Report of the benefits brought by the adoption of the UUV technology in monitoring deep-water ecosystems

Activity 5.1 - Individuation of the study areas - Potential of UUV technology for biodiversity study

WP5 - Ecosystem protection and sustainable fisheries

SUSHI DROP project (ID 10046731)

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Abstract

WP5 is dedicated to the usage of the findings of the underwater drone system in surveying sea beds. This WP comprehends an analysis of the benefits that could be brought by the adoption of the UUV technology based on the surveys performed within the project missions.

Overview

This deliverable analyses all the benefits that could be bring by the use of the drone in monitoring deep and shallow water ecosystems. The Blucy system developed and tested within the SUSHI DROP project will bring several diversified impacts.

Scientific impact

From the scientific viewpoint, different subsystems on board Blucy will bring a deeper knowledge beyond the current methodological state of the art of the marine ecosystem.

The drone designed for the SUSHI DROP Project guarantees the possibility of multiple configurations for the scientific payloads. Indeed it is possible to replace or reposition the different scientific subsystems adapting them to the operational scenario of the mission. The list of scientific payloads currently on board, with which it is possible to acquire point data and distributed in space, is as follows:

1. MBES - Bathymetry, Water Column (Multibeam Echosounder R2Sonic 2020)
2. PilotCAM - High Resolution Imagery (Nikon Z6 with NIKKOR Z 24 mm f/1.8 S)
3. BottomCAM - Live Stream Video (Vivotek IB8369A Network Camera)
4. MiniCT - Conductivity, Temperature (Valeport MiniCT)
5. MiniSVS - Pressure, Sound Speed (Valeport MiniSVS)

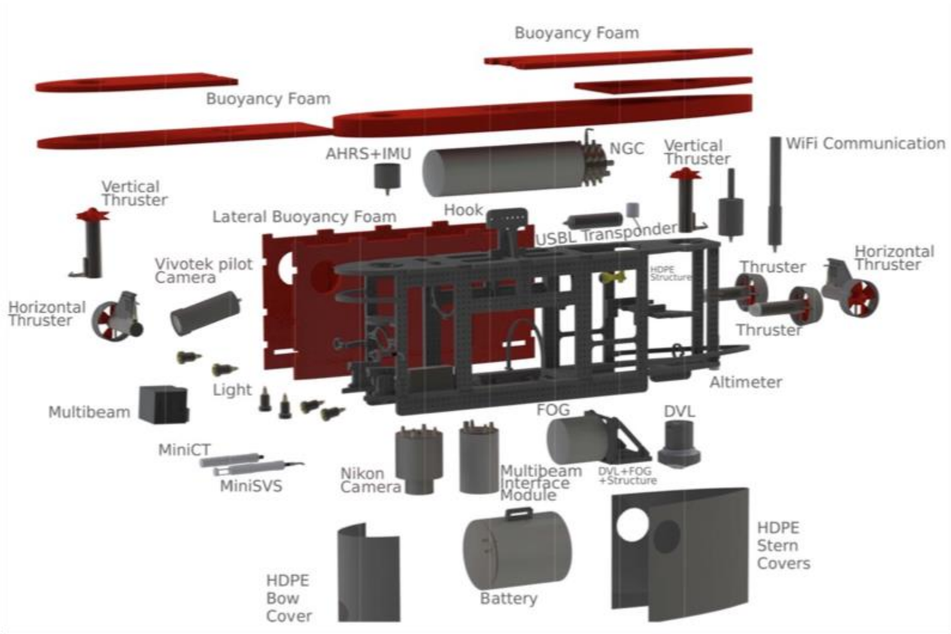

FIGURE 1 BLUCY MODULAR DESIGN

The data are logged on board Blucy and also sent in real time to the Remote Station when the mission is performed in ROV mode.

The large amount of data that can be acquired during operational missions makes possible a multitude of scientific analyses that involve different disciplines: marine biology, marine engineering, automatic control engineering, electronic engineering, signal analysis and processing engineering, geomatics, precision photogrammetry, computer engineering and algorithm development for artificial intelligence.

The ability of Unmanned Underwater Vehicles (UUVs) to periodically take well -defined images, collect data, and record precise measurements help map marine life as well as vegetation. Drone mapping at the species level assists in acquiring information about marine life and the ecosystem. Drones may also be employed to project this data onto 3D platforms (3D mapping) for improved understanding of the collected data.

The use of remotely controlled or autonomous UUVs in the field, equipped with non-invasive technologies that do not impact on marine ecosystems, represents an important tool to increase our knowledge of the real distribution and abundance of marine biological communities associated with the seabed of the Mediterranean Sea, especially in the Adriatic context due to the geological, trophic and biodynamic nature of the sea itself.

With the increase in marine pollution and relevant threatening aspects that are fatal to marine life and marine monitoring, the need for redemption is also thus increasing. The most preserving and redeeming tool comes to be UUV. Its utmost applications to deliver and ease marine services enclose military services, research and development services, weather forecasting, search and rescue operations, and delivery activities, apart from marine monitoring and surveillance. To that end, the marine ecosystem has seen the light of drones in the ways of marine services and operations that vitally factor in the progress and growth of the marine industry.

Technological impact

From the technological point of view, different subsystems will go beyond the current state of the art:

The overall outcome of the project is the definition and design of a prototype of a new class of AUV: Multi-Purpose Autonomous Underwater Vehicle since Blucy is able to be guided according to two navigation modes: ROV / AUV. These two types of navigation allow to extend the range of application of the drone, since it is possible to monitor both large areas using the multibeam sensor, and specific areas using tethered navigation and optical sensors.

In addition, drone use leads to several improvements in both mission operations:

Close seabed inspection

In comparison to the surveys carried out by divers, Blucy is able to collect a higher quantity and quality of data, allowing a quantity analysis of the species present in the surveyed environment. During this kind of mission, a relatively confined environment is surveyed, so the data collected with the on board scientific sensors allows an overall characterization of the detected environment. This approach has been applied during mission in shallow water, reachable also by divers, but it is also valid for close seabed inspection in deep water, which are not reachable by divers.

The drone system is independent from water turbidity conditions: thanks to the use of acoustic sensors, in low visibility conditions, the drone is always able to acquire data necessary for a characterization of the surrounding environment.

In addition, mission time is significantly greater than divers' dive time, allowing a larger region to be surveyed.

The transect sampling performed with the BottomCam of Blucy has returned a three-dimensional representation of the seabed of surprising sensitivity (of the order of a centimeter) and extension, which suggests the ability to create maps of the seabed that are exhaustive of the entire area and indicative of the presence of biogenic formations of interest. This work is unthinkable for divers, considering the characteristics of the water column on the mid-Adriatic coast, the extension and the biological richness of the sublittoral ecosystem with rocky substrate.

MBES Surveys

data acquisition through multibeam using Blucy, are easier than a surface vessel, because the drone is not affected by external disturbances (surface currents and wave motions) since it navigates at a depth where these disturbances are negligible. Furthermore, the drone has a high stability to pitch and roll dynamics that can be generated if subjected to marine currents.

These features allow to obtain MBES raw data that do not require an intensive post-processing and also the time required to perform tests for the calibration of the instrument is reduced.

Machine Learning

The Artificial Intelligence and Machine Learning accompanying drone technology, the applications of these dynamic and vivid innovations in the field of marine surveillance deliberately eases the operations required to be performed. Drone mapping and imagery with the association of machine learning may be so utilized to cultivate optimal algorithms to process the data or images captured. Through Computer Vision, underwater drones are enabled to detect and monitor marine ecosystems, enhancing primitive features in the likes of self -navigation, object tracking, collision prevention techniques, and more.

Figure 2 Species recogniscion with Machine Learning Algorithms

Social impact

Environment preserving: the drone system is a tool that allows to perform monitoring of marine environments with non-invasive methodology. Unlike traditional methodologies that are based on trawling nets, the systems equipped on Blucy allow a monitoring without contact, preserving the marine fauna and flora with zero ecological impact. In particular, using the MBES instrument it is possible to acquire data by positioning the drone up to a height of 100mt from the seabed. With the optical sensor, depending on the turbidity of the water, it is possible to approach up to a few meters away without disturbing the local fauna. During the missions carried out in the project, it has been noticed that fish are not disturbed b the presence of the drone.

The use of UUV technologies provides a huge amount of data, taken over the real extension of the seabed in a continuous and non-point source, which by their nature are characterized by high representativeness and accuracy, especially on small spatial and temporal scales. It is interesting to analyze what can be done for the enhancement and protection of underwater ecosystems by exploiting technological progress and use it as an incentive to regulate traditional fishing activities.

AQUACULTURE FARMERS: introduction of a new tool for aquaculture health monitoring, reducing product loss, resulting in increasing efficiency of farming techniques. In addition, thanks to the exploitation of machine learning, it is possible to perform studies on the current and future health/growth status of a mussel farming or fish aquaculture plant.

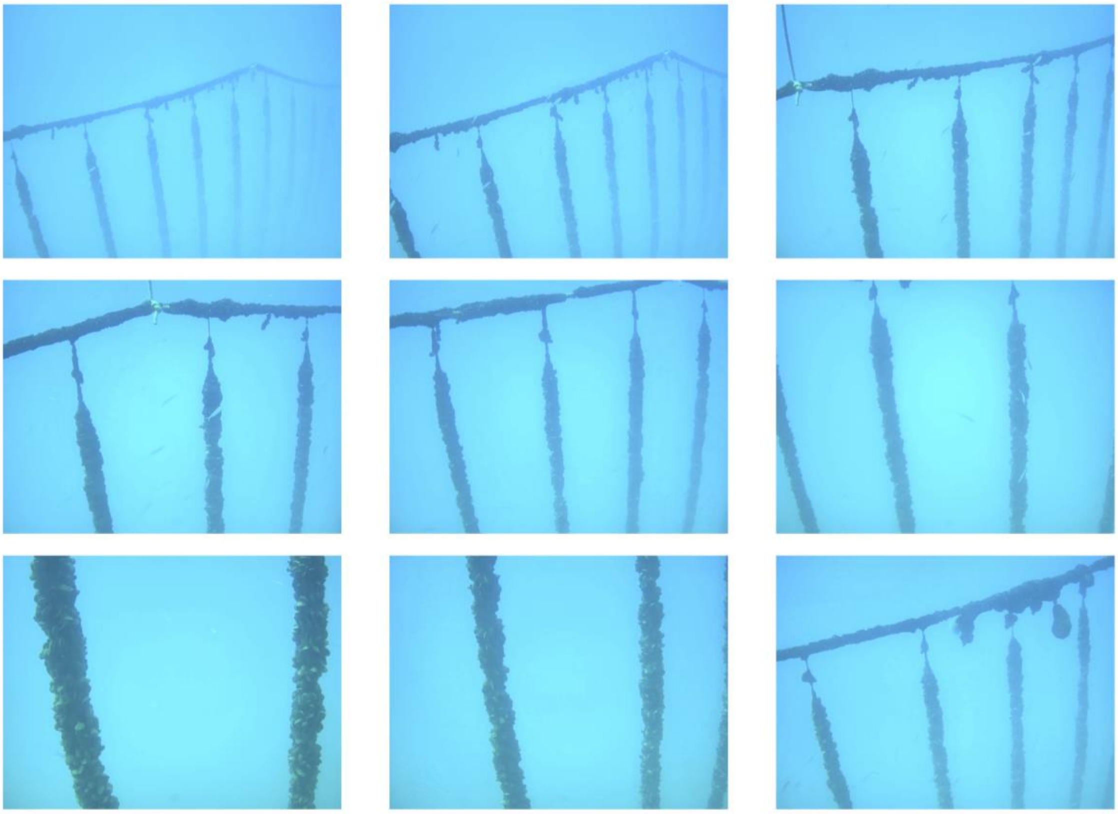

FIGURE 3 MUSSEL FARMING INSPECTION

UNDERWATER INFRASTRUCTURE MANAGERS AND OPERATORS: the capability of multipurpose missions in dangerous environments leads to a reduction of the human life risks; increased reliability and efficiency of operations. In cases of strong currents that can put the operators at risk, the drone allows to operate safely. Thanks to the fluid dynamic study carried out to develop and design its shape, it is able to advance smoothly even against current.

AUV SUPERVISOR/PILOT: a new highly specialized professional figure able to manage the drone system.

Economic impact

COST REDUCTION: the availability of a new flexible tool for mapping, and imagery in the space of marine monitoring and inspection within the same mission aids to optimistically cut down the cost of surveying, data collection, imagery, and contents. These operations yield more accurate results in a lesser span of time, which ultimately contributes to the reduction of cost. Blucy's modular design philosophy allows for a double mode of operation, either ROV or AUV and also can be reconfigured based on the specific tasks of the missions. The idea is to have availability of a drone that can perform different mission scenarios as marine monitoring, underwater infrastructure inspections, aquaculture monitoring, archeology research.

INCREASED COMPETITIVENESS: Operators in the sector could benefit of a service allowing the refinement of farming techniques at affordable cost, thus increasing their competitiveness in the global market. In particular, drone operations can reduce the need to employ larger vessels, while also reducing the consumption and resulting cost of fuel and especially the pollution created by the use of traditional fossil fuel propulsion.

CONSUMER SATISFACTION: the increased aquaculture monitoring quality will lead to a better-quality product available for consumers.

VIRTUAL REALITY FOR UNDERWATER TOURISM: From the processing of data collected by multiple sensors on board Blucy is possible to obtain detailed three-dimensional models of the underwater environment and elements anchored to the seabed. For example: benthic communities, wrecks, and other objects of broad cultural interest. These three-dimensional models can easily be shared with a variety of stakeholders, including the public interested in the underwater environment, who will be able to experience the underwater world through the modern techniques of Virtual Reality. This sector in recent very strong development will lead in the coming years to a huge economic return in the context of virtual tourism.

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

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