D.5.2.5. Specification and scenario of the demonstration 2

InnovaMare project

Blue technology - Developing innovative technologies for sustainability of Adriatic Sea

WP5 – Cooperation in innovation on robotic and sensors solution (TT) – pilot actions

Project References

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Contents

INTRODUCTION

The Adriatic Sea is one of the crucial industrial and touristic sites of the north east Mediterranean Sea and mitigate the anthropogenic impact on this area is crucial to protect the health of the ecosystems and of the people that leave by it. One of the main aims of InnovaMare Project is the monitoring of the health of the Adriatic Sea via an innovative robotic system and, specifically, the goal of WP5 is to put into practice the collaboration among the partners on robotics solutions to be used for the sustainability of the Adriatic Sea.

To achieve this goal, two different scenarios were identified in different environmental conditions, specifically Scenario 2 was designed for the Biograd na Moru area. Biograd na Moru has a touristic marina and a refueling station for boats and it is widely popular. All types of vessels operate in the area from ferries to yachts, but also touristic and fishing boats. Thus, there may be sea litter accumulated in the sea bottom.

The remainder of this report is organized as follows. The general scenario description is presented in the next section. Then, the goals of the demonstration are briefly highlighted before introducing the equipment to be used. Participants, Participants responsibilities, Operating area, Event-setup and Health and Safety complement the document. Finally, the section Conclusions draws some conclusions.

GENERAL SCENARIO DESCRIPTION

Within the Innovamare activity 5.2, FER and CNR started a proposal on the definition of applicative scenarios both in Italy (Venice) and Croatia (Šibenik) for the use of the robotic solution and sensors in order to reach the GES for the MSFD descriptors. These use cases were presented in D5.2.1. For this demonstration, a combined use case of bathymetric mapping with litter detection has been chosen. This use case involved the Korkyra ASV from FER, the SWAMP ASV from CNR and the Surface Vessel from GEOMAR as support vessel presented in D5.2.2 and the Smart Buoy from FER presented in D5.2.3.

GOALS OF DEMONSTRATION

Main objectives of the demonstration are to show functionalities of the autonomous surface vehicles Korkyra and SWAMP, integration of the ASV Korkyra with the Blueye Pro ROV, as well as intra-partner vehicles' communication and collaboration, featuring integration of agents in the Multifunctional Smart Buoy system for information relaying and vehicle monitoring. In addition, the demonstration will also show the hydrographic capabilities of GEOMAR's surface vessel. For ASV Korkyra this encompasses:

1. Streaming of video recorded by the Blueye Pro ROV relayed over ASV Korkyra's WiFi to the ROV operator, as well as relaying of manual gamepad/Blueye ROS2 GUI controls from the operator to the ROV,
2. acoustic localization (and its precision) of the ROV w.r.t. the ASV Korkyra using WaterLinked UWGPS G2 system integrated with ROS2 by UNIZG-FER team,
3. Intra-partner vehicles UDP communication over ROS or simple JSON messages that enables collaboration and/or cooperation of the vehicles, with the Multifunctional Smart Buoy

surface unit serving as communication relay (see Deliverable D.5.2.4. Specification and scenario of the demonstration 1)
4. offline bathymetric map generation based on its integrated Norbit MBES with Applanix INS,
5. (optional) tether management system (TMS) testing of automatic tether length control based on acoustic localization of the ROV,
6. (optional) landing platform (LP) testing of manual landing of a UAV and its docking on top of the ASV Korkyra – the UAV can be used to detect sea litter from air in shallow waters.

The optional scenario involving the UAV, Korkyra ASV and BluEye ROV for sea litter detection in the context of mariculture inspection is shown in Figure 1.

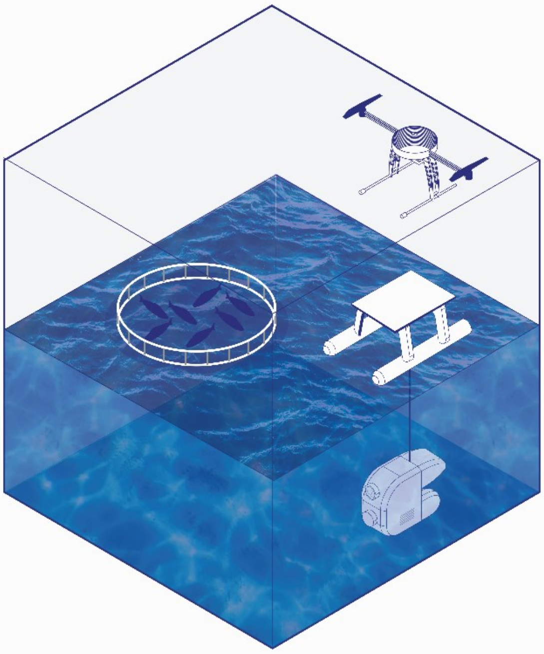

Figure 1: Depiction of the scenario where an AUV is used together with Korkyra ASV and BluEye ROV to help detecting sea litter in a mariculture inspection.

The main demonstration scenario would include ASVs Korkyra with Blueye Pro ROV mounted onto it, ASV SWAMP, the Buoy surface unit, and the GEOMAR surface vessel. The GEOMAR Surface vessel is deployed with its multi-beam to obtain an initial high-resolution bathymetric map. This bathymetric map will act as a benchmark to be compared with the ones obtained by Korkyra ASV and SWAMP ASV. BluEye ROV is used to collect visual data of the seafloor with an objective to find sea litter and other pollution factors. ASV Korkyra is controlled to follow the ROV in order to reduce the chance of tether entanglement in case the ROV goes too far. Once ROV operator identifies sea litter, the estimated georeferenced location is sent to the ASV SWAMP over WiFi using the Smart Buoy as a relay. The georeferenced location is computed based on ASV Korkyra's known global location fused with ROV's position relative to Korkyra. When ASV SWAMP receives the estimated location of the detected sea litter it moves to the given location to prove the communication and the data exchange between the two vehicles. The buoy monitors the vehicles during the entire length of the mission, displaying their telemetry and status data on a graphical dashboard.

For ASV SWAMP equipped with multibeam, the demonstration encompasses:
1. Antenna and multibeam calibration

2. Acquisition of bathymetry and backscatter with Qinsy commercial software
3. Bathymetric acquisition with in-house software

Alternatively, SWAMP can also mount the ROV or SUNA V2 respectively for continuous hyperspectral measurements and nutrients

EQUIPMENT TO BE USED

SWAMP ASV with MBES R2Sonic setup

SWAMP - Shallow Water Autonomous Multipurpose Platform - is a portable, modular Unmanned Surface Vehicle (USV), designed and built by CNR-INM Genoa research group. It is a catamaran, equipped with four azimuth Pump-Jet thrusters, all contained within the hulls, and designed specifically for SWAMP. The hulls are made of a soft-foam lightweight material, each hull hosts a propelling and control unit (MINION) (see D.5.2.4 for more details).
The multibeam chosen to be integrated into this vehicle is an R2Sonic 2020. Its highly portability, compactness (140 x 161 x 133.5 mm), lightness (4.4 kg) and low power consumption (20 W average) makes it the best choice to be mounted on an autonomous vehicle (see D.5.2.3 for references on sensors description)
To protect the single components of the full installation (sonar head, SIM, MRU and mini-SVP), a special mounting frame made of plastics and polyurethane foam was designed exclusively for the sea testing and trials of the instrumentation purchased for the Innovamare project.
All electronic components sensitive to water have been closed in a waterproof container (see image below).

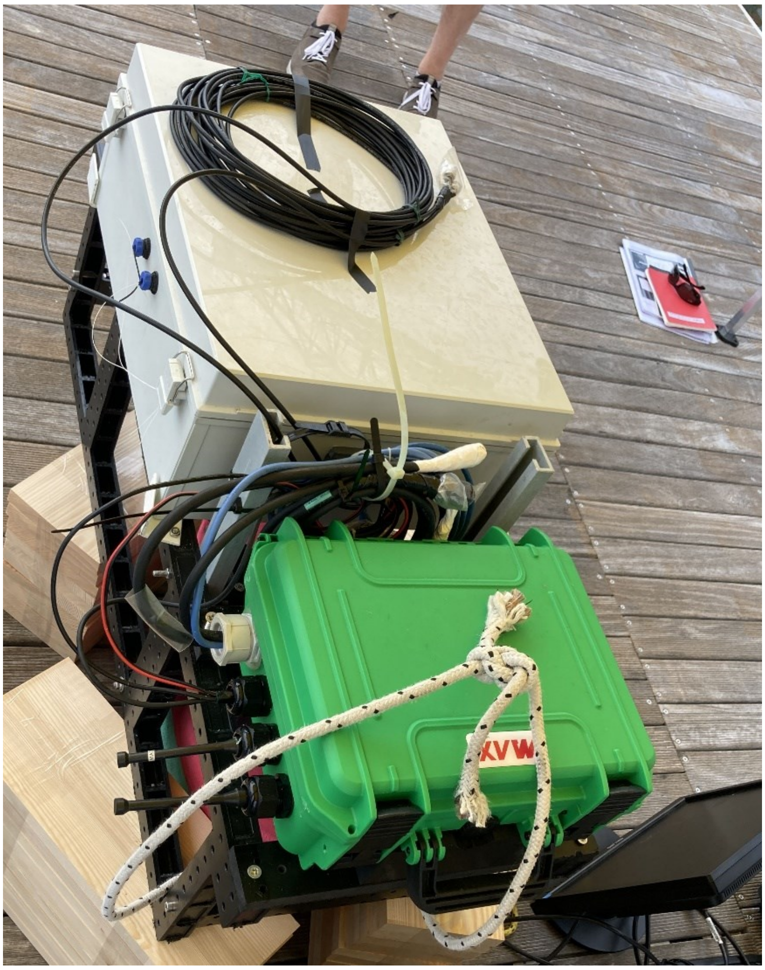

Fig. 2: two waterproof containers mounted on multibeam supported structure

The acquisition test was performed in Arsenale, a safe place with calm and shallow water, where we checked all the connections, the communication between the instruments (MBES, SIM, IMU, antennas, MINION), the manoeuvrability of the entire system, the quality of output data and the battery life in this working conditions.

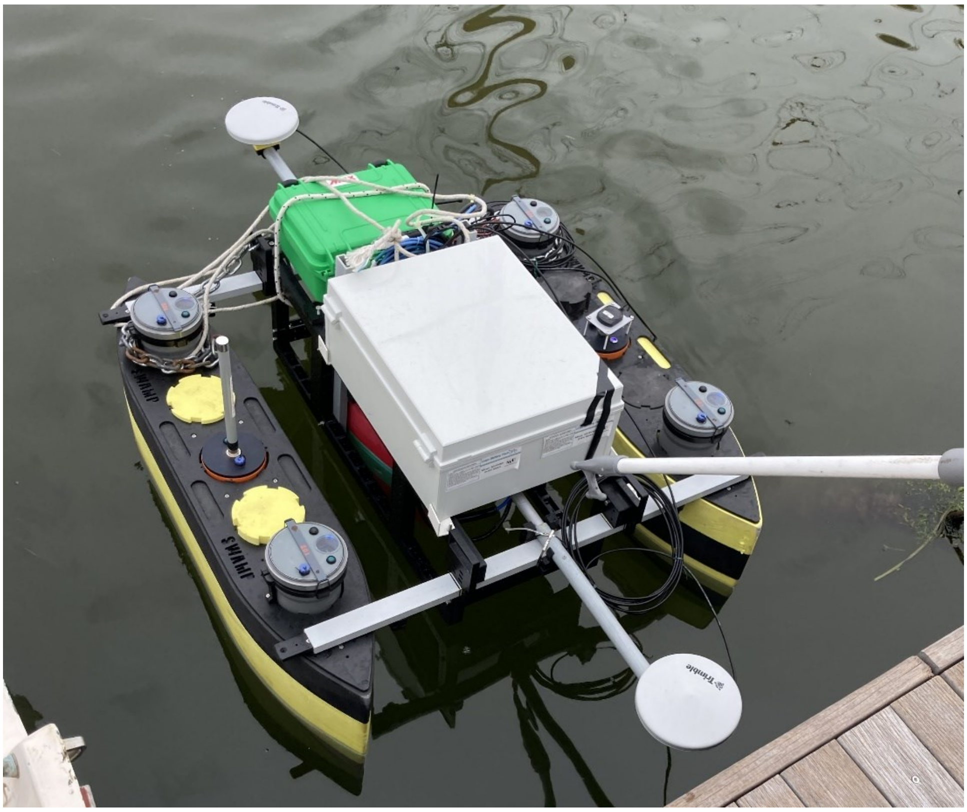

Fig. 3: R2Sonic MBES system integrated on SWAMP

A human operator, who connects to the onboard access point and guides the vehicle, controls SWAMP remotely. Another human operator, connected remotely with computer dedicated to mbes, controls its acquisition.
The MBES computer was also connected to SWAMP WIFI network and to another wifi to receive the correction on GPS signal (RTK).
During the test, all the connections worked properly.
The vehicle control operator was able to drive the vehicle on straight routes and to performed the GAMS calibration (antenna calibration) manoeuvring the vessel through turns (figure 8 and s-turns).
Unfortunately, the GPS signal was degraded throughout the test. An inadequate satellite coverage in the Arsenale area where we conducted the test or antennas mounted too close to water could be the cause (or causes) of this failure.
Otherwise, the multibeam head properly detected sea bottom, based on the depth well known from previous surveys (see image below).

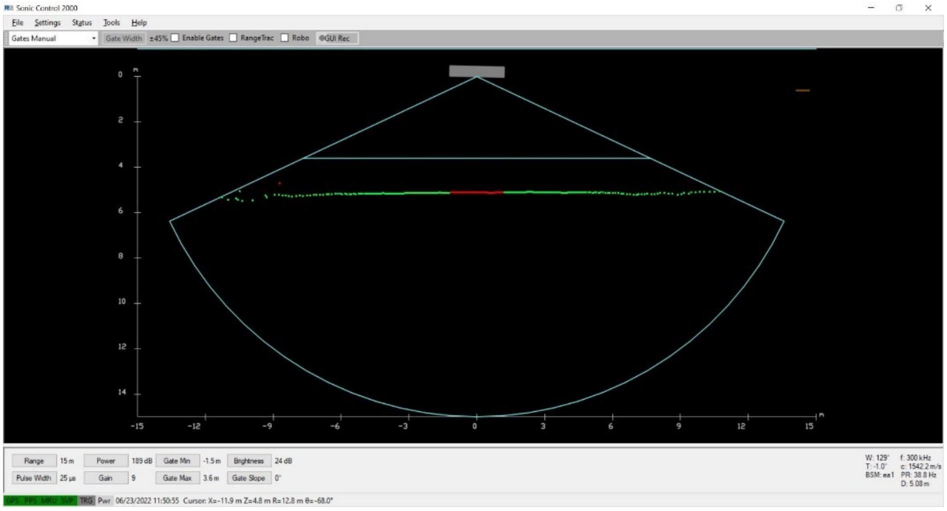

Fig. 3: sea bottom detected by sonar head

Buoy

A smart buoy being developed by FER and already tested in Scenario 1 (D5.2.4) will be used in this scenario as a relay of communications between SWAMP ASV and Korkyra ASV and as a way of monitoring the ASVs missions. The buoy can operate as a remote marine platform performing water quality measurements, as well as a relay for sensor network. Algorithms based on the buoy's inertial measurements can be used to estimate and report on wave height and sea state, and image processing algorithms can be used to implement video monitoring and potential intrusion detection using the buoy's camera for instance for archaeological sites. Three configurations are available (detailed in D5.2.3) but only the static buoy configuration will be used in this scenario.
Communication-wise, the buoy represents a node in a smart city network with real-time remote access. Besides serving as a hub transmitting relocation requests and points of interest between the ASVs, the buoy monitors the vehicles and sensor units during the entire length of the mission, collecting their telemetry, sensor, and status data over all communication channels, finally relaying it to be displayed on a user-friendly graphical IoT dashboard.

Korkyra ASV

The Korkyra Autonomous Surface Vehicle (ASV) will be used together with the Blueye ROV in the search and detection of sea litter. This ASV can be seen as complimentary to the SWAMP ASV as it has a different size, top speed and sensor suite. The description of this ASV can be found in D5.2.2. The Korkyra ASV will follow the Blueye ROV until the detection spot and transmit that position to SWAMP ASV through the Smart Buoy.

Blueye Pro ROV

This Remotely Operated Vehicle (ROV) is a commercial product. However, it will be tethered to the Korkyra ASV and acoustically monitored. The Tether Management System (TMS) was developed by FER and the acoustic monitoring system was integrated by FER as well. While preliminary testing of the TMS occurred in the INNOVAMARE public event in Dubrovnik, further testing will be done in this scenario as well as for the acoustic monitoring system. A description of the Blueye ROV can be found in D5.2.2.

Surface vessel

The INNOVAMARE partner GEOMAR has a Surface Vessel (SV) that can be used in support of trials. This surface vessel can be used for various tasks such as Multi-beam sonar (MBES) surveys, ROV tasks and sampling by various sensors. This vessel (of up to 10m) can serve a platform for performing various tasks, surveys as well as an office at sea, especially in locations such as ports, mariculture farms, etc. The current vessel can be seen in Fig. 4.

Fig. 4 GEOMAR's hydrographic vessel (8 m).

The surface vessel has the same modularity as the SWAMP ASV and the Korkyra ASV. Typical sensors mounted in this boat are:

- multibeam echosounder (MBES) Teledyne RESON SeaBat T20-P;
- sound velocity profiler Valeport mini SVP;
- Trimble-Applanix positioning system;
- geological parametric sub bottom profiler (SBP) Innomar ses 2000 Light for geological surveys.

The vessel will be used to perform an initial bathymetric survey to support further planning of trials.

PARTICIPANTS

Participating partners are FER, CNR and GEOMAR. Other relevant partners may join the trials if appropriate.

PARTICIPANTS RESPONSIBILITIES

FER is responsible for providing the logistics of deployment and for organizing the demonstration. CNR and GEOMAR are responsible for bringing the adequate equipment described above and participating in the trials according to the plans laid down in this document.

OPERATING AREA REQUIREMENTS

Here put logistic and size/type of area requirements if we are not sure of locations for trials

Equipment storage Since ASV Korkyra is a catamaran of dimensions 2x1x1.5m, a storage room will be needed for UNIZG-FER team to safely store it together with ASV SWAMP, Blueye Pro ROV with its tether management system, the underwater localization equipment and ASV mounts, and the standard network equipment, tools, possibly even the landing platform (1.15x1x0.3m) and the UAV (1.2x1.2x0.45m).

Deployment ASV Korkyra weighs over 100kg but it has wheels – two fixed at the back and two swivel wheels at the front for maneuvering. It needs slanted flat concrete access to the sea, or any (non-concrete slabs) beach if there is such near the demonstration location. Also, Korkyra has metal hooks on its top deck so it can be lowered down by a crane from a workboat or a pier.

Support boat It would be good to have a small support boat support in case of an emergency.

Internet access Depending on the location of the demonstration, the host partner should provide Internet access to the teams working with the vehicles for, at least 3G. UNIZG-FER team has an LTE mobile internet modem so even in case of a location without cable/optical internet access, this could be a fallback plan, of course if the signal is strong enough.

Freight The equipment will be transported by van(s) so in case of border crossing, the host partner should help with the documentation needed for equipment-in-transit processing with a freight company.

Workspace In case that the demonstration is controlled from a ground station, the host partner should provide a gazebo or a big sunshade with tables as chairs. In case the demo is performed at sea, the host should provide a workboat with a shaded workspace. Workboat automatically needs a crane for Korkyra deployment.

Optional NTrip base station access, aggregate and fuel in case of a remote location or power outage, power extension cables, LiIon fire protection battery bags

EVENTS SET-UP

Depending on which vehicles and subsystems are used and in which mode, the given scenario can be broken down into the following testing setups:

1. GEOMAR's Surface Vessel performs a bathymetric map of the area to have as a reference and further trials planning.
2. Korkyra is controlled manually by a gamepad as well as Blueye ROV. Sea litter is detected manually. UWGPS system and TMS aren't used so ROV's tether is at a fixed length – long enough to enable shallow water sea litter inspection close to the sea floor, but as short as possible to reduce the estimated ROV's position once litter is detected and SWAMP goes to sample it.
3. Korkyra is controlled manually by a gamepad as well as Blueye ROV. Sea litter is detected manually. UWGPS system is used so ROV's tether can be arbitrarily unwound since TMS isn't used.

4. Korkyra is controlled manually by a gamepad as well as Blueye ROV. Sea litter is detected manually. UWGPS system is used and ROV's tether is automatically (un)wound by the TMS.
5. Korkyra is controlled manually by a gamepad as well as Blueye ROV. Sea litter is detected manually. UWGPS system is used and ROV's tether is automatically (un)wound by the TMS. The UAV also detects sea litter manually in shallow waters and is manually controlled, but the LP isn't used so the UAV is deployed from and lands from the testing site.
6. Korkyra is controlled manually by a gamepad as well as Blueye ROV. Sea litter is detected manually. UWGPS system is used and ROV's tether is automatically (un)wound by the TMS. The UAV also detects sea litter manually in shallow waters and is fully manually controlled, and the LP is used for UAV take-off and landing/docking.
7. Korkyra is controlled automatically so it follows the ROV. Blueye ROV is controlled manually. Sea litter is detected manually. UWGPS system is used and ROV's tether is automatically (un)wound by the TMS.
8. Korkyra is controlled automatically so it follows the ROV. Blueye ROV is controlled manually. Sea litter is detected manually. UWGPS system is used and ROV's tether is automatically (un)wound by the TMS. The UAV also detects sea litter manually in shallow waters and is fully manually controlled, and the LP is used for UAV take-off and landing/docking.

Scenario Agenda: SEPTEMBER 26-29 2022

Sunday, September 25th :

8:00-13:00

- CNR, UNIZG-FER, and GEOMAR teams' arrival
- briefing

14:00-18:00

- Equipment deployment to the storage room
- CNR and FER equipment setting evaluation for the next days

Monday, September 26th :

8:00-13:00

- Briefing for GEOMAR's bathymetric mission.
- Initial setup of GEOMAR's mission.

14:00-18:00

- GEOMAR's Surface Vessel performs a bathymetric map of the area to have as a reference and further trials planning.

Tuesday, September 27th :

8:00-13:00

- Briefing for the ASV Korkyra, ROV Blueye, Buoys, and ASV SWAMP vehicle tests.
- Initial setup of all vehicles and network.

14:00-18:00

- ASV Korkyra basic manual and auto control, and comms tests.
- Blueye-ROS2 interface and control tests.

- TMS and UWGPS testing.
- Buoys setup tests and comms.
- ASV SWAMP manual and automatic control, and comms tests.

Wednesday, September 28th :
8:00-13:00

- Briefing for inter-vehicle communication.
- Basic setup of the vehicles and the network.

14:00-18:00

- Tests of Events 2-4 described above.

Thursday, September 29th :
8:00-13:00

- Briefing for the demo.

14:00-18:00

- Demo showcasing one of Events 2-4 described above.

HEALTH AND SAFETY

Maintaining a safe working environment is the shared responsibility of all test team members. The Test Leads (FER) shall perform the duties of a Test Safety Coordinator with the responsibility and authority to manage the safe conduct of all participants and make on scene decisions concerning all technical and safety aspects of these tests.

The Test Leads will brief all participating personnel daily on safety considerations and procedures. If new information becomes available during testing, the Test Leads will conduct an immediate review for safety aspects, and take appropriate action, to include suspending testing until all issues are resolved. If unsafe conditions are encountered, the Test Leads have the responsibility to stop the test for as long as necessary to correct the problem. The Test Leads will make the determination to resume testing after a safety review is completed.

None of the anticipated test conditions are considered unusual or hazardous for the equipment being tested or the personnel involved. No unmitigated safety hazards are anticipated for the test program. Standard safety operating procedures shall be observed at all times for all operations.

CONCLUSIONS

This report describes in detail the foreseen scenario to test the platforms developed and used by InnovaMare Project partners. The scenario includes one vessel, 2 Autonomous Surface Vessels, one Remotely Operated Vehicle and one buoy acting as relay for communications. This complex scenario was designed to be implemented in the Biograd na Moru area where both CNR and FER had conducted collaborative experiments previously and are aware of all the needed logistics. In order to design this scenario, a series of regular meetings have taken place among partners, looking at the different possibilities of collaboration. A showcase of the platforms is foreseen at the upcoming Breaking the Surface 2022 workshop.

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GLOSSARY

AP Access Point
ASV: Autonomous Surface Vehicle
Benthic zone: is the ecological region at the lowest level of a body of water such as an ocean, lake, or stream, including the sediment surface and some sub-surface layers.
CDOM Coloured Dissolved Organic Matter
CRI Color Rendering Index
DDNS Dynamic Domain Name System
EPA: Environmental Protection Agency
GES MSFD: Good Environmental Status descriptors of Marine Strategy Framework Directive
GIS: geographic information system
GNSS: Global Navigation Satellite System
GPS: Global Positioning System
GUI Graphical User Interface
IMU Inertial Measurement Unit
IMC Inter-Module Communication
IoT Internet of Things
IoUT Internet of Underwater Things
LABUST Laboratory for Underwater Systems
LL Living Lab
LoRaWAN Long Range Wide Area Network
LTE Long Term Evolution
MBES: MultiBeam EchoSounder
MPA: Marine Protected Area
MQTT Message Queuing Telemetry Transport
NGC Navigation, Guidance and Control

Ortophoto: is an aerial photograph or satellite imagery geometrically corrected ("orthorectified") such that the scale is uniform: the photo or image follows a given map projection.
PTZ Pan-Tilt-Zoom
ROV: Remote Operated Vehicle
RTK Real Time Kinematic
RTSP Real Time Streaming Protocol
SA Station Adapter
SBP Sub Bottom Profiler
SDK Software Development Kit
SV: Surface Vehicle
SWAMP: Shallow Water Autonomous Multipurpose Platform
TMS Tether Management System
UNESCO United Nations Educational, Scientific and Cultural Organization
USBL Ultra-Short BaseLine