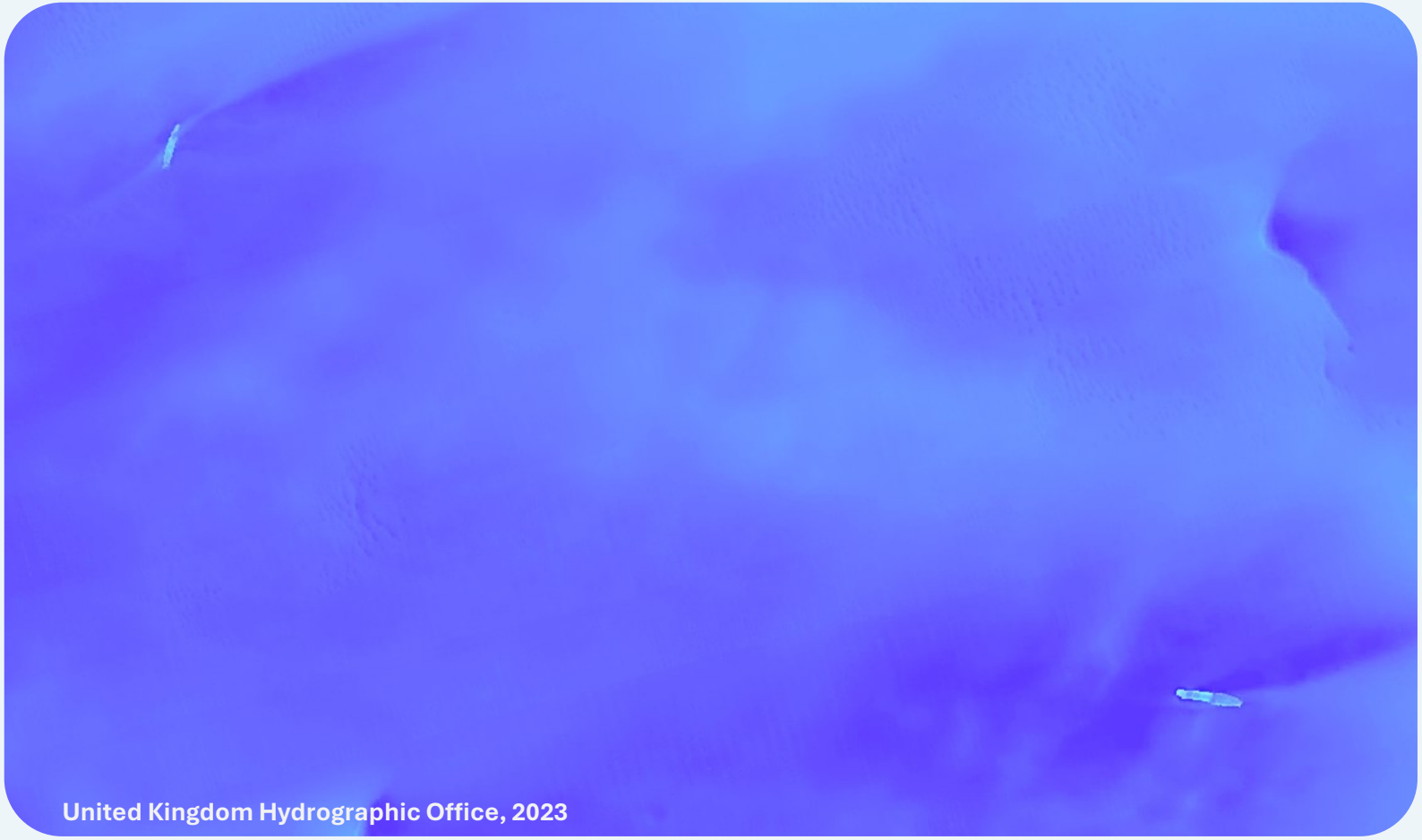
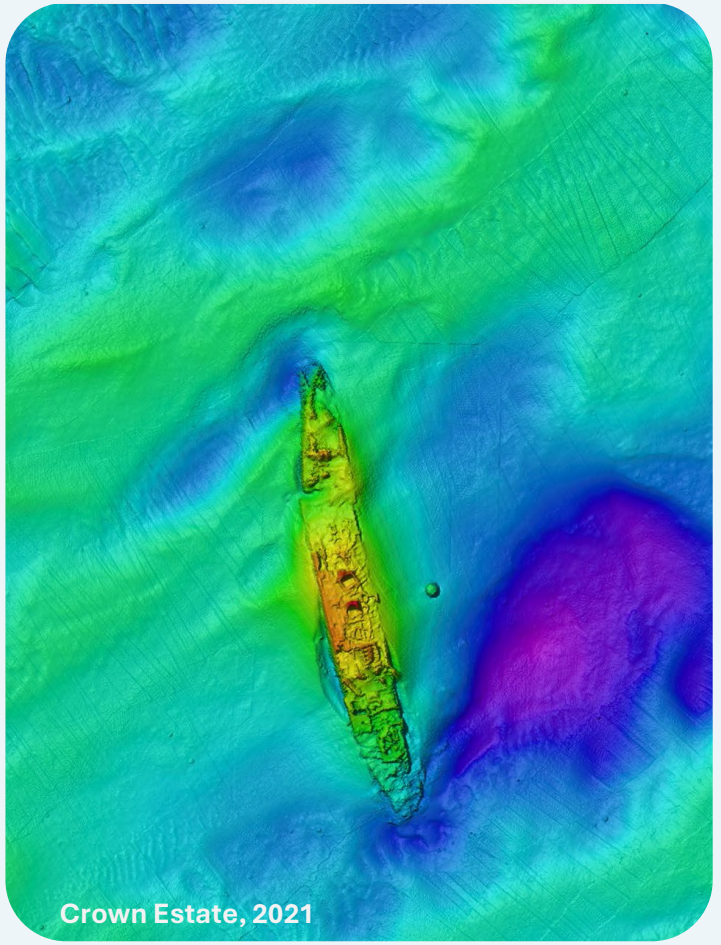
Computer Vision in Maritime Archaeology: Machine Learning for Shipwreck Detection and Analysis


United Kingdom Hydrographic Office, 2023


Crown Estate, 2021

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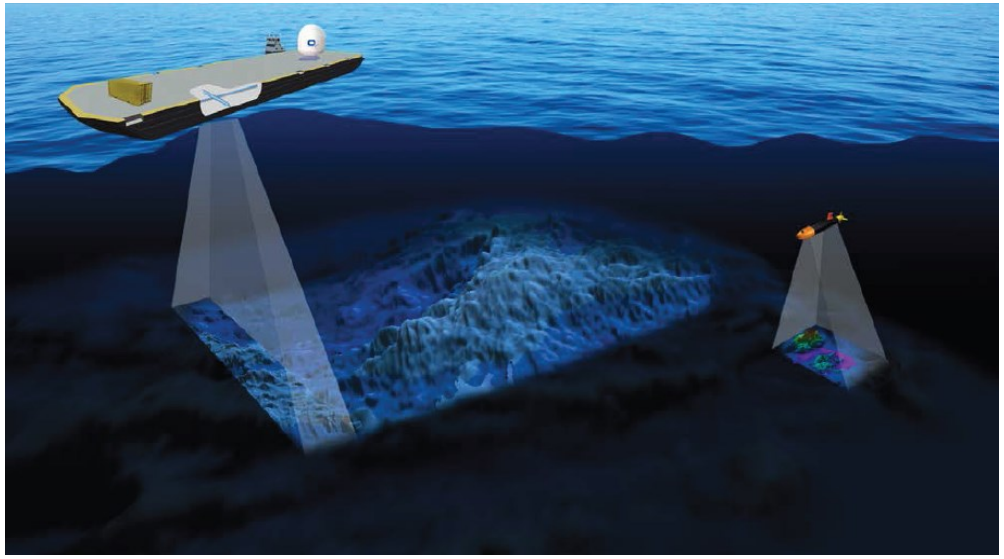
Cal T. Pols

LEVERHULME TRUST

Background and Research Rationale

- Why use Machine Learning?
- Remote Sensing ‘Data Explosion’ (Bennett, Cowley, De Laet, 2014)
- High-resolution, ‘Big’ marine datasets (Jakobssen *et al.*, 2017; Andreou *et al.*, 2022)
- Seabed 2030 Project (GEBCO-Nippon Foundation)
- Archaeological Implications
- Imperative for accurate quantification and understanding of underwater cultural heritage (McCartney, 2022)



Jakobsson *et al.*, 2017: 18

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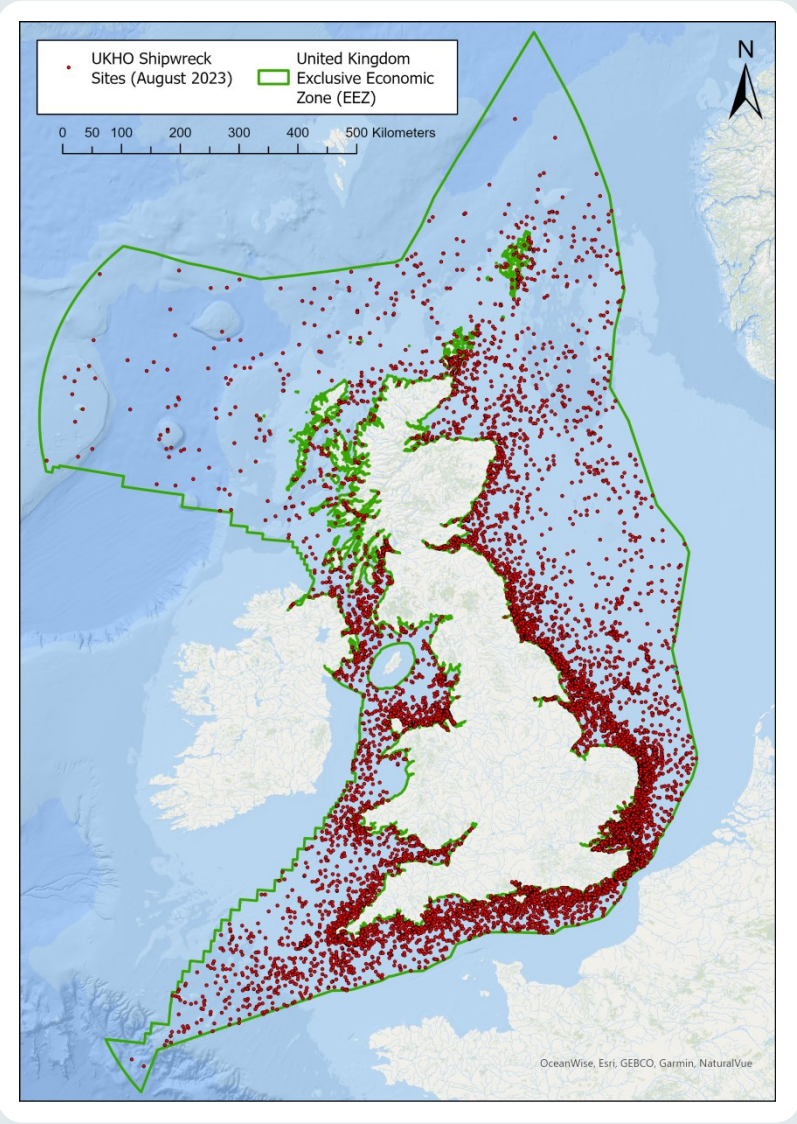
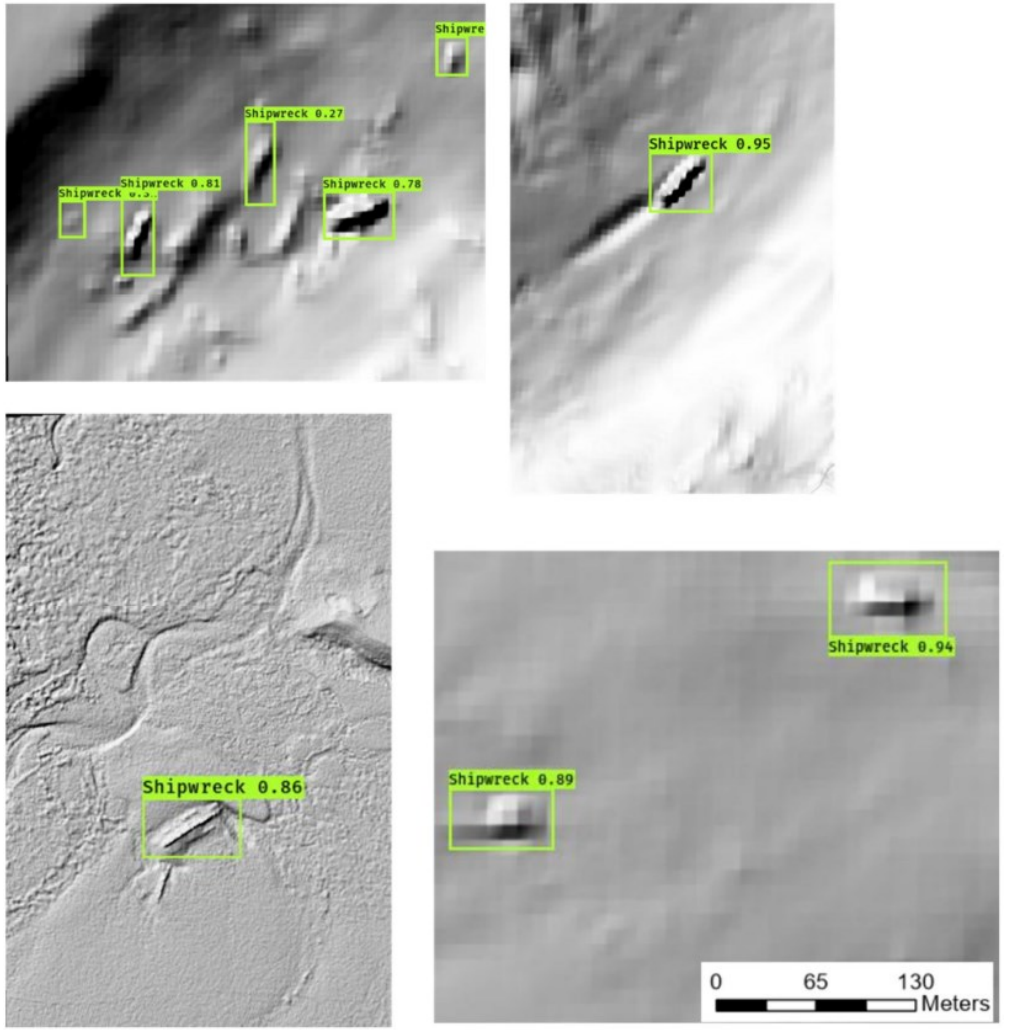


Machine Learning in Maritime Archaeology

- Fewer Studies in Maritime Contexts
- Applications for Shipwreck detection
- Closest comparable study – Character *et al.*, 2019



Character *et al.*, 2021: 5

Current Research [Paper 1]

Research Question

How effective are machine learning methods for identifying shipwreck sites across large areas of seabed using bathymetry data?

1. Utility and Suitability of Ready-Made Tools for Shipwreck Detection

    - Machine Learning Tools for Object Detection (Character *et al.*, 2021)
    - Topographic Approach (Inverse Depression Analysis; Davis *et al.*, 2020)

2. Open-Access Data

    - Bathymetry Data (Seabed Topography)
    - United Kingdom continental shelf

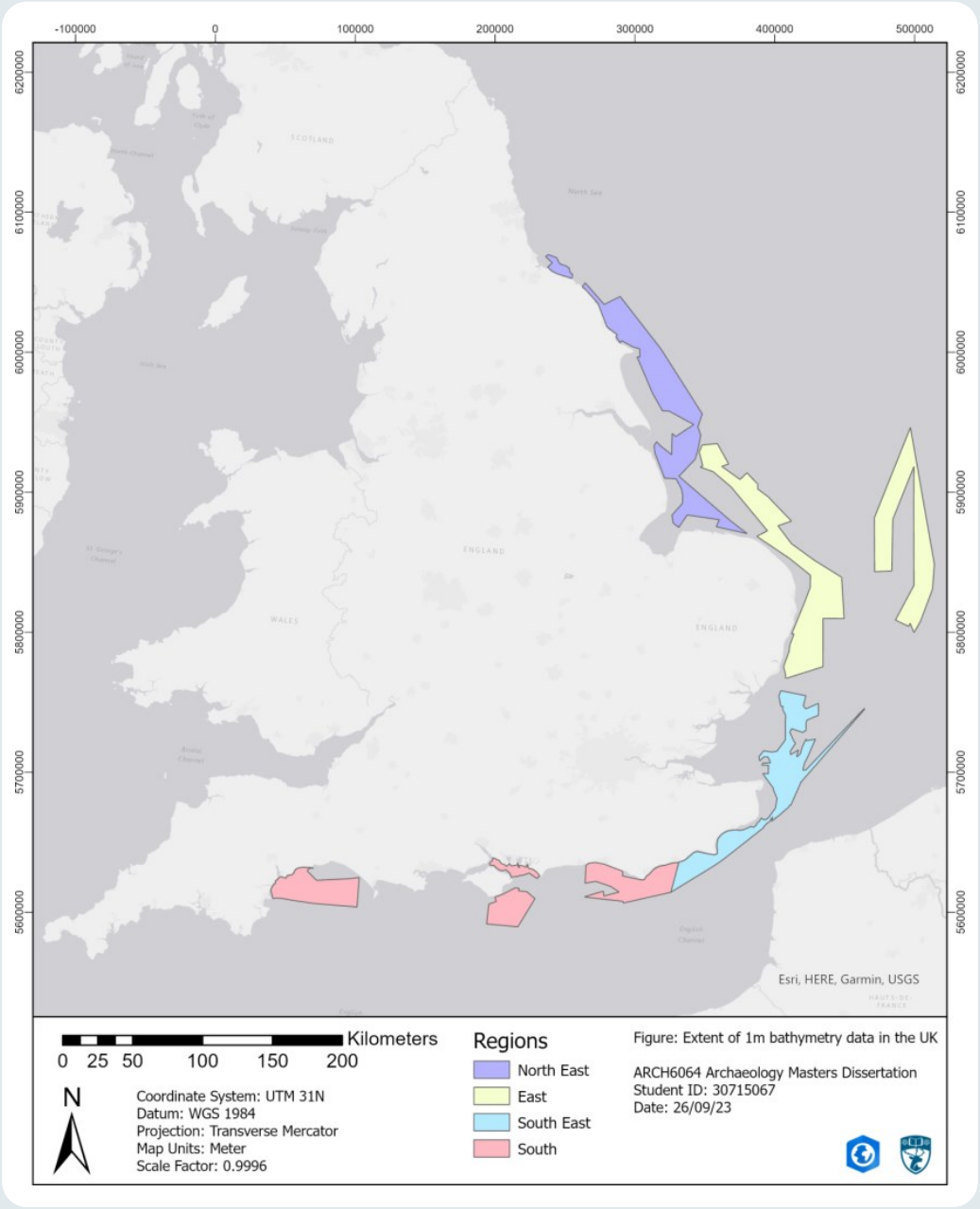
3. Feasibility of semi-automated methods for maritime archaeological assessments

    - Time, Cost, but also *Labour*-effective

Data Sources

- Admiralty Bathymetry, 1m resolution (4,664 km^2)
- Training/ Testing (Cross-Validation)
- UKHO Wrecks & Obstructions Database

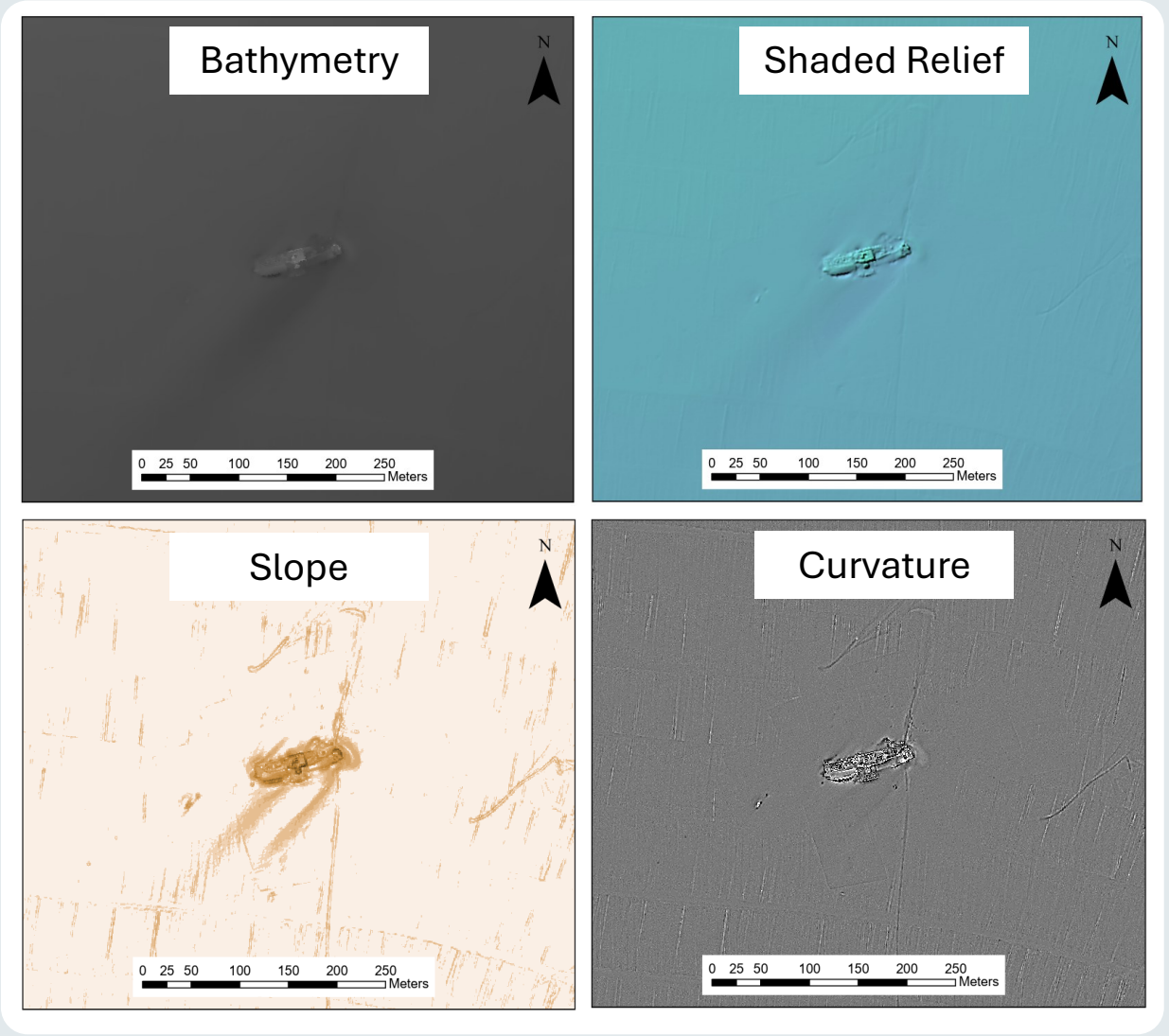
Region		No. of Training Images	No. of Shipwrecks
North East	**(NE)**	2,611	285
East	**(E)**	3,090	340
South East	**(SE)**	3,255	389
Total		8,956	1,014



Visualising Shipwrecks

- Importance of Visualisation to improve detection
- Variation of Shipwreck Sites
  - ➢ Preservation Levels
  - ➢ Seabed Sediment
  - ➢ Seabed Bedforms

= Challenges for semi-automated detection



Methodology

1. Custom Machine Learning

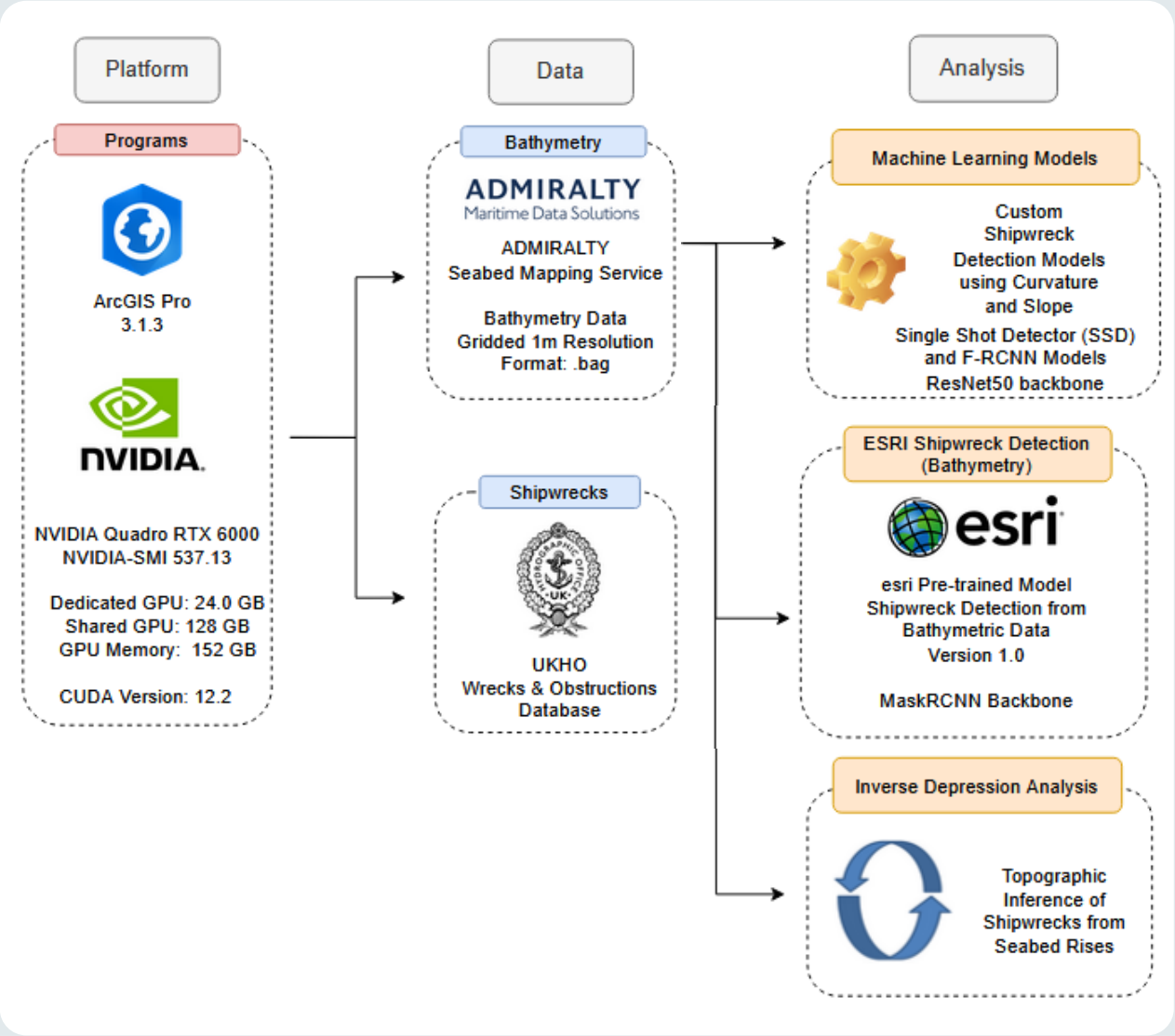
    - Hillshade, Curvature, Slope
    - Single Shot Detector and F-RCNN

2. ESRI Pre-trained Machine Learning Model

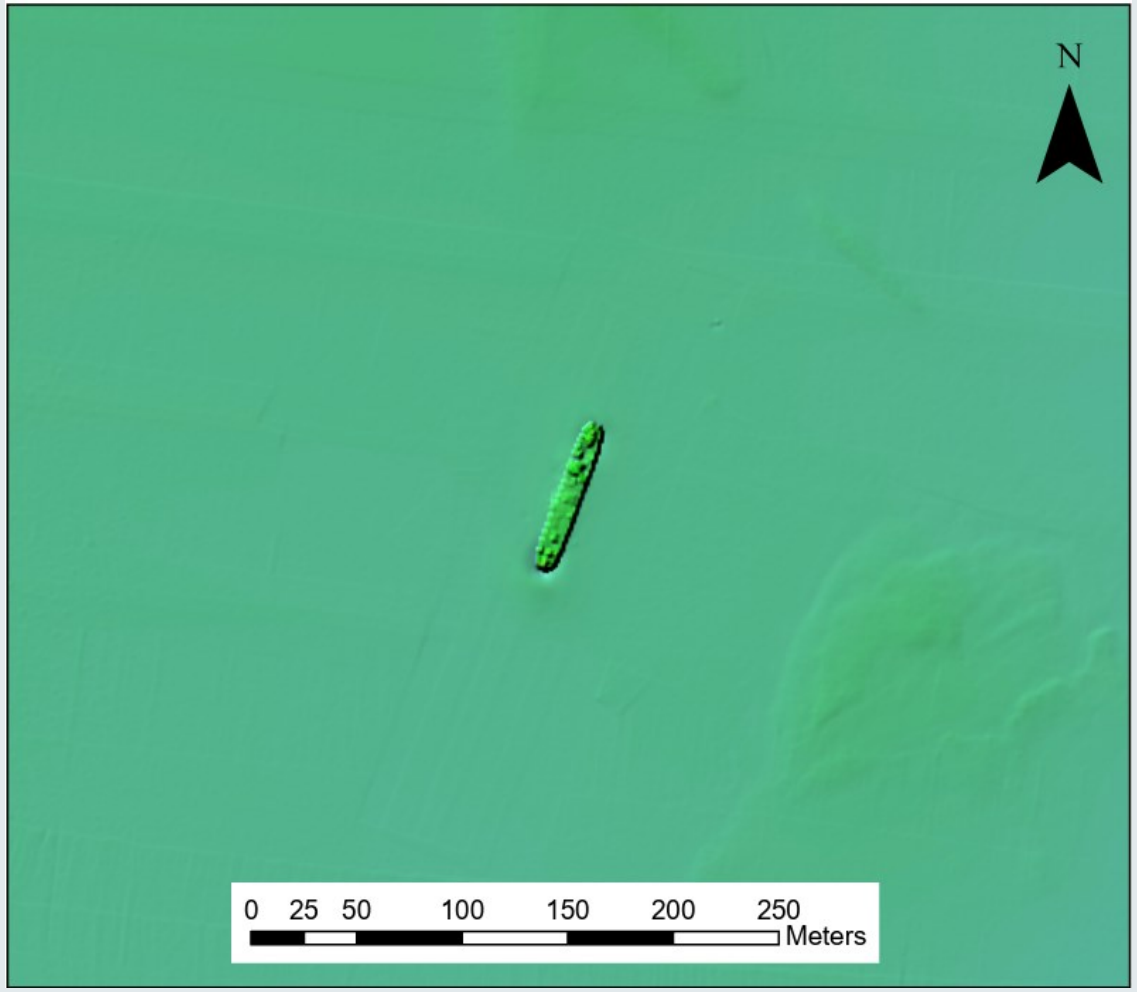
    - Shaded Relief (Hillshade)
    - Mask RCNN

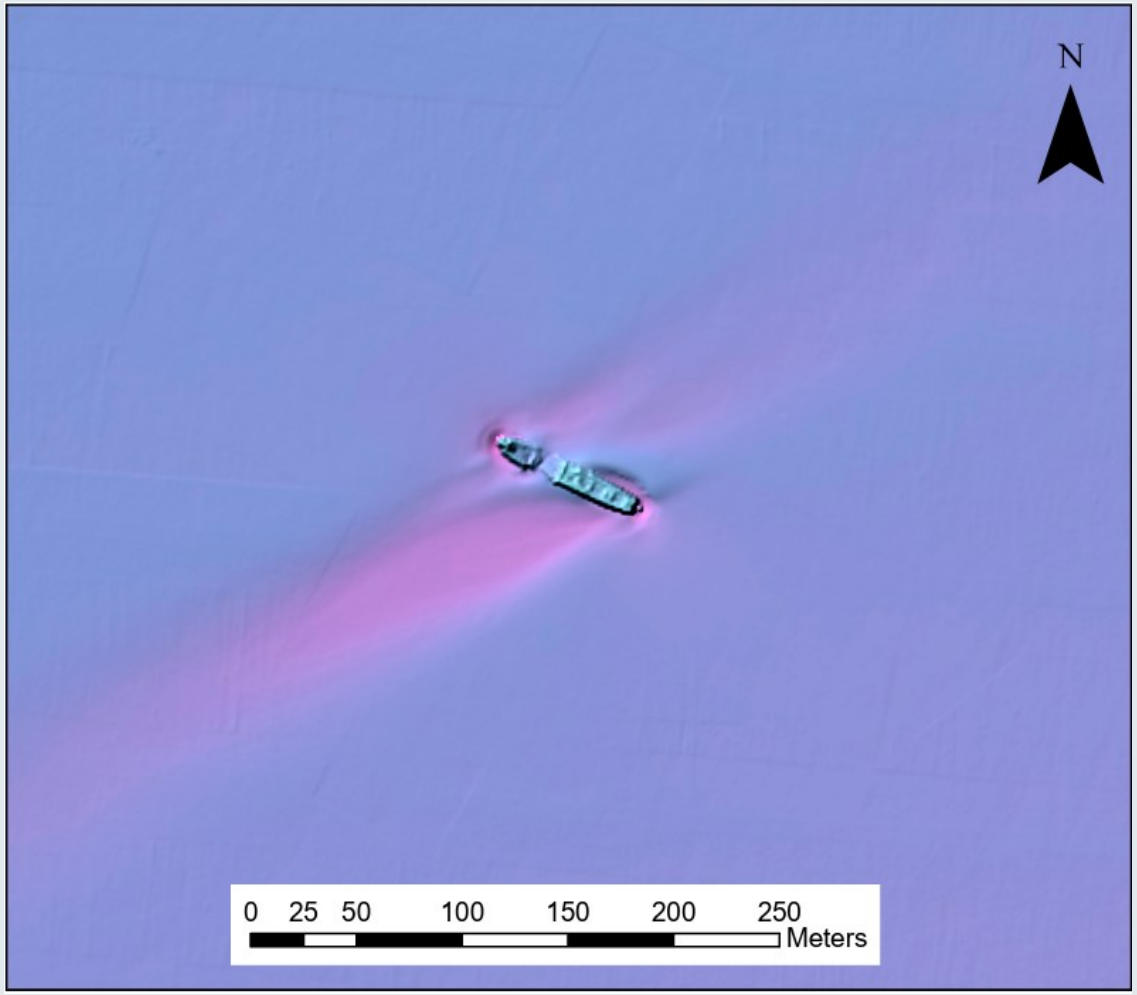
3. Topographic Inference Approach

    - Inverse Digital Surface Model (DSM)
    - Sinkhole Extraction Toolbox (Wu *et. al.*, 2016; Davis *et al.*, 2020)



What does a shipwreck look like?





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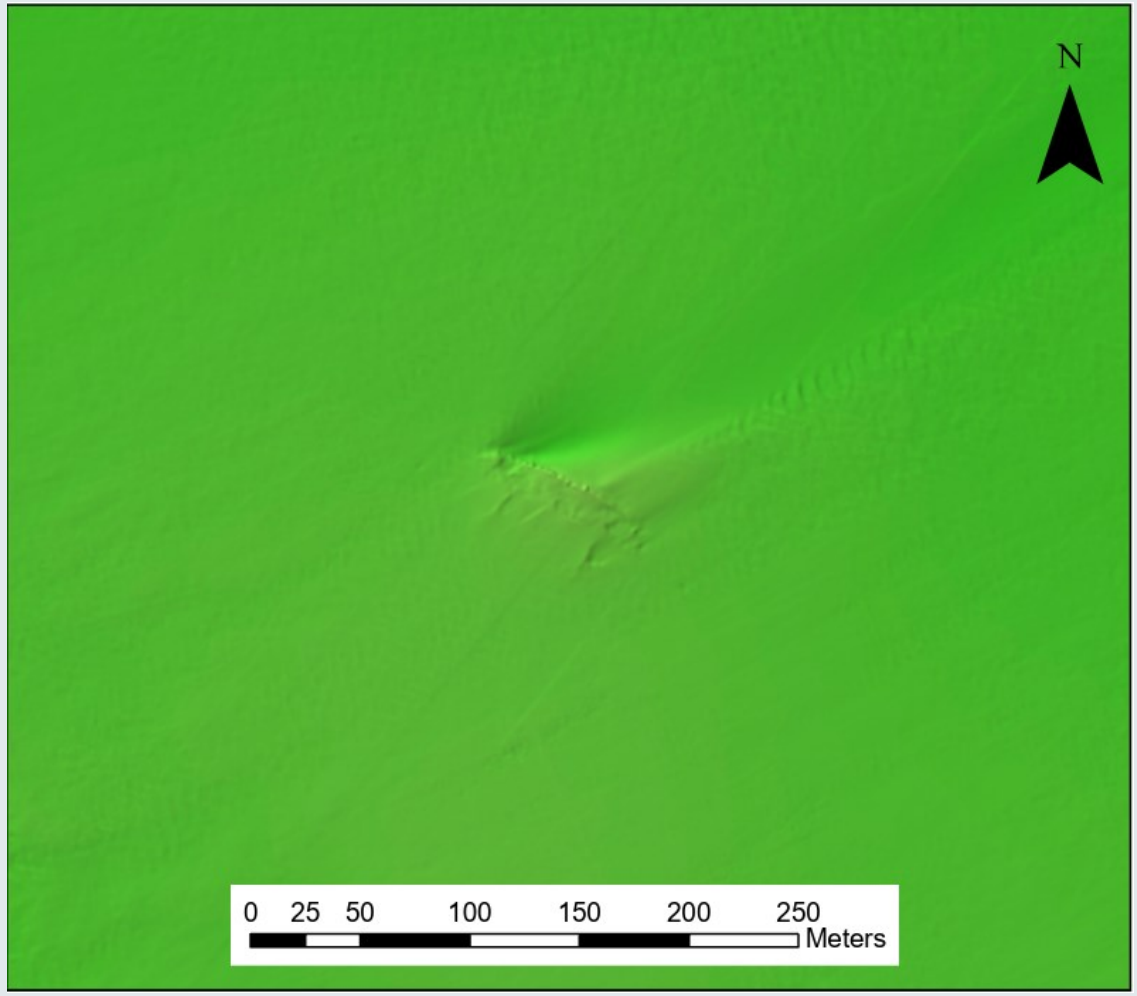
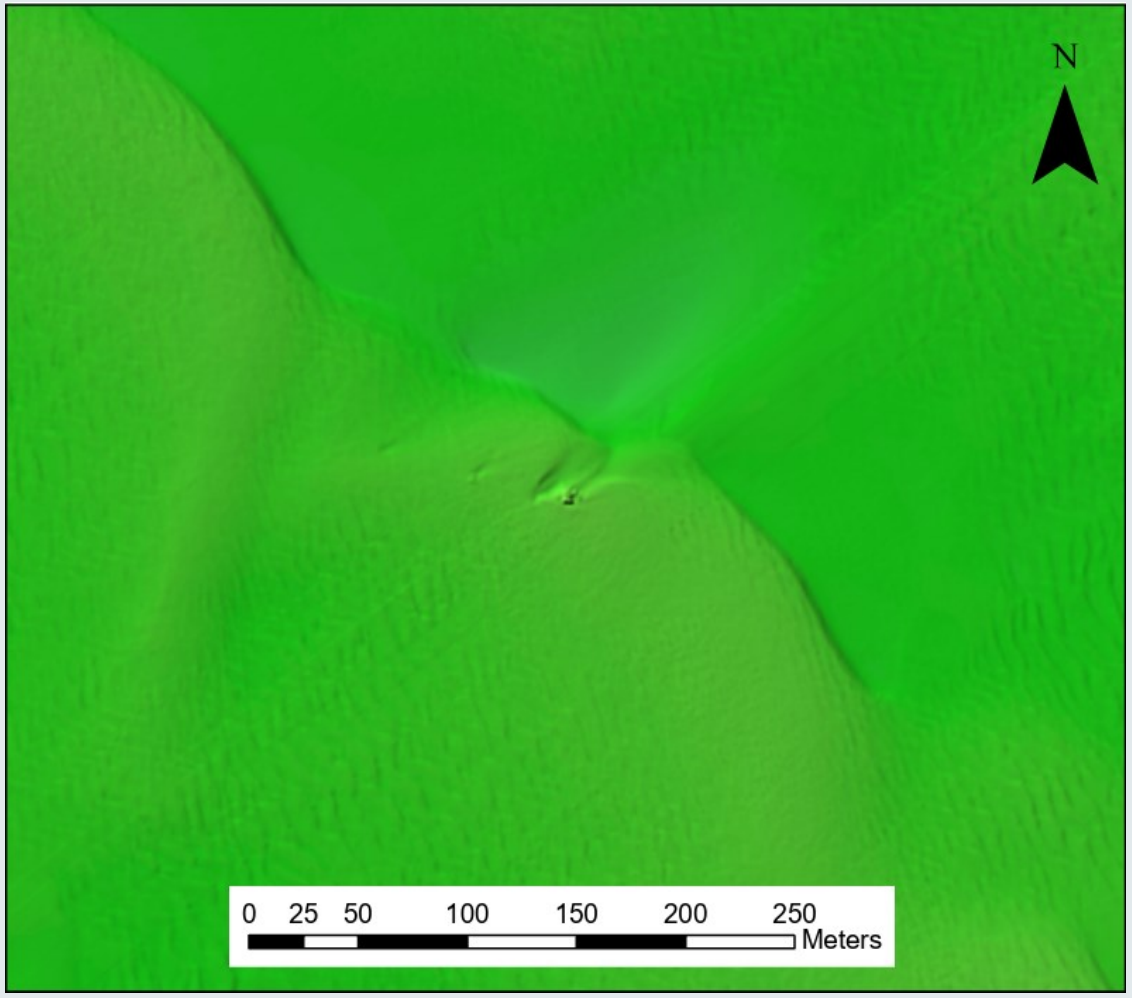




Preliminary Results – Custom Machine Learning Models

Hillshade

Possible (All)	SSD	F-RCNN
Recall	**0.74**	0.36
Precision	0.02	**0.45**
F1 Score	0.04	**0.40**

Probable	SSD	F-RCNN
Recall	**0.91**	0.71
Precision	0.01	**0.38**
F1 Score	0.02	**0.49**

Curvature

Possible (All)	SSD	F-RCNN
Recall	**0.68**	0.44
Precision	0.11	**0.35**
F1 Score	0.18	**0.39**

Probable	SSD	F-RCNN
Recall	**0.94**	0.85
Precision	0.06	**0.29**
F1 Score	0.12	**0.43**

Confidence Threshold: 0.6
SSD w/ Resnet50
F-RCNN w/ Resnet34

Testing Region – South
No. Possible (All) Shipwrecks = 253
No. Probable Shipwrecks = 107

Training Epochs: 50
No. Training Images: 8,956
No. Total Training Shipwrecks: 1,014

Training Shipwrecks (Possible): 441
Training Shipwrecks (Probable): 573

Future Work

1. Shipwreck Preservation (Inter-site)

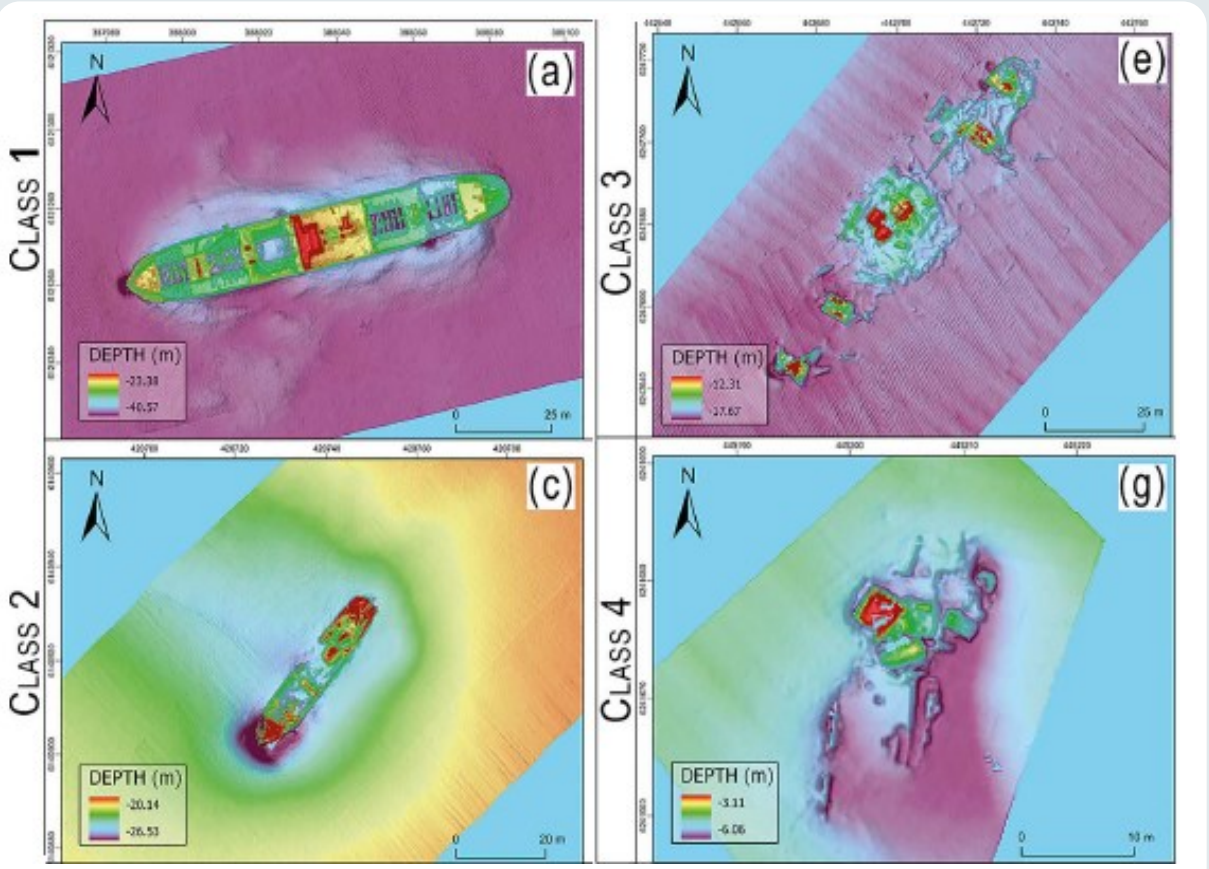
    - ML assessment of preservation levels
    - Potential for baseline monitoring

2. Shipwreck Type (Inter-site)

    - ML assessment of vessel type
    - Date range estimate

3. Intra-Site Level Analysis

    - Very high-resolution datasets (3D Models)
    - Applications for specific feature extraction (boilers, hull, etc.)



Gregory *et al.*, 2024: 8

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