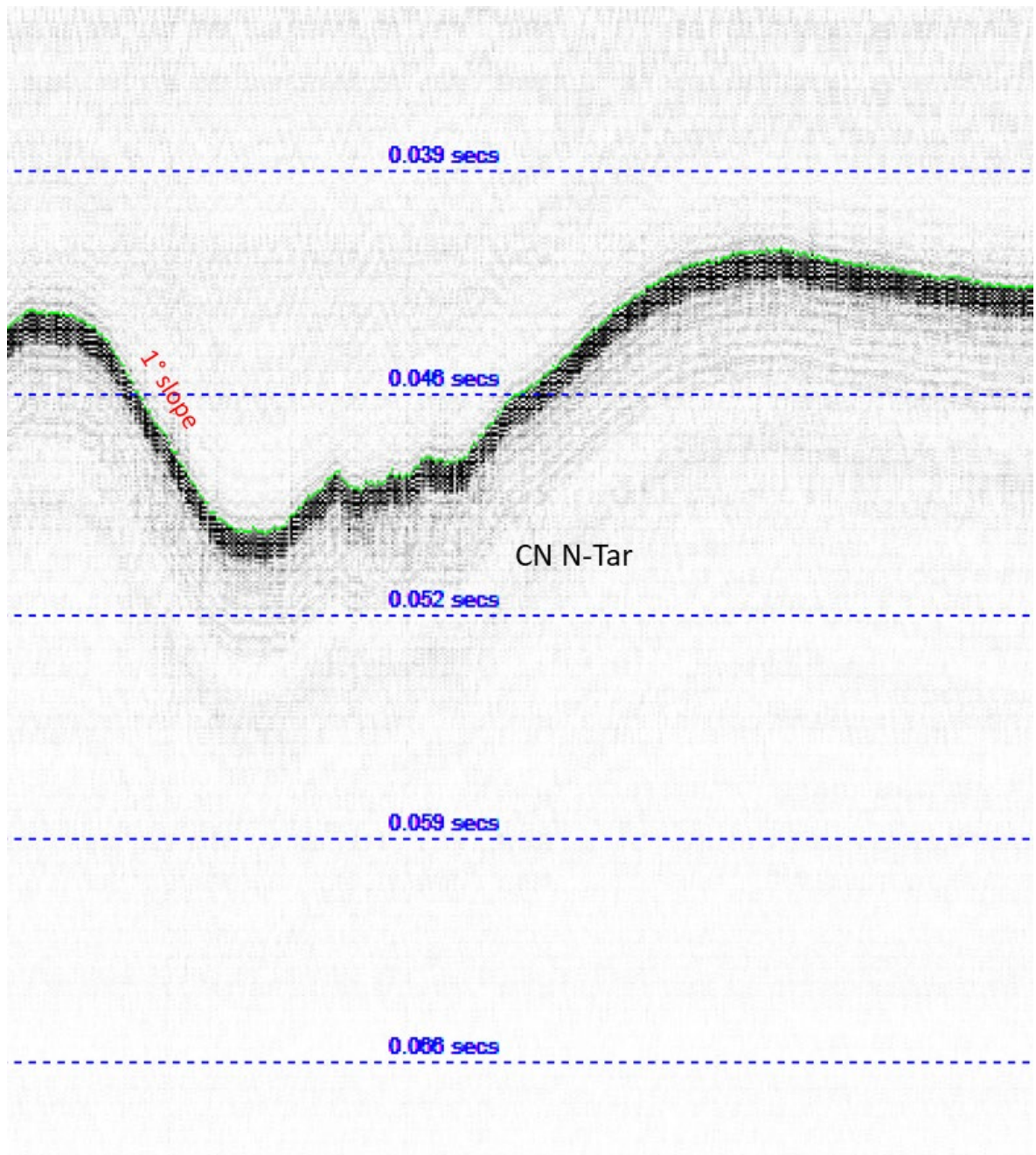


Figure 23: Central Site North Anchor Target (N-Tar) Subbottom

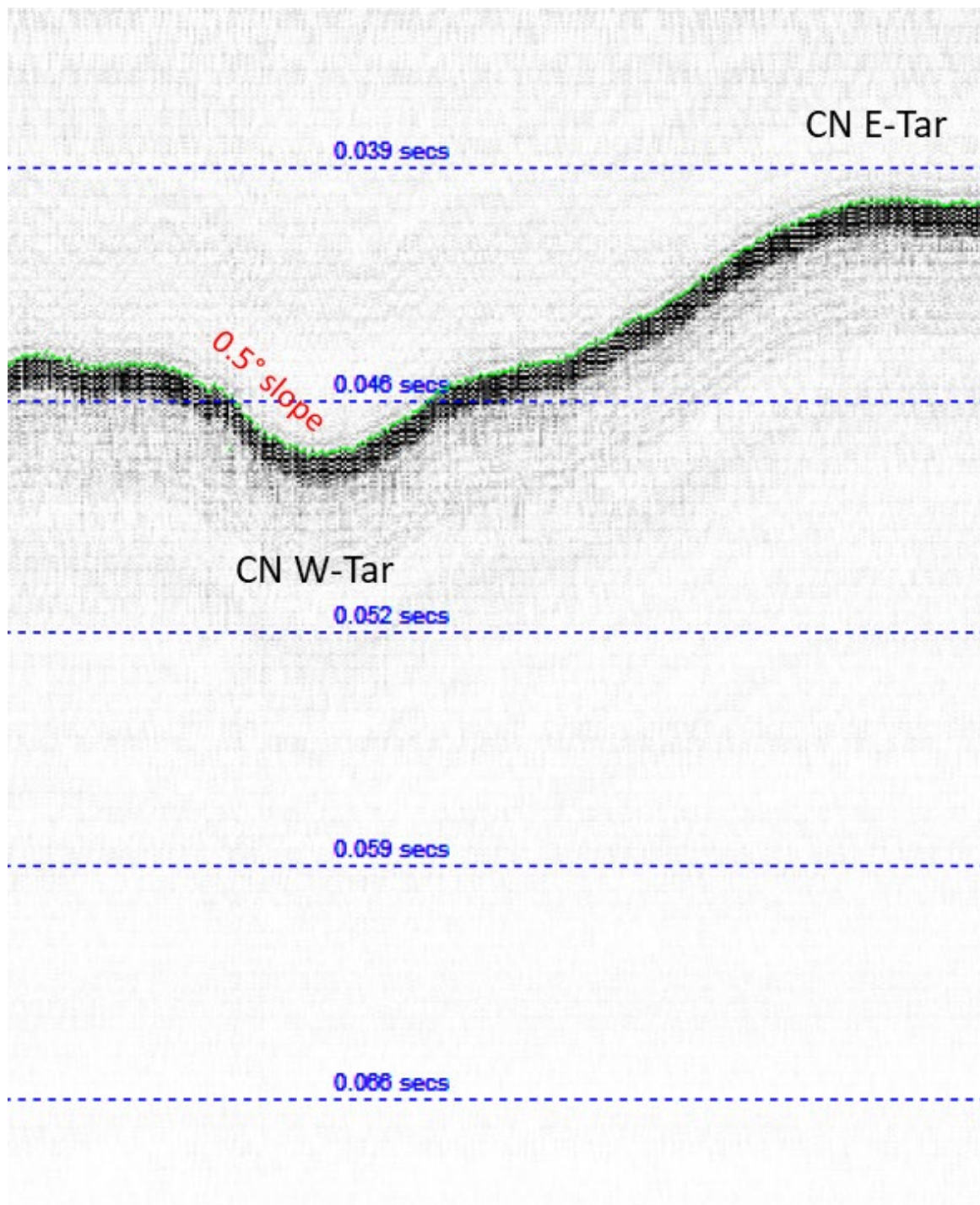


Figure 24: Central Site East & West Anchor Targets (E-Tar, W-Tar) Subbottom

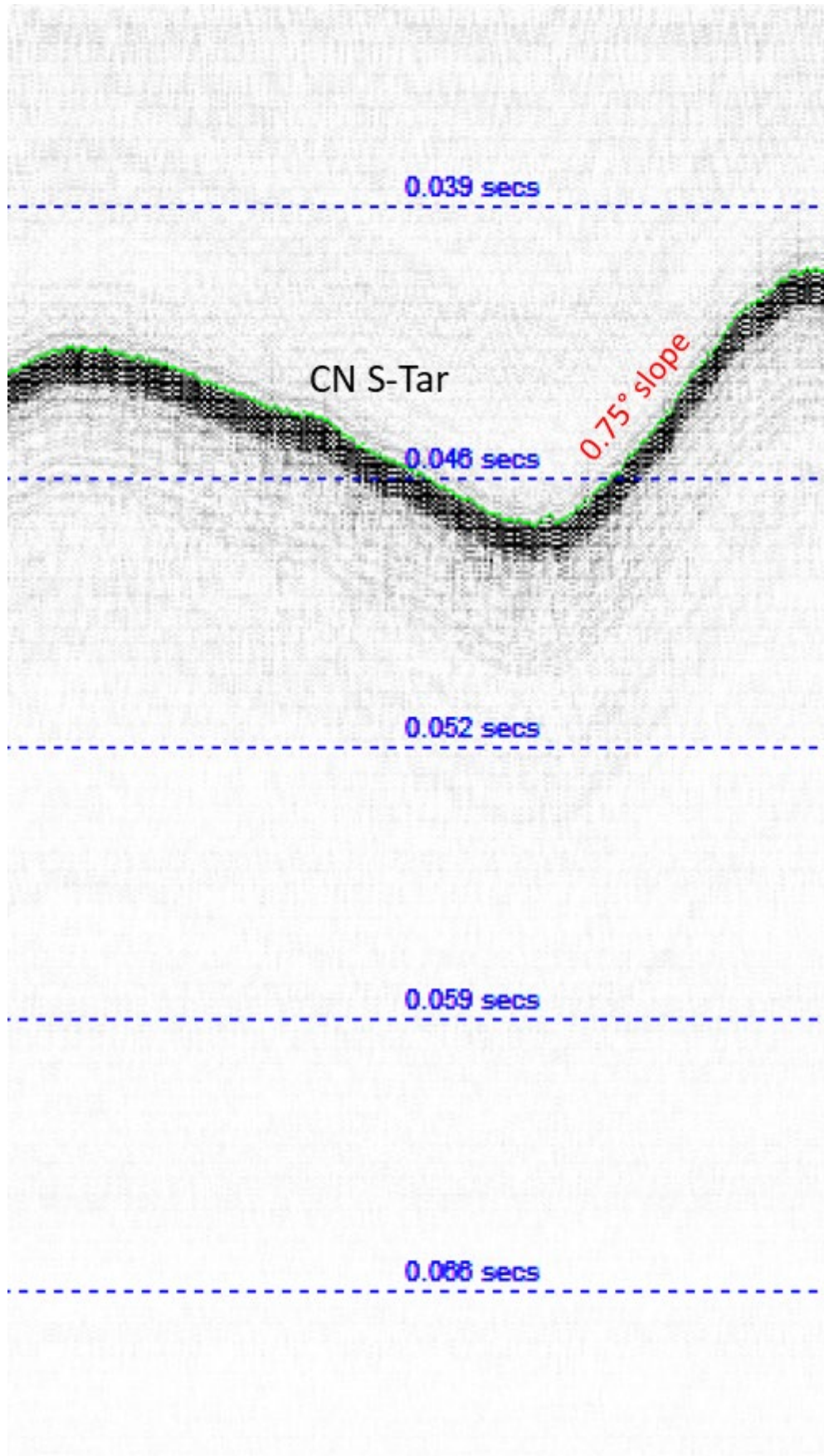


Figure 25: Central Site South Anchor Target (S-Tar) Subbottom

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.

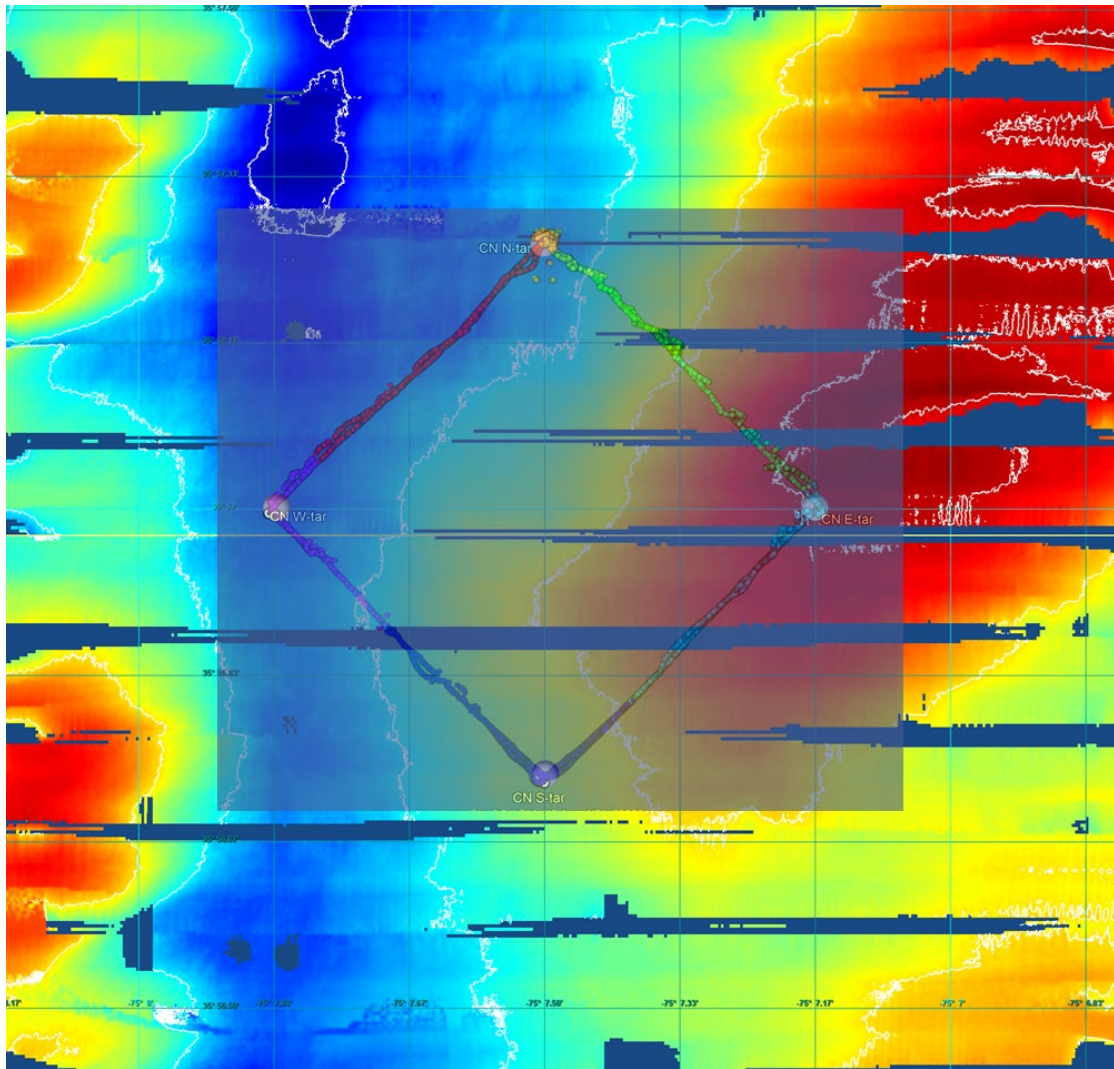


Figure 26: ROV Track at Central Site

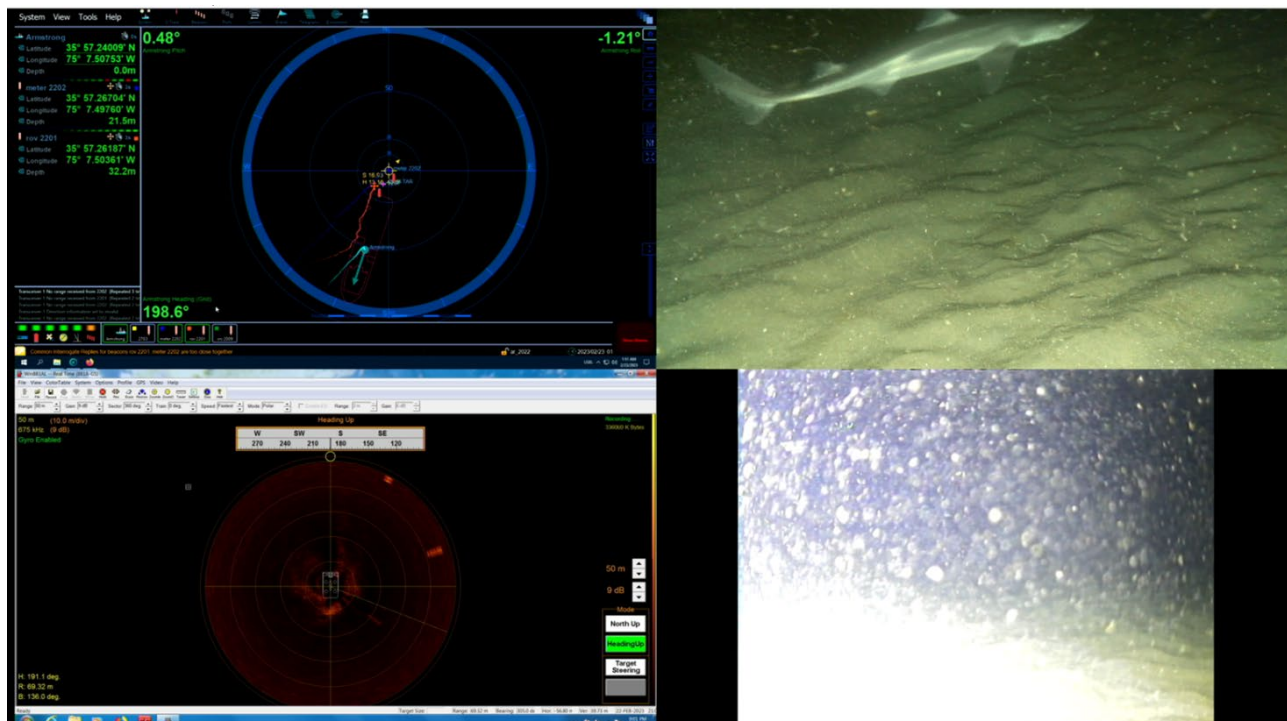


Figure 27: ROV Imagery at Central Site, North Anchor Target

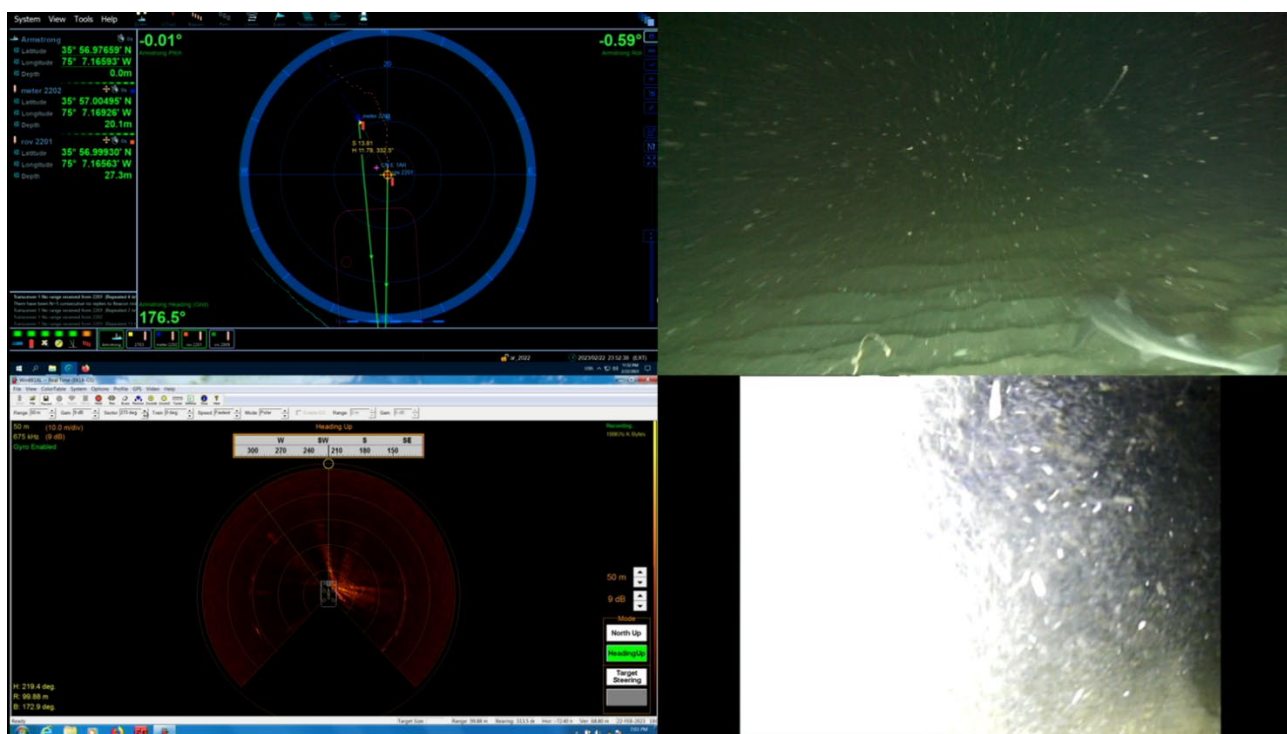


Figure 28: ROV Imagery at Central Site, East Anchor Target

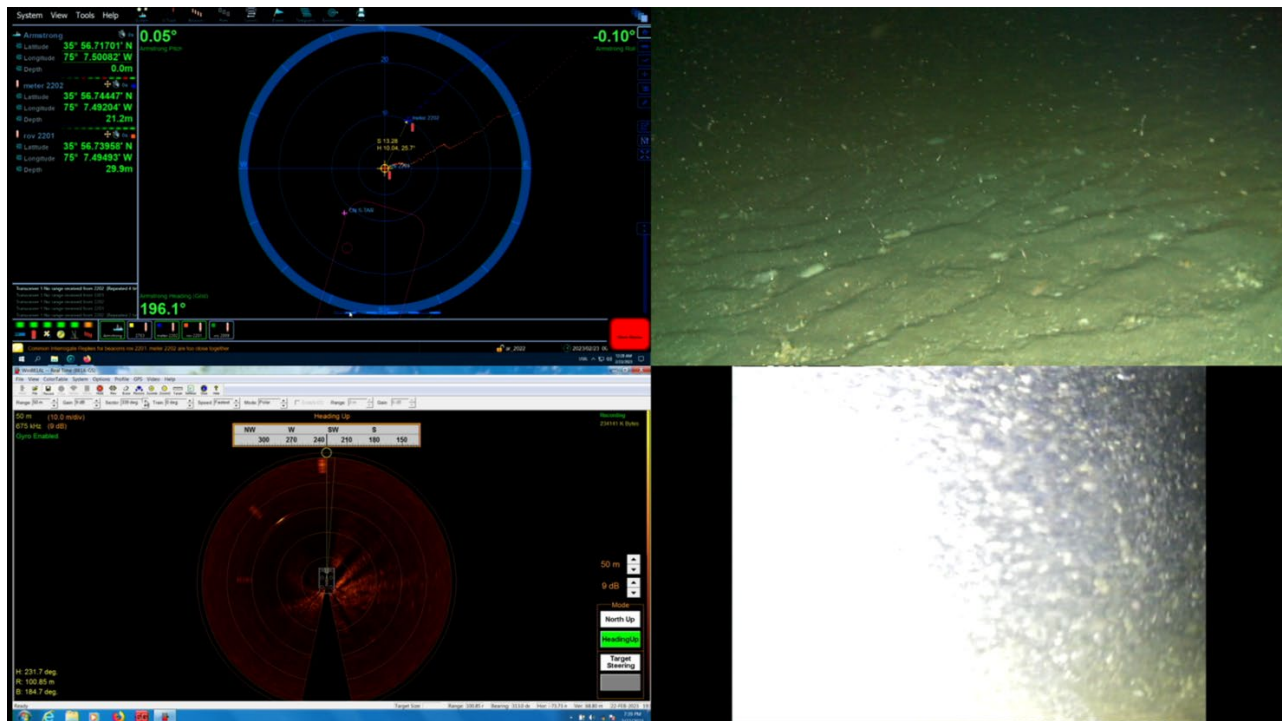


Figure 29: ROV Imagery at Central Site, South Anchor Target

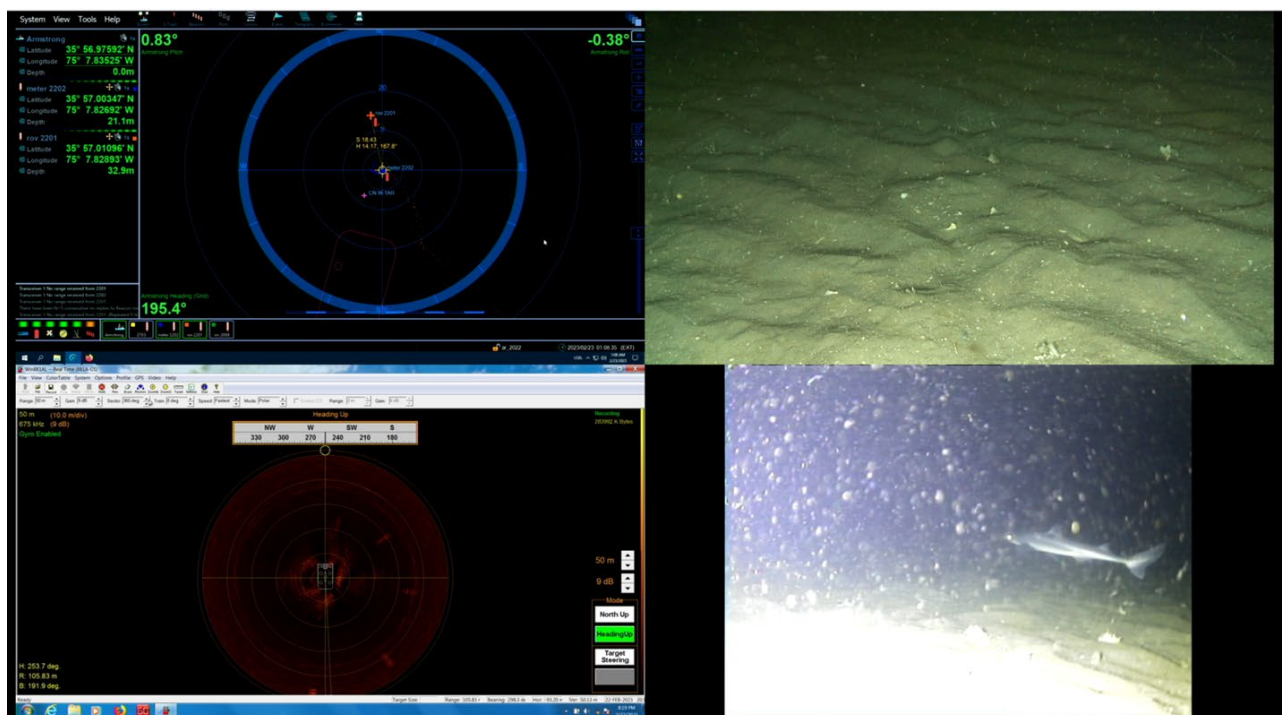


Figure 30: ROV Imagery at Central Site, West Anchor Target

8.3. East

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.

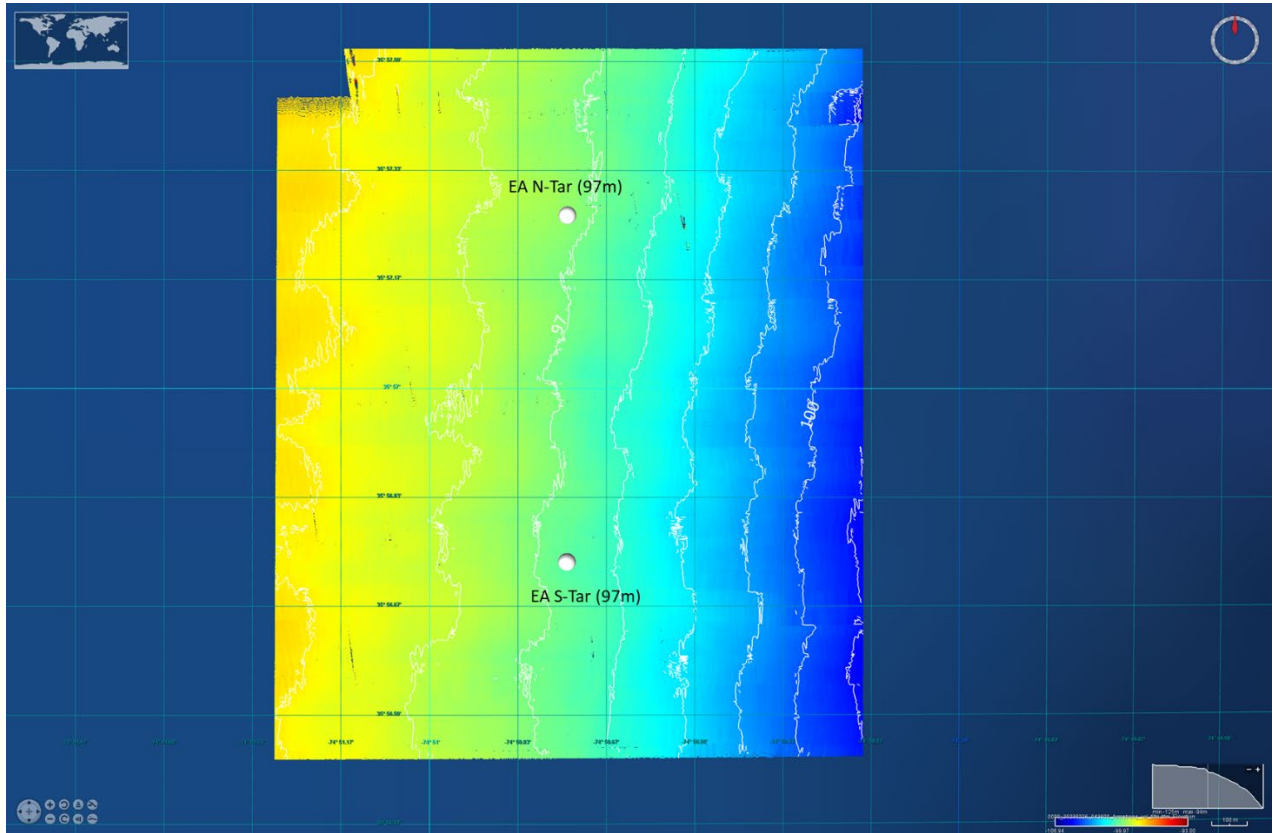


Figure 31: East Site Digital Terrain Model (1m contours)

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).

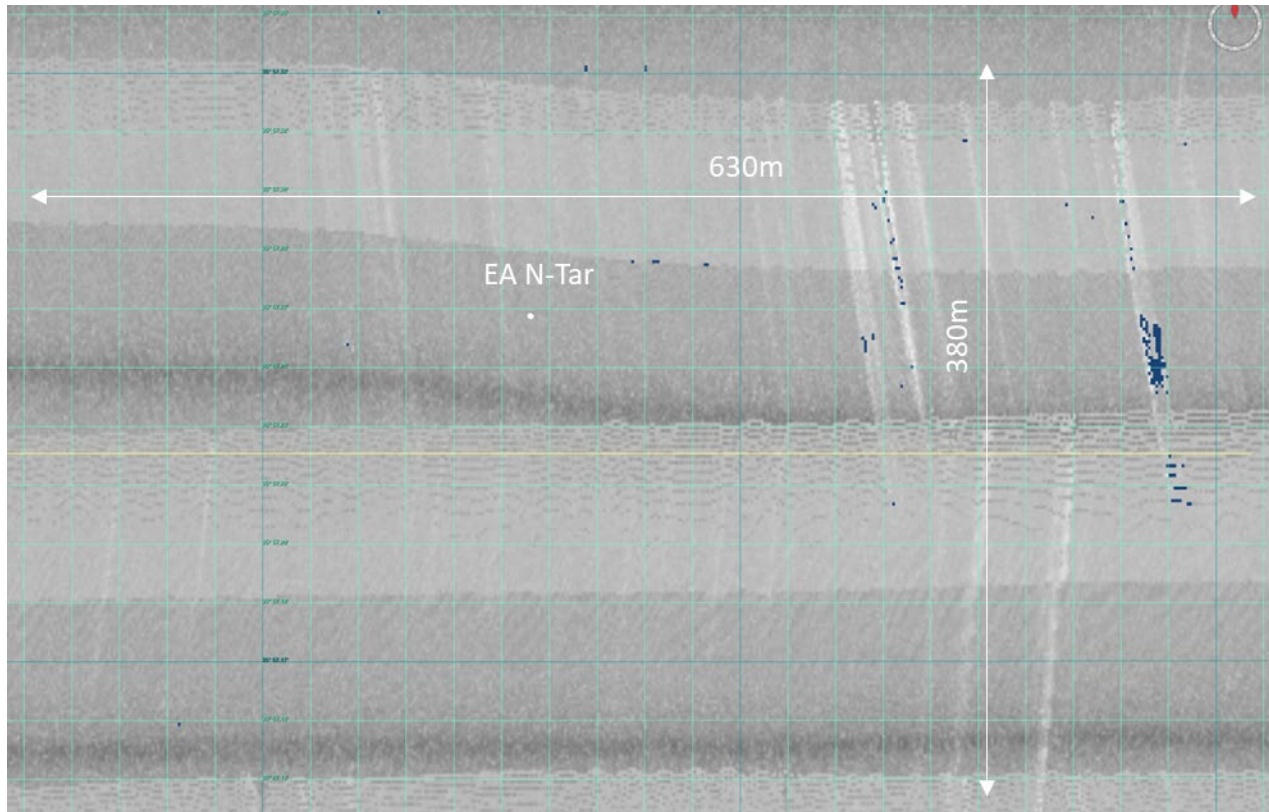


Figure 32: East Site North Anchor Target (N-Tar) Backscatter

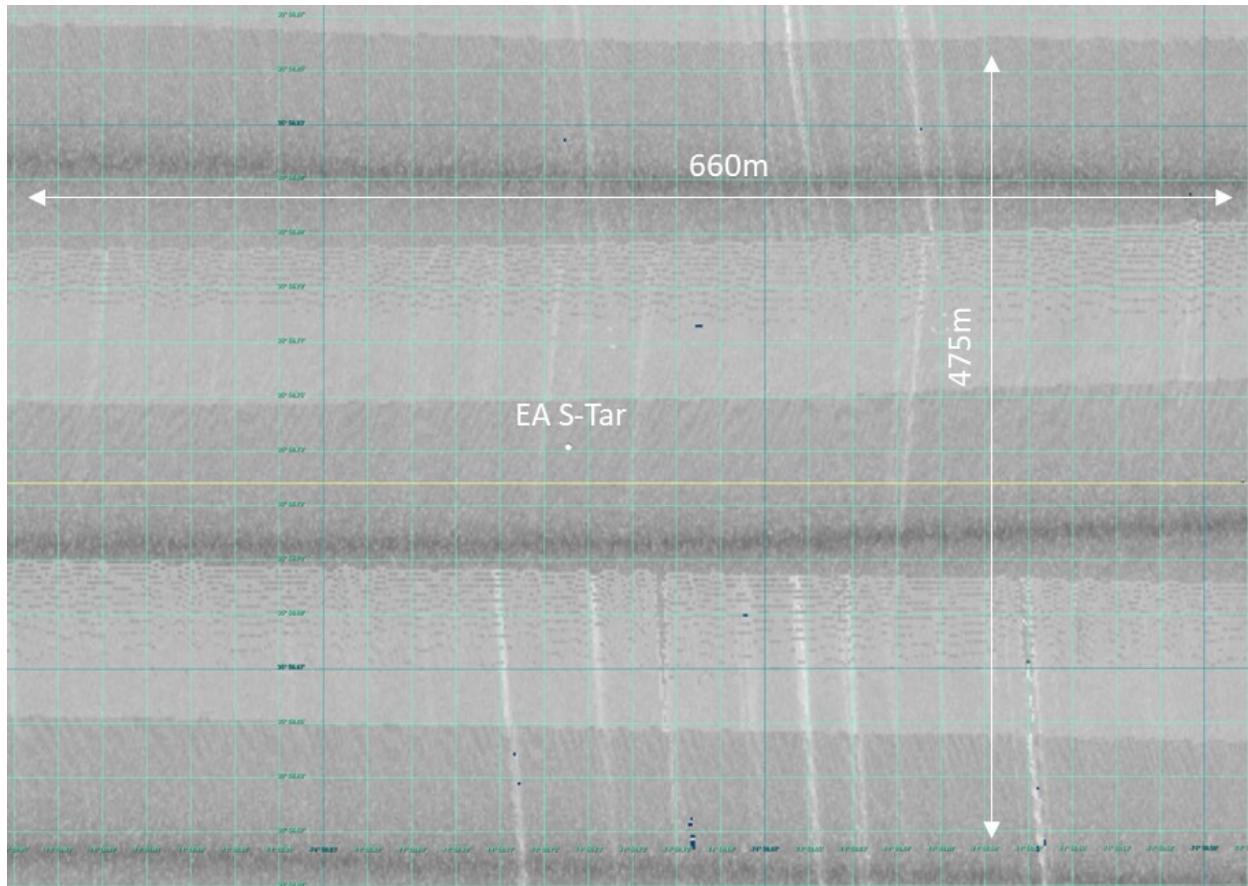


Figure 33: East Site South Anchor Target (S-Tar) Backscatter

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° .

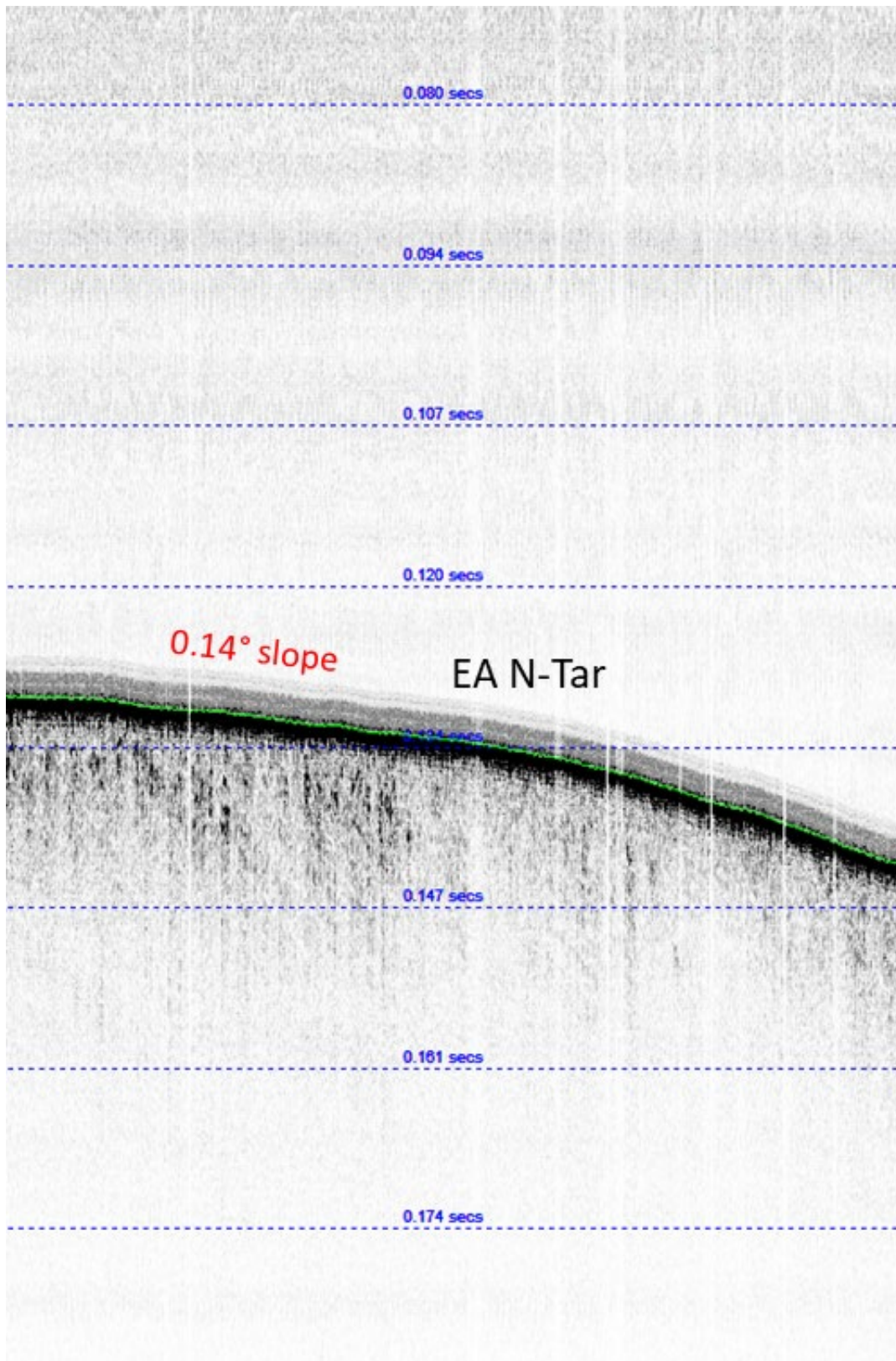


Figure 34: East Site North Anchor Target (N-Tar) Subbottom

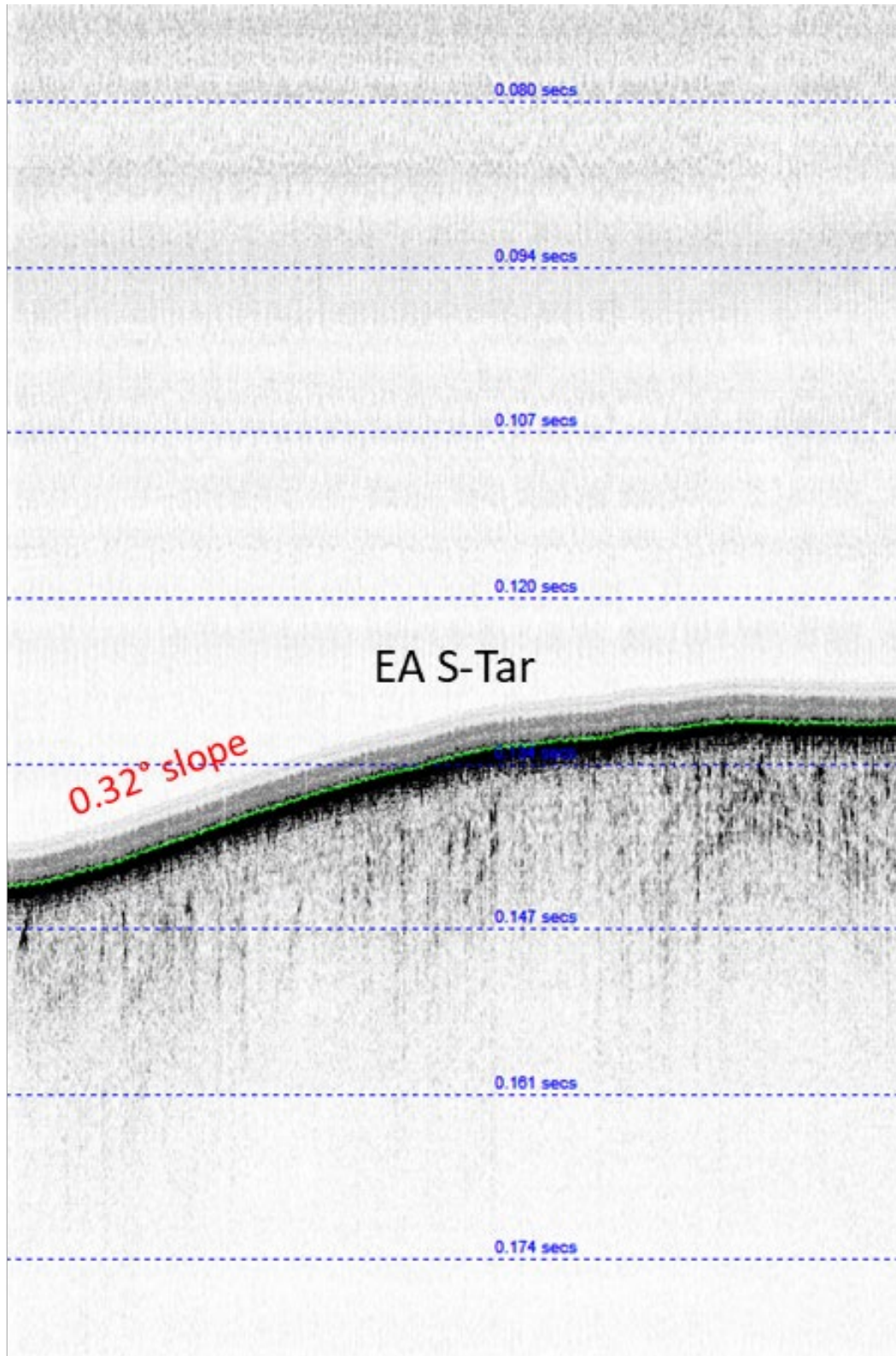


Figure 35: West Site South Anchor Target (S-Tar) Subbottom

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.

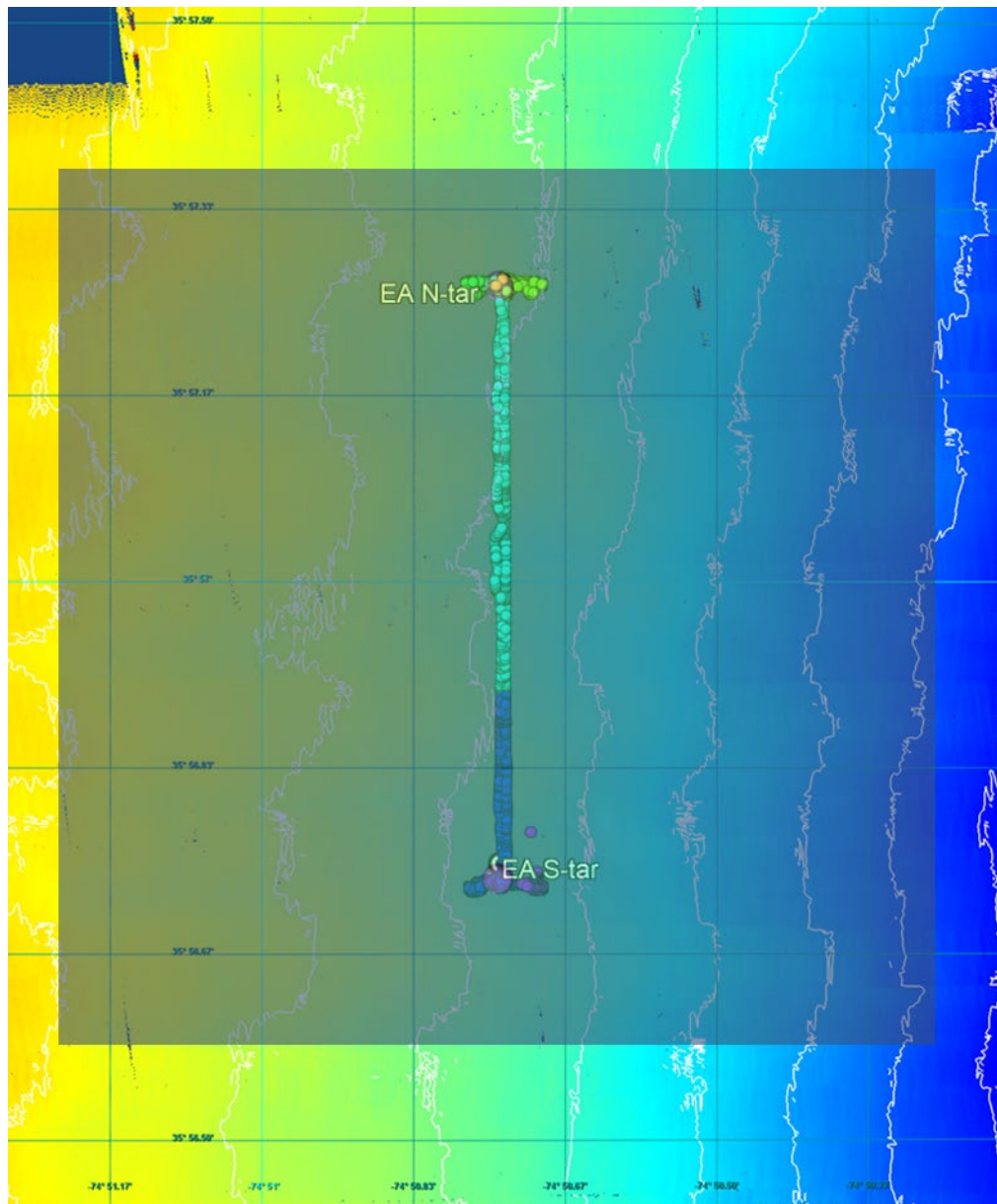


Figure 36: ROV Track at East Site

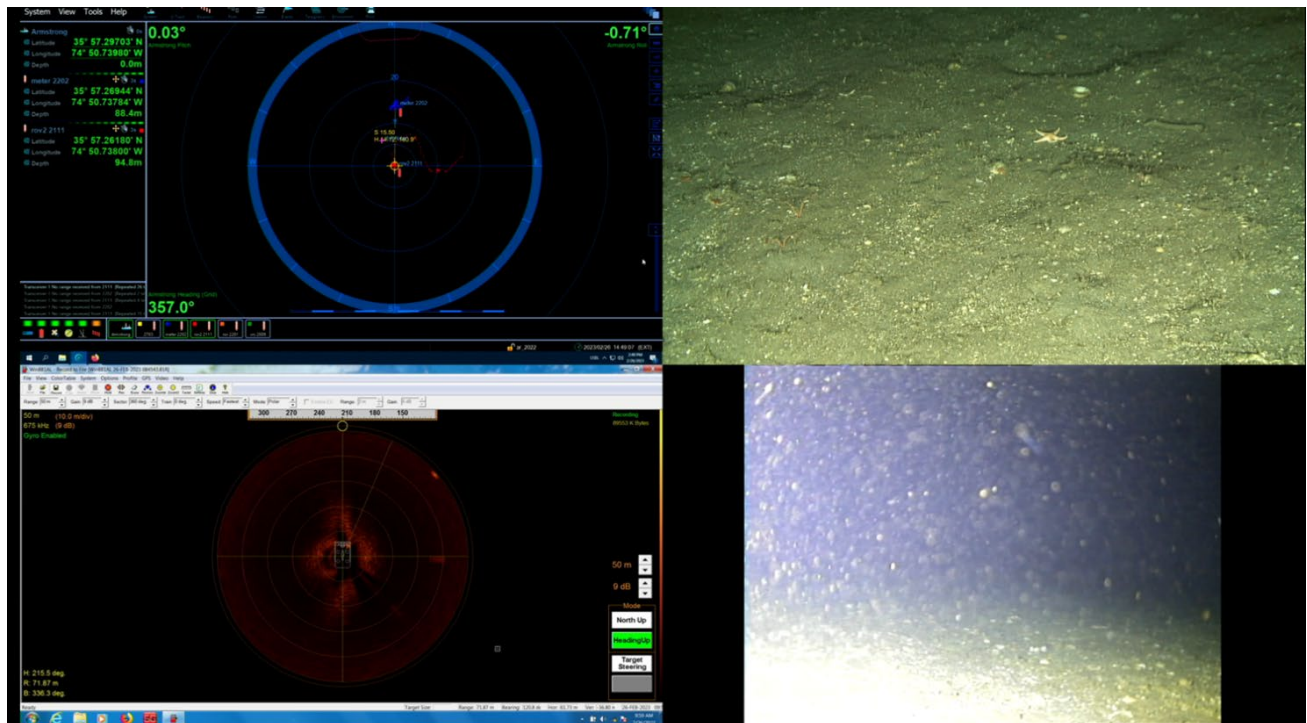


Figure 37: ROV Imagery at East Site, North Anchor Target

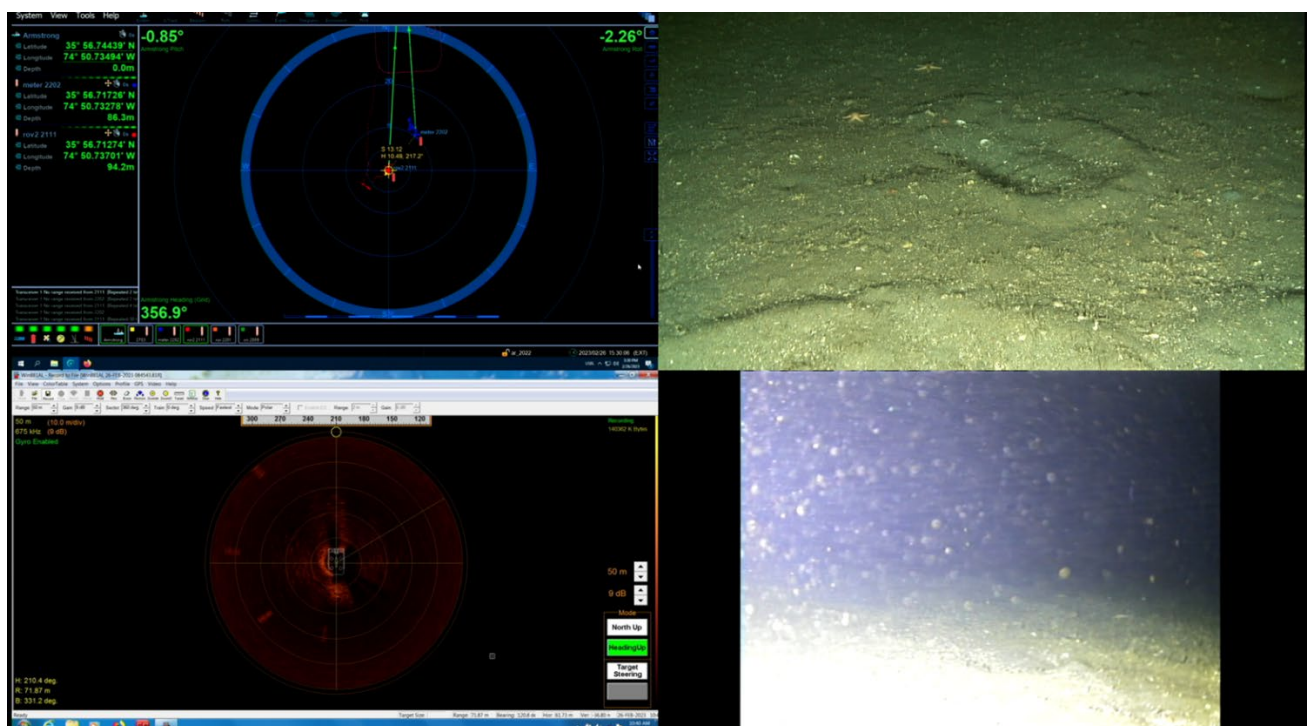


Figure 38: ROV Imagery at West Site, South Anchor Target

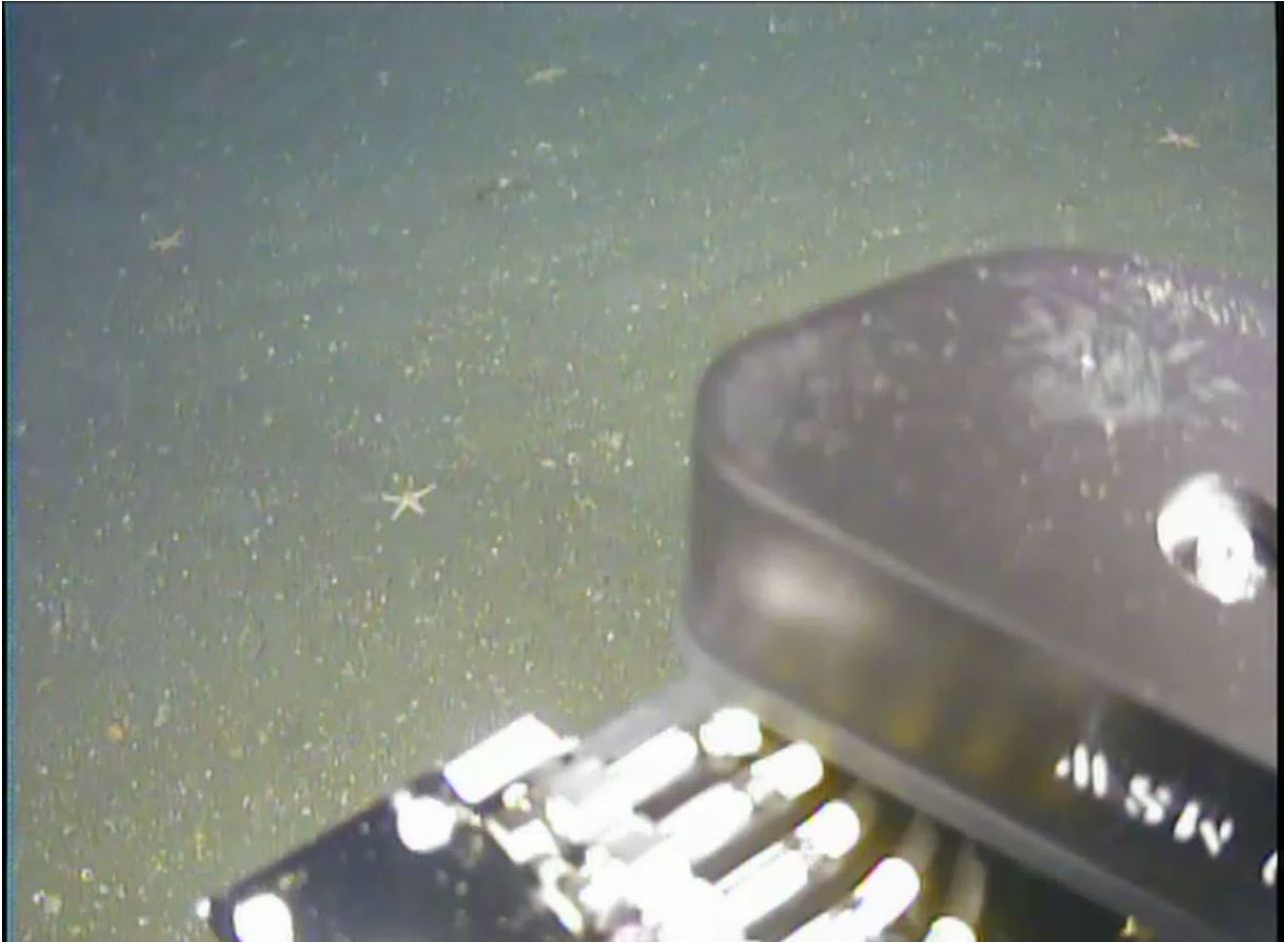


Figure 39: Sandy, Gravelly, Shelly Seabed East Site, South Anchor Target

8.4. North

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.

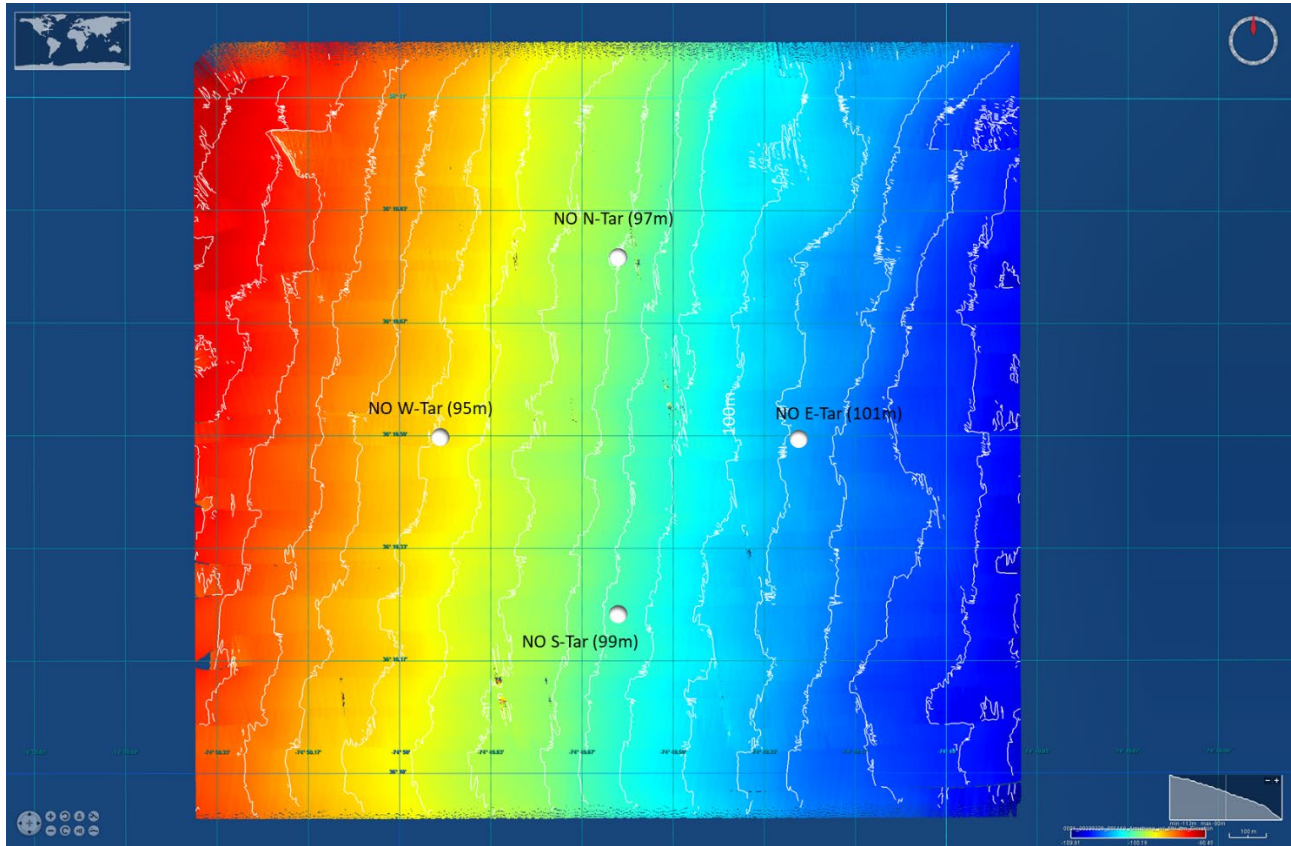


Figure 40: West Site Digital Terrain Model (1m contours)

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).

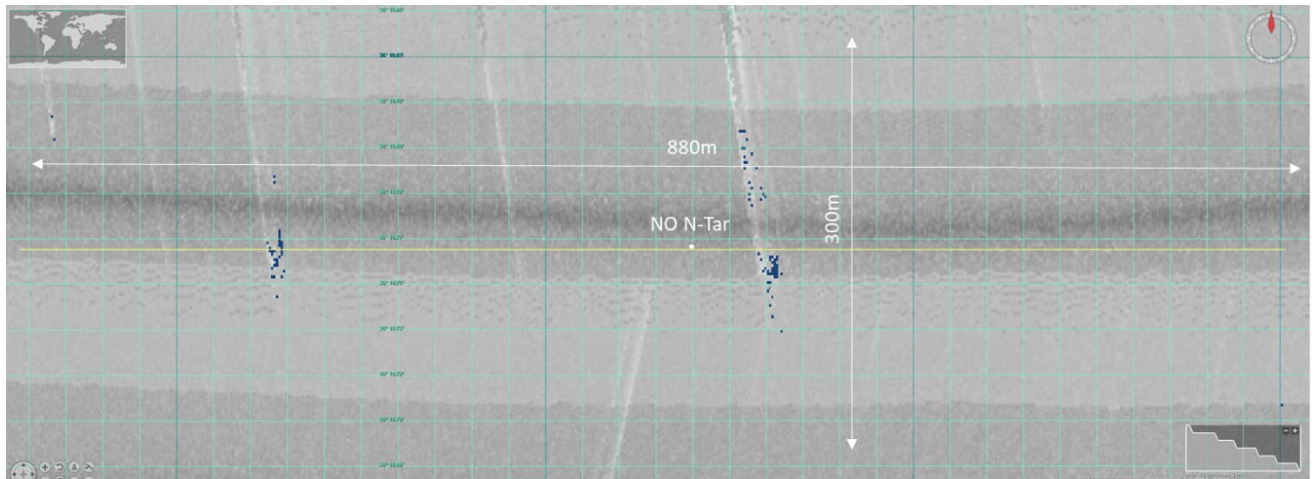


Figure 41: North Site North Anchor Target (N-Tar) Backscatter

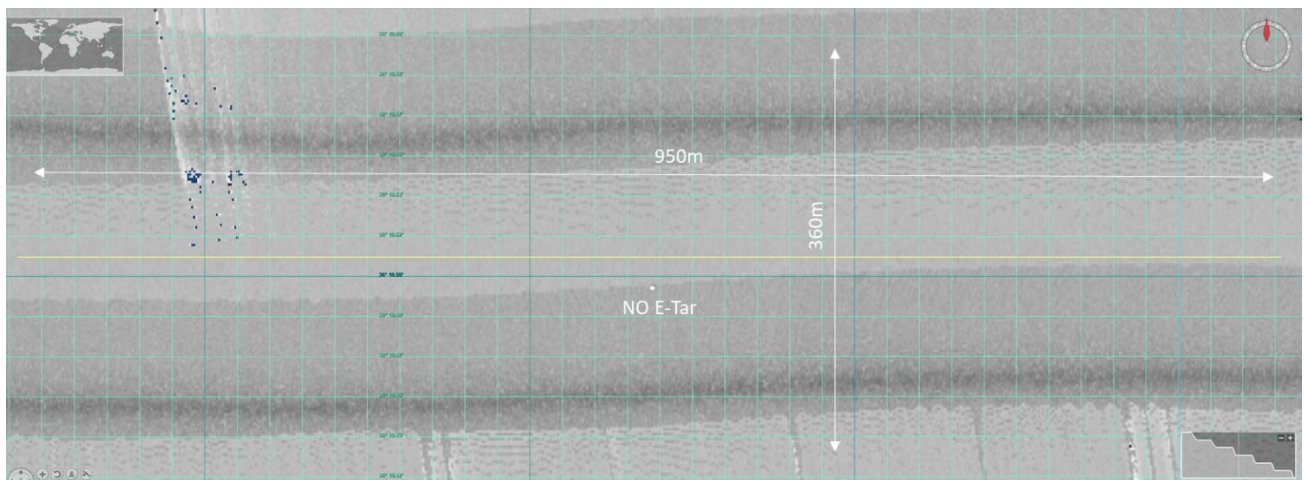


Figure 42: North Site East Anchor Target (E-Tar) Backscatter

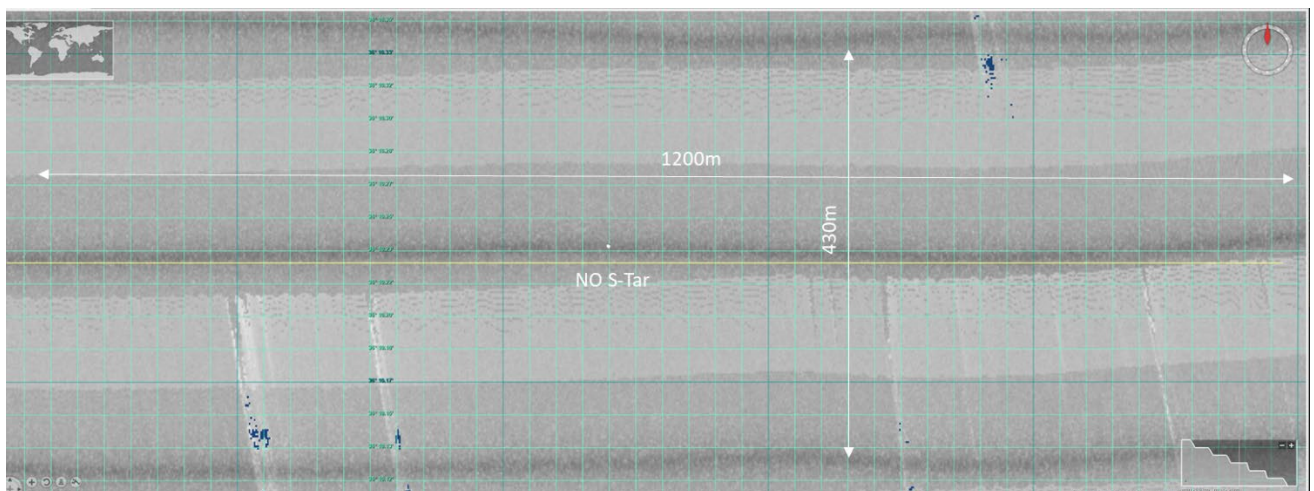


Figure 43: North Site South Anchor Target (S-Tar) Backscatter

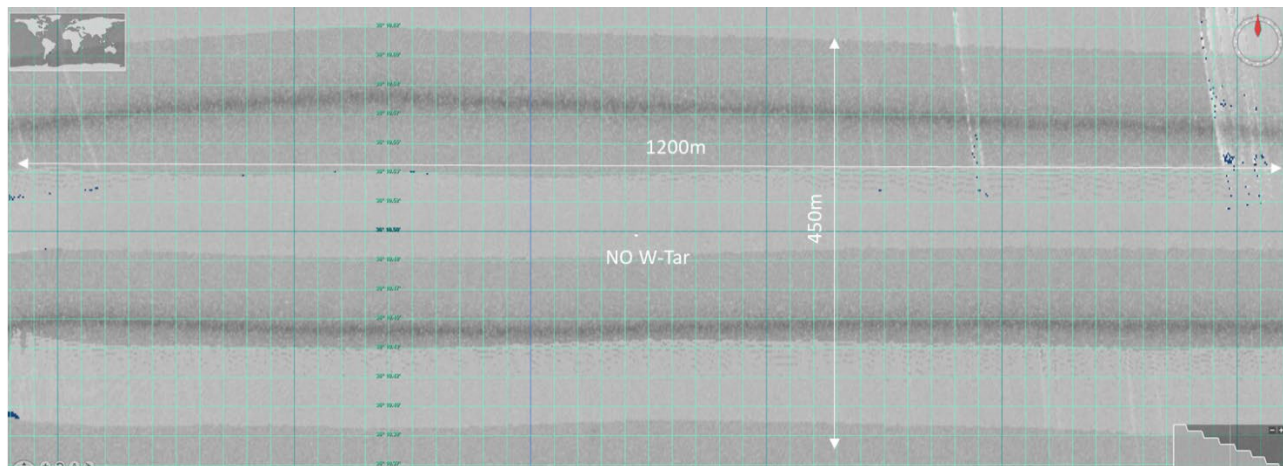


Figure 44: North Site West Anchor Target (W-Tar) Backscatter

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 $\sim 0.5^\circ$.

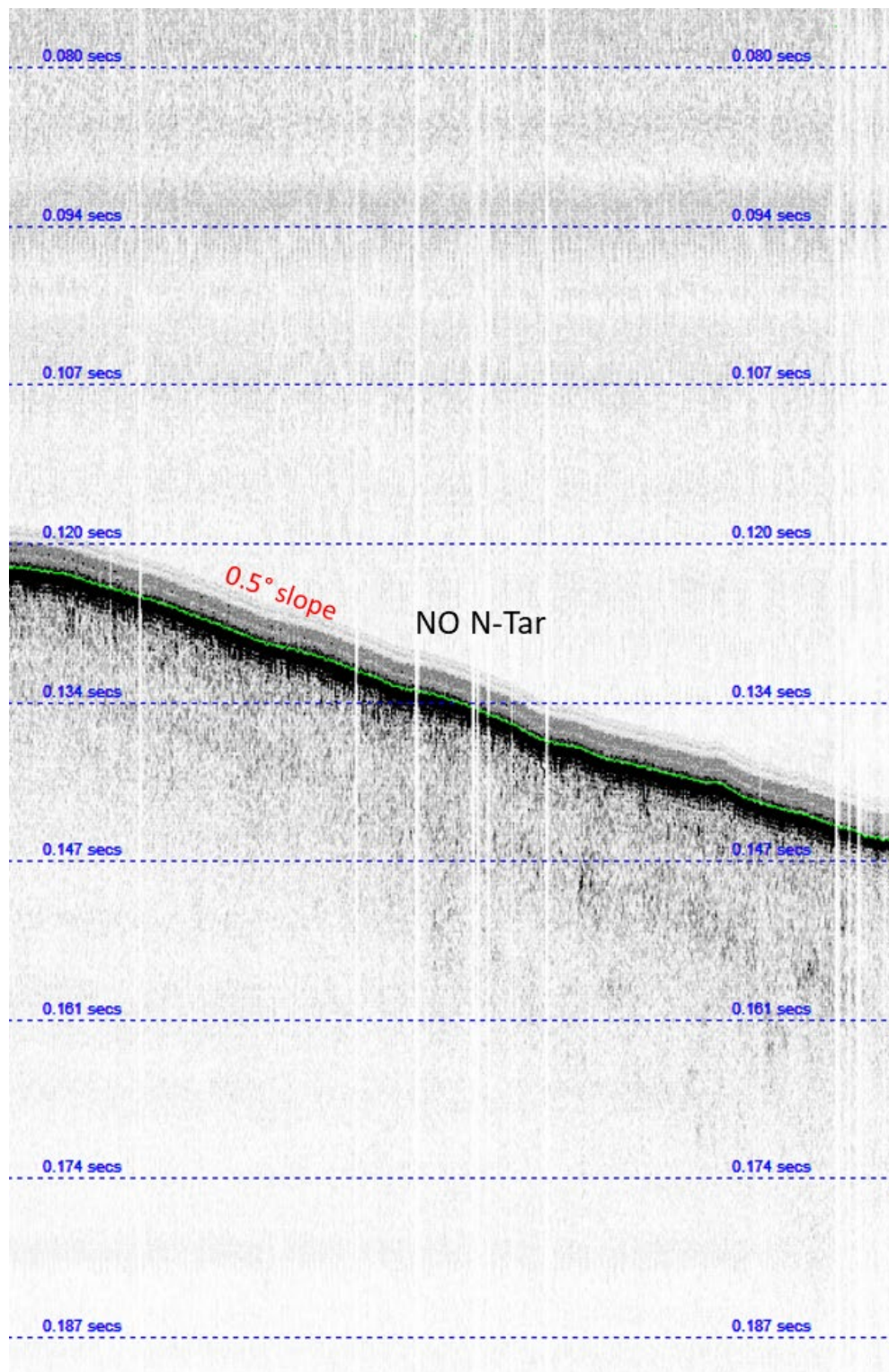


Figure 45: North Site North Anchor Target (N-Tar) Subbottom

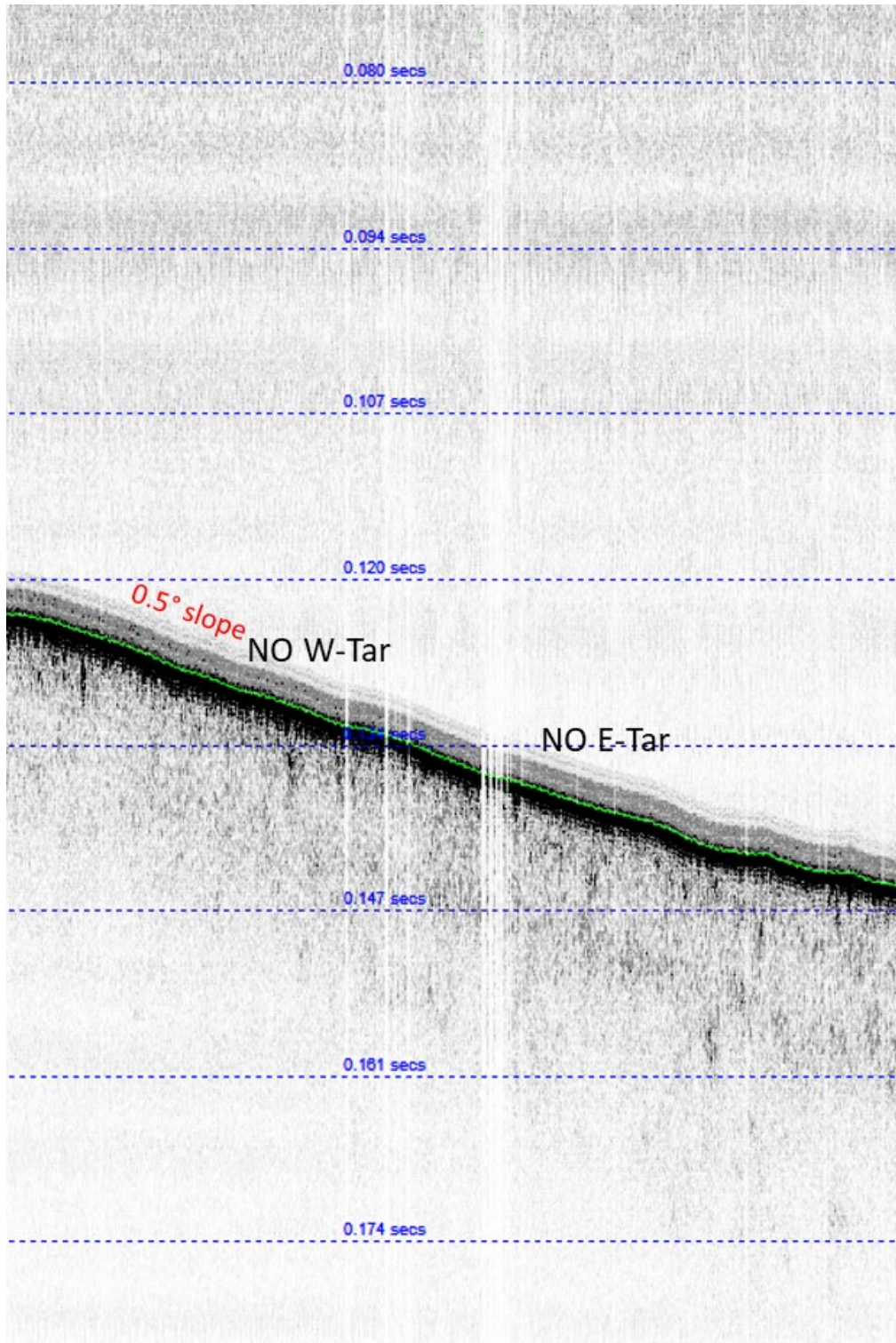


Figure 46: North Site East & West Anchor Targets (E-Tar, W-Tar) Subbottom

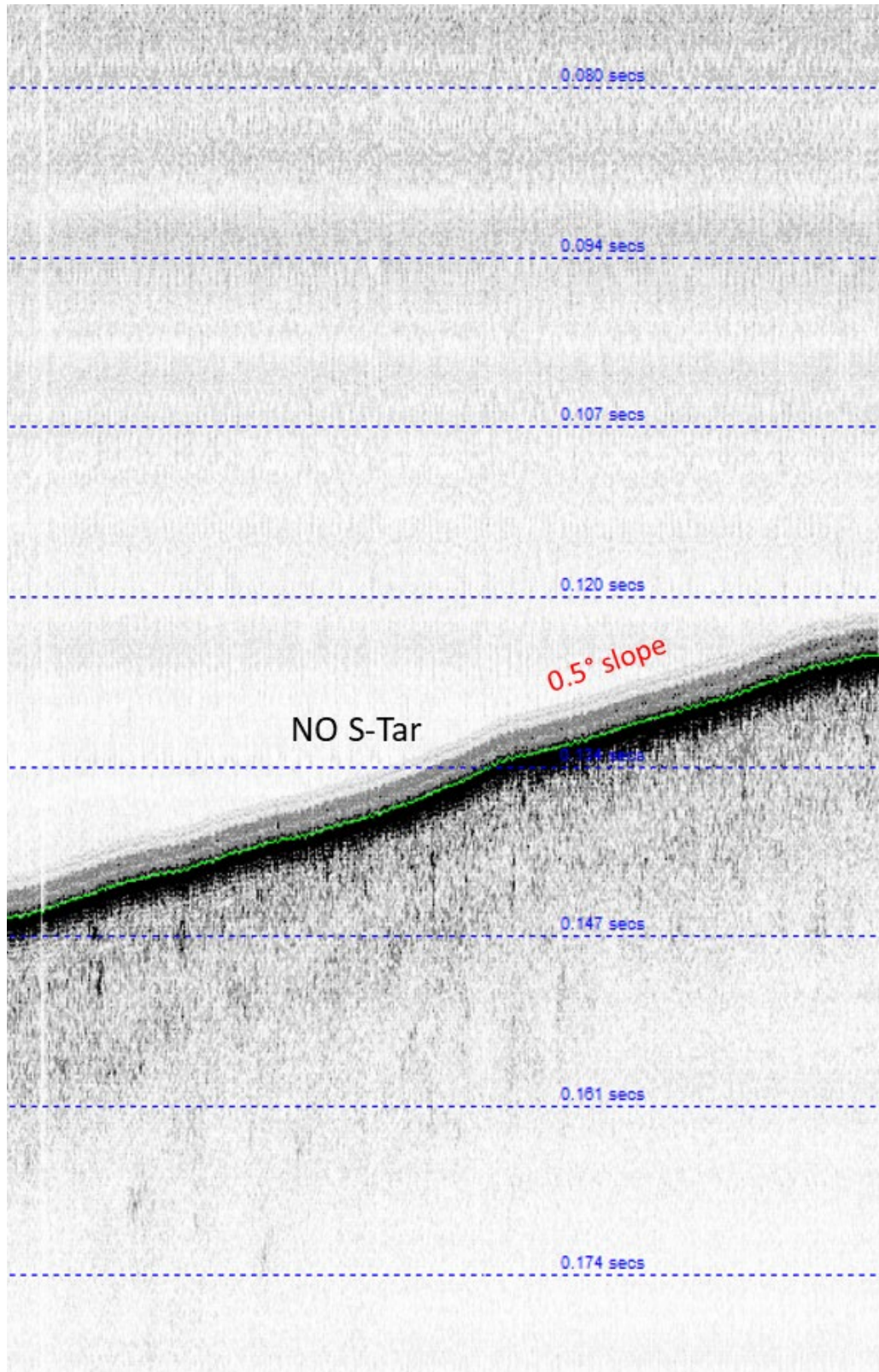


Figure 47: North Site South Anchor Targets (S-Tar) Subbottom

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.

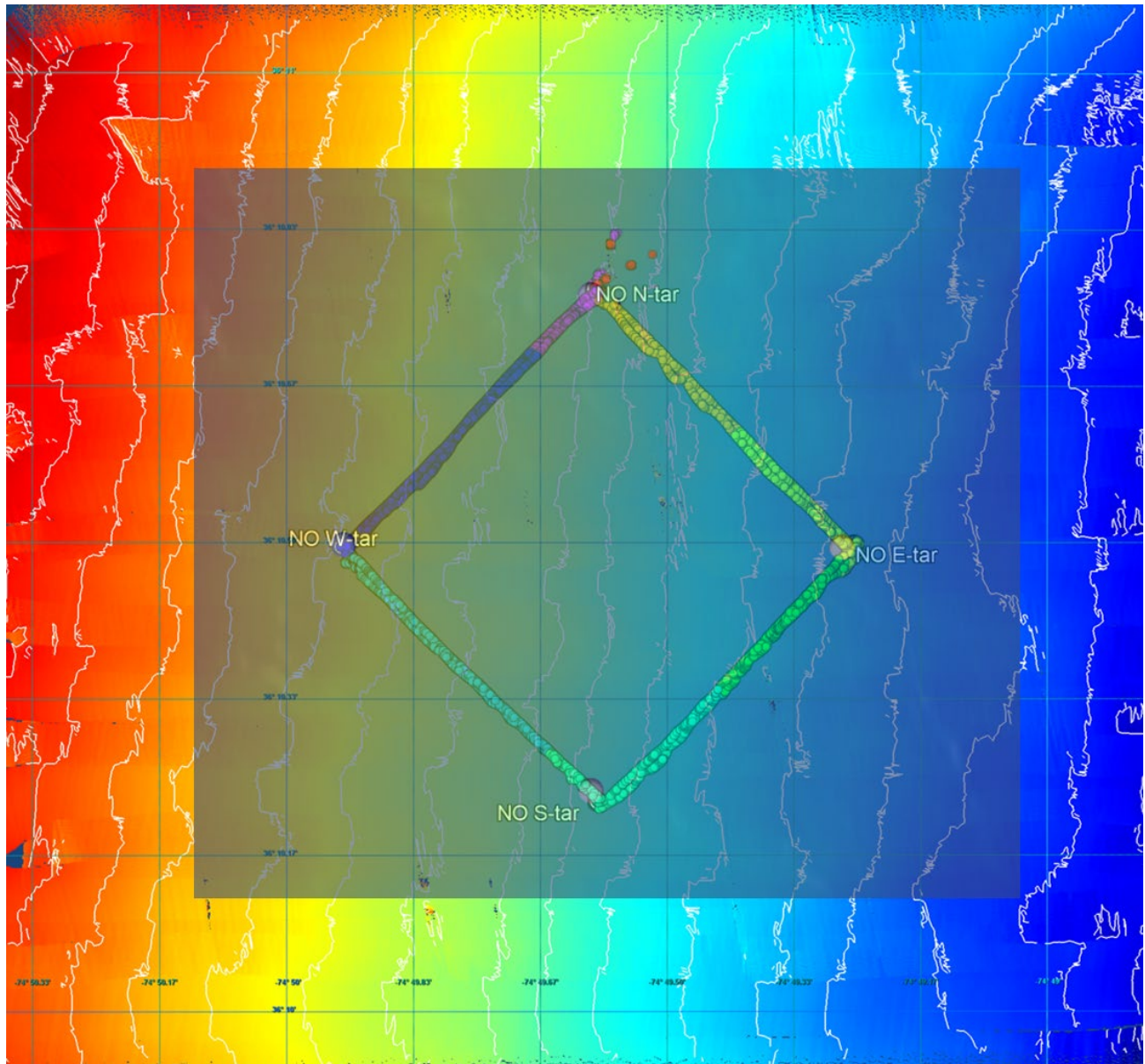


Figure 48: ROV Track at North Site

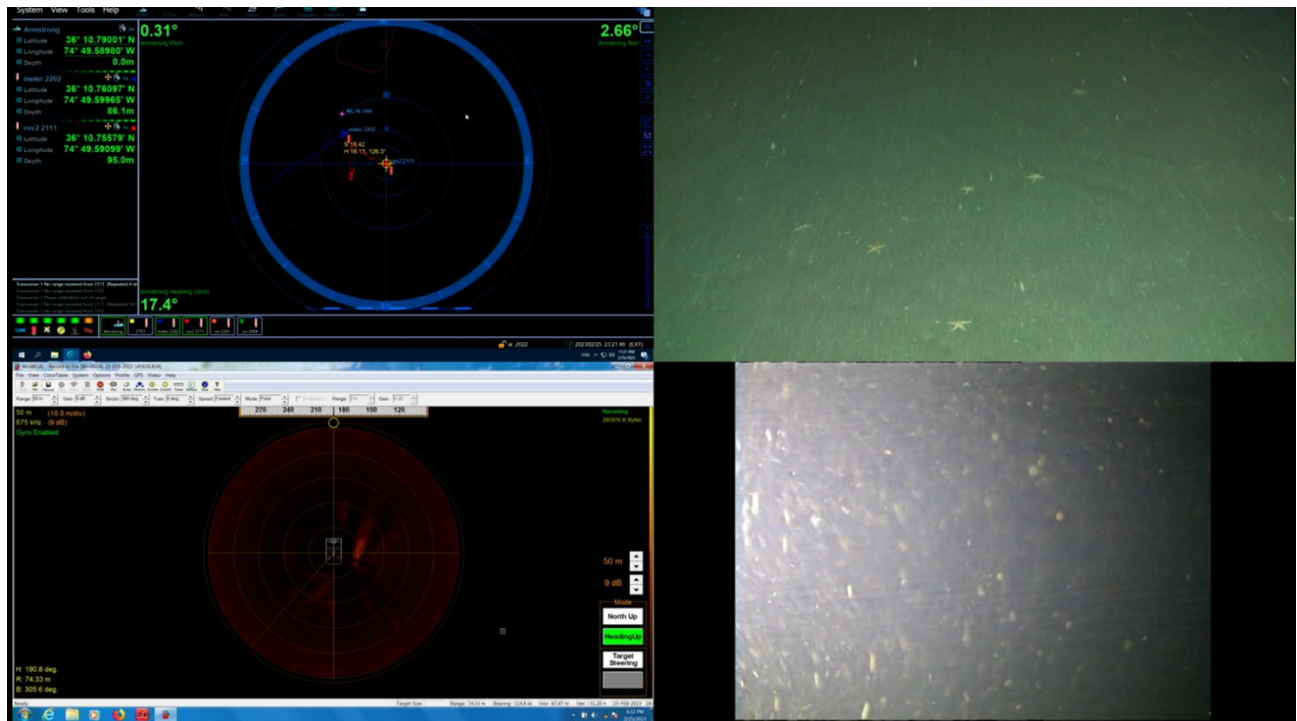
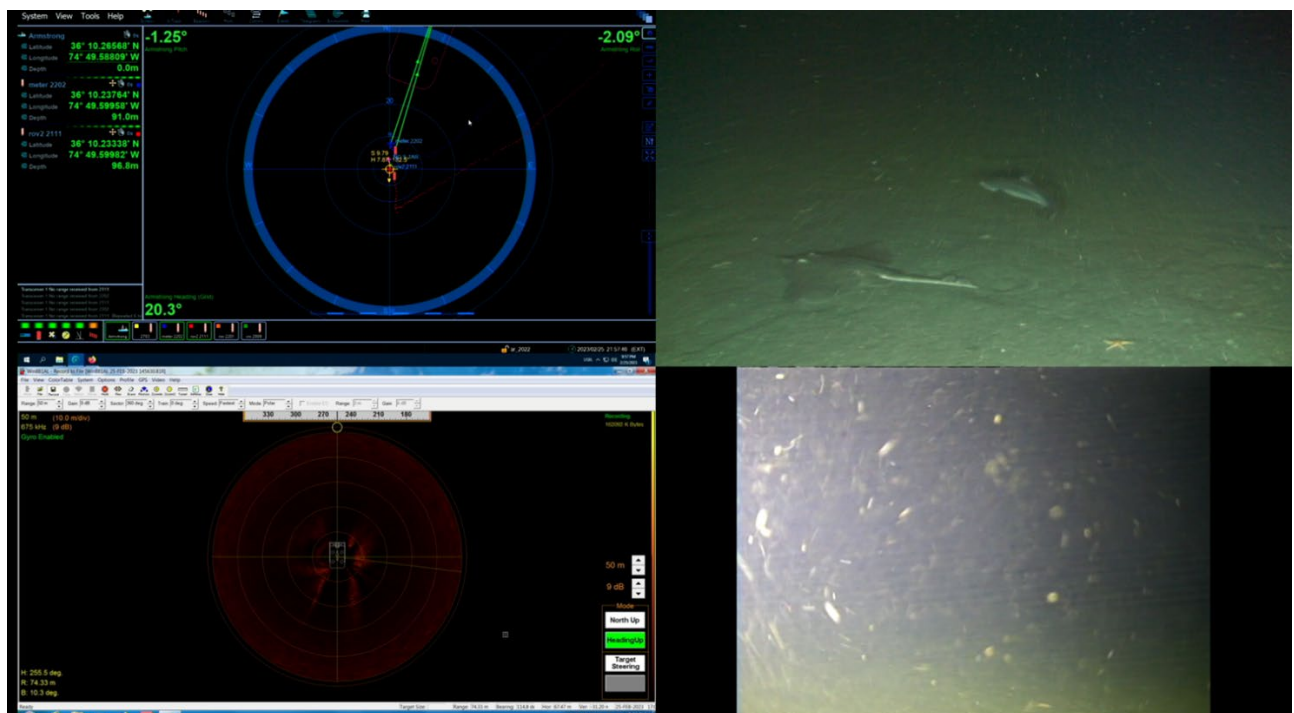
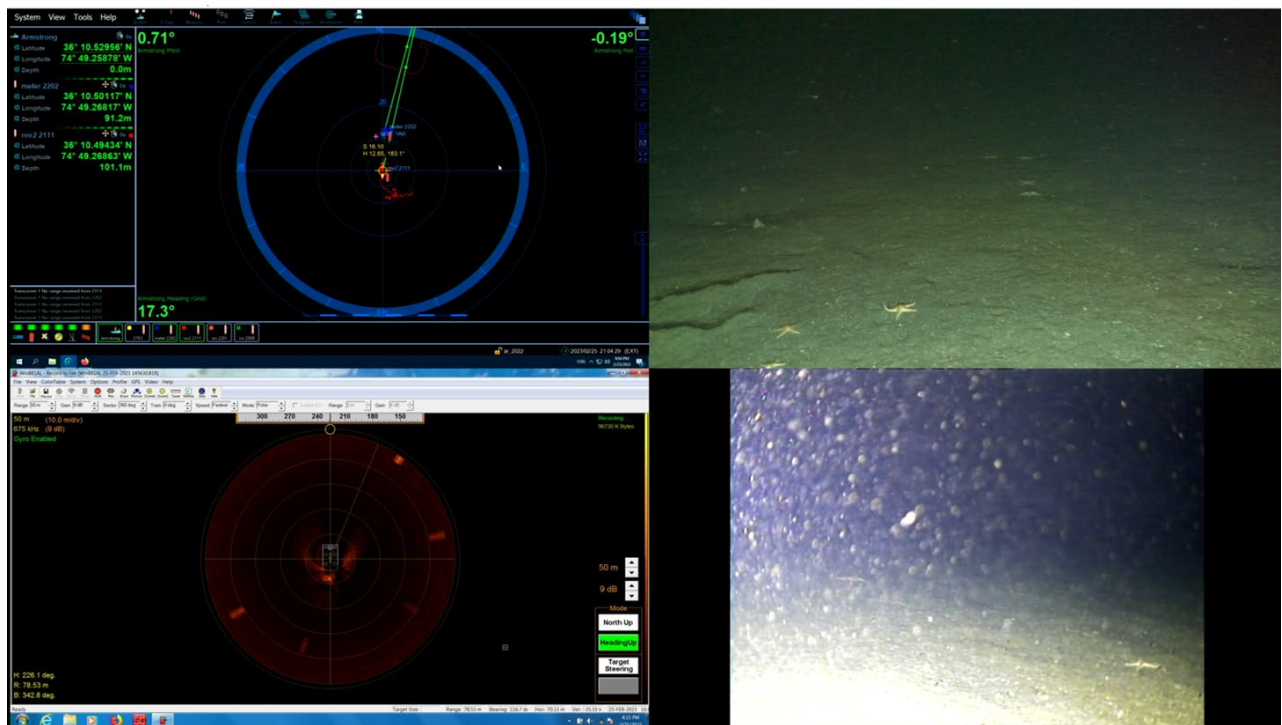


Figure 49: ROV Imagery at North Site, North Anchor Target



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



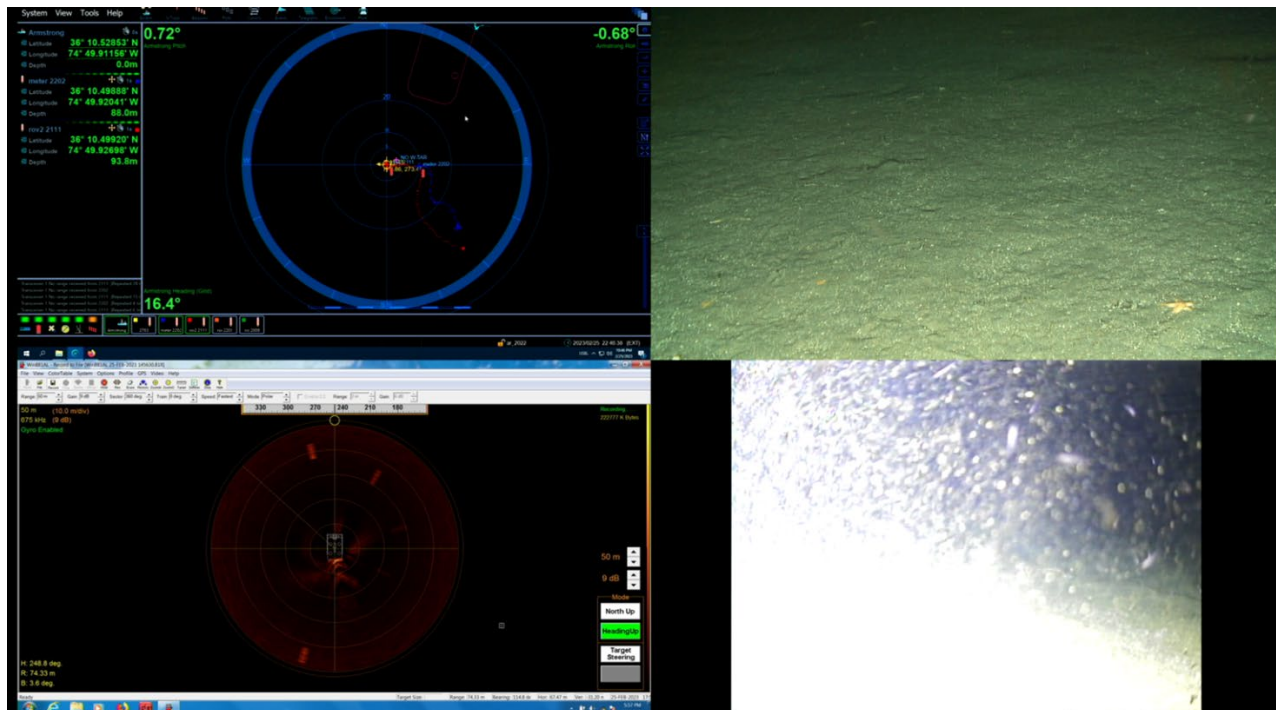


Figure 53: ROV Imagery at North Site, West Anchor Target

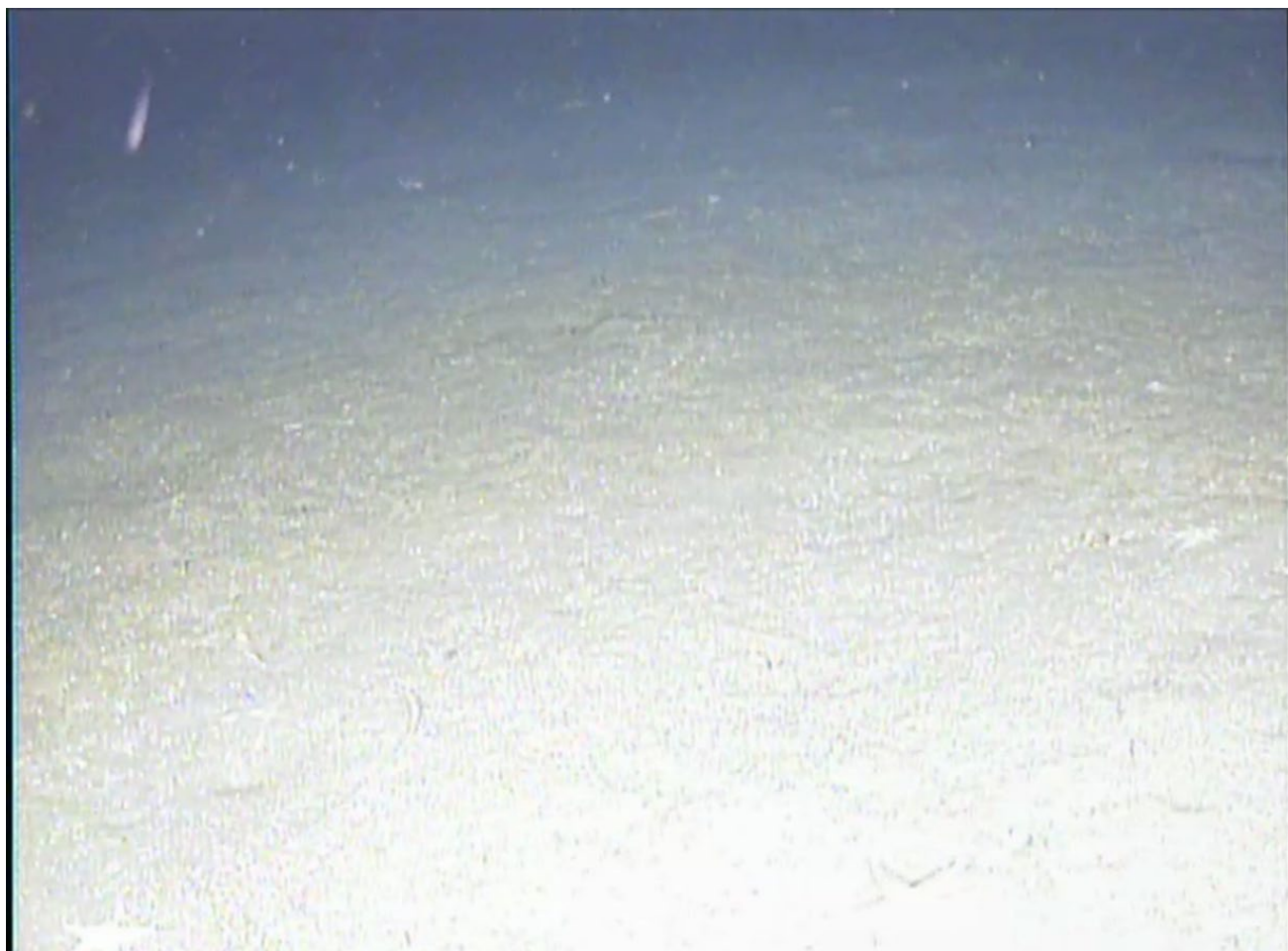


Figure 54: Sandy, Gravelly, Shelly Seabed North Site, West Anchor Target

8.5. South

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.

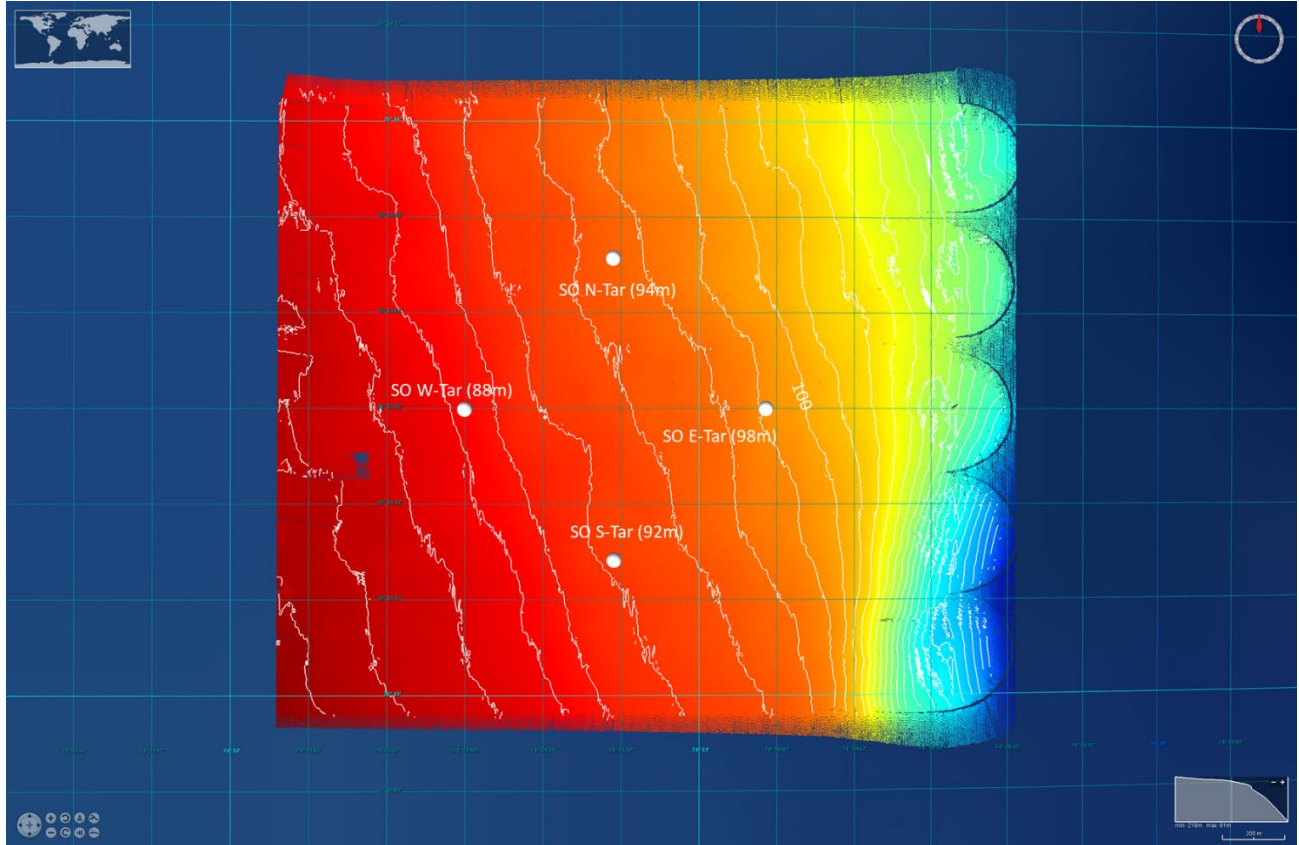


Figure 55: South Site Digital Terrain Model (2m contours)

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).

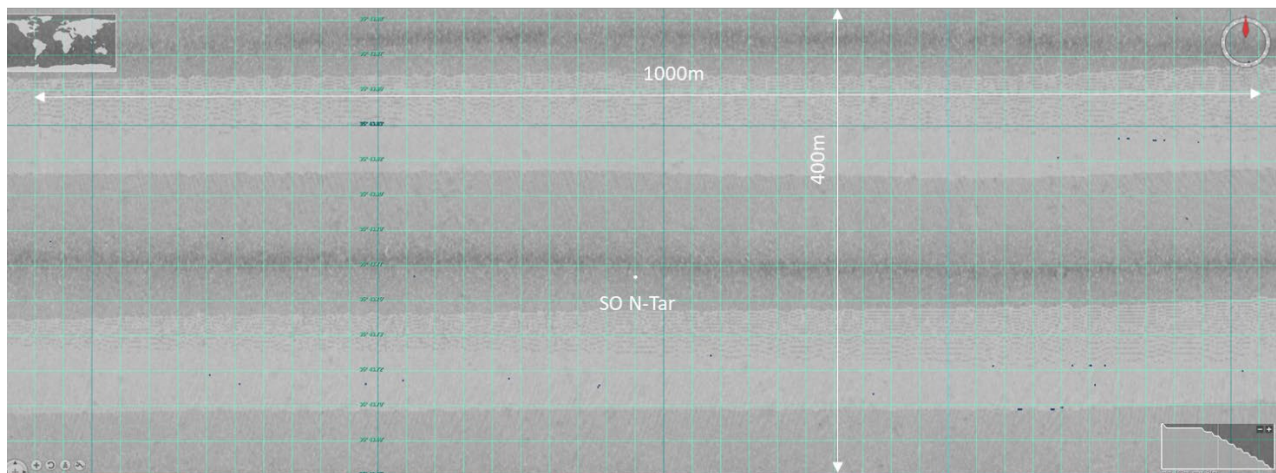


Figure 56: South Site North Anchor Target (N-Tar) Backscatter

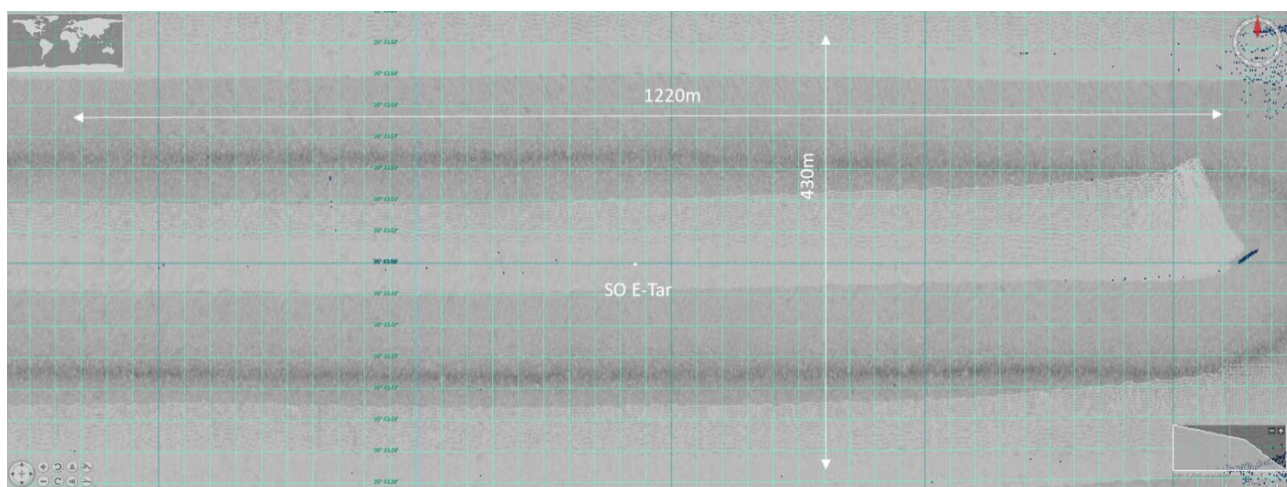


Figure 57: South Site East Anchor Target (E-Tar) Backscatter

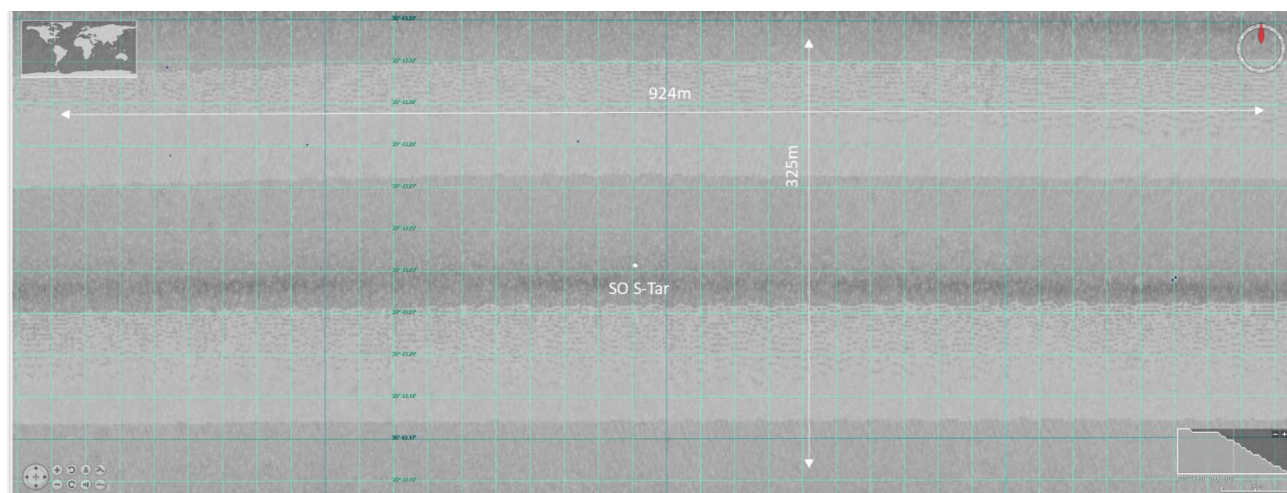


Figure 58: South Site South Anchor Target (S-Tar) Backscatter

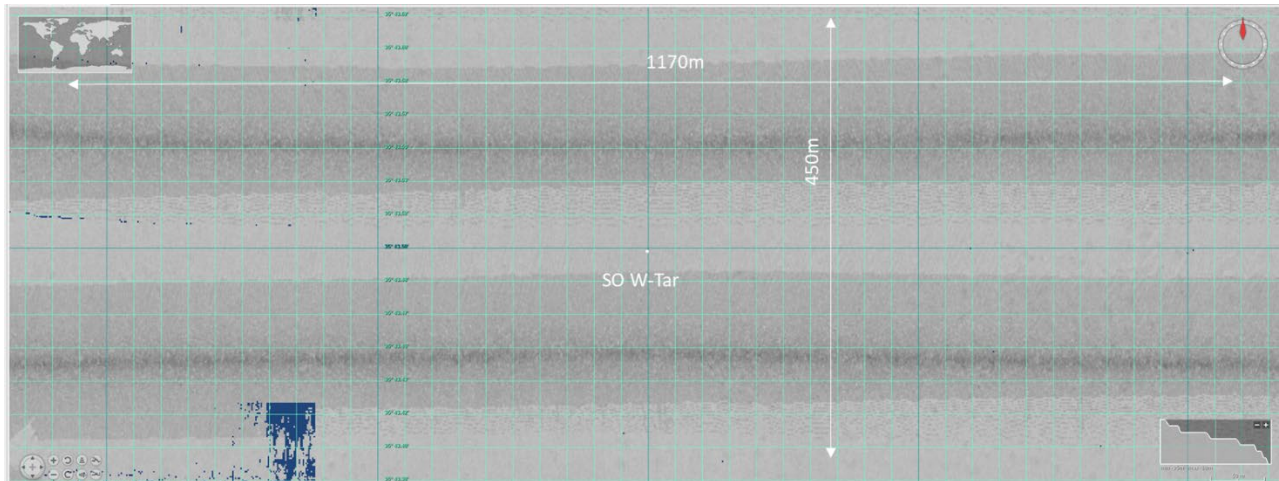


Figure 59: South Site West Anchor Target (W-Tar) Backscatter

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°.

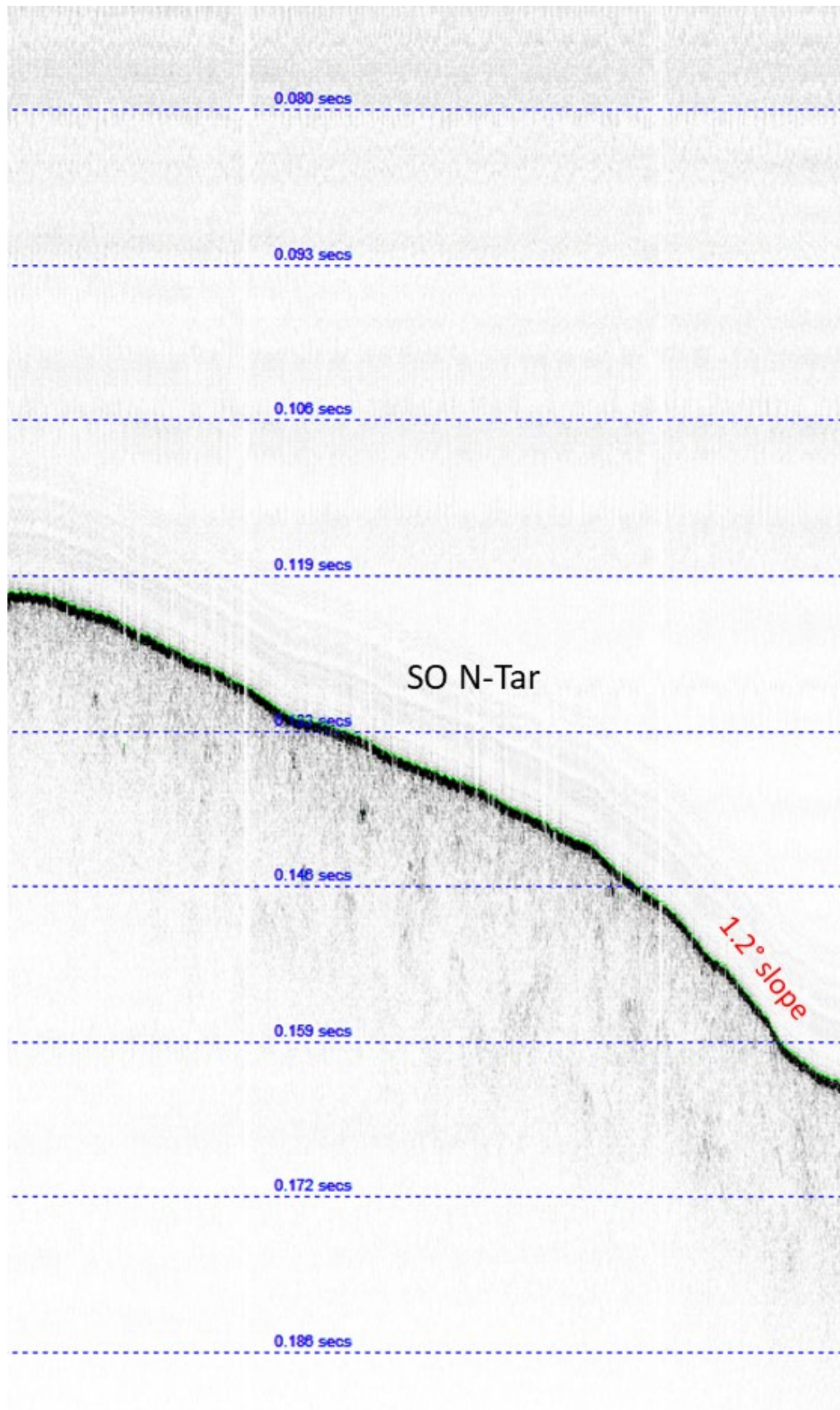


Figure 60: South Site North Anchor Target (N-Tar) Subbottom

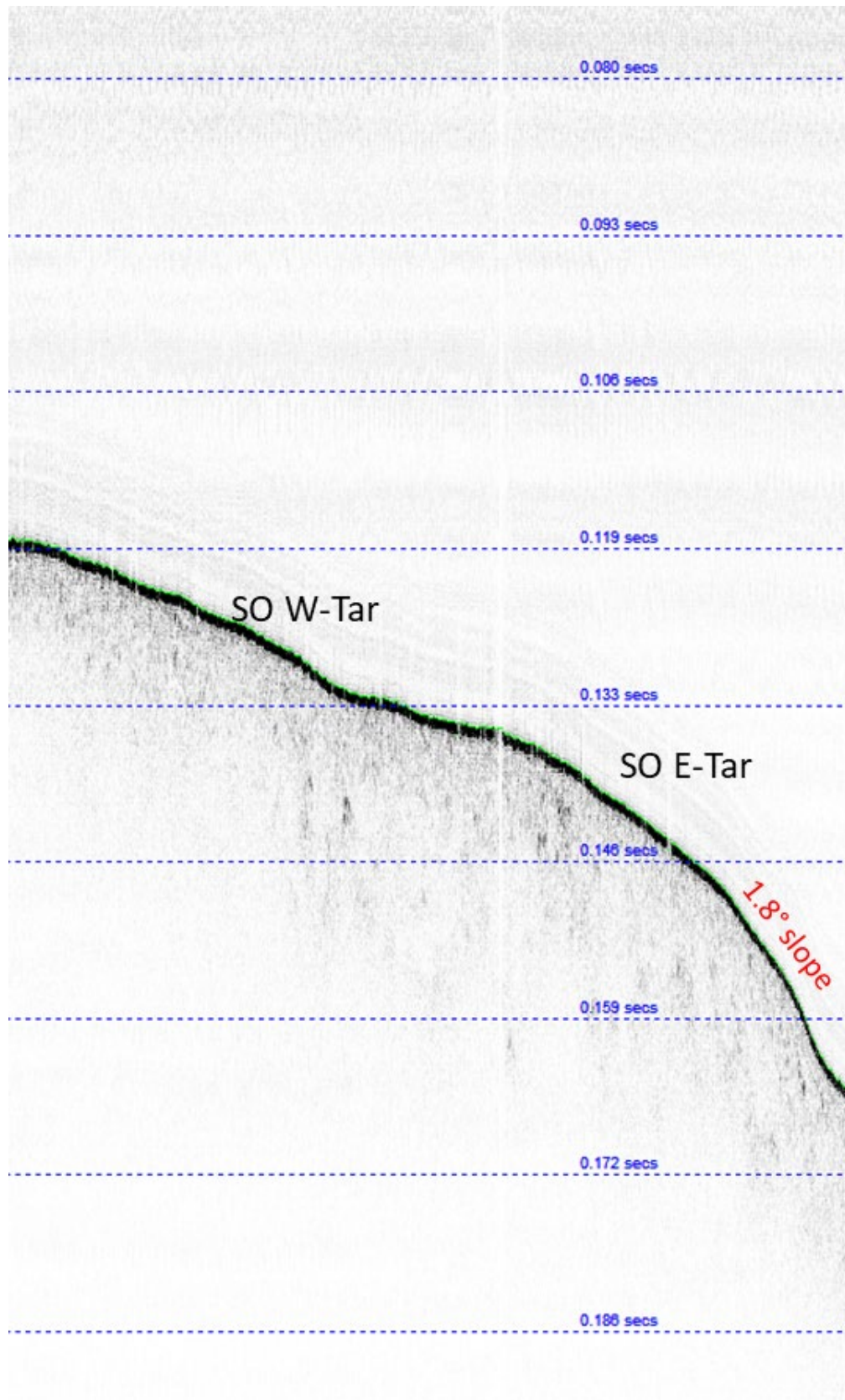


Figure 61: South Site East & West Anchor Targets (E-Tar, W-Tar) Subbottom

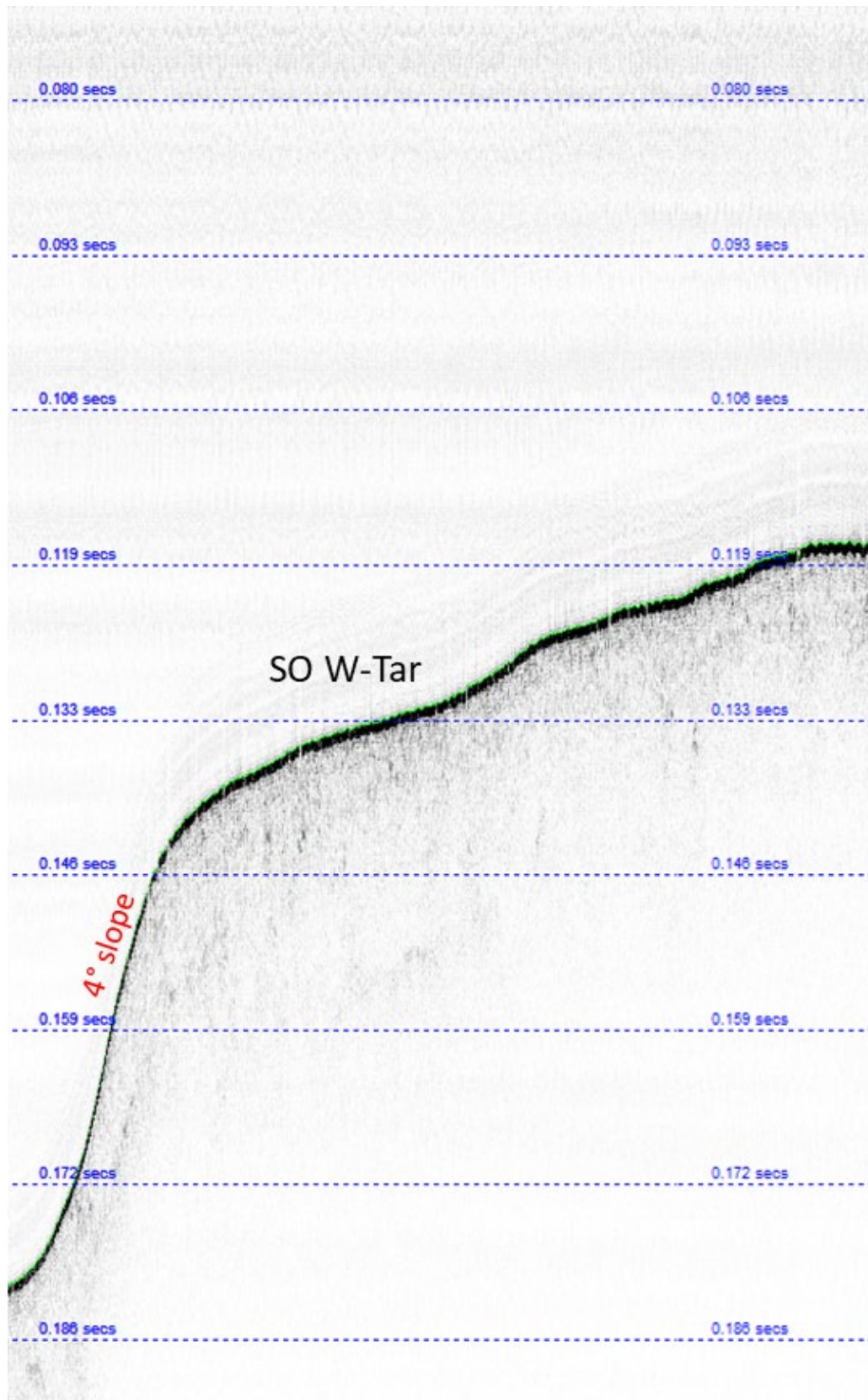


Figure 62: South Site West Anchor Target (W-Tar) Subbottom

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.

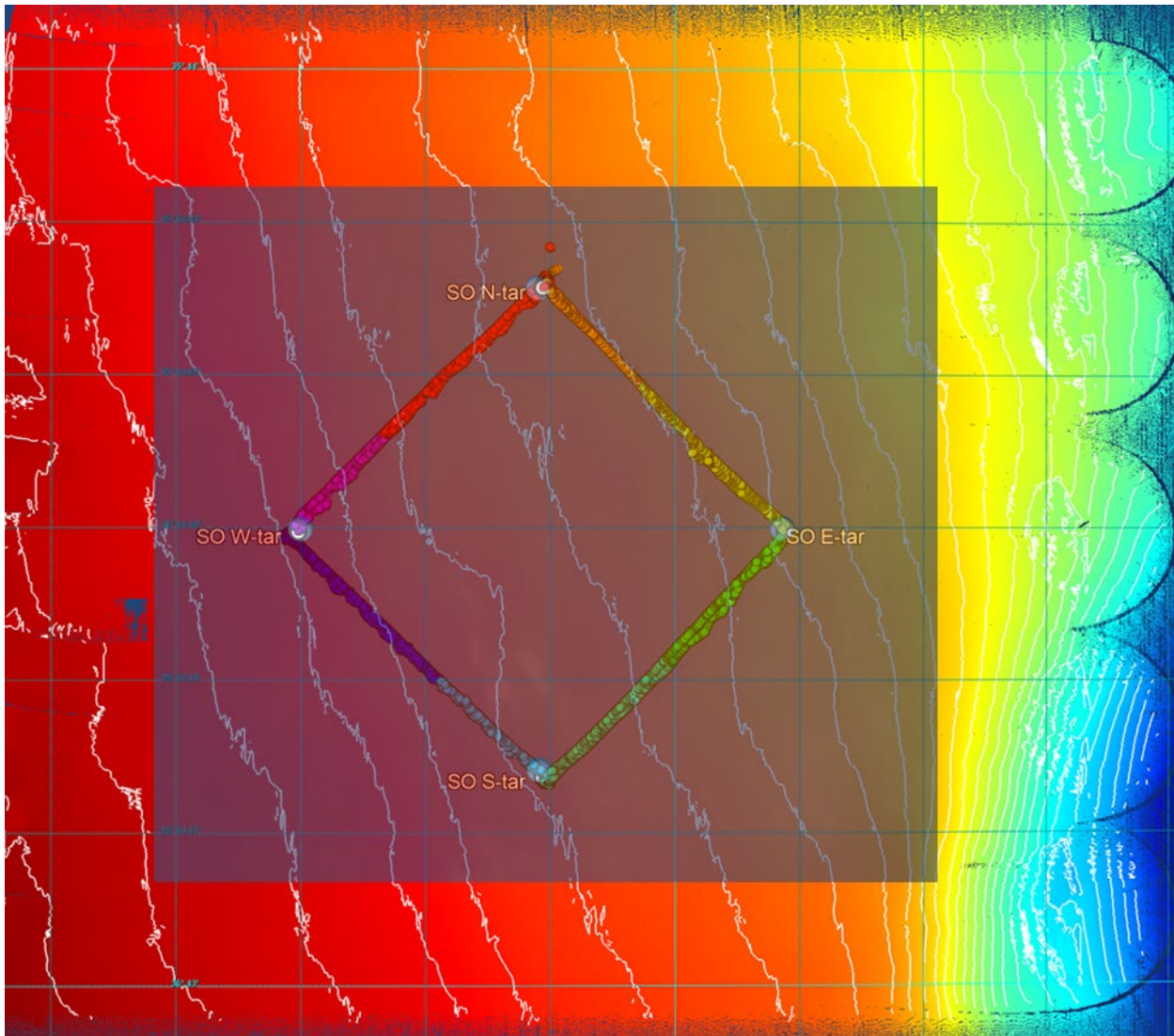


Figure 63: ROV Track at South Site

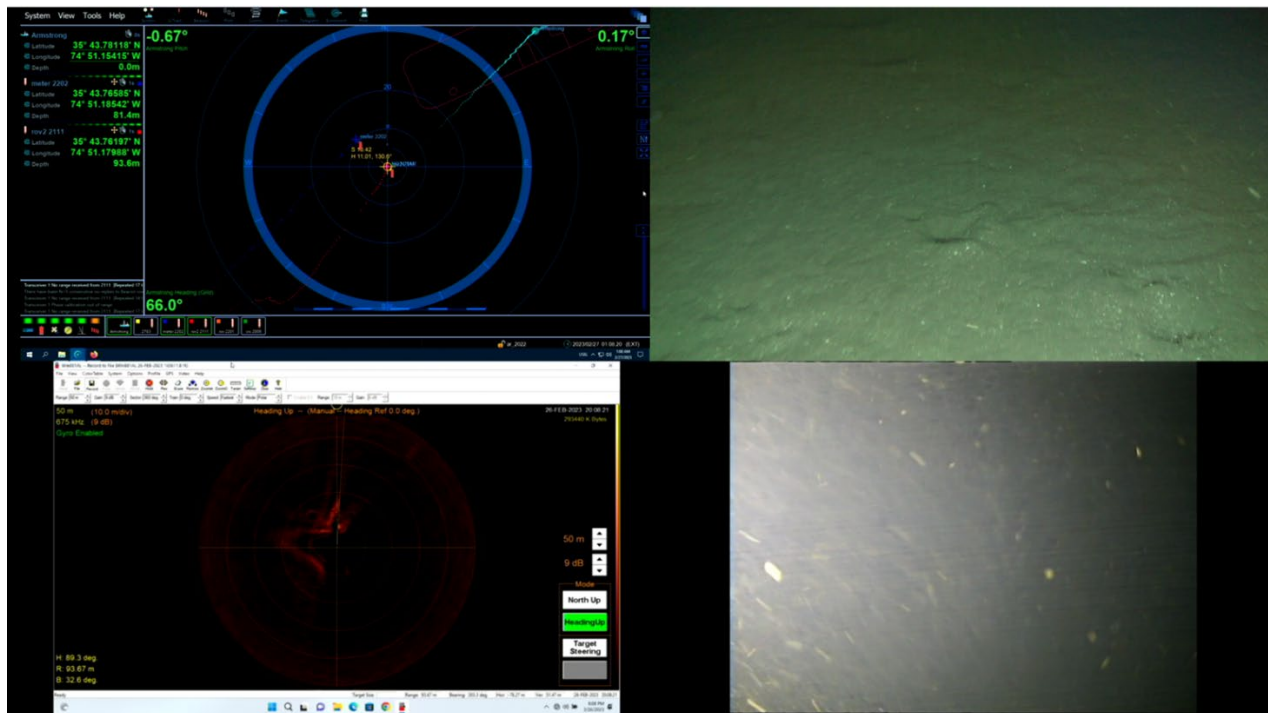


Figure 64: ROV Imagery at South Site, North Anchor Target

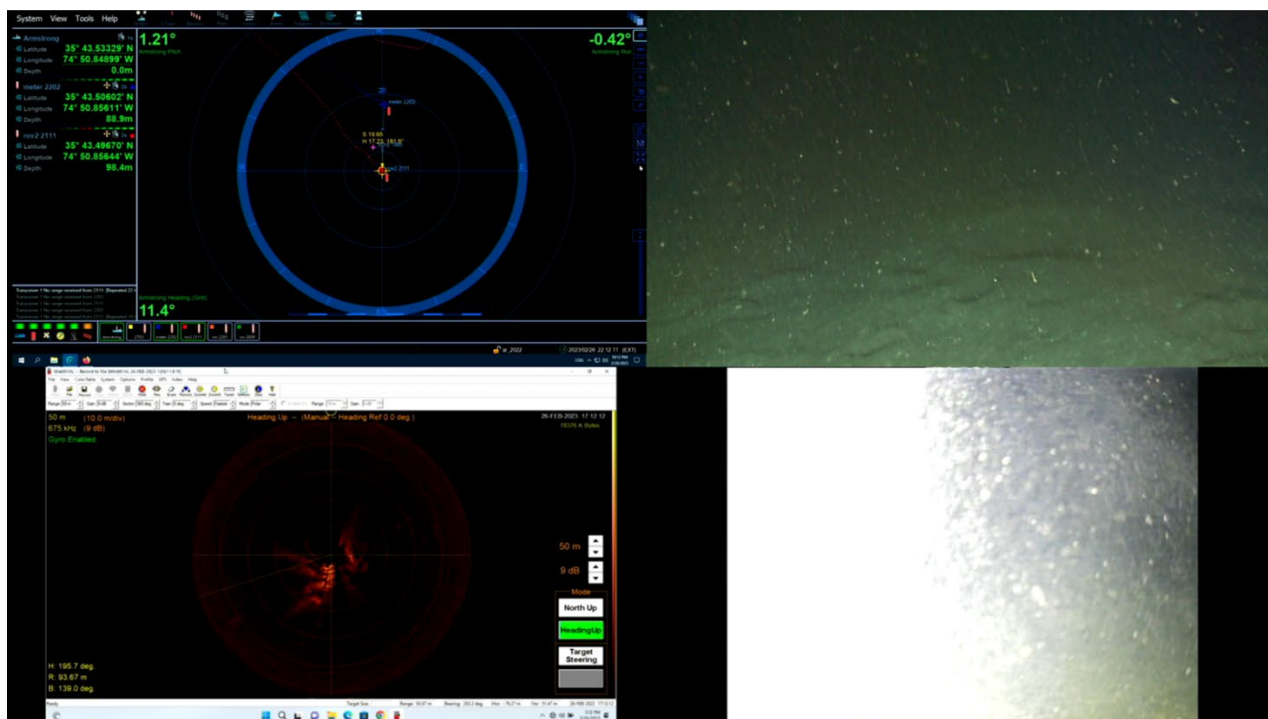


Figure 65: ROV Imagery at South Site, East Anchor Target

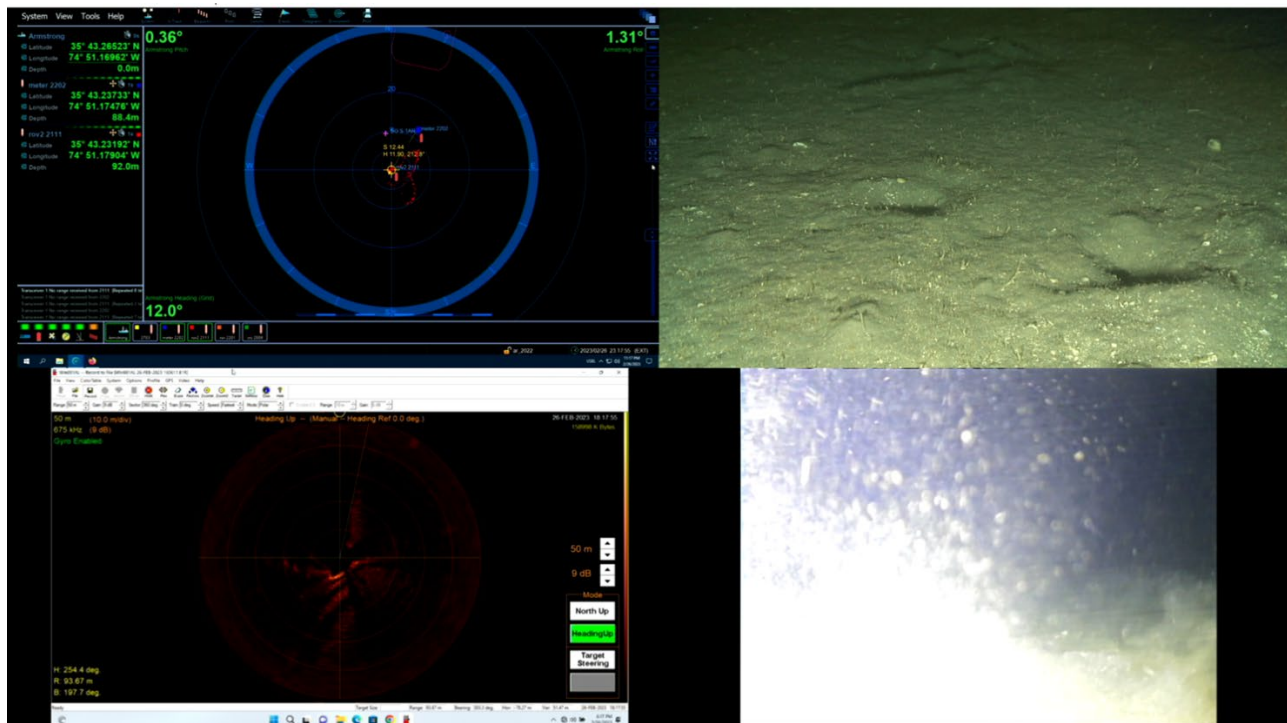


Figure 66: ROV Imagery at South Site, South Anchor Target



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

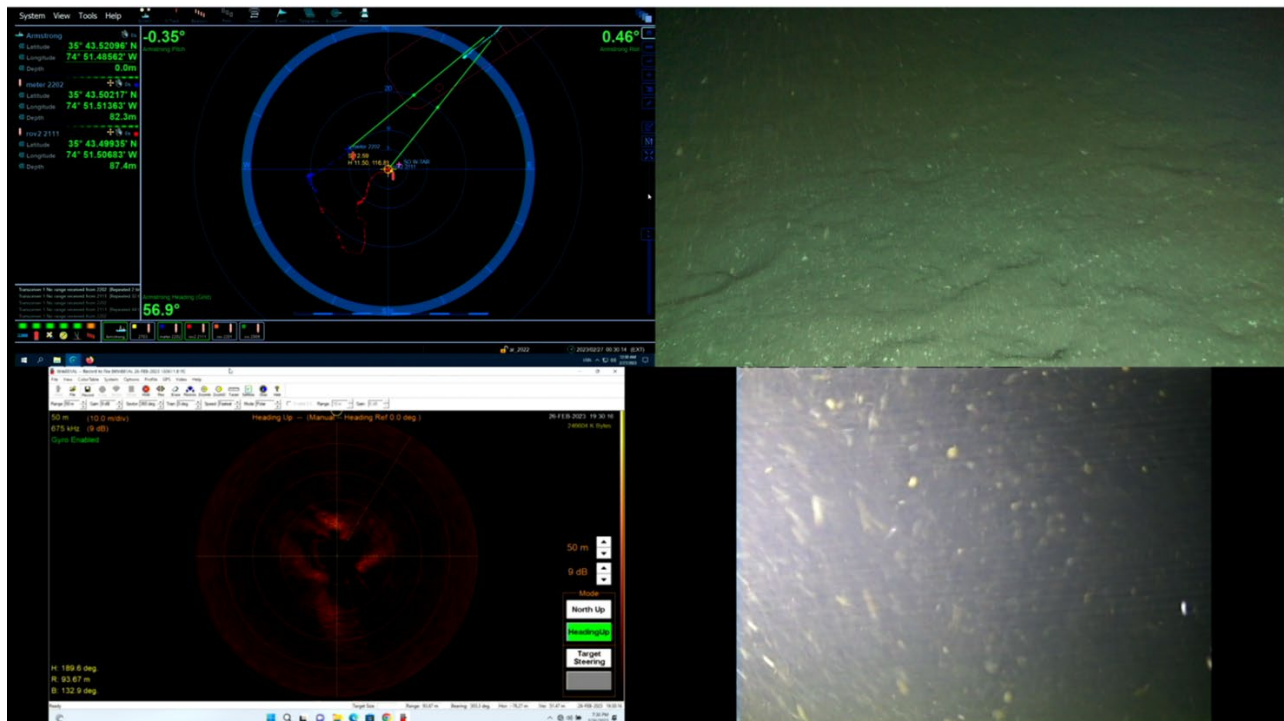


Figure 68: ROV Imagery at South Site, West Anchor Target

8.6. Northeast

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.

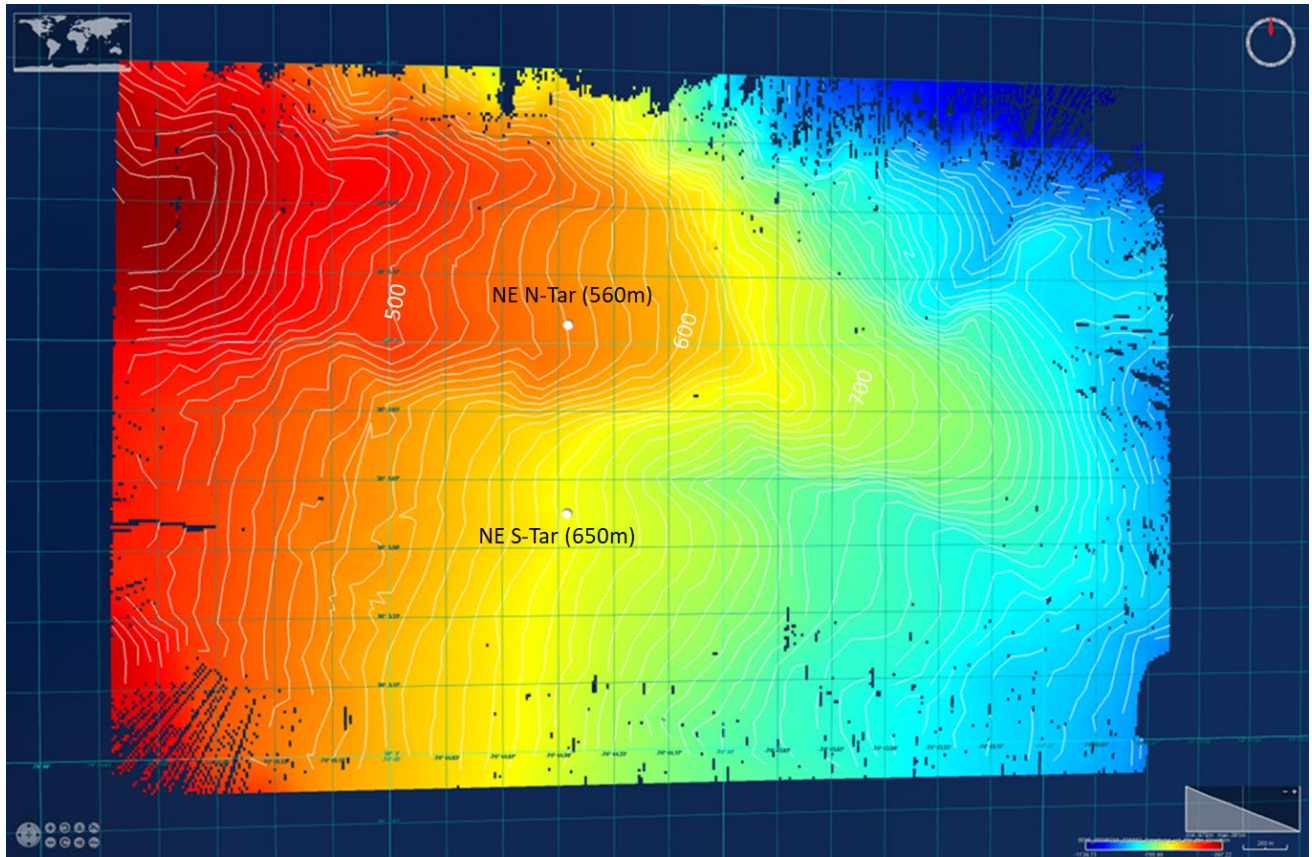


Figure 69: Northeast Site Digital Terrain Model (10m contours)

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).

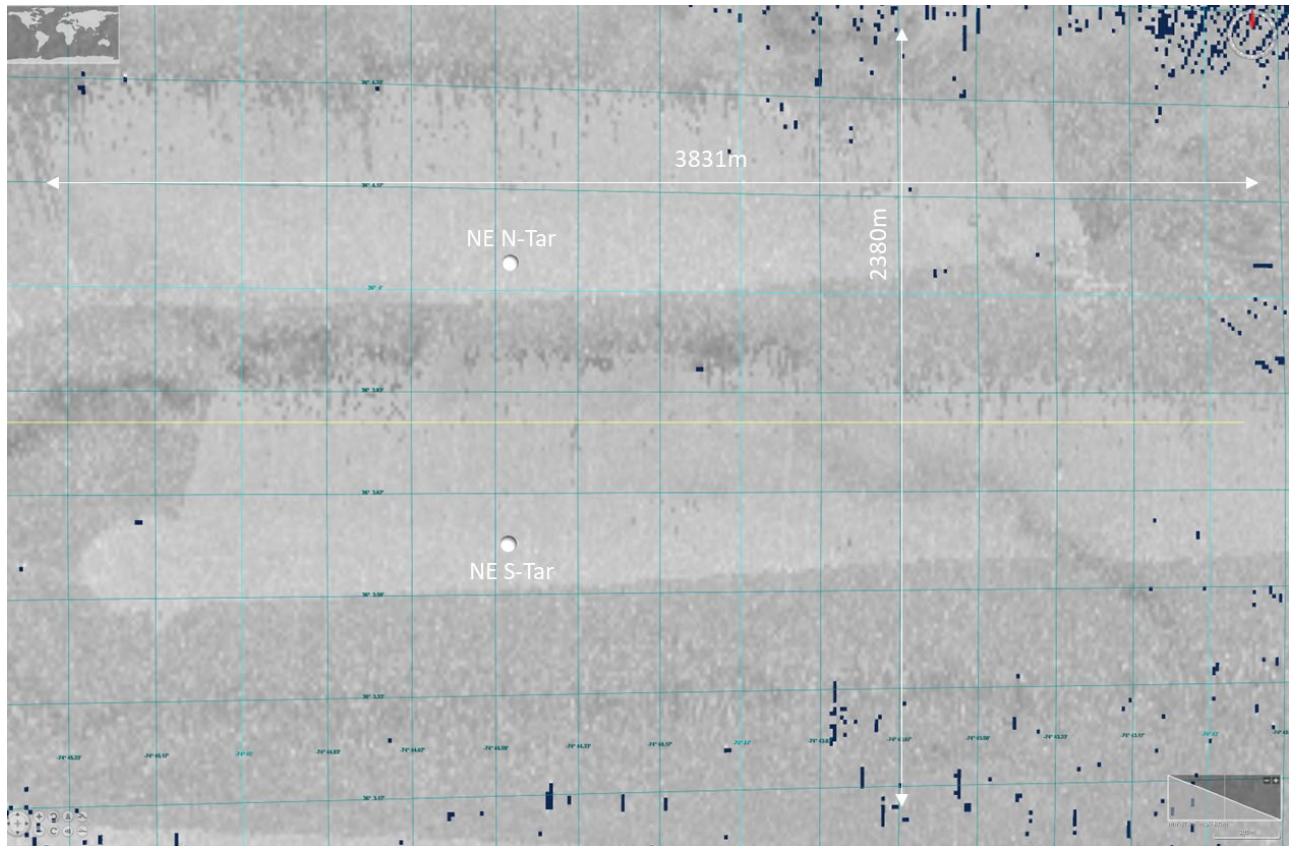


Figure 70: Northeast Site North & South Anchor Targets (N-Tar, S-Tar) Backscatter

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.

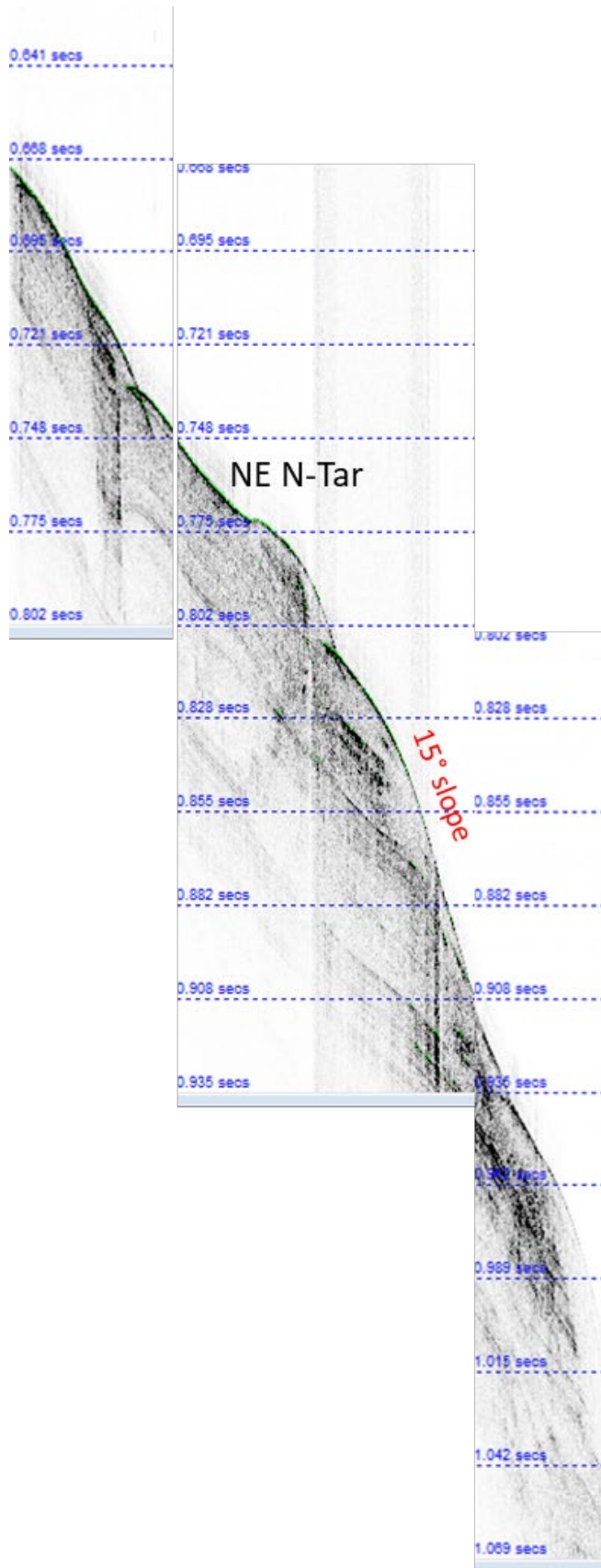


Figure 71: Northeast Site North Anchor Target (N-Tar) Subbottom

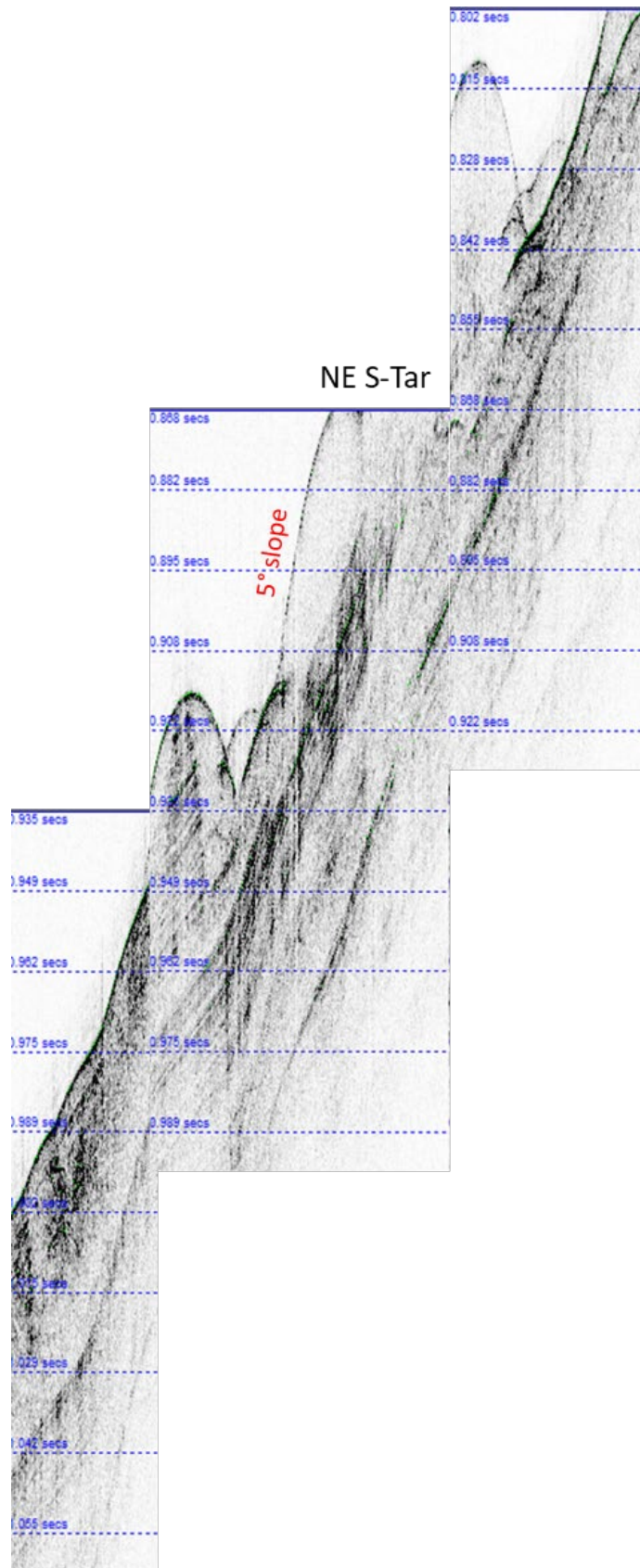


Figure 72: Northeast Site South Anchor Target (S-Tar) Subbottom

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.

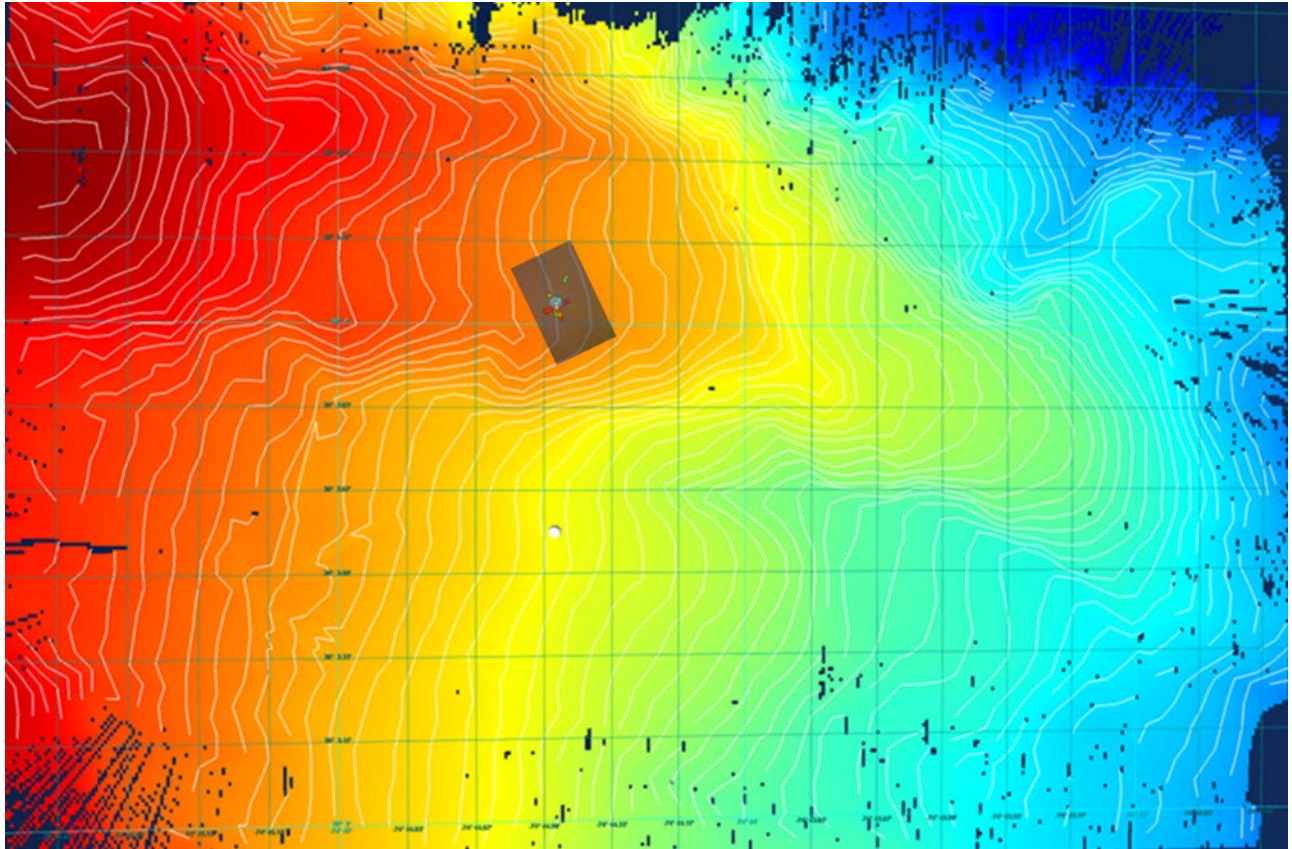


Figure 73: ROV Track at Northeast Site

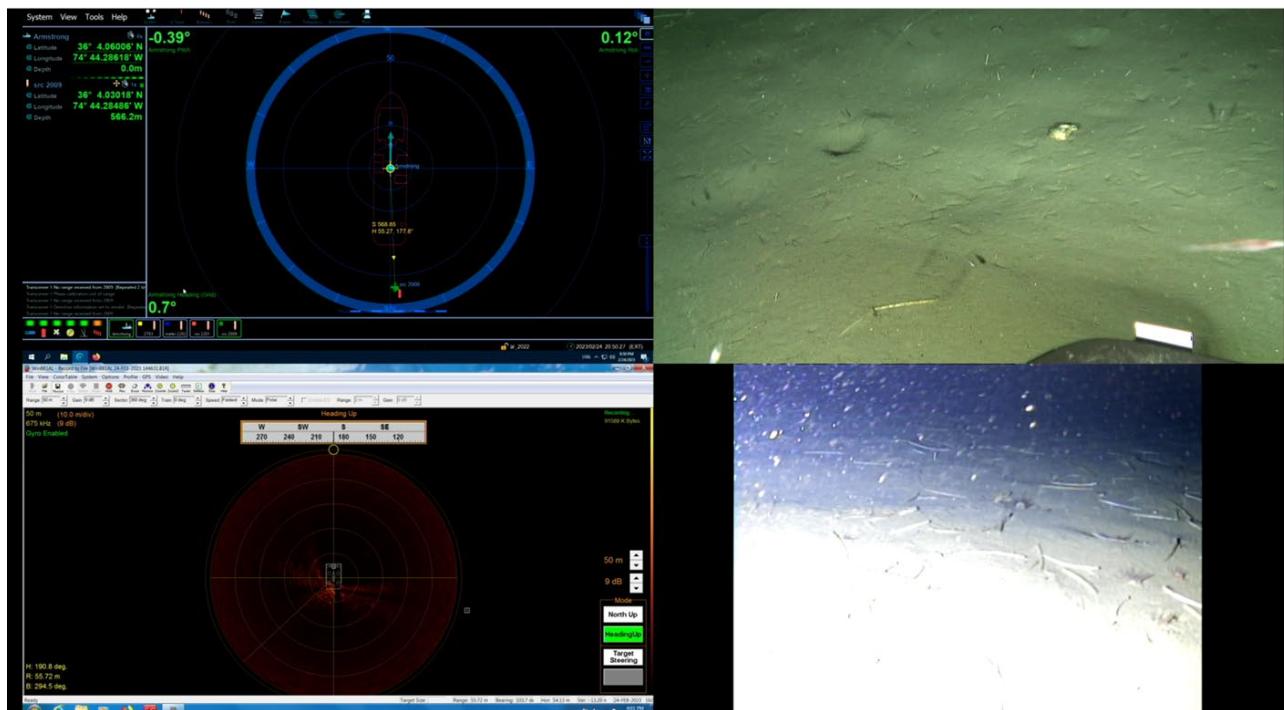


Figure 74: ROV Imagery at Northeast Site, North Anchor Target

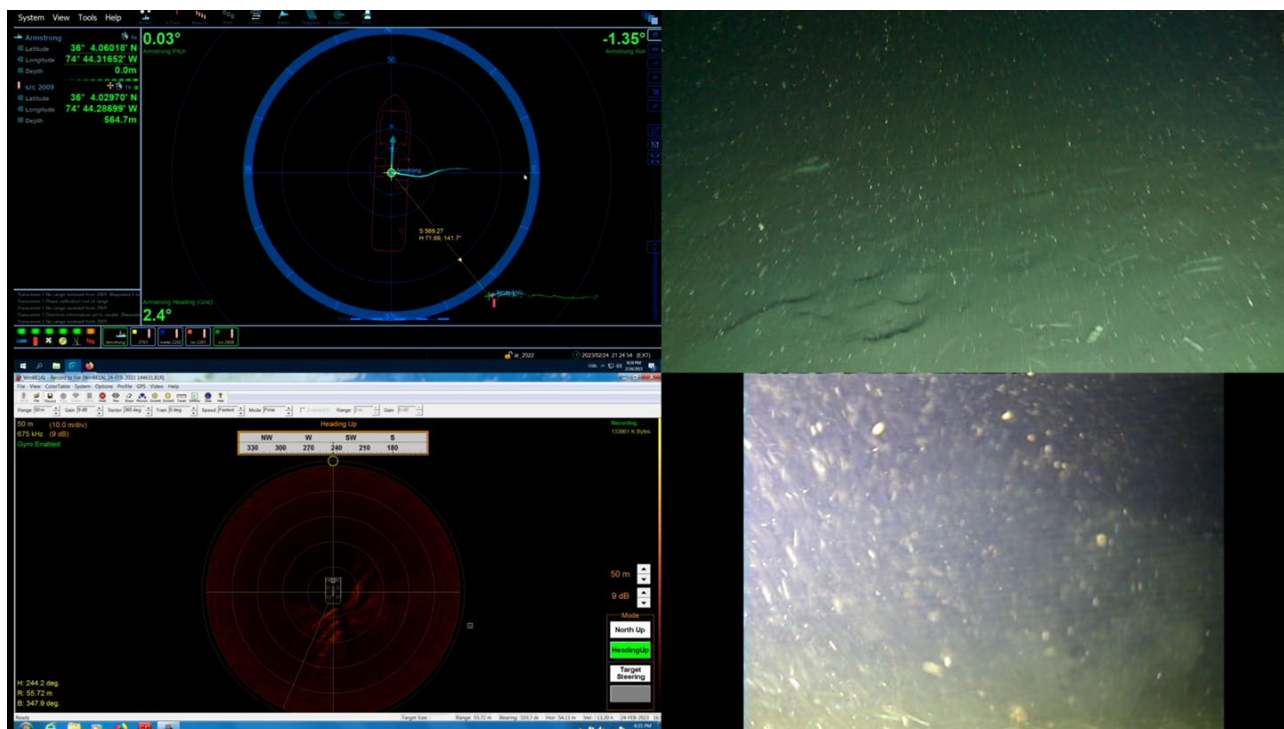


Figure 75: ROV Imagery at Northeast Site, North Anchor Target

8.7. Southeast

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.

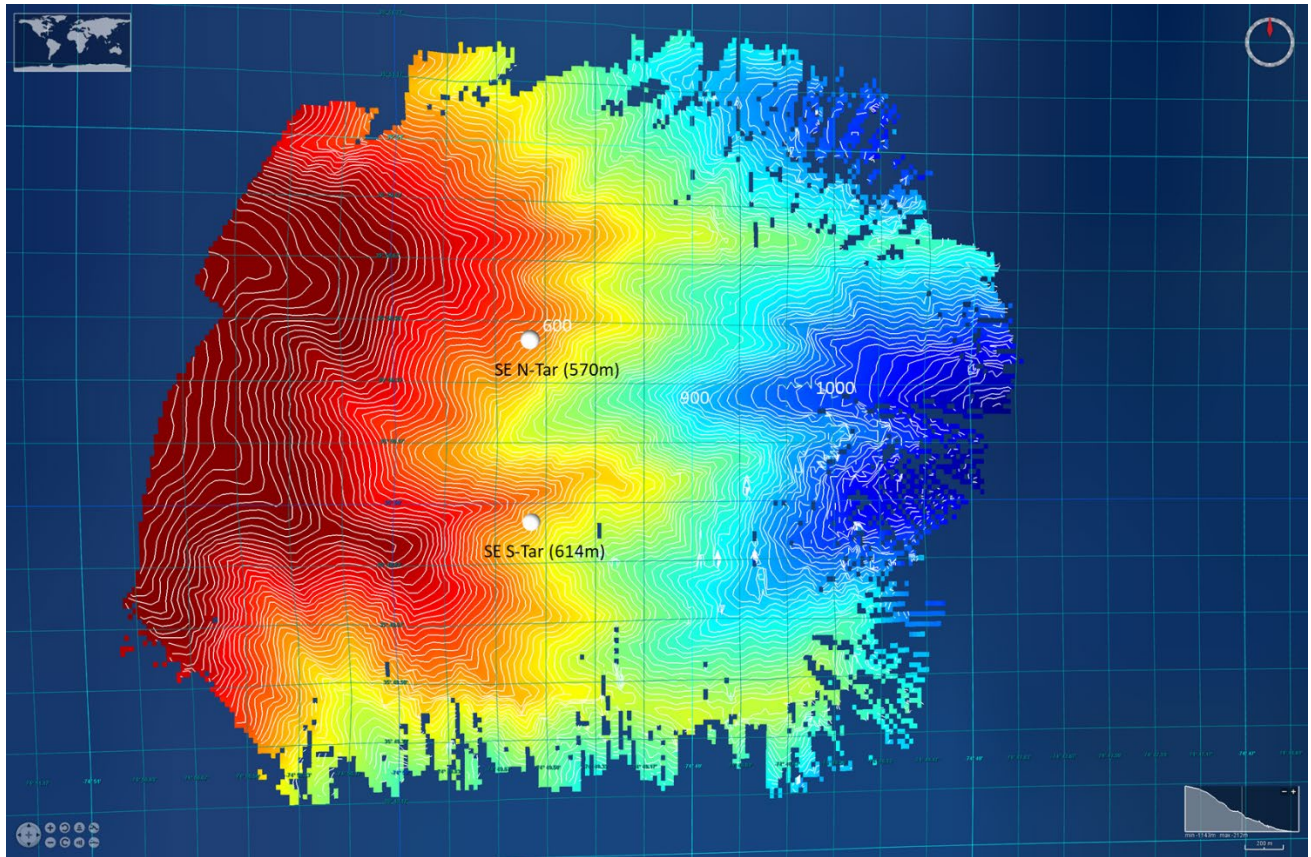


Figure 76: Southeast Site Digital Terrain Model (10m contours)

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).

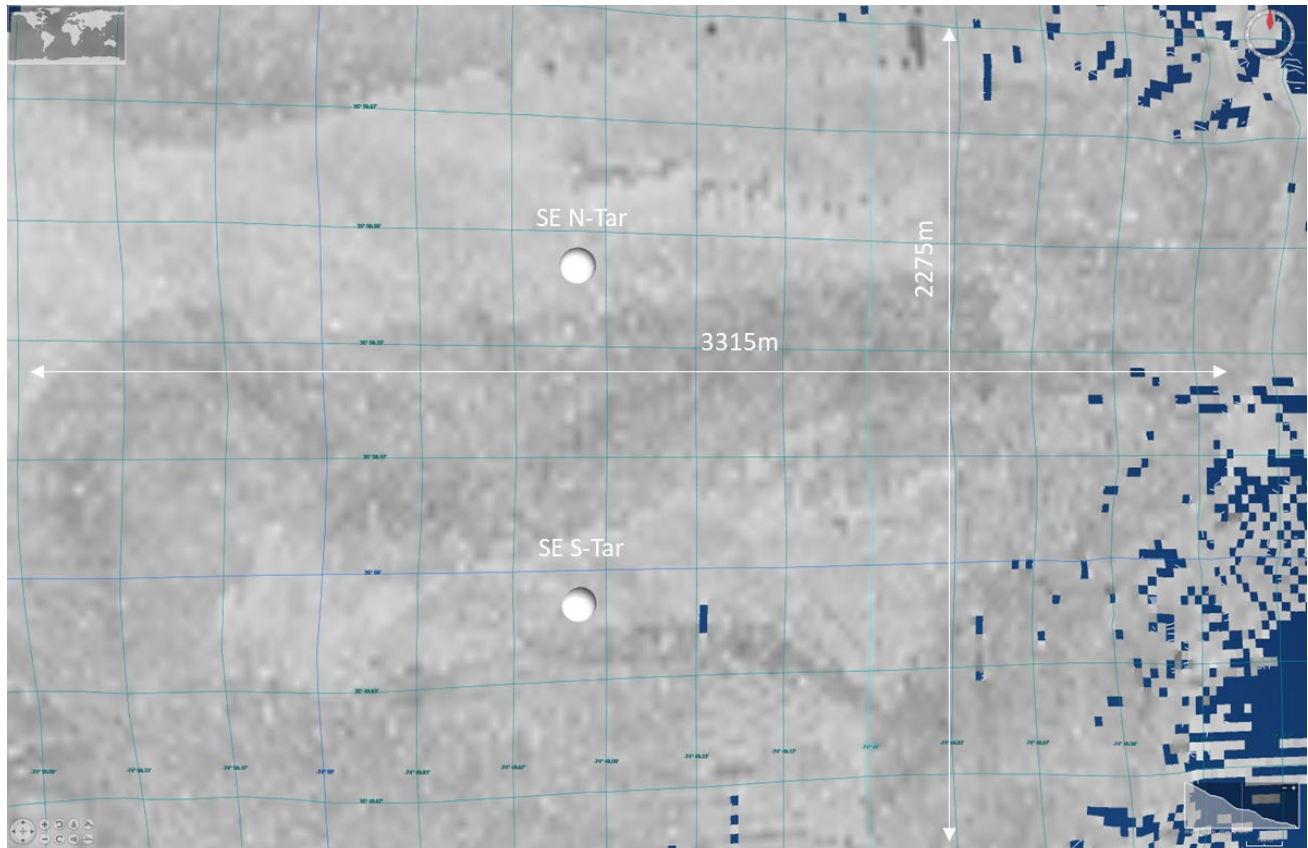


Figure 77: Southeast Site North & South Anchor Targets (N-Tar, S-Tar) Backscatter

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.

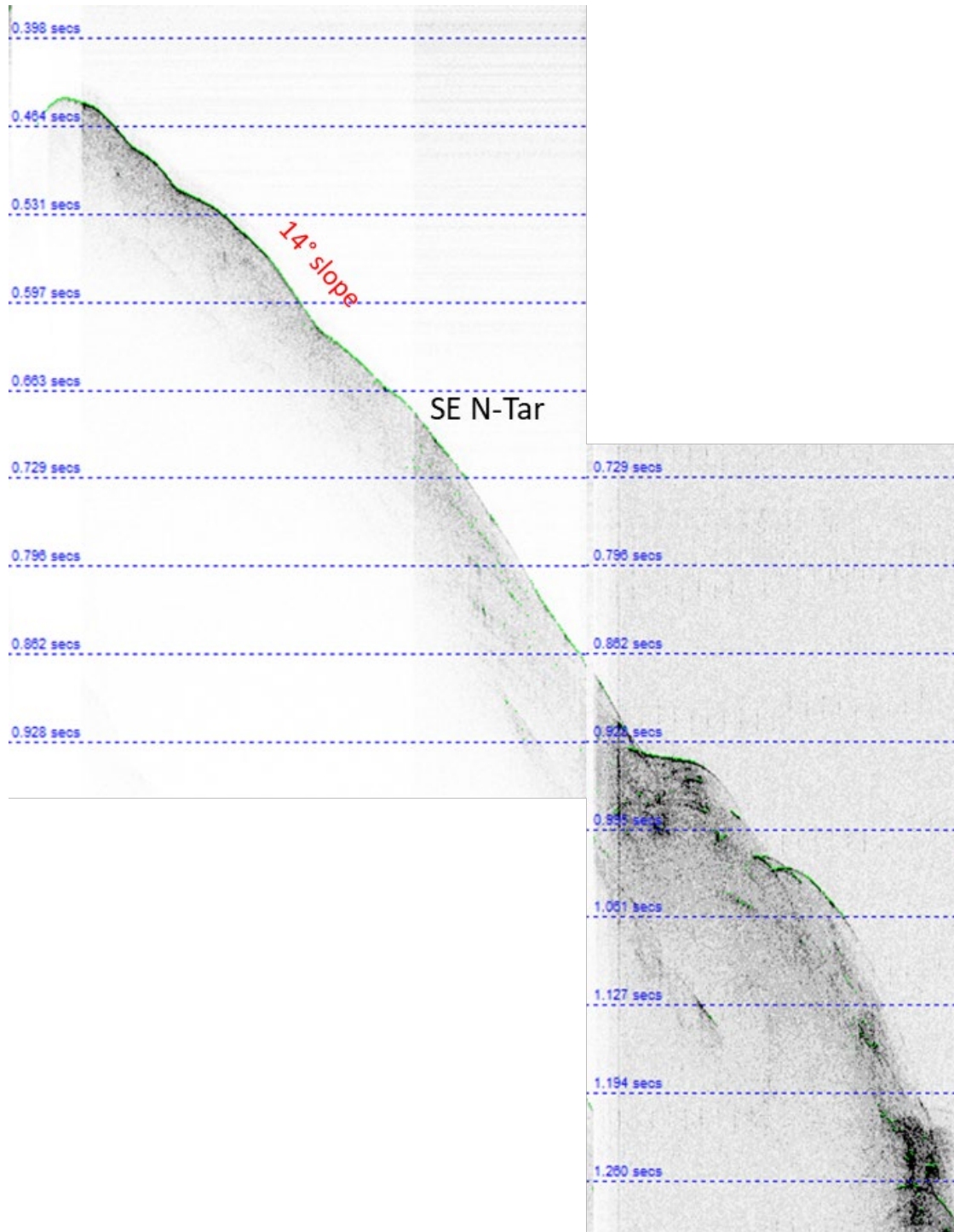


Figure 78: Southeast Site North Anchor Target (N-Tar) Subbottom

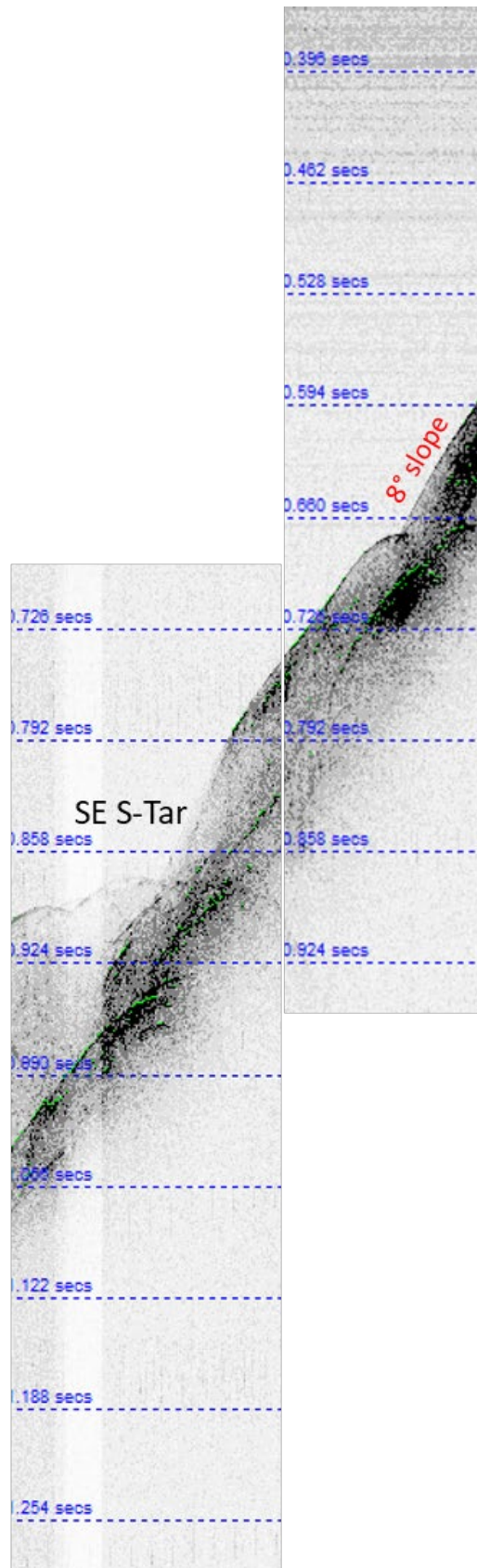


Figure 79: Southeast Site South Anchor Target (S-Tar) Subbottom

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.

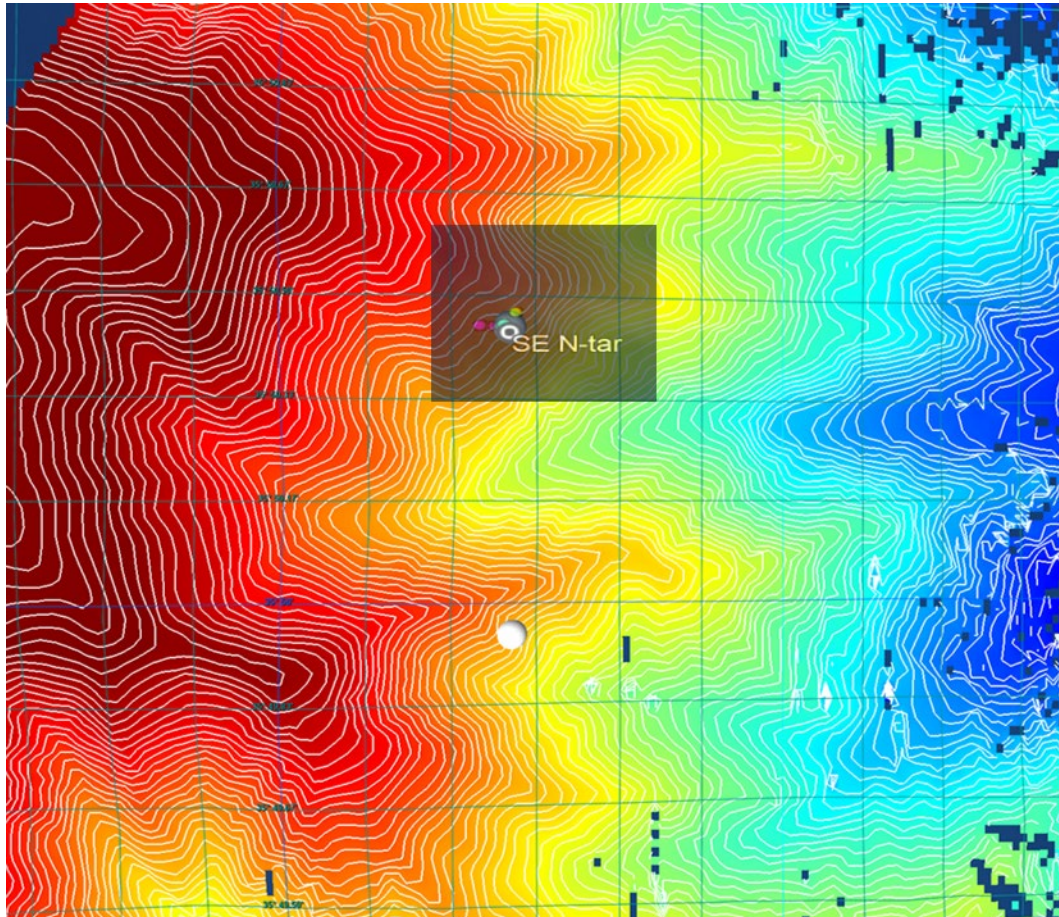


Figure 80: ROV Track at Southeast Site

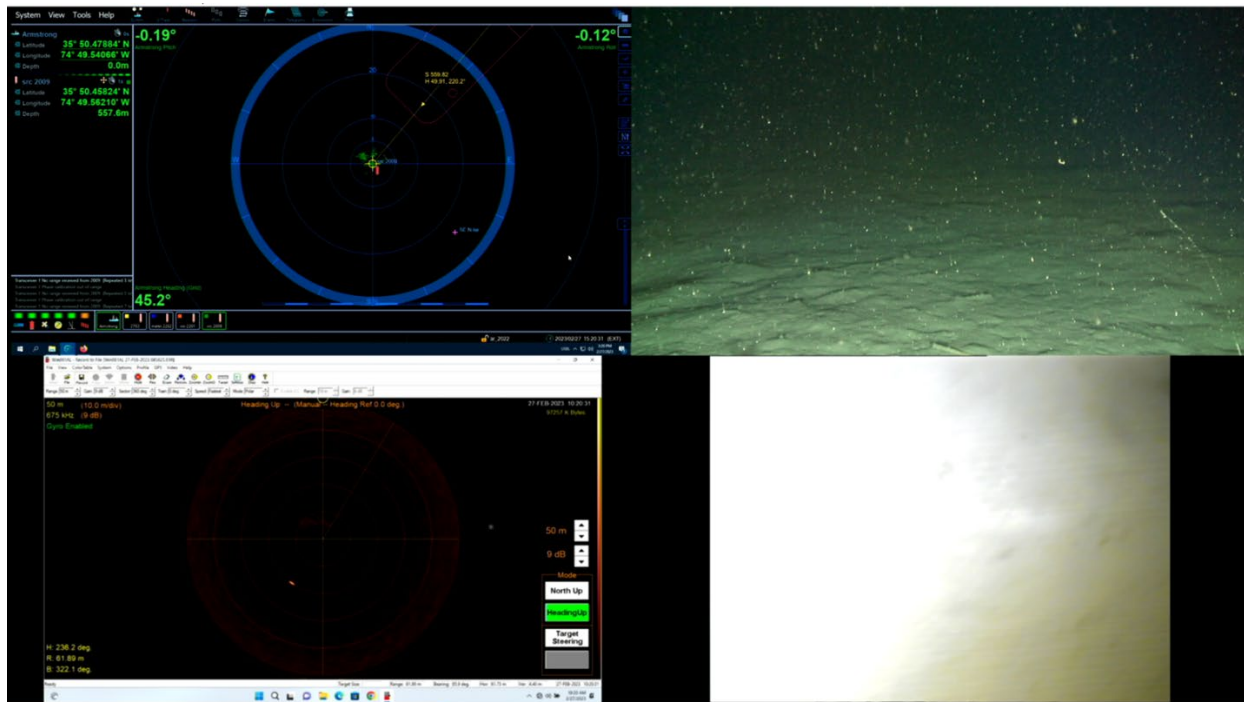


Figure 81: ROV Imagery at Southeast Site, North Anchor Target



Figure 82: Sandy Seabed Southeast Site, North 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: Engineering 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.
NORTHEAST	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.	Retain anchor targets as planned. Slopes at anchor targets are less than 30°. Conduct South anchor target ROV inspection prior to deployment. If slope impacts deployment or recovery, consider moving North anchor target away from ridge slope.
SOUTHEAST	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.	Retain anchor targets as planned. Slopes at anchor targets are less than 30°. Conduct South anchor target ROV inspection prior to deployment. If slope impacts deployment or recovery, consider moving both targets to a shallower, less steep location.

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.
NORTHEAST	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.
SOUTHEAST	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.

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 Pioneer MAB 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 7: Areas of Interest

Area	Site	Distance from Nearest Anchor Target (m)	Water Depth (m)
1	Central	300	30
2	South	272	85.7
3	South	50	93.7
4	Northeast	230	567
5	Southeast	50	557

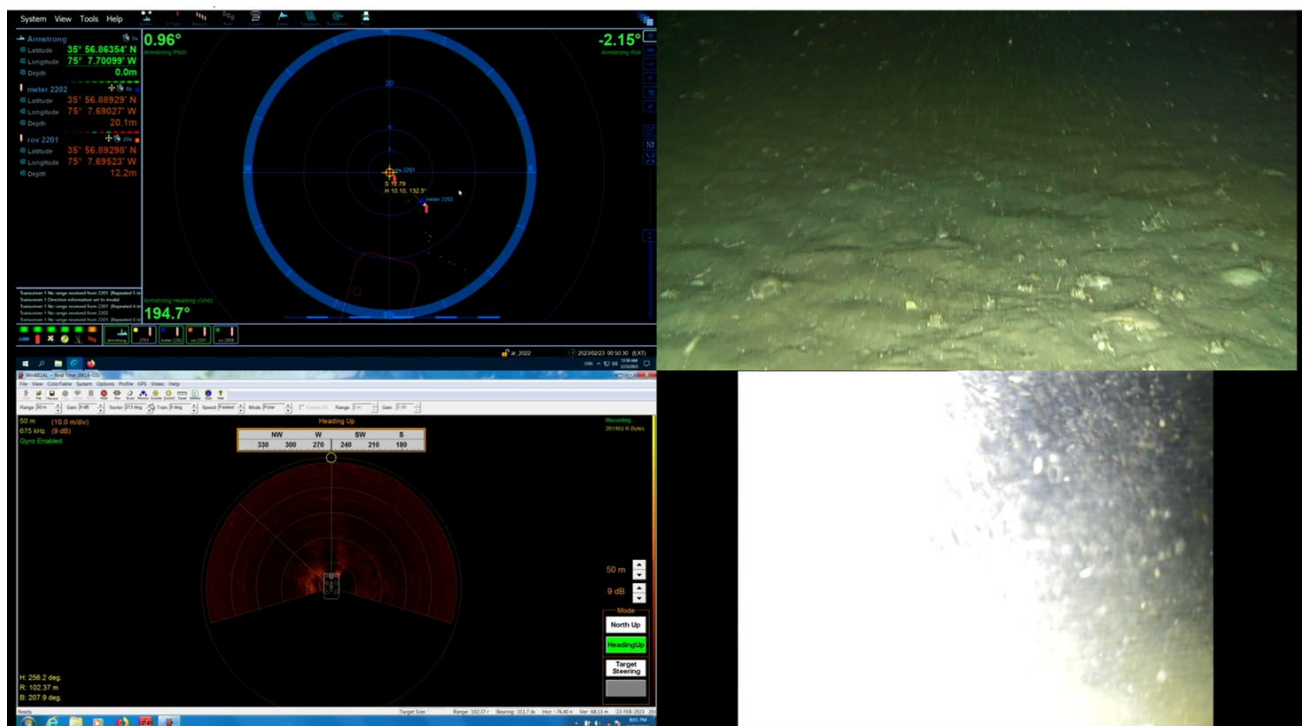


Figure 83: Area of Interest #1, Central Site: Shell and skeleton debris, sea star, scattered vertical worm tubes

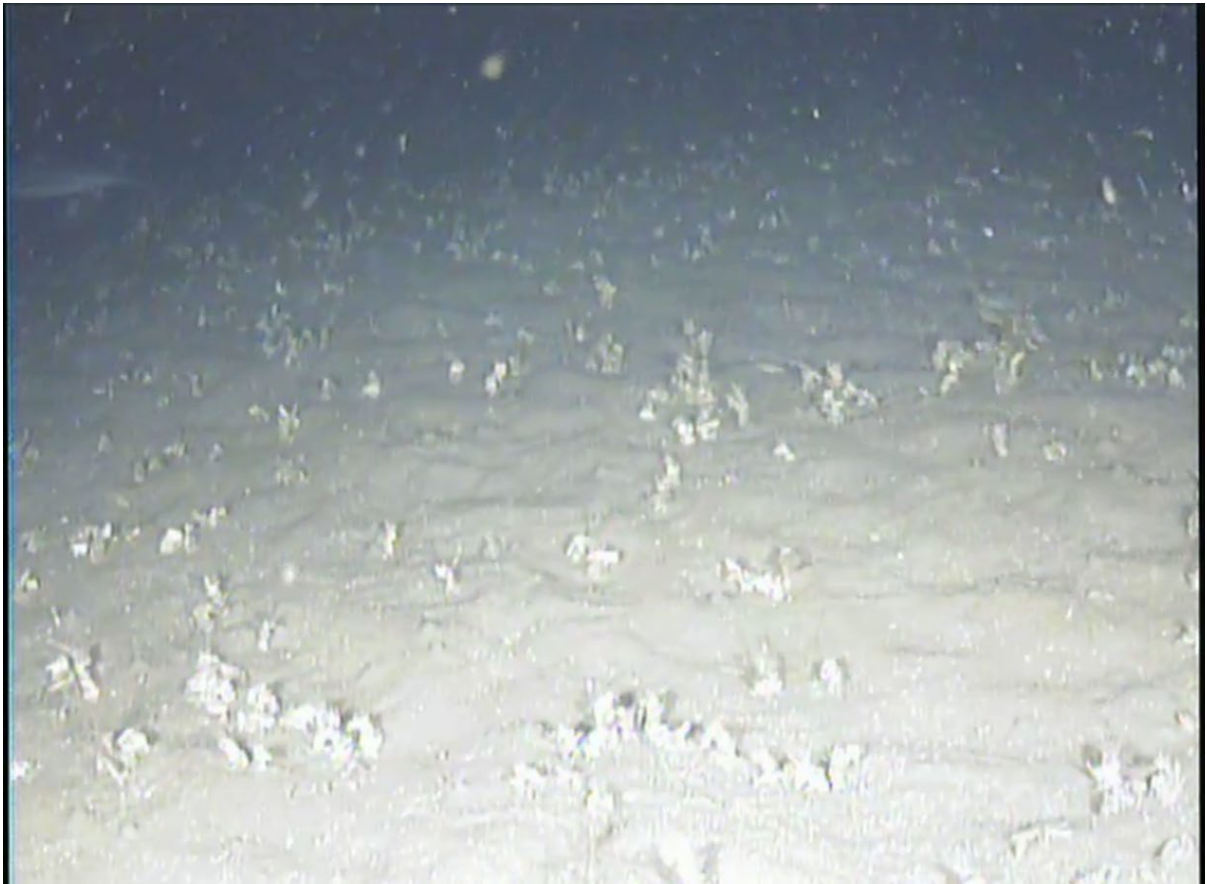


Figure 84: Area of Interest #1, Central Site: Shell and skeleton debris, sponges

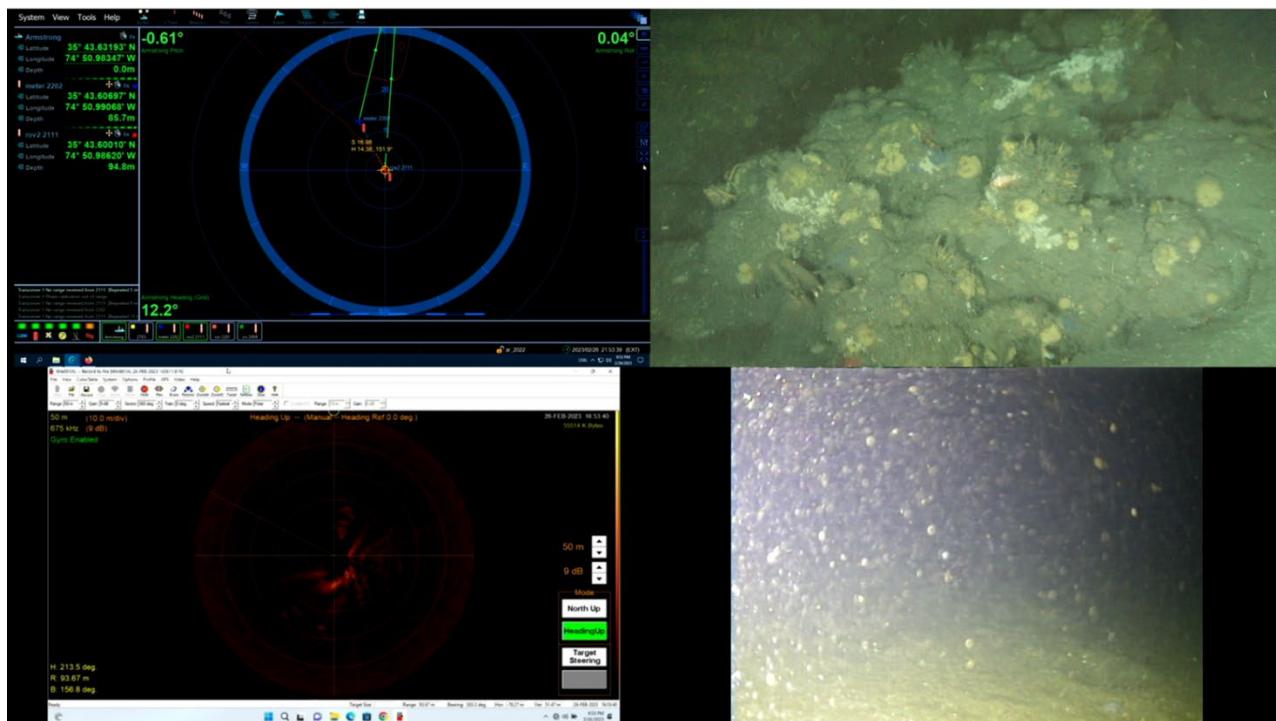


Figure 85: Area of Interest #2, South Site: Lithotherm-like substrate, sponges, Galatheid crabs, Bryozoan-like animals

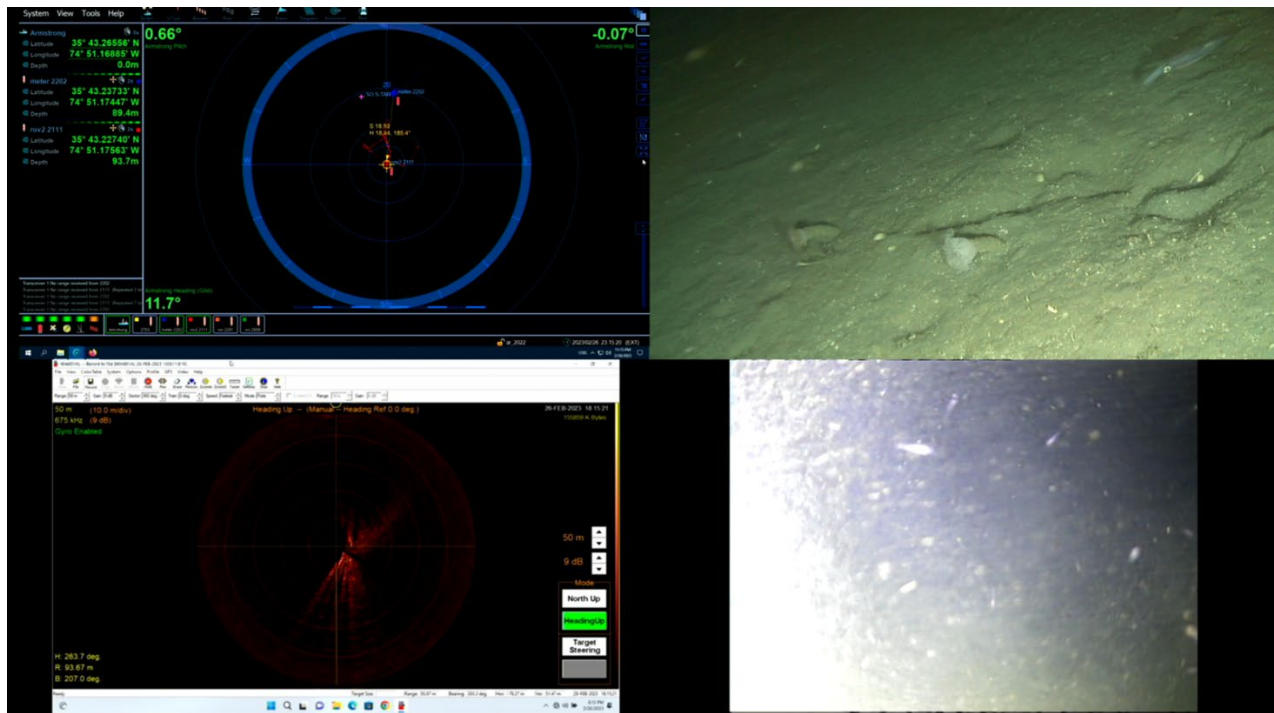


Figure 86: Area of Interest #3, South Site: Anemones (solitary hydroids), shell debris, squid, small Polychaete Hyalinoecia worm tubes

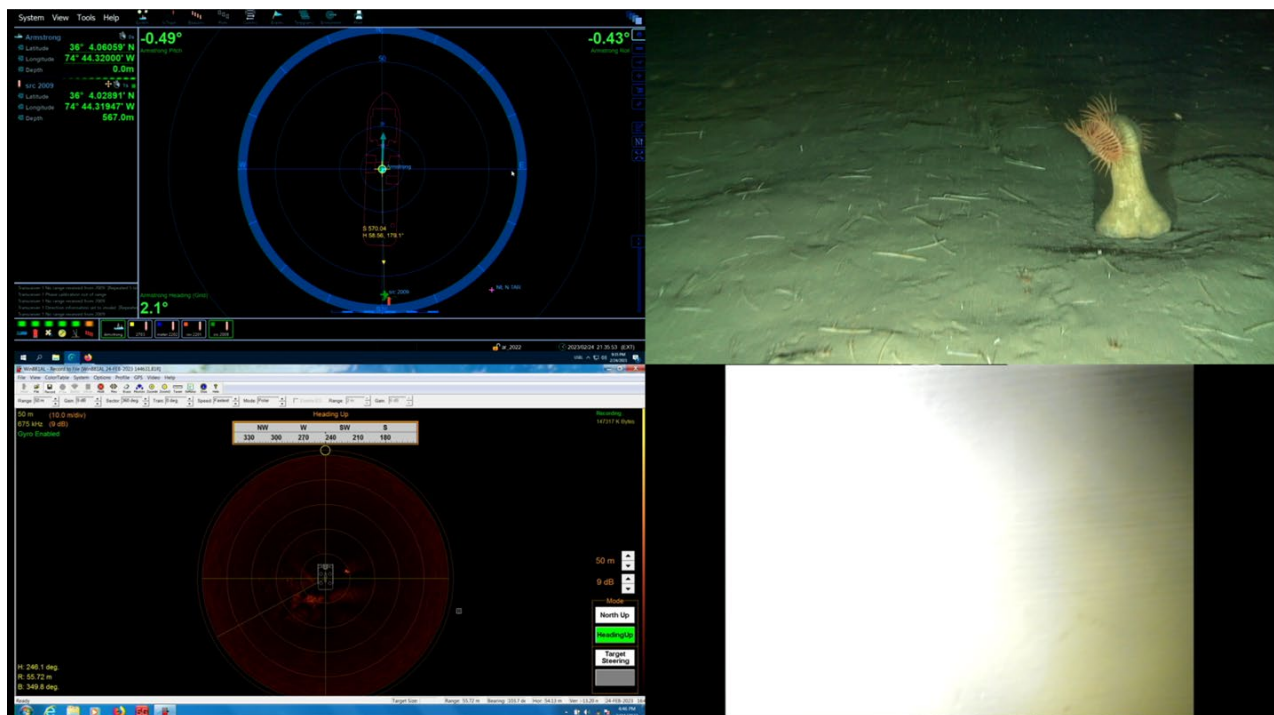


Figure 87: Area of Interest #4, Northeast Site: Actinoscyphia Venus Flytrap anemone, Polychaete Hyalinoecia worm tubes



Figure 88: Area of Interest #4, Northeast Site: Anemones, squid, Polychaete Hyalinoecia worm tubes

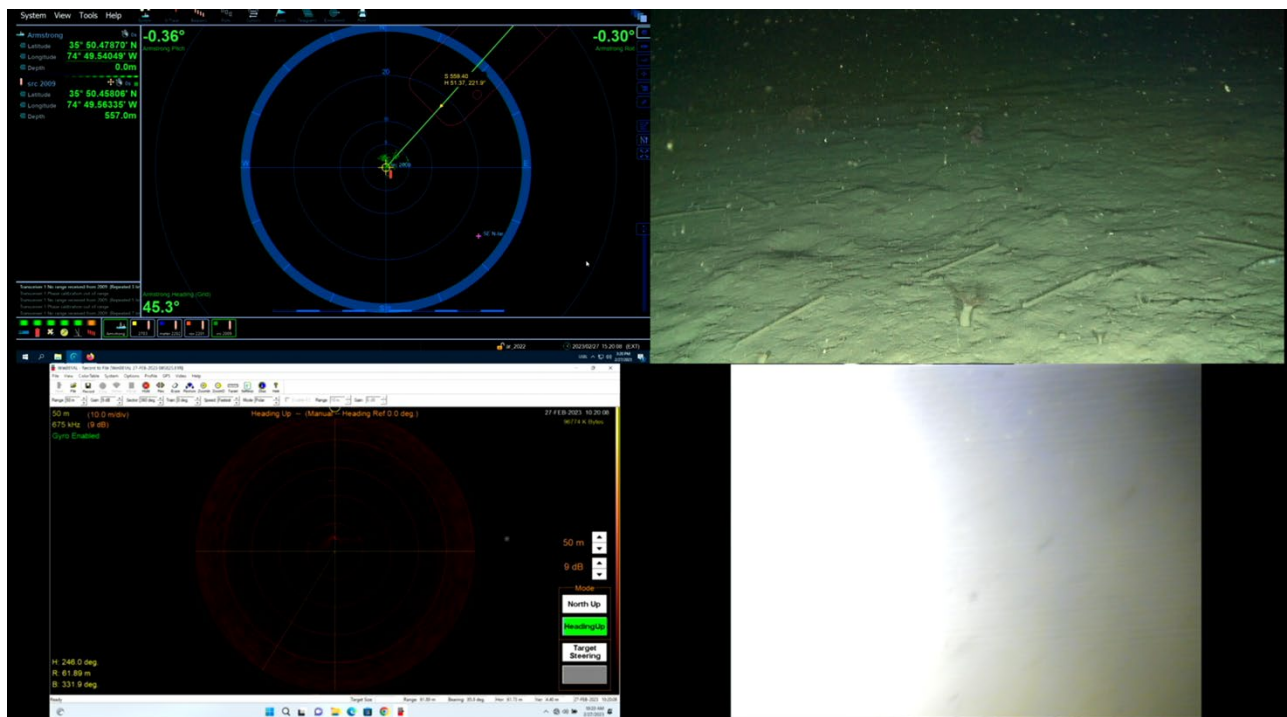


Figure 89: Area of Interest #5, Southeast Site: Polychaete Hyalinoecia worm tubes, tube anemones