Use of 3D data in advancing seabed mapping techniques for deep-water habitat classification

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INTRODUCTION

- **Cold-water Coral (CWC) reefs** are complex structural habitats that are considered biodiversity 'hotspots' in deep-sea environments and are **subject to several climate and anthropogenic threats**.
- This research focused on the application **underwater photogrammetry** to improve **classification of CWCs** on the **Porcupine Bank Canyon (PBC)**
- As one of the **largest submarine canyons in Ireland**, the **PBC** is key to understand CWC habitats and deep ocean environments.

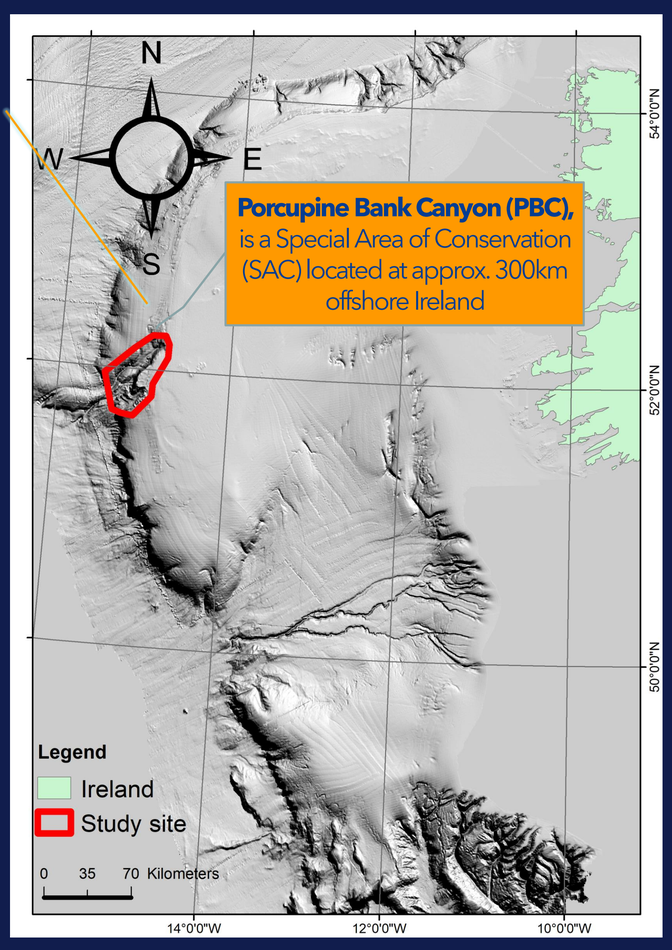

Figure 1: Map of Porcupine Bank Canyon and its relative position to Ireland.

3D PHOTOGRAMMETRY

ROV video data digital stills and camera positioning information were used to produce the 3D reconstructions in this study

SfM utilises multiple **overlapping images** at various angles to reconstruct 3D models of complex scenes

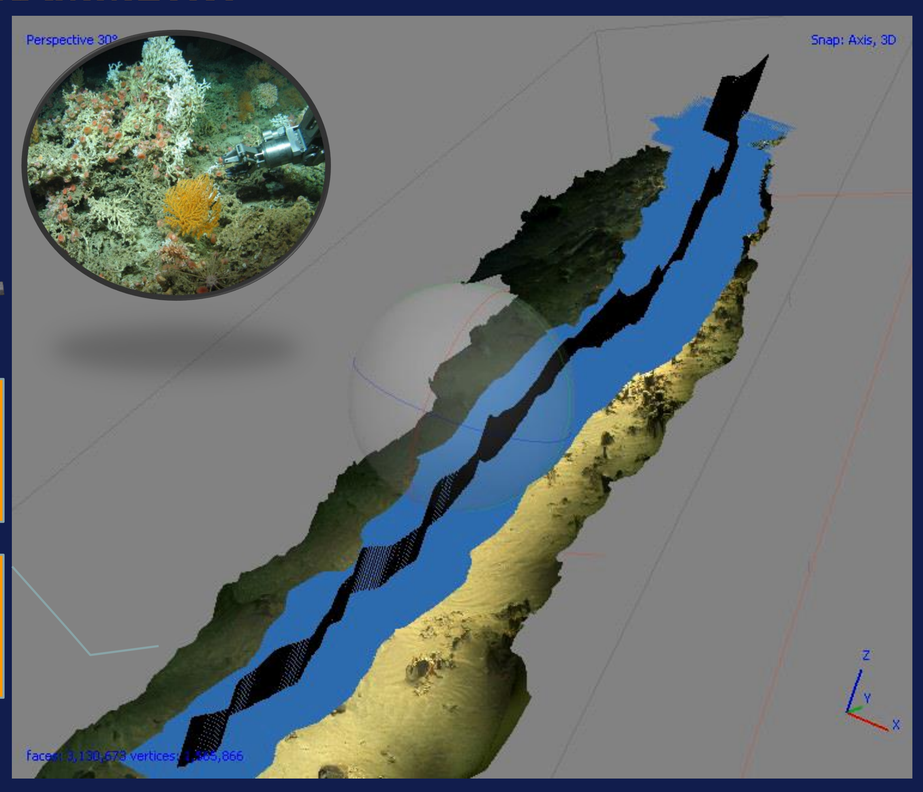

Figure 2: Video of a 3D reconstruction with underwater photogrammetry. The blue line represents the camera flight paths

- **Photogrammetry has** now been widely used to map and understand seabed habitats
- **The use 2D images from 3D objects** to analyse seabed features can lead to loss of data
- **Consequently,** 3D structures (x, y, z) such as CWC and submarine canyons can be misrepresented
- **Structure-from-Motion (SfM) photogrammetry** is considered a time- and cost-effective method for seabed mapping that allows high-resolution environment reconstructions

AIMS

- **Evaluate** different classification methods and analyse what information can be provided in 3D and 2D
- **Develop** an efficient 3D classification workflow for deep-water habitats
- **Advance** seabed mapping techniques for habitat classification in submarine canyons and cold-water coral habitats;

MATERIALS AND METHODS

- **ROV video data, USBL positioning** were converted into **3D reconstructions** in Agisoft Metashape (2019)
- **Point clouds, orthomoisaics** and DEM were **used to analyse the classification workflows**
- Dense clouds were manually annotated by an expert and segmented into classes: coral and seabed.
- **Three classification workflows were developed and** applied to underwater photogrammetric reconstructions of CWC habitats in the PBC:

Multiscale geometrical classification (MGC) | Colour and Geometrical classification (CGC) | Object-based classification (OBIA)

RESULTS

Colour and Geometrical classification (CGC)

Eight 3D reconstructions were produced using **3681 images in total**. Dense clouds were composed of a total of 165,356,594 points.

- The **percentage distribution of the coral and seabed** samples from the annotated test set showed an average of 7.19% coral and 92.81% seabed across different locations at the PBC
- The average **classification accuracy score** using the **CGC method** was approximately 67.9% with an average balanced accuracy of 58.1%.

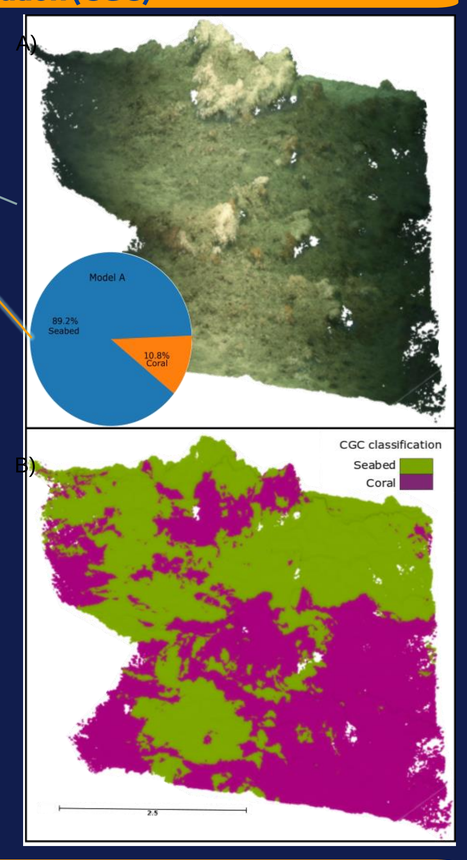

Figure 3: A) Dense cloud of the coral mounds generated with photogrammetry. Pie chart: Coral and seabed distribution on the dense cloud B) Example of CGC classification output Magenta:coral/Green:seabed.

Multiscale geometrical classification (MGC)

- **Eleven SVM classifiers were built** with different combinations of **annotated samples from the training dataset**
- Overall classifier training results averaged 89.85% (ba) and fdr ratio of 4.27. Classifier 6 **presented the best ba and fdr** with values of 99.8% and 8.98 respectively
- **Average accuracy and balanced accuracy scores** were 68.2% and 74.7% respectively

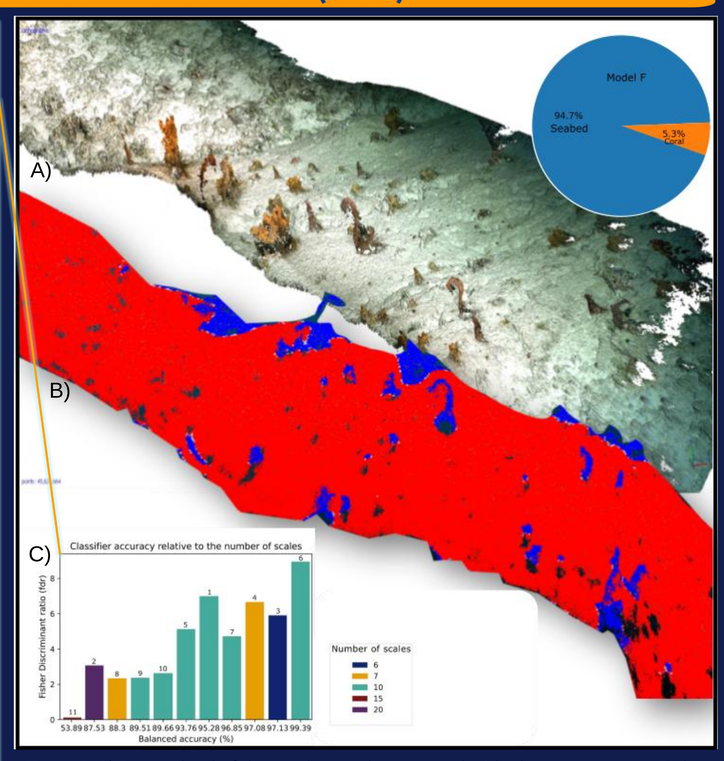

Figure 4: A) Dense cloud of the coral mounds generated with photogrammetry. Right: Pie chart with Coral and seabed distribution on the dense cloud B) Example of MGC classification output . Red:coral/Blur :seabed. C) Classifier accuracy relative to the number of scales

Object-based classification (OBIA)

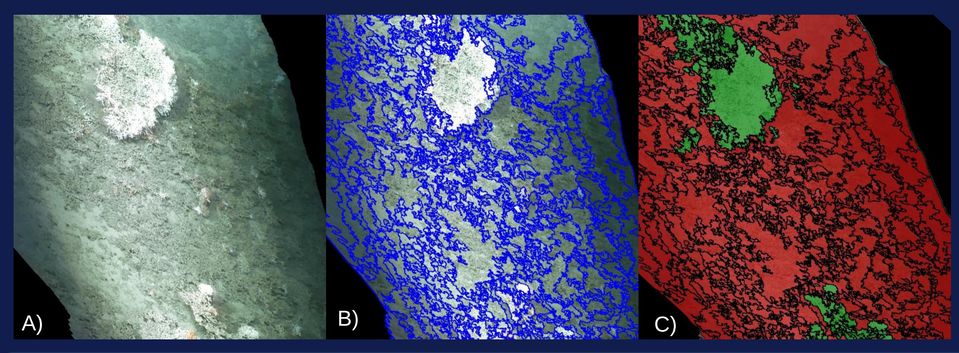

Figure 5: A)Orthomosaic generated with photogrammetry B) Example of Object-Based image analysis(OBIA) with automated segmentation of object C) Manually classified objects. Green: coral; Red: seabed

- We compared the results to an OBIA classification methods to **analyse the difference between 2D and 3D classification results**
- The average of the difference between class distributions from 3D methods and OBIA method was 0.2%.
- This shows that there is potential impact of at least a decimal point order of magnitude in using 2D methods to represent objects that are naturally 3D structures

CONCLUSIONS

- **Cold-water corals** significantly contribute to **deep-sea biodiversity** due to their **3D structure and reef-building capacity**
- **This study describes 3 classification methods applied to CWC reefs** within the Porcupine Bank Canyon SAC in the North East Atlantic
- **The workflows provide** an **original and not yet applied methodology** for the classification of 3D reconstructed marine environments at the PBC.
- Workflows designed for 3D point clouds showed a **similar accuracy**. However, ach method has benefits for specific applications pertinent to the wider marine scientific community

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