Importance of Sub Seabed Archaeology Surveys for Wind Farm Development

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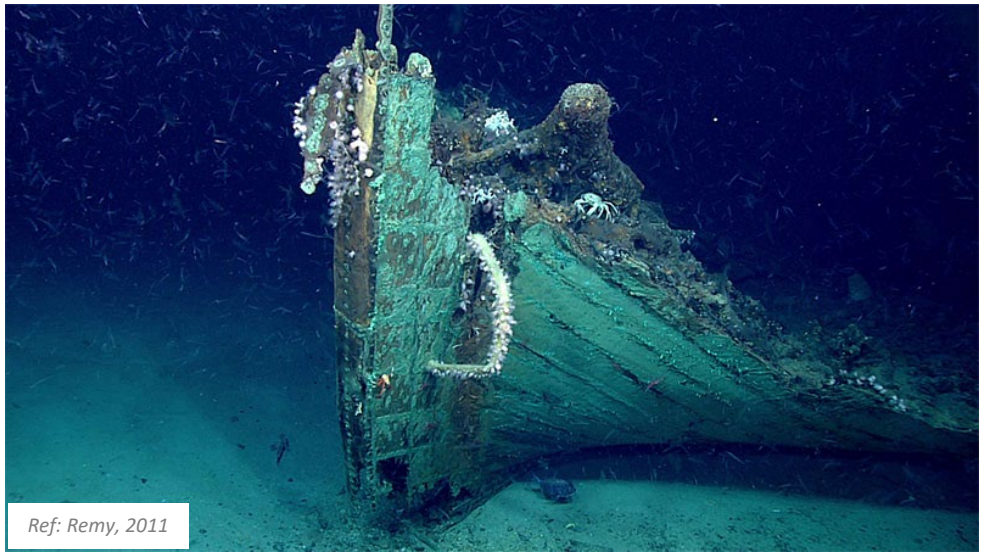
KRS-GRP-HSEQ-PPT-002 Rev 2.0

Problem Statement

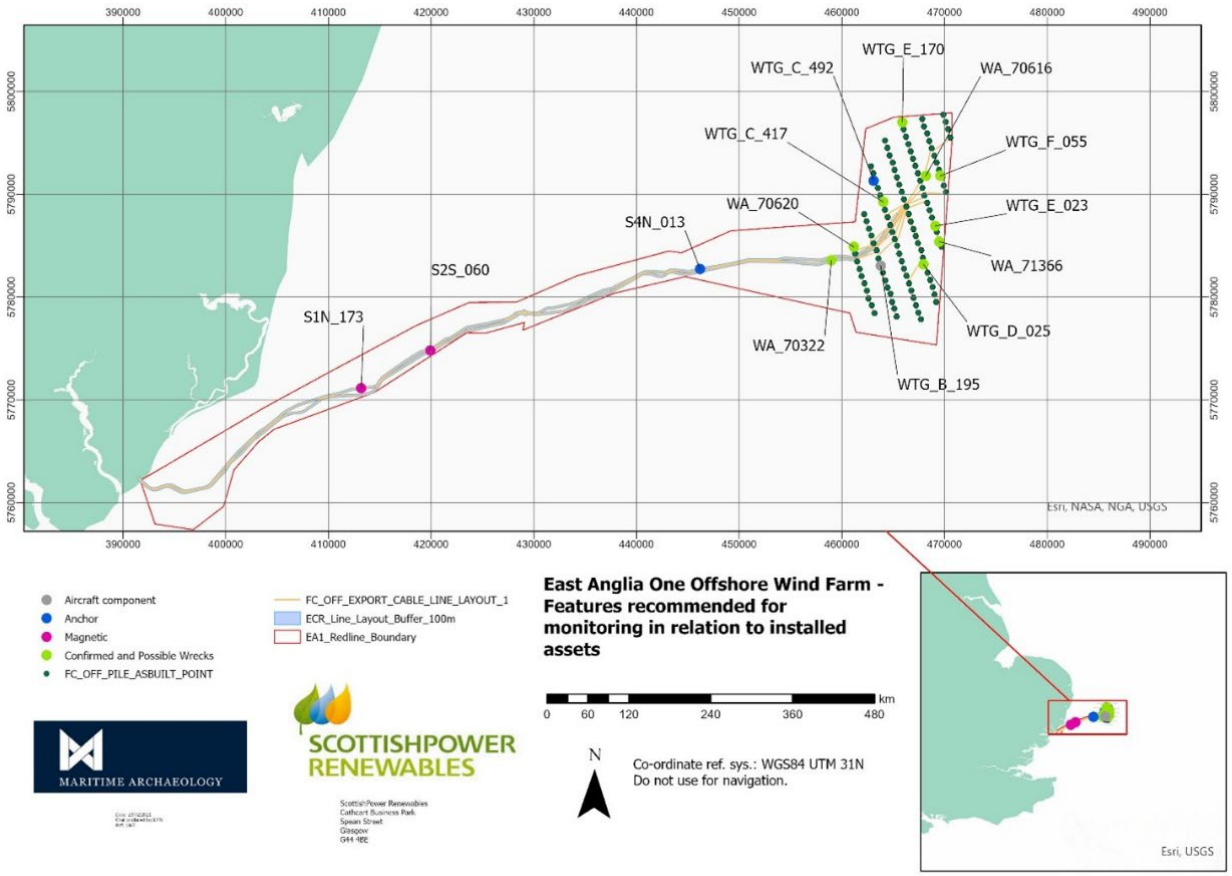
- Archeological sites are an important consideration during the development of wind farms for two main reasons:
  - Preservation of archeological sites and important historical finds.
  - Safe installation of wind farm foundations, inter array cables, and export cable.
- Since historic items have been on the seabed for hundreds of years it is possible that the items can be buried, or partially buried, beneath the seabed leaving them undetected by traditional hydroacoustic devices.



Ref: Remy, 2011

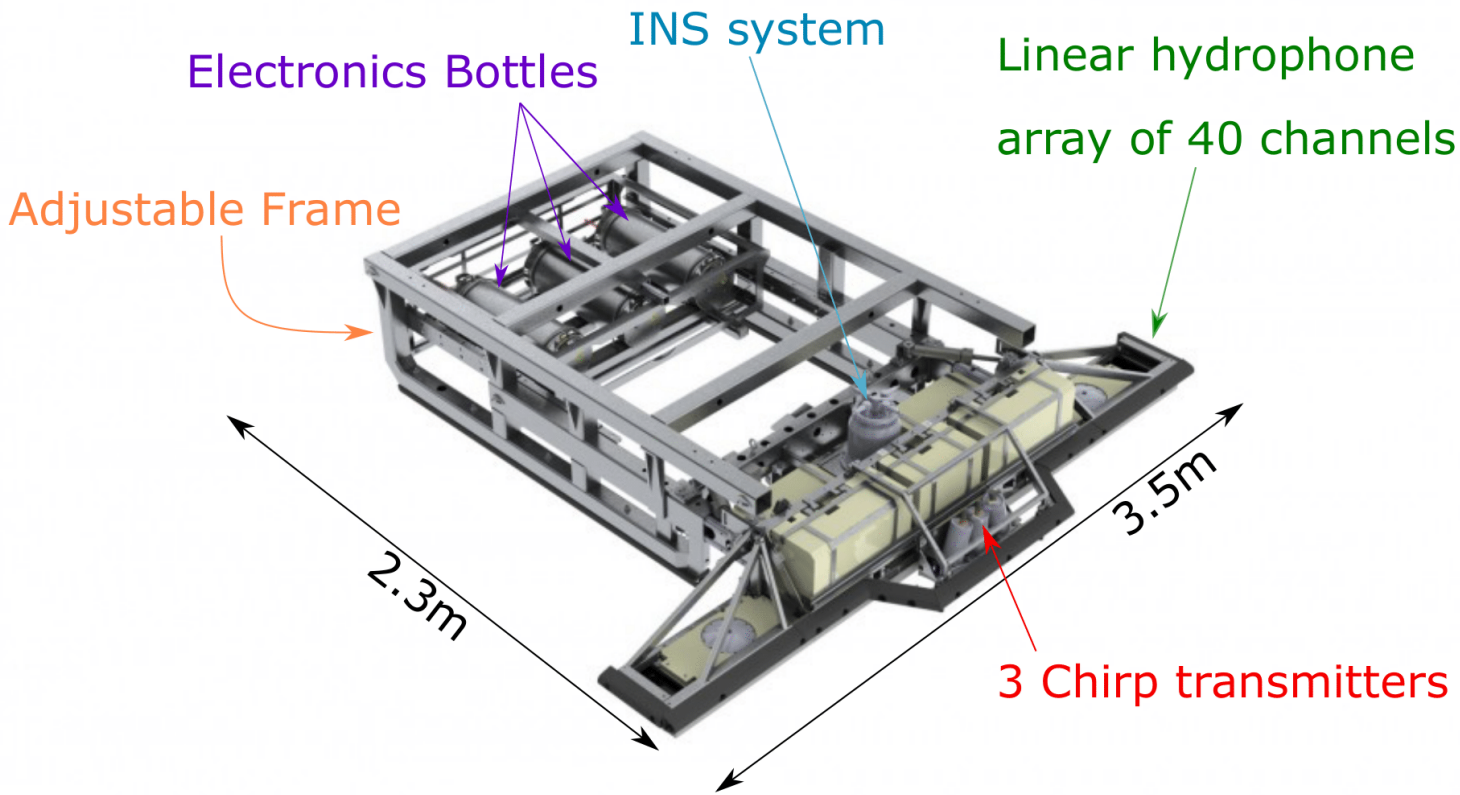
Introduction

- The East Anglia One (EA1) Windfarm was completed in 2020 and has 102 turbines and generators.
- During the construction of EA1 several potential archeological sites were identified and continuously monitored.
- Kraken Robotics, formerly PanGeo Subsea, was hired by Scottish Power Renewables to perform a Sub Bottom Imager Survey (SBI) over the archeological sites.
- The SBI data was collected in 5 m x 5 m and 20 m x 20 m grids around expected archeological targets such as Anchors, aircraft components, shipwrecks, and magnetic anomalies.



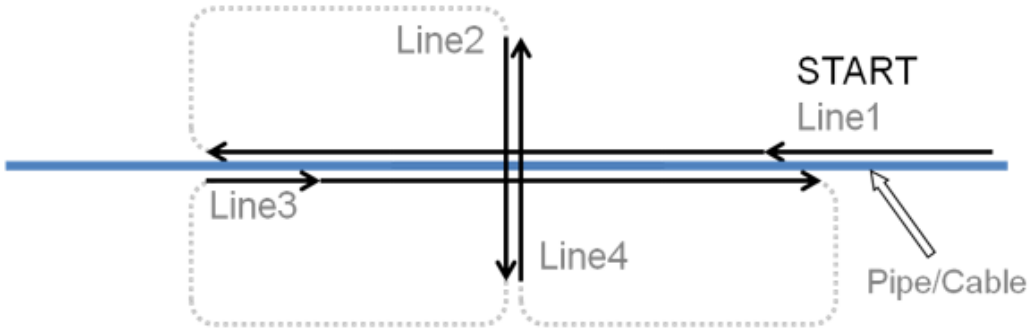
Equipment

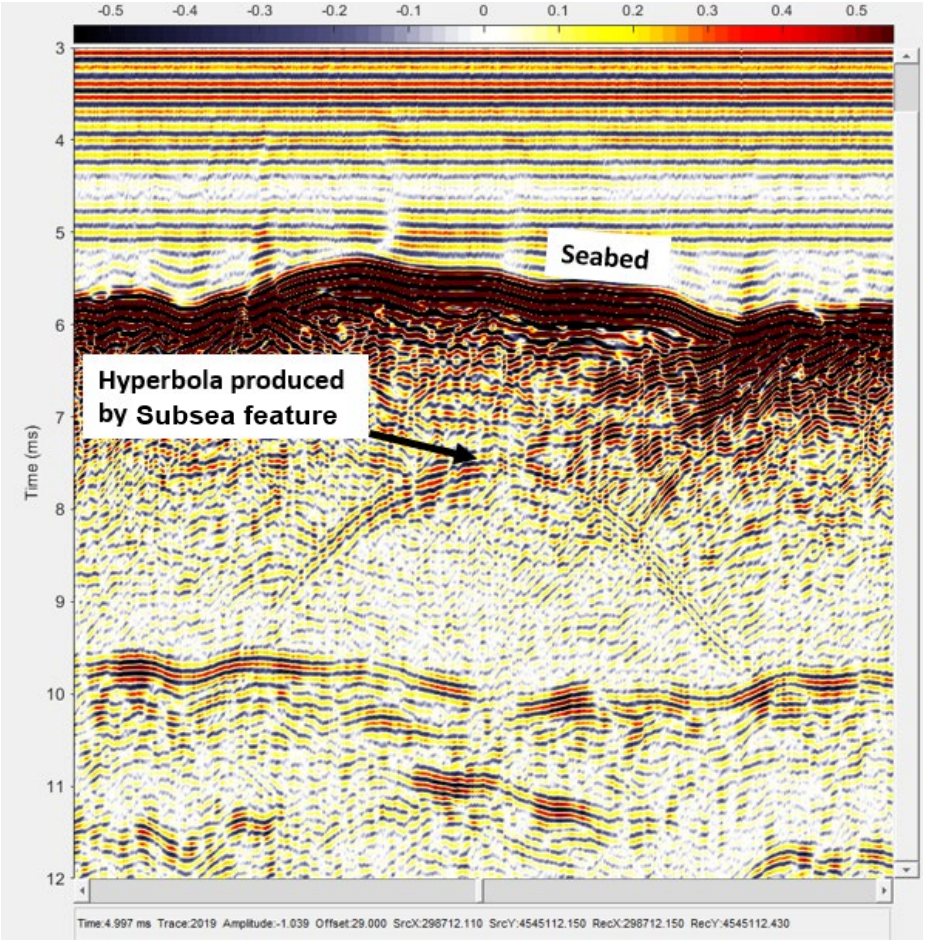
- The SBI was mounted to a Work Class Remotely Operated Vehicles (WROV). The SBI configuration consists of the following items:
  - 3 x chirp projectors
  - 5 x Hydrophones
  - SBI transmitter bottle
  - SBI receiver bottle
  - Interface cables (power and network)
  - Inertial Navigation System (INS)
  - Depth Senor
  - Velocimeter
  - Doppler Velocity Log (DVL)



Equipment - Calibration

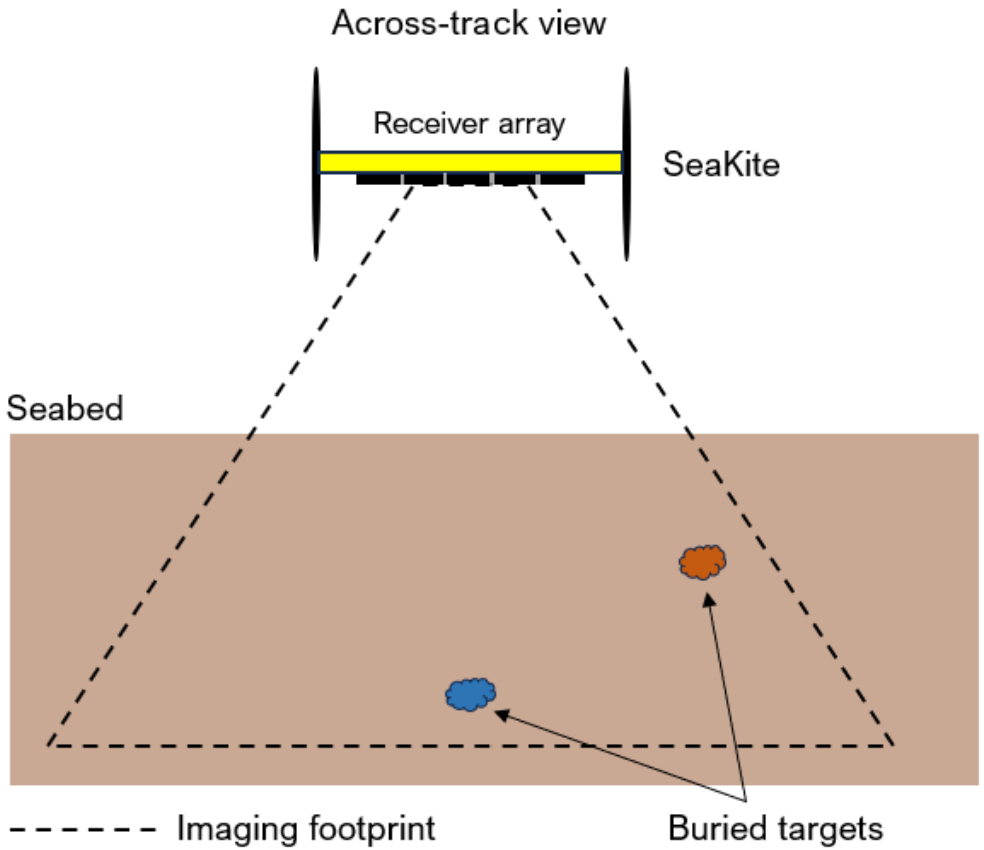
- The SBI requires system calibration for positional accuracy and velocity semblance.
- The SBI is run in a four-line pattern over a cable or known object to confirm position, repeatability, and positioning of the SBI data.
- Using in house seismic processing and visualization software, ZoomSpace, velocity of the subsurface is determined to further enhance the accuracy of the data.





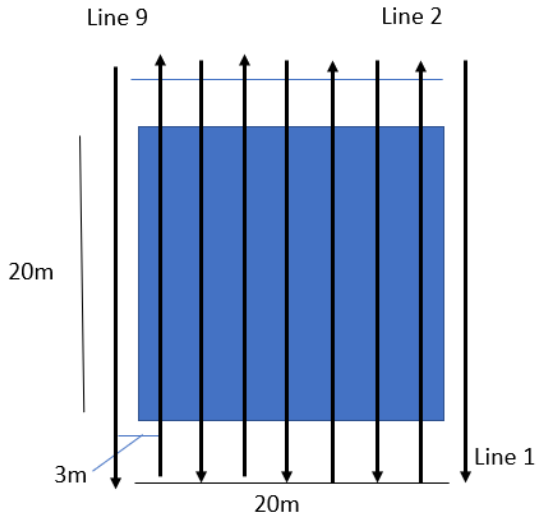
Data Acquisition & Imaging

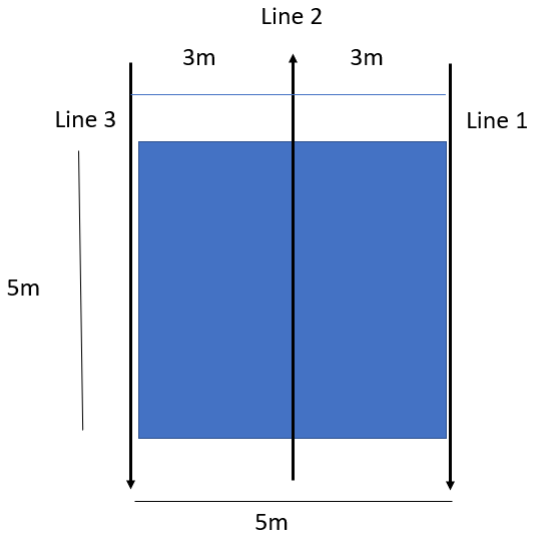
- Source frequencies 4.5 – 12.5 kHz
- The SBI uses
  - delay & sum beamformer in the across-track direction
  - SAS processing in the direction of travel.
- Fly height ~ 3.5 m above the seabed
- Speed ~ 1.6 m/s
- Images in real-time a 5 m width (at the seabed) by 8 m deep section

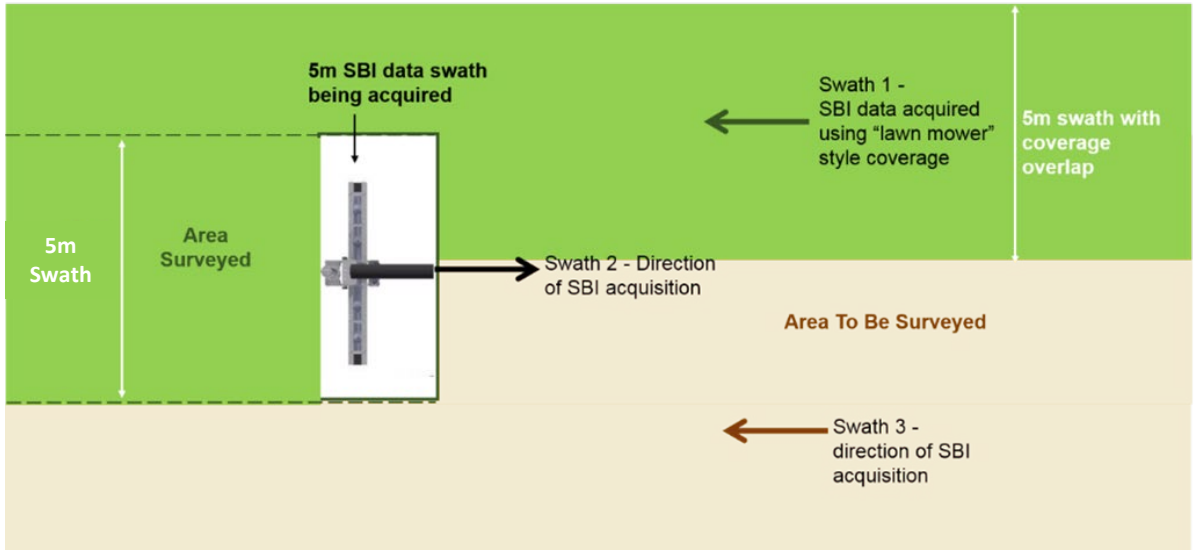


Data Acquisition - Pattern

- The data was acquired in 5 m x 5 m and 20 m x 20 m grids over potential and previously known targets.
- To collect 200 % data coverage within the grids the line spacing needed to be three metres and collected in a ‘lawnmower’ pattern.
- Data coverage was confirmed in QGIS using an inhouse plugin developed to highlight areas that have 100%, 200%, and zero percent coverage.







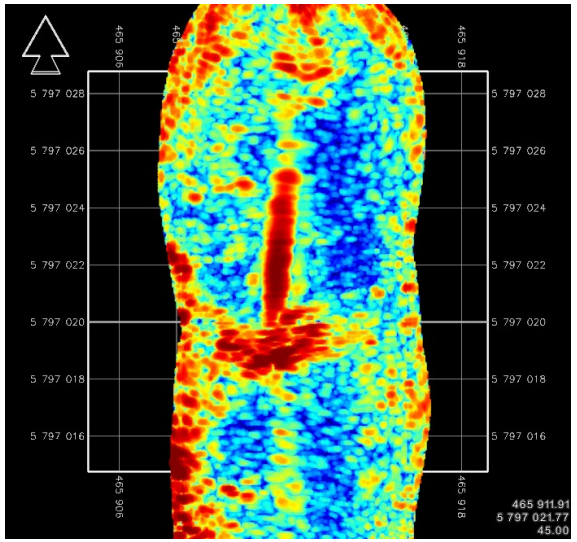
Data Acquisition - Targets

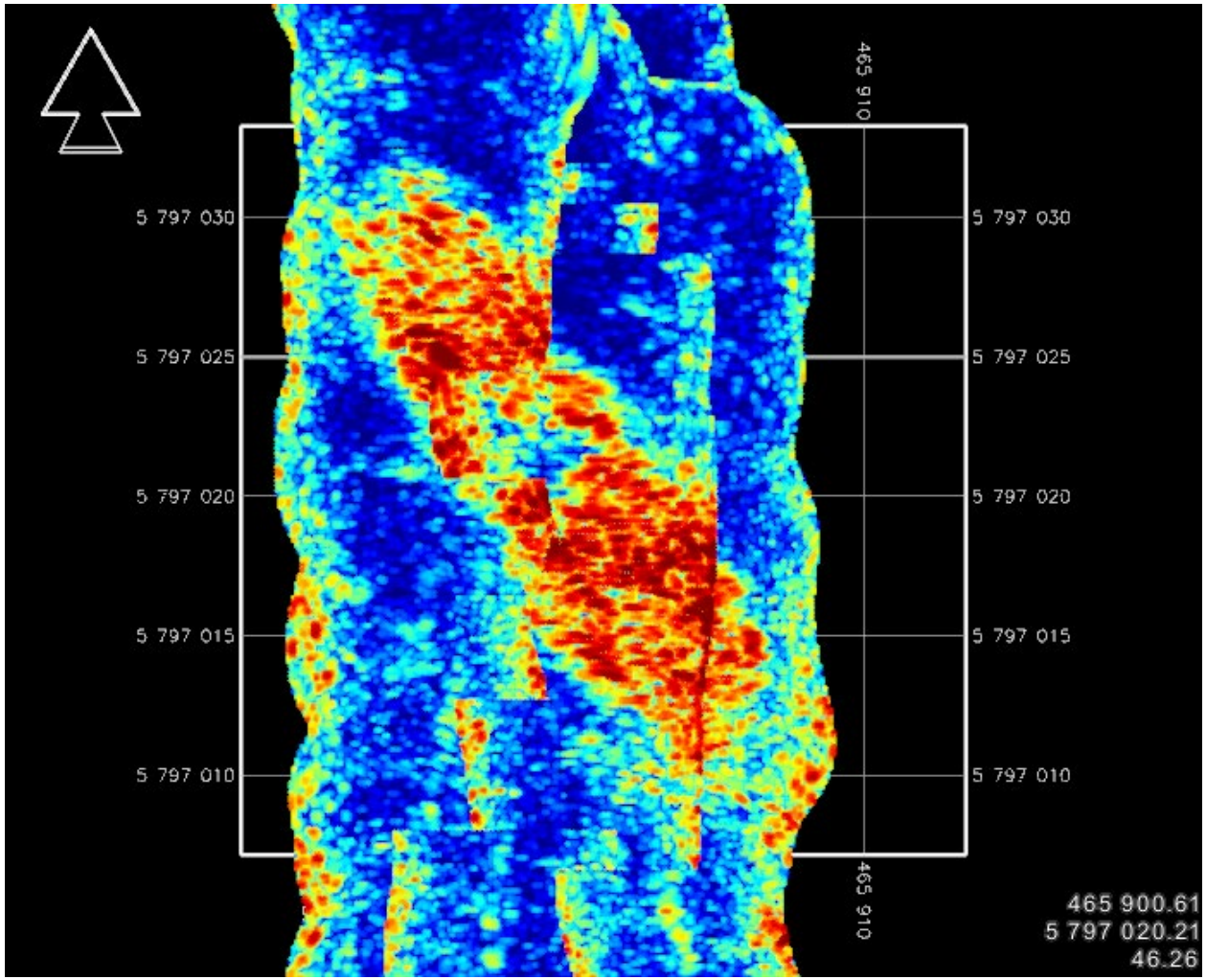
- 15 targets were identified for the SBI survey consisting of:
  - 3 Anchors
  - 1 Aircraft Component
  - 2 Magnetic targets
  - 9 Shipwrecks

TARGET ID	TYPE	WATER DEPTH	GRID SIZE (METERS)
S4N_013	Anchor	38m	< 5x5
WTG_D_154	Anchor	38m	< 5x5
WTG_C_492	Anchor	41m	< 5x5
WTG_B_195	Aircraft component	44m	< 5x5
S1N_173	Magnetic	25m	< 20x20
S2S_060	Magnetic	30m	< 20x20
WA_70616	Shipwreck	40m	< 20x20
WA_70620	Shipwreck	43m	> 20x20
WA_70322	Shipwreck	48m	< 20x20
WA_71366	Shipwreck	40m	> 20x20
WTG_C_417/420	Shipwreck	40m	> 20x20
WTG_D_025	Shipwreck	45m	< 20x20
WTG_E_023	Shipwreck	40m	< 20x20
WTG_E_170	Shipwreck	46m	< 20x20
WTG_F_055	Shipwreck	40m	< 20x20

SBI Survey Results - 1

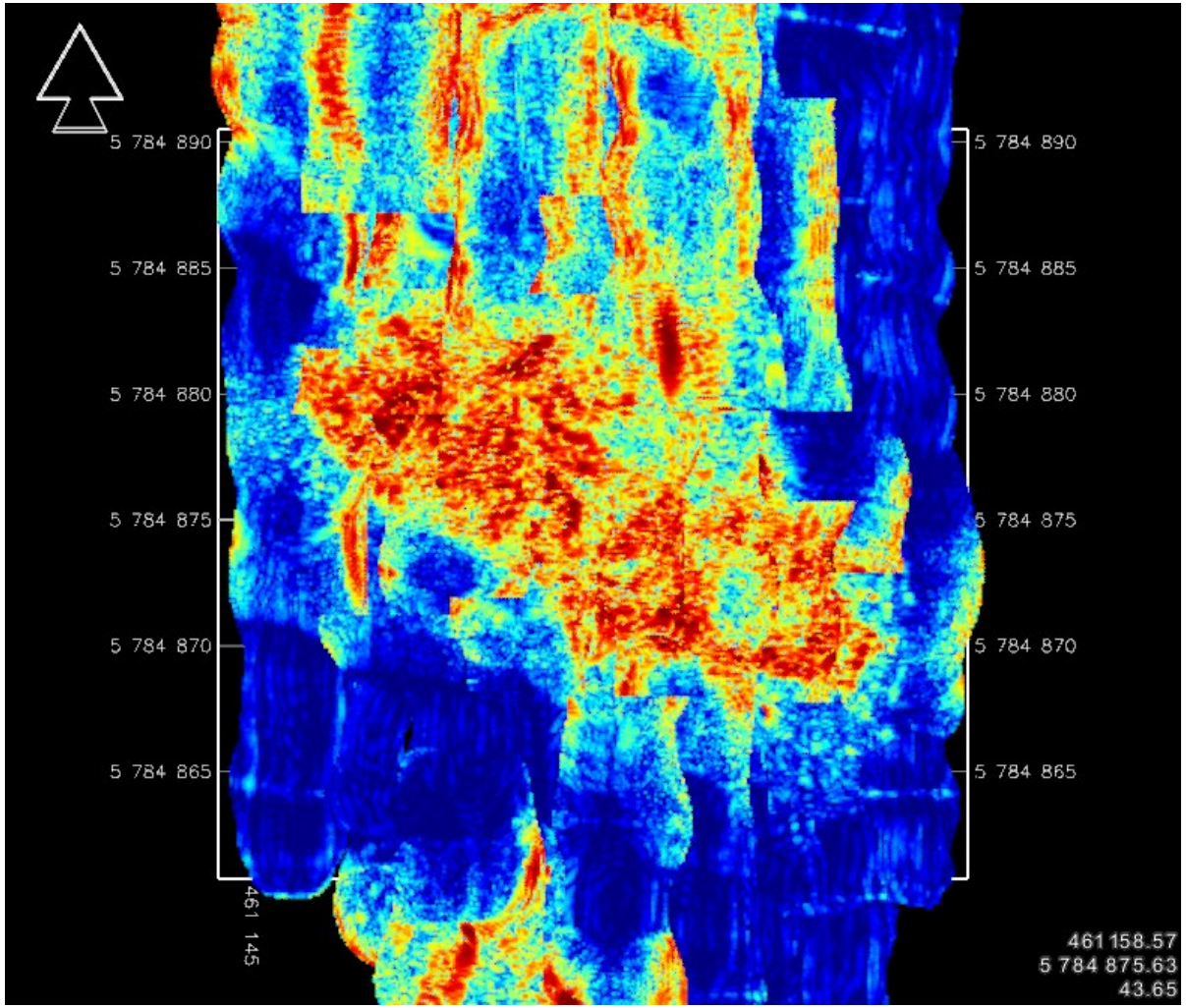
- Site WTG_E_170 was a potential shipwreck target.
- A large elliptical feature sized 25 m x 10 m was located 2 m below the seafloor. The anomaly was an acoustic response from a feature suggestive of a shipwreck.
- A secondary feature was located on the extents of the 20 m x 20 m grid.
- The acoustic anomaly measured 8 m in length and was indicative of debris associated with a shipwreck





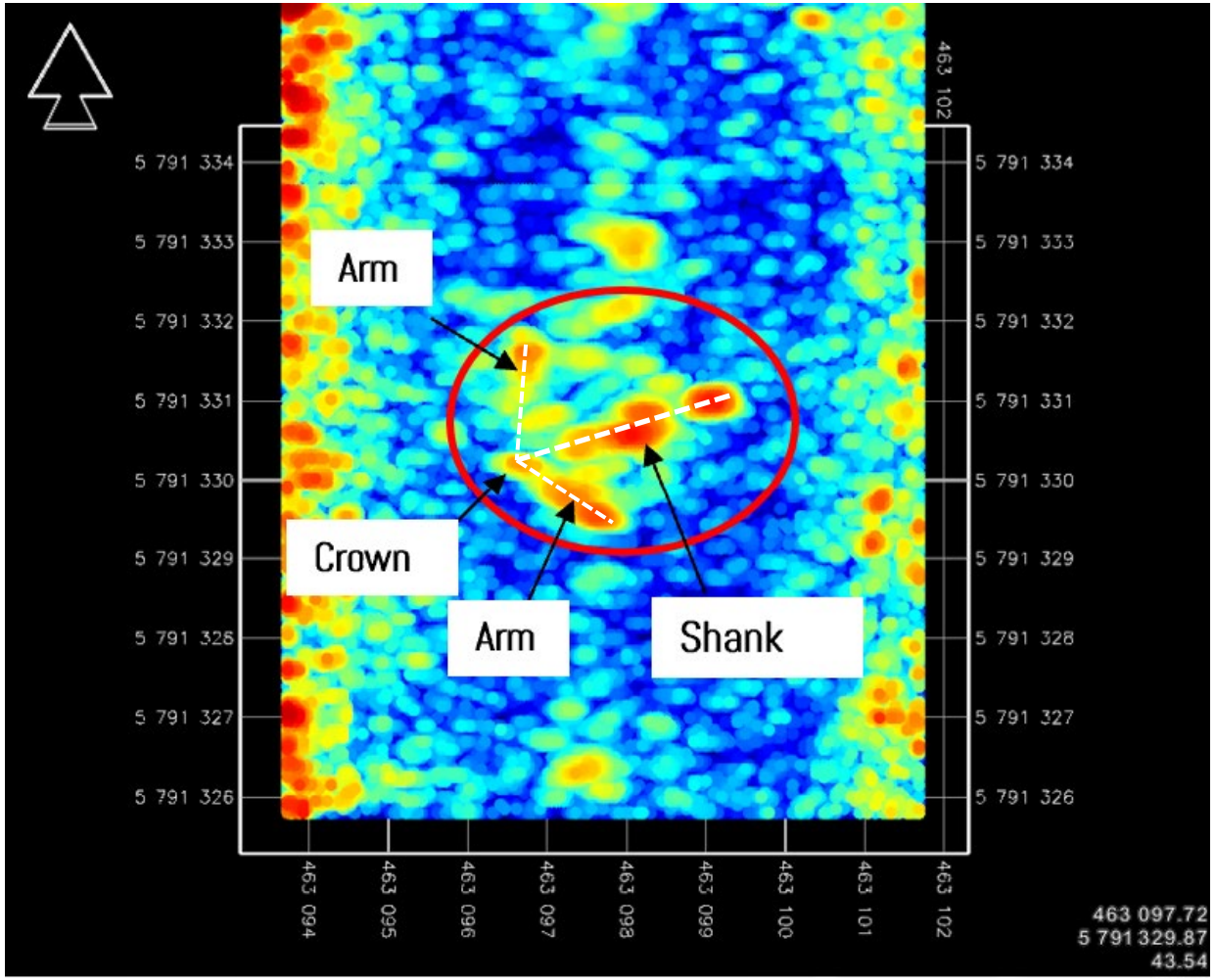
SBI Survey Results - 2

- Site WA_70620 was a potential shipwreck target.
- A large elliptical feature sized 30.4 m x 7.9 m. The anomaly was an acoustic response from a feature suggestive of a shipwreck.



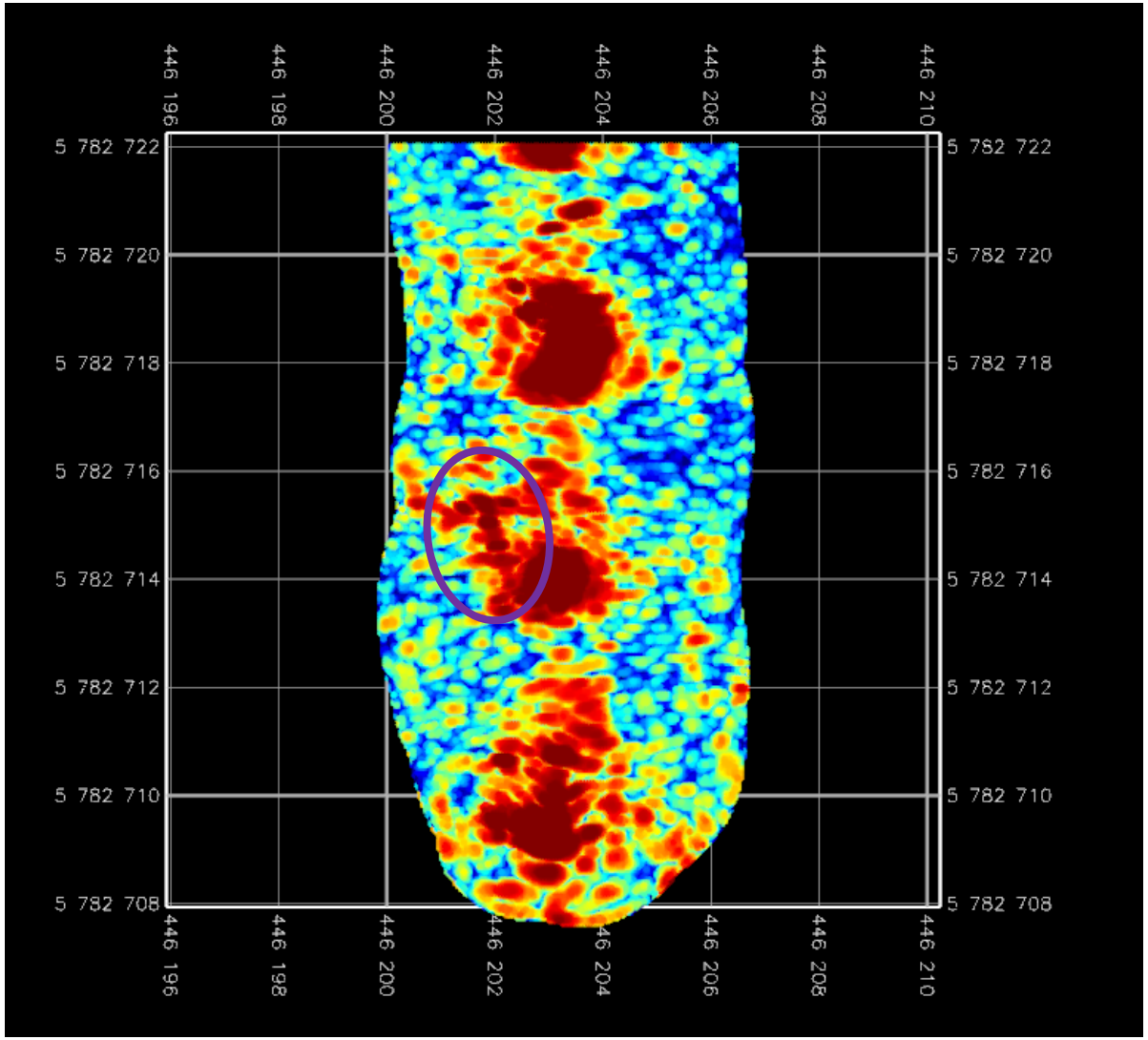
SBI Survey Results - 3

- Site WTG_C_492 was an anchor target.
- The results showed an acoustic anomaly acoustic is suggestive of the anchor. The shank, arm and crown of the anchor are visible, but some potential corrosion has impacted the visualization of the target.



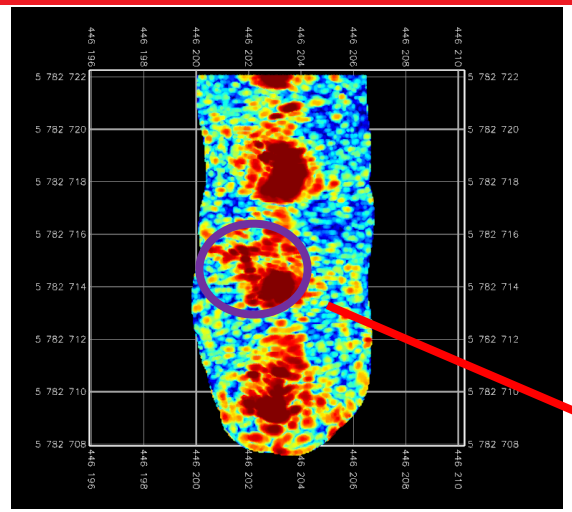
SBI Survey Results - 4

- Site S4N_013 was an anchor target.
- The results showed an acoustic anomaly which was suggestive of the anchor. The shank, arm and crown of the anchor are visible.

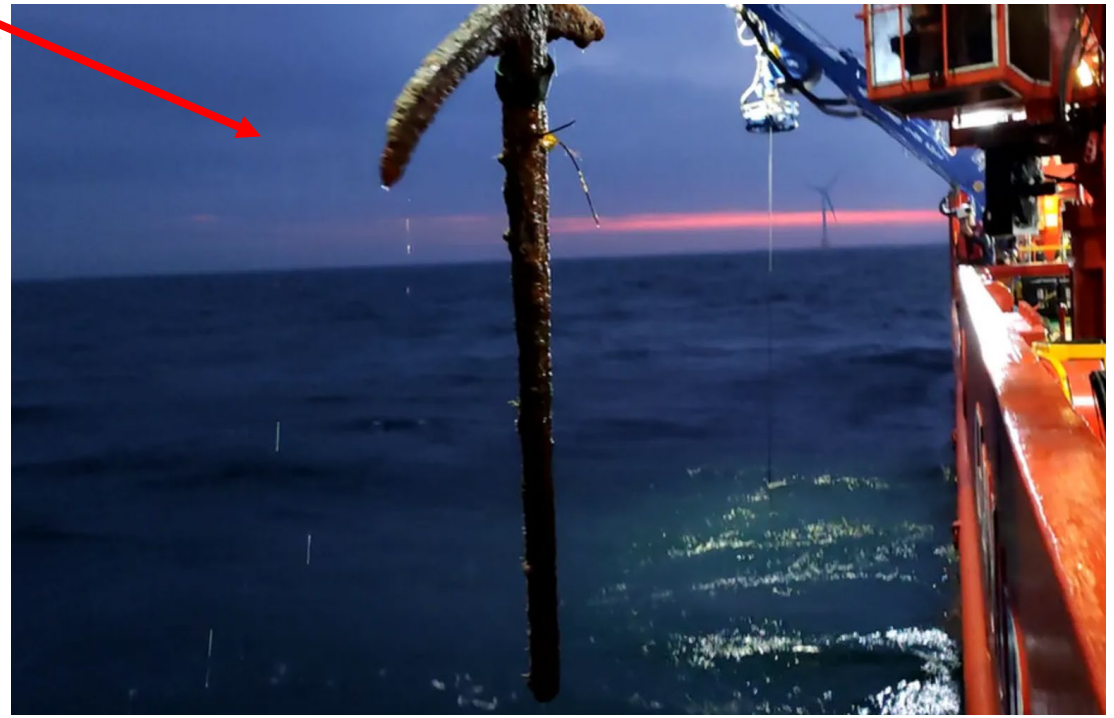


Key Findings

- Following further investigation, the anchor turned out to be a Roman anchor. The Roman anchor is anywhere from 1,600 to 2,000 years old used by a vessel approximately 500 tonnes.



- The anchor is on display in the Ipswich, UK museum. It is one of three pre – Viking anchors from northern Europe waters outside the Mediterranean.



Conclusion

- All 15 sites were surveyed with the predetermined grid sizes and 200% coverage.
- Of all anomalies discovered using the SBI 91 % of the anomalies were fully or partially buried beneath the seabed.
- Integrating MBES and MAG data with the SBI data archeological finds can be fully characterized and determine if the anomaly is ferrous.

References

- British Broadcasting Corporation (BBC). (2022). Roman-era anchor found at windfarm on display in Ipswich.
- Melina, Remy. (2011). Shipwrecks Gallery *Secrets of the Deep.*
- Power Technology. (2022). NKT installs power cables for Hornsea II offshore wind farm.

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