



FROM IMAGE TO INSIGHT

**Unlocking the potential of marine
imagery with AI and Photogrammetry**

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Outline

- **Background**
- **Coral Reef Photogrammetry**
- **Deep Sea AI-supported Image Classification**
- **Future Perspectives**

Background

- University of Oldenburg (2016 – 2021)



- University of Algarve (2021 – 2022)



- Master's Thesis in Madagascar (2022 – 2023)



- Research Technician at INES Solutions (2024 - current)



Photogrammetry in Madagascar

- Northwest Madagascar
- Nosy Be archipelago
- 5 Coral Reefs at Nosy Sakatia
- +400 species of Corals

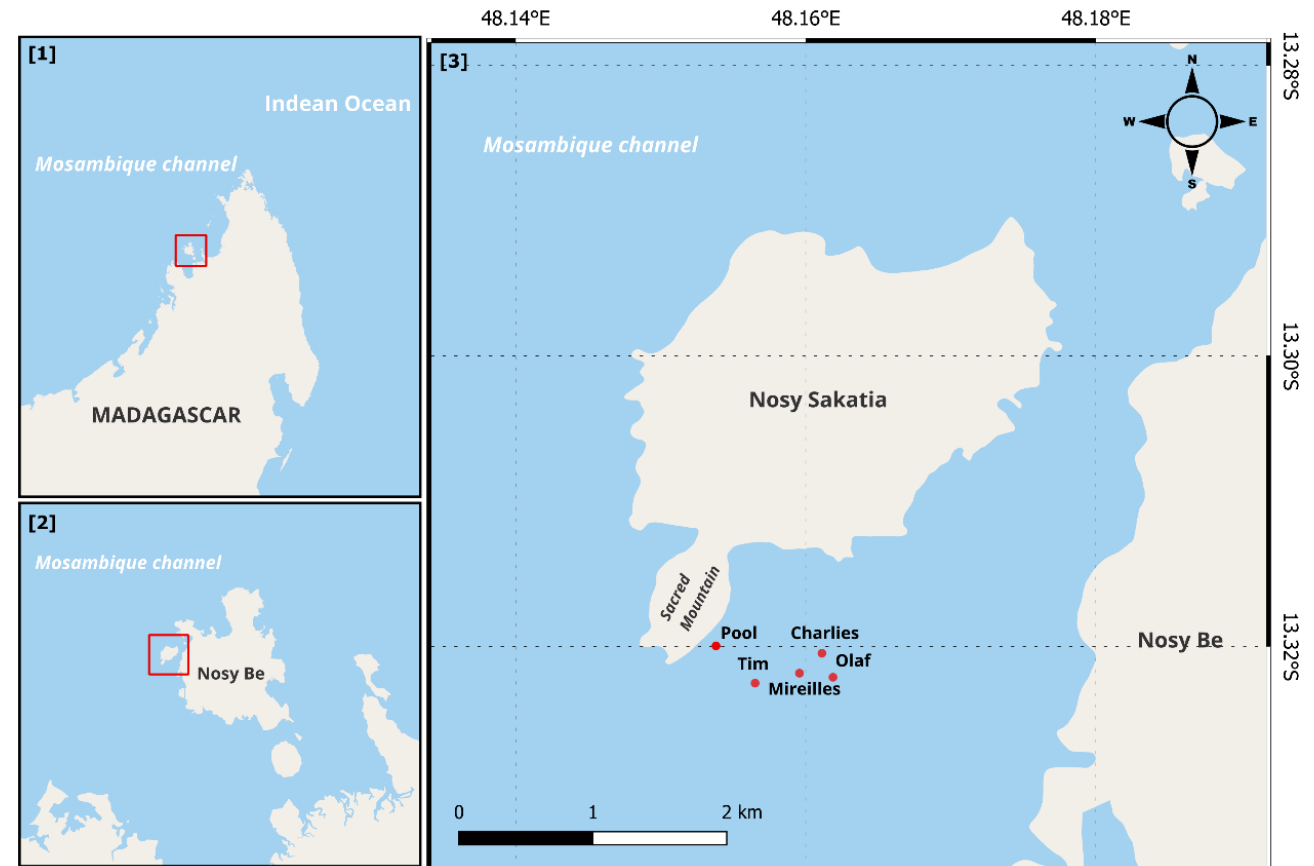


Fig. 1: Map of the study area, located north-west of Madagascar at the Nosy Be Archipelago.

Photogrammetry in Madagascar

- Small team of scientific divers
- Limited regional experience
- 2 GoPro Cameras and an Agisoft license



Fig. 2: The research team during dive preparations.

Preparation



Fig. 3: Metric reference build out of PCR tubes and filled with sand.



Fig. 4: Self-made camera stabilizer supporting stereovision.

Deployment

- 20m Transect Line [A]
- Corner flip-flops (6 m distance) [B]
- Metric Scales [C, D]
- North direction [D]

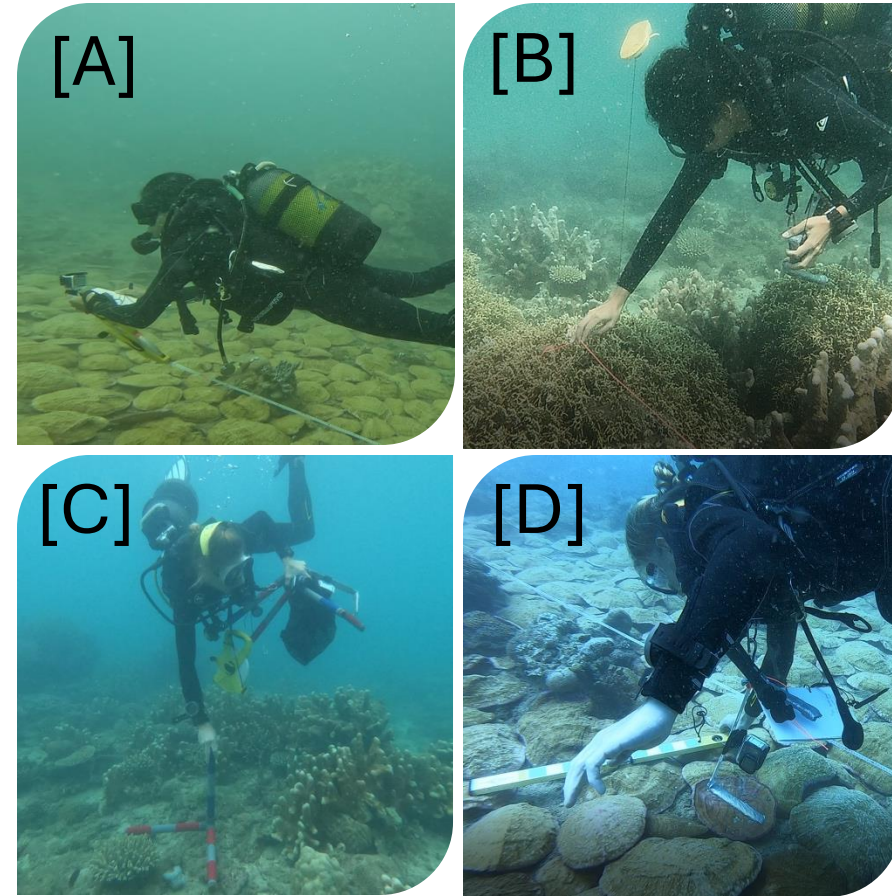


Fig. 5: Preparing the photogrammetry transects. With [A] deploying the transect line, [B] setting up the corner markers, and [C, D] placing the metric references.

Execution

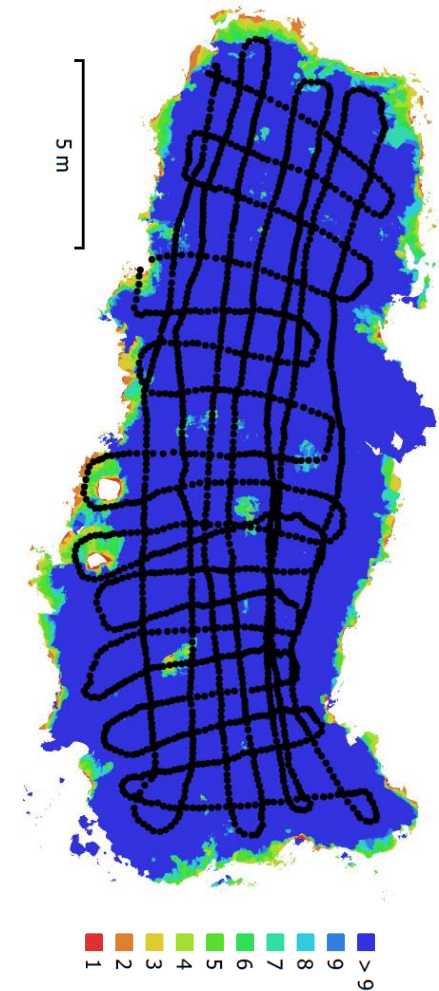


Fig. 6: Moving pattern and image coverage per region.

Image Processing

- Agisoft Metashape Professional
- Easy and generic workflow
- Outputs:
 - 3D Model
 - Digital Elevation Model (DEM)
 - Orthomosaic

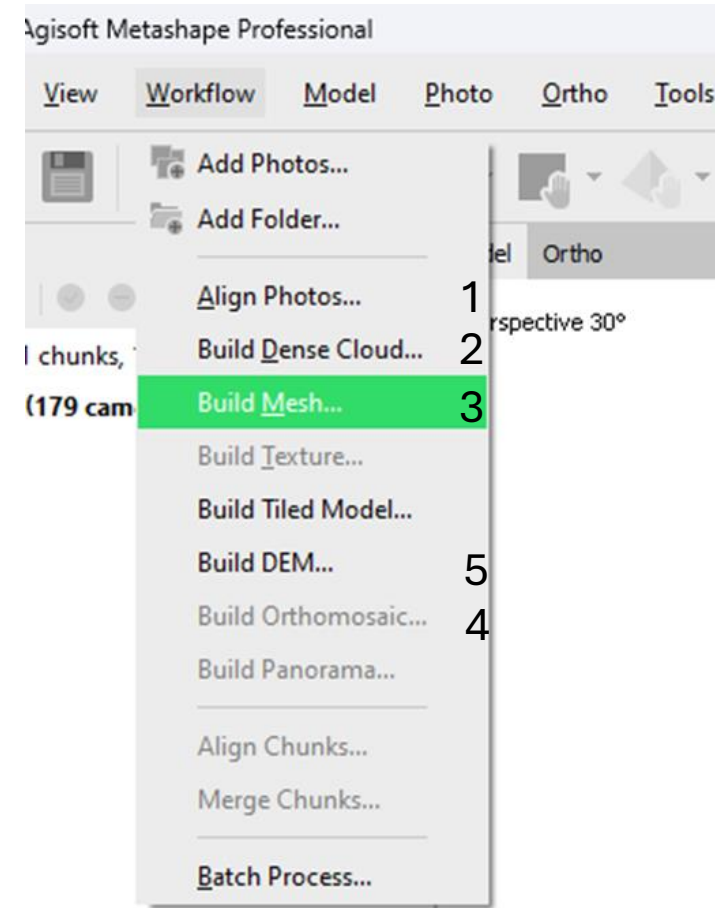
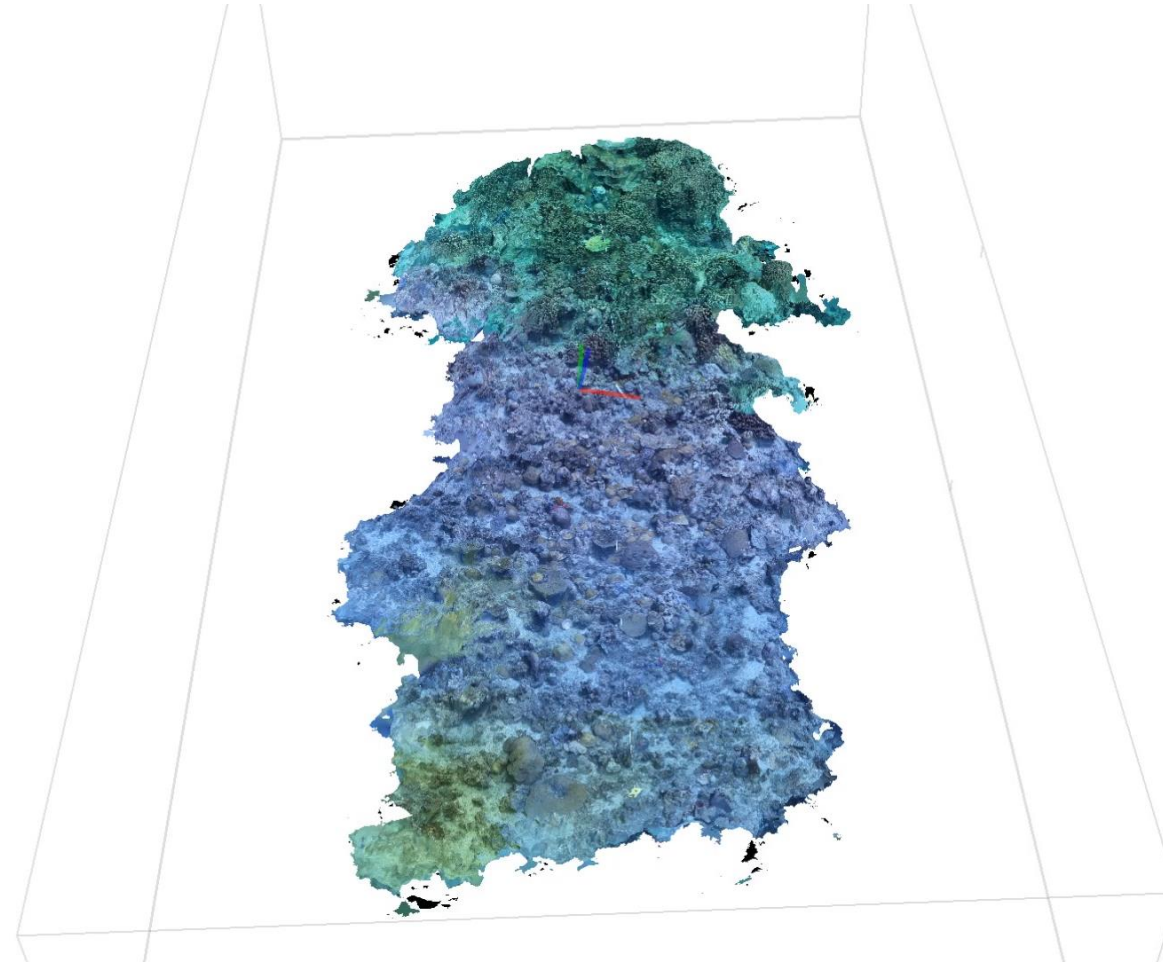


Fig. 6: Generic photogrammetry workflow in Agisoft Metashape.

3D Model



Digital Elevation Model

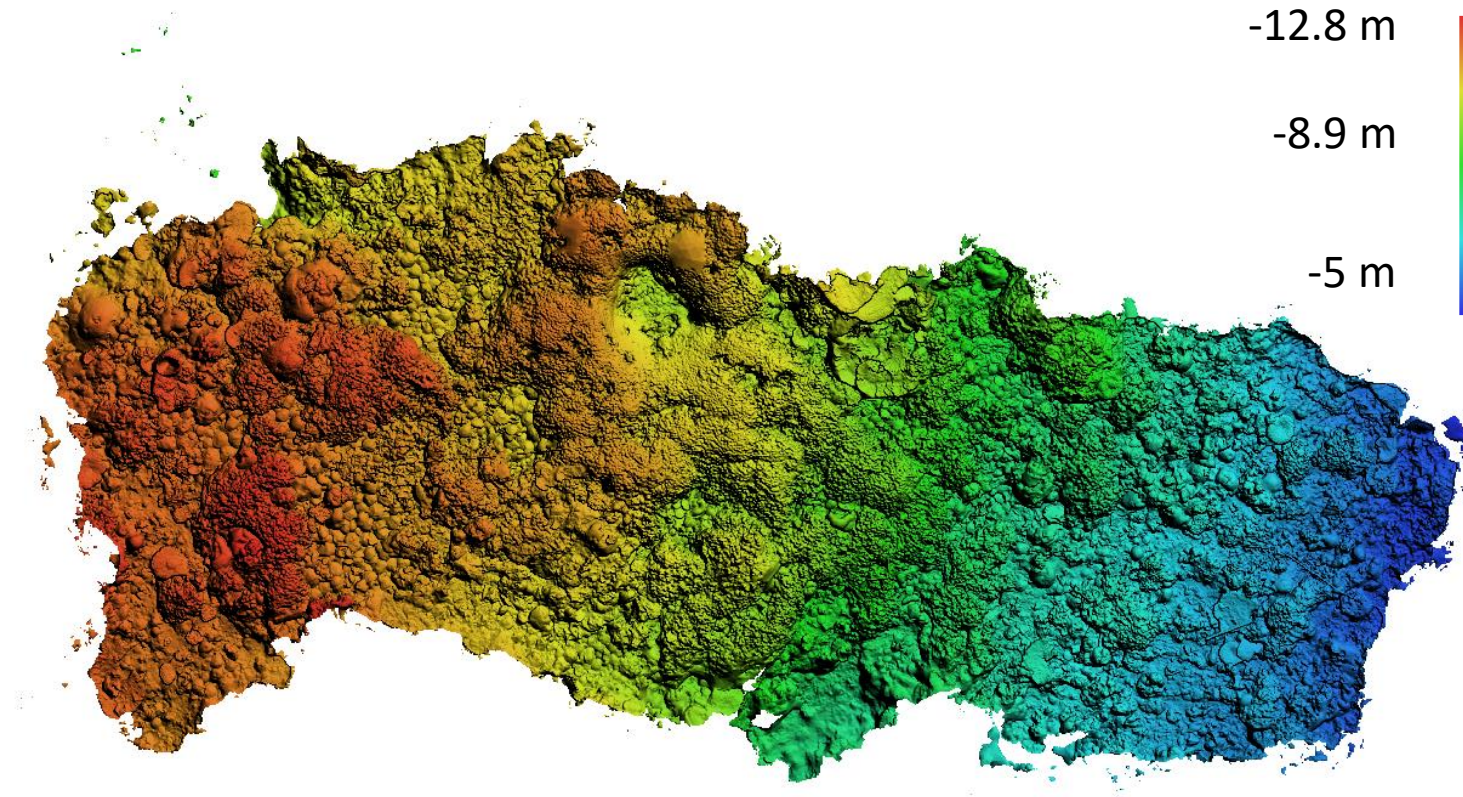


Fig. 8: Digital Elevation Model (DEM) of the 3D model. Color variations indicate elevations and depressions at a 0.294 mm/pix resolution.

Previously

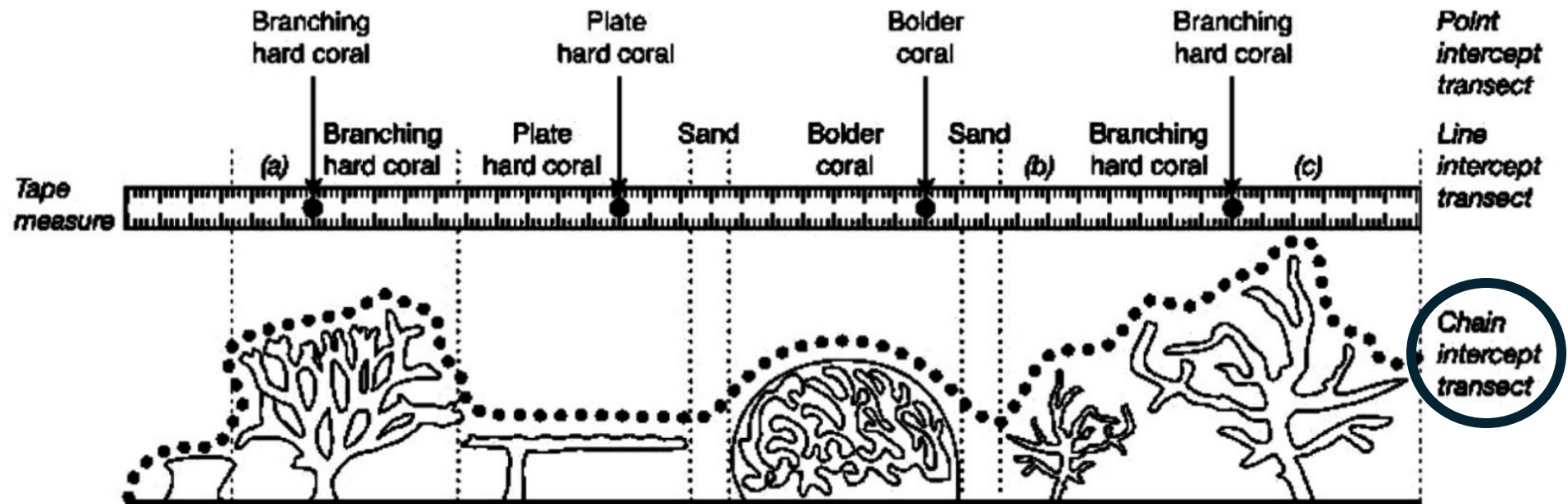


Fig. 9: Sketch illustrating the regosity measurement method using a chain. Image extracted from Hill and Wilkinson in *Methods for Ecological Monitoring of Coral Reefs*, 2004.

Orthomosaic

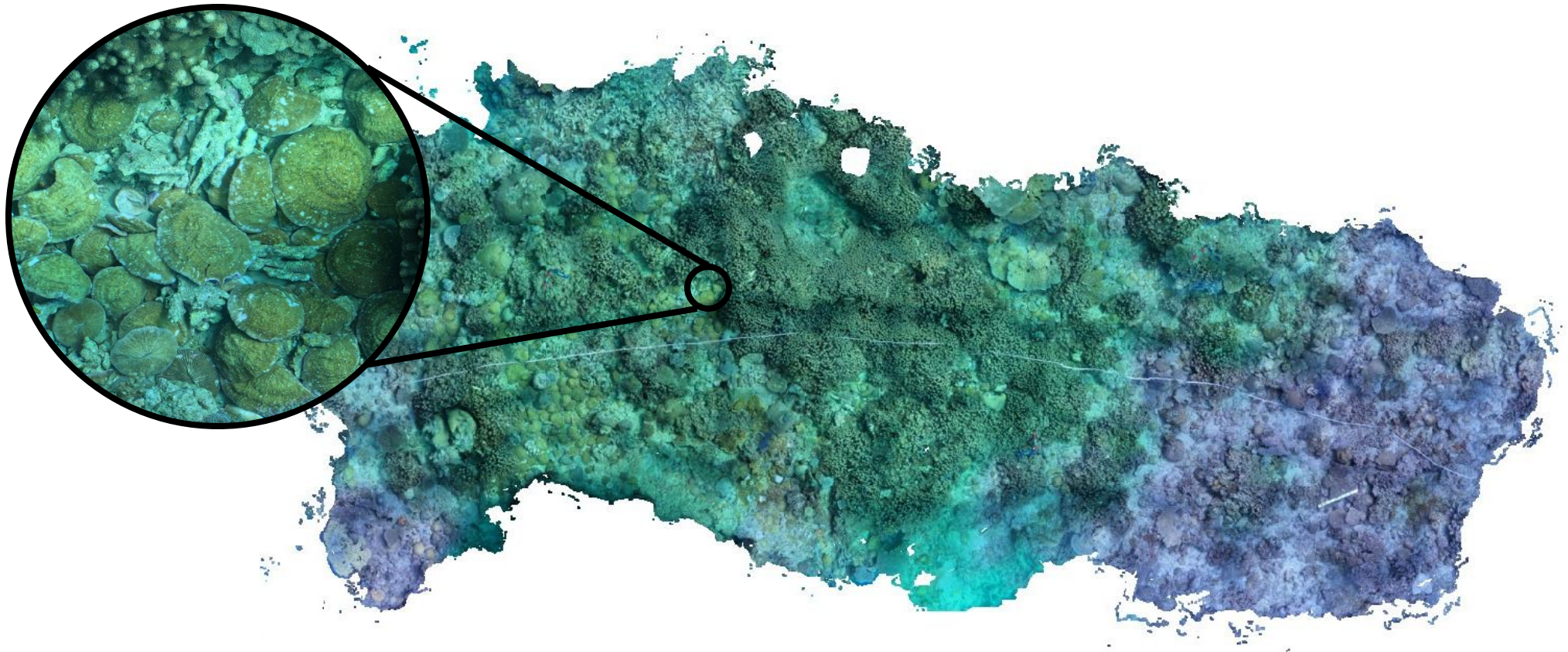


Fig. 8: Orthomosaic of the 3D model at a 0.294 mm/pixel resolution, including a zoom in (black circle).

Orthomosaic Processing

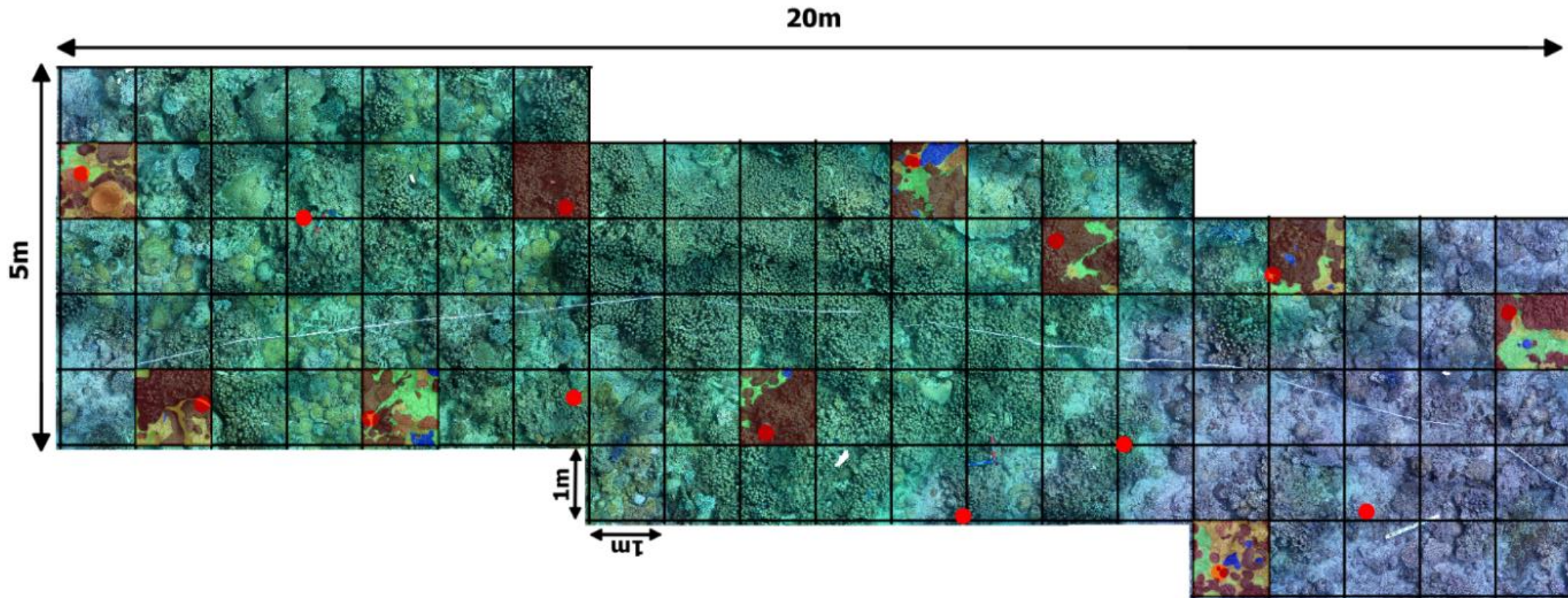


Fig. 9: Orthomosaic cropped to 100m² with a 1m² grid division. Ten grids were selected semi-randomly for annotation.

Drawing Polygons

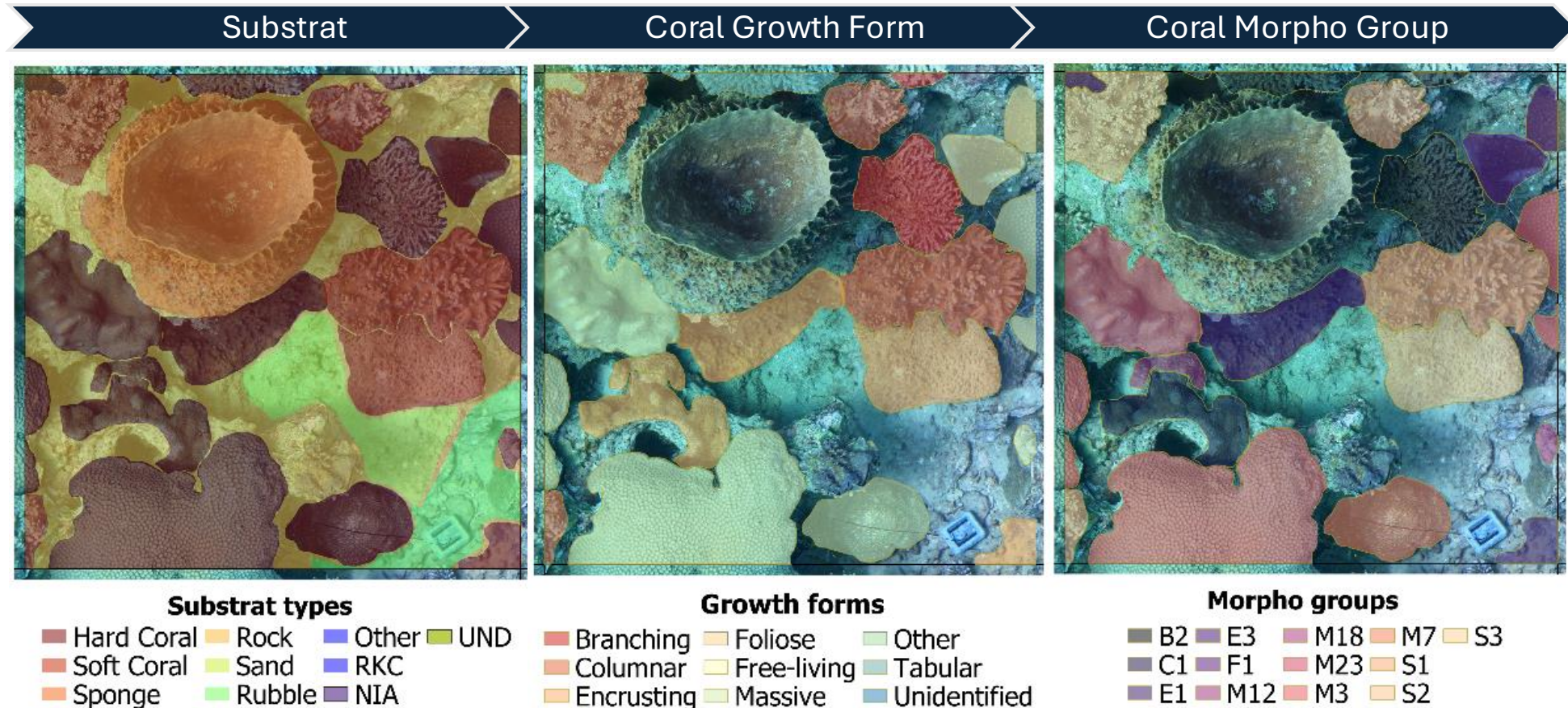
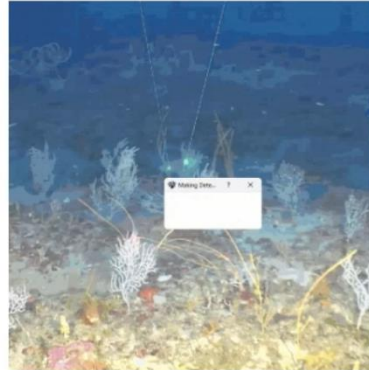


Fig. 10: Grids were classified using polygon annotations categorizing content into Substrat types, Growth forms, and Morpho groups.

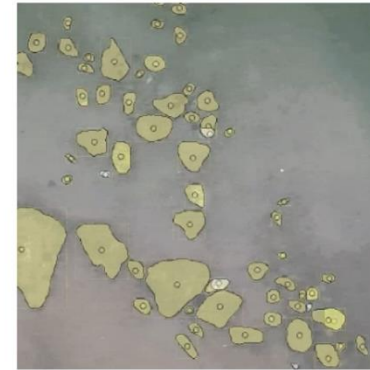
CoralNet Toolbox



Image Classification



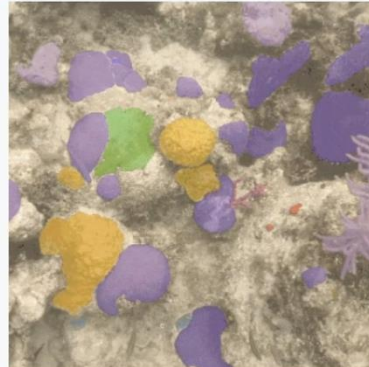
Object Detection



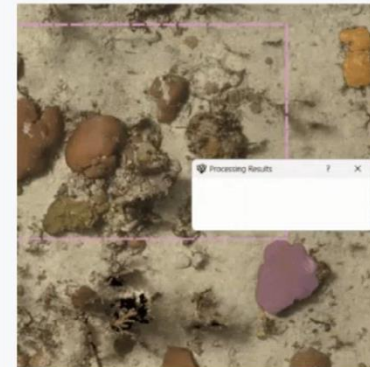
Instance Segmentation



Segment Anything (SAM)

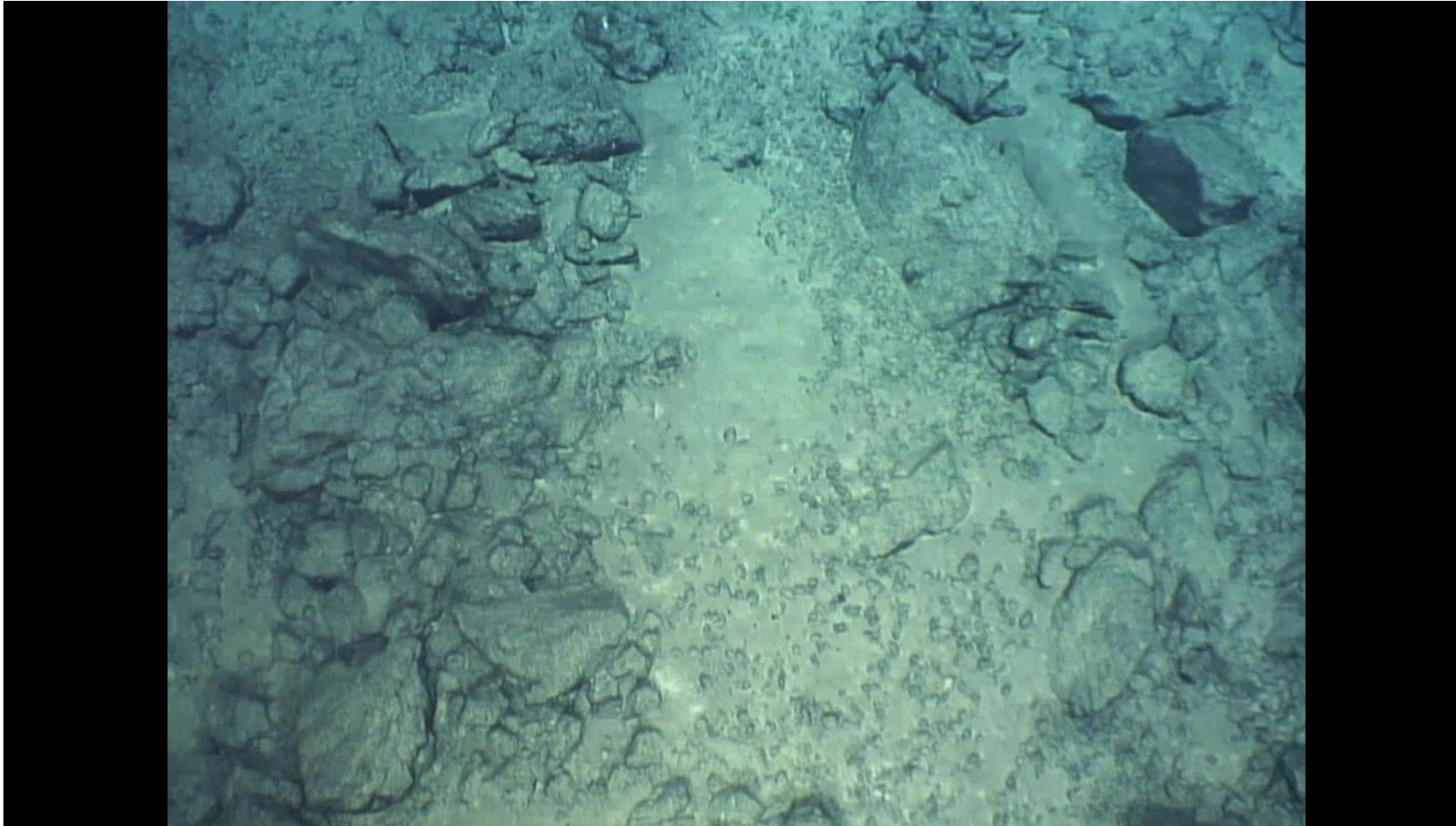


Polygon Classification

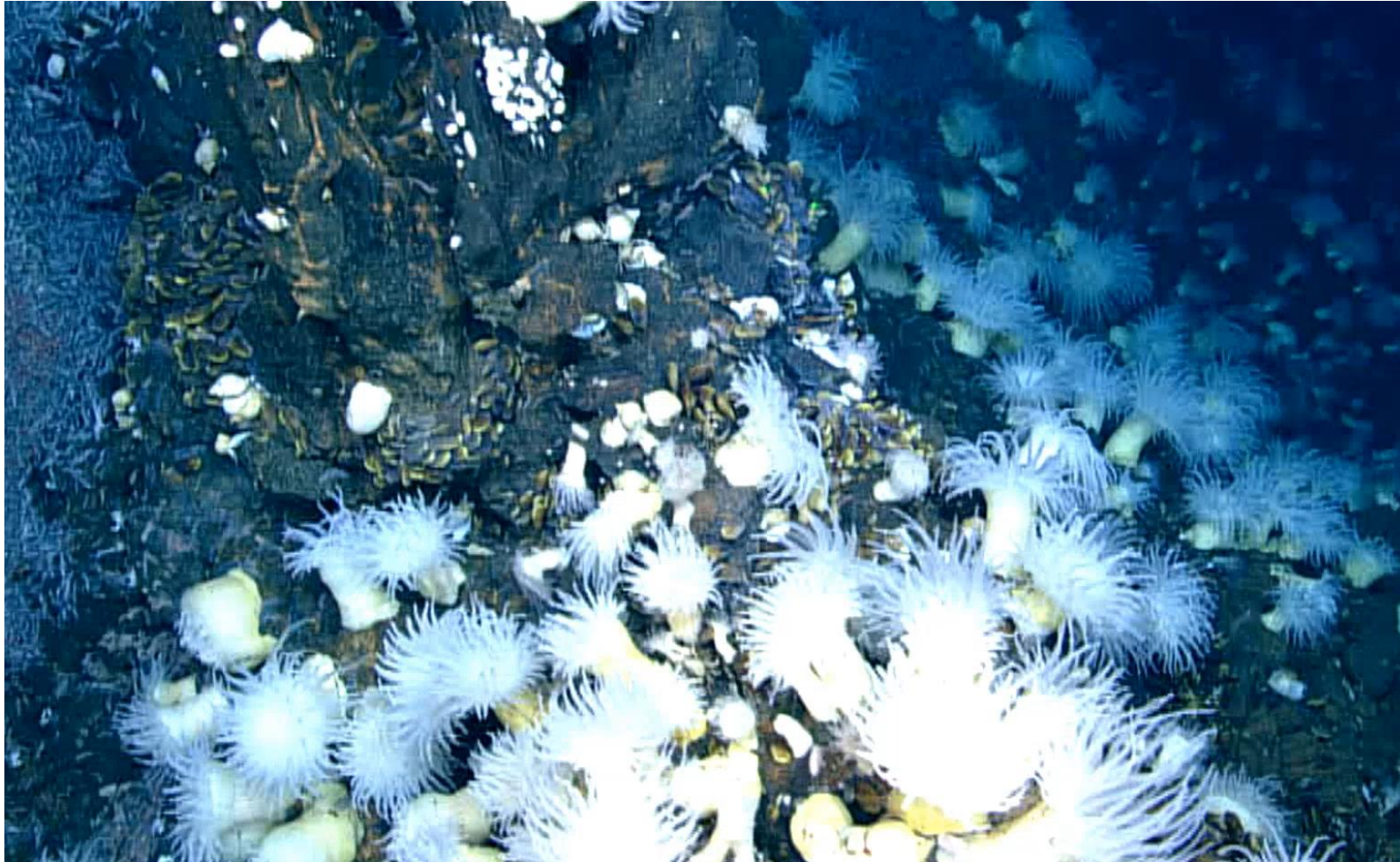


Region-based Detection

Central Indian Ridge Deep Sea Fauna



Central Indian Ridge Deep Sea Fauna



AI Friendly Annotations

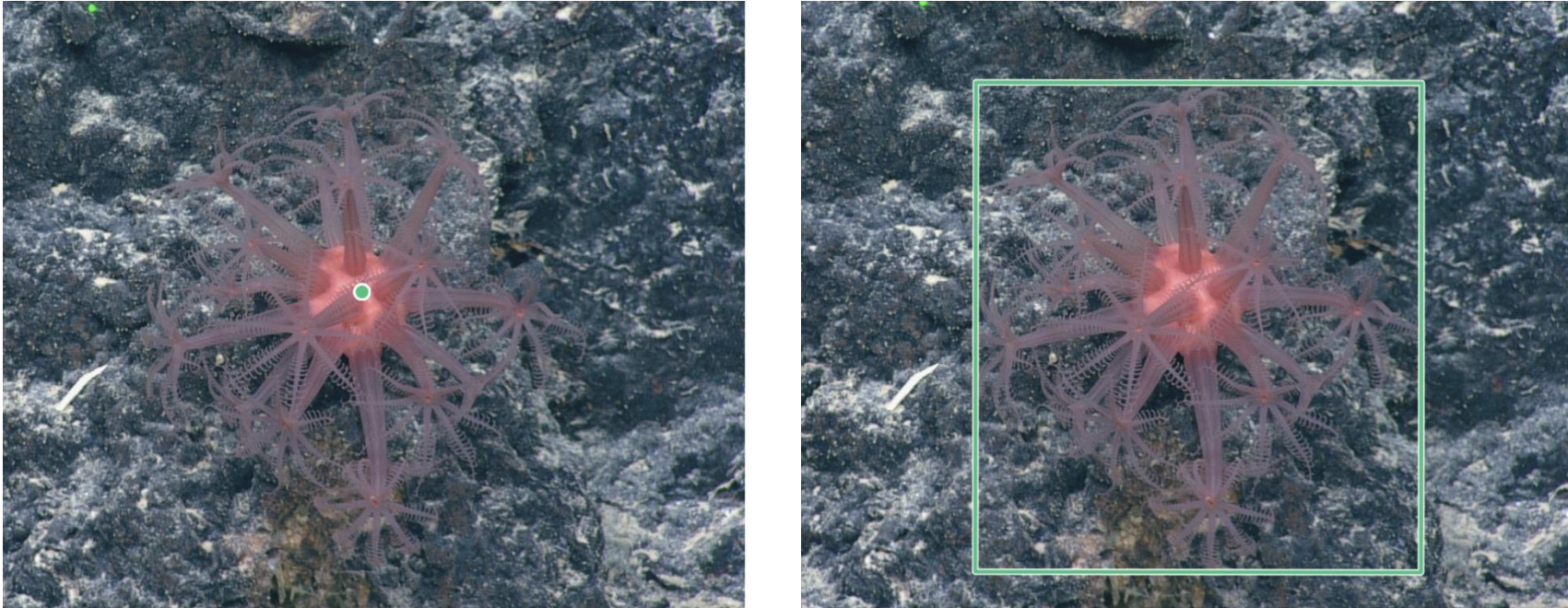


Fig. 11: Image annotation using point (left) and bounding-box (right) annotation format. Bounding-box annotations can be used for machine learning; point annotations cannot.

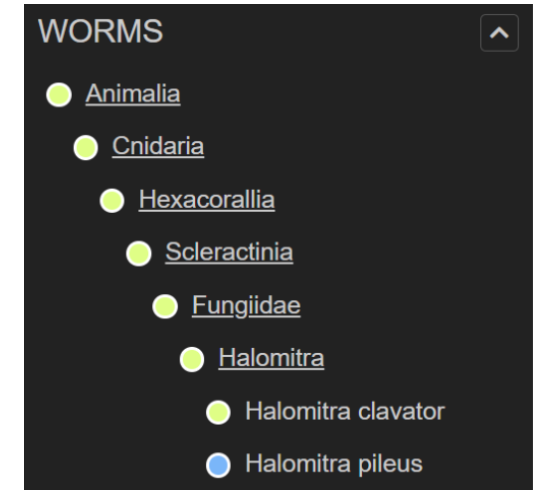


Fig. 12: Full hierarchical key imported from the World Register of Marine Species (WORMS).

Train an AI Model

 Train Example for Object Detection Task

Python CLI

```
from ultralytics import YOLO

# Load a pre-trained YOLO model (you can choose n, s, m, l, or x versions)
model = YOLO("yolo11n.pt")

# Start training on your custom dataset
model.train(data="path/to/dataset.yaml", epochs=100, imgsz=640)
```

Fig. 13: Fine-tuning a pretrained YOLO (You Only Look Once) model using domain-specific annotated underwater images to improve model predictions.

Cleaning up AI predictions

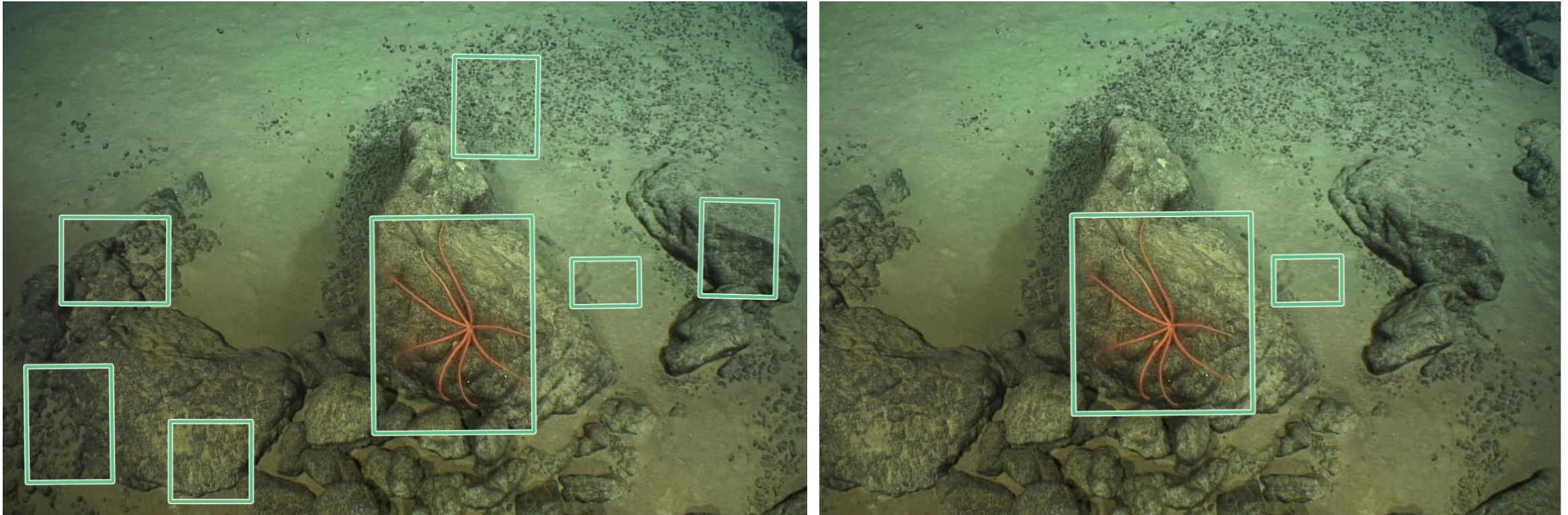
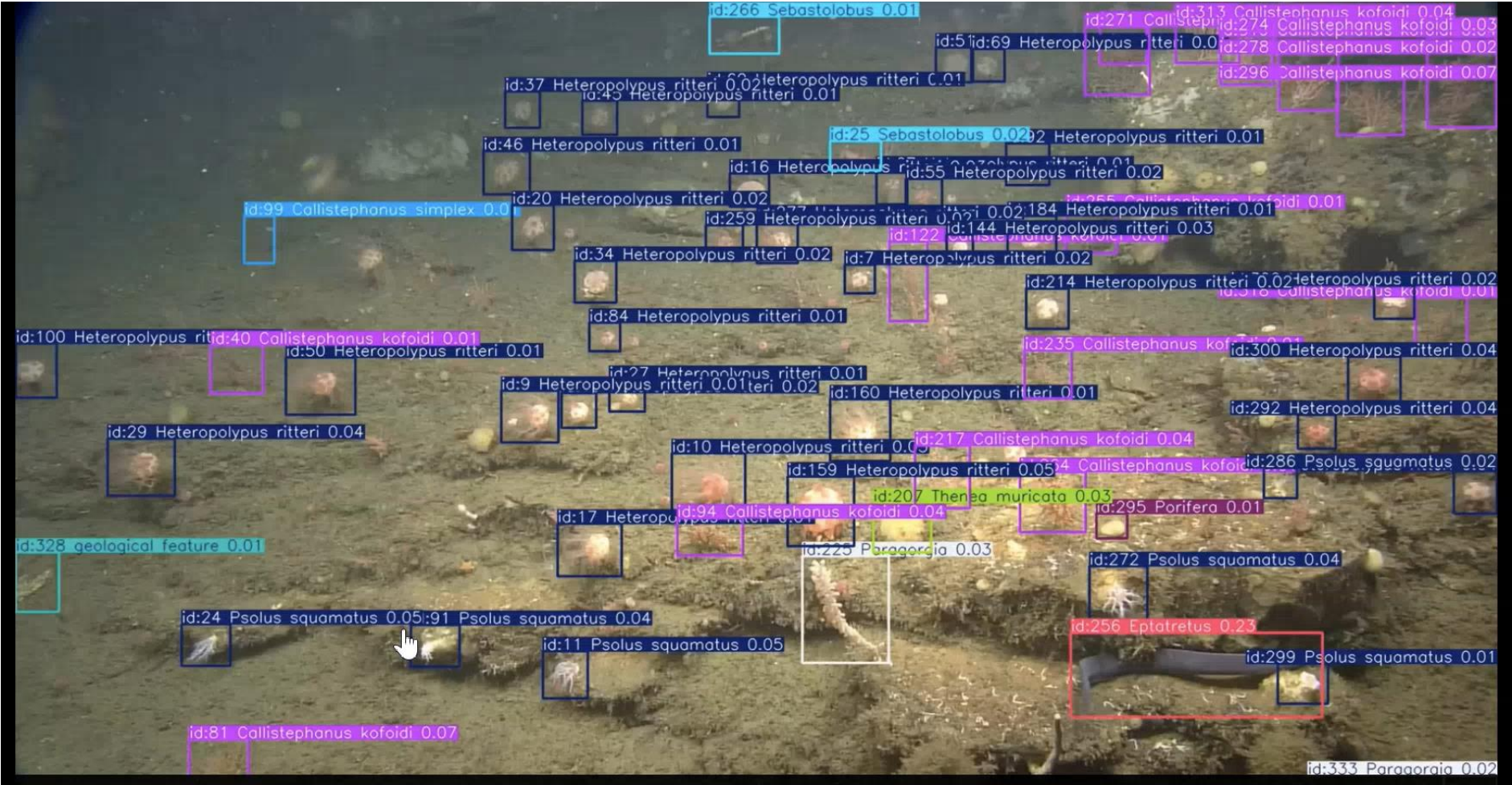


Fig. 14: Annotated Images after model predictions (left) and after manual cleaning (right).

YOLO Model MBARI-315k



Global Dataset of Annotated Images

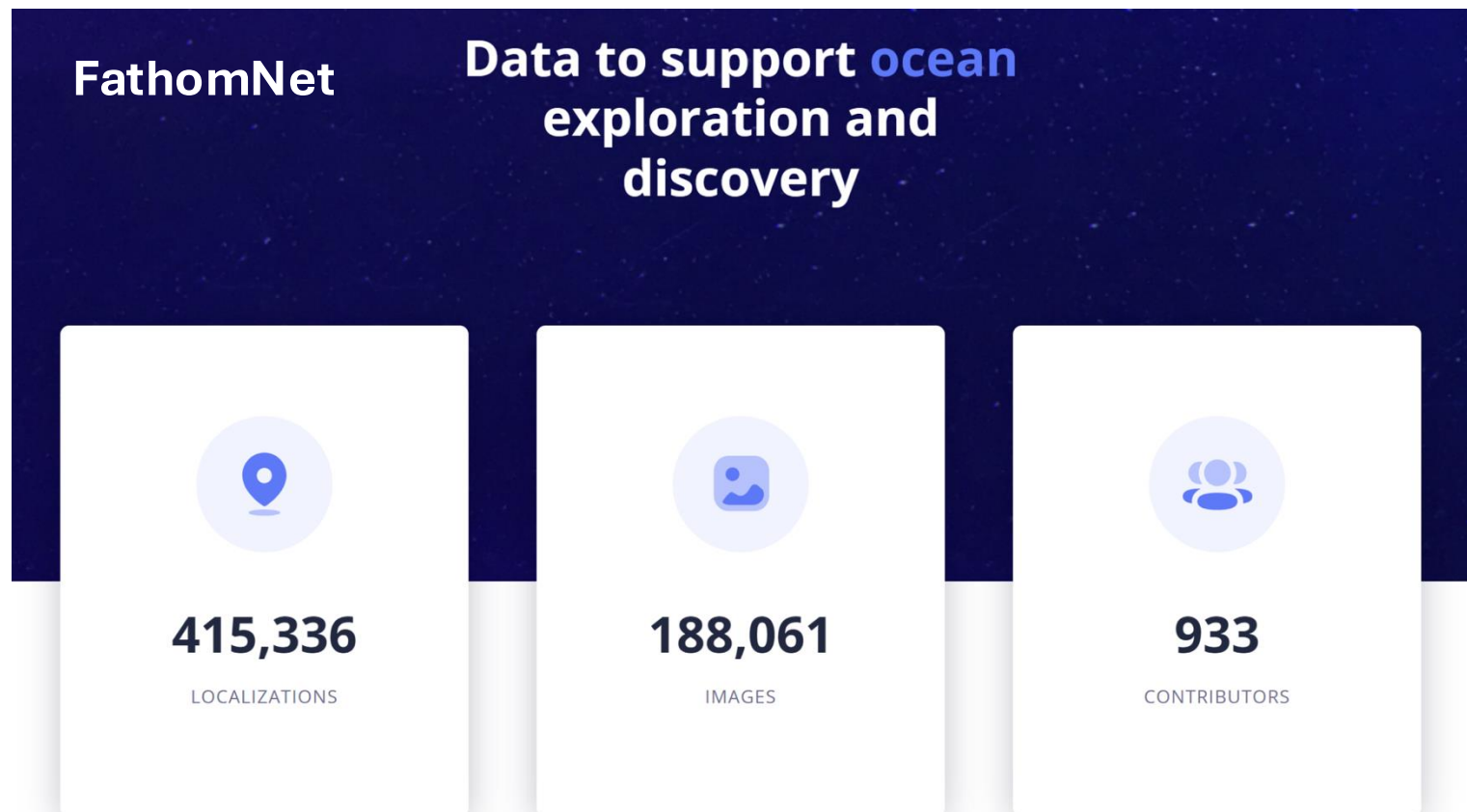
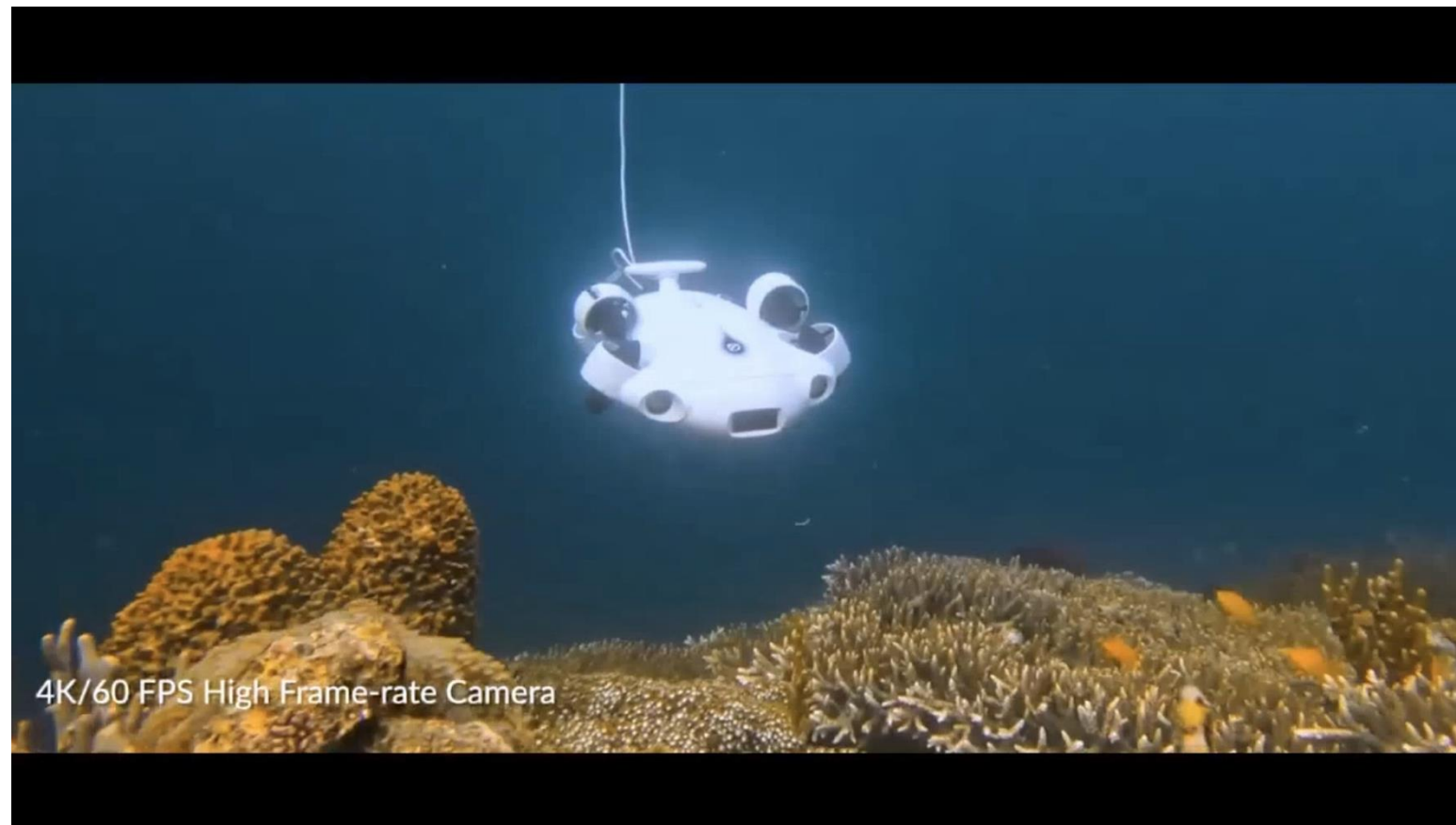


Fig. 15: FathomNet: a public repository of annotated underwater images for AI training by MBARI (Information Status: 6/14/2025).



Fig. 16: Fathomverse: a mobile game to explore deep-sea animals, have fun, and contribute to the FathomNet respiratory.

Underwater Drones



Take Home Message

- Modern computer software can effectively support marine ecology
- These tools can be used without a degree in computer science or specialized imaging equipment
- Collaborations across disciplines can further improve access to these tools.

pocacito

**Many thanks for
your attention!**



Closing Statement

Carbon Dioxide Exchange Between Atmosphere and Ocean and the Question of an Increase of Atmospheric CO₂ during the Past Decades

"...human beings are now carrying out a large scale geophysical experiment of a kind that could not have happened in the past or be reproduced in the future.... This experiment, if adequately documented, may yield a far-reaching insight into the processes determining weather and climate."

Fig. 16: Source