Report about the quantitative results in terms of accuracy, obtained in the whole area and in sub-areas with different contexts

Activity 4.2 - Comparative evaluation of the implemented monitoring technologies

WP4 - Implementation of the Georeferenced Open Access Database

SUSHI DROP project (ID 10046731)

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Abstract

WP4 is dedicated to the main challenges in the development of adequate procedure and software implementations to design and manage UUV missions and to process the huge amount of data collected during surveying operations. Within this WP, the activity number 2 consists in a quantitative analysis of the data acquired during the Sea Mission exploiting the new UUV technology.

Overview

This deliverable describes the quantitative results obtained through sea missions using UUV technology. In particular, the methodologies used during the surveys are described, as well as the results obtained based on the data analyzed from the various scientific payloads on board. The report is organized as follow:

- Survey Mission Method: description of the two survey methodology, based on the main scientific payload used.
- Quantitative methodology for deep water survey: description of the operation and results.
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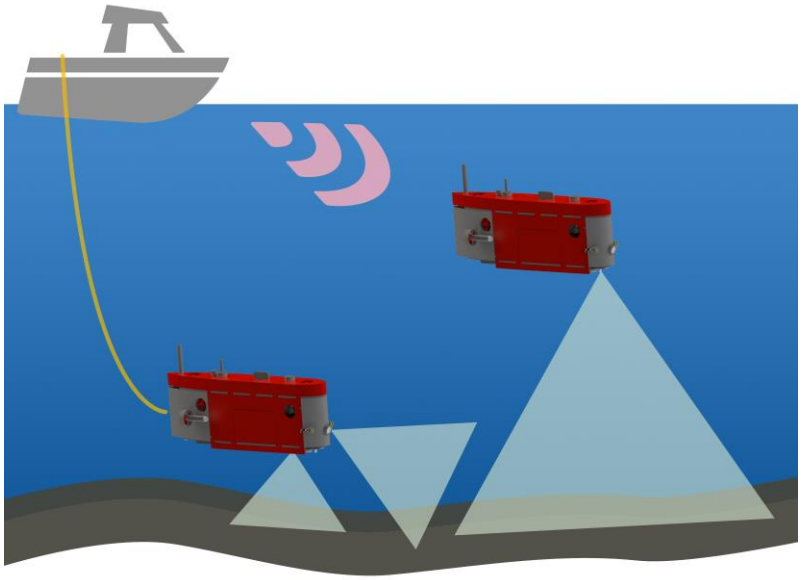
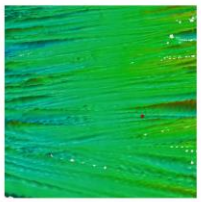


Raw CAM data (depth range: 1–10 m)



Raw MBES data (depth range: 10–100 m)

FIGURE 1 COMPARISON BETWEEN MBES AND CLOSE SEABED SURVEY WITH BOTTOMCAM AND PILOTCAM

Survey Mission Methods

The different types of missions are strictly related to the main payload sensor used. Following this philosophy, Blucy is able to perform two different types of surveys:

- MBES Survey
- Close Seabed Inspection

It has to be noticed that the two types of surveys differ in the type of data acquired, time of acquisition in terms of area surveyed, Blucy navigation mode and 3D waypoints or survey lines.

MBES Survey

Using MBES, it is possible to scan a large area in a short time. At this stage Blucy navigates at constant depth that is not affected by surface currents or wave motion. At the same time, it is always at a safe distance, away from the seabed, avoiding any interference with it. During these missions are always recorded information about physic measures of the underwater environment such as temperature, sound velocity, conductivity, pressure.

Fundamentally, this mission mode is suitable for surveying large areas at high cruising speed in safe condition, considering that the maximum range of Blucy is of 6 h of continuous navigation. A typical survey in this mode must necessarily follow a path previously planned through the use of waypoints at a safe distance from the seabed and any other obstacle. It is important to highlight that the MBES is independent of the visibility conditions of the water and relative turbidity. The following factors were considered when planning a survey with the MBES:

- The geography and extension of the survey area.
- Suitable areas for calibration patch test.
- Echo sounder coverage.
- Seabed topography.
- Sound Speed variations.
- Weather conditions.

In MBES survey, the operator has to plan the surveys lines carefully based on swath coverage that defines the multibeam system. The survey lines should be designed so that there is at least 80% overlap in coverage between adjacent lines. As swath width is a function of distance from the seafloor, it follows that the spacing between the lines may not be constant. The planning survey lines are designed with a trade off between Blucy navigation depth, seabed morphology (slopes, rocky formations), seabed type (grain size characteristics of the seabed) and swath width. With MBES the lines are planned to be perpendicular to slope directions to maintain a constant swath coverage.

The 3 acquisition modes of the MBES (Bathymetry, SideScanSonar, WaterColumn) allow to obtain a 3D reconstruction of the surveyed environment, highlighting not only morphological characteristics but also information about the presence of benthic species or the presence and extension of fish schools. Through these 3D maps it is also possible to evaluate the presence of areas where it is necessary to carry out an inspection using optical instrumentation.

Close Seabed Survey

During this operation it is necessary to use Blucy in ROV mode because it navigates in hostile environment with low altitude from 5.0 m to 1.0 m depending on turbidity found in surveyed area. Furthermore, the data are transferred in real time with fiber optical cable with constant supervision by an operator who can perform corrective navigation maneuvers as needed. Moreover, the acquisition of appropriate optical images is possible only in situations of suitable seabed with a reduced suspension of sediment in water, at close distance from the seabed itself and in particular periods of the year in view of the fixed marine currents. In spite of the previous precautions, it may also be necessary to improve the images during post-processing through the use of specific algorithms and color correction.

In this operation the survey lines are designed taking into account the following parameters:

1. Constant Blucy navigation altitude from the seabed based on water turbidity;
2. FOV at seabed;
3. Speed of navigation;
4. Interval between images;
5. Appropriate overlap for underwater surveys.

Using the 24 mm focal length of the BottomCAM lens at a reference altitude of 5.0 m, it is possible to cover a seabed swath width of 7.5 m with a GSD of 1 mm, thanks to the 24 mpixel sensor.

Through this type of survey, it is possible to make 3D reconstructions of the surveyed area using the data collected by the BottomCam and PilotCam. With these models it is possible to perform a recognition of the individual species and to estimate the total number of species present in the surveyed area.

FIGURE 2 CLOSE SEABED SURVEY: (A) PILOTCAM IN SHALLOW WATER, (B) BOTTOMCAM IN DEEP WATER

Quantitative Methodology for deep water surveys

This methodology is applied in the depth range from a minimum of 15 mt to the maximum depth of

blucy operations (approx. 250 mt). Mainly this mission is divided into distinct sub-missions: MBES Survey and Close Seabed Inspection. During the first phase, a complete survey of the area under investigation is performed, using MBES. In this phase Blucy navigates at a constant depth and acquires mainly bathymetric data, WaterColumn, Side Scan Sonar and data on the chemical and physical characteristics of the environment (temperature, sound speed, salinity, pressure). The 3D reconstruction resulting from these acquisition could allow to identify hot-spots, areas of limited extension, in which perform further close seabed inspection using optical sensors, increasing the level of detail and knowledge of the area surveyed. With the combined use of MBES and Optical sensors, it is possible to perform a quantitative characterization of the benthic communities present in the surveyed area. The amount of data obtained during the missions is currently analyzed manually by the operator during the processing of data in the laboratory, at the conclusion of the operational phases of the survey.

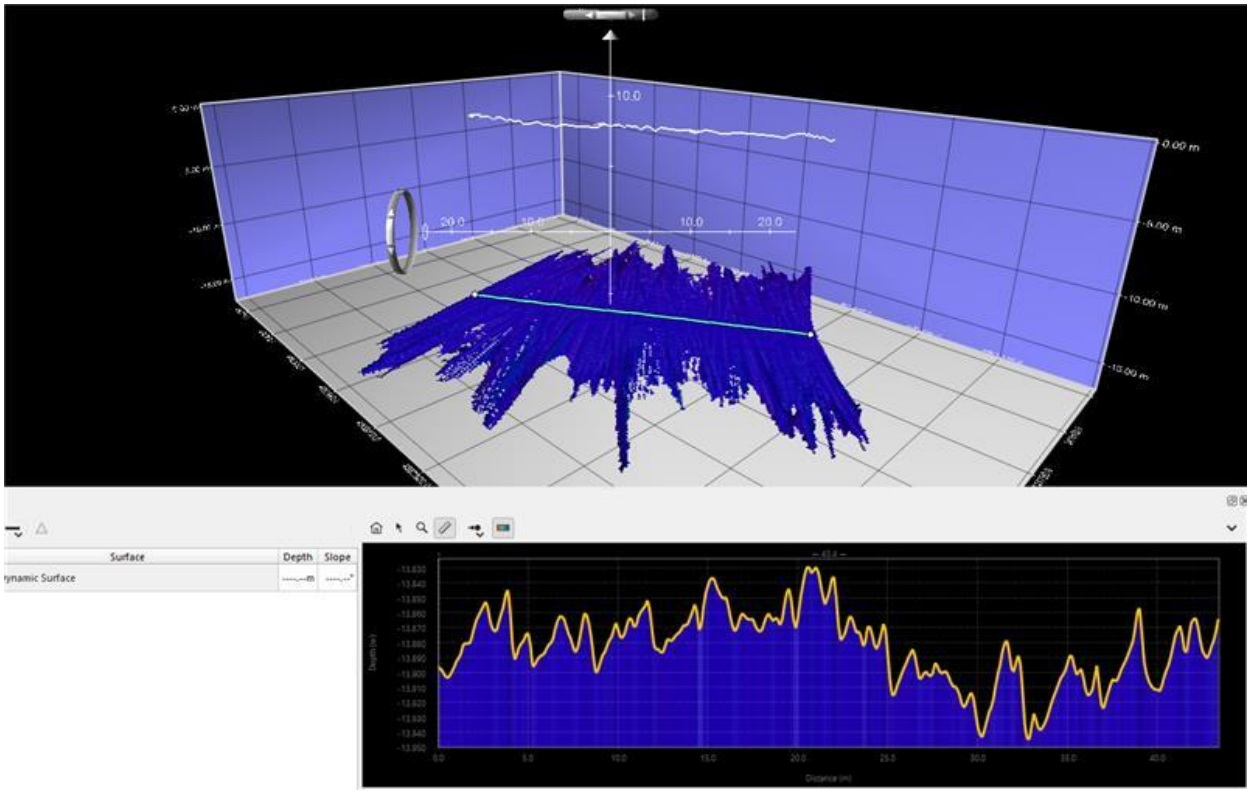


FIGURE 3 MBES 3D RECONSTRUCTION OF FLAT SEABED (14 MT DEPT, AREA OF 1200M^2)

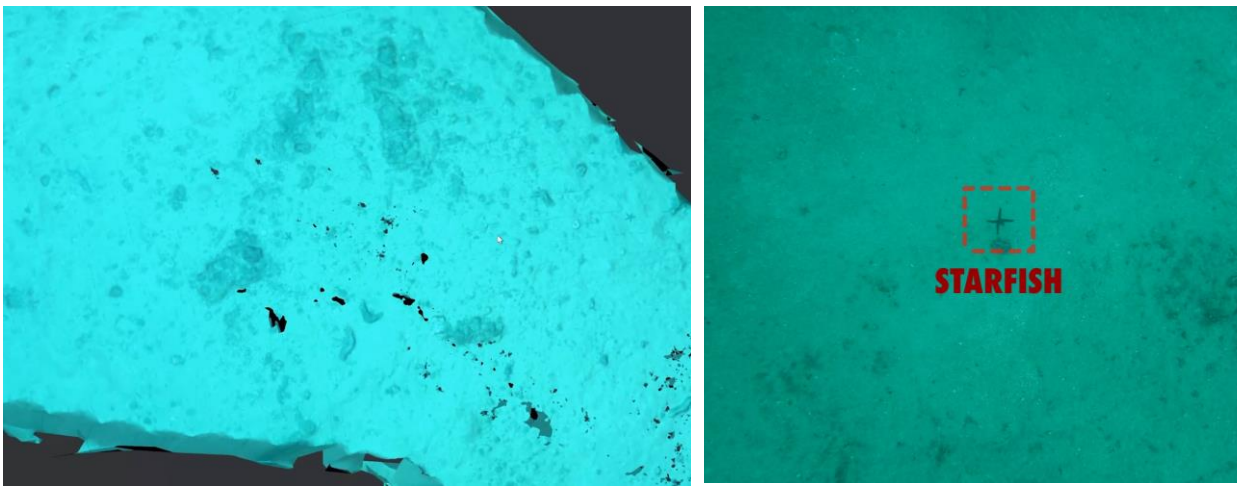


FIGURE 4 3D SEABED RECONSTRUCTION IN DEEP WATER (45MT DEPTH, BOTTOMCAM) DURING CROATIAN MISSION SURVEY

Quantitative methodology for shallow water survey

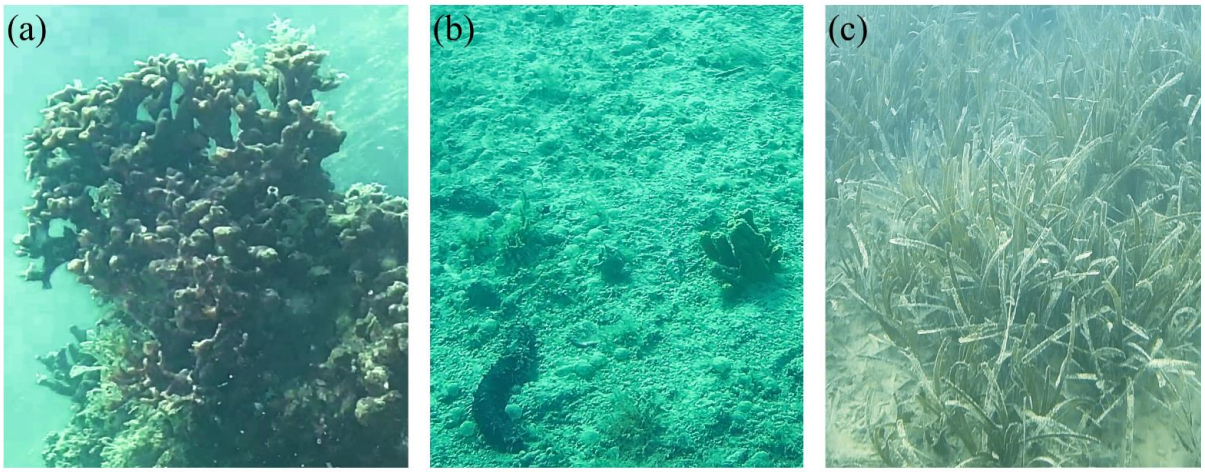


FIGURE 5 SHALLOW WATER SURVEY (PILOTCAM IMAGES): (A) *SCHIZOPORELLA ERRATA*. (B) *AXINELLA* SP., *HOLOTHURIA* SP., EGGS MASSES OF *POLYCHAETA*. (C) *POSIDONIA OCEANICA*.

In shallow water inspection, a relatively small environment is monitored, Blucy is able to monitor the extent of the seabed observed in a continuous and non-point source. The large amount of data collected is sufficient for an exhaustive description of the environment, thanks also to the possibility to observe from at least two different points of view: BottomCAM and PilotCAM. In this scenario, a precision navigation is required, obtained through a real-time streaming of the position and video feedback of the optical cameras through the fiber optic cable in ROV mode.
Through an accurate positioning, possible thanks to the inertial and acoustic sensors, it is possible to perform multi-temporal surveys of the same environment allowing a subsequent repositioning in the same area of investigation.
In conclusion, through the combined use of sensors equipped on a UUV as Blucy, it is possible to acquire a significant amount of scientific data that allow to characterize the marine environment in an exhaustive way. Thanks to an accurate planning of the survey it is possible to obtain complete three-dimensional models of the seabed and natural elements, at different spatial and temporal scales.

Visual census analysis consists of the identification and counting of species (e.g., fishes, benthic species) observed within the surveyed area. Visual census can be used to estimate the variety, numbers and even sizes of common, easily seen, easily identified species in areas where the recorded quality images were very good. A first preliminary video assessment analysis is performed in real-time during navigation to better plan the mission. More detailed work is carried out in the laboratory by processing

all the photographic frames taken by the high-resolution BottomCam and the video stream recorded by the PilotCam. The strength of ROV-imaging is the ability to explore the seabed with non-invasive technique that allows the evaluation of the ecosystem without impacting on the benthic species present. Thanks to the images provided by the UUV it was possible to census numerous benthic species such as: holothurian, sponges, hermit crab, cnidaria and Posidonia as represented in ().

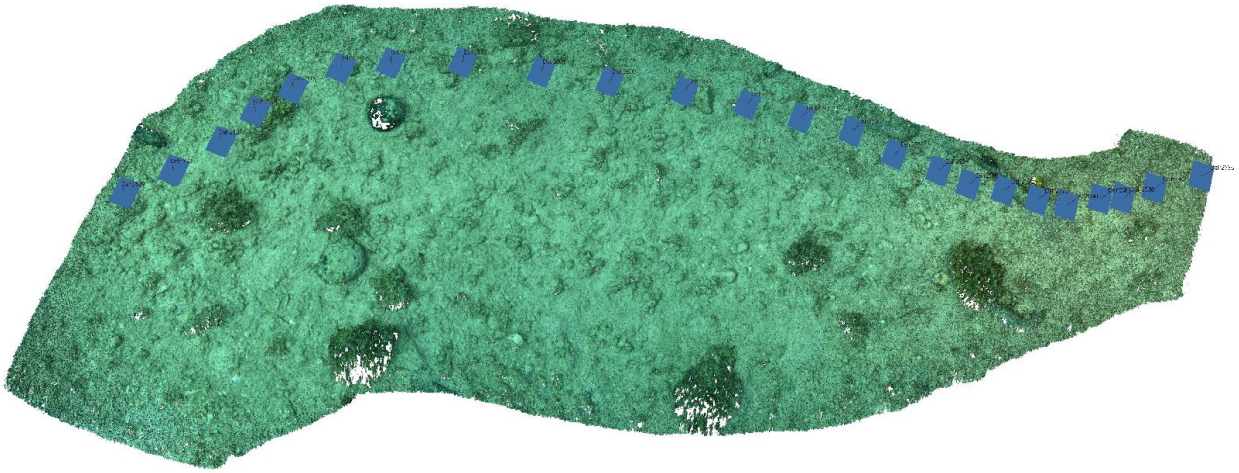


FIGURE 6 3D SEABED RECONSTRUCTION IN SHALLOW WATER (8MT DEPTH, BOTTOMCAM) DURING CROATIAN MISSION SURVEY

Abbreviations

The following abbreviations are used in this deliverable:

AHRS Attitude and Heading Reference System

AUV Autonomous Underwater Vehicle

DEM Digital Elevation Model

DT Digital Twin

DVL Doppler Velocity Log

EKF Extended Kalman Filter

FDI Fault Detection and Isolation

FOG Fiber Optic Gyroscope

FOV	Field of View
GNSS	Global Navigation Satellite System
GSD	Ground Sample Distance
INS	Inertial Navigation System
MBES	Multibeam Echosounder
NGC	Navigation, Guidance and Control
ROV	Remotely Operated Vehicle
RS	Remote Station
SFM	Structure from Motion
USBL	Ultra-Short Baseline
UUV	Unmanned Underwater Vehicle
GIS	Geographic Information System
CoG	Centre of Gravity
NMEA	National Marine Electronic Association
UDP	User Data Protocol

Acknowledgement

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