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Seafloor Disturbance and Recovery Monitoring at the Block Island Wind Farm, Rhode Island - Summary Report (Year 6)

U.S. Department of the Interior
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DISCLAIMER

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ABOUT THE COVER

Photo by John Tiggelaar, CSA

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List of Abbreviations and Acronyms

CONUS	Continental United States
AIS	automatic identification system
AML	Applied Microsystems Ltd.
BIWF	Block Island Wind Farm
BOEM	Bureau of Ocean Energy Management
CSA	CSA Ocean Sciences Inc.
DEM	digital elevation model
EPIRB	emergency position-indicating radio beacon
GIS	geographic information system
GNSS	global navigation satellite system
HSSE	health, safety, security, and environment
IMU	inertial measurement unit
INS	inertial navigation system
MBES	multibeam echosounder
MLW	mean low water
NOAA	National Oceanic and Atmospheric Administration
PLB	personnel locator beacons
PPE	personal protective equipment
PR	Puerto Rico
RTK	real-time kinetic
SART	Search and Rescue Transponder
SOLAS	International Convention for the Safety of Life at Sea
SVP	sound velocity profile
USCG	U.S. Coast Guard
UTM	Universal Transverse Mercator
VRS	virtual reference system
WGS84	World Geodetic System 1984
WTG	wind turbine generator

1 Introduction

1.1 Background

The United States (U.S.) Department of Interior's Bureau of Ocean Energy Management (BOEM) is responsible for managing the exploration and development of the nation's offshore energy resources. The BOEM conducts environmental reviews, including National Environmental Policy Act (NEPA) analyses, for each major stage (leasing, site assessment, construction, operations, and decommissioning) of proposed offshore energy development projects. Through these reviews and analyses, the BOEM evaluates potential environmental impacts from the proposed offshore activities on the human, coastal, and marine environments. The NEPA analysis is used to inform the decision-making process for whether and/or how to proceed with the approval of the offshore energy development.

To conduct the required analyses and effectively analyze the potential environmental impacts under NEPA, the BOEM requires data on impact-producing factors (stressors) and their effects on ecosystems and individual receptors. Development of offshore wind energy is new to the U.S.; therefore, data necessary for assessment of environmental impacts are not readily available.

Thus, the BOEM has initiated the Real-Time Opportunity for Development Environmental Observations (RODEO) Program. The purpose of this program is to make direct, real-time measurements of the nature, intensity, and duration of potential stressors during the construction and/or initial operations of selected offshore wind facilities.

Data collected under the RODEO Program may be used as input to analyses or models that are employed to evaluate effects or impacts from future offshore activities. The first facility to be part of the RODEO Program monitoring is the Block Island Wind Farm (BIWF) Project, which is located off the coast of Rhode Island.

1.2 Seafloor Disturbance and Recovery Monitoring

The seafloor can be disturbed by various activities during the construction and operational phases of a wind farm development. During construction and/or maintenance, vessel anchoring activities and spud penetrations may result in depressions in the seafloor. In addition, while a lift boat is positioned on site, scour can develop around the legs that penetrate the seafloor. Evidence of those impacts on the environment can disappear as sediment is reworked and transported due to natural processes after construction equipment is removed from the seafloor. The recovery rate from a seafloor disturbance primarily depends on sediment type, bottom current flow conditions (e.g., speed, duration, direction, etc.), and size of the disturbance feature.

The RODEO Program for the BIWF includes the continuation of seafloor monitoring for recovery from disturbance, evaluation of benthic disturbance around foundations, and evaluation of the source of the disturbance by using repeated high-resolution hydrographic surveys as a multi-temporal analysis tool to monitor for disturbance and recovery of the seafloor associated with the prior BIWF construction activities. The principal objective of the geophysical survey was to collect updated soundings1 data to assess the recovery of the seafloor disturbances associated with the BIWF construction activities. The hydrographic data collected was evaluated to examine the spatial extent of seafloor disturbances around each turbine related to prior construction activities to evaluate seafloor changes over time.

1.3 Purpose of Document

CSA Ocean Sciences Inc. (CSA) has prepared this Seafloor Disturbance and Recovery Monitoring at the Block Island Wind Farm, Rhode Island - Summary Report (Year 6) to document the methods, data, observations, results, and major conclusions from seafloor disturbance and recovery monitoring survey conducted in and around the Block Island Wind Farm (BIWF) located off of Block Island, Rhode Island (**Figure 1**) during the summer of 2021. The results of this monitoring effort are compared to the previous BIWF seafloor monitoring results (Fugro 2019) to effectively evaluate disturbance and recovery since the previous survey which occurred in September 2018.

[1] The action or process of measuring the depth of the sea or other body of water.

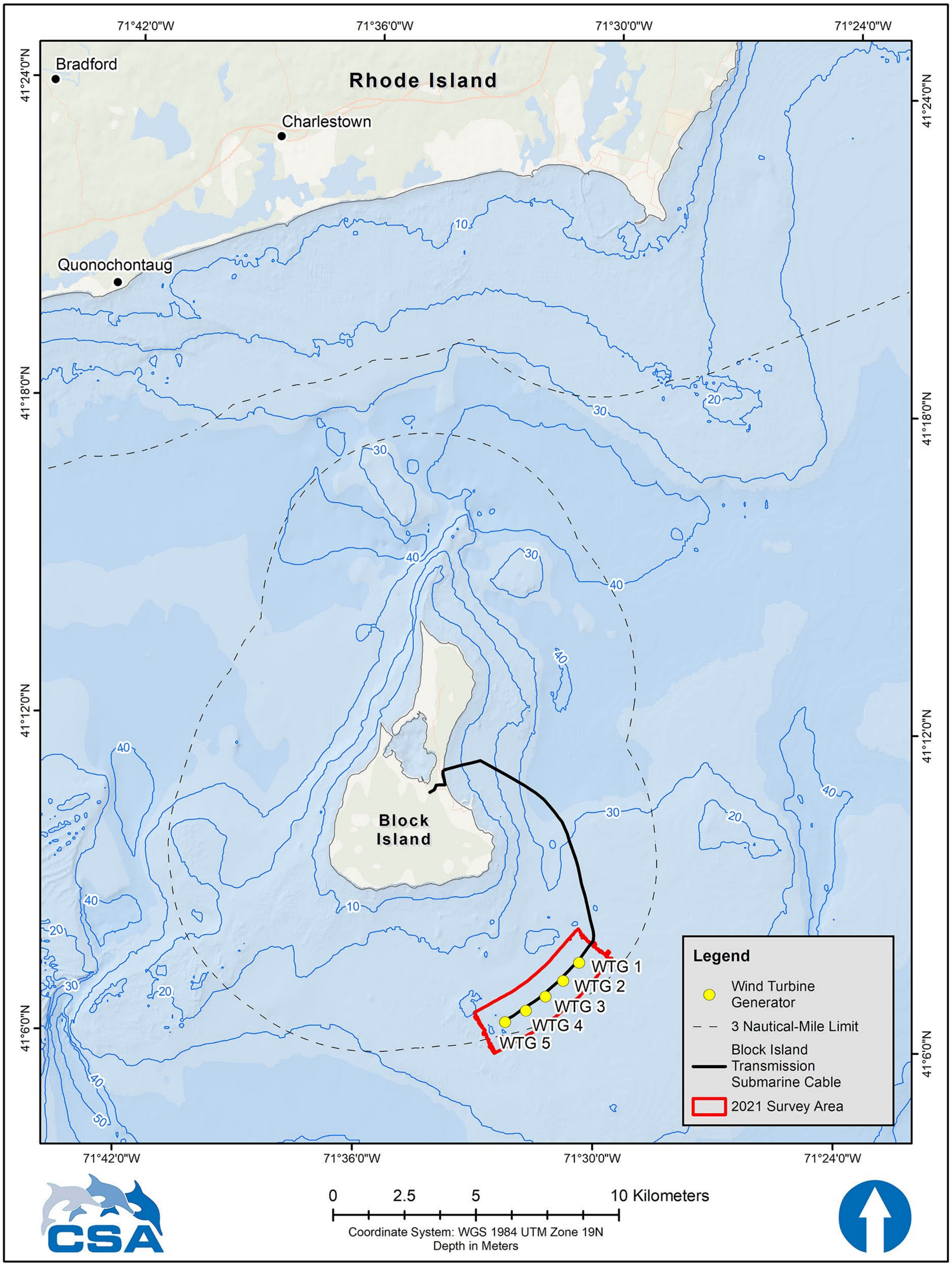

Figure 1. Location of the Block Island Wind Farm
WTG = wind turbine generator.

1.4 General Scope of Work – Hydrographic Data Collection

The scope of work for this Task Order is to provide a record of seafloor alteration and recovery by performing high resolution hydrographic surveys of the BIWF project area to evaluate seafloor changes compared to the previous hydrographic survey completed in September 2018. Results of the previous five surveys can be found in Fugro (2019) and HDR (2020).

2 Survey Methods

2.1 Vessel Overview

The survey was conducted from the R/V *Dolphin*, a 49 ft (15 m) aluminum multipurpose marine science platform specially configured to support geophysical survey operations (**Figure 2**). The vessel layout includes a large aft working deck, a raised wheelhouse with 360° viewing windows, and a structured multi-use service area below decks.

The R/V *Dolphin* is powered by twin diesel motors with a 20-kW generator providing the vessel's electrical supply. On deck are two high-speed integrated winches, each with 6-pass slip rings to support custom instrument interfacing. Each winch is capable of up to 1,500-pound pull with electronic controls for local or remote operation. A 1,500-pound safe working load articulating A-frame is located on the vessel's transom. The legs are spaced 3 m wide for the launch and recovery of large, towed instruments. Two modular J-frames are incorporated on the outboard side of each cross member to provide additional tow points and wider spread for the simultaneous deployment of towed gear.

The below decks service area features an enclosed, climate-controlled cabin 7 m in length by 3.5 m wide and survey desks with three dedicated online workstations. A server rack contains data acquisition computers, uninterrupted power supplies, and rack-mounted instrument accessories. Forward, two offline workstations are dedicated for PSOs and/or client representatives. Likewise, the bridge deck can also be configured to support a PSO workstation proximate to the ideal PSO observation point. A cellular-based wireless network supplies high-speed internet throughout the entire salon deck.

The vessel is complete with all mandated health, safety, security, and environmental (HSSE) gear, such as an Emergency Position-indicating Radio beacon (EPIRB), automatic identification system (AIS), Search and Rescue Transponder (SART), life raft, immersion suits, and personnel locator beacons (PLB). Specifications for the R/V *Dolphin* are provided in **Table 1**.

Figure 2. The 49 ft (15 m) R/V *Dolphin* utilized during the Block Island Wind Farm Geophysical Survey with starboard side pole mount

Table 1. Specifications for the R/V *Dolphin*

R/V *Dolphin* General and Equipment Specifications			
General Specifications			
Length: 14.9 m	Draft: 1.1 m	Beam: 4.6 m	Hull: Aluminum
Electrical System: 20 kW Generator		Electrical Power Supply: 110 V, 230 V	
Fridge and freezer for food storage		Enclosed head	
USCG and SOLAS compliant PPE		SART, EPIRB, PLB, fall protection	
- **Vessel Equipment**			
• 10-foot articulating A-frame with dual J-frames at 1,500-pound safe working load capacity; 8 working pad eye positions			
• 2 × attached J-frames at 750-pound safe working load			
• 2 × Ocean Instruments HS-100 geophysical winches			
• Dual side pole mounts for ultrashort baseline, multibeam, or other sensors			
• Moving vessel profiler mount			
• Sea chest with 0.4 m × 0.4 m dimensions for transducer, echosounder, or custom instrument integration			
• Shock-mounted server rack supporting custom geophysical integrations			
• 3 × IMU mounting plates at vessel common reference point			
• 11 × monitors in salon with duplicated monitors to bridge			
• 3 × online workstations; 2 x offline workstations			
• 2 × GNSS antenna amounts atop wheelhouse			
• Closed circuit camera system for 360° view of vessel and work deck			
• 10,000-pound rated tugger winch			

EPIRB = Emergency Position-indicating Radio Beacon; GNSS = global navigation satellite system; IMU = inertial measurement unit; PLB = personal locator beacon; PPE = personal protective equipment; SART = Search and Rescue Transponder; SOLAS = International Convention for the Safety of Life at Sea; USCG = United States Coast Guard.

2.2 Hydrographic Survey Methods

2.2.1 Mobilization

An R2Sonic 2024 MBES, complete with an integrated inertial navigation system (INS), was mobilized onboard the R/V *Dolphin*. The MBES transceiver/receiver projector was installed on a side pole mounted configuration (**Figure 2**). **Table 2** provides the data collection specifications for the MBES.

Table 2. Multibeam data collection specifications during the Block Island Wind Farm Geophysical Survey

Hydrographic Data Collection Specifications	
Survey vessel	RV *Dolphin*
Vessel draft	3.5 ft
Positioning system	POS MV OceanMaster
Acquisition system	R2Sonic 2024 Multi Beam Echo Sounder
Acquisition software	HYPACK 2020 64bit
Multibeam frequency	430 kHz
Tide application method	PR VRS – RTK 30sec avg.
Referenced tide gauge locations	Quonsit Point, RI, 845049
Heave, pitch, roll method	Applanix POS MV OceanMaster
Datum correction method	NOAA Datum Version 3.1
Sound velocity profiler	AML Base X_2
Post-processing software	HYSWEEP Editor 64 (2020)

AML = Applied Microsystems Ltd.; NOAA = National Oceanic and Atmospheric Administration; PR = Puerto Rico; RTK = real-time kinematic; VRS = virtual reference system.

2.2.2 Sound Velocity

During survey operations, the speed of sound through water data were collected by R2Sonic 2024's built-in AML Micro X sound velocity sensor that measured sound velocity at the MBES head only. Additionally, prior to and after field activities, sound velocity profile (SVP) casts were collected with AML's Base X_2 independent sound velocity profiler and applied during post-processing to refine the soundings taken by the MBES. Multiple cast locations were used to capture representative SVPs of the survey area

In general, the speed of sound was consistent throughout the project area and water column from the 35 SVP's taken over the project duration. Daily sound profile casts during the survey changed by no more than 2 m s^{-1} in any given day. Readings at the sonar head via the R2 Sonics Micro SVP consistently matched those collected by the AML-3 SVP cast (at the head depth).

2.2.3 Navigation and Positioning

For navigation, CSA employed the latest version of HYPACK navigation software supplied with position and motion data from an Applanix POS MV OceanMaster INS.

Surface positioning was obtained from the Applanix POS MV system. CSA conducted data acquisition in WGS84 and applied real-time kinetic (RTK) corrections to global navigation satellite system (GNSS) navigation data. RTK corrections were obtained through virtual reference system (VRS) provided via the Hexagon HxGN SmartNet. R/V *Dolphin*'s internet facilities were utilized to access the VRS. During the calibration test, the two positioning systems were tightly correlated. Easting, northing and height values all fell within the required specification of a maximum of 0.3 m difference between the primary and secondary systems.

The use of a motion sensor was necessary to account for errors in the soundings due to vessel movement. The Applanix POS MV system was installed on the survey vessel to blend GNSS data with angular rate and acceleration data from an IMU integral to the Applanix system and heading provided a robust and accurate full 6° of freedom positioning and orientation solution, ultimately enhancing the accuracy of the MBES.

2.2.4 Patch Test

Prior to the survey, the R/V *Dolphin* performed a patch test on 25 August 2021 to calibrate the hydrographic survey sensors, correcting for systematic (heading, roll, and pitch) errors created by the positioning and mounting angles of the MBES. The patch test data was acquired near Fiske Rock at the southern point of Prudence Island. The patch test calibration test results are shown in **Figure 3**.

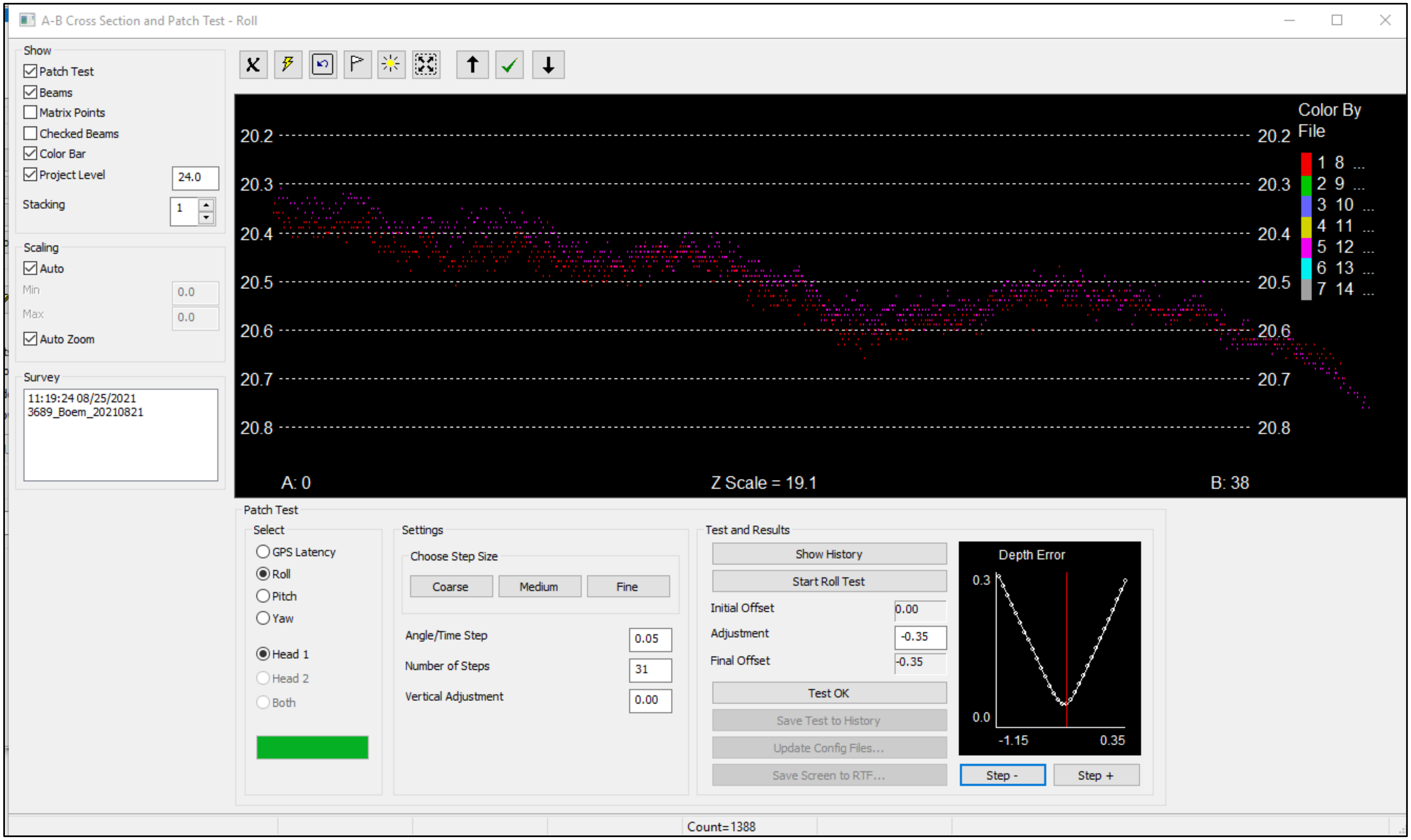

Figure 3. Patch test calibration results

2.2.5 Hydrographic Survey/Bathymetric Data Collection

Hydrographic survey soundings were measured along proposed survey lines using a single R2Sonic 2024 high resolution multibeam echo sounder (MBES). CSA provided a 20% overlap in multibeam data coverage to the extent practical. The MBES operated at a frequency of 430 kHz with an along track beam angle of 100 to 115° depending on water depth. Sonar settings were captured using the auto ping rate function with a range between 9 and 30 Hz. Given the varying water depths and detection requirements, the ping rate and range needed to change to accommodate the different water depths. Other settings such as power, gain, absorption, spreading loss, and pulse length remained constant. The average survey speed was approximately 4 knots. The MBES sonar data setting was selected in the operating software and acquired using the TruePix application. The CSA Survey Team collected sound velocity data using an Applied Microsystems Ltd. (AML) sound velocity sensor.

A survey line plan for the hydrographic survey was developed based on area (1,957 acres), water depths (10 to 32 m), and estimated MBES swarth coverage of the study area. The line plan was developed in HYPACK and exported as geographic information system (GIS) shape files with attributes.

MBES swath width is a function of water depth hence the deeper the water the wider the swath width. The beam angle used was 100 to 115° MBES swath depending on the water depth with a 20% overlap factor. This made the survey acquisition data file sizes manageable and allowed sonar settings to remain consistent within sections for backscatter data compliance.

Execution of the survey included running a series of parallel sounding lines within the defined survey area (**Figure 4**) to provide adequate coverage to identify seabed features, disturbance related seafloor changes, and areas of scour.

The hydrographic survey was conducted from 25 August through 01 September 2021. MBES data were collected from within the survey area along survey tracklines. Data were collected at 430-kHz frequency to provide wide swath coverage in the shallow water while not compromising data resolution.

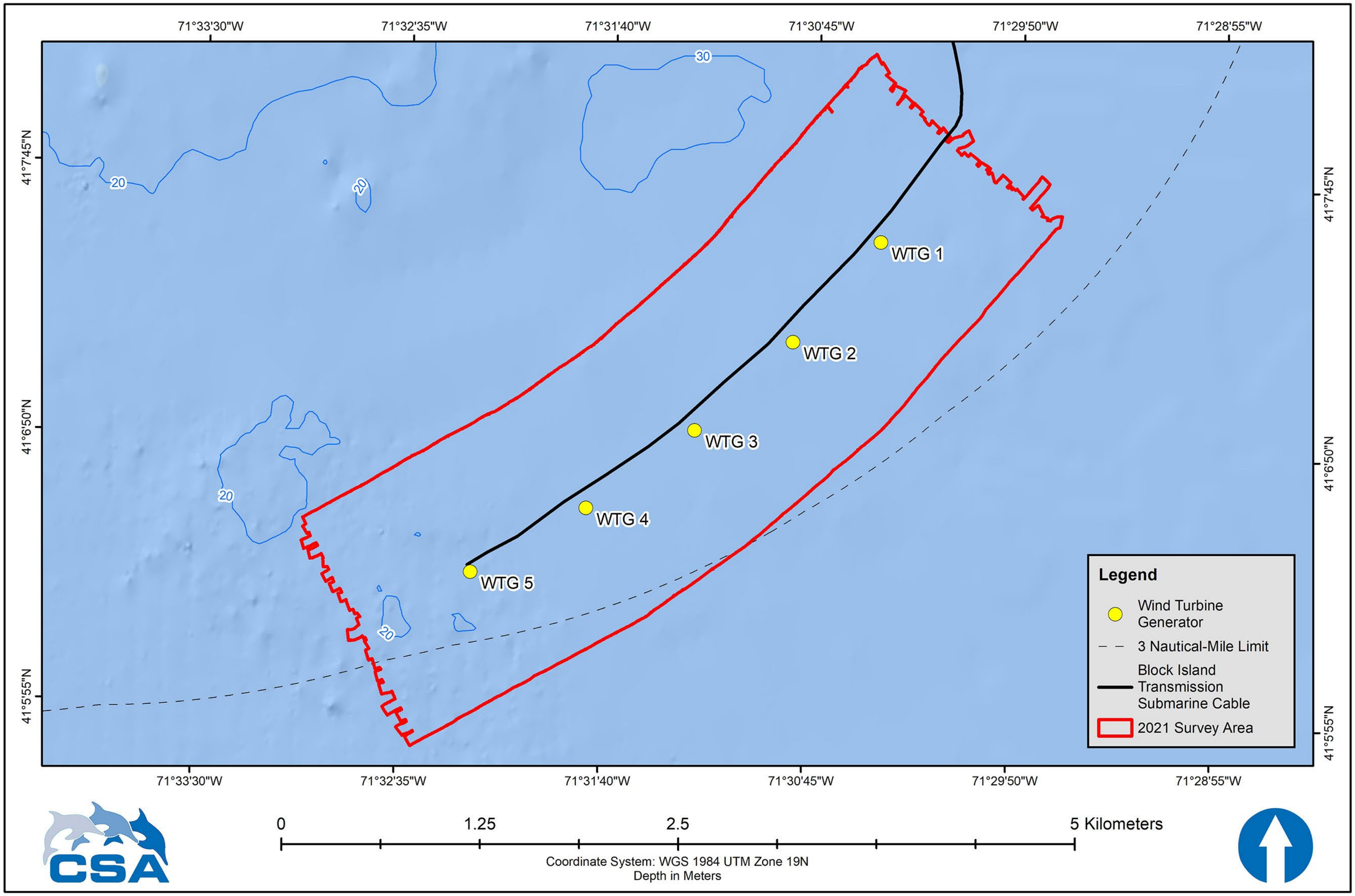

Figure 4. Survey area

The survey was conducted, and data acquired utilizing the geodetic parameters described in **Table 3**.

Table 3. Spatial reference data utilized for the Block Island Wind Farm Hydrographic Survey

Spatial Reference Information			
Horizontal		Vertical	
Projected Coordinate System	UTM North	Vertical Reference Datum	Not applicable
Datum`	WGS84	Tidal Epoch	MLW
Horizontal Zone	Zone 19	Geoid Model	GEOID18-CONUS
Projected Coordinate Units	Meters	Implied Vertical Accuracy	+/- 0.02 meters
Implied Horizontal Accuracy	+/- 0.02 meters	Vertical Control Monuments	ITRF2008

UTM = Universal Transverse Mercator; WGS84 = World Geodetic System 1984; MLW = mean low water; CONUS = Continental United States.

2.3 Data Processing

The R2Sonic 2024 MBES was installed on a pole mount system. The mounting misalignment was calculated by patch test calibration performed on 25 August 2021. The processed patch test results were applied to the online survey setup.

The bathymetric data and positioning quality remained well within the technical specifications in regard to both horizontal and vertical accuracy as well as the point density, throughout the survey duration. Navigation data were post-processed using Applanix POSPac software utilizing both GNSS and inertial technology to achieve a high level of accuracy and repeatability.

Raw MBES data were processed using the HYPACK and HYSWEEP 2020 software as well as the ArcMAP and ArcCatalog utilities within the ArcGIS 10.8 software package. HYPACK was used for both data acquisition and post-processing of the MBES data. In the post-processing application, the HYSWEEP Editor 64 utility was used to apply tide corrections, apply speed of sound corrections, then filter and de-spike the resulting bathymetric point cloud. Next, Fledermaus Geospatial Processing and Analysis Tool was used to produce the MBES bathymetry surfaces and exported for use in ArcGIS.

2.4 Data Interpretation and Analysis

Within the bathymetric data many seabed features were visible, these include (but are not limited to) varying geological features such as gravel, boulders, and vessel debris. From these repeated passes all calibration and verification tests that were conducted confirmed the instruments and software settings were correctly applied and gave the required resolution.

Processed bathymetric data were loaded into a workstation and interpreted using ArcGIS version 10.8.1 software program. In addition to the digital elevation model (DEM), ArcGIS was used to create bathymetric contours and sun-illuminated, hill shaded-relief renderings of the seafloor DEM to enhance seafloor features and aid in visually identifying seafloor disturbances. The bathymetric data from the September 2018 construction survey was compared to the August 2021 bathymetric data using the hill shade models. Hill shade models were produced to highlight shadowing effects in the seafloor terrain to indicate positive or negative relief in the map background. Half meter contour lines were produced for the 2021 dataset to capture vector polygon formations from the raster bathymetry. Report figures from the 2018 Fugro Seafloor Technical Report (Fugro 2019) were georeferenced and sediment disturbance features were digitized from each respective wind turbine generator (WTG) construction area. All calculations performed were in the project geodesy (GCS WGS 1984 UTM Zone 19N).

During the review of each feature, the user refined the digitized extent of the feature and calculated the size of each feature (e.g., area, perimeter, depth). Each digitized feature was associated with the respective construction phase and stored in a GIS database file.

Interpreted seafloor disturbance features are classified based on the following:

- **Spud**: Circular or rectangular depressions arranged in a pattern that match one of the lift boats and are generally located near a WTG.
- **Circular Depression**: Circular depression not associated with a geometric pattern that would have been created when a lift boat was on position and had all three or four legs deployed. Circular depression was generally located away from WTG position.
- **Scour**: Scour feature that formed around the leg of the jacket foundation or around the concrete mat cable protection.

The 2021 hydrographic survey data was compared to 2018 bathymetry data with particular focus on the previously identified seafloor disturbance features as well as identifying additional features. Seafloor disturbance features interpreted from the 2021 survey were compared to their extents in the 2018 survey and interpreted to be partially recovered or completely recovered. Completely recovered features indicate that the feature was no longer discernable in the data.

2.5 Data Quality

The navigation software HYPACK Survey and HYSWEEP Survey 1.21 was used for quality control and monitor all inputs and outputs from all survey equipment systems. Multiple alert displays were setup in HYSWEEP to monitor system status and notify of any deviations in all systems.

All positioning and heading were managed through the Applanix and HYPACK navigation systems. Within those systems, user accuracy alarms were set and monitored. Previous survey of the vessel geometry was utilized for computation off any offsets needed for correction of equipment position.

The R2Sonic 2024 MBES was operated at the required 430 kHz configuration. During survey operations beam steering was optimized to best achieve data coverage and density. Multibeam data acquired was good quality and well within the specifications with regard to both horizontal and vertical accuracy as well as the point density (**Table 4**). During survey operations beam steering was optimized to best achieve data coverage and density.

Table 4. Summary of multibeam echosounder settings

Multibeam Echosounder Settings				
Ave Survey Speed (kn)	Freq. (kHz)	Beam Angle	Detection Mode	Comments
4	430	100 to 115 degrees	Equidistant quad	R2 Sonic EM2024D

Sea states during the August survey were mixed resulting in several weather days during the survey; however, the raw data quality was good. Data were collected and reviewed for quality in the field by the survey team, and then transferred to the CSA office in Stuart, Florida for post-processing.

3 Results Summary

3.1 Summary of Survey 6 (2021)

Table 5 provides a summary of the interpreted features identified during the 2018 Construction Season 5 and the 2021 survey data. A total of 35 seafloor features were identified during the 2021 survey as compared to the 51 identified during the 2018 survey. Of these 26 are partially recovered and 28 have completely recovered based on the 2021 survey, including all of the drag marks. In comparison to the 2018 survey approximately 61% of the disturbed area (a reduction of impact area from 4,384 m^2 to 1,519 m^2 with 2,865 m^2) appear to be completely recovered.

Table 5. Summary of bathymetric data and interpreted features

Interpreted Features	Construction Season 5 (Sept 2018) Features		Recovery Since Sept 2018 at Time of Monitoring Event (Aug 2021)			
	Number of Features	Area (m²)	Number of Features	Partially Recovered Features	Completely Recovered features	Completely Recovered Area (m²)
Spud	16	2,430	10	9	6	583
Circular Depressions	2	12	0	0	2	12
Scour	33	1,942	25	17	20	924
Total	51	4,384	35	26	28	1,519

3.2 Characterization of Seafloor Disturbances and Recovery around Individual Turbines (Survey 6 – 2021)

Figure 5 provides a comparison of the 2018 survey data and the 2021 survey data around each WTG. As can be observed, many of the smaller features identified in the 2018 survey have continued to recover and the larger spud features are continuing to recover. This is most noticeable in **Figure 5** as seen by in the large spud depressions near WTGs 1, 2, and 4 are significantly less prominent in the 2021 survey results compared to the 2018 survey, with infilling occurring, with at least one spud depression near WTG 1 completely recovered. In addition, the depressions created by the spud legs in the southwest adjacent to WTG1 appears to be accumulating cobble and boulders or marine debris within the depression.

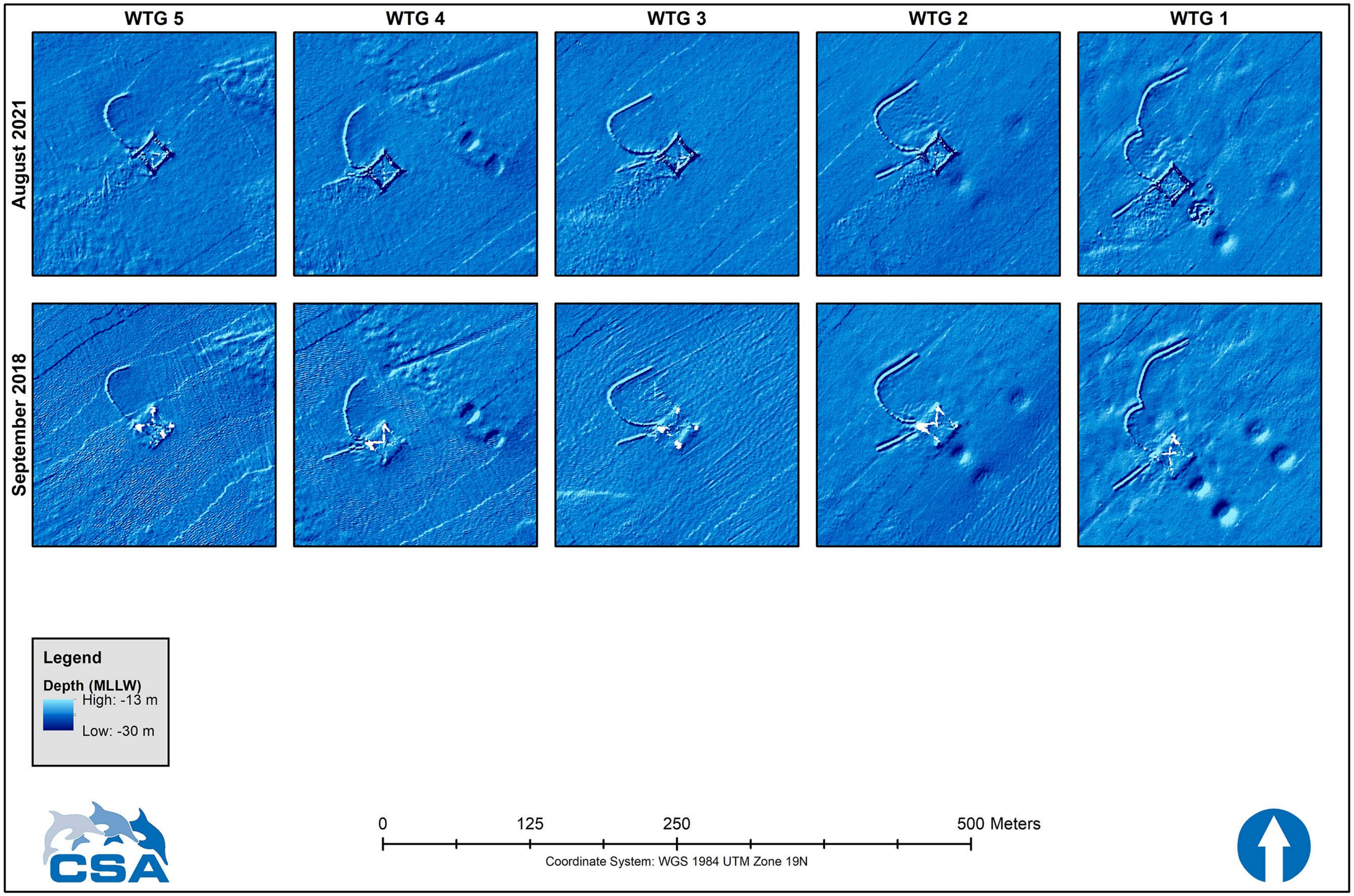

Figure 5. Side-by-side comparison of the seabed disturbance and recovery monitoring data from the 2018 and 2021 surveys

3.2.1 Turbine 1 – Summary

The 2021 bathymetric survey shows a total of 15 seafloor disturbances around WTG 1 (**Figure 6**) that comprises four spud features (pink polygons) and 11 scour locations (yellow polygons) with a total disturbed area remaining of 998 m^2 (**Table 6**). A comparison of the features identified in the 2018 survey with the 2021 survey data is shown in **Figures 6** and **7**. These figures illustrate that four of the previous spud locations (red polygons) appear to be completely recovered with four of the five remaining spud (red polygons) features partially recovered with a current average depression depth of 30 to 50 cm. The spud location in the southwest appears to be accumulating cobble and boulders or potentially marine debris with sand accumulation around it within the depression (**Figure 7**). The material has a high backscatter intensity suggesting hard material and protrudes from approximately 0.5 to 1.5 m above the bottom of the depression. Many of the previously identified scour locations from the 2018 survey appeared to have recovered (black polygons), while new scour areas have developed (**Figure 6**, yellow polygons) along the concrete mats covering the cable and have an average depth of 5 to 20 cm.

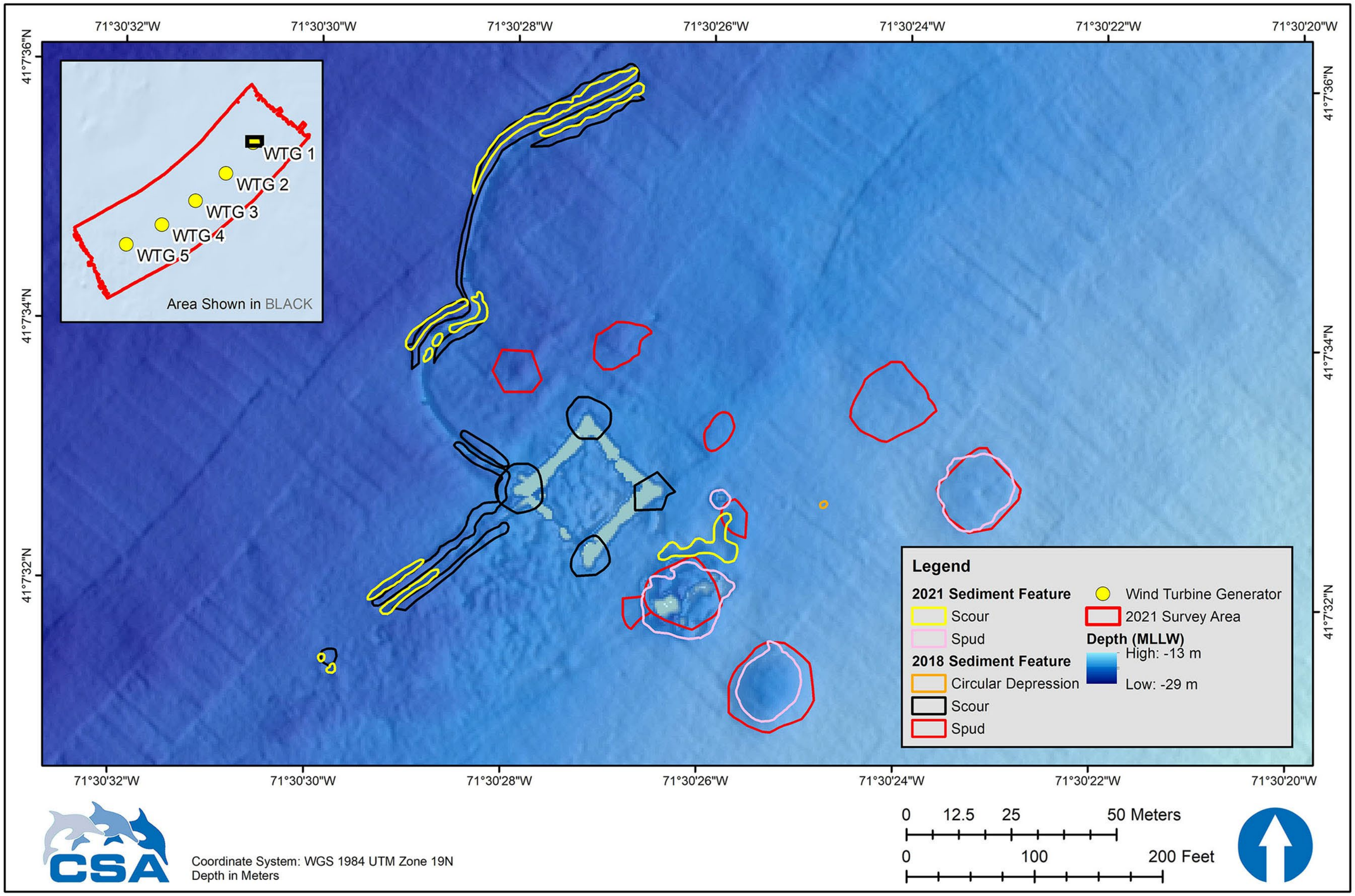

Figure 6. Comparison of seafloor disturbances at wind turbine generator (WTG) 1 between the September 2018 survey and the August 2021 survey

Table 6. Summary of interpreted features for wind turbine generator (WTG) 1 between the September 2018 survey and the August 2021 survey

	Interpreted Features	Construction Season Baseline Disturbances		Monitoring Event 2021 Disturbances					
		Construction Season 5 (Sept 2018) Features		Recovery Since Sept 2018 at Time of Monitoring Event (Aug 2021)					
		Number of Features	Area (m²)	Number of Features	Partially Recovered Features	Completely Recovered Features	Features Total Area (m²)	Partially Recovered Features Area (m²)	Completely Recovered Features Area (m²)
Wind Turbine Generator 1	Spud	9	1,370	5	4	4	735	735	489
	Circular Depressions	1	2	0	0	1	0.0	0.0	2
	Scour	11	858	10	10	5	339	263	337
	Total	21	2,230	15	14	10	1,074	998	828

Partially Recovered Features = those previously identified features that have continued infilling; Completely Recovered Features = those previously identified features that are no longer discernable.

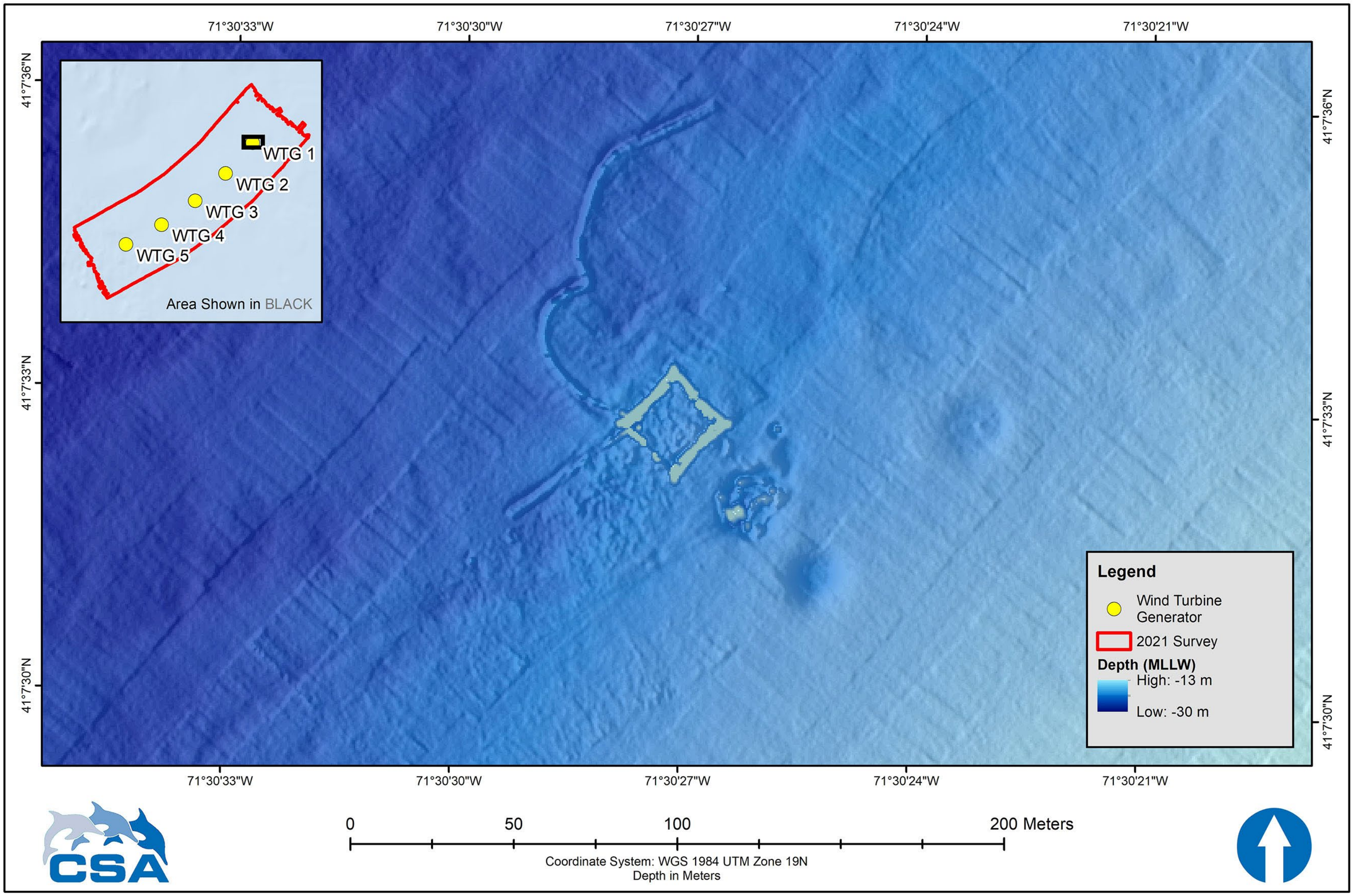

Figure 7. Bathymetry data illustrating the current condition of seafloor disturbances caused during construction activities at wind turbine generator (WTG) 1 observed during the August 2021 survey

3.2.2 Turbine 2 – Summary

Around WTG 2, the 2021 bathymetric survey shows a total of 11 seafloor disturbances (**Figure 8**) that comprise 3 spud features (pink polygons) and 8 scour locations (yellow polygons along cable route and adjacent to the southeast corner of the WTG) with a total remaining disturbed area of 452 m^2 (**Table 7**). **Figures 8** and **9** compare the features identified in the 2018 survey with the 2021 survey data and show of the five spud locations previously observed (red polygons), two are completely recovered and the remaining three are continuing to recover and have reduced in area from 698 m^2 to 373 m^2 (**Table 7**) with an average depth of 15 to 30 cm. Many of the previously identified scour locations (black polygons) appear to have recovered, while new scour locations have developed (**Figure 8,** yellow polygons) with an average depth of 2 to 20 cm.

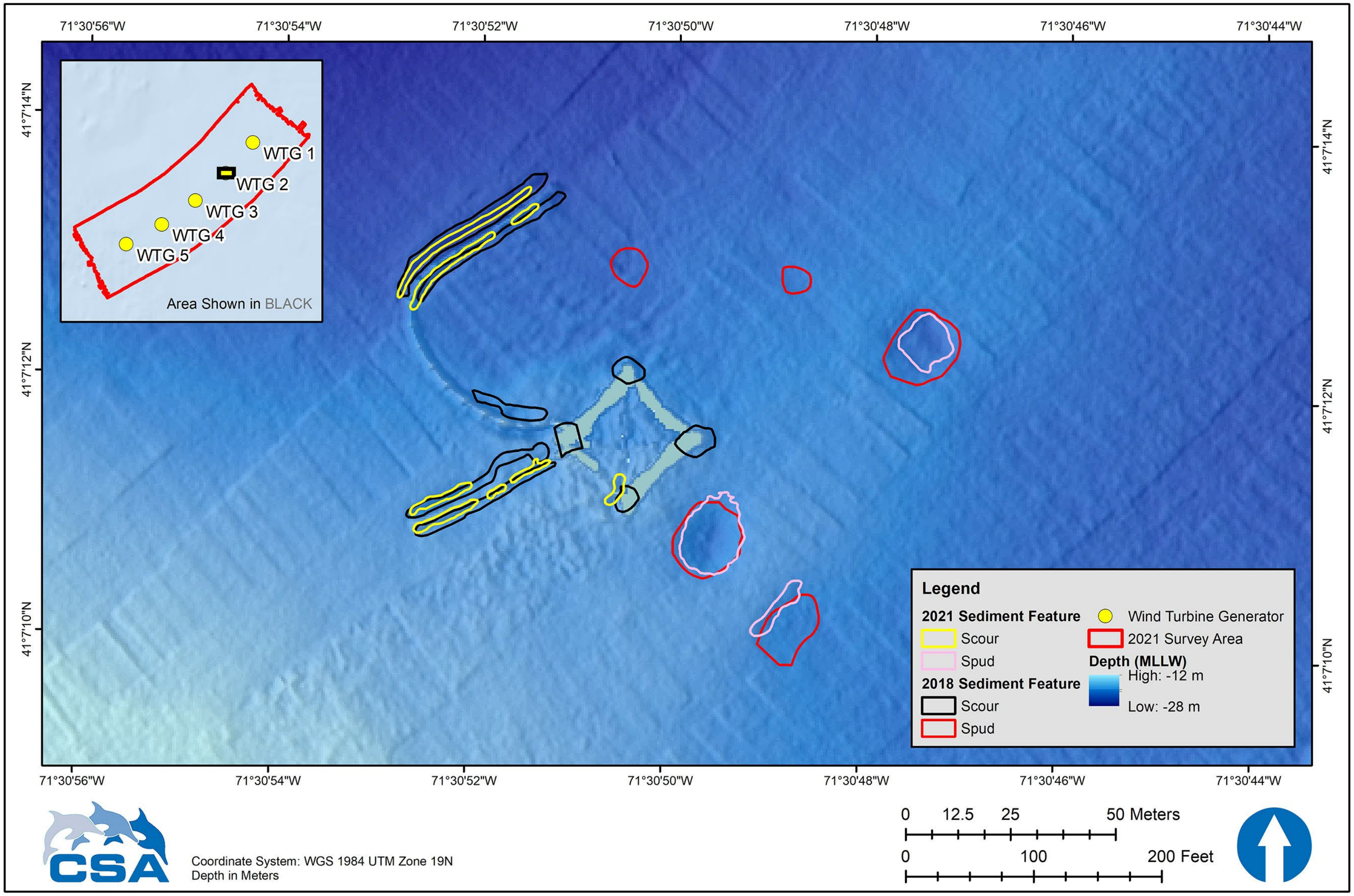

Figure 8. Comparison of seafloor disturbances at wind turbine generator (WTG) 2 between the September 2018 survey and the August 2021 survey

Table 7. Summary of interpreted features for wind turbine generator (WTG) 2 between the September 2018 survey and the August 2021 survey

	Interpreted Features	Construction Season Baseline Disturbances		Monitoring Event 2021 Disturbances					
		Construction Season 5 (Sept 2018) Features		Recovery Since Sept 2018 at Time of Monitoring Event (Aug 2021)					
		Number of Features	Area (m^2)	Number of Features	Partially Recovered Features	Completely Recovered Features	Features Total Area (m^2)	Partially Recovered Features Area (m^2)	Completely Recovered Features Area (m^2)
Wind Turbine Generator 2	Spud	5	698	3	3	2	372	372	94
	Circular Depressions	0	0.0	0	0	0	0.0	0.0	0.0
	Scour	9	589	8	6	4	208	80	163
	Total	14	1,287	11	9	6	580	452	257

Partially Recovered Features = those previously identified features that have continued infilling; Completely Recovered Features = those previously identified features that are no longer discernable.

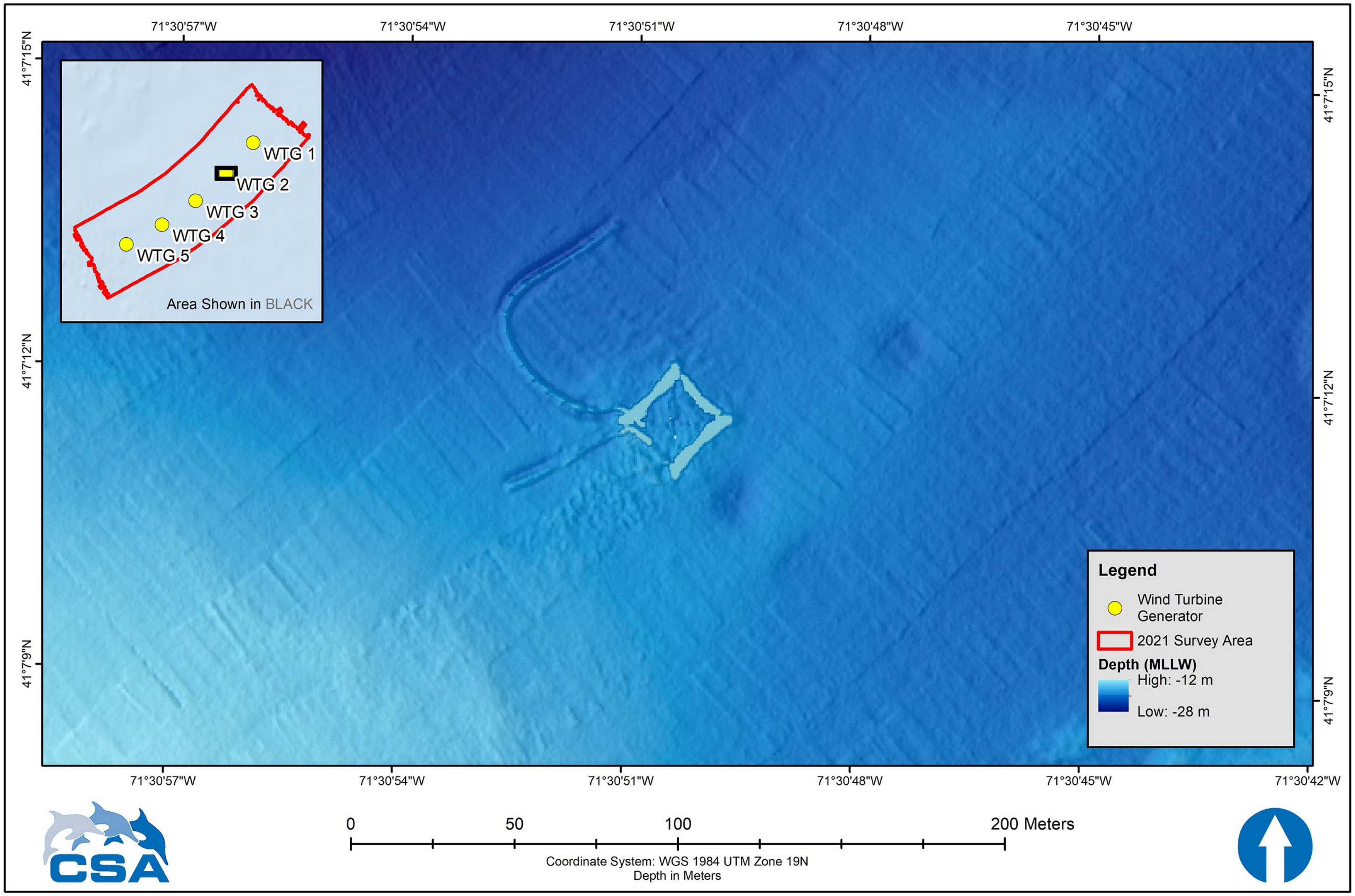

Figure 9. Bathymetry data illustrating the current condition of seafloor disturbances caused during construction activities at wind turbine generator (WTG) 2 observed during the August 2021 survey

3.2.3 Turbine 3 – Summary

The 2021 bathymetric survey shows that the five seafloor disturbances around the WTG 3 observed during the 2018 survey have recovered (**Figure 10**, black and orange polygons; **Table 8**). **Figure 11** provides the 2021 survey data and the seafloor disturbance features. In addition, all of the previously identified scour locations appear to have recovered (**Figure 10**).

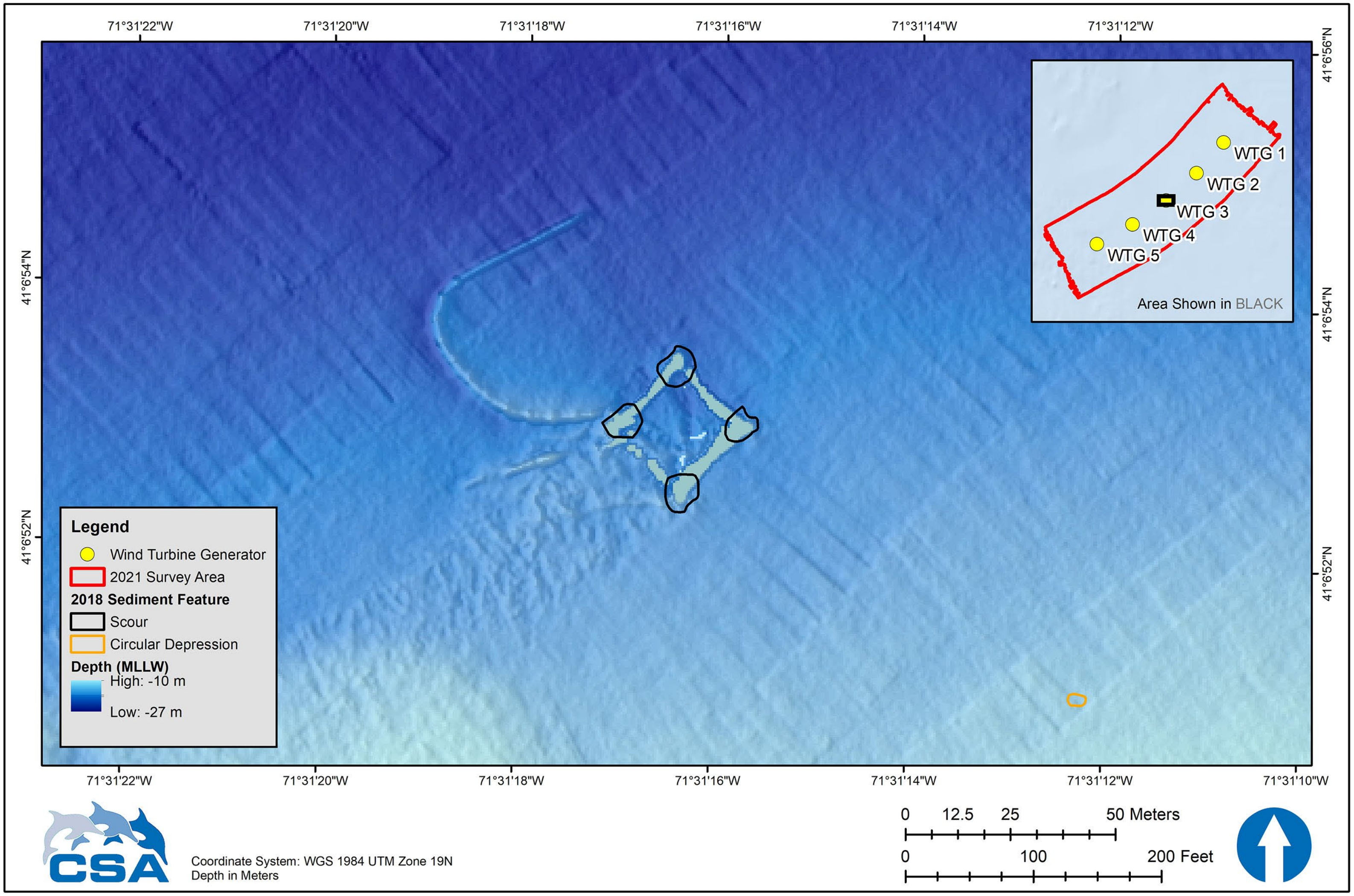

Figure 10. Comparison of seafloor disturbances at wind turbine generator (WTG) 3 between the September 2018 survey and the August 2021 survey

Table 8. Summary of interpreted features for wind turbine generator (WTG) 3 between the September 2018 survey and the August 2021 survey

	Interpreted Features	Construction Season Baseline Disturbances		Monitoring Event 2021 Disturbances					
		Construction Season 5 (Sept 2018) Features		Recovery Since Sept 2018 at Time of Monitoring Event (Aug 2021)					
		Number of Features	Area (m²)	Number of Features	Partially Recovered Features	Completely Recovered Features	Features Total Area (m²)	Partially Recovered Features Area (m²)	Completely Recovered Features Area (m²)
Wind Turbine Generator 3	Spud	0	0	0	0	0	0	0	0
	Circular Depressions	1	10	0	0	1	0	0	10
	Scour	4	210	0	0	4	0	0	210
	Total	5	220	0	0	5	0	0	220

Partially Recovered Features = those previously identified features that have continued infilling; Completely Recovered Features = those previously identified features that are no longer discernable.

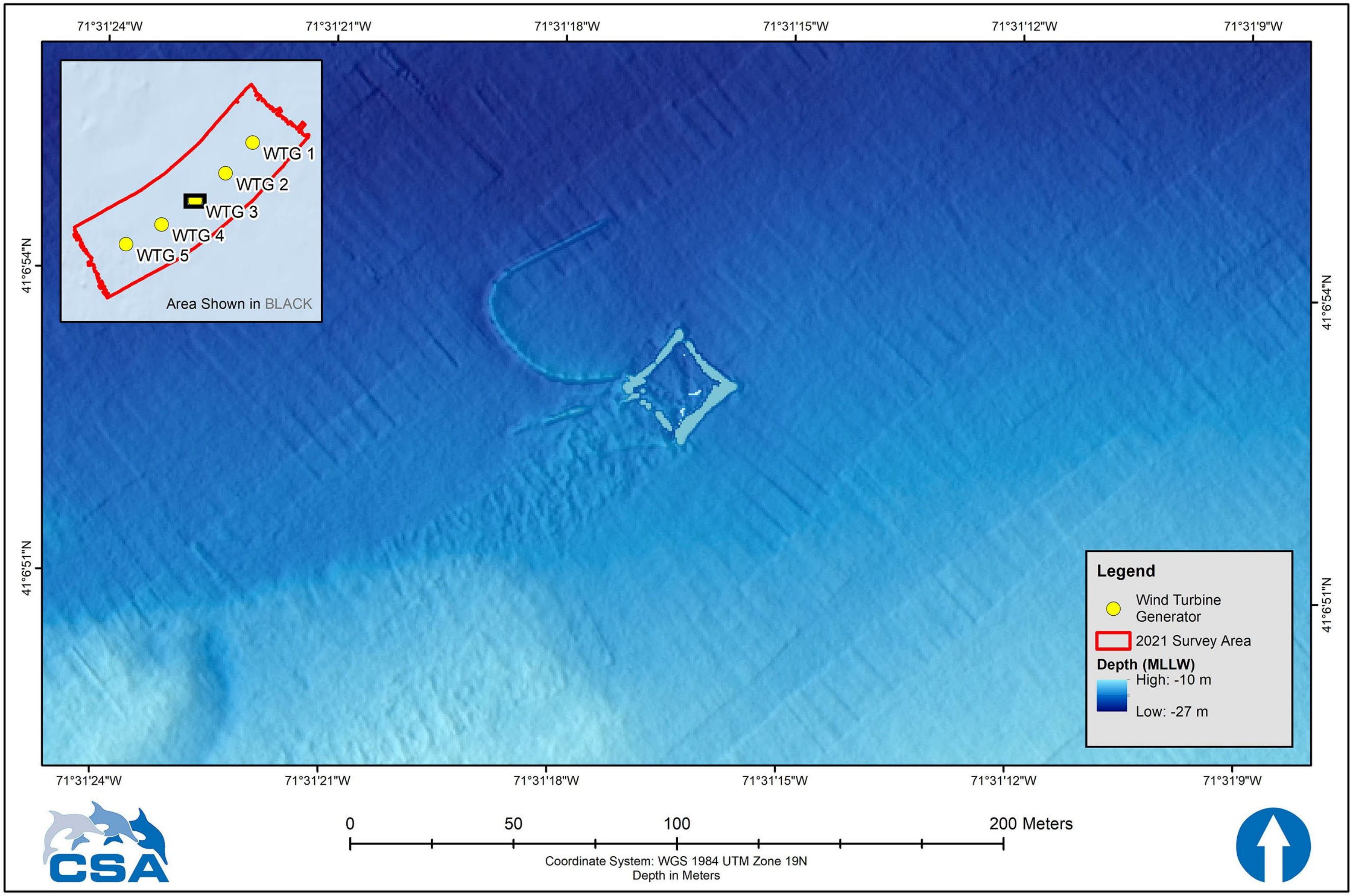

Figure 11. Bathymetry data illustrating the current condition of seafloor disturbances caused during construction activities at wind turbine generator (WTG) 3 observed during the August 2021 survey

3.2.4 Turbine 4 – Summary

Around WTG 4, the 2021 bathymetric survey shows a total of four remaining seafloor disturbances (**Figure 12**, yellow and pink polygons) comprising two spud features (pink polygons) and two scour locations (yellow polygons) with a total disturbed area of 331 m^2 (**Table 9**). As shown in **Figures 12** and **13**, which compares the 2018 and 2021 survey data, the two spud locations previously observed (red polygons) are continuing to recover and have reduced in area from 362 m^2 to 317 m^2 (**Table 9**) and have an average depth of 10 to 20 cm. Many of the previously identified scour locations appear to have recovered (black polygons), while new scour areas have developed (yellow polygons, **Figure 12**) that average 5 to 10 cm in depth.

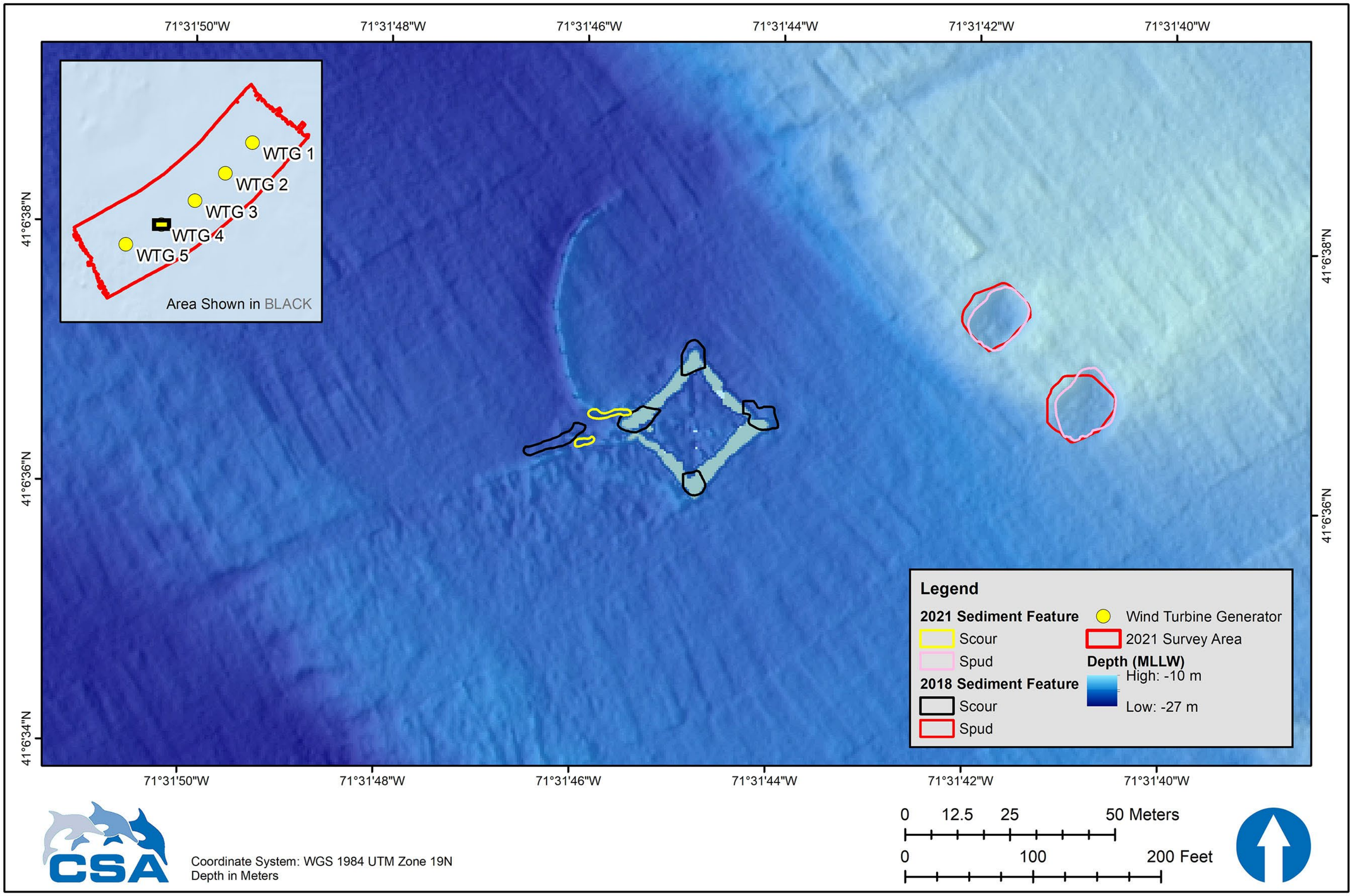

Figure 12. Comparison of seafloor disturbances at wind turbine generator (WTG) 4 between the September 2018 survey and the August 2021 survey

Table 9. Summary of interpreted features for wind turbine generator (WTG) 4 between the September 2018 survey and the August 2021 survey

	Interpreted Features	Construction Season Baseline Disturbances		Monitoring Event 2021 Disturbances					
		Construction Season 5 (Sept 2018) Features		Recovery Since Sept 2018 at Time of Monitoring Event (Aug 2021)					
		Number of Features	Area (m²)	Number of Features	Partially Recovered Features	Completely Recovered Features	Features Total Area (m2)	Partially Recovered Features Area (m²)	Completely Recovered Features Area (m²)
Wind Turbine Generator 3	Spud	2	362	2	2	0	0	317	0
	Circular Depressions	0	0	0	0	0	0	0	0
	Scour	5	170	2	1	3	0	14	99
	Total	7	532	4	3	3	0	331	99

Partially Recovered Features = those previously identified features that have continued infilling; Completely Recovered Features = those previously identified features that are no longer discernable.

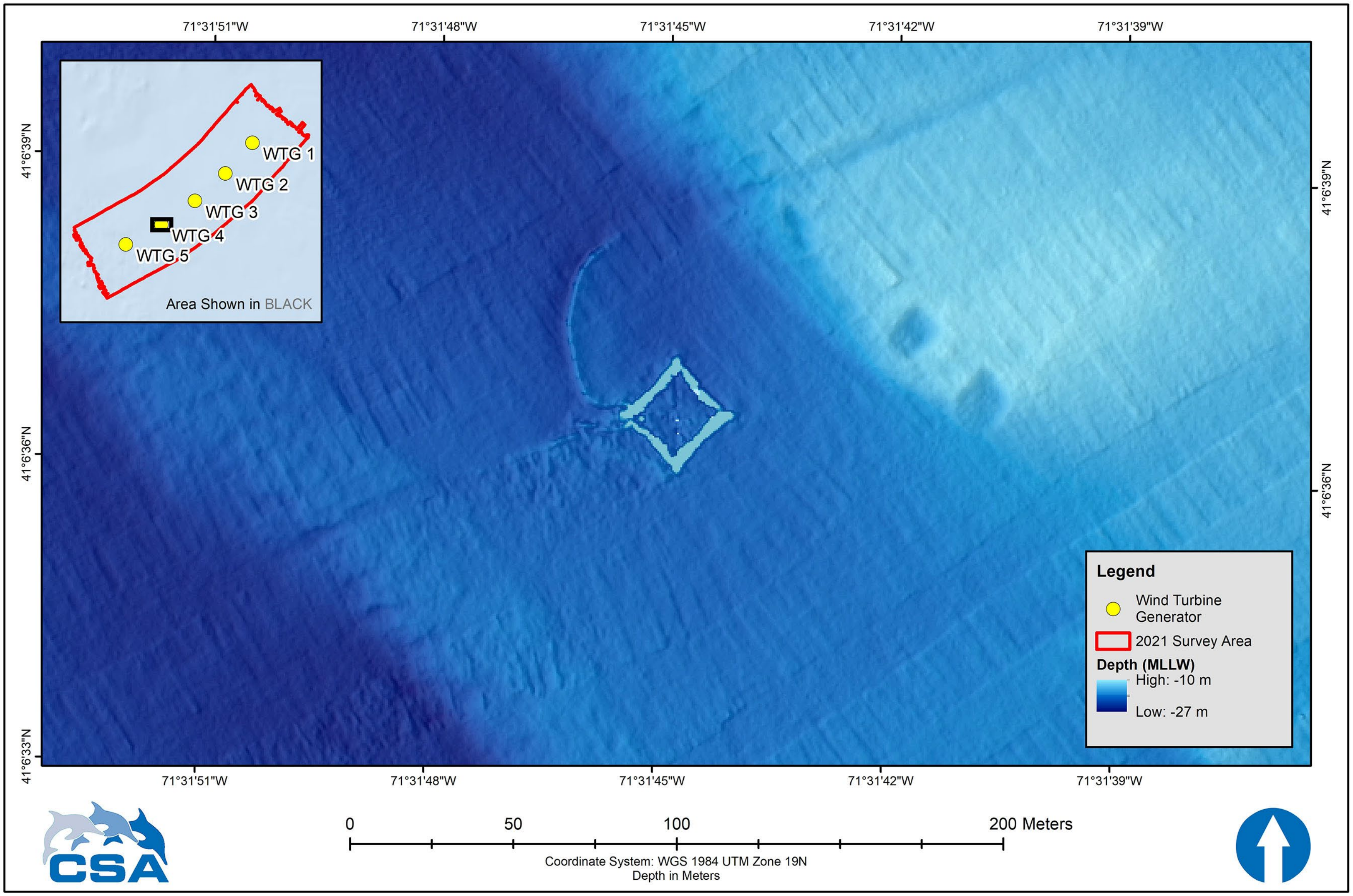

Figure 13. Bathymetry data illustrating the current condition of seafloor disturbances caused during construction activities at wind turbine generator (WTG) 4 observed during the August 2021 survey

3.2.5 Turbine 5 – Summary

The 2021 bathymetric survey shows that there are five scour areas around the WTG 5 (**Figure 14**, yellow polygons; **Table 10**). Many of the previously identified scour locations at the base of the WTG (black polygons) appear to be recovered, while new scour areas along the cable have developed (**Figure 14**, yellow polygons) that average 5 to 20 cm in depth. **Figure 15** provides the 2021 survey data and the scour areas.

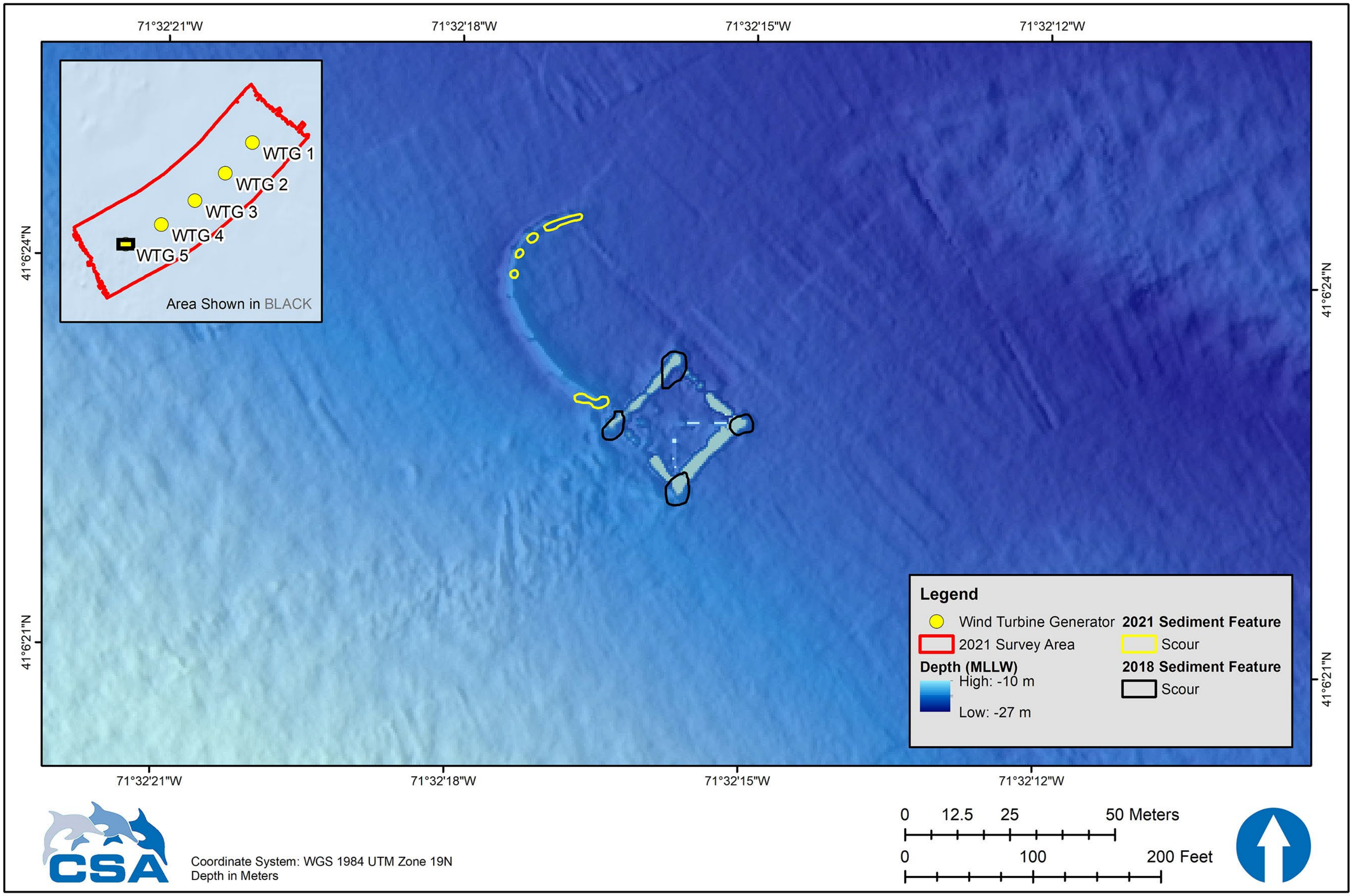

Figure 14. Comparison of seafloor disturbances at wind turbine generator (WTG) 5 between the September 2018 survey and the August 2021 survey

Table 10. Summary of interpreted features for wind turbine generator (WTG) 5 between the September 2018 survey and the August 2021 survey

	Interpreted Features	Construction Season Baseline Disturbances		Monitoring Event 2021 Disturbances					
		Construction Season 5 (Sept 2018) Features		Recovery Since Sept 2018 at Time of Monitoring Event (Aug 2021)					
		Number of Features	Area (m²)	Number of Features	Partially Recovered Features	Completely Recovered Features	Features Total Area (m²)	Partially Recovered Features Area (m²)	Completely Recovered Features Area (m²)
	Spud	0	0	0	0	0	0	0	0
	Circular Depressions	0	0	0	0	0	0	0	0
	Scour	4	115	5	0	4	37	0	115
	Total	4	115	5	0	4	37	0	115

Partially Recovered Features = those previously identified features that have continued infilling; Completely Recovered Features = those previously identified features that are no longer discernable.

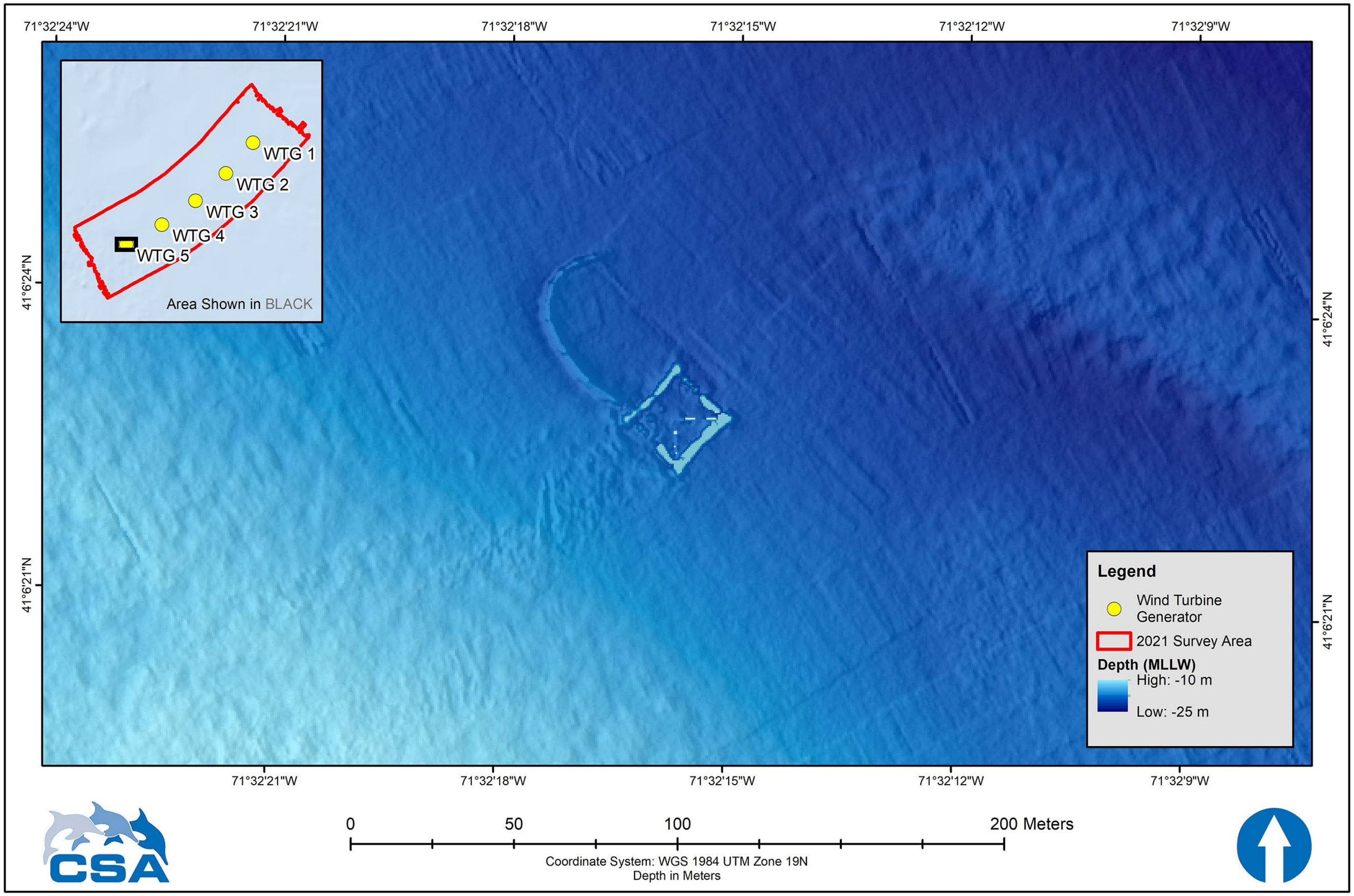

Figure 15. Bathymetry data illustrating the current condition of seafloor disturbances caused during construction activities at wind turbine generator (WTG) 5 observed during the August 2021 survey

3.3 Conclusion

The results of the 2021 hydrographic survey indicate that the spud locations appear to be continuing to recover with some no longer discernable (WTGs 1 and 2); however, the remaining spud locations adjacent to WTGs 1 and 2 are deeper than those near WTG 4 (**Figure 5**). The current spud depressions adjacent to WTGs 1 and 2 average 30 to 50 cm and 15 to 30 cm in depth, respectively, while the spud depressions adjacent to WTG 4 average 10 to 20 cm. The recovery rates could be a function of the sediment type present around the WTGs. Preliminary data from grab samples taken near WTGs 1, 3, and 5 indicate that there is more gravel component to the substrate around WTG 1 in comparison to WTGs 3 and 5 which is predominantly sand. A comparison of only the sand fraction of the sediment samples suggests that the sediment around WTG 1 contains less very coarse sand and more medium- to fine-grained sand than either WTG 3 or 5 which was comprised of predominantly coarse- and very coarse-grained sand with some medium-grained sand. Grab samples were not taken around WTGs 2 or 4.

As would be expected since the scour locations are much smaller than the spud depressions, it appears as if the scour locations are more dynamic in nature than the spud depressions with many previously identified scour locations recovered while others are now present that have an average depth range of 5 to 20 cm for WTGs 1, 2, and 5, while the scour locations around WTG 4 are shallower and average 5 to 10 cm in depth.

4 References

Fugro. 2019. Seafloor disturbance and recovery monitoring program survey 5 September 2018, Block Island Wind Farm. August 23, 2019. HDR Environmental, Operations and Construction, Inc. 22 pp + Appendices.

HDR. 2020. Seafloor Disturbance and Recovery Monitoring at the Block Island Wind Farm, Rhode Island – Summary Report. Final Report to the U.S. Department of the Interior, Bureau of Ocean Energy Management, Office of Renewable Energy Programs. OCS Study BOEM 2020-019. 317 pp.

References

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