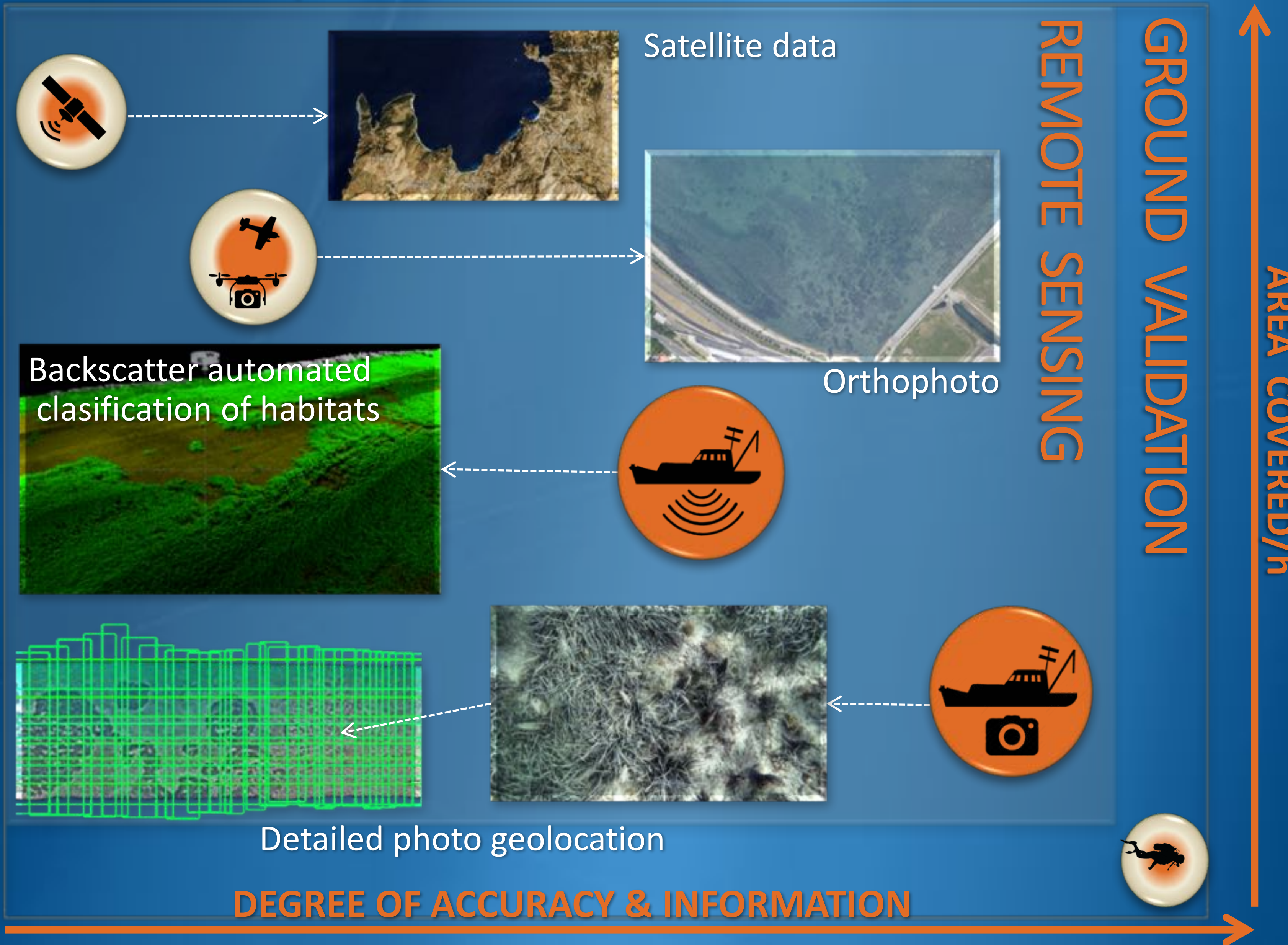
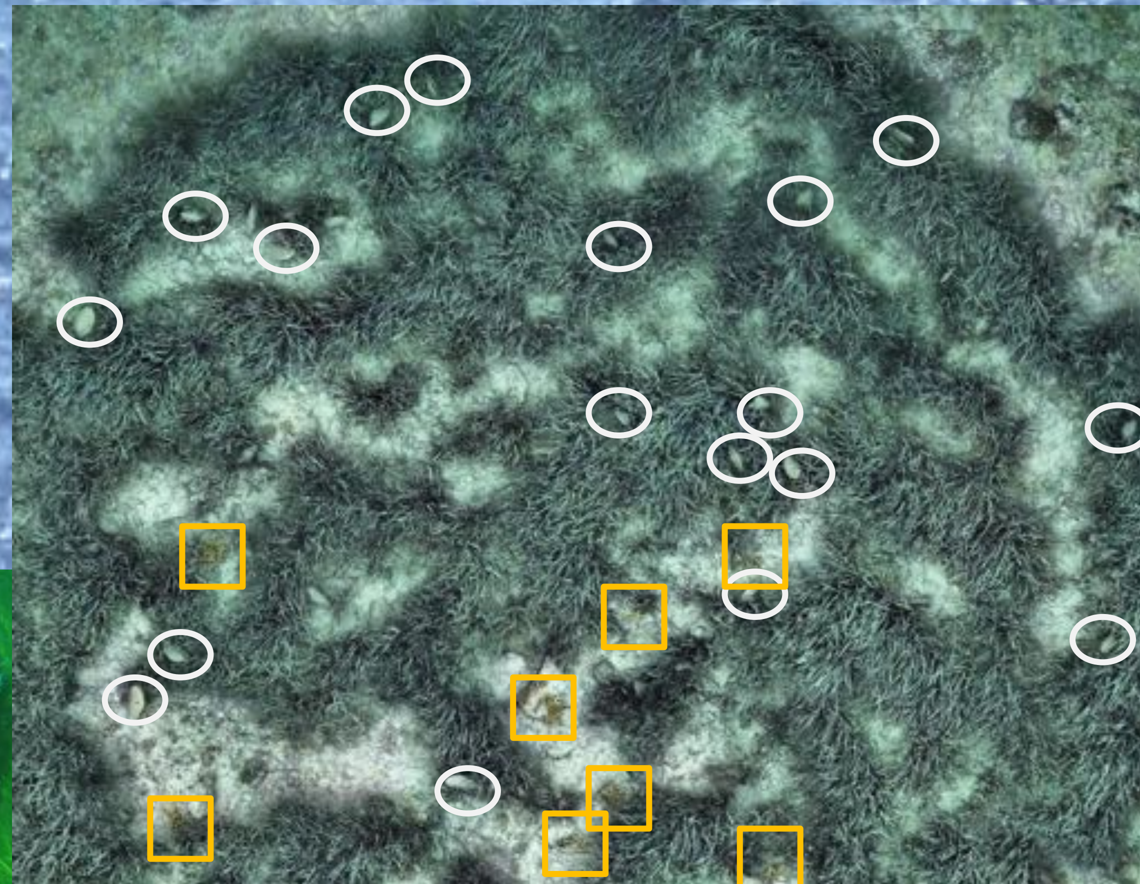
HARPHASEA

Seabed habitat mapping with underwater photogrammetry

Maja BERDEN ZRIMEC, Mojca POKLAR, Dean MOZETIČ and Duško VRANAC

Possible outputs and data scale

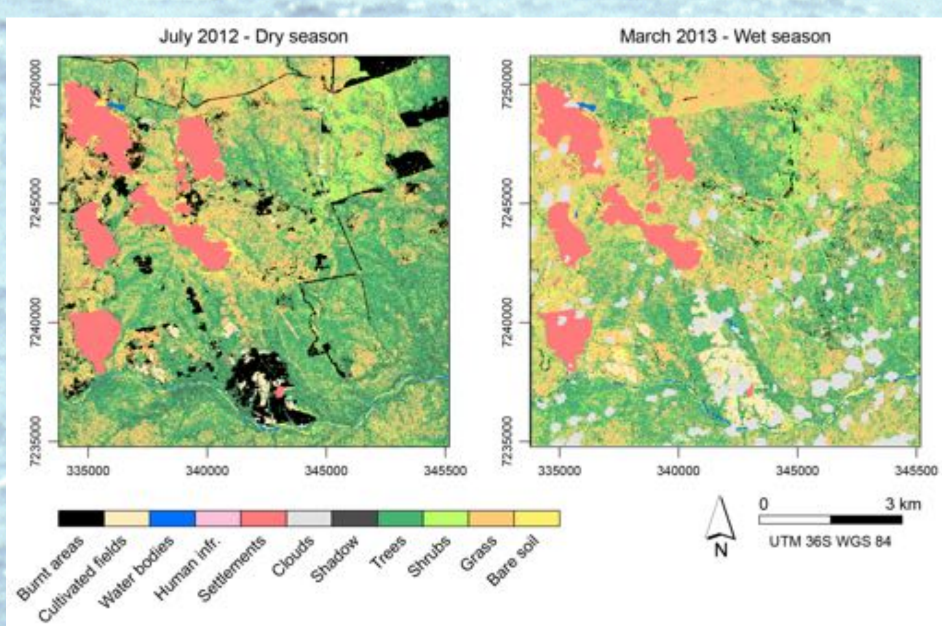


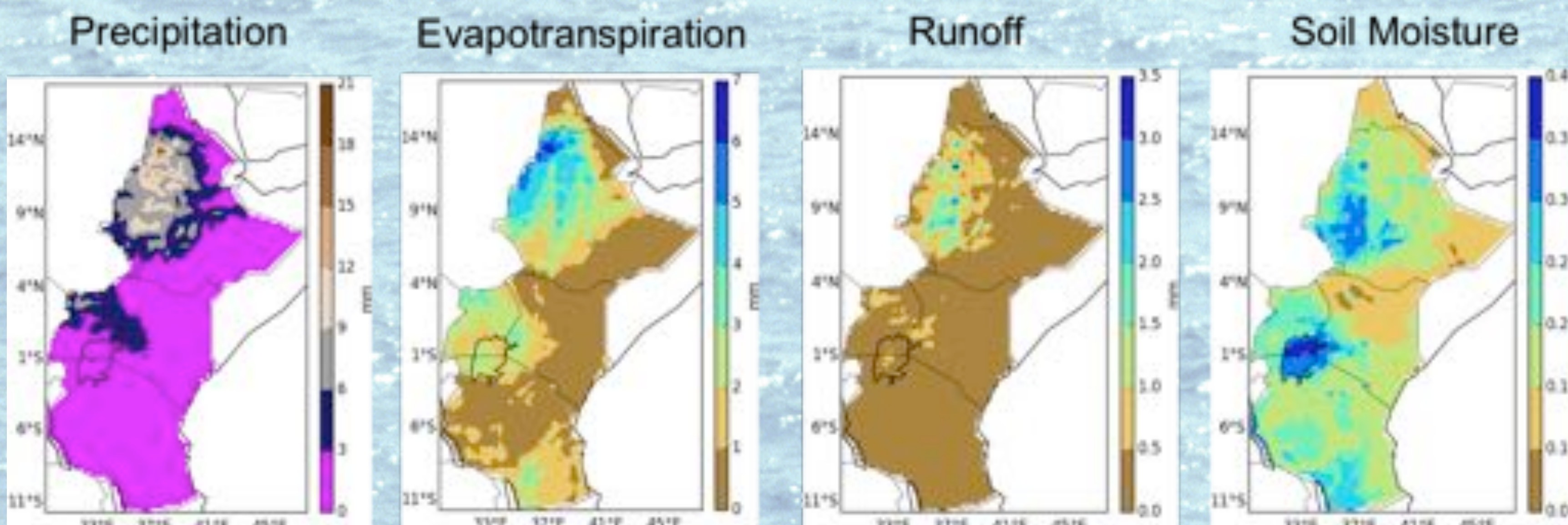


- *Verongia aerophoba*

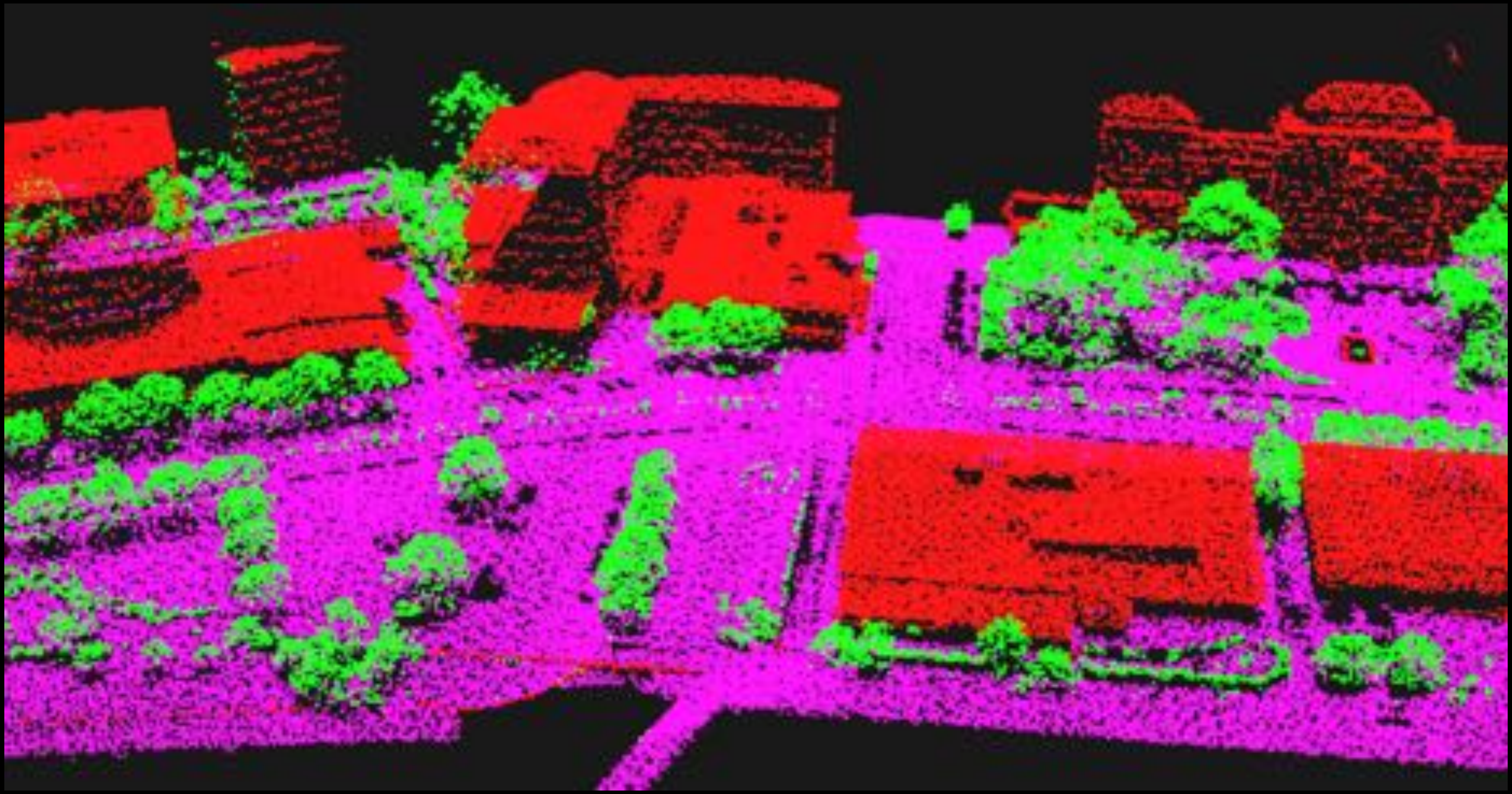
- *Pinna nobilis*

Remote sensing on land





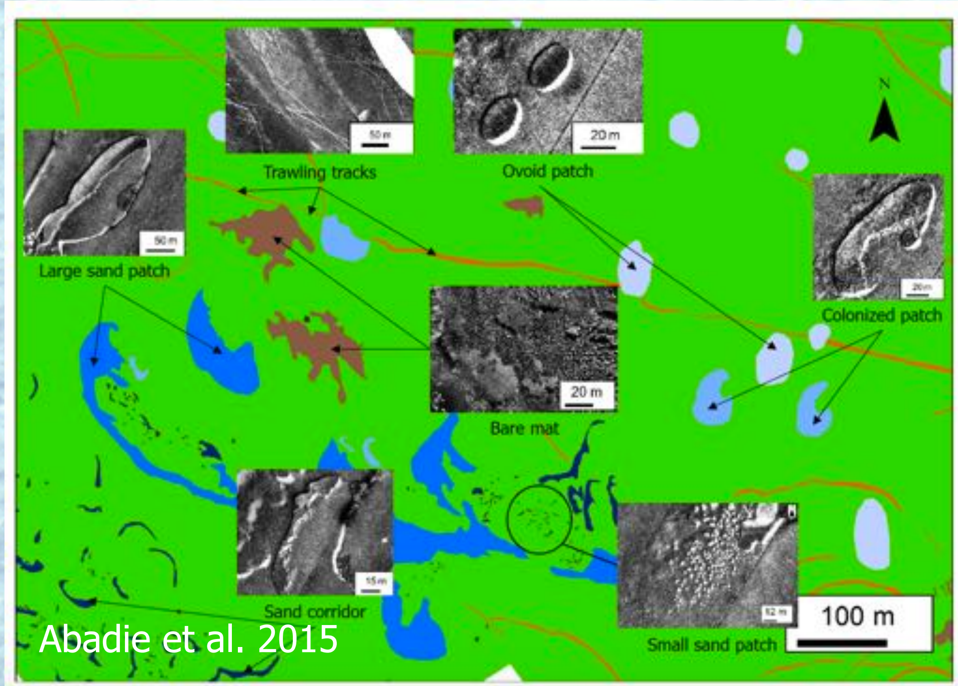
3D modelling

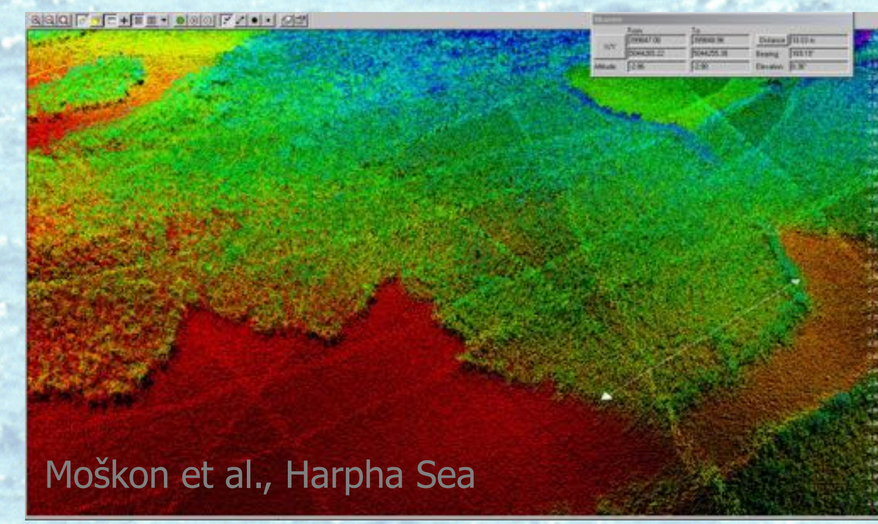


Coastal area

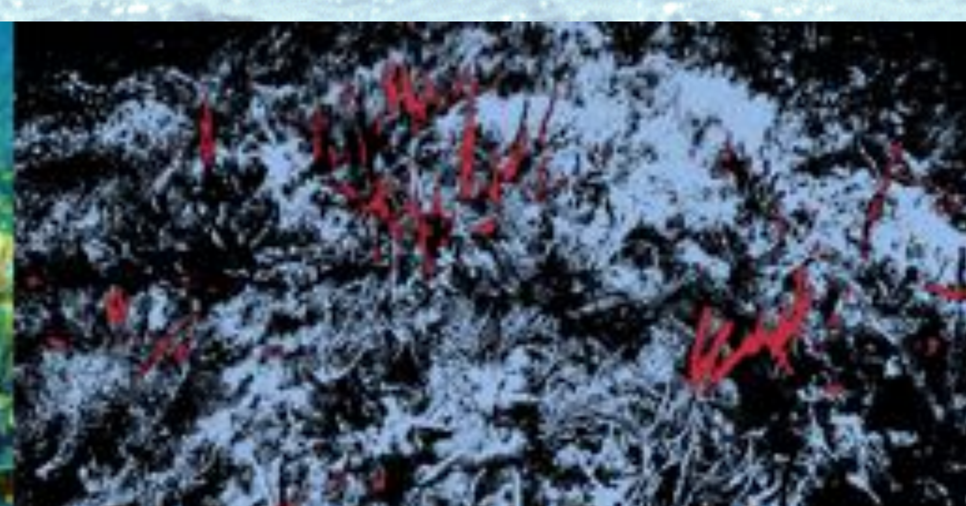
Remote measuring techniques are much more challenging in the water environment, where optics is limited by the light penetration, especially in turbid waters:

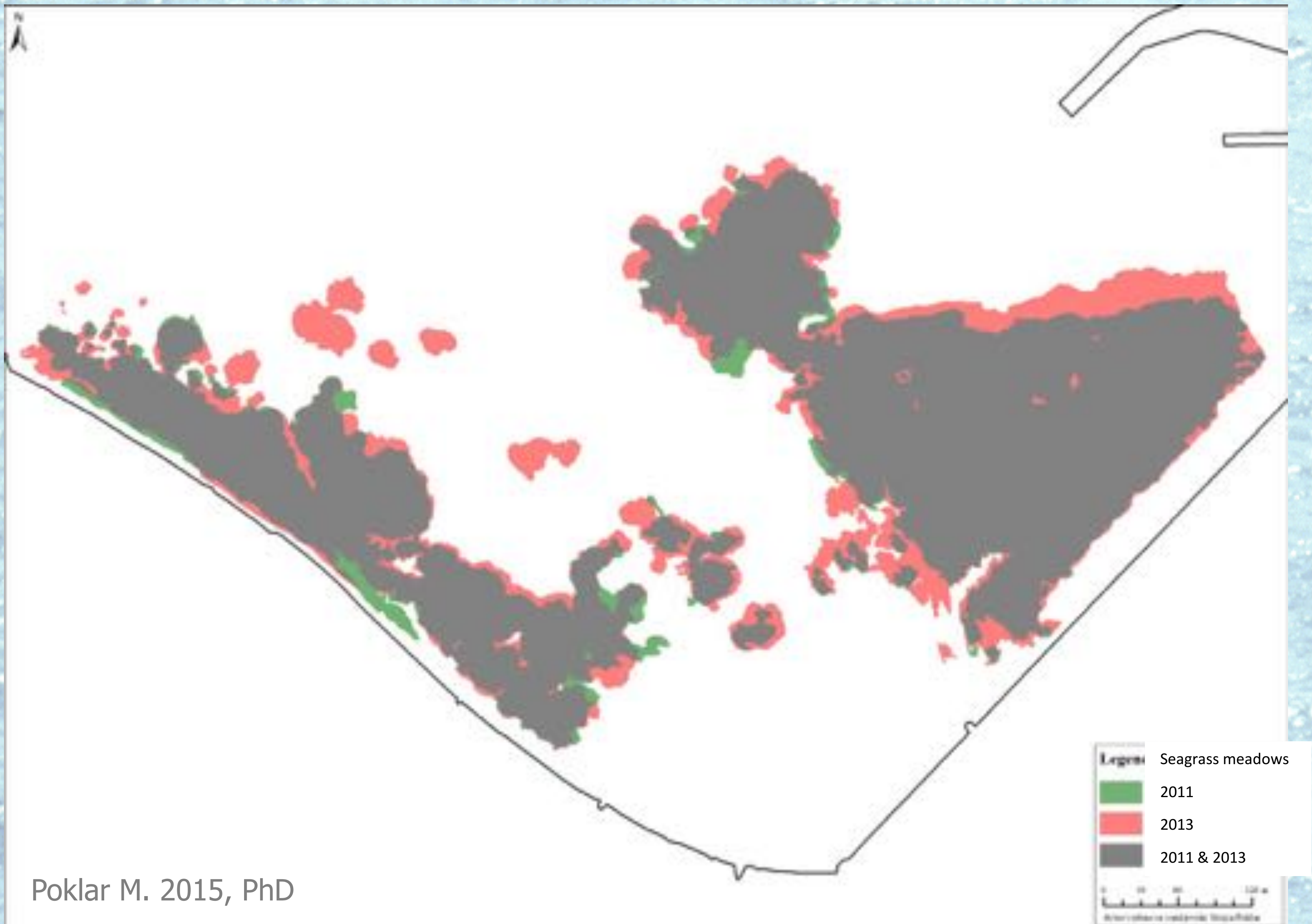
- Phytoplankton;
- Particulate organic detritus;
- Suspended sediments;
- Chromatophoric dissolved organic matter in the water column.


Trawling tracks
Ovoid patch
Large sand patch
Colonized patch
Bare mat
Sand corridor
Small sand patch
50 m
20 m
100 m
N
Abadie et al. 2015


Moškon et al., Harpha Sea


ECOTON.com





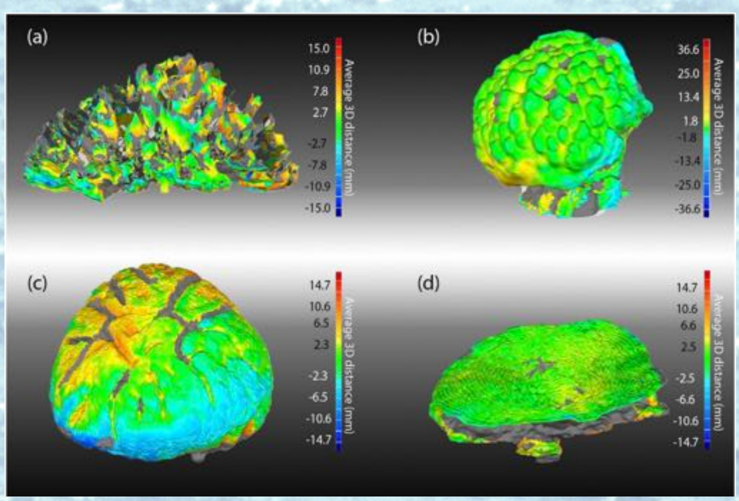
Poklar M. 2015, PhD

Photogrammetry

Photogrammetry has already a long history in the field of underwater archaeology.

Photogrammetry

In marine biology, photogrammetry has been used only for few specific challenges like to create three-dimensional (3D) models of corals and reefs from which biophysical properties of structural complexity can be quantified (Figueira et al. 2015).



Seagrass meadows

But what can be done with seagrasses?

Leaves move around, the border is blurred…

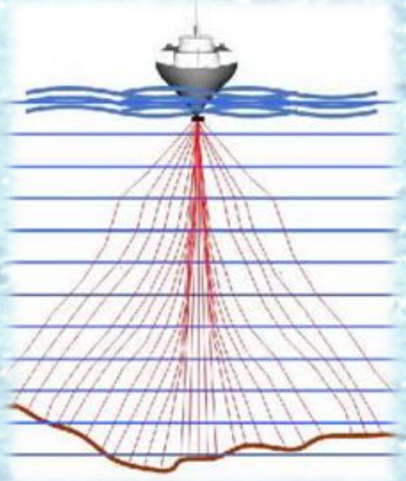
Seagrass meadows

Seagrass meadows rank amongst the most valuable coastal ecosystems on Earth in terms of goods and services they provide (Telesca et al. 2015).

At least 1.5% of the seagrass beds is lost every year and almost 29% of the areal extent of seagrass has disappeared globally since 1879, but real regression rates are hard to evaluate due to the limited spatial information (in the case of *Posidonia oceanica*, there are data only for half of the Mediterranean coast - Telesca et al. 2015).

A more detailed and comprehensive data are therefore essential and remote sensing, especially combined with photogrammetry, hold a great potential for such analysis.

Photogrammetry of seagrass meadows



Although technology advancements enable monitoring at increased signal-to-noise ratio and spatial/spectral resolutions, coastal areas still require specific algorithms that take account multivariate characteristics.

A multi-sensor data fusion is one of the approaches that can greatly improve the success of water-related remote-sensing applications and the real-time monitoring of benthic habitats and water quality.

We tested the utilisation of photogrammetry for monitoring of seagrass beds in Slovene coastal waters.


SPARUS II
VICOROB, Univ. Girona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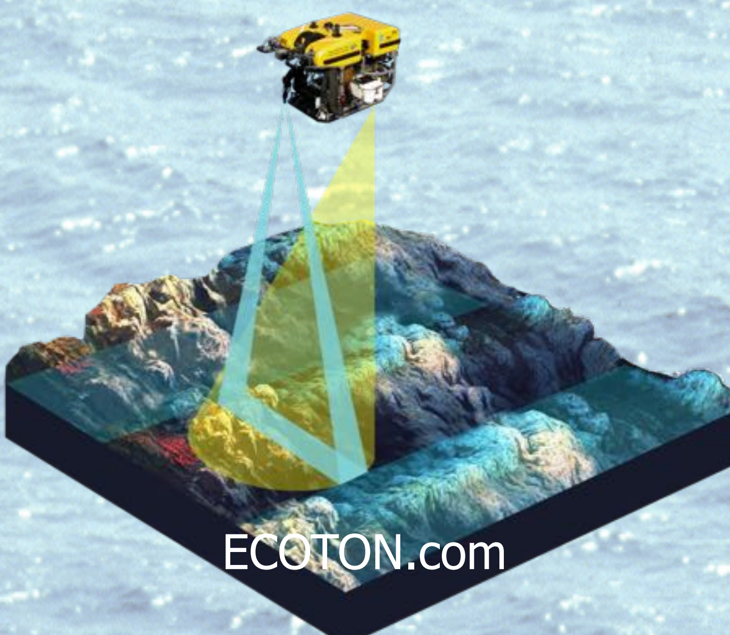
XL CATLIN
> XL CATLIN SEAVIEW SURVEY - Lady Elliot Island - 2016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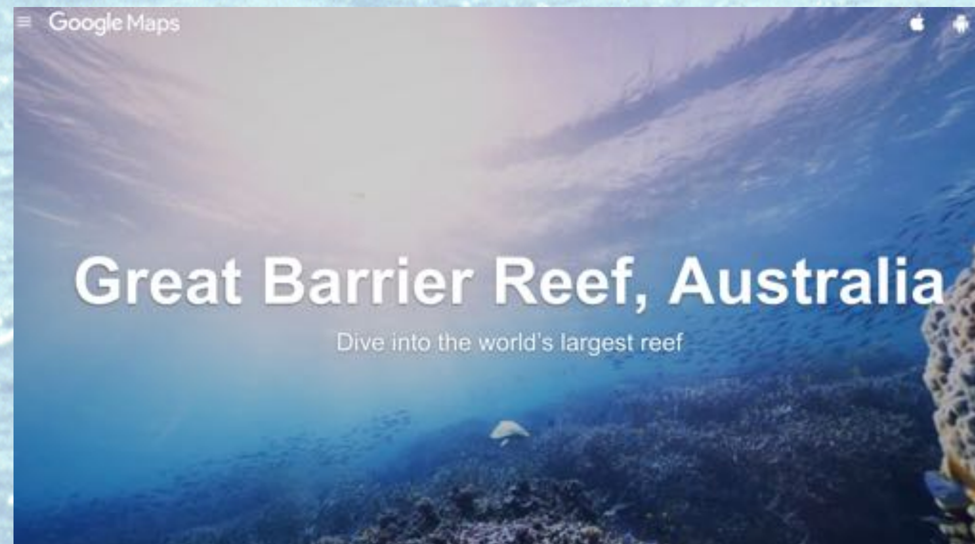
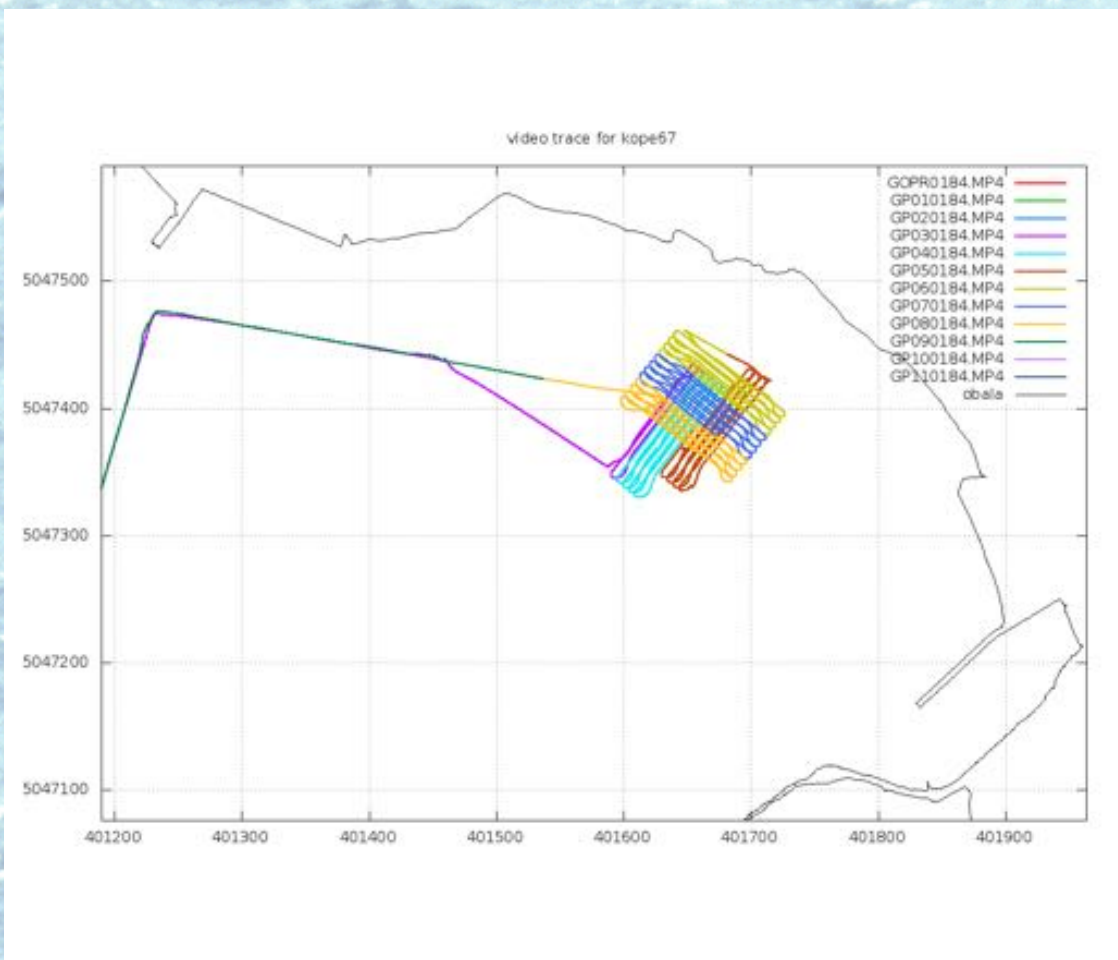

Google Maps
Great Barrier Reef, Australia
Dive into the world's largest reef

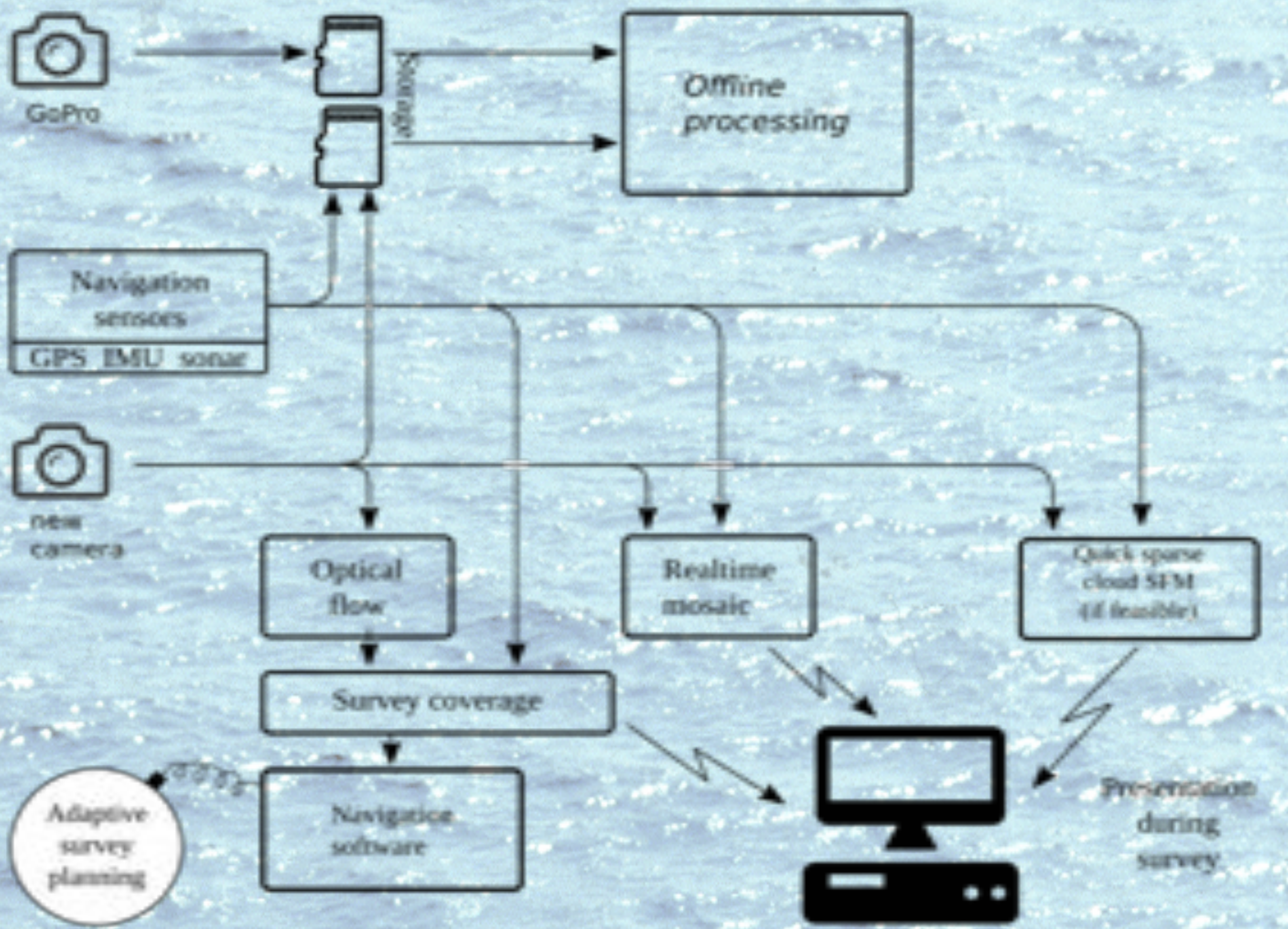
Research vehicles

Survey instruments (multibeam and sidescan echosounders, subbottom profilers, underwater cameras, etc.)

Data collection with autonomous surface vehicle APSIS



Real-time processing on board of APSIS



Data collection

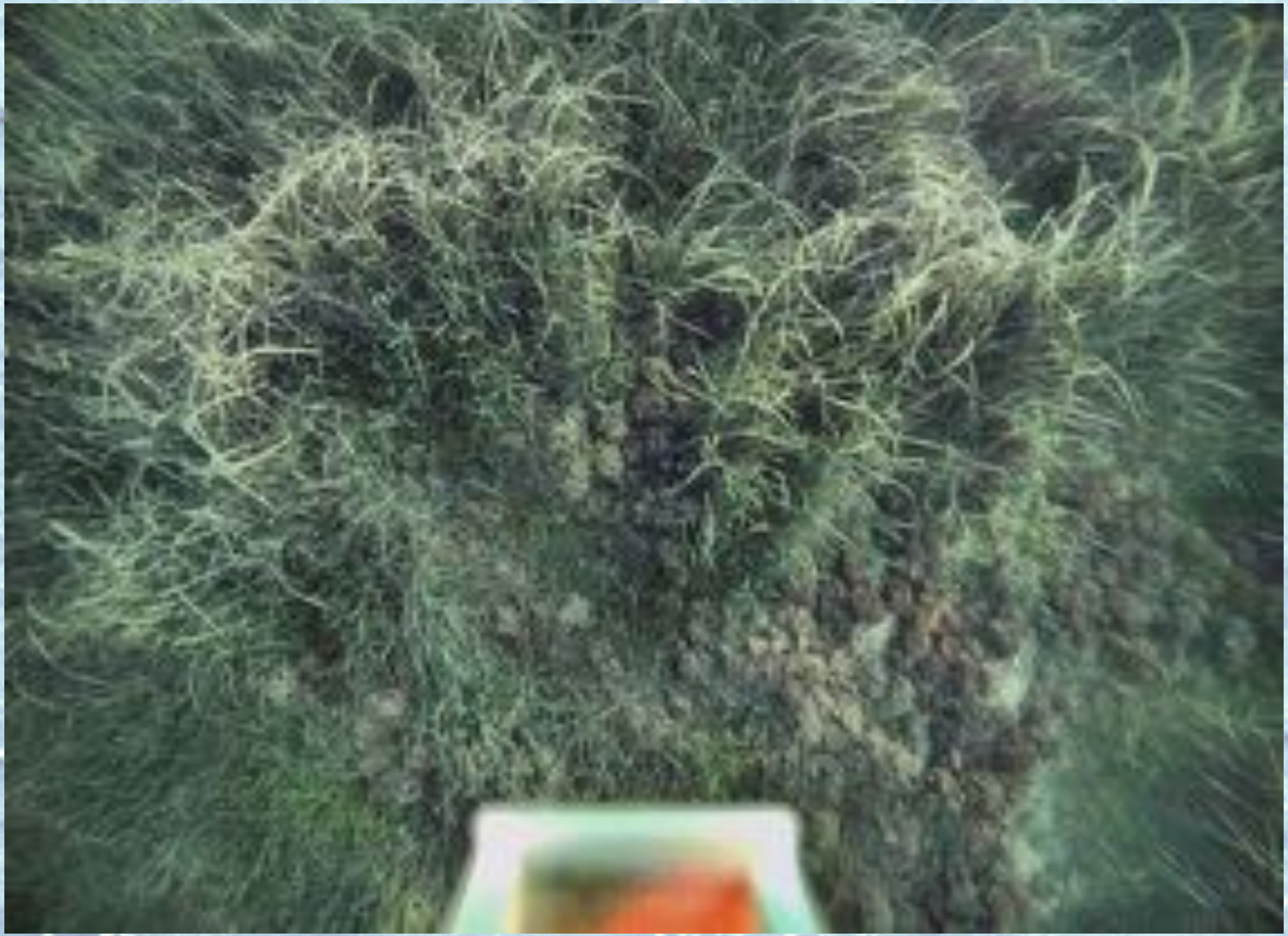
Data collection was mostly done at 0.7 – 1.3 m/s to reduce motion blur and the risk of air bubbles in camera's field of view.

The parallel tracks were planned to achieve 60% overlap between the across-track neighbouring images. Overlap in the along-track direction is not a problem when recording video rather than the single still images.

Video was recorded by a GoPro 4 Black camera in waterproof housing that can be positioned 20-50 cm below water surface.

The video modes with the aspect ratio of 4:3 and a frame rate of at least 30 fps were used, with 2.7K resolution.

A small portion of the camera's field of view is occupied by a reflector illuminated by a pulsating LED to provide precise time synchronization of the video with other information recorded by the navigation computer.

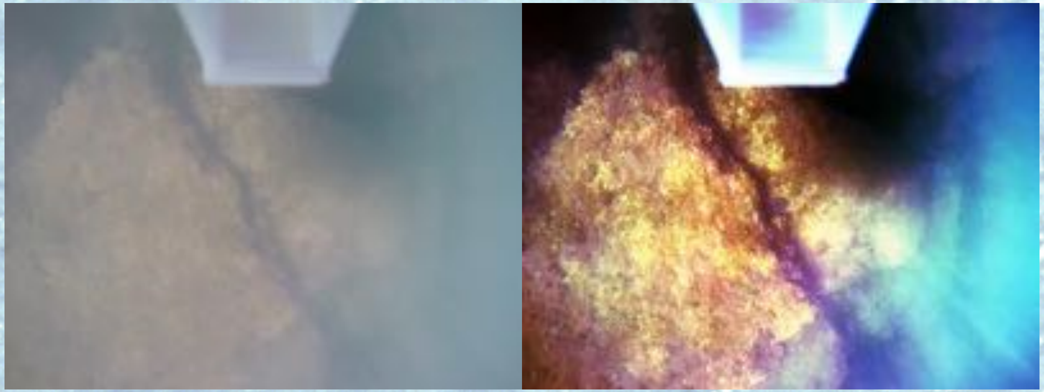


Data processing and analysis of ASV data

The time code was extracted from the video together with assigned navigational information (position, orientation, water depth) to each frame of the video.

The video frames were enhanced to counter effects of the reduced visibility under water.

A combination of “unsharp mask” and “CLAHE” (contrast limited adaptive histogram equalization) algorithm was used.



Scheme of the video data processing

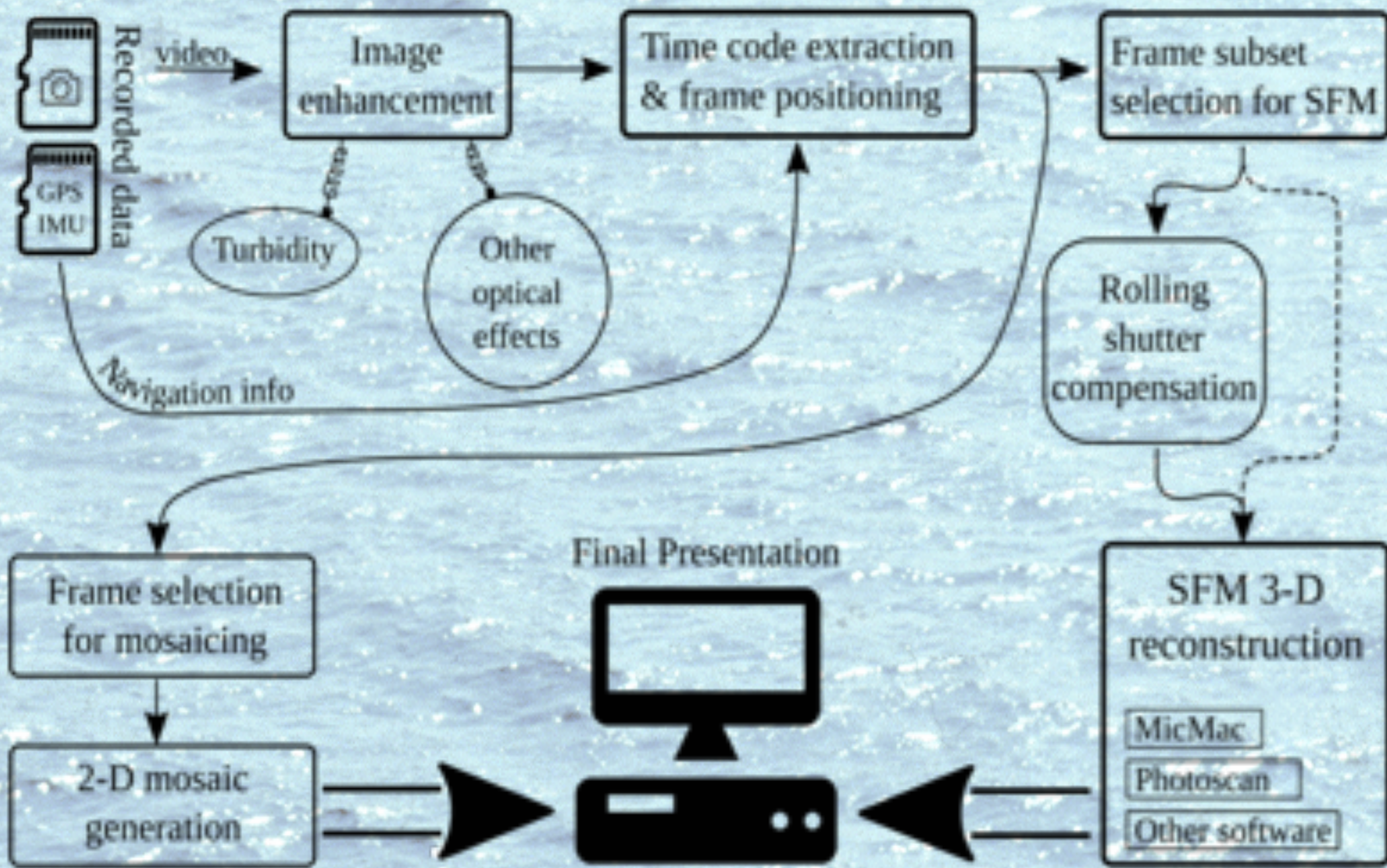
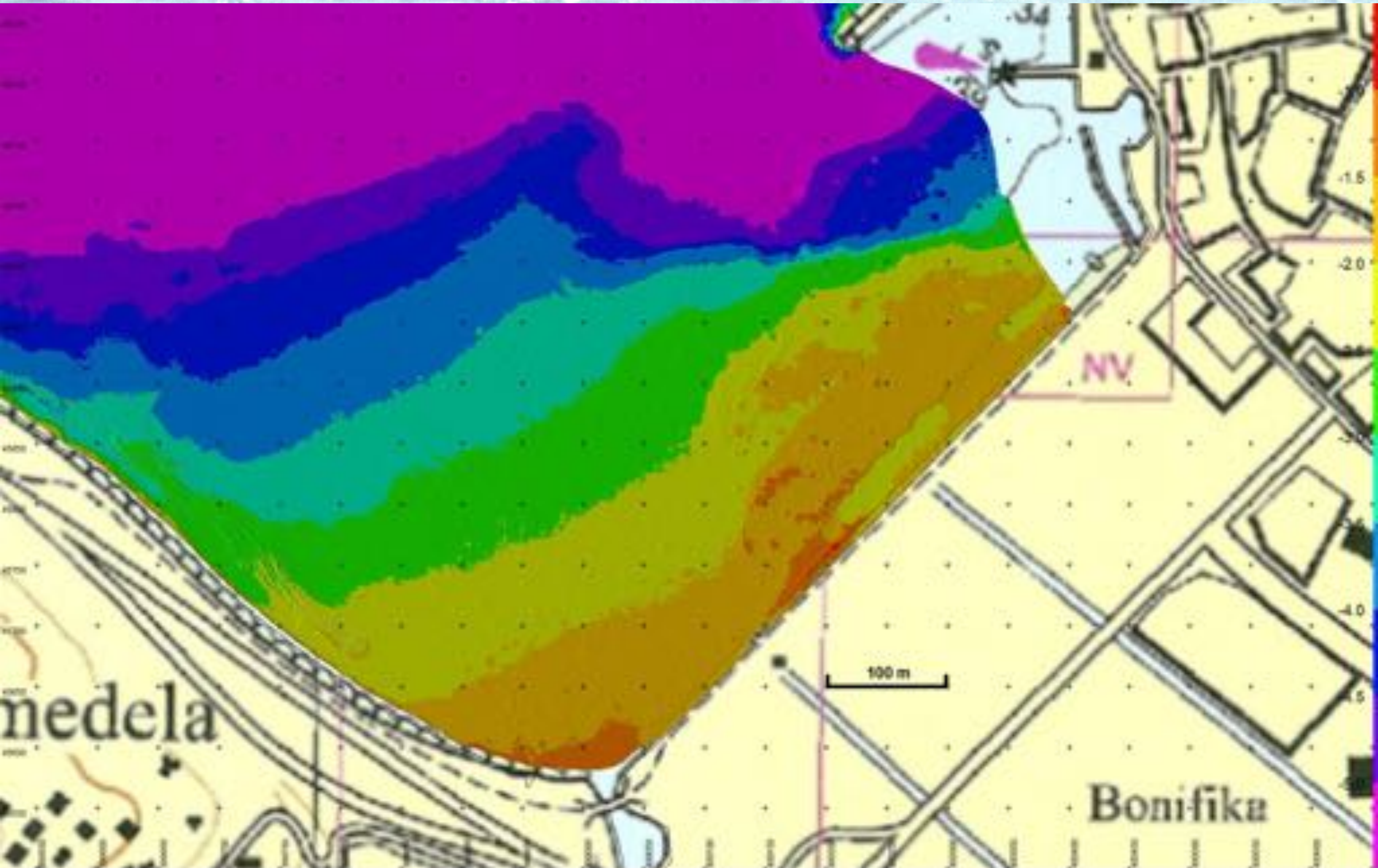


Photo-mosaic

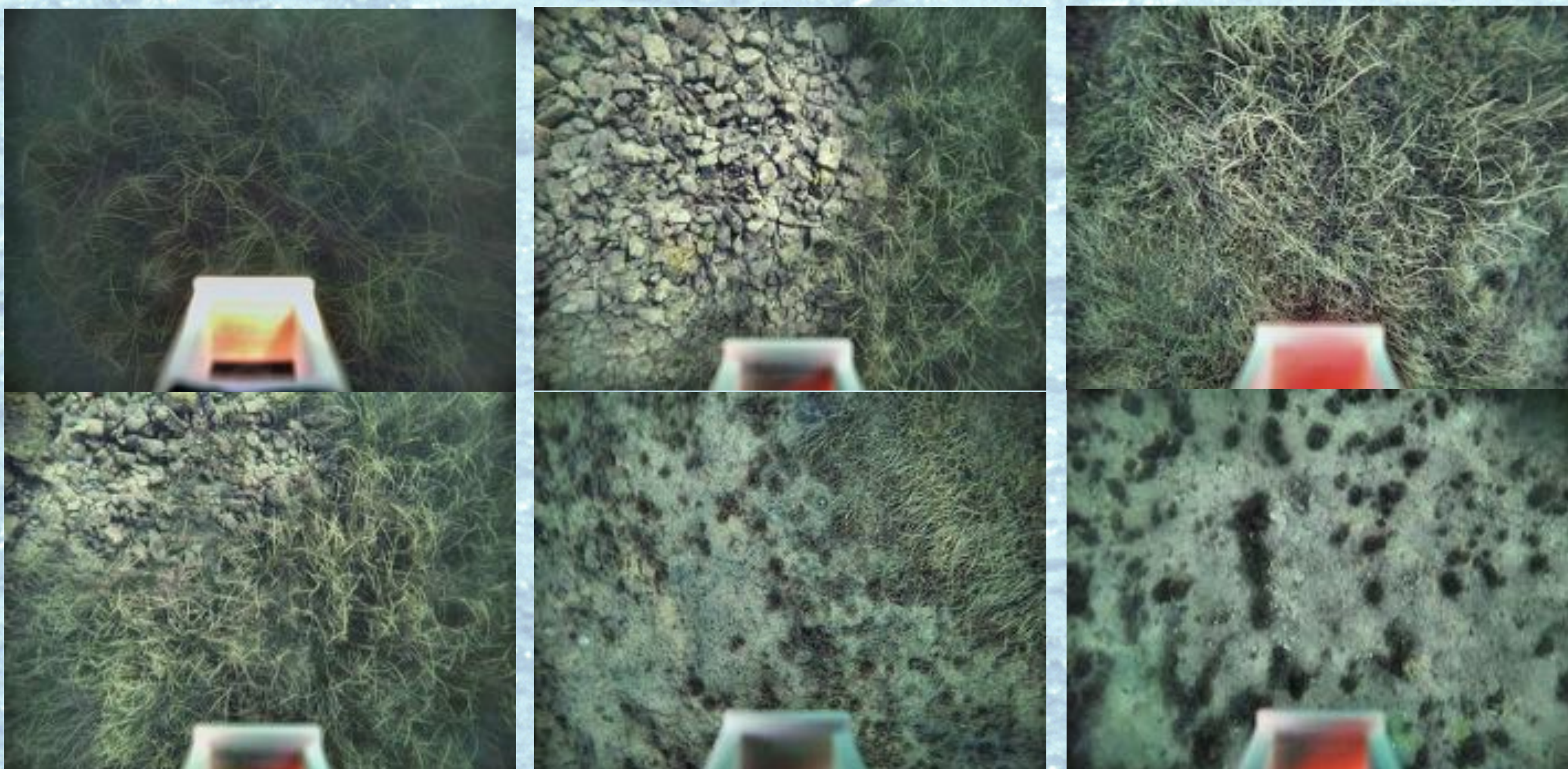
Generation of photo-mosaic was used for a quicker processing of a large area.

This is a less accurate representation of the surveyed area that can be produced on the same hardware as 3D processing, generated by projecting a subset of frames on an assumed nearly flat bottom (still considering varying water depths between frames, but not deviations from flat bottom within a single frame).

The Bay of Semedela



Seabottom in the Semedela Bay




2
1
5
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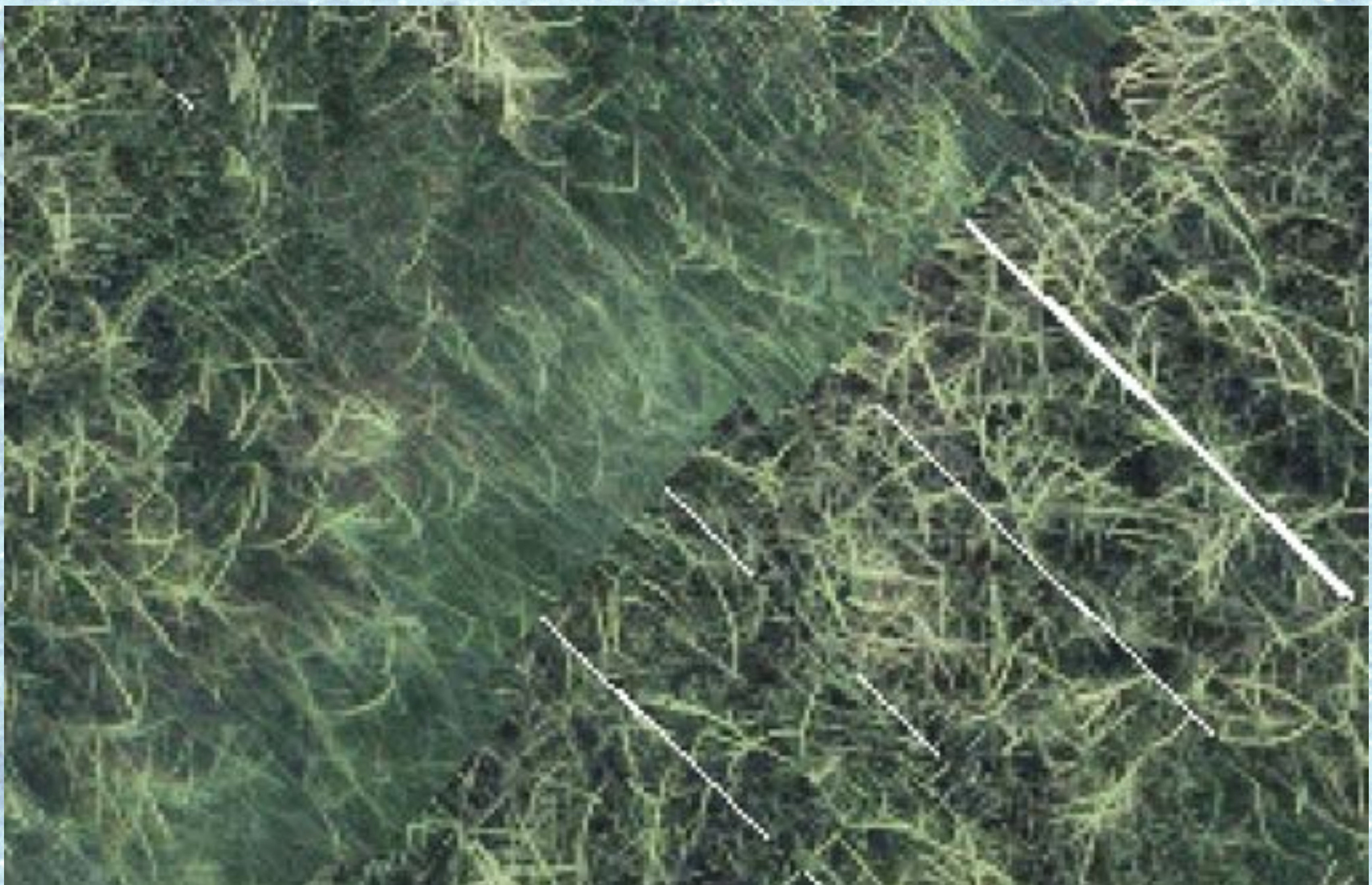
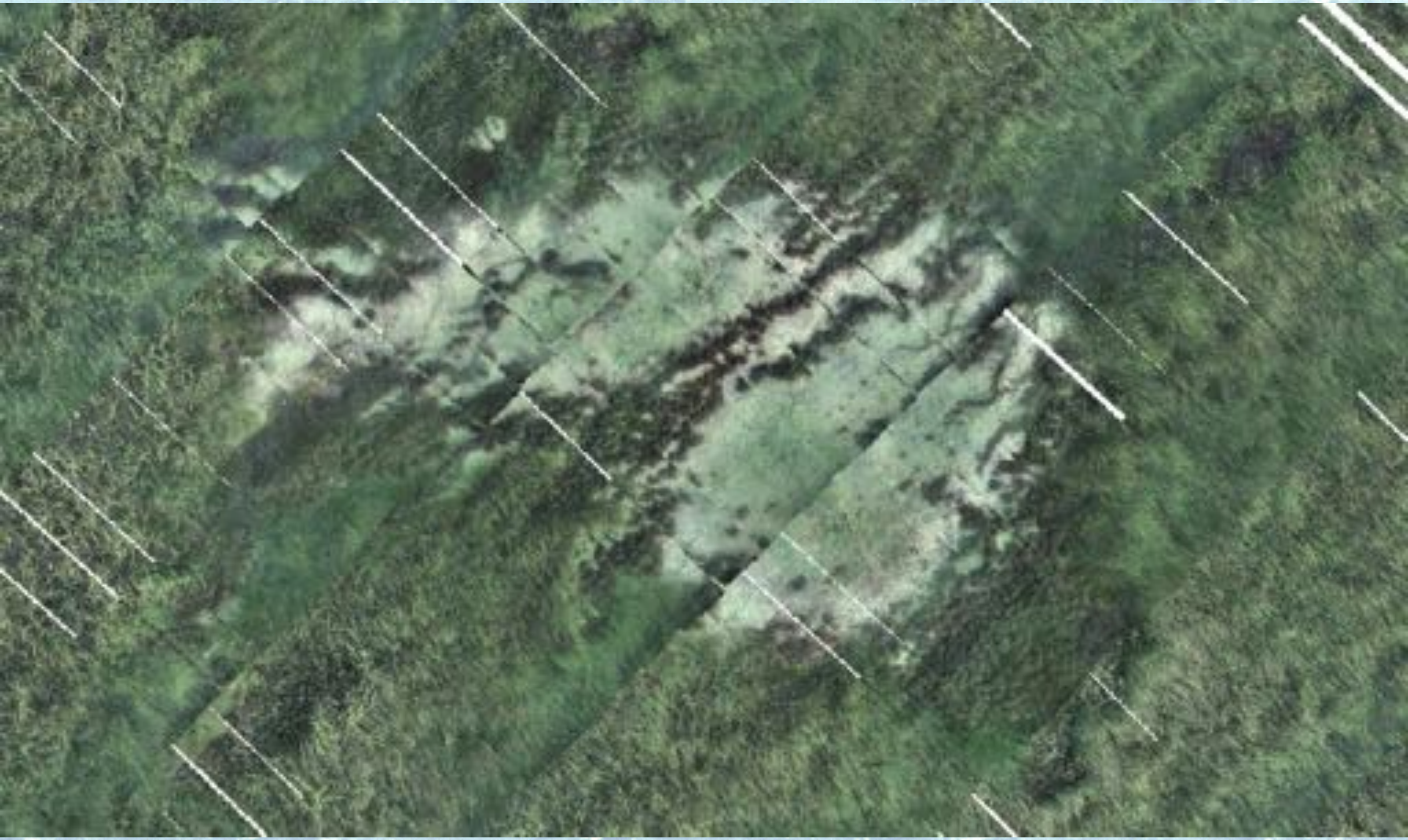
6
7





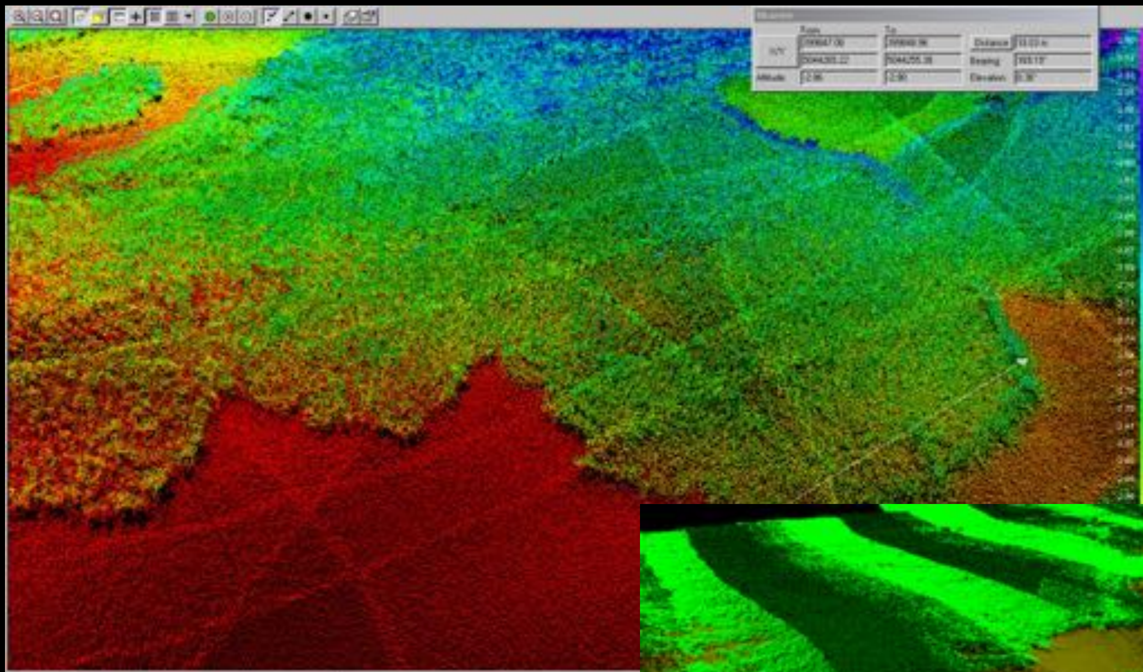
Determining seagrass meadows distribution

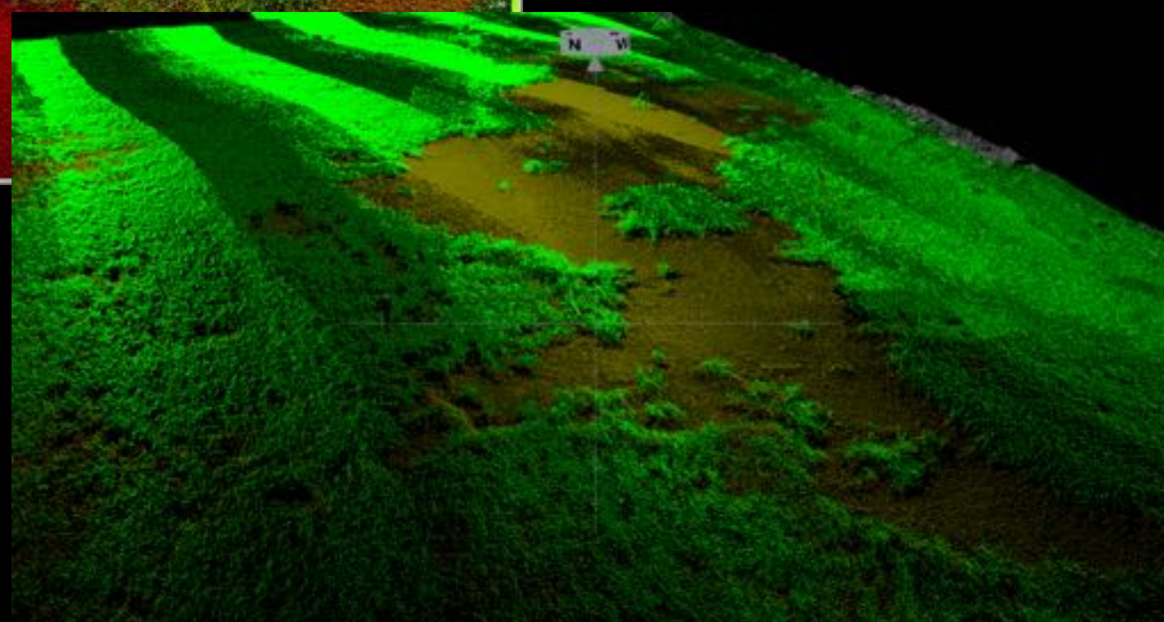
To determine the areas where a distinct type of seabed cover is present, a supervised image classification was performed with GIS software (for example ESRI ArcGIS), and subsequently, spectral signatures were computed.

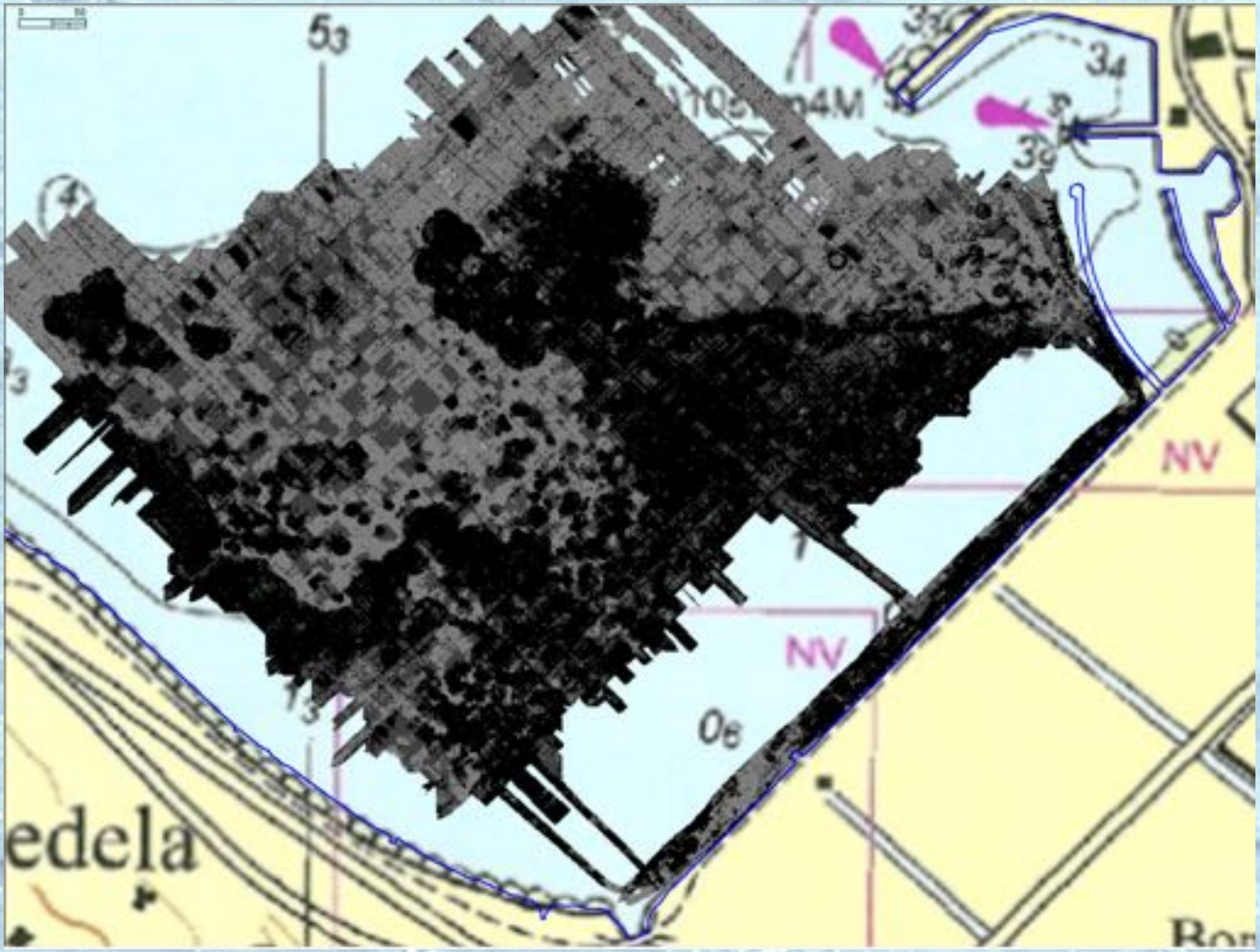
The maximum likelihood method was chosen as the main classification algorithm, but for some areas it had to be corrected manually. In manual digitalisation, we visually evaluated the fundamental elements of photo interpretation (tone, colour, contrast, texture, shadows, etc.), which is the most subjective part of the method.


Legenda
morski travniki
N
0 30 60 120 m

Seagrass meadows – Multibeam sonar



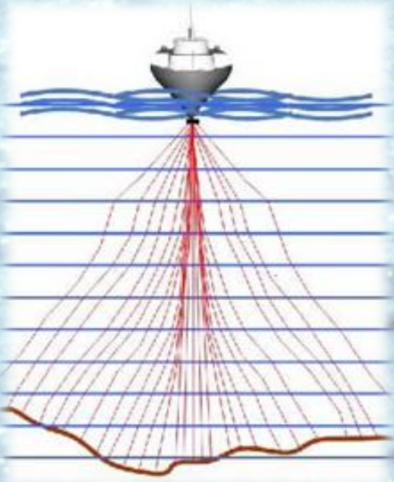


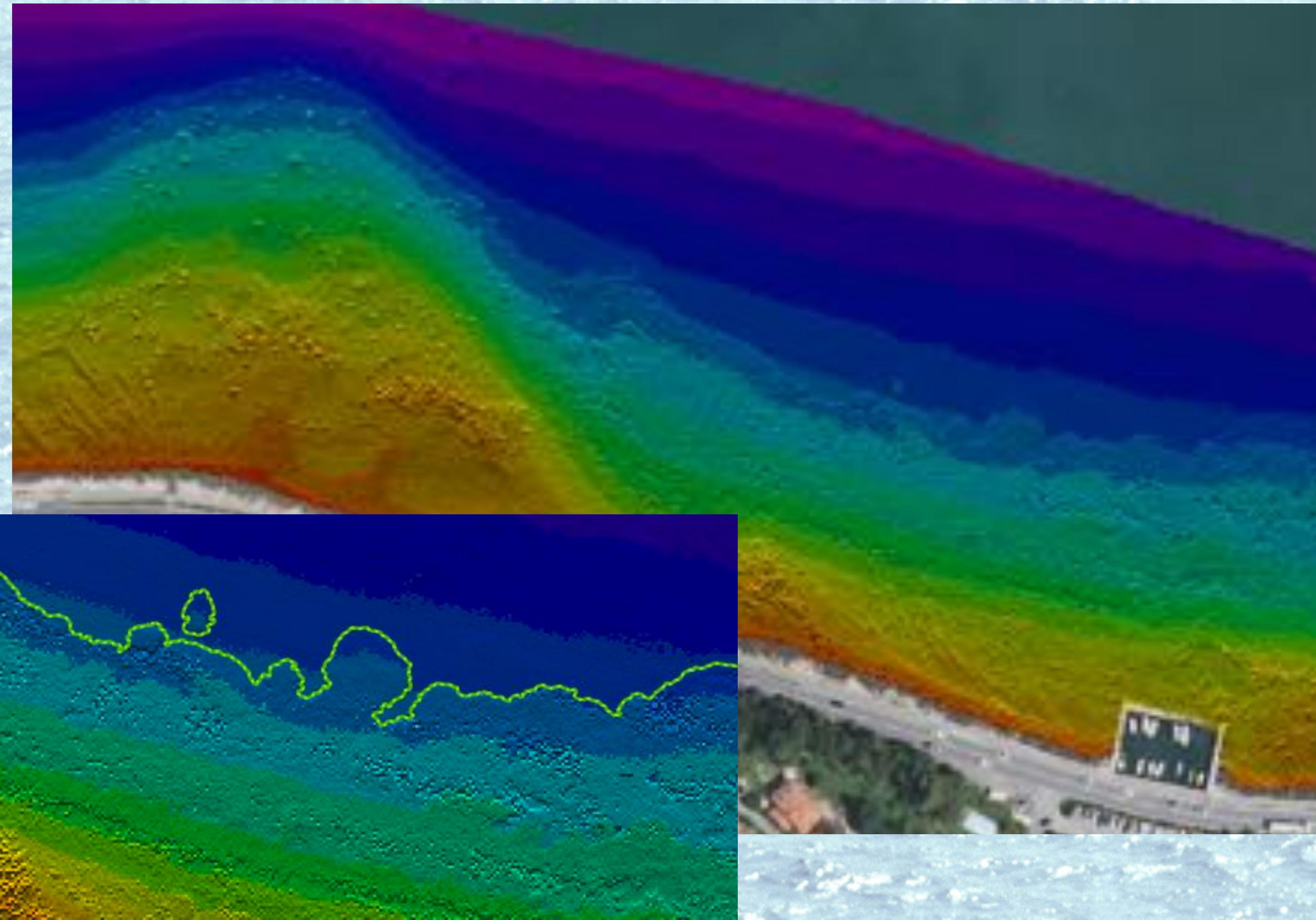


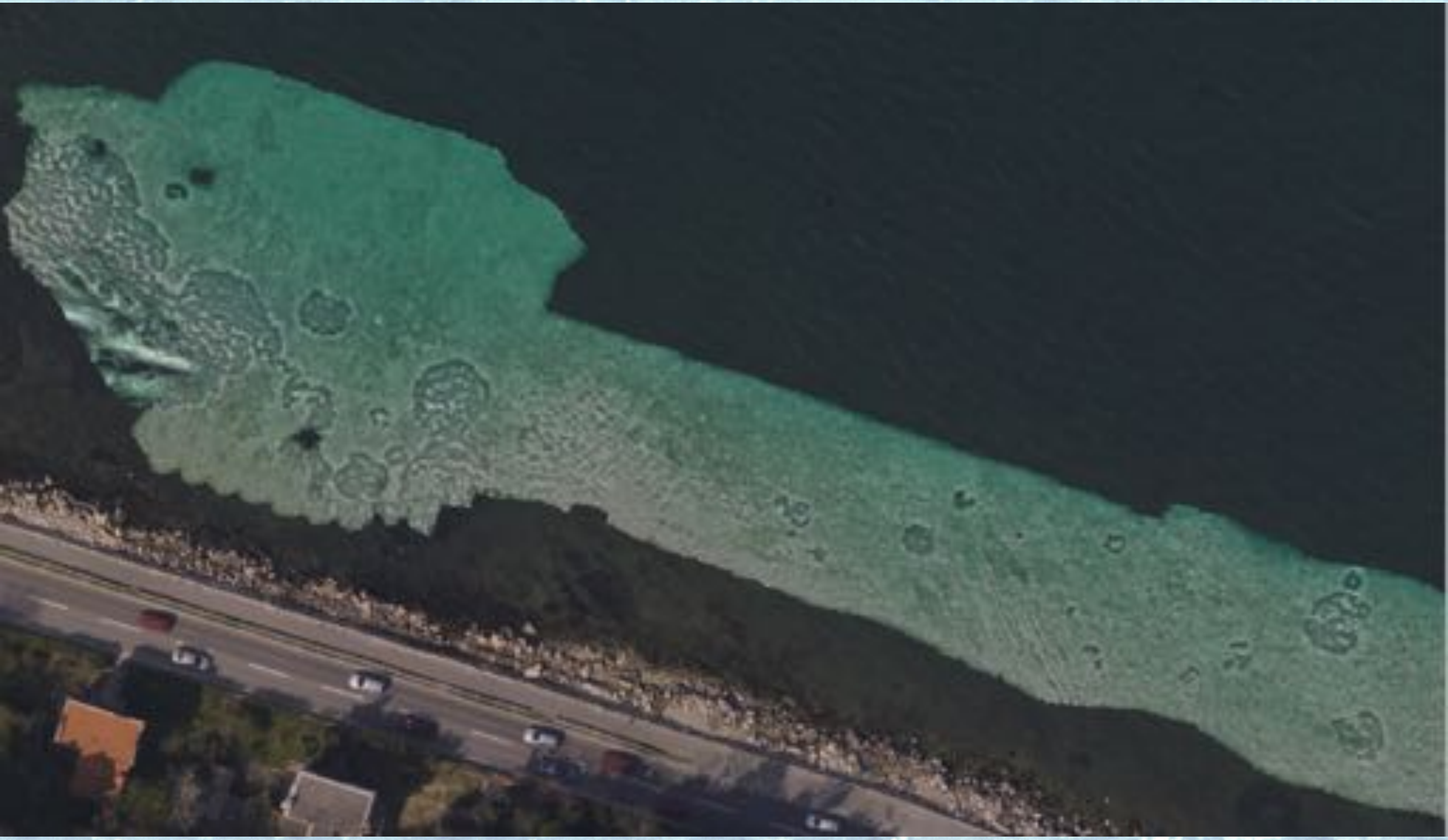
NV
NV
edela

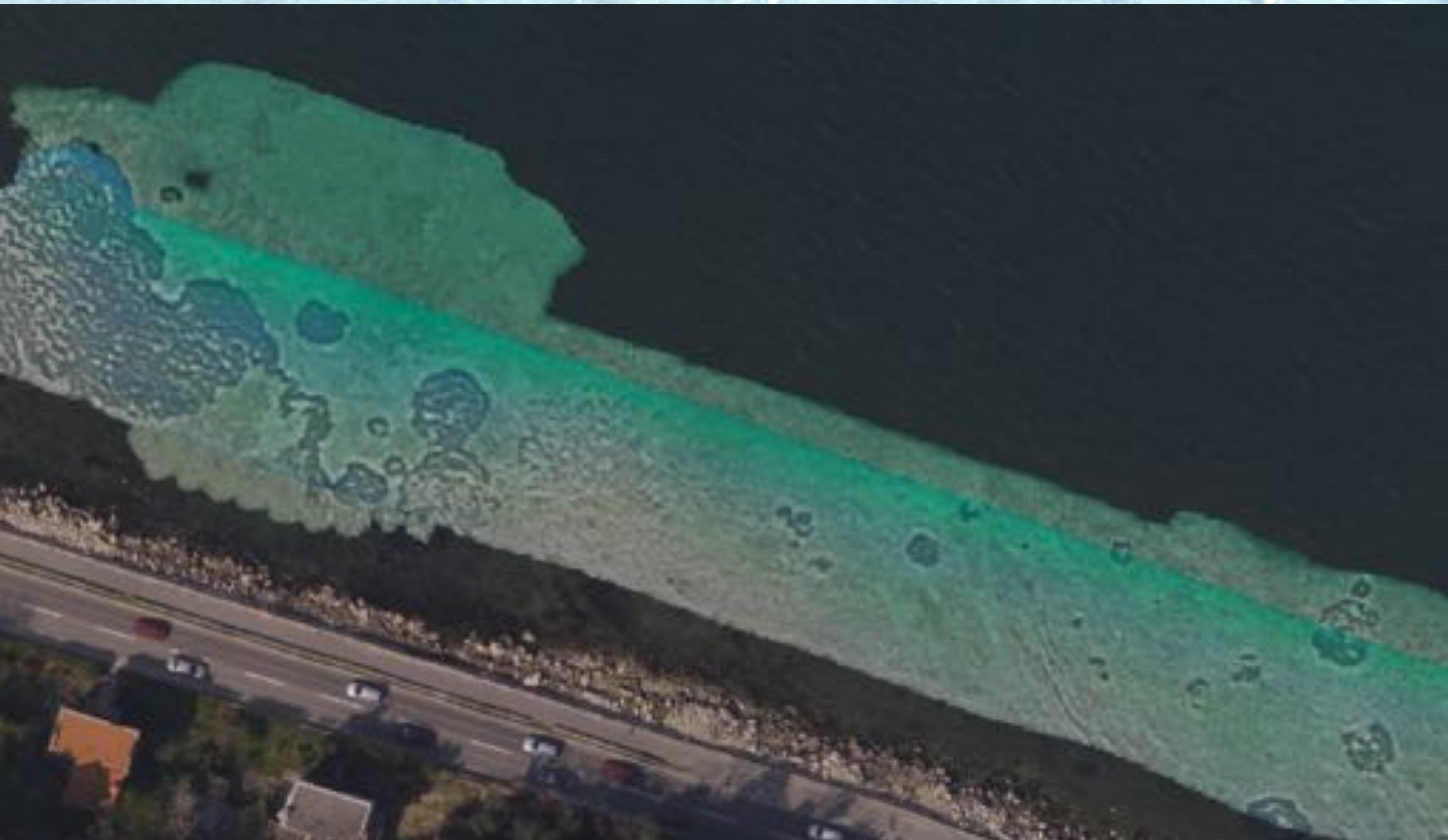

Legenda
morski travniki
N
0
45
90
180 m

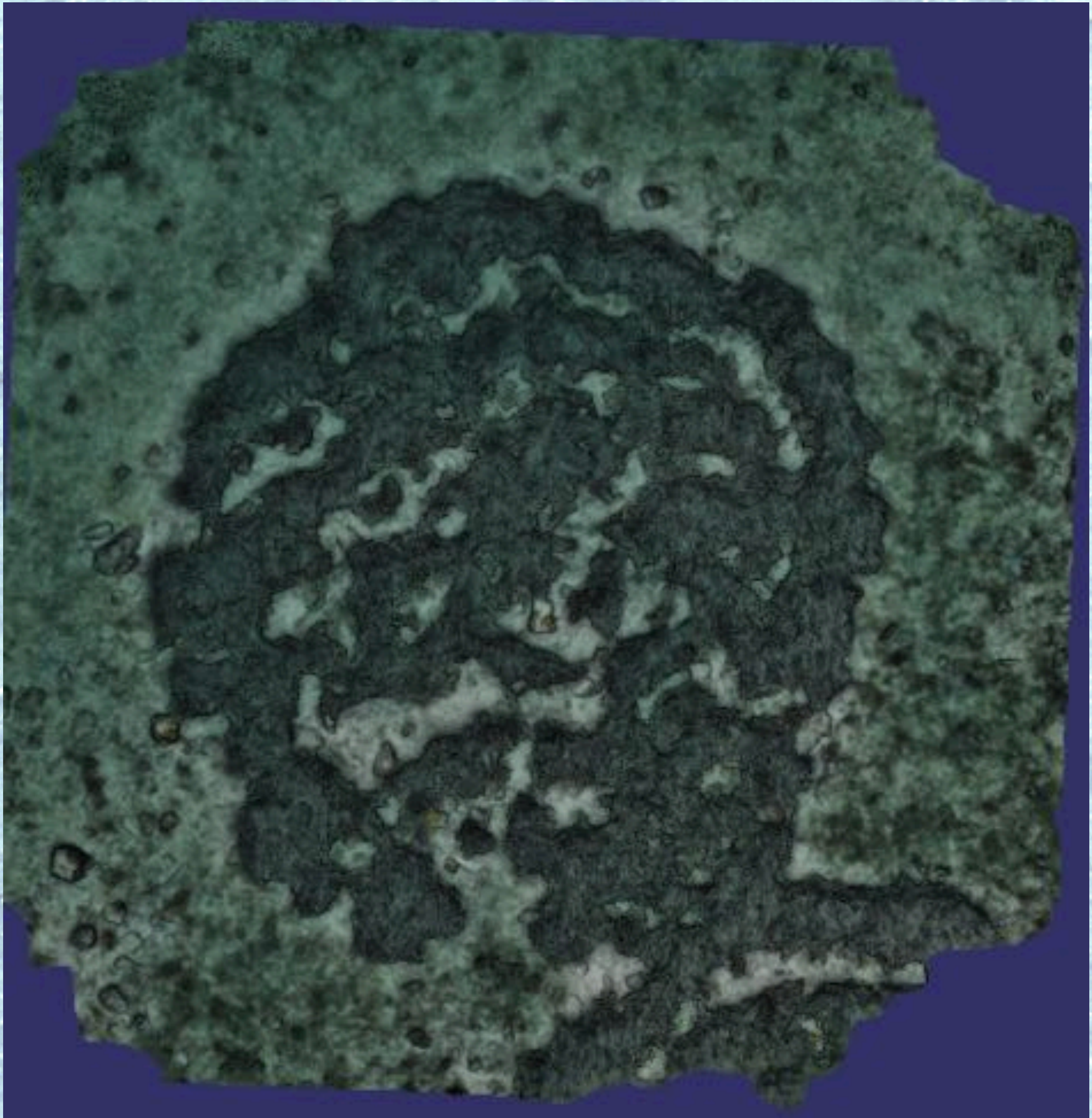
3D visualisation

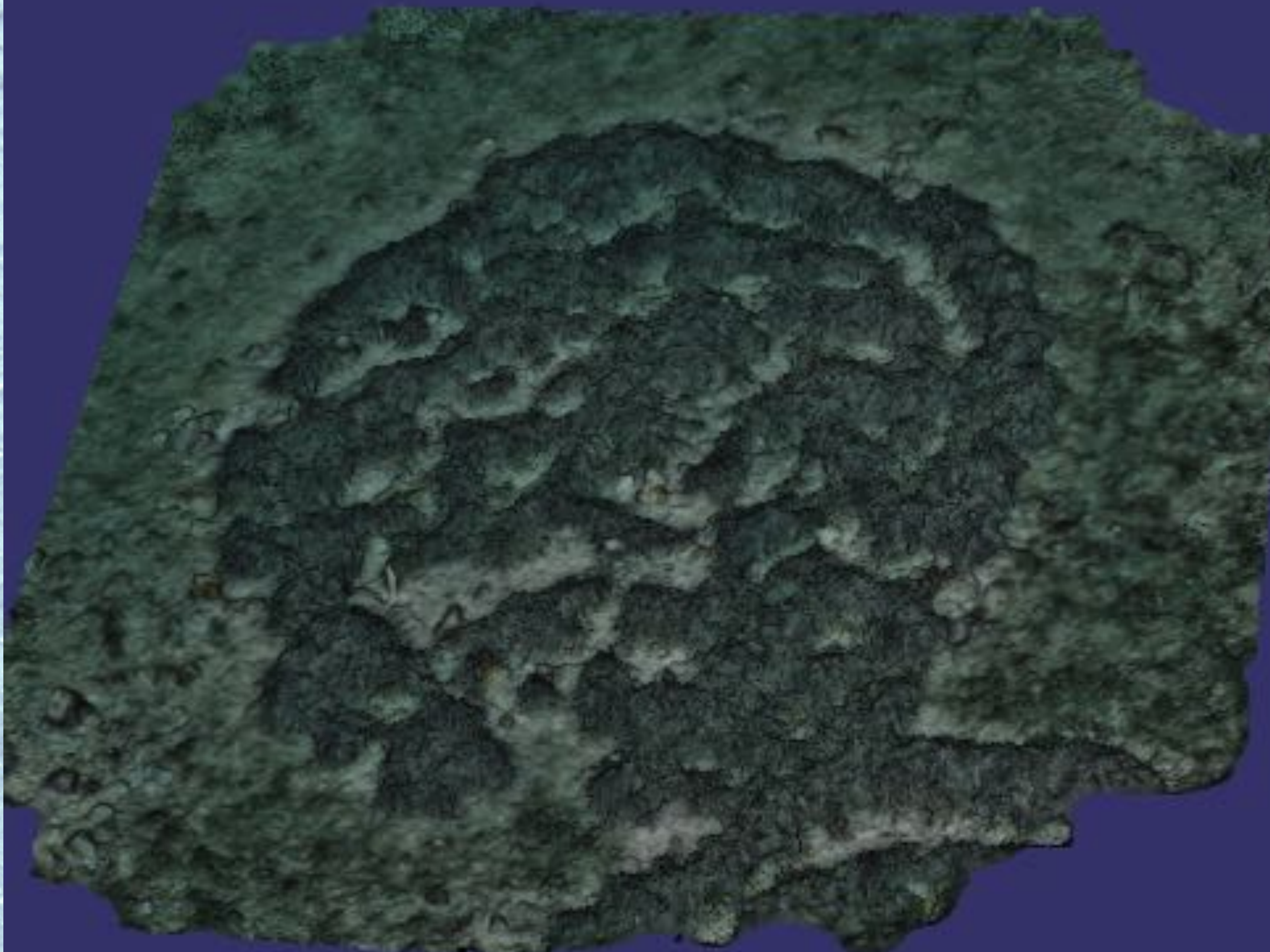


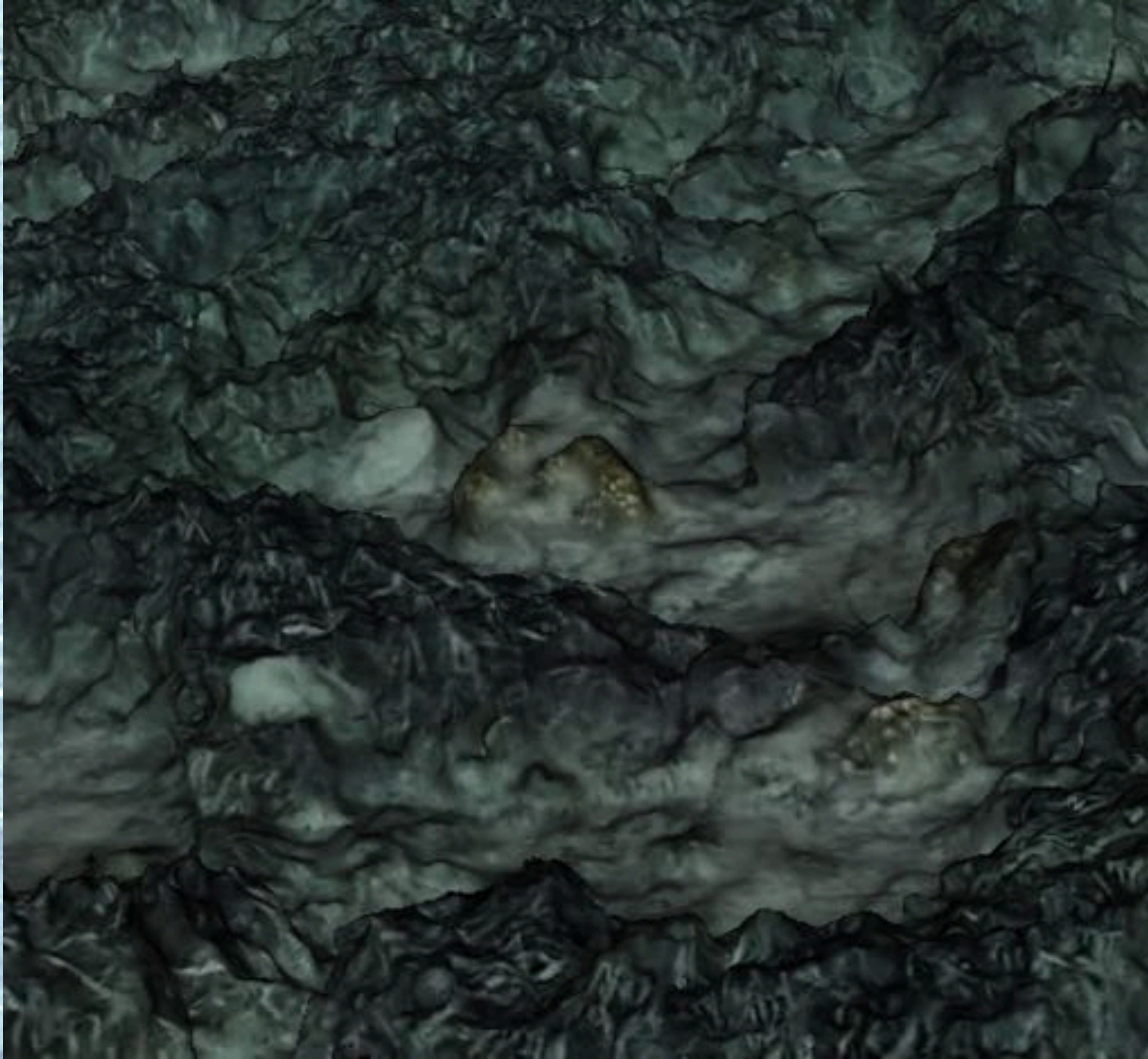










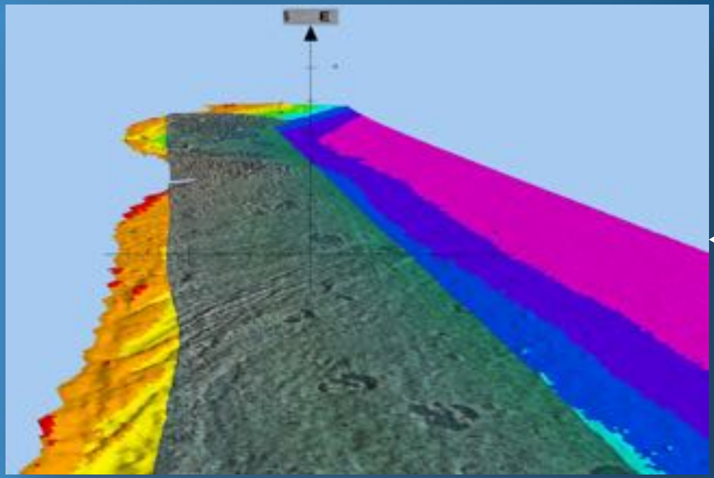


HARPHA SEA

Advanced visualisation and data manipulation

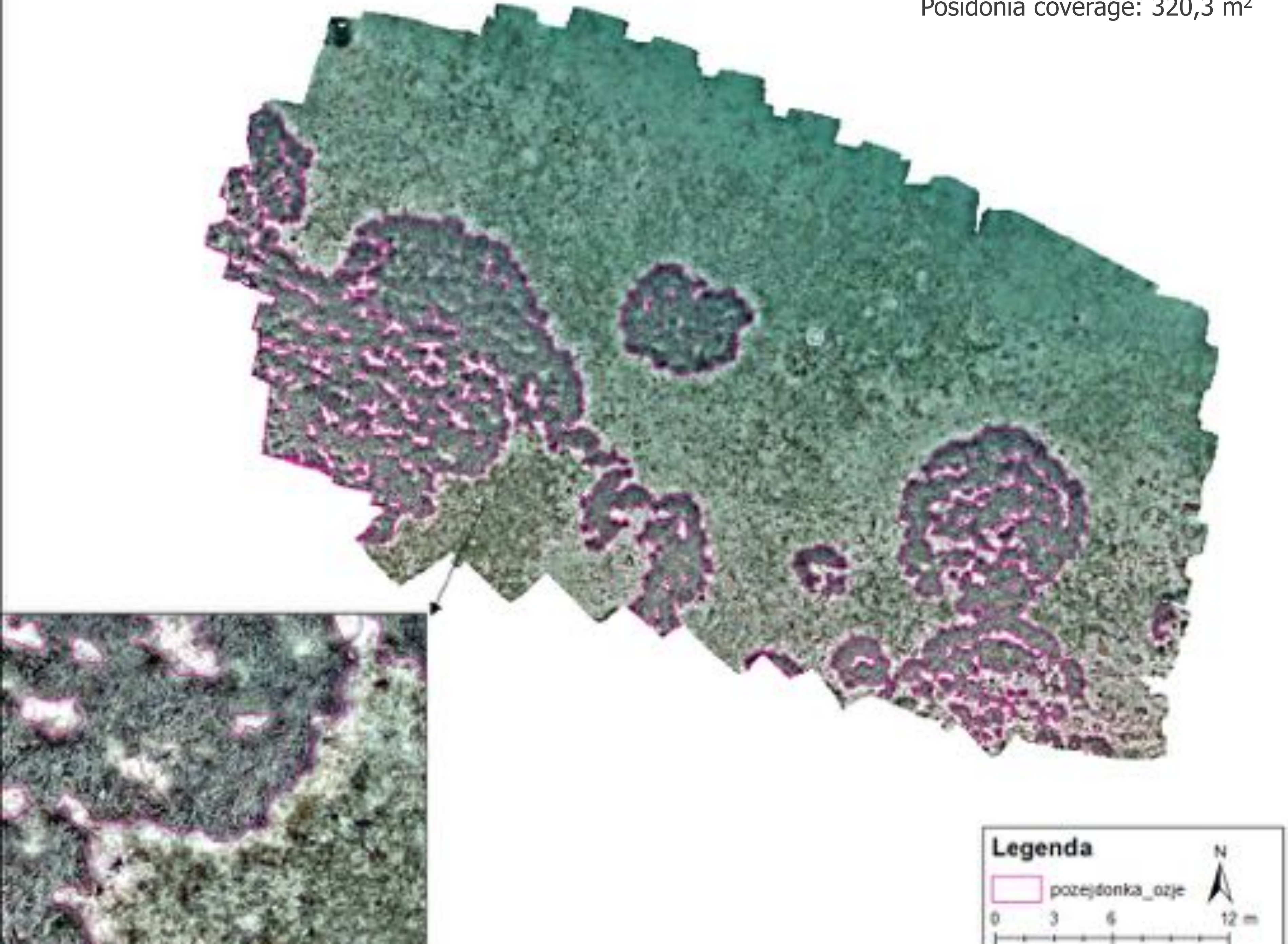
Enhanced high detail survey images

Underwater orthophoto GIS application
(*Posidonia oceanica* distribution)



3D model of terrain and vegetation

Posidonia coverage: 320,3 m^2



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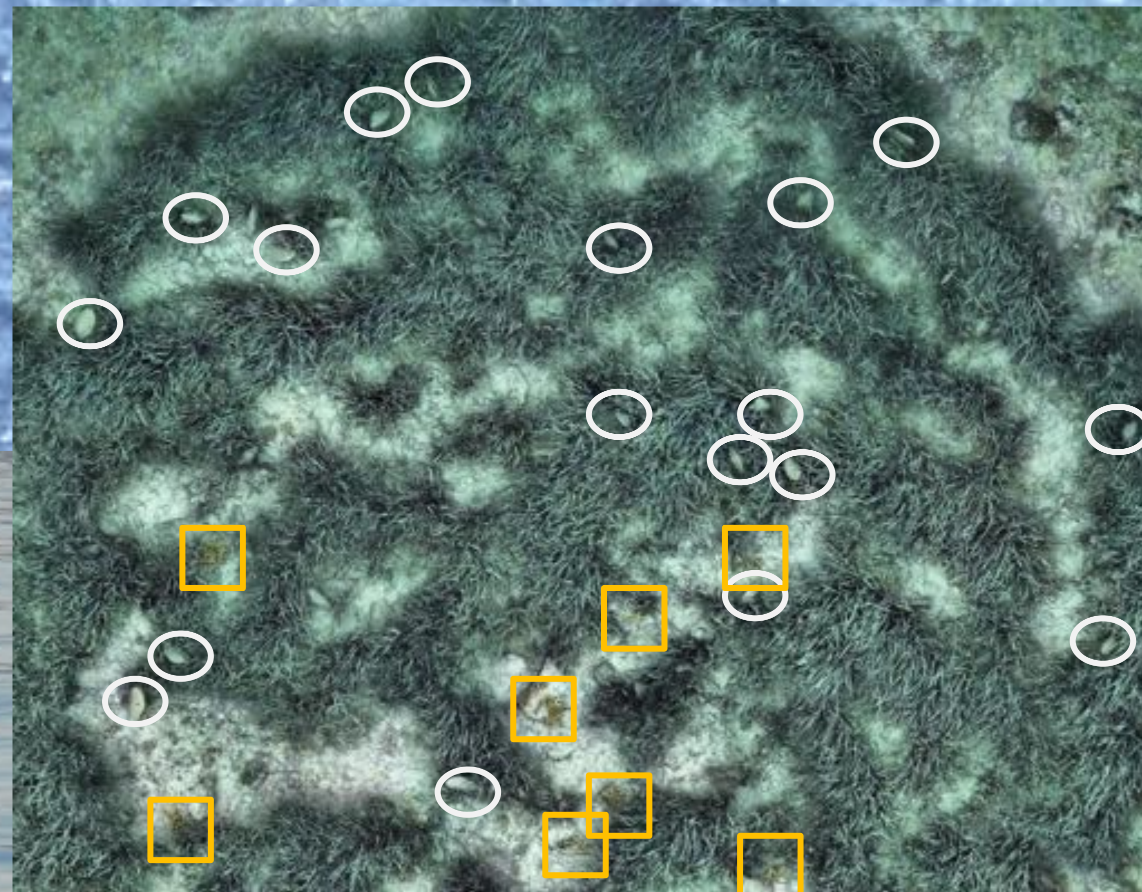

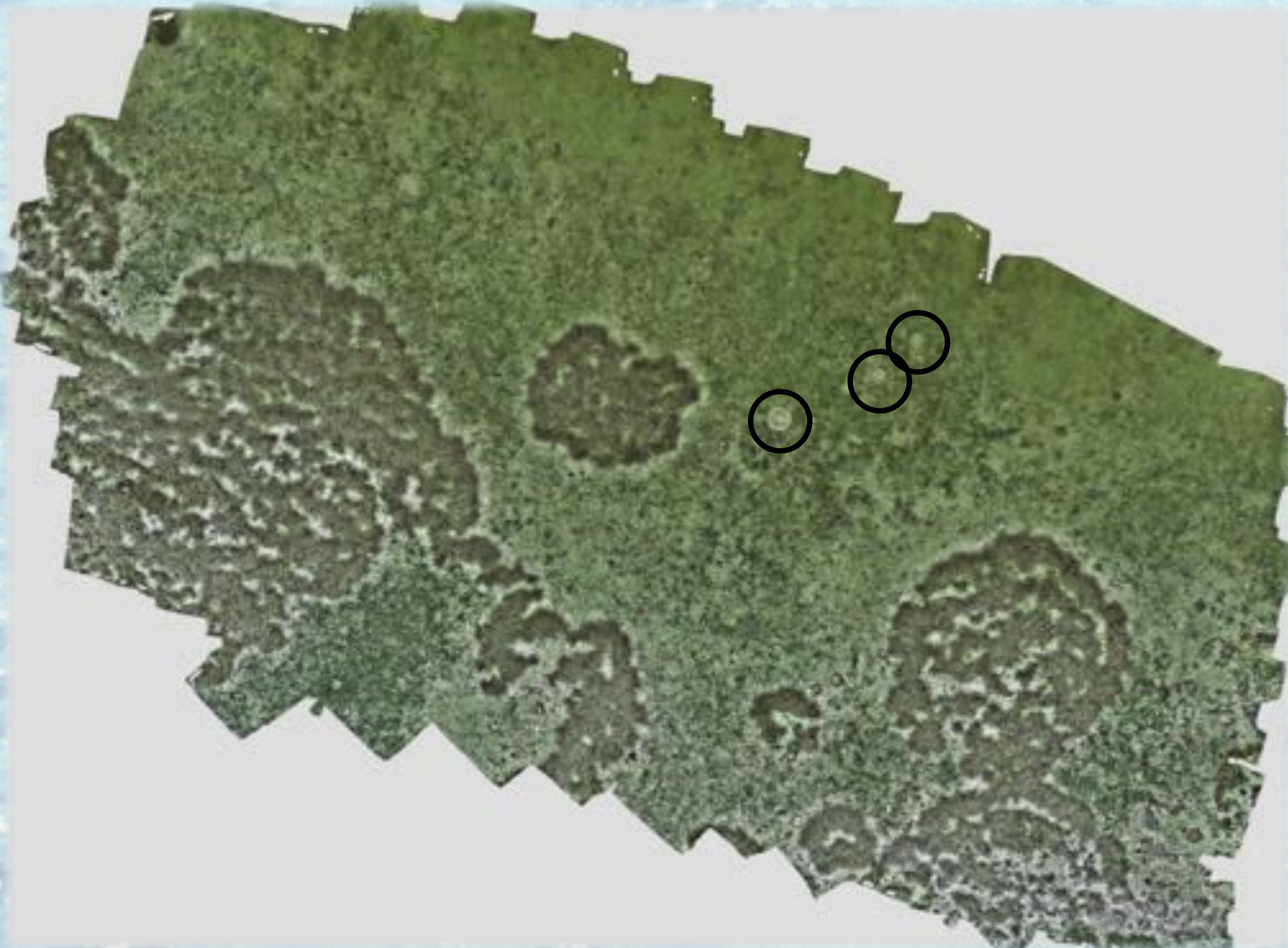

3D GIS tool

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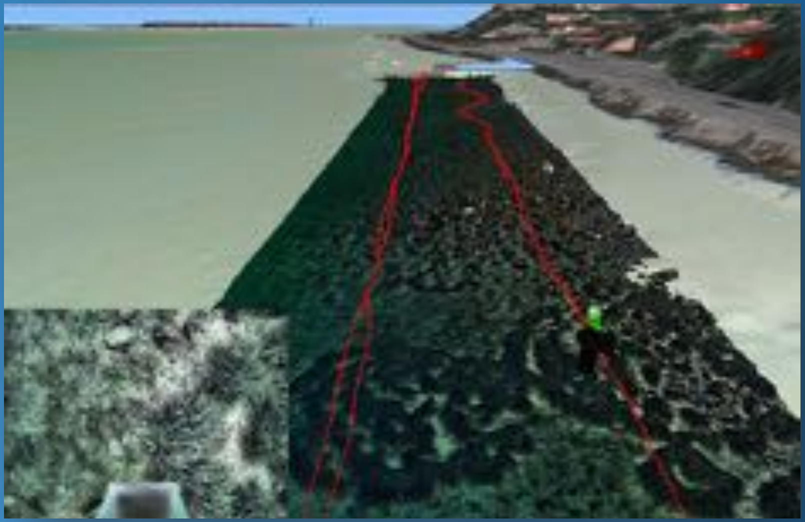
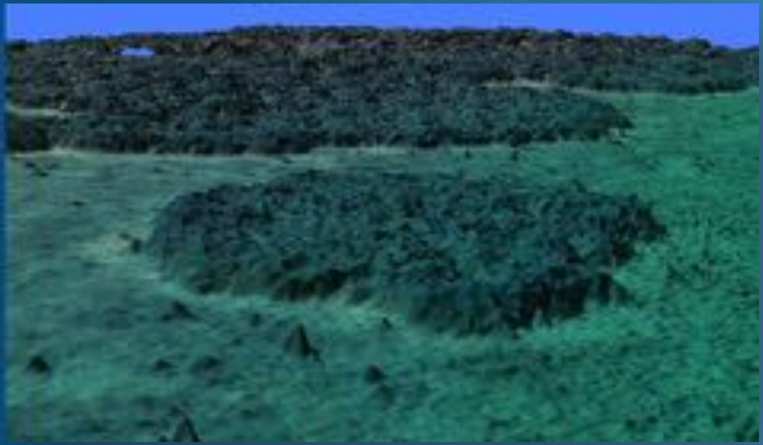
Data from different sources (like MBES, photo, video) is georeferenced and merged in 3D GIS application for quantitative and qualitative analysis.

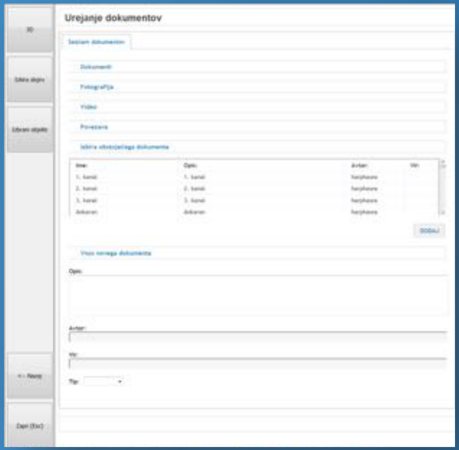
Visualization of continuous land-sea terrain model.



Video survey post processing.



Volume evaluation from 3D model.



click for demo video download

PostGIS/PostgreSQL database supporting 3D GIS.

Further work

- Exploring more effective methods to mitigate the effects of water turbidity (software, near infra-red light wavelengths).
- Using more efficient recording equipment instead of the GoPro camera.
- Compensation / mitigation of other optical effects during survey (vessel shadow on the seafloor, moving light/dark patterns on the seafloor – waves, cloudiness …).
- Near-real-time processing of data on-board the vessel during the survey.
- Optimizing criteria for selection of frames to be used for 3D reconstruction.
- Developing an improved lens distortion model for GoPro camera.
- Ability to handle larger data sets.
- Conversion of “raw” reconstruction products into a standardized coherent representation.